Scilab Textbook Companion for Solid State Devices and Materials by R. K. Singh and D. S. Chauhan[1]

Created by
Ajay Verma
B.Tech
Electronics Engineering
UPTU
College Teacher
Mr. Sunil Kumar
Cross-Checked by
Lavitha Pereira

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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

```
1 // Exa 1.2
2 clc;
3 clear;
4 close;
5 // Given data
6 format('v',13)
7 I=0.5;// in A
8 rho= 7.4;// in    /1000 ft
9 rho= rho/(3.05*10^4);// in    /cm
10 sigma= 1/rho;//in cm/
11 disp(sigma,"Conductivity in   /cm is : ")
12
13 // Part (ii)
14 n= 6.5*10^28;// in per meter cube
15 q= 1.6*10^-19;// in C
16 // Formula sigma= n*q*miu_n
17 miu_n= sigma/(n*q);// in cm^2/Vs
18 disp(miu_n,"Mobility in cm^2/Vs is : ")
19
```

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

Scilab code Exa 1.3 Hole and electron concentration

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

Scilab code Exa 1.4 Conductivity and resistivity

```
1 // Exa 1.4
2 clc;
3 clear;
4 close;
```

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

Scilab code Exa 1.5 Conductivity

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

Scilab code Exa 1.6 Fraction of the total number of electrons

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

Scilab code Exa 1.7 Ratio of electron to hole concentration

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

Scilab code Exa 1.8 Charge density of free electrons

```
1  // Exa 1.8
2  clc;
3  clear;
4  close;
5  // Given data
6  format('v',13)
7  d= 2;// in mm
8  d=d*10^-3;//in m
9  sigma= 5.8*10^7;// in s/m
10 miu_c= 0.0032;// in m^2/v-sec
11 E= 20;//in mV/m
12 E=E*10^-3;//in V/m
13 e= 1.6*10^-19;// in C
14 // Part (a)
15 n= sigma/(e*miu_c);//in /m^3
16 disp(n,"Charge density per meter cube is : ")
17
18 // Part (b)
19 J= sigma*E;//in A/m^2
20 disp(J,"Current density in A/m^2 is : ")
21
22 // Part (c)
23 Area= %pi*d^2/4;// in area of cross-section of wire
       in m^2
24 I= J*Area;// in A
25 disp(I,"Current flowing in the wire in amp is : ")
26
27 // Part (d)
28 v= miu_c*E;// in m/sec
29 disp(v,"Electron drift velocity in m/sec is : ")
```

Scilab code Exa 1.9 Time taken by the electron to travel

```
1  // Exa 1.9
2  clc;
3  clear;
4  close;
5  // Given data
6  format('v',13)
7  rho= 0.5;// in     -m
8  miu_c= 0.4;// in m^2/v-sec
9  J=100;//in A/m^2
10 distance=10;//   m
11 distance=distance*10^-6;//in sec
12 // V= miu_c*E = miu_c*J/sigma = miu_c*J*rho
13 V=  miu_c*J*rho ;// in m/sec
14 disp(V,"Drift velocity in m/sec is : ")
15 T= distance/V;// in second
16 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

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

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

Scilab code Exa 1.11 `Current sending through the solenoid`

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

Scilab code Exa 1.12 `Magnetic moment of the rod`

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

15

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

Scilab code Exa 1.13 `Relative permeability`

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

Scilab code Exa 1.14 `Flux density`

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

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

Scilab code Exa 1.15 Conductivity of a bar

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

Scilab code Exa 1.16 Hole concentration and conductivity

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

```
8  ni= 2.4*10^19;// in /m^3
9  miu_n= 3500;// in cm^2/vs
10 miu_n= miu_n*10^-4;// in m^2/vs
11 // Formula n*p= ni^2
12 p= ni^2/n;// in m^-3
13 disp(p,"Hole concentration in m^-3 is : ")
14 sigma=q*n*miu_n;// in ( -m)^-1
15 disp(sigma,"The conductivity of the extrinsic
       semiconductor in ( m )^-1 is :")
16
17 // 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

```
1  // Exa 1.17
2  clc;
3  clear;
4  close;
5  // Given data
6  ni= 1.8*10^16;// in /m^3
7  q= 1.6*10^-19;// in C
8  em=0.14;// electron mobility in m^2/v-sec
9  hm=0.05;// hole mobility in m^2/v-sec
10 resistivity= 1.2;// in  m
11 n= 1/(q*em*resistivity);// in /m^3
12 disp(n,"The electron concenration in /m^3 is :")
13 p= ni^2/n;// in /m^3
14 disp(p,"The hole concentration in /m^3 is : ")
```

Scilab code Exa 1.18 Conductivity of the material

18

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

Scilab code Exa 1.19 Conductivity of intrinsic Ge

```
1  // Exa 1.19
2  clc;
3  clear;
4  close;
5  // Given data
6  ni= 2.25*10^13;// in /cm^3
7  e= 1.6*10^-19;// in C
8  miu_n= 3800;// in cm^2/vs
9  miu_p= 1800;// in cm^2/vs
10 no=ni;
11 sigma= no*e*(miu_n+miu_p);// in s/cm
12 disp(sigma,"The intrinsic conductivity in s/cm is :"
       )
13
14 // 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

19

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

Scilab code Exa 1.21 Conductivity of Si material

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

Scilab code Exa 1.22 Conductivity of Si material

```
1  // Exa 1.22
2  clc;
```

```scilab
3  clear;
4  close;
5  // Given data
6  miu_p= 0.05; // in m^2/v-sec
7  rho=5*10^28/10^8; // in /m^3
8  q= 1.6*10^-19; // in C
9  sigma= q*rho*miu_p; // in ( m )^-1
10 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

```
1  // Exa 2.1
2  clc;
3  clear;
4  close;
5  // Given data
6  miu= 0.3;// in m^2/vs
7  V= 50;// in mV
8  V=V*10^-3;// in V
9  d=0.4;// in mm
10 d=d*10^-3;// in m
11 // Part (a)
12 // miu= vd/E and vd= miu*E, so
13 vd= miu*V/d;// in m/s
14 disp(vd,"Drift velocity in m/s is : ")
15
16 // Part (b)
17 T= d/vd;// in sec
18 disp(T*10^6,"Time required for an electron to move
     in s is :")
```

Scilab code Exa 2.2 Value of intrinsic conductivities

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

Scilab code Exa 2.3 Free electrons and hole mobilities

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

Scilab code Exa 2.4 `Conductivity of Si sample`

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

Scilab code Exa 2.5 `Conductivity of copper`

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

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

```
1  // Exa 2.6
2  clc;
3  clear;
4  close;
5  // Given data
6  // For silicon
7  q=1.6*10^-19;// in C
8  ni= 2.5*10^12;// in /cm^3
9  miu_n= 1700;// in cm^2/Vs
10 miu_p= 600;// in cm^2/Vs
11 sigma= 0.2;// in ( m )^-1
12 // Formula sigma= q*n*miu_n
13 n= sigma/(q*miu_n);// in /cm^3
14 p= ni^2/n;// in /cm^3
15 disp("For silicon")
16 disp(n,"Concentration of electron in /cm^3 is : ")
17 disp(p,"Concentration of holes in /cm^3 is : ")
18 // For germanium
19 ni= 3.4*10^15;// in /cm^3
20 miu_n= 3600;// in cm^2/Vs
21 miu_p= 1600;// in cm^2/Vs
22 sigma= 150;// in ( m )^-1
23 p= sigma/(q*miu_p);// in /cm^3
24 n= ni^2/p;// in /cm^3
25 disp("For germanium")
26 disp(n,"Concentration of electron in /cm^3 is : ")
27 disp(p,"Concentration of holes in /cm^3 is : ")
```

