

Scilab Textbook Companion for
Solid State Devices
by B. S. Nair and S. R. Deepa¹

Created by
Sakshi Sharma
B.tech
Electronics Engineering
Dr. A.P.J. Abdul Kalam Technical University
College Teacher
None
Cross-Checked by
Bhavani Jalkrish

June 2, 2016

¹Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website <http://scilab.in>

Book Description

Title: Solid State Devices

Author: B. S. Nair and S. R. Deepa

Publisher: Phi Learning, New Delhi

Edition: 1

Year: 2010

ISBN: 978-81-203-4106-7

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes	4
1 CRYSTAL STRUCTURES	5
2 ENERGY BAND THEORY OF SOLIDS	15
3 CARRIER TRANSPORT IN SEMICONDUCTOR	43
4 EXCESS CARRIER IN SEMICONDUCTOR	55
5 PN JUNCTION DIODE	60
6 ELECTRICAL BREAKDOWN IN PN JUNCTIONE	87
7 BIPOLAR JUNCTION TRANSISTORB	107
8 THE FIELD EFFECT TRANSISTOR	117
10 SILICON CONTROLLED RECTIFIER	132

List of Scilab Codes

Exa 1.4	PACKING FRACTION OF SIMPLE CUBIC	5
Exa 1.5	PACKING FRACTION OF BCC	5
Exa 1.6	PACKING FRACTION OF FCC	6
Exa 1.8	PACKING FRACTION OF DIAMOND CRYSTAL STRUCTURE	7
Exa 1.9	PACKING FRACTION OF BCC	7
Exa 1.10	MILLER INDICES OF LATTICE PLANE	8
Exa 1.11	MILLER INDICES OF LATTICE PLANE	8
Exa 1.12	MILLER INDICES OF LATTICE PLANE	9
Exa 1.13	MILLER INDICES OF LATTICE PLANE	10
Exa 1.14	MILLER INDICES OF LATTICE PLANE	10
Exa 1.15	MILLER INDICES OF LATTICE PLANE	11
Exa 1.16	NO OF SILICON ATOMS	12
Exa 1.17	VOLUME DENSITY OF A BCC LATTICE	12
Exa 1.18	VOLUME DENSITY OF SILICON	13
Exa 1.19	DENSITY OF SILICON	13
Exa 1.20	VOLUME DENSITY OF A FCC LATTICE	14
Exa 2.1	MINORITY CARRIER CONCENTRATION	15
Exa 2.2	CURRENT GENERATED BY MINORITY CARRIER MOVEMENT	15
Exa 2.3	CURRENT GENERATED BY MINORITY CARRIER MOVEMENT	16
Exa 2.4	FREQUENCY OF RADIATION EMITTED BY GaAs	17
Exa 2.5	FREQUENCY OF RADIATION EMITTED	17
Exa 2.6	FERMI DIREC DISTRIBUTION FUNCTION	18
Exa 2.7	FERMI DIREC DISTRIBUTION FUNCTION	19
Exa 2.8	FERMI DIREC DISTRIBUTION FUNCTION	20
Exa 2.9	FERMI DIREC DISTRIBUTION FUNCTION	21

Exa 2.10	FERMI DIRECT DISTRIBUTION FUNCTION	22
Exa 2.11	FERMI DIRECT DISTRIBUTION FUNCTION	22
Exa 2.12	NUMBER OF HOLES IN A MEDIUM DOPED N SEMICONDUCTOR	23
Exa 2.13	VALUE OF FERMI LEVEL	24
Exa 2.14	NUMBER OF HOLES IN A HEAVILY DOPED N SEMICONDUCTOR	24
Exa 2.15	VALUE OF INTRINSIC CONCENTRATION	25
Exa 2.16	VALUE OF n	25
Exa 2.17	VALUE OF n_0	26
Exa 2.18	RESISTIVITY AND RESISTANCE OF SEMICONDUCTOR	27
Exa 2.19	VALUE OF DRIFT CURRENT	28
Exa 2.20	FREQUENCY OF RADIATION EMITTED	29
Exa 2.21	BAND GAP ENERGY AND VALUE OF X	30
Exa 2.22	VALUE OF THERMAL EQUILIBRIUM HOLE CONCENTRATION IN SILICON	31
Exa 2.23	FRACTION OF ELECTRONS THAT ARE STILL IN THE DONOR STATE	31
Exa 2.24	FRACTION OF HOLES THAT ARE STILL IN THE ACCEPTOR STATE	32
Exa 2.25	ELECTRON AND HOLE CONCENTRATION	33
Exa 2.26	ELECTRON AND HOLE CONCENTRATION	34
Exa 2.27	ELECTRON AND HOLE CONCENTRATION	34
Exa 2.28	VALUE OF THERMAL EQUILIBRIUM HOLE CONCENTRATION IN SILICON	35
Exa 2.29	INTRINSIC CARRIER CONCENTRATION	36
Exa 2.30	VALUE OF DONOR CONCENTRATION	38
Exa 2.31	DONOR CONCENTRATION IN SILICON	39
Exa 2.32	INTRINSIC CARRIER CONCENTRATION	40
Exa 2.33	RATIO OF INTRINSIC CONCENTRATION	42
Exa 3.1	VALUE OF HALL ELECTRIC FIELD	43
Exa 3.2	VALUE OF HALL COEFFICIENT	44
Exa 3.3	VALUE OF HALL VOLTAGE	45
Exa 3.4	VALUE OF HALL RESISTANCE	45
Exa 3.8	MINIMUM CONDUCTIVITY AND MAXIMUM RESISTIVITY	46
Exa 3.10	VALUE OF DIFFERENCE IN FERMI LEVELS	47

Exa 3.11	HOLE CURRENT AND STORED EXCESS HOLE CHARGES	48
Exa 3.12	ELECTRONIC CONCENTRATION AND MOBILITY	49
Exa 3.14	INDUCED ELECTRIC FIELD	50
Exa 3.17	ELECTRON AND HOLE CONCENTRATION AND DRIFT CURRENT DENSITY	51
Exa 3.18	ELECTRON AND HOLE CONCENTRATION AND DRIFT CURRENT DENSITY	52
Exa 3.19	VALUE OF THERMAL EQUILIBRIUM HOLE CON- CENTRATION	53
Exa 3.20	CURRENT THROUGH THE BAR	54
Exa 4.2	DIELECTRIC RELAXATION TIME	55
Exa 4.3	ELECTRON HOLE RECOMBINATION	56
Exa 4.4	GENERATION AND RECOMBINATION RATE OF EHPS AND MAJORITY CARRIER LIFETIME . . .	56
Exa 4.5	QUASI FERMI LEVELS	57
Exa 4.6	ENERGY DIFFERENCE BETWEEN E_{Fn} AND E_{Fi}	58
Exa 5.5	FERMI LEVEL IN P AND N JUNCTION AND CON- TACT POTENTIAL	60
Exa 5.6	VALUE OF JUNCTION POTENTIAL	61
Exa 5.7	VALUE OF REVERSE AND FORWARD CURRENT	62
Exa 5.8	VALUE OF BUILT IN POTENTIAL	63
Exa 5.9	VALUE OF BUILT IN POTENTIAL	64
Exa 5.10	VALUE OF DEPLETION WIDTH AND ACCEPTOR CONCENTRATION	65
Exa 5.12	VALUE OF MAXIMUM ELECTRIAL FIELD	66
Exa 5.13	VALUE OF N TYPE DOPING CONCENTRATION .	67
Exa 5.14	VALUE OF JUNCTION CAPACITANCE	68
Exa 5.15	VALUE OF JUNCTION CAPACITANCE	69
Exa 5.16	VALUE OF INTRINSIC CONCENTRATION	70
Exa 5.18	VALUE OF V_{bi} AND FERMI LEVEL AND V_{bi} FROM FERMI LEVEL	71
Exa 5.19	VALUE OF V_{bi} AND FERMI LEVEL AND V_{bi} FROM FERMI LEVEL	72
Exa 5.20	VALUE OF IMPURITY CONCENTRATION AND V_{bi}	73
Exa 5.21	VALUE OF N_a X_n X_p AND E_{max}	74
Exa 5.22	VALUE OF TEMPERATURE	75
Exa 5.23	VALUE OF V_{bi} AND TEMPERATURE	76

Exa 5.24	VALUE OF V_{bi} AND W AND X_n AND X_p AND E_{max}	77
Exa 5.25	MAGNITUDE OF APPLIED REVERSE BIAS	79
Exa 5.26	VALUE OF DOPING CONCENTRATION	80
Exa 5.27	VALUE OF JUNCTION CAPACITANCE	81
Exa 5.28	VALUE OF REVERSE SATURATION CURRENT	82
Exa 5.29	VALUE OF REVERSE SATURATION CURRENT	84
Exa 5.30	VALUE OF THE CHANGE IN THE APPLIED VOLT- AGE	85
Exa 5.31	RELATIVE CHANGE IN I_o	86
Exa 6.2	VALUE OF E_g E_v E_c and V_{bi}	87
Exa 6.4	VALUE OF DONOR CONCENTRATION	89
Exa 6.5	VALUE OF THE BARRIER HEIGHT AND BUILT IN POTENTIAL	90
Exa 6.6	VALUE OF DEPLETION WIDTH DIFFUSION LENGTH AND SATURATION HOLE CURRENT DENSITY	91
Exa 6.8	MAXIMUM N TYPE DOPING CONCENTRATION	93
Exa 6.9	VALUE OF REVERSE BREAK DOWN VOLTAGE	94
Exa 6.10	VALUE OF REVERSE BREAK DOWN VOLTAGE	95
Exa 6.11	VALUE OF REVERSE BREAK DOWN VOLTAGE	96
Exa 6.12	VALUE OF THE BARRIER HEIGHT AND BUILT IN POTENTIAL AND DEPLETION WIDTH AND MAX- IMUM ELECTRICAL FIELD	97
Exa 6.13	VALUE OF MAXIMUM ELECTRICAL FIELD AND JUNCTION CAPACITANCE PER UNIT AREA	98
Exa 6.14	VALUE OF V_B X_n AND E_{max}	100
Exa 6.15	CAPACITANCE OF A GOLD SILICON JUNCTION	101
Exa 6.17	VALUE OF LOWERING OF BARRIER HEIGHT	103
Exa 6.18	VALUE OF IDEAL REVERSE SATURATION CUR- RENT AND THE DIODE CURRENT	103
Exa 6.19	VALUE OF FORWARD VOLTAGE	104
Exa 6.20	VALUE OF REVERSE SATURATION CURRENT	105
Exa 7.1	MAGNITUDE OF I_o AND COLLECTOR CURRENT	107
Exa 7.2	CONCENTRATION OF n_{EO} p_{BO} AND n_{CO}	108
Exa 7.3	VALUE OF p_{BO} AND n_B	109
Exa 7.5	VALUE OF BASE WIDTH	110
Exa 7.7	VALUE OF Δ	111
Exa 7.8	COMMON BASE AND COMMON EMITTER CUR- RENT GAIN	111

Exa 7.9	CHANGE IN THE NEUTRAL BASE WIDTH	114
Exa 7.10	CHANGE IN THE COLLECTOR CURRENT	115
Exa 8.1	CAPACITANCE C_{ox} AND C_o	117
Exa 8.2	MAXIMUM SPACE CHARGE WIDTH	118
Exa 8.3	MAXIMUM SPACE CHARGE WIDTH	119
Exa 8.5	METAL SEMICONDUCTOR WORK FUNCTION DIFFERENCE	120
Exa 8.7	CAPACITANCE C_o AND FLAT BAND VOLTAGE	120
Exa 8.9	THRESHOLD VOLTAGE	121
Exa 8.10	VALUE OF I_d	123
Exa 8.13	MINIMUM CAPACITANCE AND FLAT BAND CAPACITANCE	124
Exa 8.14	VALUE OF Q_{ss}	125
Exa 8.15	VALUE OF I_d	126
Exa 8.16	VALUE OF I_d	127
Exa 8.17	RATIO OF W AND L	128
Exa 8.18	PINCH OFF VOLTAGE	129
Exa 8.20	VALUE OF r_{DS}	130
Exa 10.2	VALUE OF PUNCH THROUGH VOLTAGE	132
Exa 10.3	VALUE OF THE DIFFERENTIAL TERM	133

Chapter 1

CRYSTAL STRUCTURES

Scilab code Exa 1.4 PACKING FRACTION OF SIMPLE CUBIC

```
1 clc
2 a=1
3 disp("a= "+string(a)) //initializing value of
   lattice constant(a)=1.
4 r=a/2
5 disp("r=a/2 = "+string(r)) //initializing value of
   radius of atom for simple cubic.
6 v=((4*%pi*(r^3))/3)
7 disp("Volume of one atom ,v=((4*%pi*(r^3))/3) = "+
   string(v)) //calculation.
8 V=a^3
9 disp("Total Volume of the cube ,V=a^3 = "+string(V))
   //calculation.
10 Fp=(v*100/V)
11 disp("Fp(S.C)=(v*100/V) = "+string(Fp)+"%") //
   calculation
```

Scilab code Exa 1.5 PACKING FRACTION OF BCC

```

1  clc
2  a=1
3  disp("a= "+string(a)) //initializing value of
    lattice constant(a)=1.
4  r=(sqrt(3)*(a^2/4))
5  disp("Radius of the atoms ,r=(sqrt(3)*(a^2/4)) = "+
    string(r)) //initializing value of radius of atom
    for BCC.
6  v=((4*%pi*(r^3))/3)*2
7  disp("Volume of two atom ,v=((4*%pi*(r^3))/3)*2 = "+
    string(v)) //calcuation .
8  V=a^3
9  disp("Total Volume of the cube ,V=a^3 = "+string(V))
    //calcuation .
10 Fp=(v*100/V)
11 disp("Fp(B.C.C)=(v*100/V) = "+string(Fp)+"%")//
    calculation

```

Scilab code Exa 1.6 PACKING FRACTION OF FCC

```

1  clc
2  a=1
3  disp("a= "+string(a)) //initializing value of
    lattice constant(a)=1.
4  r=(a/(2*sqrt(2)))
5  disp("Radius of the atom ,r=(a/(2*sqrt(2)))= "+string
    (r)) //initializing value of radius of atom for
    FCC.
6  v=((4*%pi*(r^3))/3)*4
7  disp("Volume of the four atom ,v((((4*%pi*(r^3))/3)
    *4) = "+string(v)) //calcuation .
8  V=a^3
9  disp("Total volume of the cube ,V=a^3 = "+string(V))
    //calcuation .
10 Fp=(v*100/V)

```

```
11 disp("Fp(F.C.C)=(v*100/V) = "+string(Fp)+"%") //
    calculation
```

Scilab code Exa 1.8 PACKING FRACTION OF DIAMOND CRYSTAL STRUCTURE

```
1 clc
2 a=1
3 disp("a= "+string(a)) //initializing value of
    lattice constant(a)=1.
4 r=((sqrt(3)*a/8))
5 disp("Radius of the atom,r=(sqrt(3)*a/8) = "+string
    (r)) //initializing value of radius of atom for
    diamond.
6 v=((4*%pi*(r^3))/3)*8)
7 disp("v=((4*%pi*(r^3))/3)*8) = "+string(v)) //
    calculation.
8 V=a^3
9 disp("V=a^3 = "+string(V)) //calculation.
10 Fp=(v*100/V)
11 disp("Fp(Diamond)=(v*100/V) = "+string(Fp)+"%") //
    calculation
```

Scilab code Exa 1.9 PACKING FRACTION OF BCC

```
1 clc
2 a=5*10^-8
3 disp("a = "+string(a)+" cm") //initializing value of
    lattice constant.
4 r=(sqrt(3)*(a/4))
5 disp("Radius of the atom,r=(sqrt(3)*(a/4)) = "+
    string(r)) //initializing value of radius of atom
    for BCC.
```

```

6 v=((4*%pi*(r^3))/3)*2
7 disp("Volume of the two atoms ,v=((4*%pi*(r^3))/3)*2
   = "+string(v)) //calculation.
8 V=a^3
9 disp("Total Volume of the cube ,V=a^3 = "+string(V))
   //calcuation.
10 Fp=(v*100/V)
11 disp("Fp(B.C.C)=(v*100/V) = "+string(Fp)+"%")//
   calculation

```

Scilab code Exa 1.10 MILLER INDICES OF LATTICE PLANE

```

1 clc
2 x=1
3 disp("x intercept = "+string(x)) //initializing
   value of x intercept..
4 y=%inf
5 disp("y intercept = "+string(y)) //initializing
   value of y intercept.
6 z=%inf
7 disp("z intercept = "+string(z)) //initializing
   value of z intercept.
8 h=[1/x]
9 disp("miller indices ,h=(1/x) = "+string(h))//
   calculation
10 k=[1/y]
11 disp("k=(1/y) = "+string(k))//calculation
12 l=[1/z]
13 disp("l=(1/z) = "+string(l))//calculation

```

Scilab code Exa 1.11 MILLER INDICES OF LATTICE PLANE

```

1 clc

```

```

2 x=%inf
3 disp("x intercept = "+string(x)) //initializing
  value of x intercept.
4 y=%inf
5 disp("y intercept = "+string(y)) //initializing
  value of Y intercept.
6 z=1
7 disp("z intercept = "+string(z)) //initializing
  value of Z intercept.
8 h=[1/x]
9 disp("miller indices ,h=[1/x] = "+string(h))//
  calculation
10 k=[1/y]
11 disp("k=[1/y] = "+string(k))//calculation
12 l=[1/z]
13 disp("l=[1/z] = "+string(l))//calculation

```

Scilab code Exa 1.12 MILLER INDICES OF LATTICE PLANE

```

1 clc
2 x=%inf
3 disp("x intercept = "+string(x)) //initializing
  value of X intercept.
4 y=1
5 disp("y intercept = "+string(y)) //initializing
  value of Y intercept.
6 z=%inf
7 disp("z intercept = "+string(z)) //initializing
  value of Z intercept.
8 h=[1/x]
9 disp("miller indices ,h=[1/x] = "+string(h))//
  calculation
10 k=[1/y]
11 disp("k=[1/y] = "+string(k))//calculation
12 l=[1/z]

```

```
13 disp("l=[1/z] = "+string(1))//calculation
```

Scilab code Exa 1.13 MILLER INDICES OF LATTICE PLANE

```
1 clc
2 x=1
3 disp("x intercept = "+string(x)) //initializing
  value of X intercept.
4 y=1
5 disp("y intercept = "+string(y)) //initializing
  value of Y intercept.
6 z=%inf
7 disp("z intercept = "+string(z)) //initializing
  value of Z intercept.
8 h=[1/x]
9 disp("miller indices ,h=[1/x] = "+string(h))//
  calculation
10 k=[1/y]
11 disp("k=[1/y] = "+string(k))//calculation
12 l=[1/z]
13 disp("l=[1/z] = "+string(1))//calculation
```

Scilab code Exa 1.14 MILLER INDICES OF LATTICE PLANE

```
1 clc
2 x=%inf
3 disp("x intercept = "+string(x)) //initializing
  value of X intercept.
4 y=1
5 disp("y intercept = "+string(y)) //initializing
  value of Y intercept.
6 z=1
```

```

7 disp("z intercept = "+string(z)) //initializing
  value of Z intercept.
8 h=[1/x]
9 disp("miller indices ,h=[1/x] = "+string(h))//
  calculation
10 k=[1/y]
11 disp("k=[1/y] = "+string(k))//calculation
12 l=[1/z]
13 disp("l=[1/z] = "+string(l))//calculation

```

Scilab code Exa 1.15 MILLER INDICES OF LATTICE PLANE

```

1 clc
2 x=2
3 disp("x intercept = "+string(x)) //initializing
  value of X intercept.
4 y=2
5 disp("y intercept = "+string(y)) //initializing
  value of Y intercept.
6 z=2
7 disp("z intercept = "+string(z)) //initializing
  value of Z intercept.
8 c=2
9 disp("common factor of all the intercept=" +string(c
  )) //initializing value of common factor of all
  the intercepts.
10 h=[c/x]
11 disp("miller indices ,h=[c/x] = "+string(h))//
  calculation
12 k=[c/y]
13 disp("k=[c/y] = "+string(k))//calculation
14 l=[c/z]
15 disp("l=[c/z] = "+string(l))//calculation