Scilab code Exa 2.7 Resistivity of Ge drops

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

Scilab code Exa 2.8 `Resistivity of intrinsic Si`

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

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

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

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

Scilab code Exa 2.10 Minority carrier concentration

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

```
11  MCC= ni^2/dopingConcentration; // Minority carrier
        concentration per cube meter
12  miu_n= 1/(2*rho*q*ni);// in m^3/Vs
13  disp(miu_n,"The value of  n  in m^3/Vs is : ")
14
15  // Part (b)
16  sigma= q*n*miu_n;//in ( m )^-1
17  rho= 1/sigma;// in  m
18  disp(rho,"Resistivity in  m  is : ")
19
20  // Part(c)
21  kT= 26*10^-3;//in V
22  no= n;// in /m^3
23  Shift_inFermiLevel= kT*log(no/ni);// in eV
24  disp(Shift_inFermiLevel,"Shift in Fermi level due to
        doping in eV is :")
25  disp("Hence, E_F lies "+string(Shift_inFermiLevel)+"
        eV above Fermi level Ei")
26
27  // Part (d)
28  MCC= ni^2/dopingConcentration; // Minority carrier
        concentration per cube meter
29  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

```
1  // Exa 2.11
2  clc;
3  clear;
4  close;
5  // Given data
6  miu_n= 1700;//in cm^2/Vs
7  miu_p= 560;//in cm^2/Vs
8  ni= 2.5*10^10;// in /cm^3
```

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

Scilab code Exa 2.12 `Resistivity of Si`

```
 1  // Exa 2.12
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  ni= 1.45*10^10;// in /cm^3
 7  q=1.6*10^-19;// in C
 8  miu_n= 1300;// in cm^2/Vs
 9  density= 5*10^22;// density of silicon atom in /cm^3
10  N_D= density/10^12;
11  n=N_D;
12  // n*p= ni^2
13  p= ni^2/n;//in /cm^3
14  sigma= q*n*miu_n;// in ( cm )^-1
15  rho= 1/sigma;// in  cm
16  disp(rho,"Resistivity of silicon in  cm  is : ")
17
18  // 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`

```
 1  // Exa 2.13
```

29

```
2  clc;
3  clear;
4  close;
5  // Given data
6  q=1.6*10^-19;// in C
7  rho=75;//in cm
8  N_D= 10^13;// in /cm^3
9  N_A= 5*10^12;//in /cm^3
10 E=3;// in V/cm
11 ni= 2.7*10^12;// in /cm^3
12 sigma= 1/rho;// in ( cm )^-1
13 // miu_p/miu_n= 1/3 or miu_n=3*miu_p
14 // sigma= q*ni*(miu_n+miu_p) = q*ni*(3*miu_p+miu_p)
      = q*ni*(4*miu_p)
15 miu_p= sigma/(q*ni*4);
16 miu_n= 3*miu_p;
17 // n+N_A= p+N_D  or  n= p+N_D-N_A
18 // n*p= ni^2  or  (p+N_D-N_A)*p= ni^2
19 // p^2 + (N_D-N_A)*p-ni^2 =0
20 // values= [1 (N_D-N_A) -ni^2];
21 p = roots([1 5*10^12 -7.29*10^24])
22 p=p(2);//discarding -ve value
23 n=p+N_D-N_A;
24 I= q*(n*miu_n+p*miu_p)*E// in A/m^2
25 disp(I,"The total conduction current in A/m^2 is : "
      )
26
27 // Note: There is some difference between book
      answer and coding. The reson behind this is that
28 //         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

```
1  // Exa 2.14
```

```
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  N_D= 10^20;// in /cm^3
 7  ni= 2.5*10^12;// in /cm^3
 8  kT=26;// in meV
 9  kT=kT*10^-3;// in eV
10  n= N_D;// as N_D>>ni
11  p= ni^2/n;//in /cm^3
12  disp(p,"The minority carrier concentration per cm^3
        is :")
13
14  // Part (b)
15  LocationOfFermiLevel= kT*log(N_D/ni);// in eV
16  disp("The Fermi Level will be "+string(
        LocationOfFermiLevel)+" eV above Fermi level")
17
18  //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

```
 1  // Exa 2.15
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  miu_n= 1300;// in cm^2/Vs
 7  q=1.6*10^-19;// in C
 8  ni= 4.3*10^-6;// in /cm^3
 9  V= 1;// in volt
10  L=8;// in cm
```

```
11  A=0.8*0.8;// in cm^2
12  I=4*10^-3;// in A
13  // R= rho*L/A = V/I
14  R= V/I;// in
15  sigma= L/(R*A);// in ( cm )^-1
16  // sigma= q*n*miu_n
17  n= sigma/(q*miu_n);
18  N_D= n;
19  disp(N_D,"The value of N_D is :")
20  // Part (b)
21  d=L;
22  E= V/d;
23  vd=miu_n*E;// in cm/s
24  disp(vd,"Drift velocity in cm/s is : ")
```

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

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

Scilab code Exa 2.17 Resistivity of the material

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

Scilab code Exa 2.18 Conductivity of Si material

```
1  // Exa 2.18
2  clc;
3  clear;
4  close;
5  // Given data
6  miu_n= 0.13;// in m^2/Vs
7  miu_p= 0.05;// in m^2/Vs
8  q=1.6*10^-19;// in C
9  ni=1.5*10^16;// per m^3
10 sigma_intrinsic= q*ni*(miu_n+miu_p);// in ( m )^-1
11 disp(sigma_intrinsic,"The conductivity of silicon in
       Intrinsic condition in ( m )^-1 is : ")
12
13 // Part (b)
14 n= 5*10^28/10^9;
15 sigma= q*n*miu_n;// in ( m )^-1
16 disp(sigma,"The conductivity with donar impurity in
    ( m )^-1 is : ")
17
18 // Part (c)
```

```
19  p= 5*10^28/10^8;
20  sigma= q*p*miu_p;// in ( m )^-1
21  disp(sigma,"The conductivity with acceptor impurity
        in ( m )^-1 is : ")
22
23  // Part (d)
24  p_desh= p-n;// in /m^3
25  sigma= q*p_desh*miu_p;// in ( m )^-1
26  disp(sigma,"The conductivity with donar and acceptor
        impurity in ( m )^-1 is : ")
27
28  // 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

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

Scilab code Exa 2.20 Resistivity

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

Scilab code Exa 2.21 Conductivity and mobility for a copper wire

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

Scilab code Exa 2.22 Conductivity and resistivity of an intrinsic Si

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

Scilab code Exa 2.23 The value of intrinsic conductivity

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

Scilab code Exa 2.24 Intrinsic carrier concentration of Ge

```
1  // Exa 2.24
```

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

Scilab code Exa 2.25 Conductivity of Si sample

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

Scilab code Exa 2.26 Conductivity and resistivity of Ge

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

Scilab code Exa 2.27 Conductivity of extrinsic semiconductor

```
1  // Exa 2.27
2  clc;
3  clear;
4  close;
5  // Given data
6  e=1.6*10^-19;// in C
7  miu_n= 0.13;// in m^2/v-s
8  miu_p= 0.05;// in m^2/v-s
9  N_D= 5*10^28/(2*10^8);// per m^3
10 n=N_D;// per m^3
11 ni= 1.5*10^16;// per m^3
12 p= ni^2/N_D;// per m^3
13 sigma= e*(n*miu_n+p*miu_p);// in s/m
14 disp(sigma,"Conductivity of the intrinsic
      semiconductor in s/m is ")
```

Scilab code Exa 2.28 Fraction of the total number of electrons

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

Scilab code Exa 2.29 Ratio of electron to hole concentration

```
1  // Exa 2.29
2  clc;
3  clear;
4  close;
5  // Given data
6  N_D= 1.4*10^24;// per m^3
7  ni= 1.4*10^18;// per m^3
8  n=N_D;//per m^3
9  p=ni^2/n;// per m^3
10 R= n/p;// ratio of electron to holes concentration
11 disp(R,"Ratio of electron to holes concentraiton is
       : ")
```

Scilab code Exa 2.30 Charge density of free electrons

39

```
1  // Exa 2.30
2  clc;
3  clear;
4  close;
5  // Given data
6  e=1.6*10^-19;// in C
7  miu_e= 0.0032;// in m^2/v-s
8  sigma= 5.8*10^7;// in s/m
9  E= 20*10^-3;// in V/m
10 d=0.002;// in m
11 Area= %pi*d^2/4;// in m^2
12
13 // Part (a)
14 n= sigma/(e*miu_e);// per m^3
15 disp(n,"The charge density per meter cube is : ")
16
17 // Part (b)
18 J= sigma*E;// in A/m^2
19 disp(J,"Current density in A/m^2 is : ")
20
21 // Part (c)
22 I= J*Area;// in A
23 disp(I,"Current flowing in the wire in ampere is : "
    )
24
25 // Part (d)
26 v=miu_e*E;// in m/sec
27 disp(v,"Electron drift velocity in m/sec is : ")
```

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

```
1  // Exa 2.31
2  clc;
3  clear;
4  close;
```

```
5  // Given data
6  format('v',13)
7  rho= 0.5;// in    −m
8  miu_c= 0.4;// in m^2/v−sec
9  J=100;//in A/m^2
10 distance =10;//  m
11 distance=distance*10^-6;//in sec
12 // V= miu_c*E = miu_c*J/sigma = miu_c*J*rho
13 V=  miu_c*J*rho ;// in m/sec
14 disp(V,"Drift velocity in m/sec is : ")
15 T= distance/V;// in second
16 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

```
1  // Exa 2.32
2  clc;
3  clear;
4  close;
5  // Given data
6  e=1.6*10^-19;// in C
7  miu_e= 3800;// in cm v−s
8  miu_p= 1800;// in cm v−s
9  ni= 2.5*10^13;// per cm^3
10 N_D= 4.4*10^22*10^-7;// per cm^3
11 n=N_D;// per cm^3
12 p= ni^2/N_D;// holes/cm^3
13 sigma_i= ni*e*(miu_e+miu_p);// in ( cm )^−1
14 sigma_n= e*N_D*miu_e;// in ( cm )^−1
15 disp(sigma_i,"Intrinsic conductivity in ( cm )^−1 is
      : ")
16 disp(n,"Concentration of electrons per cm^3 is : ")
17 disp(p,"Concentration of holes per cm^3 is : ")
18 disp(sigma_n,"The conductivity in n−type Ge
```

semiconductor in (cm)^−1 is : ")

Scilab code Exa 2.33 Electron and hole drift velocity

```
1  // Exa 2.33
2  clc;
3  clear;
4  close;
5  // Given data
6  e=1.6*10^-19; // in C
7  a= 0.004*0.0015; // in m^2
8  ni= 2.5*10^19; // per m^3
9  miu_e= 0.38; // in m^2/ v-s
10 miu_p= 0.18; // in m^2/v-s
11 V=10; // in V
12 i= 25; // in mm
13 i=i*10^-3; // in m
14 E= V/i; // in V/m
15 // Part (a)
16 ve= miu_e*E; // in m/sec
17 disp(ve,"Electric drift velocity in m/sec is : ")
18 vp= miu_p*E; // in m/sec
19 disp(vp,"Hole drift velocity in m/sec is : ")
20
21 // Part (b)
22 sigma_i= ni*e*(miu_e+miu_p); // in ( cm )^−1
23 disp(sigma_i,"Intrinsic carrier conductivity of Ge
      in ( cm )^−1 is : ")
24
25 // Part (c)
26 I= sigma_i*E*a; // in A
27 I=I*10^3; // in mA
28 disp(I,"Total current in mA is : ")
```

Scilab code Exa 2.34 Intrinsic carrier concentration in Si

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

Scilab code Exa 2.35 Junction potential

```
1  // Exa 2.35
2  clc;
3  clear;
4  close;
5  // Given data
6  N_A= 4.4*10^22/10^8;// in /m^3
7  N_D= 10^3*N_A;// in /m^3
8  ni= 2.5*10^13;// /cm^3
9  Vt= 26;// in mV
```

```
10  Vt= Vt*10^-3;// in V
11  Vj= Vt*log(N_A*N_D/ni^2);// in V
12  disp(Vj,"The junction potential in volts is : ")
```

Scilab code Exa 2.36 Current flowing in the diode

```
1  // Exa 2.36
2  clc;
3  clear;
4  close;
5  // Given data
6  I_o= 0.3;// in  A
7  I_o= I_o*10^-6;// in A
8  V_F= 0.15;// in V
9  I= I_o*%e^(40*V_F);// in A
10 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

```
1  // Exa 2.37
2  clc;
3  clear;
4  close;
5  // Given data
6  format('v',11)
7  Io= 1;// in nA
8  Io= Io*10^-9;// in A
9  T= 27+273;//in K
10 V_T= T/11600;// in V
11 V_F= 0.3;// in V
12 n=1;
13 I_F= Io*[%e^(V_F/(n*V_T))-1];// in A
```

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```
14 disp(I_F,"The forward current of diode in ampere is
    : ")
```

Scilab code Exa 2.38 Dynamic resistance of Ge pn junction diode

```
1  // Exa 2.38
2  clc;
3  clear;
4  close;
5  // Given data
6  format('v',11)
7  I_F= 2;// in mA
8  I_F= I_F*10^-3;// in A
9  V_T= 25;// in mV
10 V_T=V_T*10^-3;// in V
11 n=1;
12 r_F= n*V_T/I_F;// in
13 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

```
1  // Exa 2.39
2  clc;
3  clear;
4  close;
5  // Given data
6  T=300;// in K
7  n=1;
8  V_T= 26;// in mV
9  V_T=V_T*10^-3;// in V
10 V_F= 200;// in mV
11 V_F=V_F*10^-3;// in V
```

```
12  Io= 1;// in  A
13  Io= Io*10^-6;// in A
14  r_F= n*V_T/(Io*%e^(V_F/(n*V_T)));// in
15  disp(r_F,"The ac resistance of a semiconductor diode
       in    ")
```

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

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

Chapter 3

Junction Diode And Capacitance

Scilab code Exa 3.1 The transition capacitance of diode

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

Scilab code Exa 3.2 The diffusion capacitance in pn junction diode

```
1  // Exa 3.2
```

```
 2 clc;
 3 clear;
 4 close;
 5 // Given data
 6 toh= 10^-6;// in sec
 7 I=10;// in mA
 8 I=I*10^-3;// in A
 9 n=1;
10 V_T= 26;// in mV
11 V_T= V_T*10^-3;// in V
12 C_D= toh*I/(n*V_T);// in F
13 disp(C_D*10^9,"The diffusion capacitance in p-n
      junction diode in nF")
14
15 // 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
16 //            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

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

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

Scilab code Exa 3.4 The constant n for the diode

```
1 // Exa 3.4
2 clc;
3 clear;
4 close;
5 // Given data
6 Vd_1= 0.3;// in V
7 V_T= 25;// in mV
8 V_T= V_T*10^-3;// in V
9 // when Id_1= 1 mA
10 Id_1= 1;// in mA
11 Id_1=Id_1*10^-3;// in A
12 // Formula Id_1= Io*[%e^(Vd/(n*V_T))-1]= Io*[e^(Vd/(
     n*V_T))]
13 // Id_1= Io*[e^(Vd_1/(n*V_T))]                (i)
14
15 // when Id_2= 200 mA
16 Id_2= 200;// in mA
17 Id_2=Id_2*10^-3;// in A
18 Vd_2= 0.45;// in V
19 // Id_2= Io*[e^(Vd_2/(n*V_T))]                (ii)
20 // Dividing (ii) by (i), we have
21 n= (Vd_2-Vd_1)/(log(Id_2/Id_1)*V_T);
22 disp(n,"The value of the constant for the diode is "
     )
```

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

```
1 // Exa 3.5
2 clc;
```

```
 3  clear ;
 4  close ;
 5  // Given data
 6  T =300; //  in K
 7  V_T= T/11600; //  in V
 8  n =1; //  assuming value
 9  Jd =10^5; //  in A/m^2
10  Jo =250; //  in mA/m^2
11  Jo= Jo *10^ -3; //  in A/m^2
12  //Formula  Id=  Io *(%e^(Vd/V_T)−1)  and  after  dividing
        both  the  sides  by  area  of  the  junction , we  have
13  //  Jd=  Jo *(%e^(Vd/V_T)); //  approx  by  neglecting  1
14  Vd= V_T*log ( Jd/Jo ); //  in  volt
15  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

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