```

Scilab code Exa 1.16 NO OF SILICON ATOMS

```
1 clc
2 Wa=28.1
3 disp("Wa = "+string(Wa)) //initializing value of
  atomic weight.
4 D=2.33
5 disp("D = "+string(D)+" gram/cm^3") //initializing
  value of density.
6 Na=6.02*10^23
7 disp("Na = "+string(Na)+" atoms/mole") //initializing
  value of avagadro number.
8 na =(Na*D)/(Wa)
9 disp("na =(Na*D)/(Wa)= "+string(na)+" atoms/cm^3")//
  calculation
10
11 //the value of na (number of atoms in 1 cm^3 of
  silicon), provided after calculation in the book
  is wrong.
```

Scilab code Exa 1.17 VOLUME DENSITY OF A BCC LATTICE

```
1 clc
2 a=5*10^-8
3 disp("a= "+string(a)+"cm") //initializing value of
  lattice constant.
4 N=2
5 disp("N= "+string(N)) //initializing value of no.of
  atoms in unit cell.
6 V=a^3
7 disp("V=a^3 = "+string(V)+"cm^3") //initializing
  value of total Volume of the unit cell.
```

```

8 na =(N/(V))
9 disp("na=(no. of atoms in unit cell/Volume of the
    unit cell) =(N/(V))= "+string(na))//calculation

```

Scilab code Exa 1.18 VOLUME DENSITY OF SILICON

```

1 clc
2 a=5.43*10^-8
3 disp(" a = "+string(a)+"cm") //initializing value of
    lattice constant.
4 N=8
5 disp("N = "+string(N)) //initializing value of no.
    of atoms in a unit cell.
6 ns =(N/(a^3))
7 disp("Number of atom in the cm^3,ns =(N/(a^3))= "+
    string(ns))//calculation

```

Scilab code Exa 1.19 DENSITY OF SILICON

```

1 clc
2 a=5.43*10^-8
3 disp(" a = "+string(a)+"cm") //initializing value of
    lattice constant.
4 Wa=28.1
5 disp(" Wa = "+string(Wa)) //initializing value of
    atomic weight.
6 Na=6.02*10^23
7 disp(" Na = "+string(Na)) //initializing value of
    avadro number.
8 ns=5*10^22
9 disp(" ns = "+string(ns)+"atoms/cm^3") //
    initializing value of atoms/cm^3.
10 D =(ns*Wa)/(Na)

```

```
11 disp(" Density of silicon ,D =(ns*Wa)/(Na) = "+string
      (D)+" gm/cm^2")//calculation
```

Scilab code Exa 1.20 VOLUME DENSITY OF A FCC LATTICE

```
1 clc
2 a=4.75*10^-8
3 disp(" a = "+string(a)+"cm") //initializing value of
  lattice constant.
4 N=4
5 disp(" N = "+string(N)) //initializing value of
  number of atoms in the unit cell.
6 na =(N/(a^3))
7 disp(" na =(N/(a^3)) = "+string(na))//calculation
```

Chapter 2

ENERGY BAND THEORY OF SOLIDS

Scilab code Exa 2.1 MINORITY CARRIER CONCENTRATION

```
1 clc
2 n=1014
3 disp("n = "+string(n)+" /cm3") //initializing value
   of electrons/cm3.
4 no=1.5*1010
5 disp("no. of EHPs/cm3 = "+string(no)+" /cm3") //
   initializing value of electron hole pairs/cm3.
6 p=(no2/n)
7 disp("minority carriers concentration ,p=(no2/n)= "
   +string(p)+" /cm3")//calculation
```

Scilab code Exa 2.2 CURRENT GENERATED BY MINORITY CARRIER MOVEMENT

```
1 clc
2 e=1.6*10-19
```

```

3 disp(" electron charge = "+string(e)+" columns") //
  initializing the value of electron charge.
4 no=1.5*10^10
5 disp("no. of EHPs/cm^3 = "+string(no)+"/cm^3") //
  initializing value of electron hole pairs/cm^3.
6 n=(1/e)
7 disp("Number of free electrons in 1 columns ,n=(1/e)
  )= "+string(n))// calculation
8 i=(1/n)
9 disp("Current by movement of one electrons ,i=(1/n))
  = "+string(i)+" Amphere ")// calculation
10 I=(no*i)
11 disp("Current by movement of (1.5*10^10) electrons ,
  I=(no*i))= "+string(I)+" Amphere ")// calculation

```

Scilab code Exa 2.3 CURRENT GENERATED BY MINORITY CARRIER MOVEMENT

```

1 clc
2 e=1.6*10^-19
3 disp(" Electron charge = "+string(e)+" columns") //
  initializing the value of electron charge.
4 no=2.5*10^13
5 disp("Number of free electrons/cm^3 in Ge ,n
  =2.5*10^13)= "+string(no)+"/cm^3")//
  calculation
6 n=(1/e)
7 disp("Number of free electrons in 1 columns ,n=(1/e)
  )= "+string(n))// calculation
8 i=(1/n)
9 disp("Current by movement of one electrons ,i=(1/n))
  = "+string(i)+" amphere ")// calculation
10 I=(no*i)
11 disp("Current by movement of (2.5*10^13) electrons
  in Ge, I=(no*i))= "+string(I)+" amphere ")//

```

calculation

Scilab code Exa 2.4 FREQUENCY OF RADIATION EMITTED BY GaAs

```
1 clc
2 Eg=1.43*1.6*10^-19
3 disp(" energy gap = "+string(Eg)+" Volt") //
  initializing the value of energy gap.
4 h=6.624*10^-34
5 disp(" plank constant = "+string(h)+" joule")//
  initializing the value of plank constant.
6 c=3*10^8
7 disp(" light speed = "+string(c)+"m/s") //
  initializing the value of speed of light.
8 f=(Eg/h)
9 disp("frequency of radiation emitted ,f=(Eg/h))= "+
  string(f)+" Hz ")//calculation
10 lamda=(c/f)
11 disp("wavelength of radiation emitted ,lamda=(c/f))=
  "+string(lamda)+" metre ")//calculation
```

Scilab code Exa 2.5 FREQUENCY OF RADIATION EMITTED

```
1 clc
2 Eg1=1.43
3 disp(" Energy gap of GaAs = "+string(Eg1)+"eV") //
  initializing the value of energy gap of GaAs.
4 Eg2=2.43
5 disp(" Energy gap of GaP = "+string(Eg2)+"eV")//
  initializing the value of energy gap of Gap.
6 h=6.624*10^-34
7 disp(" plank constant = "+string(h)+" joule")//
  initializing the value of plank constant.
```

```

8 c=3*10^8
9 disp(" light speed = "+string(c)+"m/s") //
  initializing the value of speed of light.
10 x=(Eg2-Eg1)
11 disp(" Difference between the energy gap of GaAs and
  GaP ,x=(Eg2-Eg1))= "+string(x)+" eV")//
  calculation
12 g=(0.5*x)
13 disp(" Excess energy gap added to GaAs to form GaAsP
  =(0.5*x))= "+string(g)+" eV ")// calculation
14 Eg=(Eg1+g)
15 disp(" Band gap energy GaAs(0.5)P(0.5) ,Eg=(Eg1+g))= "
  +string(Eg)+" eV ")// calculation
16 lamda=(c*h/(Eg*1.6*10^-19))
17 disp(" Wavelength of radiation emitted ,w=(c*h/Eg))= "
  +string(lamda)+" metre ")// calculation

```

Scilab code Exa 2.6 FERMI DIREC DISTRIBUTION FUNCTION

```

1 clc
2 E=1.1
3 disp(" E = "+string(E)+"eV") //initializing the
  value of energy level E in the crystal.
4 Ef=0.6
5 disp(" Ef = "+string(Ef)+"eV")//initializing the
  value of energy of fermi level of material.
6 T=300
7 disp(" temp = "+string(T)+"K")//initializing the
  value of temperature.
8 e=2.718
9 disp(" e = "+string(e)) //initializing the value of
  exponential.
10 k=1.38*10^-23
11 disp(" k = "+string(k)+"J/k") //initializing the
  value of boltzmann constant.

```

```

12 a=((E-Ef)*1.6*10^-19)/(k*T)
13 disp(" alpha ,a=(((E-Ef)*1.6*10^-19)/(k*T))= "+
      string(a))//calculation
14 fE=(1/(1+(e^a)))
15 disp(" fE(Fermi Direc Distribution Function),fE
      =(1/(1+(e^a)))= "+string(fE))//calculation
16
17 //the value of Ef is different in the question than
      used in the solution.
18 //I have used the value ,used in the solution(i.e Ef
      =0.6)

```

Scilab code Exa 2.7 FERMI DIREC DISTRIBUTION FUNCTION

```

1 clc
2 E=0.6
3 disp(" E = "+string(E)+"eV") //initializing the
      value of energy level E in the crystal.
4 Ef=1.1
5 disp(" Ef = "+string(Ef)+"eV")//initializing the
      value of fermi level of material.
6 T=300
7 disp(" temp = "+string(T)+" kelvin")//initializing
      the value of temperature.
8 k=1.38*10^-23
9 disp(" k = "+string(k)+" J/k") //initializing the
      value of boltzmann constant.
10 e=2.718
11 disp(" e = "+string(e)) //initializing the value of
      exponential.
12 a=(((-(Ef-E))*1.6*10^-19)/(k*T))
13 disp(" alpha ,a=(((-(Ef-E))*1.6*10^-19)/(k*T))= "+
      string(a))//calculation
14 fE=(1/(1+(e^a)))
15 disp(" fE(Fermi Direc Distribution Function),fE

```



```

    =(1/(1+(e^a)))= "+string(fE))//calculation
16
17 //the value of E is different in the question than
    used in the solution.
18 //I have used the value ,used in the solution(i.e E
    =0.6)

```

Scilab code Exa 2.8 FERMI DIREC DISTRIBUTION FUNCTION

```

1  clc
2  E=1.1
3  disp(" E = "+string(E)+"eV") //initializing the
    value of energy level E in the crystal.
4  Ef=0.6
5  disp(" Ef = "+string(Ef)+"eV")//initializing the
    value of fermi level of material.
6  T=1000
7  disp(" Temp = "+string(T)+"K")//initializing the
    value of temperature.
8  k=1.38*10^-23
9  disp(" k = "+string(k)+"J/k") //initializing the
    value of boltzmann constant.
10 e=2.718
11 disp(" e = "+string(e)) //initializing the value of
    exponential.
12 a=(((-Ef+E)*1.6*10^-19)/(k*T))
13 disp(" alpha ,a=(((-E+Ef)*1.6*10^-19)/(k*T))= "+
    string(a))//calculation
14 fE=(1/(1+(e^a)))
15 disp(" fE(Fermi Direc Distribution Function),fE
    =(1/(1+(e^a)))= "+string(fE))//calculation
16
17 //The value of Ef is different in the question than
    used in the solution.
18 //I have used the value ,used in the solution(i.e Ef

```

=0.6)

Scilab code Exa 2.9 FERMI DIREC DISTRIBUTION FUNCTION

```
1  clc
2  Ef=0.6
3  disp(" Ef = "+string(Ef)+"eV") //initializing the
   value of fermi level of material.
4  E=1.1
5  disp(" E = "+string(E)+"eV")//initializing the value
   of level E in a crystal.
6  T=1000
7  disp(" Temp = "+string(T)+" kelvin")//initializing
   the value of temperature.
8  k=1.38*10^-23
9  disp(" k = "+string(k)+"J/k") //initializing the
   value of boltzmann constant.
10 e=2.718
11 disp(" e = "+string(e)) //initializing the value of
   exponential.
12 a=((E-Ef)*1.6*10^-19)/(k*T)
13 disp(" alpha ,a=(((E-Ef)*1.6*10^-19)/(k*T)))= "+
   string(a)//calculation
14 fE=(1/(1+(e^a)))
15 disp(" fE(Fermi Direc Distribution Function),fE
   =(1/(1+(e^a)))= "+string(fE))//calculation
16
17 //The value of Ef ,temperature is different in the
   question than used in the solution.
18 //I have used the value of Ef,used in the solution(i
   .e Ef=0.6)and value of temperature used is T=1000
   K
19 //The value of a(alpha),provided in the solution
   after calculation is wrong.As book has used
   different value of the temperature in solution
```

than provided in the question.

Scilab code Exa 2.10 FERMI DIREC DISTRIBUTION FUNCTION

```
1  clc
2  E=1.1
3  disp(" E = "+string(E)+"eV") //initializing the
   value of level E in a crystal.
4  Ef=0.6
5  disp(" Ef = "+string(Ef)+"eV")//initializing the
   value of fermi level of material.
6  T=2500
7  disp(" temp = "+string(T)+"K")//initializing the
   value of temperature.
8  k=1.38*10^-23
9  disp(" k = "+string(k)+"J/k") //initializing the
   value of boltzmann constant.
10 e=2.718
11 disp(" e = "+string(e)) //initializing the value of
   exponential.
12 a=(((E-Ef)*1.6*10^-19)/(k*T))
13 disp(" alpha ,a=(((E-Ef)*1.6*10^-19)/(k*T))= "+
   string(a))//calculation
14 fE=(1/(1+(e^a)))
15 disp(" fE(Fermi Direc Distribution Function),fE
   =(1/(1+(e^a)))= "+string(fE))//calculation
16
17 //The value of Ef is different in the question than
   used in the solution.
18 //I have used the value ,used in the solution(i.e Ef
   =0.6)
```

Scilab code Exa 2.11 FERMI DIREC DISTRIBUTION FUNCTION

```

1  clc
2  E=0.6
3  disp(" E = "+string(E)+"eV") //initializing the
    value of level E in a crystal.
4  Ef=1.1
5  disp(" Ef = "+string(Ef)+"eV")//initializing the
    value of fermi level of the material.
6  T=2500
7  disp(" Temp = "+string(T)+" kelvin")//initializing
    the value of temperature.
8  k=1.38*10^-23
9  disp(" k = "+string(k)+" J/k") //initializing the
    value of boltzmann constant.
10 e=2.718
11 disp(" e = "+string(e)) //initializing the value of
    exponential.
12 a=(((-(Ef-E))*1.6*10^-19)/(k*T))
13 disp(" a ,a=((E-Ef)*1.6*10^-19)/(k*T))= "+string(a)
    )//calculation
14 fE=(1/(1+(e^a)))
15 disp(" fE(Fermi Direc Distribution Function),fE
    =(1/(1+(e^a)))= "+string(fE))//calculation
16
17
18 //The value of E is different in the question than
    used in the solution.
19 //I have used the value ,used in the solution(i.e E
    =0.6)

```

Scilab code Exa 2.12 NUMBER OF HOLES IN A MEDIMUM DOPED
N SEMICONDUCTOR

```

1  clc
2  n=10^16
3  disp(" n = "+string(n)+" /cm^3") //initializing value

```

```

of number of electrons per cm3.
4 no=1.5*1010
5 disp("no = "+string(no)+" /cm3") //initializing
value of electron hole pairs/cm3.
6 p=(no2/n)
7 disp("Number of hole ,p=(no2/n))= "+string(p)+" /cm
3")//calculation

```

Scilab code Exa 2.13 VALUE OF FERMI LEVEL

```

1 clc
2 e=1.6*10-19
3 disp("e = "+string(e)+" columb") //initializing the
value of electronic charge.
4 n=1*1016
5 disp("n = "+string(n)) //initializing the value of
number of electrons per cm3.
6 no=1.5*1010
7 disp("no = "+string(no)+" /cm3") //initializing
value of electron hole pairs/cm3..
8 T=300
9 disp("T = "+string(no)+" K") //initializing value of
temperature.
10 k=1.38*10-23
11 disp("k = "+string(k)+" J/K") //initializing value
of boltzmann constant.
12 Ef=((k*T/e)*log(n/no))
13 disp("fermi level ,Ef-Efi=((k*T/e)*ln(n/no)) )= "+
string(Ef)+" eV")//calculation

```

Scilab code Exa 2.14 NUMBER OF HOLES IN A HEAVILY DOPED N SEMICONDUCTOR

```

1  clc
2  no=1.5*10^10
3  disp("no = "+string(no)+"/cm^3") //initializing
    value of electrons and hole per cm^3.
4  n=1*10^18
5  disp("n = "+string(n)+"/cm^3") //initializing value
    of number of electrons per cm^3.
6  p=(no^2/n)
7  disp("number of holes ,p=(no^2/n))= "+string(p)+" /
    cm^3")//calculation
8
9
10
11 //this is solved problem 2.1 of chapter 2.

```

Scilab code Exa 2.15 VALUE OF INTRINSIC CONCENTRATION

```

1  clc
2  n=1*10^5
3  disp("n = "+string(n)+"/cm^3") //initializing value
    of electrons and hole per cm^3.
4  p=1*10^19
5  disp("p = "+string(p)+"/cm^3") //initializing value
    of number of hole per cm^3
6  no=sqrt(n*p)
7  disp("Value of intrinsic concentration ,no=sqrt(n*p))
    = "+string(no)+"/cm^3")//calculation
8
9
10
11 //this is solved problem 2.2 of chapter 2.

```

Scilab code Exa 2.16 VALUE OF n

```

1  clc
2  e=1.6*10^-19
3  disp("e = "+string(e)+" coulomb") //initializing the
    value of electronic charge.
4  Ef_Efi=0.309
5  disp("Ef-Efi = "+string(Ef_Efi)+" eV") //
    initializing the value of difference in the
    energy levels.
6  no=2.5*10^13
7  disp("no = "+string(no)+" /cm^3") //initializing
    value of number of electrons per cm^3
8  T=300
9  disp("T = "+string(T)+" K") //initializing value of
    temperature.
10 ex=2.718
11 disp("exp = "+string(ex)) //initializing the value
    of exponential.
12 k=1.38*10^-23
13 disp("k = "+string(k)+" J/K") //initializing value
    of boltzmann constant.
14 n=no*(ex^((Ef_Efi*e)/(k*T)))
15 disp("number of electrons per cm^3, n=no*(ex^((Ef-
    Efi)/kT))= "+string(n)+" /cm^3") //calculation
16
17
18
19 //This is solved problem 2.3 of chapter 2.
20 //The value used for "Ef-Efi" in the solution is
    different than provided in the question.
21 //I have used the value provided in the solution (i.
    e Ef_Efi=0.309)

```

Scilab code Exa 2.17 VALUE OF no

```

1  clc

```

```

2 e=1.6*10^-19
3 disp("e = "+string(e)+" coulomb") //initializing the
  value of electronic charge.
4 Ef=0.4065
5 disp("Ef = "+string(Ef)+" eV") //initializing the
  value of fermi level.
6 n=10^17
7 disp("n = "+string(n)+" /cm^3") //initializing value
  of number of electrons per cm^3.
8 T=300
9 disp("T = "+string(T)+" K") //initializing value of
  temperature.
10 ex=2.718
11 disp("exp = "+string(ex)) //initializing the value
  of exponential.
12 k=1.38*10^-23
13 disp("k = "+string(k)+" J/K") //initializing value
  of boltzmann constant.
14 no=n/(ex^((Ef*e)/(k*T)))
15 disp("Number of electrons per cm^3, no=n/(ex^((Ef)/
  kT))= "+string(no)+" electrons/cm^3")//
  calculation
16
17
18 //this is solved problem 2.4 of chapter 2.
19 //the value used for "n" in the solution is
  different than provided in the question.
20 //I have used the value provided in the solution (i.
  e n=10^17)

```

Scilab code Exa 2.18 RESTIVITY AND RESISTANCE OF SEMICONDUCTOR

```

1 clc
2 e=1.6*10^-19

```



```

3 disp("e = "+string(e)+" columb") //initializing the
  value of electronic charge.
4 n=1*10^22
5 disp("n = "+string(n)+" /m^3") //initializing value
  of number of electrons per cm^3
6 u=1200*10^-4
7 disp("u = "+string(u)+" m^2/Vs") //initializing the
  value of mobility.
8 L=0.1*10^-2
9 disp("L = "+string(L)+" m") //initializing the value
  of length.
10 A=100*10^-12
11 disp("A = "+string(A)+" m^2") //initializing the
  value of area of cross section.
12 sigma=n*e*u
13 disp(" conductivity ,sigma=n*e*u)= "+string(sigma)+"
  siemen/m")//calculation.
14 p=(1/sigma)
15 disp(" Resistivity ,p=(1/sigma))= "+string(p)+" ohm
  metre")//calculation.
16 R=(p*L/A)
17 disp(" resistance ,R=(p*L/A))= "+string(R)+" ohm")//
  calculation.
18
19
20 //this is solved problem 2.5 of chapter 2.
21 //the value used for "A" in the solution is
  different than provided in the question.
22 //I have used the value provided in the solution (i.
  e A=100*10^-12)

```

Scilab code Exa 2.19 VALUE OF DRIFT CURRENT

```

1 clc
2 R=52.08 *10^3

```

```

3 disp("R = "+string(R)+"ohm") //initializing value of
  Resistance.
4 V=5
5 disp("V = "+string(V)+" volt") //initializing value
  of voltage.
6 I=(V/R)
7 disp(" Drift current ,I=(V/R))= "+string(I)+" ampere"
  )//calculation
8
9
10 //this is solved problem 2.6 of chapter 2.