```
     1
16  V= n*k*T*log(J/Jo)/e;
17  disp(V,"Voltage to be applied across the junction in
        volt is")
18
19  // 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
20  //                  the answer in the book is wrong.
```

Scilab code Exa 3.7 Junction forward bias voltage

```
 1  // Exa 3.7
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  n=2;
 7  V_T=26;// in mV
 8  Io= 30;// in mA
 9  // (i) when
10  I_D= 0.1;// in mA
11  V_D= n*V_T*log(I_D/Io);// in mV
12  disp(V_D,"(i) When I_D is 0.1 mA, The junction
        forward-bias voltage in mV is : ")
13  // (ii) when
14  I_D= 10;// in mA
15  V_D= n*V_T*log(I_D/Io);// in mV
16  disp(V_D,"(ii) When I_D is 10 mA, The junction
        forward-bias voltage in mV is : ")
17
18  // 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

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

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

```
1  // Exa 3.9
2  clc;
3  clear;
4  close;
5  // Given data
6  nita= 2;
7  T1= 25;// in  C
8  T2= 150;// in  C
9  k= 8.62*10^-5;
10 V_T150= k*(T2+273);// in V
11 V_T25= k*(T1+273);// in V
12 V= 0.4;// in V
13 // Io150= Io25*2^(T2-T1)
14 Io150byIo25= 2^((T2-T1)/10);
```

```
15  I150byI25= Io150byIo25 *( %e^(V/(nita*V_T150))-1)/(
        %e^(V/(nita*V_T25))-1);
16  disp(I150byI25,"The factor by which the current will
        get multiplied when its temperature is raised
        from 25 C  to 150 C  is : ")
17
18  // 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 )
19  // are putted (respectively 5800, 0.0364, 0.026)
        whereas the accurate values of these are
20  // 5792.6188 , 0.0364626 and 0.0256876
```

Scilab code Exa 3.10 Forward and reverse resistance

```
1  // Exa 3.10
2  clc;
3  clear;
4  close;
5  // Given data
6  I_F= 100; // in mA
7  I_F=I_F*10^-3; // in A
8  V_F= 0.75; // in V
9  R_F= V_F/I_F; // in ohm
10 disp(R_F,"Forward resistance in ohm is ")
11 // At
12 V_R= 50; // in V
13 I_R= 100; // in nA
14 I_R= I_R*10^-9; // in A
15 R_R= V_R/I_R; // in ohm
16 disp(R_R*10^-6,"Reverse resistance in Mohm is ")
```

Scilab code Exa 3.11 Dynamic resistance

```
1  // Exa 3.11
2  clc;
3  clear;
4  close;
5  // Given data
6  I_F= 70;// in mA
7  V_F= 26;// in mV
8  delta_I_F= 60;// in mA
9  delta_I_F=delta_I_F*10^-3;// in A
10 delta_V_F= 0.025;// in V
11 r_d= delta_V_F/delta_I_F;// in ohm
12 disp(r_d,"Dynamic resistance in ohm is : ")
13 // and the stimated value of the dynamic resistance
       is
14 r_d= V_F/I_F;// in ohm
15 disp(r_d,"The stimated value of the Dynamic
       resistance in ohm is : ")
```

Scilab code Exa 3.12 Forward and reverse dynamic resistance

```
1  // Exa 3.12
2  clc;
3  clear;
4  close;
5  // Given data
6  Io= 1;// in micro amp
7  Io=Io*10^-6;// in amp
8  V_F= 0.52;// in V
9  V_R= -0.52;// in V
10 nita= 1;
11 T=300;// in K
12 V_T= T/11600;// in volt
13 V_T=round(V_T*10^3);// in mV
14
15 // (i)
```

```
16  r_F= nita*V_T*10^-3/(Io*%e^(V_F/(nita*V_T*10^-3)));
17  disp(r_F,"Dynamic resistance in the forward biased
        condition in ohm")
18
19  // (ii)
20  r_r= nita*V_T*10^-3/(Io*%e^(V_R/(nita*V_T*10^-3)));
21  disp(r_r,"Dynamic resistance in the reverse biased
        condition in ohm")
```

Scilab code Exa 3.13 Static and dynamic resistance

```
1  // Exa 3.13
2  clc;
3  clear;
4  close;
5  // Given data
6  V_F= 0.2;// in V
7  T=300;// in K
8  V_T= T/11600;// in volt
9  Io= 1;// in micro amp
10  Io=Io*10^-6;// in amp
11  Id= Io*(%e^(V_F/V_T)-1)
12  I_F=Id;
13  r_dc= V_F/I_F;// in ohm
14  disp(r_dc,"Dynamic resistance in ohm is : ")
15  r_ac= .026/I_F;// in ohm
16  disp(r_ac,"Static resistance in ohm is : ")
```

Scilab code Exa 3.14 DC resistance levels

```
1  // Exa 3.14
2  clc;
3  clear;
```

```
 4  close ;
 5  // Given data
 6  // Part (i)
 7  I_D=2;// in mA
 8  I_D=I_D*10^-3;// in amp
 9  V_D= 0.5 ; // in volt
10  R_DC= V_D/I_D;// in ohm
11  disp(R_DC,"DC resistance levels for the diode in ohm
        ")
12
13  // Part (ii)
14  I_D=20;// in mA
15  I_D=I_D*10^-3;// in amp
16  V_D= 0.8 ; // in volt
17  R_DC= V_D/I_D;// in ohm
18  disp(R_DC,"DC resistance levels for the diode in ohm
        ")
19
20  // Part (iii)
21  I_D=-1;// in micro amp
22  I_D=I_D*10^-6;// in amp
23  V_D= -10 ; // in volt
24  R_DC= V_D/I_D;// in ohm
25  disp(R_DC*10^-6,"DC resistance levels for the diode
        in Mohm")
```

Scilab code Exa 3.15 Junction dynamic resistance

```
1  // Exa 3.15
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  T1= 25;// in  C
7  T2= 100;// in  C
```

```
8  deltaT= T2-T1;// in  C
9  deltaV_F= -1.8*10^-3;// in mV/ C
10 I_F= 26;// in mA
11 V_F1= 0.7;// in V (at T1)
12 V_F2= V_F1+(deltaT*deltaV_F);// in V (at T2)
13 // At 25 C
14 T= 25+273;// in K
15 rd= 26/I_F*T/298;// in
16 disp(rd,"Junction dynamic resistance at 25 C  in
      is ")
17 // At 100 C
18 T= 100+273;// in K
19 rd= 26/I_F*T/298;// in
20 disp(rd,"Junction dynamic resistance at 100 C  in
       is ")
```

Scilab code Exa 3.16 Dynamic resistance of a diode

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

Scilab code Exa 3.17 Dynamic resistance

```
1  // Exa  3.17
2  clc ;
3  clear ;
4  close ;
5  // Given  data
6  I= 30; // in   A
7  I=I *10^ -6; // in A
8  T=125+273; // in K
9  r_F= T/(11600* I*%e^( -0.32/T) *11600) ; // in
10 disp ( r_F *10^3 , " The  dynamic  resistance  in  m   is  : ")
11
12 // 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) .
13 //               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

```
1  // Exa 4.1
2  clc;
3  clear;
4  close;
5  // Given data
6  Ep= 0.0153*10^-17; //in J
7  lamda= 1300; // in nm
8  nita_ext= 0.1;
9  e = 1.6*10^-19; //in C
10 Eg= 1.42*e; // in eV
11 S= nita_ext*Eg/e; // in W/A  (where S= deltaP/deltaI
       )
12 disp(S,"Slope of efficiency in W/A is : ")
13
14 // 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

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

Scilab code Exa 4.3 Power radiated by an LED

```
1  // Exa 4.3
2  clc;
3  clear;
4  close;
5  // Given data
6  lamda= 670;// in nm
7  h_int= 1/100;
8  EpIn_eV= 1248/lamda;// in eV
9  I=50;// in mA
10 P= h_int*EpIn_eV*I;// in mW
11 disp(P,"Power radiated by an LED in mW is : ")
12
13 // Note : There is a calculation error in evaluating
          the value of P so the answer in the book is
```