```

Scilab code Exa 2.20 FREQUENCY OF RADIATION EMITTED

```

1 clc
2 Eg1=1.43
3 disp(" Energy gap of GaAs = "+string(Eg1)+"eV") //
  initializing the value of energy gap of GaAs.
4 Eg2=2.43
5 disp(" Energy gap of GaP = "+string(Eg2)+"eV")//
  initializing the value of energy gap of Gap.
6 h=6.624*10^-34
7 disp(" Plank constant = "+string(h)+"joule")//
  initializing the value of plank constant.
8 c=3*10^8
9 disp(" Light speed = "+string(c)+"m/s") //
  initializing the value of speed of light.
10 x=(Eg2-Eg1)
11 disp(" Difference between the energy gap of GaAs and
  GaP ,x=(Eg2-Eg1))= "+string(x)+" eV")//
  calculation
12 g=(0.4*x)
13 disp(" Excess energy gap added to GaAs to form GaAsP
  ,(0.4*x))= "+string(g)+" eV ")//calculation
14 Eg=(Eg1+g)

```

```

15 disp("Band gap energy GaAsP,Eg=(Eg1+g))= "+string(Eg
    )+" eV ")//calculation
16 lamda=(c*h/(Eg*1.6*10^-19))
17 disp("wavelength of radiation emitted,lamda=(c*h/Eg)
    )= "+string(lamda)+" metre ")//calculation
18
19 //this is solved problem 2.7 of chapter 2.

```

Scilab code Exa 2.21 BAND GAP ENERGY AND VALUE OF X

```

1 clc
2 Eg1=1.43
3 disp(" Energy gap of GaAs = "+string(Eg1)+" eV") //
    initializing the value of energy gap of GaAs.
4 Eg2=2.43
5 disp(" Energy gap of GaP = "+string(Eg2)+" eV")//
    initializing the value of energy gap of Gap.
6 h=6.624*10^-34
7 disp(" Plank constant = "+string(h)+" joule")//
    initializing the value of plank constant.
8 c=3*10^8
9 disp(" Light speed = "+string(c)+" m/s") //
    initializing the value of speed of light.
10 lamda=540*10^6
11 disp(" lamda = "+string(lamda)+" m") //initializing
    the value of wavelength.
12 x=(Eg2-Eg1)
13 disp(" Difference between the energy gap of GaAs and
    GaP ,x=(Eg2-Eg1))= "+string(x)+" eV")//
    calculation
14 Eg=((c*h/(lamda*(1.6*10^-19))))
15 disp("Band gap energy ,Eg=(c*h/lamda*(1.6*10^-19))=
    "+string(Eg)+" eV")//calculation
16 X=Eg-(Eg1)
17 disp("X=Eg-(Eg1)= "+string(X))//calculation

```

```

18
19
20
21
22 //this is solved problem 2.8 of chapter 2.
23 //the value of Eg(band gap energy )is provided wrong
    in the book after calculation.Due to this value
    of X ,also differ.

```

Scilab code Exa 2.22 VALUE OF THERMAL EQUILIBRIUM HOLE CON-
CENTRATION IN SILICON

```

1  clc
2  T1=500
3  disp(" Temperature 1 = "+string(T1)+"K") //
    initializing the value of temperature 1.
4  Nv=2*10^19
5  disp(" Nv = "+string(Nv)+"cm^-3")//initializing the
    value of effective density of state for valence
    band .
6  T2=300
7  disp(" Temperature 2 = "+string(T2)+"K")//
    initializing the value of temperature 2.
8  NV=(Nv*((500/300)^(3/2)))
9  disp("NV at 500K=(Nv((500/300)^(3/2)))= "+string(NV
    )+" cm^-3 ")//calculation
10
11
12 //this is solved problem 2.9 of chapter 2.

```

Scilab code Exa 2.23 FRACTION OF ELECTRONS THAT ARE STILL
IN THE DONOR STATE

```

1  clc
2  Nd=1*10^17
3  disp("Nd = "+string(Nd)+"cm^-3") //initializing the
    value of effective energy density of state.
4  Ec_Ed=0.045
5  disp(" Ec_Ed = "+string(Ec_Ed))//initializing the
    value of donor ionisation level.
6  Vt=0.0259
7  disp("Vt = "+string(Vt)+" eV ")//initializing the
    value of thermal voltage.
8  Nc=2.8*10^19
9  disp(" Nc = "+string(Nc)+"cm^-3")//initializing the
    value of effective density of state of conduction
    band.
10 e=2.718
11 disp("exp = "+string(e))//initializing the value of
    exponential.
12 N=((Nc/Nd)*e^((-Ec_Ed)/Vt))+1)^-1
13 disp("Fraction of electron still in the donor state
    ,(nd/(nd+n)=(((Nc/Nd)*e^((-Ec_Ed)/Vt))+1)^-1)= "+
    string(N))//calculation
14
15
16 //this is solved problem 2.10 of chapter 2.

```

Scilab code Exa 2.24 FRACTION OF HOLES THAT ARE STILL IN THE ACCEPTOR STATE

```

1  clc
2  Na=1*10^16
3  disp("Na = "+string(Na)+" cm^-3")//initializing the
    value of acceptor concentration.
4  Ea_Ev=0.045
5  disp("Ea_Ev = "+string(Ea_Ev))//initializing the
    value of boron acceptor ionization energy.

```

```

6 Nv=(1.04*10^19)
7 disp("Nv = "+string(Nv)+" cm^-3")//initializing the
  value of effective density of state for valence
  band.
8 Vt=(0.0259)
9 disp("Vt = "+string(Vt)+" eV")//initializing the
  value of thermal voltage.
10 p=(1+((Nv/(4*Na))*exp(-(Ea-Ev)/Vt)))^(-1)
11 disp("Fraction of holes that are still in the
  acceptor state ,(pa/(pa+p))=(1+((Nv/4*Na)*exp(-(Ea
  -Ev)/Vt)))^(-1)= "+string(p))//calculation
12
13 //this is solved problem 2.11 of chapter 2.

```

Scilab code Exa 2.25 ELECTRON AND HOLE CONCENTRATION

```

1 clc
2 Nd=1*10^17
3 disp("Nd = "+string(Nd)+" cm^-3") //initializing the
  value of donor concentration.
4 Na=0
5 disp("Na = "+string(Na)+" cm^-3")//initializing the
  value of acceptor concentration.
6 no=1.5*10^10
7 disp("ni = "+string(no)+" cm^-3")//initializing the
  value of electron hole per cm^3.
8 n=(-(Na-Nd)+sqrt((Na-Nd)^2+4*no))/2
9 disp("Electron concentration ,n=(-(Na-Nd)+sqrt((Na-Nd)
  )^2+4*no))/2)= "+string(n)+" cm^-3")//calculation
10 p=(no^2/n)
11 disp("Hole concentration ,p)= "+string(p)+" cm^-3")//
  calculation
12
13
14

```

15 //this is solved problem 2.13 of chapter 2.

Scilab code Exa 2.26 ELECTRON AND HOLE CONCENTRATION

```
1  clc
2  Nd=6*10^16
3  disp("Nd = "+string(Nd)+" cm^-3") //initializing the
   value of donor concentration.
4  Na=10^17
5  disp("Na = "+string(Na)+" cm^-3")//initializing the
   value of acceptor concentration.
6  no=1.5*10^10
7  disp("no = "+string(no)+" cm^-3")//initializing the
   value of electron and hole per cm^3.
8  p=((Na-Nd)+sqrt((Na-Nd)^2+4*no))/2
9  disp("Hole concentration ,n=(-(Na-Nd)+sqrt((Na-Nd)
   ^2+4*no))/2)= "+string(p)+" cm^-3")//calculation
10 n=(no^2/p)
11 disp("Electron concentration ,n=(no^2/p))= "+string(n
   )//calculation
12
13
14
15 //this is solved problem 2.14 of chapter 2.
16 //the value of Na,Nd in the solution is different
   than provided in the question
17 //I have used the value used in the solution(i.e Na
   =10^17,Nd=6*10^16)
```

Scilab code Exa 2.27 ELECTRON AND HOLE CONCENTRATION

```
1  clc
2  Nd=6*10^16
```

```

3 disp("Nd = "+string(Nd)+" cm-3") //initializing the
    value of donor concentration.
4 Na=1017
5 disp("Na = "+string(Na)+" cm-3")//initializing the
    value of acceptor concentration.
6 no=1.5*1010
7 disp("no = "+string(no)+" cm-3")//initializing the
    value of electron and hole per cm3.
8 p=((Na-Nd)+sqrt((Na-Nd)2+4*no))/2
9 disp("Hole concentration ,n=(-(Na-Nd)+sqrt((Na-Nd)
    ^2+4*no))/2)= "+string(p)+" cm-3")//calculation
10 n=(no2/p)
11 disp("Electron concentration ,n=(no2/p))= "+string(n
    )//calculation
12
13
14 //this is solved problem 2.15 of chapter 2.
15 //the value of Na,Nd in the solution is different
    than provided in the question
16 //I have used the value used in the solution(i.e Na
    =1017,Nd=6*1016)

```

Scilab code Exa 2.28 VALUE OF THERMAL EQUILIBRIUM HOLE CON-
CENTRATION IN SILICON

```

1 clc
2 Nv1=1.04*1019
3 disp("Nv = "+string(Nv1)+" cm-3")//initializing the
    value of valence band concentration at 300K.
4 Ef_Ev=0.3
5 disp("Ef_Ev = "+string(Ef_Ev)+" eV")//initializing
    the value of boron acceptor ionization energy.
6 T1=300
7 disp("T = "+string(T1)+"K")//initializing the value
    of temperature 1.

```



```

8 T2=500
9 disp("T = "+string(T2)+"K")//initializing the value
  of temperature 2.
10 Vt1=0.0259
11 disp("Vt1 = "+string(Vt1)+"eV")//initializing the
  value of thermal voltage at 300K.
12 k=1.38*10^-23
13 disp("k = "+string(k)+"J/K") //initializing value of
  boltzmann constant.
14 e=1.6*10^-19
15 disp("e = "+string(e)+"columb") //initializing the
  value of electronic charge.
16 K1=(Nv1/((T1)^(3/2)))
17 disp(" Value of constant ,K1=(Nv/((T)^(3/2)))= "+
  string(K1)+" cm^-3 K(-2/3)")//calculation
18 Nv2=K1*T2^(3/2)
19 disp(" Value of valence band concentration at 500K,Nv
  =K1*T(3/2)= "+string(Nv2)+" cm^-3")//calculation
20 VT=(k*T2/e)
21 disp(" Value of parameter VT at 500K,VT=(K*T/e)= "+
  string(VT)+" cm^-3")//calculation
22 p=(Nv2*(exp(-(Ef_Ev)/(VT))))
23 disp(" Hole concentration ,p=(Nv*(exp(Ef_Ev)/(VT)))= "
  +string(p)+" cm^-3")//calculation
24
25 //this is solved problem 2.16 of chapter 2.

```

Scilab code Exa 2.29 INTRINSIC CARRIER CONCENTRATION

```

1 clc
2 Nv=7*10^18
3 disp("Nv = "+string(Nv)+"cm^-3")//initializing the
  value of valence band concentration at 300K.
4 Nc=4.7*10^17
5 disp("Nc = "+string(Nc)+"cm^-3")//initializing the

```

```

        value of conduction band concentration at 300K.
6 T1=300
7 disp("T = "+string(T1)+"K")//initializing the value
  of temperature 1.
8 T2=450
9 disp("T = "+string(T2)+"K")//initializing the value
  of temperature 2.
10 Vt1=0.0259
11 disp("Vt1 = "+string(Vt1)+"eV")//initializing the
  value of thermal voltage at 300K.
12 Vt2=0.03881
13 disp("Vt2 = "+string(Vt2)+"eV")//initializing the
  value of thermal voltage at 450K.
14 Eg=1.42
15 disp("Eg = "+string(Eg)+"eV")//initializing the
  value of thermal voltage.
16 no=(sqrt(Nc*Nv*(exp(-Eg/Vt1))))
17 disp("intrinsic concentration at 300K,no=(sqrt(Nc*Nv
  *(exp(-Eg/Vt1))))= "+string(no))//calculation
18 K1=(Nc/((T1)^(3/2)))
19 disp("Value of constant ,K1=(Nc/((T)^(3/2)))= "+
  string(K1))//calculation
20 k1=(K1*T2^(3/2))
21 disp("Value of constant k1 at 450K ,k1=(K1*T2^(3/2))
  = "+string(k1))//calculation
22 K2=(Nv/((T1)^(3/2)))
23 disp("Value of constant ,K2=(Nv/((T1)^(3/2)))= "+
  string(K2))//calculation
24 k2=(K2*T2^(3/2))
25 disp("Value of constant k2 at 450K ,k2=(K2*T2^(3/2))
  = "+string(k2))//calculation
26 K=k1*k2
27 disp("Value of constant K,= "+string(K))//
  calculation
28 no1=(sqrt(K*(exp(-Eg/Vt2))))
29 disp("intrinsic concentration at 450K,no=(sqrt(K*(
  exp(-Eg/Vt2))))= "+string(no1)+" cm^3")//
  calculation

```

30 //this is solved problem 2.17 of chapter 2.

Scilab code Exa 2.30 VALUE OF DONOR CONCENTRATION

```
1  clc
2  Nv=1.04*10^19
3  disp("Nv = "+string(Nv)+"cm^-3")//initializing the
   value of valence band concentration at 300K.
4  Nc=2.8*10^19
5  disp("Nc = "+string(Nc)+"cm^-3")//initializing the
   value of conduction band concentration at 300K.
6  T1=300
7  disp("T = "+string(T1)+"K")//initializing the value
   of temperature 1.
8  T2=550
9  disp("T = "+string(T2)+"K")//initializing the value
   of temperature 2.
10 Vt1=0.0259
11 disp("Vt1 = "+string(Vt1)+"eV")//initializing the
   value of thermal voltage at 300K.
12 Vt2=0.0474
13 disp("Vt2 = "+string(Vt2)+"eV")//initializing the
   value of thermal voltage at 550K.
14 Eg1=1.12
15 disp("Eg1 = "+string(Eg1)+"eV")//initializing the
   value of thermal voltage.
16 no=(sqrt(Nc*Nv*(exp(-Eg1/Vt1))))
17 disp("intrinsic concentration at 300K,no=(sqrt(Nc*Nv
   *(exp(-Eg1/Vt1))))= "+string(no))// calculation
18 K1=(Nc/((T1)^(3/2)))
19 disp("Value of constant ,K1=(Nc/((T)^(3/2)))= "+
   string(K1))// calculation
20 k1=(K1*T2^(3/2))
21 disp("Value of constant k1 at 550K ,k1=(K1*T2^(3/2))
   = "+string(k1))// calculation
```

```

22 K2=(Nv/((T1)^(3/2)))
23 disp(" Value of constant ,K2=(Nv/((T1)^(3/2)))= "+
      string(K2))// calculation
24 k2=(K2*T2^(3/2))
25 disp(" Value of constant k2 at 550K ,k2=(K2*T2^(3/2))
      = "+string(k2))// calculation
26 K=k1*k2
27 disp(" Value of constant K,= "+string(K))//
      calculation
28 no1=(sqrt(K*(exp(-Eg1/Vt2))))
29 disp(" Intrinsic concentration at 550K,no=(sqrt(K*(
      exp(-Eg1/Vt2))))= "+string(no1)+" cm^3")//
      calculation
30 Nd=(4*(no1^2)/(1.2))
31 disp(" Donor concentration at which intrinsic
      concentration is 10% of the total electron
      concentration ,Nd=(4*(no1^2)/(1.2))= "+string(Nd)+
      " cm^3")// calculation
32 //this is solved problem 2.18 of chapter 2.
33 //the value of temperature and % of the intrinsic
      carrier concentration given in the question is
      different than used in the solution.
34 //I have used the value provided in the solution (i.
      e T2=550 and % of the intrinsic carrier
      concentration =10%)
35 //the value of Donor concentration at which
      intrinsic concentration is 10% of the total
      electron concentration(Nd),is provided wrong in
      the book after calculation.

```

Scilab code Exa 2.31 DONOR CONCENTRATION IN SILICON

```

1 clc
2 Ec_Ef=0.2
3 disp(" Ec_Ef = "+string(Ec_Ef)+" eV") //initializing

```

```

    the value of difference in the energy levels.
4  Nc=2.8*10^19
5  disp("Nc = "+string(Nc)+" cm^-3")//initializing the
    value of conduction band concentration.
6  Na=3*10^16
7  disp("Na = "+string(Na)+" cm^-3")//initializing the
    value of acceptor concentration.
8  Vt=0.0259
9  disp("Vt = "+string(Vt)+" eV")//initializing the
    value of thermal voltage at 300K.
10 Nd=(Nc*(exp(-(Ec_Ef)/(Vt))))+(Na)
11 disp("Donor concentration ,Nd=(Nc*(exp(-(Ec_Ef)/(Vt))
    ))+(Na)= "+string(Nd)+" cm^-3")//calculation
12
13
14 //this is solved problem 2.19 of chapter 2.

```

Scilab code Exa 2.32 INTRINSIC CARRIER CONCENTRATION

```

1  clc
2  Nv=6*10^18
3  disp("Nv = "+string(Nv)+" cm^-3")//initializing the
    value of valence band concentration at 300K.
4  Nc=1.04*10^19
5  disp("Nc = "+string(Nc)+" cm^-3")//initializing the
    value of conduction band concentration at 300K.
6  T1=300
7  disp("T1 = "+string(T1)+"K")//initializing the value
    of temperature 1.
8  T2=200
9  disp("T2 = "+string(T2)+"K")//initializing the value
    of temperature 2.
10 Vt1=0.0259
11 disp("Vt1 = "+string(Vt1)+" eV")//initializing the
    value of thermal voltage at 300K.

```

```

12 Vt2=0.0173
13 disp("Vt2 = "+string(Vt2)+"eV")//initializing the
    value of thermal voltage at 200K.
14 Eg1=0.60
15 disp("Eg1 = "+string(Eg1)+"eV")//initializing the
    value of thermal voltage used for 300K .
16 no=(sqrt(Nc*Nv*(exp(-Eg1/Vt1))))
17 disp("intrinsic concentration at 300K,no=(sqrt(Nc*Nv
    *(exp(-Eg1/Vt1))))= "+string(no))//calculation
18 Eg2=0.66
19 disp("Eg2 = "+string(Eg2)+"eV")//initializing the
    value of thermal voltage used for 200K.
20 K1=(Nc/((T1)^(3/2)))
21 disp("Value of constant ,K1=(Nc/((T)^(3/2)))= "+
    string(K1))//calculation
22 k1=(K1*T2^(3/2))
23 disp("Value of constant k1 at 200K ,k1=(K1*T2^(3/2))
    = "+string(k1))//calculation
24 K2=(Nv/((T1)^(3/2)))
25 disp("Value of constant ,K2=(Nv/((T1)^(3/2)))= "+
    string(K2))//calculation
26 k2=(K2*T2^(3/2))
27 disp("Value of constant k2 at 200K ,k2=(K2*T2^(3/2))
    = "+string(k2))//calculation
28 K=k1*k2
29 disp("Value of constant K,= "+string(K))//
    calculation
30 no1=(sqrt(K*(exp(-Eg2/Vt2))))
31 disp("intrinsic concentration at 200K,no=(sqrt(K*(
    exp(-Eg2/Vt2))))= "+string(no1)+" cm^3")//
    calculation
32
33 //this is solved problem 2.20 of chapter 2.
34 //The answer of intrinsic concentration at 300K,(no)
    is provided wrong in the book.

```

Scilab code Exa 2.33 RATIO OF INTRINSIC CONCENTRATION

```
1 clc
2 Eg1=2
3 disp("Eg1 = "+string(Eg1)+" eV") //initializing the
   value of band energy gap for semiconductor1.
4 Eg2=2.2
5 disp("Eg2 = "+string(Eg2)+" eV")//initializing the
   value of band energy gap for semiconductor2.
6 Vt=0.0259
7 disp("Vt = "+string(Vt)+" eV")//initializing the
   value of thermal voltage at 300K.
8 No=sqrt(exp((-Eg1/Vt)-(-Eg2/Vt)))
9 disp("Ratio of their intrinsic concentration at 300K
   ,(no1/no2)=sqrt(exp((-Eg1/Vt)-(-Eg2/Vt)))= "+
   string(No))// calculation
```

Chapter 3

CARRIER TRANSPORT IN SEMICONDUCTOR

Scilab code Exa 3.1 VALUE OF HALL ELECTRIC FIELD

```
1 clc
2 I=5*10^-3
3 disp("I = "+string(I)+" amphere") //initializing
  value of current flowing through the sample.
4 B=1*10^-6
5 disp("B= "+string(B)+" Tesla") //initializing value
  of magnetic field.
6 w=0.01*10^-2
7 disp("w = "+string(w)+" m") //initializing value of
  width of germanium sample.
8 l=0.1*10^-2
9 disp("l = "+string(l)+" m") ////initializing value
  of length of germanium sample.
10 t=0.001*10^-2
11 disp("t = "+string(t)+" m") ////initializing value
  of thickness of germanium sample.
12 p=10^17
13 disp("p = "+string(p)+" atoms/m^3") //initializing
  value of doped acceptor atoms.
```



```

14 e=1.6*10^-19
15 disp("e = "+string(e)+" coulomb") //initializing
    value of charge of electron.
16 EH=(I*B)/(w*t*p*e)
17 disp("Hall electric field ,EH=(I*B)/(w*t*p*e)= "+
    string(EH)+" V/m")//calculation
18 E=EH*10^-2
19 disp("Hall electric field in centimeter ,EH=(I*B)/(w*
    t*p*e)= "+string(E)+" V/cm")//calculation

```

Scilab code Exa 3.2 VALUE OF HALL COEFFICIENT

```

1 clc
2 I=5*10^-3
3 disp("I = "+string(I)+" ampere") //initializing
    value of current flowing through the sample.
4 B=1*10^-6
5 disp("B= "+string(B)+" Tesla") //initializing value
    of magnetic field.
6 w=0.01*10^-2
7 disp("w = "+string(w)+" m") //initializing value of
    width of germanium sample.
8 l=0.1*10^-2
9 disp("l = "+string(l)+" m") //initializing value of
    length of germanium sample.
10 t=0.001*10^-2
11 disp("t = "+string(t)+" m") //initializing value of
    thickness of germanium sample.
12 p=10^17
13 disp("p = "+string(p)+" atoms/cm^3") //initializing
    value of doped acceptor atoms.
14 e=1.6*10^-19
15 disp("e = "+string(e)+" coulomb") //initializing
    value of charge of electron.
16 Rh=(1/(p*e))

```

```
17 disp(" hall coefficient ,Rh=(1/(p*e))= "+string(Rh)+"  
    cm^3/C")//calculation
```

Scilab code Exa 3.3 VALUE OF HALL VOLTAGE

```
1 clc  
2 I=10*10^-3  
3 disp("I = "+string(I)+" ampere") //initializing  
    value of current flowing through the sample.  
4 B=10*10^-6  
5 disp("B= "+string(B)+" Tesla") //initializing value  
    of magnetic field.  
6 w=0.01*10^-2  
7 disp("w = "+string(w)+" m") //initializing value of  
    width of germanium sample.  
8 l=0.1*10^-2  
9 disp("l = "+string(l)+" m") //initializing value of  
    length of germanium sample.  
10 t=0.001*10^-2  
11 disp("t = "+string(t)+" m") //initializing value of  
    thickness of germanium sample.  
12 n=10^16  
13 disp("n = "+string(n)+" atoms/cm^3") //initializing  
    value of doped donor atoms.  
14 e=1.6*10^-19  
15 disp("e = "+string(e)+" columb") //initializing  
    value of charge of electron.  
16 Vh=((I*B)/(n*e*t))  
17 disp(" Hall voltage ,Vh=((I*B)/(n*e*t))= "+string(Vh)  
    +" V")//calculation
```

Scilab code Exa 3.4 VALUE OF HALL RESISTANCE

```

1 clc
2 I=10*10^-3
3 disp("I = "+string(I)+" ampere") //initializing
  value of current flowing through the sample.
4 B=10*10^-6
5 disp("B= "+string(B)+" Tesla") //initializing value
  of magnetic field.
6 w=0.01*10^-2
7 disp("w = "+string(w)+" m") //initializing value of
  width of germanium sample.
8 l=0.1*10^-2
9 disp("l = "+string(l)+" m") ////initializing value
  of length of germanium sample.
10 t=0.001*10^-2
11 disp("t = "+string(t)+" m") ////initializing value
  of thickness of germanium sample.
12 p=10^18
13 disp("p = "+string(p)+" atoms/cm^3") //initializing
  value of doped donor atoms.
14 e=1.6*10^-19
15 disp("e = "+string(e)+" columb") //initializing
  value of charge of electron.
16 Yh=((B)/(p*e*t))
17 disp("Hall voltage ,Yh=((B)/(p*e*t))= "+string(Yh)+"
  ohm")//calculation

```

Scilab code Exa 3.8 MINIMUM CONDUCTIVITY AND MAXIMUM RESISTIVITY

```

1 clc
2 no=1.5*10^10
3 disp("no = "+string(no)) //initializing value of
  electron hole per cm^3.
4 n=2*10^16
5 disp("n= "+string(n)) //initializing value of number

```

```

        of electrons per cm3.
6 un=1200
7 disp("un = "+string(un)) //initializing value of
    mobility of n-type carrier.
8 up=500
9 disp("up = "+string(up)) ////initializing value of
    mobility of p-type carrier.
10 e=1.6*10-19
11 disp("e = "+string(e)+" columb") //initializing
    value of charge of electron.
12 p=(1/(2*e*no*(sqrt(un*up))))
13 disp(" resistivity ,p=(1/(2*e*no*(sqrt(un/up))))= "+
    string(p)+" ohm")//calculation
14 sigmamin=(1/p)
15 disp(" conductivity ,s=(1/p))= "+string(sigmamin)+" S
    /cm")//calculation
16 sigma=e*no*(un+up)
17 disp("intrinsic conductivity ,sigma=e*no*(un+up))= "
    +string(sigma)+" S/cm")//calculation

```

Scilab code Exa 3.10 VALUE OF DIFFERENCE IN FERMI LEVELS

```

1 clc
2 po=1018
3 disp("po = "+string(po)+" cm-3") //initializing
    value of N type doping level.
4 no=1.5*1010
5 disp("no = "+string(no)+" /cm-3") //initializing
    value of electron and hole concentration per cm
    ^3.
6 Po=1017
7 disp("P(o)= "+string(Po)+" cm-3") //initializing
    value of excess hole concentration.
8 A=0.1
9 disp("A = "+string(A)+" cm-2") //initializing the

```

```

    value of area.
10 up=300
11 disp("up = "+string(up)+" cm^2/Vs") //initializing
    value of mobility of p-type carrier.
12 t=7*10^-9
13 disp("t = "+string(t)+" sec") //initializing value
    of transit time.
14 T=300
15 disp("T = "+string(T)+" K") //initializing value of
    temperature.
16 Vt=0.0259
17 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage at 300K.
18 x=500*10^-8
19 disp("x = "+string(x)+" cm") //initializing value of
    distance at which difference in fermi level is
    to calculated.
20 Dp=(Vt*up)
21 disp(" Diffusion coefficient ,Dp=(Vt*up))= "+string(Dp)
    +" cm^2/s")// calculation
22 Lp=(sqrt(Dp*t))
23 disp(" Diffusion length ,Lp=(sqrt(Dp*t))= "+string(Lp)
    )+" cm")// calculation
24 px=(po+(Po*exp(-x/Lp)))
25 disp(" Excess charge generated ,p(x)=(po+(P(o)*exp(-x/
    Lp)))= "+string(px)+" cm^-3")// calculation
26 Efi_Efp=(Vt*log(px/no))
27 disp(" Fermi level ,Efi_Efp=(Vt*log(p(x)/no))= "+
    string(Efi_Efp)+" eV")// calculation

```

Scilab code Exa 3.11 HOLE CURRENT AND STORED EXCESS HOLE CHARGES

```

1 clc
2 A=0.1*10^-4

```

```

3 disp("A = "+string(A)+" cm^2") //initializing value
  of area.
4 Dp=7.77*10^-4
5 disp("Dp= "+string(Dp)+" cm^2/s") //initializing
  value of diffusion coefficient.
6 Lp=0.233*10^-5
7 disp("Lp = "+string(Lp)+" cm") //initializing value
  of diffusion length.
8 x=500*10^-8
9 disp("x = "+string(x)+" cm") //initializing value of
  distance
10 P=10^17*10^6
11 disp("P(O)-po = "+string(P)) //initializing value of
  P(O)-po
12 e=1.6*10^-19
13 disp("e = "+string(e)+" column")//initializing value
  of charge of electron.
14 I=(((e*A*Dp*P)/Lp)*exp(-x/Lp))
15 disp("Hole current , I=(((e*A*Dp*[P(O)-po])/Lp)*exp(-x
  /Lp))= "+string(I)+" amphere")// calculation
16 Q=(e*A*Dp*Lp*P)
17 disp("stored excess hole ,Q=(e*A*Dp*Lp*P))= "+string
  (Q)+"C")// calculation
18
19 //the value of current(I) given after calculation in
  the book is wrong, (as the value of Lp used in
  the formula while finding value of hole current (
  I)at two places //is used different).
20 //I have used the value Lp=0.233*10^-5 cm

```

Scilab code Exa 3.12 ELECTRONIC CONCENTRATION AND MOBILITY

```

1 clc
2 I=2*10^-3

```

```

3 disp("I = "+string(I)+" ampere") //initializing
  value of current flowing through the sample.
4 B=1000*10^-4
5 disp("B= "+string(B)+" Tesla") //initializing value
  of magnetic field.
6 w=0.2*10^-3
7 disp("w = "+string(w)+" mm") //initializing value of
  width of sample.
8 l=2*10^-3
9 disp("l = "+string(l)+" m") //initializing value of
  length of sample.
10 t=0.02*10^-3
11 disp("t = "+string(t)+" m") //initializing value of
  thickness of sample.
12 Vaa=10
13 disp("Vaa = "+string(Vaa)+" V") //initializing value
  of applied voltage.
14 Vh=-10*10^-3
15 disp("Vh = "+string(Vh)+" V") //initializing value
  of hall voltage.
16 e=1.6*10^-19
17 disp("e = "+string(e)+" columb") //initializing
  value of charge of electron.
18 n=((I*B)/(e*t*Vh))
19 disp("electron concentration ,n=((I*B)/(e*t*Vh))= "+
  string(n)+" m^-3")//calculation
20 un=(I*l/(e*abs(n)*Vaa*w*t))
21 disp("mobility ,un=(I*L/(e*n*Vaa*w*t))= "+string(un)+
  " m^2/Vs")//calculation

```

Scilab code Exa 3.14 INDUCED ELECTRIC FIELD

```

1 clc
2 disp("ND_x = ((10^17)-(10^18*x))") //donor
  concentration in an N type semiconductor

```

```

3 disp("differentiating above equation with resprct to
      x")
4 disp("d[ND_x]/dx = (-10^18) cm^-4")
5 disp("now, electric field is given by ")
6 disp("E_x = -(VT/ND_x)*(d[ND_x]/dx) = (0.0259*10^18)
      /((10^15)-(10^18*x))") // equation for electric
      field
7 disp("for x = 0")
8 x = 0
9 E_x = (0.0259*10^18)/((10^15)-(10^18*x))
10 disp("E_x = "+string(E_x)+"V/cm")
11 disp("for x = 1*10^-4 cm")
12 x = 1*10^-4
13 E_x = (0.0259*10^18)/((10^15)-(10^18*x))
14 disp("E_x = "+string(E_x)+"V/cm")

```

Scilab code Exa 3.17 ELECTRON AND HOLE CONCENTRATION AND DRIFT CURRENT DENSITY

```

1 clc
2 Nd=10^17
3 disp("Nd = "+string(Nd)+" /cm^3") //initializing
      value of donor concentration.
4 Na=0
5 disp("Na= "+string(Na)+" /cm^3") //initializing
      value of acceptor concentration.
6 no=1.8*10^6
7 disp("no = "+string(no)+" /cm^3") //initializing
      value of electron and hole concentration per cm
      ^3.
8 E=5
9 disp("E = "+string(E)+" V/cm") ////initializing
      value of electric field.
10 un=7500
11 disp("un = "+string(un)+" cm^2/s") ////initializing

```



```

        value of mobility.
12 n1=10^17
13 disp("n1= "+string(n1)+" cm^-3") //initializing
    value of impurity concentration.
14 e=1.6*10^-19
15 disp("e = "+string(e)+" columb") //initializing
    value of charge of electron.
16 n=(-(Na-Nd)+sqrt((Na-Nd)^2+4*no))/2
17 disp("Electron concentration ,n=(-(Na-Nd)+sqrt((Na-Nd)
    )^2+4*no))/2)= "+string(n)+" cm^-3")//calculation
18 p=(no^2/n)
19 disp("Hole concentration ,p=(no^2/n))= "+string(p)+"
    cm^-3")//calculation
20 Jdrift=n1*un*e*E
21 disp("Drift current density ,Jdrift=n1*un*e*E)= "+
    string(Jdrift)+" A/cm^2")//calculation

```

Scilab code Exa 3.18 ELECTRON AND HOLE CONCENTRATION AND DRIFT CURRENT DENSITY

```

1 clc
2 Nd=0
3 disp("Nd = "+string(Nd)+" /cm^3") //initializing
    value of donor concentration.
4 Na=10^17
5 disp("Na= "+string(Na)+" /cm^3") //initializing
    value of acceptor concentration.
6 no=1.8*10^6
7 disp("no = "+string(no)+" /cm^3") //initializing
    value of electron and hole concentration per cm
    ^3.
8 E=10
9 disp("E = "+string(E)+" V/cm") ////initializing
    value of electric field.
10 un=200

```

```

11 disp("un = "+string(un)+" cm^2/s") ///initializing
    value of mobility.
12 p1=10^17
13 disp("p1= "+string(p1)+" cm^-3") //initializing
    value of impurity concentration.
14 e=1.6*10^-19
15 disp("e = "+string(e)+" columb") //initializing
    value of charge of electron.
16 p=-(-(Na-Nd)-sqrt((Na-Nd)^2+4*(no^2)))/2
17 disp("Electron concentration ,p=-(-(Na-Nd)-sqrt((Na-
    Nd)^2+4*(no^2)))/2= "+string(p)+" cm^-3")//
    calculation
18 n=(no^2/p)
19 disp("Hole concentration ,n=(no^2/p))= "+string(n)+"
    cm^-3")//calculation
20 Jdrift=p1*un*e*E
21 disp("Drift current density ,Jdrift=n1*un*e*E)= "+
    string(Jdrift)+" A/cm^2")//calculation

```

Scilab code Exa 3.19 VALUE OF THERMAL EQUILIBRIUM HOLE CON- CENTRATION

```

1 clc
2 D=120
3 disp("D = "+string(D)+" A/cm^2") //initializing
    value of drift current density.
4 E=5
5 disp("E = "+string(E)+" V/cm") //initializing value
    of electric field.
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columb") //initializing
    value of charge of electron.
8 p=(D/(450*e*E))
9 disp("thermal equilibrium value of hole
    concentration ,p=(D/(450*e*E))= "+string(p)+" /

```

```
cm^3")//calculation
```

Scilab code Exa 3.20 CURRENT THROUGH THE BAR

```
1 clc
2 Nd=5*10^16
3 disp("Nd = "+string(Nd)+" /cm^3") //initializing
  value of donor concentration.
4 A=50*10^-8
5 disp("A= "+string(A)+" cm^2") //initializing value
  of area.
6 l=0.2
7 disp("l = "+string(l)+" /cm") //initializing value
  of length.
8 E=10
9 disp("E = "+string(E)+" V") //initializing value of
  electric field.
10 up=1100
11 disp("un = "+string(up)+" cm^2/s") //initializing
  value of mobility.
12 p=5*10^16
13 disp("p= "+string(p)+" /cm^-3") //initializing value
  of impurity concentration.
14 e=1.6*10^-19
15 disp("e = "+string(e)+" coulomb") //initializing
  value of charge of electron.
16 I=(p*up*e*E*A)/l
17 disp("Current through the bar ,I=(p*up*e*E*A)/l)= "+
  string(I)+"A")//calculation
```

Chapter 4

EXCESS CARRIER IN SEMICONDUCTOR

Scilab code Exa 4.2 DIELECTRIC RELAXATION TIME

```
1 clc
2 Nd=2*10^17
3 disp("Nd = "+string(Nd)+"cm^-3") //initializing
  value of donor concentration.
4 Er=11.9
5 disp("Er = "+string(Er)) //initializing value of
  relative dielectric constant.
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
8 Eo=8.854*10^-14
9 disp("eo = "+string(Eo)) //initializing value of
  permittivity of free space.
10 un=1350
11 disp("un = "+string(un)+"cm2/Vs") //initializing
  value of mobility.
12 sigma=e*un*Nd
13 disp(" conductivity ,sigma=e*un*Nd)=" +string(sigma)+"
  S/cm")//calculation
```

```

14 td=((Er*Eo)/sigma)
15 disp(" Dielectric relaxation time ,td=((Er*Eo)/sigma)
    )="+string(td)+" s")//calculation

```

Scilab code Exa 4.3 ELECTRON HOLE RECOMBINATION

```

1  clc
2  n=10^15
3  disp("n = "+string(n)+"cm^-3") //initializing value
    of concentration of electrons/cm^3.
4  no=10^10
5  disp("no = "+string(no)+"cm^-3") //initializing
    value of intrinsic concentration of electron.
6  t=10^-6
7  disp("t = "+string(t)+" s") //initializing value of
    carrier lifetime.
8  c=1*10^14
9  disp("Excess electron concentration = "+string(c)+"
    cm^-3") //initializing value of excess electrons
    concentration.
10 R=(c/t)
11 disp("electron hole recombination ,R=(c/t)="+string(
    R)+" /cm^3s")//calculation

```

Scilab code Exa 4.4 GENERATION AND RECOMBINATION RATE OF EHPS AND MAJORITY CARRIER LIFETIME

```

1  clc
2  Nd=10^15
3  disp("Nd = "+string(Nd)+"cm^-3") //initializing
    value of donor concentration..
4  tn=10*10^-6

```

```

5 disp("minority carrier lifetime = "+string(tn)+"s")
  //initializing value of minority carrier lifetime
.
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
  value of electron and hole concentration per cm
  ^3.
8 p=(no^2/Nd)
9 disp("excess carrier concentration ,p=(no^2/Nd)= "+
  string(p)+" /cm^3") //calculation
10 R=(p/tn)
11 disp("electron hole generation and recombination
  rate ,R=(p/t)="+string(R)+" /cm^3s") //calculation
12 t=Nd/R
13 disp("majority carrier concentration ,t=Nd/R="+
  string(t)+"s") //calculation.
14
15
16 //the value of majority carrier concentration ,t=Nd/R
  (after calculation),is provided wrong in the
  solution.