Scilab code Exa 4.4 Internal quantum efficiency and optical power generated

```
1  // Exa 4.4
2  clc;
3  clear;
4  close;
5  // Given data
6  I=40;// in mA
7  I=I*10^-3;// in A
8  lamda=1310*10^-9;// in m
9  h= 6.62*10^-34; // in Js
10 c= 3*10^8;// in m/s
11 e= 1.6*10^-19;// in C
12 toh_r= 30;// in ns
13 toh_nr= 100;// in ns
14 toh= toh_r*toh_nr/(toh_r+toh_nr);
15 nita_int= toh/toh_r;
16 disp(nita_int,"The internal quantum efficiency is :
     ")
17 Ep= h*c/lamda;// in J
18 P= nita_int*Ep*I/e;// in W
19 disp(P*10^3,"The optical power generated internally
     to the LED in mW is : ");
20
21 // 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

```
1  // Exa 4.5
```

```
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  // Part (a)
 7  R= 0.85; // in A/W
 8  Pop= 1; // in mW
 9  Ip= R*Pop; // in mA
10  disp(Ip,"Part (a)   The photocurrent in mA is : ")
11  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`

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

Scilab code Exa 4.7 `Responsivity of an InGaAs photo diode`

```
1  // Exa 4.7
2  clc;
3  clear;
4  close;
5  // Given data
```

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

Scilab code Exa 4.8 `Responsivity`

```
 1  // Exa 4.8
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  n=50/100;
 7  lamda= 900; // in nm
 8  R= n*lamda/1248; // in A/W
 9  disp(R,"Responsivity in A/W is : ")
10
11  // Part (b)
12  Ip= 10^-6; // in A
13  Pop= Ip/R; // in W
14  disp(Pop,"The received optical power in W is : ")
15
16  // Part (c)
17  h= 6.62*10^-34; // in Js
18  c= 3*10^8; // in m/s
19  // Pop= n*h*c/lamda
20  n= Pop*lamda*10^-9/(h*c);
21  disp(n,"The corresponding number of received photons
        is : ")
```

```
22
23  // 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

```
 1  // Exa 4.9
 2  clc ;
 3  clear ;
 4  close ;
 5  // Given data
 6  V=4;// in V
 7  Vr1= 0.7;// in V
 8  Vr2= 0.3;// in V
 9  R1= 4;// in k
10  R2= 4;// in k
11  I1= (V-Vr1)/R1;// in mA
12  I2= (V-Vr2)/R2;// in mA
13  disp(I1,"The value of I1 in mA is : ")
14  disp(I2,"The value of I2 in mA is : ")
```

Scilab code Exa 4.10 Minimum and maximum values of LED current

```
 1  // Exa 4.10
 2  clc ;
 3  clear ;
 4  close ;
 5  // Given data
 6  V_Dmin= 1.5;// in V
 7  V_Dmax= 2.3;// in V
 8  Vs= 10;// in V
 9  R1= 470;// in
```

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

Scilab code Exa 4.11 `Supply voltage`

```
1  // Exa 4.11
2  clc;
3  clear;
4  close;
5  // Given data
6  V_Dmin= 1.8;// in V
7  V_Dmax= 3;// in V
8  // Case first
9  Vs= 24;// in V
10  R1= 820;// in
11  Imin=  (Vs-V_Dmax)/R1;// in A
12  Imax= (Vs-V_Dmin)/R1;// in A
13  disp(Imax*10^3-Imin*10^3,"The variation in current
      in first case in mA is : ")
14  // Case second
15  Vs= 5;// in V
16  R1= 120;// in
17  Imin=  (Vs-V_Dmax)/R1;// in A
18  Imax= (Vs-V_Dmin)/R1;// in A
19  disp(Imax*10^3-Imin*10^3,"The variation in current
      in first case in mA is : ")
20  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.")
```

65

Scilab code Exa 4.12 `Smallest standard resistor value`

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

Scilab code Exa 4.13 `Responsivity of the photo diode`

```
1  // Exa 4.13
2  clc;
3  clear;
4  close;
5  // Given data
```

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

Scilab code Exa 4.14 `Power radiated by an LED`

```
1  // Exa 4.14
2  clc;
3  clear;
4  close;
5  // Given data
6  lamda= 800;// in nm
7  EpIn_eV= 1248/lamda;// in eV
8  h_int= 5/100;
9  I=50;// in mA
10 P= h_int*EpIn_eV*I;// in mW
11 disp(P,"Power radiated by an LED in mW is : ")
```

Scilab code Exa 4.15 `Internal quantum efficiency`

```
1  // Exa 4.15
2  clc;
3  clear;
4  close;
5  // Given data
6  toh_r= 35;// in ns
7  toh_nr= 110;// in ns
8  toh= toh_r*toh_nr/(toh_r+toh_nr);// in ns
9  nita_int= toh/toh_r;
10 disp(nita_int,"The internal quantum efficiency is :
     ")
```

```
11
12  // 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

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

Scilab code Exa 4.17 Responsivity of an InGaAs photo diode

```
1  // Exa 4.17
2  clc ;
3  clear ;
4  close ;
5  // Given data
6  e= 1.6*10^-19;// in C
7  Eg= 0.75*e;// in J
8  h= 6.62*10^-34; // in Js
9  c= 3*10^8;// in m/s
10 n=90/100;
11 // Formula Eg= h*c/lamda
12 lamda= h*c/Eg;// in m
```

```
13  lamda = lamda *10^9; // in nm
14  R= n* lamda /1248; // in A/W
15  disp (R,"Responsivity in A/W is : ")
```

Scilab code Exa 4.18 Minimum and maximum values of LED current

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

Scilab code Exa 4.19 Supply voltage

```
1  // Exa 4.19
2  clc;
3  clear;
4  close;
5  // Given data
6  V_Dmin= 2.5; // in V
7  V_Dmax= 5; // in V
8  // Case First
9  Vs= 25; // in V
```

```
10  Rs= 250;// in
11  Imax= (Vs-V_Dmin)/Rs;// in A
12  Imin=  (Vs-V_Dmax)/Rs;// in A
13  disp(Imax*10^3-Imin*10^3,"The variation in current
        in first case in mA is : ")
14  // Case sec
15  Vs= 10;// in V
16  Rs= 130;// in
17  Imax= (Vs-V_Dmin)/Rs;// in A
18  Imin=  (Vs-V_Dmax)/Rs;// in A
19  disp(Imax*10^3-Imin*10^3,"The variation in current
        in second case in mA is : ")
20  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

```
1   // Exa 4.20
2   clc;
3   clear;
4   close;
5   // Given data
6   V1= 0.3;// in V
7   V2= 0.7;// in V
8   R1= 6;// in  k
9   R2= 6;// in  k
10  Vs= 12;// in V
11  I1= (Vs-V1)/R1;// in mA
12  I2= (Vs-V2)/R2;// in mA
13  disp(I1,"The value of I1 in mA is : ")
14  disp(I2,"The value of I2 in mA is : ")
```

Scilab code Exa 4.21 Responsivity and received optical power

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

Scilab code Exa 4.22 Internal quantum efficiency and optical power generated

```
1  // Exa 4.22
2  clc;
3  clear;
4  close;
5  // Given data
6  I=35;// in mA
7  I=I*10^-3;// in A
8  lamda=1300*10^-9;// in m
9  h= 6.62*10^-34; // in Js
10 c= 3*10^8;// in m/s
11 e= 1.6*10^-19;// in C
12 toh_r= 30;// in ns
13 toh_nr= 90;// in ns
14 toh= toh_r*toh_nr/(toh_r+toh_nr);// in ns
15 nita_int= toh/toh_r;
16 disp(nita_int,"The internal quantum efficiency is :
      ")
```

```
17  Ep= h*c/lamda;// in J
18  P= nita_int*Ep*I/e;// in W
19  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

```
1  // Exa 4.23
2  clc;
3  clear;
4  close;
5  // Given data
6  lamda= 600;// in nm
7  h_int= 4/100;
8  EpIn_eV= 1248/lamda;// in eV
9  I=50;// in mA
10 P= h_int*EpIn_eV*I;// in mW
11 disp(P,"Power radiated by an LED in mW is : ")
```

Scilab code Exa 4.24 Minimum and maximum values of LED current

```
1  // Exa 4.24
2  clc;
3  clear;
4  close;
5  // Given data
6
7  V_Dmin= 2;// in V
8  V_Dmax= 4;// in V
9  Vs= 15;// in V
10 R1= 470;// in
11 Imax= (Vs-V_Dmin)/R1;// in A
12 Imin=  (Vs-V_Dmax)/R1;// in A
```

```
13  disp(Imax*10^3,"The maximum value of current in mA
        is : ")
14  disp(Imin*10^3,"The minimum value of current in mA
        is : ")
```

Scilab code Exa 4.25 Smallest standard resistor value

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

Scilab code Exa 4.26 The slope efficiency

```
1  // Exa 4.26
2  clc;
3  clear;
4  close;
5  // Given data
6  Ep= 0.0153*10^-17;//in J
7  lamda= 1300;// in nm
8  nita_ext= 0.1;
9  e = 1.6*10^-19;//in C
10  Eg= 1.42*e;// in eV
```

```
11  S= nita_ext*Eg/e;// in W/A   (where S= deltaP/deltaI
         )
12  disp(S,"Slope of efficiency in W/A is : ")
13
14  // 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

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

Scilab code Exa 4.28 Probability of exciting electron

```
1  // Exa 4.28
2  clc;
3  clear;
```

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

Scilab code Exa 4.29 Ratio of majority to minority charge carrier

```
1 // Exa 4.29
2 clc ;
3 clear ;
4 close ;
5 k= 1.38*10^-23;
6 T= 300;// in K (assume)
7 V_D= 0.7;// The depletion voltage for silicon
8 e=1.6*10^-19;// in C
9 // n_n/n_p= p_p/p_n = %e^(e*V_D/(k*T))
10 ratio= %e^(e*V_D/(k*T));// ratio of majority to
     minority charge carriers in n and p of a silicon
     semiconductor
11 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

```
1  // Exa 5.2
2  clc;
3  clear;
4  close;
5  // Given data
6  C1= 5;  // in pF
7  C1= C1*10^-12;// in F
8  C2= 50;  // in pF
9  C2= C2*10^-12;// in F
10 L= 10;// in mH
11 L= L*10^-3;// in H
12 TuningRange= 1/(2*%pi*sqrt(L*C1*C2/(C1+C2)));// in
     Hz
13 disp(TuningRange*10^-3,"The tuning range for the
     circuit in kHz is : ")
14
15 // Note : In the book, this example is not solved.
     Only given data is shown.
```

Scilab code Exa 5.2 The value of CT

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

Scilab code Exa 5.3 Space charge capacitance

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

Scilab code Exa 5.4 The value of CT

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

Scilab code Exa 5.5 The depletion layer capacitance

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

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Scilab code Exa 5.6 Decrease in capacitance

```
1  // Exa 5.6
2  clc;
3  clear;
4  close;
5  // Given data
6  V1= 5;// in V
7  IncreaseInVolt= 1.5;// in V
8  C_T1= 20;// in pF
9  // Formula C_T= lamda/sqrt(V)
10 lamda= C_T1*sqrt(V1);
11 // When
12 V2= V1+IncreaseInVolt;// in V
13 C_T2= lamda/sqrt(V2);
14 disp(C_T1-C_T2,"The decrease in capacitance in pF is
       : ")
```

Scilab code Exa 5.7 Diffusion capacitance for a Si diode

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

Scilab code Exa 5.8 `Transition capacitance`

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

Scilab code Exa 5.9 `Decrease in capacitance`

```
1  // Exa 5.9
2  clc;
3  clear;
4  close;
5  // Given data
6  V1= 5;// in V
7  V2 = V1+1;// in V
8  C_T1= 20;// in pF
9  // C_T2/C_T1 = sqrt(V1/V2)
```

```
10  C_T2= C_T1* sqrt(V1/V2);
11  disp(C_T2,"The capacitance for 1-V increase in bias
        in pF is : ")
12  disp(C_T1-C_T2,"Therefore, the decrease in
        capacitance in pF is :")
13
14  // 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

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

Scilab code Exa 5.11 Tuning range for the circuit

```
1   // Exa 5.11
```

```
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  C1= 6;// in pF
 7  C2= 50;// in pF
 8  L=12*10^-3;// in H
 9  C_Tmin= C1*C1/(C1+C1);// in pF
10  C_Tmin= C_Tmin*10^-12;// in F
11  C_Tmax= C2*C2/(C2+C2);// in pF
12  C_Tmax= C_Tmax*10^-12;// in F
13  Fc_max= 1/(2*%pi*sqrt(L*C_Tmin));// in Hz
14  Fc_min= 1/(2*%pi*sqrt(L*C_Tmax));// in Hz
15  disp(Fc_max*10^-6,"Maximum resonance frequency in
       MHz is :")
16  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

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

Scilab code Exa 6.2 `Transfer curve`

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

Scilab code Exa 6.3 `Value of Vgs and gm`

```
1  // Exa 6.3
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= 1.65;// in mA
7  I_DSS=I_DSS*10^-3;// in A
8  V_P= -2;// in V
9  I_D= 0.8;// in mA
10 I_D=I_D*10^-3;// in A
11 V_BB= 24;// in V
12 // Part (a)
13 V_GS= V_P*(1-sqrt(I_D/I_DSS));// in V
14 disp(V_GS,"The value of V_GS in volts is : ")
15
16 // Part (b)
```

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

Scilab code Exa 6.4 `value of Vgs`

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

Scilab code Exa 6.5 `The value of transconductance of a FET`

```
1  // Exa 6.5
2  clc;
3  clear;
4  close;
5  // Given data
6  delta_I_D= 1.9-1.0;// in mA
7  delta_V_GS= 3.3-3.0;// in V
8  gm= delta_I_D/delta_V_GS;//in mA/V
9  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

```
1  // Exa 6.6
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= 5.6*10^-3;// in A
7  V_P= 4;// in volt
8  Vi= 10;// in V
9  R1= 4.7;// in k
10 R1= R1*10^3;// in
11 Rs= 10;// in k
12 Rs= Rs*10^3;// in
13 V1=-24;// in V
14 Vs= 12;// in V
15 // Appling KVL to the gate source loop, we get, Vs=
       I_D*Rs-V_GS
16 // V_GS= I_D*Rs-Vs           (i)
17 // I_D= I_DSS*(1-V_GS/V_P)^2 = I_DSS*(1-(I_D*Rs-Vs)/
       V_P)^2
18 I_D= 1.49;// in mA
19 I_D= I_D*10^-3;// in A
20 V_GS= I_D*Rs-Vs;
21 Vo= Vs-I_D*Rs;// in volt
22 disp(V_GS,"The value of V_GS in volts is : ")
23 disp(Vo,"The value of Vo in volts is : ")
```

Scilab code Exa 6.7 Drain to source voltage

```
1  // Exa 6.7
2  clc;
```

```
3 clear;
4 close;
5 // Given data
6 I_D= 5;// in mA
7 I_D=I_D*10^-3;// in A
8 V_DD= 10;// in V
9 R_D= 1;// in k
10 R_D= R_D*10^3;// in
11 Rs= 500;// in
12 Vs= I_D*Rs;// in volt
13 V_D= V_DD-I_D*R_D;// in V
14 V_DS= V_D-Vs;// in V
15 V_GS= -Vs;// in V
16 disp(V_DS,"The value of drain-to-source voltage in
       volts is : ")
17 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

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

Scilab code Exa 6.9 `Transconductance`

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

Scilab code Exa 6.10 `The value of VGS`

```
1  // Exa 6.10
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= 10;// in mA
7  I_DSS= I_DSS*10^-3;// in A
8  gm= 10;// in ms
9  gm=gm*10^-3;// in s
10 // V_GSoff = V_GS = Vp   so  , gm = gmo = -2*I_DSS/
        V_GSSoff
11 V_GSoff= -2*I_DSS/gm;// in volt
12 disp(V_GSoff,"The value of V_GS(off) in volts is : "
        )
```

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Scilab code Exa 6.11 `Minimum value of VDS`