```

Scilab code Exa 4.5 QUASI FERMI LEVELS

```

1 clc
2 Nd=10^16
3 disp("Nd = "+string(Nd)+" cm^-3") //initializing
  value of donor concentration.
4 p=10^6
5 disp("p = "+string(p)+" cm^-3") //initializing value
  of minority hole concentration.
6 no=10^10
7 disp("no = "+string(no)+" cm^-3") //initializing
  value of electron and hole concentration per cm
  ^3..

```

```

8 n1=10^15
9 disp("n* = "+string(n1)+" cm^-3") //initializing
  value of excess electron carrier concentration(
  denoted by n*).
10 p1=10^15
11 disp("p* = "+string(p1)+" cm^-3") //initializing
  value of excess hole carrier concentration(
  denoted by p*).
12 KT=0.0259
13 disp("KT = "+string(KT)+" eV") //initializing value
  of multiplication of temperature and bolzmann
  constant.
14 T=300
15 disp("T = "+string(T)+" K") //initializing value of
  temperature.
16 Ef_Efi=(log(Nd/no)*KT)
17 disp("Thermal equilibrium fermi level ,( Ef_Efi)=(KT*
  log (n/no))=" +string(Ef_Efi)+" eV") // calculation .
18 Efn_Efi=log((Nd+n1)/no)*KT
19 disp("Quasi-fermi levels for n-type dopant ,( Efn_Efi)
  =(KT*log ((n+n*)/no))=" +string(Efn_Efi)+" eV") //
  calculation .
20 Efi_Efp=log((Nd+p1)/no)*KT
21 disp("Quasi-fermi levels for p-type dopant ,( Efi_Efp)
  =(KT*log ((p+p*)/no))=" +string(Efi_Efp)+" eV") //
  calculation .
22
23 //the answer for Efn_Efi ,Efi_Efp is provided wrong
  in the book.
24 //In this question ,Nd=(n(used in the formula)).

```

Scilab code Exa 4.6 ENERGY DIFFERENCE BETWEEN EF_n AND EF_i

```

1 clc
2 Nd=5*10^16

```

```

3 disp("Nd = "+string(Nd)+"cm-3") //initializing
  value of donor ion concentration.
4 Na=0
5 disp("Na = "+string(Na)+"cm-3") //initializing
  value of acceptor ion concentration.
6 no=1.5*1010
7 disp("no = "+string(no)+"cm-3") //initializing
  value of electron and hole concentration per cm
  ^3.
8 n1=5*1014
9 disp("n* = "+string(n1)+"cm-3") //initializing
  value of excess electron carrier concentration.
10 p1=5*1014
11 disp("p* = "+string(p1)+"cm-3") //initializing
  value of excess hole carrier concentration.
12 KT=0.0259
13 disp("KT = "+string(KT)) //initializing value of
  thermal voltage.
14 Ef_Efi=(KT*log(Nd/no))
15 disp("thermal equilibrium fermi level ,(Ef_Efi)=(KT*
  log(n/no))=" +string(Ef_Efi)+"eV") // calculation.
16 Efn_Efi=log((Nd+n1)/no)*KT
17 disp("Excess carrier concentration ,(Efn_Efi)=(KT*
  log((n+n*)/no))=" +string(Efn_Efi)+"eV") //
  calculation.
18 Efi_Efp=log((Na+p1)/no)*KT
19 disp("(Ef_Efi)=(KT*log((p+p*)/no))=" +string(Efi_Efp)
  +"eV") // calculation.

```

Chapter 5

PN JUNCTION DIODE

Scilab code Exa 5.5 FERMI LEVEL IN P AND N JUNCTION AND CONTACT POTENTIAL

```
1 clc
2 Na=10^17
3 disp("Na = "+string(Na)+"/cm^3") //initializing
  value of medium p doping concentration.
4 Nd=10^15
5 disp("Nd = "+string(Nd)+"/cm^3") //initializing
  value of light n doping .
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
  value of intrinsic carrier concentration.
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
10 K=1.38*10^-23
11 disp("K = "+string(K)+"J/k") //initializing value of
  boltzmann constant.
12 T=300
13 disp("T = "+string(T)+"K") //initializing value of
  temperature.
14 Efi_Efp=((K*T/e)*log(Na/no))
```

```

15 disp("(a)fermi level in the P region ,Efi_Efp=((KT/e)
    *log(Na/no))=")+string(Efi_Efp)+"eV")//
    calculation .
16 Efn_Efi=((K*T/e)*log(Nd/no))
17 disp("fermi level in the n region ,Efn_Efi=((KT/e)*
    log(Nd/no))=")+string(Efn_Efi)+"eV")// calculation
    .
18 Efn_Efp=(Efi_Efp)+(Efn_Efi)
19 disp("(b)junction potential at room temperature ,
    Efn_Efp=(Efi_Efp)+(Efn_Efi))=")+string(Efn_Efp)+"
    eV")// calculation .

```

Scilab code Exa 5.6 VALUE OF JUNCTION POTENTIAL

```

1 clc
2 Na=10^17
3 disp("Na = "+string(Na)+"/cm^3") //initializing
    value of medium p doping concentration .
4 Nd=10^15
5 disp("Nd = "+string(Nd)+"/cm^3") //initializing
    value of light n doping .
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
    value of intrinsic carrier concentration .
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columbs") //initializing
    value of charge of electrons .
10 K=1.38*10^-23
11 disp("K = "+string(K)+" J/k") //initializing value of
    boltzmann constant .
12 T=300
13 disp("T = "+string(T)+"K") //initializing value of
    temperature .
14 Vj=((K*T/e)*log((Na*Nd)/(no)^2))
15 disp(" Junction potential ,Vj=((K*T/e)*log((Na*Nd)/(no)

```

```
)^2))="+string(Vj)+"eV")// calculation .
```

Scilab code Exa 5.7 VALUE OF REVERSE AND FORWARD CURRENT

```
1 clc
2 Pp=10^18
3 disp("Pp = "+string(Pp)+"/cm^3") //initializing
  value of doping concentration in p region.
4 Nn=10^15
5 disp("Nn = "+string(Nn)+"/cm^3") //initializing
  value of doping concentration in n region.
6 tp=7*10^-6
7 disp("tp = "+string(tp)+"s") //initializing value of
  hole lifetime.
8 tn=0.2*10^-6
9 disp("tn = "+string(tn)+"s") //initializing value of
  electron lifetime.
10 up=800
11 disp("up = "+string(up)+"cm2/Vs") //initializing
  value of P side mobility.
12 un=300
13 disp("un = "+string(un)+"cm2/Vs") //initializing
  value of n side mobility.
14 no=1.5*10^10
15 disp("no = "+string(no)+"cm^-3") //initializing
  value of intrinsic concentration.
16 Vf=0.6
17 disp("Vf = "+string(Vf)+"V") //initializing value of
  forward bias voltage.
18 A=100*10^-6
19 disp("A = "+string(A)+"m^2") //initializing value of
  diode cross-sectional area.
20 e=1.6*10^-19
21 disp("e = "+string(e)+"columns") //initializing
  value of charge of electrons.
```

```

22 K=1.38*10^-23
23 disp("K = "+string(K)+" J/k") //initializing value of
    boltzmann constant.
24 T=300
25 disp("T = "+string(T)+"K") //initializing value of
    temperature.
26 Vt=(K*T/e)
27 disp("Vt=(K*T/e)="+string(Vt)+" eV") // calculation.
28 Dp=Vt*un
29 disp("Dp=Vt*un="+string(Dp)+" cm^-3") // calculation.
30 Dn=Vt*up
31 disp("Dn=Vt*up="+string(Dn)+" cm^-3") // calculation.
32 Lp=sqrt(Dp*tp)
33 disp("Lp=(sqrt(Dp*tp))="+string(Lp)+" cm") //
    calculation.
34 Ln=(sqrt(Dn*tn))
35 disp("Ln=(sqrt(Dn*tn))="+string(Ln)+" cm") //
    calculation.
36 npo=(no^2/Pp)
37 disp("npo=(no^2/Pp)="+string(npo)+" cm^-3") //
    calculation.
38 Ppo=(no^2/Nn)
39 disp("Ppo=(no^2/Nn)="+string(Ppo)+" cm^-3") //
    calculation.
40 Io=((Dp*Ppo)/(Lp))+((Dn*npo)/(Ln))*e*A
41 disp("Reverse saturation current ,Io=((Dp*Ppo)/(Lp)
    )+((Dn*npo)/(Ln))*e*A="+string(Io)+"A") //
    calculation.
42 If=Io*((exp(Vf/Vt))-1)
43 disp("Diode forward current ,If=Io*((exp(Vf/Vt))-1)="+
    string(If)+"A") // calculation.
44 //the value of Io(reverse saturation current ),after
    calculation is provided wrong in the book.Due to
    which If (diode forward current )also differ.

```

Scilab code Exa 5.8 VALUE OF BUILT IN POTENTIAL

```
1 clc
2 Na=4*10^16
3 disp("Na = "+string(Na)+"cm^-3") //initializing
  value of acceptor concentration.
4 Nd=2*10^19
5 disp("Nd = "+string(Nd)+"cm^-3") //initializing
  value of donor concentration.
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
  value of intrinsic carrier concentration.
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
10 K=1.38*10^-23
11 disp("K = "+string(K)+"J/k") //initializing value of
  boltzmann constant.
12 T=300
13 disp("T = "+string(T)+"K") //initializing value of
  temperature.
14 Vbi=((K*T/e)*log((Na*Nd)/(no)^2))
15 disp(" Built in potential potential ,Vbi=((K*T/e)*log
  ((Na*Nd)/(no)^2))="+string(Vbi)+"V")//calculation
  .
16
17 //The value used for Nd in the book for solution is
  different than provided in the question.
18 //I have used the value provided in the solution(i.e
  Nd=2*10^19)
```

Scilab code Exa 5.9 VALUE OF BUILT IN POTENTIAL

```
1 clc
2 Na=4*10^16
```

```

3 disp("Na = "+string(Na)+"cm-3") //initializing
  value of acceptor concentration.
4 Nd=2*1019
5 disp("Nd = "+string(Nd)+"cm-3") //initializing
  value of donor concentration.
6 no=1.8*106
7 disp("no = "+string(no)+"cm-3") //initializing
  value of intrinsic carrier concentration.
8 e=1.6*10-19
9 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
10 K=1.38*10-23
11 disp("K = "+string(K)+"J/k") //initializing value of
  boltzmann constant.
12 T=300
13 disp("T = "+string(T)+"K") //initializing value of
  temperature.
14 Vbi=((K*T/e)*log((Na*Nd)/(no)2))
15 disp(" Built in potential potential ,Vbi=((K*T/e)*log
  ((Na*Nd)/(no)2)="+string(Vbi)+"V")// calculation
.

```

Scilab code Exa 5.10 VALUE OF DEPLETION WIDTH AND ACCEP-
TOR CONCENTRATION

```

1 clc
2 Na=1016
3 disp("Na = "+string(Na)+" /cm3") //initializing
  value of medium p doping concentration.
4 Nd=1018
5 disp("Nd = "+string(Nd)+" /cm3") //initializing
  value of light n doping .
6 Vbi=0.64
7 disp("Vbi = "+string(Vbi)+"V") //initializing value
  of built in voltage.

```

```

8 e=1.6*10^-19
9 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
10 Er=11.9
11 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant .
12 Eo=8.854*10^-14
13 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
14 E=Eo*Er
15 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
  )//calculation .
16 W=sqrt((2*E*Vbi/e)*((Nd+Na)/(Na*Nd)))
17 disp("W=sqrt((2*E*Vbi/e)*((Nd+Na)/(Na*Nd)))="+
  string(W)+" cm")//calculation .
18 xn=((W*Na)/(Nd+Na))
19 disp("xn=((W*Na)/(Nd+Na))="+string(xn)+" cm")//
  calculation .
20 xp=((W*Nd)/(Nd+Na))
21 disp("xp=((W*Nd)/(Nd+Na))="+string(xp)+" cm")//
  calculation .
22 Emax=(-e*Nd*xn)/E
23 disp("Emax=(-e*Nd*xn)/E="+string(Emax)+"V/cm")//
  calculation .
24
25 //the value and unit of W(depletion width),provided
  after calculation in the book is wrong.Due to
  this xn,xp ,Emax also differ .

```

Scilab code Exa 5.12 VALUE OF MAXIMUM ELECTRIAL FIELD

```

1 clc
2 Na=10^16
3 disp("Na = "+string(Na)+"/cm^3") //initializing
  value of medium p doping concentration.

```

```

4 Nd=10^18
5 disp("Nd = "+string(Nd)+"/cm^3") //initializing
  value of light n doping .
6 Vbi=0.64
7 disp("Vbi = "+string(Vbi)+"V") //initializing value
  of built in voltage.
8 Vr=20
9 disp("Vr = "+string(Vr)+"V") //initializing value of
  applied reverse voltage.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
12 Er=11.9
13 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant .
14 Eo=8.854*10^-14
15 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
16 E=Eo*Er
17 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
  )//calculation .
18 Emax=- (sqrt(((2*e*(Vbi+Vr))/(E))*((Nd*Na)/(Na+Nd))))
19 disp("Emax=- (sqrt(((2*e*(Vbi+Vr))/(E))*((Nd*Na)/(Na+
  Nd))))="+string(Emax)+"V/cm") //calculation .

```

Scilab code Exa 5.13 VALUE OF N TYPE DOPING CONCENTRATION

```

1 clc
2 Emax=2*10^5
3 disp("Emax = "+string(Emax)+"V/cm") //initializing
  value of maximum electric field.
4 Nd=10^18
5 disp("Nd = "+string(Nd)+"/cm^3") //initializing
  value of donor concentration .
6 Vbi=0.54

```



```

7 disp("Vbi = "+string(Vbi)+"V") //initializing value
  of built in voltage.
8 Vr=20
9 disp("Vr = "+string(Vr)+"V") //initializing value of
  applied reverse voltage.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
12 Er=11.9
13 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant .
14 Eo=8.854*10^-14
15 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
16 E=Eo*Er
17 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
  )//calculation .
18 Na=(Emax^2*E*Nd)/((2*e*(Vbi+Vr)*Nd)-(Emax^2*E))
19 disp("Na=(Emax^2*E*Nd)/((2*e*(Vbi+Vr)*Nd)-(Emax^2*E)
  )="+string(Na)+"cm^-3")//calculation .

```

Scilab code Exa 5.14 VALUE OF JUNCTION CAPACITANCE

```

1 clc
2 Na=10^16
3 disp("Na = "+string(Na)+" /cm^3") //initializing
  value of acceptor concentration .
4 Nd=10^18
5 disp("Nd = "+string(Nd)+" /cm^3") //initializing
  value of donor concentration .
6 A=1
7 disp("A = "+string(A)+"cm^2") //initializing value
  of area for finding junction capacitance per unit
  area .
8 Vj=0.54

```

```

9 disp("Vj = "+string(Vj)+"V") //initializing value of
    built in voltage.
10 Va=10
11 disp("Va = "+string(Va)+"V") //initializing value of
    applied reverse voltage.
12 e=1.6*10^-19
13 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
14 Er=11.9
15 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
16 Eo=8.854*10^-14
17 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
18 E=Eo*Er
19 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation .
20 Cj=sqrt((e*E*A^2/(2*(Va+Vj)))*((Na*Nd)/(Na+Nd)))
21 disp("Cj=sqrt((e*E*A^2/(2*(Va+Vj)))*((Na*Nd)/(Na+Nd))
    )=" +string(Cj)+" f/cm^2")//calculation .

```

Scilab code Exa 5.15 VALUE OF JUNCTION CAPACITANCE

```

1 clc
2 Na=10^15
3 disp("Na = "+string(Na)+" cm^-3") //initializing
    value of acceptor concentration.
4 Nd=10^18
5 disp("Nd = "+string(Nd)+" cm^-3") //initializing
    value of donor concentration.
6 no=1.8*10^6
7 disp("no = "+string(no)+" cm^-3") //initializing
    value of intrinsic carrier concentration.
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columbs") //initializing

```

```

    value of charge of electrons.
10 K=1.38*10^-23
11 disp("K = "+string(K)+" J/k") //initializing value
    of boltzmann constant.
12 T=300
13 disp("T = "+string(T)+" K") //initializing value of
    temperature.
14 Vbi=((K*T/e)*log((Na*Nd)/(no)^2))
15 disp(" Built in potential potential ,Vbi=((K*T/e)*log
    ((Na*Nd)/(no)^2))="+string(Vbi)+" V")//
    calculation.

```

Scilab code Exa 5.16 VALUE OF INTRINSIC CONCENTRATION

```

1 clc
2 Na=10^18
3 disp("Na = "+string(Na)+" cm^-3") //initializing
    value of acceptor concentration.
4 Nd=10^18
5 disp("Nd = "+string(Nd)+" cm^-3") //initializing
    value of donor concentration.
6 Vbi=1.4
7 disp("Vbi = "+string(Vbi)+" V") //initializing value
    of built in voltage.
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columbs") //initializing
    value of charge of electrons.
10 K=1.38*10^-23
11 disp("K = "+string(K)+" J/k") //initializing value
    of boltzmann constant.
12 T=300
13 disp("T = "+string(T)+" K") //initializing value of
    temperature.
14 Vt=0.0259
15 disp("Vt = "+string(Vt)+" eV") //initializing value

```

```

    of thermal voltage.
16 no=sqrt((Na*Nd)/(exp(Vbi/Vt)))
17 disp("no=sqrt((Na*Nd)/(exp(Vbi/Vt)))="+string(no)+"
    cm-3")//calculation.

```

Scilab code Exa 5.18 VALUE OF Vbi AND FERMI LEVEL AND Vbi FROM FERMI LEVEL

```

1  clc
2  Na=1017
3  disp("Na = "+string(Na)+" cm-3") //initializing
    value of acceptor concentration.
4  Nd=5*1016
5  disp("Nd = "+string(Nd)+" cm-3") //initializing
    value of donor concentration.
6  e=1.6*10-19
7  disp("e = "+string(e)+" columbs") //initializing
    value of charge of electrons.
8  no=1.5*1010
9  disp("no = "+string(no)+" cm3") //initializing
    value of intrinsic carrier concentration.
10 T=300
11 disp("T = "+string(T)+" K") //initializing value of
    temperature.
12 Vt=0.0259
13 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
14 Vbi=(Vt*(log(Na*Nd/(no2))))
15 disp("(a) Vbi=(Vt*(log(Na*Nd/(no2))))="+string(Vbi)+
    " V")//calculation.
16 Efi_Efp=(Vt*log(Na/(no)))
17 disp("(b) value of fermi level on each side of
    junction , Efi_Efp=(Vt*log(Na/(no)))="+string(
    Efi_Efp)+" V")//calculation.
18 Efn_Efi=(Vt*log(Nd/(no)))

```

```

19 disp(" Efn_Efi=(Vt*log (Nd/(no)))=" +string(Efn_Efi)+
    V") // calculation .
20 disp("(c)The energy band digram is similar to Fig P5
    .3")
21 Vbi=((Efi_Efp)+(Efn_Efi))
22 disp("(d) Vbi=((Efi_Efp)+(Efn_Efi))/(e)=Vj=" +string(
    Vbi)+ " V") // calculation .

```

Scilab code Exa 5.19 VALUE OF Vbi AND FERMI LEVEL AND Vbi FROM FERMI LEVEL

```

1  clc
2  Na=5*10^17
3  disp("Na = " +string(Na)+"/cm^3") //initializing
    value of medium p doping concentration.
4  Nd=5*10^17
5  disp("Nd = " +string(Nd)+"/cm^3") //initializing
    value of light n doping .
6  no=1.5*10^10
7  disp("no = " +string(no)+ "cm^-3") //initializing
    value of intrinsic concentration.
8  e=1.6*10^-19
9  disp("e = " +string(e)+ "columbs") //initializing
    value of charge of electrons.
10 K=1.38*10^-23
11 disp("K = " +string(K)+ "J/k") //initializing value of
    boltzmann constant.
12 T=300
13 disp("T = " +string(T)+ "K") //initializing value of
    temperature.
14 Vbi=((K*T/e)*log((Na*Nd)/(no)^2))
15 disp("(a)Built in potential potential ,Vbi=((K*T/e)*
    log((Na*Nd)/(no)^2))=" +string(Vbi)+ "eV") //
    calculation .
16 Efi_Efp=((K*T/e)*log(Na/no))

```

```

17 disp("(b)fermi level in the P region and N region ,
    Efi_Efp=((KT/e)*log(Na/no))=" + string(Efi_Efp) +
    eV") // calculation .
18 VBI=2*(Efi_Efp)
19 disp("(c)VBI from the fermi level ,VBI=2*(Efi_Efp))="
    + string(VBI) + "V") // calculation .