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

Scilab code Exa 6.12 `Effective input impedance`

```
1  // Exa 6.12
2  clc;
3  clear;
4  close;
5  // Given data
6  R_G= 1;// in M
7  R_G= R_G*10^6;// in
8  V_DD= 24;// in V
9  R_D= 56;// in k
10 R_D=R_D*10^3;// in
11 Rs= 4;// k
12 Rs= Rs*10^3;// in
```

```
13  // Part (a)
14  I_DSS= 1;// in mA
15  I_DSS= I_DSS*10^-3;// in A
16  V_P= -1;// in V
17  V_D= 10;// in V
18  I_D= (V_DD-V_D)/R_D;// in A
19  // I_D= I_DSS*(1-V_GS/V_P)^2;// in A
20  V_GS= V_P*(1-sqrt(I_D/I_DSS));// in V
21  R1= abs(V_GS)/I_D;// in
22  disp(R1*10^-3,"The value of R1 in k   is : ")
23
24  // Part (b)
25  gmo= -2*I_DSS/V_P;// A/V
26  gm= gmo*(1-(V_GS)/V_P);// A/V;
27  Ri= R_G/(1-gm*Rs/(1+gm*Rs)*Rs/(Rs+R1));// in
28  disp(Ri*10^-6,"The effective input impedence in M
        is :")
```

Scilab code Exa 6.13 q value of VDS

```
1  // Exa 6.13
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= -4;// in mA
7  V_P= 4;// in V
8  R1= 1.3*10^6;// in
9  R2= 200*10^3;// in
10 V_DD= -60;// in V
11 R_D= 18;// in k
12 R_D= R_D*10^3;// in
13 Rs= 4;// in k
14 Rs= Rs*10^3;// in
15 V_GG= V_DD*R2/(R1+R2);// in V
```

```
16  R_G= R1*R2/(R1+R2);// in
17  // V_GS= V_GG−V_P*I_D
18  //   I_D= I_DSS*(1−(V_GG−V_P*I_D)/V_P)^2;// in mA or
19  // I_D^2*I_DSS + I_D*(2*(1−V_GG/V_P)*I_DSS−1) +((1−
       V_GG/V_P)^2*I_DSS)
20  I_D= [I_DSS (2*(1-V_GG/V_P)*I_DSS-1) ((1-V_GG/V_P)
       ^2*I_DSS)]
21  I_D=roots(I_D);
22  I_D=I_D(2);// in mA
23  I_D=I_D*10^-3;// in A
24  V_GS= V_GG-Rs*I_D;// in V
25  V_DS= V_DD-I_D*(R_D+Rs);// in V
26  disp(I_D*10^3,"The value of I_D in mA is : ")
27  disp(V_GS,"The value of V_GS in volts is ")
28  disp(V_DS,"The value of V_DS in volts is ")
```

Scilab code Exa 6.14 The value of VGS and VDS

```
1  // Exa 6.14
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= 4;// in mA
7  I_DSS= I_DSS*10^-3;// in A
8  V_P= -2;// in V
9  V_DD= 10;// in V
10 V_SS= V_DD;// in V
11 V_GS2=0;// in V
12 I_D= I_DSS*(1-V_GS2/V_P)^2;// in A
13 // since I_D= I_DSS
14 V_GS= 0;// in volt
15 // Formula V_SS= V_DS−V_GS
16 V_DS= V_SS-V_GS;// in volt
17 disp(I_D*10^3,"The value of I_D in mA is :")
```

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```
18  disp(V_GS,"The  value  of  V_GS  in  volt  is  : ")
19  disp(V_DS,"The  value  of  V_DS  in  volts  is  :")
20
21  if  V_DS  >  V_GS-V_P  then
22      disp("The  active  region  operation  of  the  upper
             JFET  is  confirmed  ")
23  end
```

Scilab code Exa 6.15 The value of VGS and ID

```
1  // Exa  6.15
2  clc;
3  clear;
4  close;
5  // Given  data
6  I_DSS= 16;// in mA
7  I_DSS= I_DSS*10^-3;// in A
8  V_P= -4;// in V
9  V_DD= 18;// in V
10 V_GG= 0;// in V
11 R_D= 500;// in
12 Rs= R_D;// in
13 // V_GS= V_GG-V_P*I_D  or = I_D= -V_GS/Rs   (as V_GSS=
      0)        (i)
14 // I_D= I_DSS*(1-V_GS/V_P)^2              (ii)
15 // From (i) and (ii)
16 // V_GS^2*(1/V_P^2) + V_GS*(1/(I_DSS*Rs)-2/V_P) +1
      =0
17 V_GS= [(1/V_P^2) (1/(I_DSS*Rs)-2/V_P) 1]
18 V_GS= roots(V_GS);
19 V_GS= V_GS(2);// since 0>= V_GS >=-4
20  I_D= I_DSS*(1-V_GS/V_P)^2;// in A
21  V_DS= V_DD-I_D*(R_D+Rs);// in V
22 disp(I_D*10^3,"The  value  of  I_D  in  mA  is  : ")
23 disp(V_GS,"The  value  of  V_GS  in  volts  is  : ");
```

```
24 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

```
1  // Exa 6.16
2  clc;
3  clear;
4  close;
5  // Given data
6
7  I_DSS= 10;// in mA
8  I_DSS= I_DSS*10^-3;// in A
9  V_P= -4;// in V
10 V_DD= 12;// in V
11 V_GG= 0;// in V
12 // Part (a) when
13 V_GS= -2;// in V
14 I_D= I_DSS*(1-V_GS/V_P)^2;// in A
15 disp(I_D*10^3,"When V_GS= -2 then, the value of I_D
       in mA ")
16 // Part (b) when
17 I_D= 9*10^-3;// in A
18 V_GS= V_P*(1-(sqrt(I_D/I_DSS)));// in V
19 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

```
1  // Exa 6.17
2  clc;
3  clear;
```

```
4  close;
5  // Given data
6  I_DSS= 8.7;// in mA
7  I_DSS= I_DSS*10^-3;// in A
8  V_P= -3;// in V
9  V_GS= -1;// in V
10 I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
11 disp(I_DS*10^3,"The value of I_DS in mA is : ")
12 gmo= -2*I_DSS/V_P*1000;// ms
13 gm= gmo*(1-V_GS/V_P); // in ms
14 disp(gmo,"The value of gmo in ms is")
15 disp(gm,"The value of gm in ms is")
```

Scilab code Exa 6.20 The value of VGS and ID

```
1  // Exa 6.20
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= 6;// in mA
7  I_DSS= I_DSS*10^-3;// in A
8  V_P= -4.5;// in V
9  // Part (i)
10 // At V_GS= −2V
11 V_GS= -2;// in V
12 I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
13 disp(I_DS*10^3,"At V_GS= −2V, the value of I_DS in
       mA is : ")
14 // At V_GS= −3.6V
15 V_GS= -3.6;// in V
16 I_DS= I_DSS*(1-V_GS/V_P)^2;// in A
17 disp(I_DS*10^3,"At V_GS= −3.6V, the value of I_DS in
       mA is : ")
18
```

```
19  // Part (ii)
20  // At I_DS= 3mA
21  I_DS= 3*10^-3;// in A
22  V_GS= V_P*(1-sqrt(I_DS/I_DSS));
23  disp(V_GS,"At I_DS= 3mA, the value of V_GS in volts
        is :")
24  // At I_DS= 5.5mA
25  I_DS= 5.5*10^-3;// in A
26  V_GS= V_P*(1-sqrt(I_DS/I_DSS));
27  disp(V_GS,"At I_DS= 5.5mA, the value of V_GS in
        volts is :")
28
29  // 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

```
1   // Exa 6.21
2   clc;
3   clear;
4   close;
5   // Given data
6   I_DSS= 10;// in mA
7   I_DSS= I_DSS*10^-3;// in A
8   V_P= -2;// in V
9   // Part (i)
10  // At V_GS= 0V
11  V_GS= 0;// in V
12  r_DS= V_P^2/(2*I_DSS*(V_GS-V_P));// in
13  disp(r_DS,"At V_GS=0 , the drain source resistance
        in    is : ")
14  // Part (ii)
15  // At V_GS= -0.5V
16  V_GS= -0.5;// in V
```