```

Scilab code Exa 5.20 VALUE OF IMPURITY CONCENTRATION AND Vbi

```

1 clc
2 Nc=2.8*10^19
3 disp("Nc = " + string(Nc) + " /cm^3") //initializing
    value of number of electron in the conduction
    band.
4 Nv=1.04*10^19
5 disp("Nv = " + string(Nv) + " /cm^3") //initializing
    value of number of electron in the valence band..
6 no=1.5*10^10
7 disp("no = " + string(no) + " cm^-3") //initializing
    value of intrinsic carrier concentration.
8 e=1.6*10^-19
9 disp("e = " + string(e) + " columbs") //initializing
    value of charge of electrons.
10 K=8.62*10^-5
11 disp("K = " + string(K) + " J/k") //initializing value
    of boltzmann constant.
12 T=300
13 disp("T = " + string(T) + " K") //initializing value of
    temperature.
14 Vt=0.0259
15 disp("Vt = " + string(Vt) + " eV") //initializing value
    of thermal voltage.
16 Ec_Ef=0.21
17 disp("Ec_Ef = " + string(Ec_Ef) + " eV") //initializing

```

```

    value of energy difference between conduction
    band and fermi level.
18 Ef_Ev=0.18
19 disp("Ef_Ev = "+string(Ef_Ev)+" eV") //initializing
    value of energy difference between fermi level
    and valence band.
20 Nd=(Nc/exp((Ec-Ef)/(K*T)))
21 disp("Nd=(Nc/exp((Ec-Ef)/(K*T)))="+string(Nd)+" cm
    ^-3")//calculation.
22 Na=(Nv/exp((Ef-Ev)/(K*T)))
23 disp("Na=(Nv/exp((Ef-Ev)/(K*T)))="+string(Na)+" cm
    ^-3")//calculation.
24 Vbi=(Vt*(log(Na*Nd/(no^2))))
25 disp("Built in potential potential,Vbi=(Vt*(log(Na*
    Nd/(no^2))))="+string(Vbi)+" V")//calculation.

```

Scilab code Exa 5.21 VALUE OF Na Xn Xp AND Emax

```

1 clc
2 Vbi=1.2
3 disp("Vbi = "+string(Vbi)+"/cm^3") //initializing
    value of built in voltage.
4 no=1.8*10^6
5 disp("no = "+string(no)+"cm^-3") //initializing
    value of intrinsic concentration.
6 Vt=0.0259
7 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
8 Er=13.1
9 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
10 Eo=8.854*10^-14
11 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
12 e=1.6*10^-19

```

```

13 disp("e = "+string(e)+" columbs") //initializing
    value of charge of electrons.
14 E=Eo*Er
15 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation.
16 NaNd=((no^2)*(exp(Vbi/Vt)))
17 disp("(a)NaNd=((no^2)*(exp(Vbi/Vt)))="+string(NaNd)+
    "/cm^6")//calculation.
18 Na=(sqrt(NaNd/(4)))
19 disp("Na=(sqrt(NaNd/(4)))="+string(Na)+" /cm^3")//
    calculation.
20 Nd=4*Na
21 disp("(b)Nd=4*Na="+string(Nd)+" /cm^3")//calculation
    .
22 W=sqrt((2*E*Vbi/e)*((Nd+Na)/(Na*Nd)))
23 disp("(c)W=sqrt((2*E*Vbi/e)*((Nd+Na)/(Na*Nd)))="+
    string(W)+" cm")//calculation.
24 xn=0.2*W
25 disp("(d)xn=0.2*W="+string(xn)+" cm")//calculation.
26 xp=0.8*W
27 disp("xp=0.8*W="+string(xp)+" cm")//calculation.
28 Emax=(-e*Nd*xn)/E
29 disp("(e)Emax=(-e*Nd*xn)/E="+string(Emax)+"V/cm")//
    calculation.
30 //The value of Na after calculation is provided
    wrong in the book.Due to which value of W,xn,xp
    and Emax differ ,than the answer provided in the
    book.

```

Scilab code Exa 5.22 VALUE OF TEMPERATURE

```

1 clc
2 Na=10^16
3 disp("Na = "+string(Na)+"cm^-3") //initializing
    value of acceptor concentration.

```



```

4 Nd=5*10^15
5 disp("Nd = "+string(Nd)+"cm^-3") //initializing
  value of donor concentration.
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
  value of intrinsic concentration.
8 Vbi=0.676
9 disp("Vbi = "+string(Vbi)+"V") //initializing value
  of built in voltage.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
12 K=1.38*10^-23
13 disp("K = "+string(K)+"J/k") //initializing value of
  boltzmann constant.
14 T=(Vbi*(e/K)*(1/(log((Na*Nd)/(no^2)))))
15 disp("T=(Vbi*(e/K)*(1/(log((Na*Nd)/(no^2)))))="+
  string(T)+"K") //calculation.

```

Scilab code Exa 5.23 VALUE OF Vbi AND TEMPERATURE

```

1 clc
2 Na=5*10^17
3 disp("Na = "+string(Na)+"cm^-3") //initializing
  value of acceptor concentration.
4 Nd=10^17
5 disp("Nd = "+string(Nd)+"cm^-3") //initializing
  value of donor concentration.
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
  value of intrinsic concentration.
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
10 K=1.38*10^-23

```

```

11 disp("K = "+string(K)+" J/k") //initializing value of
    boltzmann constant.
12 T=300
13 disp("T = "+string(T)+"K") //initializing value of
    temperature.
14 VBI=0.847
15 disp("VBI = "+string(VBI)+"V") //initializing value
    of VBI when VBI is reduced by 1%.
16 Vbi=((K*T/e)*log((Na*Nd)/(no)^2))
17 disp("(a) Built in potential potential ,Vbi=((K*T/e)*
    log((Na*Nd)/(no)^2))=" +string(Vbi)+" V")//
    calculation.
18 T=(e*VBI/K)*((log(Na*Nd/(no^2)))^-1)
19 disp("(b) T=(VBI*(e/K)*(1/(log((Na*Nd)/(no^2))))))=" +
    string(T)+"K") //calculation.
20 //the answer for part (b) is not provided in the
    book.

```

Scilab code Exa 5.24 VALUE OF Vbi AND W AND Xn AND Xp AND Emax

```

1 clc
2 Na=4*10^12
3 disp("Na = "+string(Na)+" /cm^3") //initializing
    value of medium p doping concentration.
4 Nd=4*10^16
5 disp("Nd = "+string(Nd)+" /cm^3") //initializing
    value of light n doping.
6 no=1.5*10^10
7 disp("no = "+string(no)+" /cm^3") //initializing
    value of intrinsic carrier concentration.
8 K=1.38*10^-23
9 disp("K = "+string(K)+" J/k") //initializing value
    of boltzmann constant.
10 T=300

```

```

11 disp("T = "+string(T)+" K") //initializing value of
    temperature.
12 e=1.6*10^-19
13 disp("e = "+string(e)+" columbs") //initializing
    value of charge of electrons.
14 Er=11.9
15 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
16 Eo=8.854*10^-14
17 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
18 E=Eo*Er
19 disp(" total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation .
20 Vbi=((K*T/e)*log((Na*Nd)/(no)^2))
21 disp(" Built in potential potential ,Vbi=((K*T/e)*log
    ((Na*Nd)/(no)^2))="+string(Vbi)+" eV")//
    calculation .
22 W=sqrt((2*E*Vbi/e)*((Nd+Na)/(Na*Nd)))
23 disp("W=sqrt((2*E*Vbi/e)*((Nd+Na)/(Na*Nd)))="+
    string(W)+" cm")//calculation .
24 xn=((W*Na)/(Nd+Na))
25 disp("xn=((W*Na)/(Nd+Na))="+string(xn)+" cm")//
    calculation .
26 xp=((W*Nd)/(Nd+Na))
27 disp("xp=((W*Nd)/(Nd+Na))="+string(xp)+" cm")//
    calculation .
28 Emax=(e*Nd*xn)/E
29 disp("Emax=(e*Nd*xn)/E="+string(Emax)+" V/cm")//
    calculation .
30 //the value of W(depletion width) ,after calculation
    is provided wrong in the book,due to this xn,xp
    ,Emax also differ.(also ,the value of Nd+Na
    substitute in the
31 //formula for for xn,xp is wrong )

```

Scilab code Exa 5.25 MAGNITUDE OF APPLIED REVERSE BIAS

```
1  clc
2  Na=4*10^17
3  disp("Na = "+string(Na)+"/cm^3") //initializing
   value of donor concentration.
4  Nd=4*10^15
5  disp("Nd = "+string(Nd)+"/cm^3") //initializing
   value of light n doping.
6  no=1.5*10^10
7  disp("no = "+string(no)+"/cm^-3") //initializing
   value of intrinsic concentration.
8  Emax=300*10^3
9  disp("Emax = "+string(Emax)+"/cm^3") //initializing
   value of maximum electric field.
10 K=1.38*10^-23
11 disp("K = "+string(K)+"/J/k") //initializing value of
   boltzmann constant.
12 T=300
13 disp("T = "+string(T)+"K") //initializing value of
   temperature.
14 e=1.6*10^-19
15 disp("e = "+string(e)+" columns") //initializing
   value of charge of electrons.
16 Er=11.9
17 disp("Er = "+string(Er)) //initializing value of
   relative dielectric permittivity constant .
18 Eo=8.854*10^-14
19 disp("Eo = "+string(Eo)+"/ F/cm") //initializing
   value of permittivity of free space.
20 E=Eo*Er
21 disp("total permittivity ,E=Eo*Er="+string(E)+"/ F/cm"
   )//calculation .
22 Vbi=((K*T/e)*log((Na*Nd)/(no)^2))
```

```

23 disp(" Built in potential potential ,Vbi=((K*T/e)*log
      ((Na*Nd)/(no)^2))=" +string(Vbi)+" V")//
      calculation .
24 xn=(E*Emax/(Nd*e))
25 disp(" xn=(E*Emax)/(e*Nd))=" +string(xn)+" cm")//
      calculation .
26 W=(xn*(Nd+Na)/Na)
27 disp("W=(xn(Nd+Na)/Na))=" +string(W)+" cm")//
      calculation .
28 Vr=((W^2*e/(2*E))*((Na*Nd)/(Na+Nd)))-(Vbi)
29 disp(" Vr=(W^2*e/(2*E))*((Na*Nd)/(Na+Nd))-(Vbi))=" +
      string(Vr)+" V")// calculation .

```

Scilab code Exa 5.26 VALUE OF DOPING CONCENTRATION

```

1  clc
2  Na=5*10^15
3  disp("Na = " +string(Na)+"cm^-3") //initializing
      value of acceptor concentration.
4  Nd=10^18
5  disp("Nd = " +string(Nd)+"cm^-3") //initializing
      value of donor concentration.
6  e=1.6*10^-19
7  disp("e = " +string(e)+" columns") //initializing
      value of charge of electrons.
8  Vr=10
9  disp("Vr = " +string(Vr)+"V") //initializing value
      reverse voltage.
10 Er=11.9
11 disp("Er = " +string(Er)) //initializing value of
      relative dielectric permittivity constant .
12 Eo=8.854*10^-14
13 disp("Eo = " +string(Eo)+" F/cm") //initializing
      value of permittivity of free space.
14 E=Eo*Er

```

```

15 disp(" total permittivity ,E=Eo*Er=" +string(E)+" F/cm"
    )//calculation .
16 Emax=10^6
17 disp("Emax = " +string(Emax)+"V/cm") //initializing
    value of maximum electric field.
18 W=(2*Vr/(Emax))
19 disp("W = " +string(W)+"cm") //calculation .
20 Nd=(Emax*E)/(W*e)
21 disp("Nd=(Emax*e)/(W*e) =" +string(Nd)+"cm^-3") //
    calculation .

```

Scilab code Exa 5.27 VALUE OF JUNCTION CAPACITANCE

```

1 clc
2 Na=5*10^15
3 disp("Na = " +string(Na)+"cm^3") //initializing value
    of acceptor concentration.
4 Nd=10^18
5 disp("Nd = " +string(Nd)+"cm^3") //initializing value
    of donor concentration .
6 no=1.5*10^10
7 disp("no = " +string(no)+"cm^-3") //initializing
    value of intrinsic carrier concentration.
8 Vr1=0
9 disp("Vr1 = " +string(Vr1)+"V") //initializing value
    of built in voltage.
10 Vr2=5
11 disp("Vr2 = " +string(Vr2)+"V") //initializing value
    of applied reverse voltage.
12 A=3*10^-5
13 disp("A = " +string(A)+"cm^2") //initializing value
    of cross sectional area.
14 e=1.6*10^-19
15 disp("e = " +string(e)+" columns") //initializing
    value of charge of electrons.

```

```

16 Er=11.9
17 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
18 Eo=8.854*10^-14
19 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
20 E=Eo*Er
21 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation .
22 Vt=0.0259
23 disp("Vt="+string(Vt)+" V")//initializing the value
    of thermal voltage .
24 Vbi=((Vt)*log((Na*Nd)/(no)^2))
25 disp("Built in potential ,Vbi=(Vt*log((Na*Nd)/(no)
    ^2))="+string(Vbi)+" V")//calculation .
26 Cj1=sqrt((e*E*(A^2)/(2*(Vr1+Vbi)))*((Na*Nd)/(Na+Nd))
    )
27 disp("Cj1=sqrt((e*E*(A^2)/(2*(Vr1+Vbi)))*((Na*Nd)/(Na
    +Nd)))="+string(Cj1)+" F")//calculation .
28 Cj2=sqrt((e*E*(A^2)/(2*(Vr2+Vbi)))*((Na*Nd)/(Na+Nd))
    )
29 disp("Cj2=sqrt((e*E*(A^2)/(2*(Vr2+Vbi)))*((Na*Nd)/(Na
    +Nd)))="+string(Cj2)+" F")//calculation .
30 //the value of Vr2 use for calculating answer of Cj2
    is different than provided in question.
31 //I have used the value provided in the solution (i.
    e.Vr2=5)

```

Scilab code Exa 5.28 VALUE OF REVERSE SATURATION CURRENT

```

1 clc
2 Na=1*10^16
3 disp("Na = "+string(Na)+"cm^3") //initializing value
    of acceptor concentration.
4 Nd=5*10^16

```

```

5 disp("Nd = "+string(Nd)+"cm^3") //initializing value
  of donor concentration .
6 no=1.5*10^10
7 disp("no = "+string(no)+"cm^-3") //initializing
  value of intrinsic concentration.
8 Dn=25
9 disp("Dn = "+string(Dn)+"cm^2/sec") //initializing
  value of diffusion coefficient on the P side.
10 Dp=10
11 disp("Dp = "+string(Dp)+"cm^2/sec") //initializing
  value of diffusion coefficient on the N side.
12 tp=5*10^-7
13 disp("tn = "+string(tp)+"s") //initializing value of
  hole lifetime.
14 tn=5*10^-7
15 disp("tp = "+string(tn)+"s") //initializing value of
  electron lifetime.
16 e=1.6*10^-19
17 disp("e = "+string(e)+"columns") //initializing
  value of charge of electrons.
18 Pno=(no^2/Nd)
19 disp("Pno=(no^2/Nd)="+string(Pno)+"cm^-3")//
  calculation.
20 Npo=(no^2/Na)
21 disp("Npo=(no^2/Na)="+string(Npo)+"cm^-3")//
  calculation.
22 Lp=(sqrt(Dp*tp))
23 disp("Lp=(sqrt(Dp*tp))="+string(Lp)+"cm")//
  calculation.
24 Ln=(sqrt(Dn*tn))
25 disp("Ln=(sqrt(Dn*tn))="+string(Ln)+"cm")//
  calculation.
26 Jo=((e*((Dp*Pno/(Lp))+(Dn*Npo)/(Ln))))
27 disp("Jo=((e*((Dp*Pno/(Lp))+(Dn*Npo)/(Ln))))="+
  string(Jo)+" A/cm^2")// calculation.

```

Scilab code Exa 5.29 VALUE OF REVERSE SATURATION CURRENT

```
1  clc
2  Na=10^15
3  disp("Na = "+string(Na)+"cm^3") //initializing value
   of acceptor concentration.
4  Nd=10^15
5  disp("Nd = "+string(Nd)+"cm^3") //initializing value
   of donor concentration .
6  no=1.5*10^10
7  disp("no = "+string(no)+"cm^-3") //initializing
   value of intrinsic carrier concentration.
8  Dn=50
9  disp("Dn = "+string(Dn)+"cm^2/sec") //initializing
   value of built in voltage.
10 Dp=20
11 disp("Dp = "+string(Dp)+"cm^2/sec") //initializing
   value of applied reverse voltage.
12 tp=5*10^-7
13 disp("tn = "+string(tp)+"s") //initializing value of
   hole lifetime.
14 tn=5*10^-7
15 disp("tp = "+string(tn)+"s") //initializing value of
   electrons lifetime.
16 e=1.6*10^-19
17 disp("e = "+string(e)+"columns") //initializing
   value of charge of electrons.
18 Pno=(no^2/Nd)
19 disp("Pno=(no^2/Nd)="+string(Pno)+"cm^-3")//
   calculation.
20 Npo=(no^2/Na)
21 disp("Npo=(no^2/Na)="+string(Npo)+"cm^-3")//
   calculation.
22 Lp=(sqrt(Dp*tp))
```

```

23 disp("Lp=(sqrt(Dp*tp))=" + string(Lp) + "cm") //
    calculation.
24 Ln=(sqrt(Dn*tn))
25 disp("Ln=(sqrt(Dn*tn))=" + string(Ln) + "cm") //
    calculation.
26 Jo=((e*((Dp*Pno)/(Lp))+(Dn*Npo)/(Ln)))
27 disp("Jo=((e*((Dp*Pno)/(Lp))+(Dn*Npo)/(Ln)))=" +
    string(Jo) + "A/cm^2") // calculation.
28 //the value of tp,tn provided in the question, is
    different than that provided in the solution.
29 //I have used the value ,provided in the solution(i.
    e.tp=tn=5*10^7)

```

Scilab code Exa 5.30 VALUE OF THE CHANGE IN THE APPLIED VOLTAGE

```

1  clc
2  Eg=-1.1
3  disp("Eg = " + string(Eg) + "V") //initializing value of
    energy gap.
4  Vf1=0.6
5  disp("Vf1 = " + string(Vf1) + "V") //initializing value
    of forward voltage for case 1.
6  T1=300
7  disp("T1 = " + string(T1) + "K") //initializing value of
    temperature for case 1.
8  T2=310
9  disp("T2 = " + string(T2) + "K") //initializing value of
    temperature for case 2 .
10 Vf2=((Eg+Vf1)*T2)/(T1)-Eg
11 disp("Forward voltage for case 2,Vf2=((Eg+Vf1)*T2)/(
    T1)+Eg)=" + string(Vf2) + " V") // calculation.