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```
17 r_DS= V_P^2/(2*I_DSS*(V_GS-V_P));// in
18 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

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

Scilab code Exa 6.23 The value of RD

```
1  // Exa 6.23
2  clc;
3  clear;
```

```
4 close ;
5 // Given data
6 I_DSS= 12; // in mA
7 I_DSS= I_DSS*10^-3; // in A
8 V_P= -4; // in V
9 Rs= 0; // in
10 V_DD= 15; // in V
11 V_DS= 0.1; // in V
12 V_GS= 0; // in V
13 if V_DS<V_GS-V_P then
14     disp("The ohmic region is confirmed.")
15 I_D= I_DSS*(2*(1-V_GS/V_P)*V_DS/(-V_P)-(V_DS/V_P)^2)
       ; // in A
16 R_D= (V_DD-V_DS)/I_D; // in
17 disp(I_D*10^6,"The value of I_D in  A  is :")
18 disp(R_D*10^-3,"The value of R_D in k   is :")
19 end
```

Scilab code Exa 6.24 `Channel resistance`

```
1 // Exa 6.24
2 clc ;
3 clear ;
4 close ;
5 // Given data
6 ro=9; // in  k
7 ro= ro*10^3; // in
8 V_P= -6; // in V
9 V_GS = -3; // in V
10 r= ro/(1-V_GS/V_P)^2; // in
11 disp(r*10^-3,"The value of chanel resistance in  k
      is : ")
12
13 // Note : The unit of chanel resistance i.e. unit of
        resistance in the book is wrong . It will be in
```

Scilab code Exa 6.25 `The value of VGS`

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

Scilab code Exa 6.26 `The value of IDSS`

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

Scilab code Exa 6.27 Minimum value of VDS

```
1  // Exa 6.27
2  clc;
3  clear;
4  close;
5  // Given data
6  I_DSS= 8;// in mA
7  V_P= -5;// in V
8  V_GS= -2;// in V
9  // Formula V_GS+ V_DSmin = V_P
10 V_DSmin= abs(V_P-V_GS);// in V
11 disp(V_DSmin,"The minimum value of V_DS in volts is
      :")
12 I_DS= I_DSS*(1-V_GS/V_P)^2;// in mA
13 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

```
1  // Exa 7.1
2  clc;
3  clear;
4  close;
5  // Given data
6  bita= 50;
7  R1= 1;// in  k
8  R1= R1*10^3;//in
9  R2= 300;// in
10 R3= 360;// in
11 R4= 640;// in
12 V1= 10;// in V
13 V2= 20;// in V
14 I_B1=19.2*10^-3;// in A
15 I_L= 1;//in A
16 V_Z= 5.6;// in V
17 V_B= R4*V1/(R3+R4);//in V
18 V_BE2= V_B-V_Z;// in V
19 V_A= V1-V_BE2;// in V
```

```
20  disp(V_A,"The value of V_A in volt is : ")
21  disp(V_B,"The value of V_B in volt is : ")
22
23  // Part (ii)
24  I1= V1/(R3+R4);// in A
25  //I1= .01*10^-3;// in A
26  I2= (V2-V_A)/R2;// in A
27  I_C2= I2-I_B1;// in A
28  I_B1= (I1+I_L)/(1+bita);// in A
29  disp(I_B1*10^3,"The base current of T1 in mA is : ")
30  I_C2= I2-I_B1;// in A
31  I_E2= I_C2;// in A
32  disp(I_E2*10^3,"The emitter current of T2 in mA is :
        ")
33
34  // part (iii)
35  I3= (V2-V_Z)/R1;// in A
36  I_Z= I3+I_E2;// in A
37  disp(I_Z*10^3,"Current through zener diode in mA is
        : ")
38  V_CE= V2-V1;// in V
39  I_C1= bita*I_B1;// in A
40  T1= V_CE*I_C1;// in W
41  disp(T1,"Power dissipation in watt is : ")
```

Scilab code Exa 7.2 Base emitter and zener diode current

```
1  // Exa 7.2
2  clc;
3  clear;
4  close;
5  // Given data
6  bita= 100;
7  R1= 1;// in k
8  R1= R1*10^3;//in
```

```
 9  R2= 300;// in
10  R3= 360;// in
11  R4= 640;// in
12  V1= 10;// in V
13  V2= 20;// in V
14  I_B1=19.2*10^-3;// in A
15  I_L= 1;//in A
16  V_Z= 5.6;// in V
17  V_B= R4*V1/(R3+R4);//in V
18  V_BE2= V_B-V_Z;// in V
19  V_A= V1-V_BE2;// in V
20  disp(V_A,"The value of V_A in volt is : ")
21  disp(V_B,"The value of V_B in volt is : ")
22
23  // Part (ii)
24  I1= V1/(R3+R4);// in A
25  //I1= .01*10^-3;// in A
26  I2= (V2-V_A)/R2;// in A
27  I_C2= I2-I_B1;// in A
28  I_B1= (I1+I_L)/(1+bita);// in A
29  disp(I_B1*10^3,"The base current of T1 in mA is : ")
30  I_C2= I2-I_B1;// in A
31  I_E2= I_C2;// in A
32  disp(I_E2*10^3,"The emitter current of T2 in mA is :
        ")
33
34  // part (iii)
35  I3= (V2-V_Z)/R1;// in A
36  I_Z= I3+I_E2;// in A
37  disp(I_Z*10^3,"Current through zener diode in mA is
        : ")
38  V_CE= V2-V1;// in V
39  I_C1= bita*I_B1;// in A
40  T1= V_CE*I_C1;// in W
41  disp(T1,"Power dissipation in watt is : ")
42
43  // Note: In the part (iv), the wrong value of I_B1
        and bita is putted, these two value is putted of
```

Scilab code Exa 7.3 `Base emitter and zener diode current`

```
1  // Exa 7.3
2  clc;
3  clear;
4  close;
5  // Given data
6  bita= 50;
7  R1= 1;// in k
8  R1= R1*10^3;//in
9  R2= 500;// in
10 R3= 400;// in
11 R4= 600;// in
12 V1= 10;// in V
13 V2= 20;// in V
14 I_B1=19.2*10^-3;// in A
15 I_L= 1;//in A
16 V_Z= 5;// in V
17 V_B= R4*V1/(R3+R4);//in V
18 V_BE2= V_B-V_Z;// in V
19 V_A= V1-V_BE2;// in V
20 disp(V_A,"The value of V_A in volt is : ")
21 disp(V_B,"The value of V_B in volt is : ")
22
23 // Part (ii)
24 I1= V1/(R3+R4);// in A
25 //I1= .01*10^-3;// in A
26 I2= (V2-V_A)/R2;// in A
```

```
27  //I2= .042;
28  I_C2= I2-I_B1;// in A
29  I_B1= (I1+I_L)/(1+bita);// in A
30  disp(I_B1*10^3,"The base current of T1 in mA is : ")
31  I_C2= I2-I_B1;// in A
32  I_E2= I_C2;// in A
33  disp(I_E2*10^3,"The emitter current of T2 in mA is :
         ")
34
35  // part (iii)
36  I3= (V2-V_Z)/R1;// in A
37  I_Z= I3+I_E2;// in A
38  disp(I_Z*10^3,"Current through zener diode in mA is
         : ")
39  V_CE= V2-V1;// in V
40  I_C1= bita*I_B1;// in A
41  T1= V_CE*I_C1;// in W
42  disp(T1,"Power dissipation in watt is : ")
43
44  // 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
45  //            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`

```
1  // Exa 7.4
2  clc;
3  clear;
4  close;
5  // Given data
6  Vmin= 2.2;// in V
7  Vmax= 4.0;// in V
```

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

Scilab code Exa 7.5 `Output voltage`

```
 1  // Exa 7.5
 2  clc;
 3  clear;
 4  close;
 5  // Given data
 6  V1= 6.2; // in V
 7  V2= 0.6; // in V
 8  V3= 0.6; // in V
 9  Vout= V1-V2-V3; // in V
10  disp(Vout,"The output voltage in volts is : ")
```