```

Scilab code Exa 5.31 RELATIVE CHANGE IN I_0

```
1  clc
2  T=300
3  disp("T = "+string(T)+" K") //initializing value of
    temperature .
4  Eg=0.7*1.6*10^-19
5  disp("Eg = "+string(Eg)+" V") //initializing value
    of Band Gap energy of the material.
6  K=1.38*10^-23
7  disp("K = "+string(K)+" J/K") //initializing value
    of boltzmann constant.
8  X=((Eg/(K*T^2)))+(3/T)
9  disp("Relative change in  $I_0$  ,...  $1/I_0*(dI_0/dT)= "$ +
    string(X))//calculation
10 //in percent form
11 disp("Relative change in  $I_0$  ,...  $1/I_0*(dI_0/dT)= "$ +
    string(X*100)+" %")//calculation
12
13 //... taking ,  $(1/I_0)*(dI_0/dT)$  as 'X'
14
15 //This is the solved example of chapter 5 (Ex 5.1)On
    page 128
```

Chapter 6

ELECTRICAL BREAKDOWN IN PN JUNCTIONE

Scilab code Exa 6.2 VALUE OF Eg Ev Ec and Vbi

```
1  clc
2  X1=4.13
3  disp("X1 = "+string(X1)+" eV") //initializing value
   of eldelta_Ectron effinity of germanium.
4  X2=4.07
5  disp("X2 = "+string(X2)+" eV") //initializing value
   of electron effinity of gallium arsenide.
6  Eg1=0.7
7  disp("Eg1 = "+string(Eg1)+" eV") //initializing
   value of energy gap of germanium.
8  Eg2=1.43
9  disp("Eg2 = "+string(Eg2)+" F/cm") //initializing
   value of energy gap of gallium arsenide..
10 Nv1=6*10^18
11 disp("Nv1 = "+string(Nv1)+" cm^-3") //initializing
   value of density of states in Valence band,Nv for
   germanium.
12 Nv2=7*10^18
13 disp("Nv2 = "+string(Nv2)+" cm^-3") //initializing
```

```

    value of density of states in Valence band,  $N_v$  for
    gallium arsenide.
14 Vt=0.0259
15 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage...  $V_t = K*T/e$ 
16 e=1.6*10^-19
17 disp("e = "+string(e)+" coulombs") //initializing
    value of electronic charge.
18 no=2.5*10^13
19 disp("no = "+string(no)+" cm^-3") //initializing
    value of intrinsic carrier concentration.
20 Pp=10^17
21 disp("Pp = "+string(Pp)+" cm^-3") //initializing
    value of hole concentration on the depletion edge
    of the N region.
22 Nd=10^17
23 disp("Nd = "+string(Nd)+" cm^-3") //initializing
    value of number of donor ions (which is equal to
    hole concentration on the depletion edge of the N
    region).
24 np=(no^2)/Pp
25 disp("np="+string(np)+" cm^-3") //calculation
26 delta_Eg=(Eg2-Eg1)
27 disp("delta_Eg=(Eg2-Eg1)="+string(delta_Eg)+" eV") //
    calculation
28 delta_Ec=(X1-X2)
29 disp("delta_Ec=(X1-X2)="+string(delta_Ec)+" eV") //
    calculation
30 delta_Ev=(delta_Eg-delta_Ec)
31 disp("delta_Ev=(delta_Eg-delta_Ec)="+string(delta_Ev)
    )+" eV") //calculation
32 Vbi=((delta_Ev*1.6*10^-19)/(e))+((Vt*log((Nv1*Nd)/(
    np*Nv2))))
33 disp("Vbi=((delta_Ev*1.6*10^-19)/(e))+((Vt*log((Nv1*
    Nd)/(np*Nv2))))="+string(Vbi)+" V") //calculation

```

Scilab code Exa 6.4 VALUE OF DONOR CONCENTRATION

```
1  clc
2  Nc=2.8*10^19
3  disp("Nc = "+string(Nc)+" cm^-3") //initializing
   value of effective density of state in the
   conduction band.
4  k=-4*10^15
5  disp("k = "+string(k)+" cm^4F^-2V^-1") //
   initializing value of slope of the (1/C^2) versus
   V curve.
6  Er=11.9
7  disp("Er = "+string(Er)) //initializing value of
   relative dielectric permittivity constant .
8  Eo=8.854*10^-14
9  disp("Eo = "+string(Eo)+" F/cm") //initializing
   value of dielectric constant of free space.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
   value of charge of electrons.
12 Vt=0.0259
13 disp("Vt = "+string(Vt)+" eV") //initializing value
   of thermal voltage.
14 VBI=0.3
15 disp("VBI = "+string(VBI)+" V") //initializing value
   of built in voltage.
16 E=Eo*Er
17 disp("total permittivity ,E=Eo*Er =" +string(E)+" F/cm
   ")//calculation
18 Nd=((-2)/(e*E)*(1/k))
19 disp("Nd=((-2)/(e*E)*(1/k))=" +string(Nd)+" cm^-3")
   //calculation
20 Vn=(Vt*(log(Nc/Nd)))
21 disp("Vn=(Vt*(log(Nc/Nd)))=" +string(Vn)+" V")//
```

```

        calculation
22 VBn=(VBI+Vn)
23 disp("VBn=(VBI+Vn)=" + string(VBn) + " V") // calculation
24
25
26 // taking ,... d(1/C^2)/dV as k,... for
    simplification

```

Scilab code Exa 6.5 VALUE OF THE BARRIER HEIGHT AND BUILT IN POTENTIAL

```

1  clc
2  Nd=2*10^17
3  disp("Nd = " + string(Nd) + "/cm^-3") //initializing
    value of donor concentration.
4  Nc=2.8*10^19
5  disp("Nc = " + string(Nc) + "/cm^-3") //initializing
    value of effective density of state in the
    conduction band.
6  Js=40*10^-6
7  disp("Js = " + string(Js) + "A/cm^2") //initializing
    value of saturation current density.
8  T=300
9  disp("T = " + string(T) + "K") //initializing value of
    absolute temperature.
10 R=110
11 disp("R = " + string(R) + " A/(K-cm^2)") //initializing
    value of richardson's constant.
12 Vt=0.0259
13 disp("Vt = " + string(Vt) + " eV") //initializing value
    of thermal voltage.
14 VBn=(Vt*(log(R*T^2/Js)))
15 disp("VBn = " + string(VBn) + " V") // calculation.
16 Vn=(Vt*(log(Nc/Nd)))
17 disp("Vn = " + string(Vn) + " V") // calculation.

```

```

18 VBI=(VBn-Vn)
19 disp("VBI=(VBn-Vn)="+string(VBI)+" V")//calculation
20
21 //The value of Vn (after calculation ) is provided
    wrong in the book,due to which VBI also differ.

```

Scilab code Exa 6.6 VALUE OF DEPLETION WIDTH DIFFUSION LENGTH AND SATURATION HOLE CURRENT DENSITY

```

1  clc
2  Nd=2*10^17
3  disp("Nd = "+string(Nd)+" /cm^-3") //initializing
    value of donor concentration.
4  Dp=30
5  disp("Dp = "+string(Dp)+" cm^2/s") //initializing
    value of diffusion coefficient.
6  Nc=2.8*10^19
7  disp("Nc = "+string(Nc)+" /cm^-3") //initializing
    value of effective density of state in the
    conduction band.
8  Js=40*10^-6
9  disp("Js = "+string(Js)+ "A/cm^2") //initializing
    value of saturation current density.
10 no=1.5*10^10
11 disp("no = "+string(no)+" cm^-3") //initializing
    value of intrinsic concentration of electrons.
12 tp=10^-6
13 disp("tp = "+string(tp)+" s") //initializing value
    of hole life-time.
14 T=300
15 disp("T = "+string(T)+" K") //initializing value of
    absolute temperature.
16 R=110
17 disp("R = "+string(R)+" A/(K-cm^2)") //initializing
    value of richardson's constant.

```



```

18 Vt=0.0259
19 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
20 e=1.6*10^-19
21 disp("e = "+string(e)+" columbs") //initializing
    value of charge of electrons.
22 Er=11.9
23 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
24 Eo=8.854*10^-14
25 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of dielectric constant of free space.
26 E=Eo*Er
27 disp("total permittivity ,E=Eo*Er)="+string(E)+" F/cm
    ")//calculation
28 VBn=(Vt*(log(R*T^2/Js)))
29 disp("VBn = "+string(VBn)+" V") // calculation.
30 Vn=(Vt*(log(Nc/Nd)))
31 disp("Vn = "+string(Vn)+" V") // calculation.
32 VBI=(VBn-Vn)
33 disp("VBI=(VBn-Vn)="+string(VBI)+" V")//calculation
34 W=(sqrt((E*VBI)/(e*Nd)))
35 disp("current density in a metal semiconductor
    junction ,W = "+string(W)+" A") // calculation.
36 Lp=(sqrt(Dp*tp))
37 disp("Diffusion length ,Lp=(sqrt(Dp*tp)) = "+string(
    Lp)+" cm") // calculation.
38 Jpo=(e*Dp*no^2)/(Lp*Nd)
39 disp("saturation hole current density ,Jpo=(e*Dp*no
    ^2)/(Lp*Nd) = "+string(Jpo)+" A/cm^2") //
    calculation.
40
41
42 //The value of Vn (after calculation ) is provided
    wrong in the book,due to which VBI differ and due
    to VBI ,current density in a metal semiconductor
    junction (W)gets changed.
43 //The value of Jpo (saturation hole current density)

```

,after calculation is also provided wrong in the book.

Scilab code Exa 6.8 MAXIMUM N TYPE DOPING CONCENTRATION

```
1 clc
2 Er=11.9
3 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant.
4 Eo=8.854*10^-14
5 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
6 VBD=20
7 disp("VBD = "+string(VBD)+" V") //initializing value
  of break down voltage.
8 e=1.6*10^-19
9 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
10 E=Eo*Er
11 disp("total permittivity ,E=Eo*Er)=" +string(E)+" F/cm
  ")//calculation
12 Emax=5*10^5
13 disp("Emax = "+string(Emax)+" V/cm") //initializing
  value of maximum critical electric field.
14 ND=(Eo*Er*(Emax^2))/(2*e*VBD)
15 disp("ND=(Eo*Er*(Emax^2))/(2*e*VBD)=" +string(ND)+"
  cm^-3")//calculation
16
17
18 //the formula given in the solution for VBD is
  somewhat written wrong.The correct formula is (
  VBD=(E*Emax^2/2*e*ND)).
```

Scilab code Exa 6.9 VALUE OF REVERSE BREAK DOWN VOLTAGE

```
1  clc
2  Er=11.9
3  disp("Er = "+string(Er)) //initializing value of
   relative dielectric permittivity constant.
4  Eo=8.854*10^-14
5  disp("Eo = "+string(Eo)+" F/cm") //initializing
   value of permittivity of free space.
6  e=1.6*10^-19
7  disp("e = "+string(e)+" columns") //initializing
   value of charge of electrons.
8  no=1.5*10^10
9  disp("no = "+string(no)+" cm^-3") //initializing
   value of intrinsic concentration of electrons.
10 Nd=1*10^16
11 disp("Nd="+string(Nd)+" cm^-3")//initializing the
   value of donor concentration.
12 Emax=2*10^5
13 disp("Emax = "+string(Emax)+" V/cm") //initializing
   value of maximum critical electric field.
14 Na=1*10^16
15 disp("Na="+string(Na)+" cm^-3")//initializing the
   value of acceptor concentration.
16 Vt=0.0259
17 disp("Vt = "+string(Vt)+" eV") //initializing value
   of thermal voltage.
18 E=Eo*Er
19 disp("total permittivity ,E=Eo*Er)="+string(E)+" F/cm
   ")//calculation
20 VBI=(Vt*(log(Na*Nd/no^2)))
21 disp("VBI=(Vt*(log(Na*Nd/no^2))) = "+string(VBI)+" V
   ") // calculation.
22 V=(E*Emax^2)/(e*Nd)
23 disp("breakdown voltage for symetrical abrupt
   junction ,VBD+VBI=(E*Emax^2)/(e*Nd)="+string(V)+"
   V")//calculation
24 VBD=V-VBI
```

```
25 disp("VBD=V-VBI)=" + string(VBD) + " V") // calculation
```

Scilab code Exa 6.10 VALUE OF REVERSE BREAK DOWN VOLTAGE

```
1 clc
2 Er=11.9
3 disp("Er = " + string(Er)) //initializing value of
  relative dielectric permittivity constant.
4 Eo=8.854*10^-14
5 disp("Eo = " + string(Eo) + " F/cm") //initializing
  value of permittivity of free space.
6 e=1.6*10^-19
7 disp("e = " + string(e) + " columns") //initializing
  value of charge of electrons.
8 no=1.5*10^10
9 disp("no = " + string(no) + " cm^-3") //initializing
  value of intrinsic concentration of electrons.
10 Emax=10^6
11 disp("Emax = " + string(Emax) + " V/cm") //initializing
  value of maximum critical electric field..
12 Nd=1*10^18
13 disp("Nd=" + string(Nd) + " cm^-3") //initializing the
  value of donor concentration.
14 Na=1*10^18
15 disp("Na=" + string(Na) + " cm^-3") //initializing the
  value of acceptor concentration.
16 Vt=0.0259
17 disp("Vt = " + string(Vt) + " eV") //initializing value
  of thermal voltage.
18 VBI=(Vt*(log(Na*Nd/no^2)))
19 disp("VBI=(Vt*(log(Na*Nd/no^2))) = " + string(VBI) + " V
  ") // calculation.
20 E=Eo*Er
21 disp("total permittivity ,E=Eo*Er)=" + string(E) + " F/cm
```

```

    ") // calculation
22 V=(E*Emax2)/(e*Nd)
23 disp("breakdown voltage for symetrical abrupt
    junction ,VBD+VBI=(E*Emax2)/(e*Nd)= "+string(V)+"
    V") // calculation
24 VBD=V-VBI
25 disp("VBD=V-VBI)= "+string(VBD)+" V") // calculation

```

Scilab code Exa 6.11 VALUE OF REVERSE BREAK DOWN VOLT- AGE

```

1  clc
2  Nd=1*1018
3  disp("Nd = "+string(Nd)+" cm-3") //initializing
    value of donor concentration.
4  Na=-1*1018
5  disp("Na = "+string(Na)+" cm3") //initializing
    value of acceptor concentration.
6  Er=11.9
7  disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
8  Eo=8.854*10-14
9  disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of dielectric constant of free space.
10 e=1.6*10-19
11 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
12 Vt=0.0259
13 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
14 Vbd=15
15 disp("Vbd = "+string(Vbd)+" eV") //initializing
    value of break down voltage.
16 W=2*10-4
17 disp("W = "+string(W)+" cm") //initializing value of

```

```

    the distance over which doping profile varies.
18 E=Eo*Er
19 disp("total permittivity ,E=Eo*Er)=" +string(E)+" F/cm
    ")//calculation
20 a=((Nd-Na)/(W))
21 disp("slope of doping profile curve ,a=((Nd-Na)/(W))=
    "+string(a)+" cm^-4")//calculation
22 Emax=(((Vbd)^2)*9*e*a/(32*E))^(1/3)
23 disp("Emax=(((Vbd)^2)*9*e*a/(32*E))^(1/3)=" +string(
    Emax)+" V/cm")//calculation

```

Scilab code Exa 6.12 VALUE OF THE BARRIER HEIGHT AND BUILT IN POTENTIAL AND DEPLETION WIDTH AND MAXIMUM ELECTRICAL FIELD

```

1 clc
2 Ew=4.55
3 disp("Ew = "+string(Ew)+" V") //initializing value
    of work function of tungsten.
4 X=4.01
5 disp("X = "+string(X)+"V") //initializing value of
    electron affinity of silicon.
6 Er=11.9
7 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant.
8 Eo=8.854*10^-14
9 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
12 Nc=2.8*10^19
13 disp("Nc = "+string(Nc)+" /cm^-3") //initializing
    value of effective density of state in the
    conduction band.

```

```

14 Nd=10^17
15 disp("Nd = "+string(Nd)+"/cm^-3") //initializing
    value of donor concentration.
16 Vt=0.0259
17 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
18 VB=(Ew-X)
19 disp("Barrier height ,VB=(Ew-X) = "+string(VB)+" V")
    // calculation.
20 Ec_Ef=(Vt*log(Nc/Nd))
21 disp("Ec_Ef=(Vt*log(Nc/Nd))="+string(Ec_Ef)+" V")//
    calculation
22 VBI=(VB-(Ec_Ef))
23 disp("VBI=(VB-(Ec_Ef))="+string(VBI)+" V")//
    calculation
24 xn=sqrt(2*Eo*Er*VBI/(e*Nd))
25 disp("Depletion width ,xn=sqrt(2*Eo*Er*VBI/(e*Nd))="+
    string(xn)+" cm")//calculation
26 Emax=(e*Nd*xn/(Eo*Er))
27 disp("maximum electric field ,Emax=(e*Nd*xn/(Eo*Er))=
    "+string(Emax)+" V/cm")//calculation

```

Scilab code Exa 6.13 VALUE OF MAXIMUM ELECTRICAL FIELD AND JUNCTION CAPACITANCE PER UNIT AREA

```

1 clc
2 Ew=4.5
3 disp("Ew = "+string(Ew)+" V") //initializing value
    of work function of tungsten.
4 X=4.01
5 disp("X = "+string(X)+"V") //initializing value of
    electron affinity of silicon.
6 Er=12
7 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant.

```

```

8 Eo=8.854*10^-14
9 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
10 Vr=3
11 disp("Vr = "+string(Vr)+" V") //initializing value
  of reverse voltage.
12 e=1.6*10^-19
13 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
14 Nc=2.8*10^19
15 disp("Nc = "+string(Nc)+"/cm^-3") //initializing
  value of effective density of state in the
  conduction band.
16 Nd=10^17
17 disp("Nd = "+string(Nd)+"/cm^-3") //initializing
  value of donor concentration.
18 Vt=0.0259
19 disp("Vt = "+string(Vt)+" eV") //initializing value
  of thermal voltage.
20 VB=(Ew-X)
21 disp("barrier height ,VB=(Ew-X) = "+string(VB)+" V")
  // calculation.
22 Ec_Ef=(Vt*log(Nc/Nd))
23 disp("Ec_Ef=(Vt*log(Nc/Nd))="+string(Ec_Ef)+" V")//
  calculation
24 VBI=(VB-(Ec_Ef))
25 disp("VBI=(VB-(Ec_Ef))="+string(VBI)+" V")//
  calculation
26 xn=sqrt((2*Eo*Er*(VBI+Vr))/(e*Nd))
27 disp("Depletion width ,xn=sqrt(2*Eo*Er*(VBI+Vr)/(e*Nd
  ))="+string(xn)+" cm")//calculation
28 Emax=(e*Nd*xn/(Eo*Er))
29 disp("maximum electric field ,Emax=(e*Nd*xn/(Eo*Er))=
  "+string(Emax)+" V/cm")//calculation
30 C=sqrt((e*Eo*Er*Nd)/(2*(VBI+Vr)))
31 disp("Capitance per unit area ,C=sqrt((e*Eo*Er*Nd)
  /(2*(VBI+Vr)))="+string(C)+" F/cm^2")//
  calculation

```



```

32 //the Value of reverse voltage(Vr) provided in the
    question is different than used in the solution.I
    have used the value provided in the solution(i.e
    Vr=3).
33 //the value of C (Capitance per unit area) after
    calculation is provided wrong in the book.

```

Scilab code Exa 6.14 VALUE OF VB Xn AND Emax

```

1  clc
2  Ew=4.28
3  disp("Ew = "+string(Ew)+" V") //initializing value
    of work function of tungusten.
4  X=4.01
5  disp("X = "+string(X)+"V") //initializing value of
    electron effinity of silicon.
6  Er=11.9
7  disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant.
8  Eo=8.854*10^-14
9  disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
12 Nc=2.8*10^19
13 disp("Nc = "+string(Nc)+"/cm^-3") //initializing
    value of effective density of state in the
    conduction band.
14 Nd=10^15
15 disp("Nd = "+string(Nd)+"/cm^-3") //initializing
    value of donor concentration.
16 Vt=0.0259
17 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.

```

```

18 VB=(Ew-X)
19 disp(" barrier height ,VB=(Ew-X) = "+string(VB)+" V")
    // calculation.
20 Ec_Ef=(Vt*log(Nc/Nd))
21 disp(" Ec_Ef=(Vt*log(Nc/Nd))=" +string(Ec_Ef)+" V") //
    calculation
22 VBI=(VB-(Ec_Ef))
23 disp(" VBI=(VB-(Ec_Ef))=" +string(VBI)+" V") //
    calculation
24 xn=sqrt(2*Eo*Er*VBI/(e*Nd))
25 disp(" Depletion width ,xn=sqrt(2*Eo*Er*VBI/(e*Nd))=" +
    string(xn)+" cm") // calculation
26 Emax=(e*Nd*xn/(Eo*Er))
27 disp(" maximum electric field ,Emax=(e*Nd*xn/(Eo*Er))=
    "+string(Emax)+" V/cm") // calculation
28
29 //the Value of donor concentration (Nd) provided in
    the question is different than used in the
    solution.I have used the value provided in the
    question(i.e Nd=10^15). ,i.e answer differs than
    provided in the book.

```

Scilab code Exa 6.15 CAPACITANCE OF A GOLD SILICON JUNCTION

```

1 clc
2 Ew=5.1
3 disp("Ew = "+string(Ew)+" V") //initializing value
    of work function of tungusten.
4 X=4.01
5 disp("X = "+string(X)+"V") //initializing value of
    electron effinity of silicon.
6 Er=11.9
7 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant.

```

```

8 Eo=8.854*10^-14
9 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
12 Nc=2.8*10^19
13 disp("Nc = "+string(Nc)+"/cm^-3") //initializing
    value of effective density of state in the
    conduction band.
14 Nd=5*10^15
15 disp("Nd = "+string(Nd)+"/cm^-3") //initializing
    value of donor concentration.
16 Vt=0.0259
17 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
18 Vr=5
19 disp("Vr = "+string(Vr)+" V") //initializing value
    of reverse voltage.
20 A=1*10^-4
21 disp("A = "+string(A)+" cm^2") //initializing value
    of area of the gold silicon junction diode..
22 VB=(Ew-X)
23 disp(" barrier height ,VB=(Ew-X) = "+string(VB)+" V")
    // calculation.
24 Ec_Ef=(Vt*log(Nc/Nd))
25 disp(" Ec_Ef=(Vt*log(Nc/Nd))="+string(Ec_Ef)+" V")//
    calculation
26 VBI=(VB-(Ec_Ef))
27 disp(" VBI=(VB-(Ec_Ef))="+string(VBI)+" V")//
    calculation
28 C1=sqrt((e*Eo*Er*Nd)/(2*(VBI+Vr)))
29 disp(" Capitance per unit area ,C1=sqrt((e*Eo*Er*Nd)
    /(2*(VBI+Vr)))="+string(C1)+" F/cm^2")//
    calculation
30 C=C1*A
31 disp(" total junction capatiance ,C=C1*A="+string(C)+"
    F")//calculation

```

Scilab code Exa 6.17 VALUE OF LOWERING OF BARRIER HEIGHT

```
1 clc
2 Er=13.1
3 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant.
4 Eo=8.854*10^-14
5 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
8 Emax=30*10^3
9 disp("Emax = "+string(Emax)+" V/cm") //initializing
  value of maximum critical electric field..
10 E=Eo*Er
11 disp("total permittivity ,E=Eo*Er)="+string(E)+" F/cm
  ")//calculation
12 V=sqrt(e*Emax/(4*pi*E))
13 disp("lowering of the barrier height ,V=sqrt(e*Emax
  /(4*pi*E))="+string(V)+" V")//calculation
14 Xmax=sqrt(e/(16*pi*E*Emax))
15 disp("position of the maximum barrier height ,Xmax=
  sqrt(e/(16*pi*E*Emax))="+string(Xmax)+" cm")//
  calculation
```

Scilab code Exa 6.18 VALUE OF IDEAL REVERSE SATURATION CUR-
RENT AND THE DIODE CURRENT

```
1 clc
2 A=10^-4
```

```

3 disp("A = "+string(A)+" cm-2") //initializing value
  of cross sectional area.
4 VBn=0.55
5 disp("VBn = "+string(VBn)+"V") //initializing value
  of barrier height.
6 T=300
7 disp("T = "+string(T)+"K") //initializing value of
  absolute temperature.
8 R=110
9 disp("R = "+string(R)+" A/(K-cm2)") //initializing
  value of richardson's constant.
10 Vt=0.0259
11 disp("Vt = "+string(Vt)+" eV") //initializing value
  of thermal voltage.
12 V=0.25
13 disp("V = "+string(V)+" V") //initializing value of
  forward bias voltage.
14 Io=A*R*T2*exp(-VBn/Vt)
15 disp("reverse saturation current ,Io=A*R*T2*exp(-VBn
  /Vt) = "+string(Io)+" A") // calculation.
16 I=Io*((exp(V/Vt))-1)
17 disp("diode current ,I=Io (exp(V/Vt) -1)=" +string(I)+"
  A")//calculation

```

Scilab code Exa 6.19 VALUE OF FORWARD VOLTAGE

```

1 clc
2 Io1=10-9
3 disp("Io1 = "+string(Io1)+" A") //initializing value
  of reverse saturation current of silicon SBD.
4 Io2=10-14
5 disp("Io2 = "+string(Io2)+"A") //initializing value
  of reverse saturation current of a PN junction.
6 Vt=0.0259
7 disp("Vt = "+string(Vt)+" eV") //initializing value

```

```

    of thermal voltage.
8 I=100*10^-6
9 disp("I = "+string(I)+" A") //initializing value of
    required current.
10 VfSBD=Vt*((log(I/Io1+1)))
11 disp("forward Voltage for silicon SBD,VfSBD=Vt*((log
    (I/Io1+1)))= "+string(VfSBD)+" V") // calculation
    .
12 VfPN=Vt*((log(I/Io2+1)))
13 disp("forward Voltage for silicon SBD,VfPN=Vt*((log(
    I/Io2+1)))=" +string(VfPN)+" V") // calculation

```

Scilab code Exa 6.20 VALUE OF REVERSE SATURATION CURRENT

```

1 clc
2 Io1=10*10^-7
3 disp("Io1 = "+string(Io1)+" A") //initializing value
    of reverse saturation current of silicon SBD.
4 Io2=10*10^-7
5 disp("Io2 = "+string(Io2)+"A") //initializing value
    of reverse saturation current of a PN junction.
6 Vt=0.0259
7 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
8 I=1*10^-3
9 disp("I = "+string(I)+" A") //initializing value of
    forward current.
10 V=0.25
11 disp("V = "+string(V)+" V") //initializing value of
    difference in the forward voltage of the two
    diode.
12 VfSBD=Vt*((log(I/Io1+1)))
13 disp("forward Voltage for silicon SBD,VfSBD=Vt*((log
    (I/Io1+1)))= "+string(VfSBD)+" V") // calculation

```

```
14 VfPN=(V+VfSBD)
15 disp("forward volage applied across the PN Diode ,
      VfPN=(V+VfSBD)=" +string(VfPN)+" V")//calculation
16 Io=(I/((exp(VfPN/Vt))-1))
17 disp("reverse saturation current of the PN junction
      Diode ,Io=(I/((exp(VfPN/Vt))-1))=" +string(Io)+" A"
      )//calculation
```

Chapter 7

BIPOLAR JUNCTION TRANSISTORB

Scilab code Exa 7.1 MAGNITUDE OF I_0 AND COLLECTOR CURRENT

```
1 clc
2 Dnb=20
3 disp("Dnb = "+string(Dnb)+" cm^2/s") //
  initialization the value of one of base
  parametre of NPN transistor.
4 nB=10^4
5 disp("nB = "+string(nB)+" /cm^3") //initialization
  the value of one of base parametre of NPN
  transistor.
6 xB=1*10^-6
7 disp("xB = "+string(xB)+" m") //initialization the
  value of one of base parametre of NPN transistor.
8 AB=10^-4
9 disp("AB = "+string(AB)+" cm^2") //initialization
  the value of one of base parametre of NPN
  transistor.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initialization
  the value of electronic charge .
```



```

12 Vbe=0.5
13 disp("Vbe = "+string(Vbe)+" V") //initialization
    the value of base emitter voltage of NPN
    transistor..
14 VT=0.0259
15 disp("VT = "+string(VT)+" V") //initialization the
    value of threshold voltage.
16 WB=10^-4
17 disp("WB = "+string(WB)+" cm") //initialization the
    value of base width of NPN transistor.
18 Io=((e*AB*Dnb*nB)/(WB))
19 disp("Magnitude of Io ,Io=((e*AB*Dnb*nB)/(WB))=" +
    string(Io)+" A")//calculation
20 Ic=Io*(exp(Vbe/VT)-1)
21 disp("Collector current ,Ic=Io((exp(Vbe/VT))-1))=" +
    string(Ic)+" A")//calculation

```

Scilab code Exa 7.2 CONCENTRATION OF nEO pBO AND nCO

```

1 clc
2 NE=5*10^17
3 disp("NE = "+string(NE)+" /cm^3") //initialization
    the value of doping concentration in the emitter
    .
4 NB=10^16
5 disp("NB = "+string(NB)+" /cm^3") //initialization
    the value of doping concentration in the base.
6 NC=10^15
7 disp("NC = "+string(NC)+" /cm^3") //initialization
    the value of doping concentration in the
    collector.
8 WB=0.8*10^-4
9 disp("WB = "+string(WB)+" cm") //initialization the
    value of base width of NPN transistor.
10 no=1.5*10^10

```

```

11 disp("no = "+string(no)+"cm-3") //initializing the
    intrinsic carrier concentration.
12 pEO=(no2/NE)
13 disp("Number of Majority holes in the emitter ,pEO=(
    no2/NE) )="+string(pEO)+" /cm3")// calculation
14 nBO=(no2/NB)
15 disp("Number of Majority holes in the base ,nBO=(no
    2/NB) )="+string(nBO)+" /cm3")// calculation
16 pCO=(no2/NC)
17 disp("Number of Majority holes in the collector ,pCO
    =(no2/NC) )="+string(pCO)+" /cm3")// calculation

```

Scilab code Exa 7.3 VALUE OF pBO AND nB

```

1 clc
2 NE=5*1017
3 disp("NE = "+string(NE)+" /cm3") //initialization
    of doping concentration in the emitter.
4 NB=1016
5 disp("NB = "+string(NB)+" /cm3") //initialization
    of doping concentration in the base.
6 NC=1015
7 disp("NC = "+string(NC)+" /cm3") //initialization
    of doping concentration in the collector.
8 WB=0.8*10-4
9 disp("WB = "+string(WB)+" cm") //initialization
    the value of base width of NPN transistor.
10 no=1.5*1010
11 disp("no = "+string(no)+"cm-3") //initializing the
    value of intrinsic carrier concentration.
12 VT=0.0259
13 disp("VT = "+string(VT)+" V") //initialization the
    value of threshold voltage.
14 VJ=0.6258
15 disp("VJ=Vbe = "+string(VJ)+" V") //initialization

```

```

    the value of base emitter voltage.
16 pEO=(no^2/NE)
17 disp("Number of Majority holes in the emitter ,pEO=(
    no^2/NE) )=" +string(pEO)+" /cm^3") // calculation
18 nBO=(no^2/NB)
19 disp("Number of Majority holes in the base ,nBO=(no
    ^2/NB) )=" +string(nBO)+" /cm^3") // calculation
20 pCO=(no^2/NC)
21 disp("Number of Majority holes in the collector ,pCO
    =(no^2/NC) )=" +string(pCO)+" /cm^3") // calculation
22 pE=pEO*(exp(VJ/VT))
23 disp("pE(O)=pEO*(exp(VJ/VT)) )=" +string(pE)+" /cm^3")
    // calculation
24 nB=nBO*(exp(VJ/VT))
25 disp("nB=(nBO*(exp(VJ/VT))) )=" +string(nB)+" /cm^3")
    // calculation
26
27
28 //the answer provided in the book for pE,nB is some
    what different than actual calculated.

```

Scilab code Exa 7.5 VALUE OF BASE WIDTH

```

1  clc
2  Db=10
3  disp("Db = " +string(Db)+" cm^2/s") //initialization
    the value of one of parametere of the transistor
    .
4  Bt=0.95
5  disp("Bt = " +string(Bt)) //initialization the value
    of base transport factor of the transistor.
6  tb=10^-7
7  disp("tb = " +string(tb)+" s") //initialization the
    value of one of parametere of the transistor.
8  Lp=(sqrt(Db*tb))

```

```

9  disp("Lp=(sqrt(Db*tb))=" + string(Lp) + " cm") //
    calculation
10 WB=(Lp*(acosh(1/Bt)))
11 disp("WB=(Lp*(acosh(1/Bt))=" + string(WB) + " cm") //
    calculation

```

Scilab code Exa 7.7 VALUE OF DELTA

```

1  clc
2  Jro=10^-9
3  disp("Jro = " + string(Jro) + " A/cm^2") //
    initialization the value of recombination
    current density.
4  Jo=10^-12
5  disp("Jo = " + string(Jo) + " A/cm^2") //initialization
    the value of reverse saturation current density.
6  Vbe=0.5
7  disp("Vbe = " + string(Vbe) + " V") //initialization
    the value of base emitter voltage.
8  VT=0.0259
9  disp("VT = " + string(VT) + " V") //initialization the
    value of threshold voltage.
10 delta=(1+((Jro/Jo)*(exp((-Vbe)/(2*VT)))))^-1
11 disp("delta (recombination factor)=(1+((Jro/Jo)*(exp
    ((-Vbe)/(2*VT))))^-1)=" + string(delta)) //
    calculation.

```

Scilab code Exa 7.8 COMMON BASE AND COMMON EMITTER CUR- RENT GAIN

```

1  clc
2  NE=1*10^17

```

```

3 disp("NE = "+string(NE)+" /cm^3") //initialization
  the value of doping concentration of emitter in
  the NPN transistor.
4 NB=10^15
5 disp("NB = "+string(NB)+" /cm^3") //initialization
  the value of doping concentration of base in the
  NPN transistor.
6 WE=0.6*10^-4
7 disp("WE = "+string(WE)+" cm") //initialization the
  value of one of parametre of the transistor.
8 WB=0.8*10^-4
9 disp("WB = "+string(WB)+" cm") //initialization the
  value of one of parametre of the transistor.
10 no=1.5*10^10
11 disp("no = "+string(no)+"cm^-3") //initializing the
  value of intrinsic carrier concentration.
12 e=1.6*10^-19
13 disp("e = "+string(e)+" columns") //initialization
  the value of electronic charge
14 DE=15
15 disp("DE = "+string(DE)+" cm^2/s") //initialization
  the value of one of parametere of the transistor
  .
16 DB=20
17 disp("DB = "+string(DB)+" cm^2/s") //initialization
  the value of one of parametere of the transistor
  .
18 tE=0.2*10^-6
19 disp("tE = "+string(tE)+" s") //initialization the
  value of one of parametere of the transistor.
20 tB=0.1*10^-6
21 disp("tB = "+string(tB)+" s") //initialization the
  value of one of parametere of the transistor.
22 Vbe=0.60
23 disp("Vbe = "+string(Vbe)+" V") //initialization
  the value of base emitter voltage .
24 VT=0.0259
25 disp("VT = "+string(VT)+" V") //initialization the

```

```

    value of threshold voltage.
26 Jro=2*10^-8
27 disp("Jro = "+string(Jro)+" A/cm^2") //
    initialization the value of recombination
    current density.
28 LE=(sqrt(DE*tE))
29 disp("LE=(sqrt(DE*tE))=" +string(LE)+" cm") //
    calculation
30 LB=(sqrt(DB*tB))
31 disp("LB=(sqrt(DB*tB))=" +string(LB)+" cm") //
    calculation
32 pEO=(no^2/NE)
33 disp("Number of Majority holes in the emitter ,pEO=(
    no^2/NE) )=" +string(pEO)+" /cm^3") // calculation
34 nBO=(no^2/NB)
35 disp("Number of Majority holes in the base ,nBO=(no
    ^2/NB) )=" +string(nBO)+" /cm^3") // calculation
36 Y=(1+(((NB*DE*LB)/(NE*DB*LE))*((tanh(WB/LB)/tanh(WE/
    LE))))^(-1)
37 disp("Emitter injection efficiency ,Y=(1+((NB*DE*LB)
    /(NE*DB*LE)*(tanh(WB/LB)/tanh(WE/LE)))) )=" +
    string(Y)) // calculation
38 Bt=(cosh(WB/LB))^(-1)
39 disp("Base transport factor ,Bt=(cosh(WB/LB))^(-1)=" +
    string(Bt)) // calculation
40 Jo=((e*DB*nBO)/(LB*tanh(WB/LB)))
41 disp("Reverse saturation current Density ,Jro=((e*DB*
    nBO)/(LB*tanh(WB/LB)))=" +string(Jo)+" A/cm^2") //
    calculation
42 delta=(1+((Jro/Jo)*(exp((-Vbe)/(2*VT))))^(-1)
43 disp("delta (recombination factor)=(1+((Jro/Jo)*(exp
    ((-Vbe)/(2*VT))))^(-1))=" +string(delta)+" A") //
    calculation
44 a=Bt*delta*Y
45 disp("common base current amplification factor ,(
    alpha=Bt*delta*Y)=" +string(a)) // calculation
46 B=(a/(1-a))
47 disp("common emitter current amplification factor ,

```

```

    Beta=(a/(1-a))=')+string(B))//calculation
48 //the value of NE provided in the question is
    different than used in the solution .
49 //I have used the value (while solving) provided in
    the question (i.e NE=10^17/cm^3).

```

Scilab code Exa 7.9 CHANGE IN THE NEUTRAL BASE WIDTH

```

1  clc
2  NB=5*10^16
3  disp("NB = "+string(NB)+" /cm^3") //initialization
    the doping concentration in the base.
4  NC=2*10^15
5  disp("NC = "+string(NC)+" /cm^3") //initialization
    the doping concentration in the collector.
6  WBm=0.6*10^-4
7  disp("WBm = "+string(WBm)+" cm") //initialization
    the value of actual base width.
8  e=1.6*10^-19
9  disp("e = "+string(e)+" columns") //initialization
    the value of electronic charge.
10 VCB1=1
11 disp("VCB1 = "+string(VCB1)+" V") //initialization
    the initial value of collector base voltage .
12 VCB2=4
13 disp("VCB2 = "+string(VCB2)+" V") //initialization
    the final value of collector base voltage.
14 Er=11.9
15 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
16 Eo=8.854*10^-14
17 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
18 no=1.5*10^10
19 disp("no = "+string(no)+" cm^-3") //initializing the

```

```

    value of intrinsic charge carriers
20 VT=0.0259
21 disp("VT = "+string(VT)+" V") //initialization the
    value of threshold voltage.
22 VBI=VT*(log((NB*NC)/no^2))
23 disp(" VBI=VT*(log((NB*NC)/no^2))="+string(VBI)+" V"
    )//calculation
24 WBS1=((2*Eo*Er*(VBI+VCB1)/e)*(NC/NB)*(1/(NC+NB)))
    ^(1/2)
25 disp("WBS=((2*Eo*Er*(VBI+VCB1)/e)*(NC/NB)*(1/(NC+NB)
    ))^(1/2))="+string(WBS1)+" cm")//calculation
26 Wb1=WBm-WBS1
27 disp("Neutral base width for VCB1,WB(neutral)=WBm-
    WBS1="+string(Wb1)+" cm")//calculation
28 WBS2=((2*Eo*Er*(VBI+VCB2)/e)*(NC/NB)*(1/(NC+NB)))
    ^(1/2)
29 disp("WBS=((2*Eo*Er*(VBI+VCB2)/e)*(NC/NB)*(1/(NC+NB)
    ))^(1/2))="+string(WBS2)+" cm")//calculation
30 Wb2=WBm-WBS2
31 disp("Neutral base width for VCB2,WB(neutral)=WBm-
    WBS2="+string(Wb2)+" cm")//calculation
32 deltaWbneutral=Wb1-Wb2
33 disp("change in the neutral base width ,deltaWb(
    neutral)=Wb1-Wb2="+string(deltaWbneutral)+" cm")
    //calculation

```

Scilab code Exa 7.10 CHANGE IN THE COLLECTOR CURRENT

```

1 clc
2 ro=500*10^3
3 disp("ro = "+string(ro)+" ohm") //initialization
    the value of output resistance .
4 Vce1=7
5 disp("Vce1 = "+string(Vce1)+" V") //initialization
    the initial value of collector emitter voltage .

```



```
6 Vce2=1
7 disp("Vce2 = "+string(Vce2)+" V") //initialization
  the final value of collector emitter voltage .
8 Vce=6
9 disp("change in the collector-emitter voltage ,Vce1-
  Vce2 = "+string(Vce)+" V") //calculation .
10 Ic=(Vce/ro)
11 disp("change in the collector current ,Ic=(Vce/ro)="
  +string(Ic)+" A")//calculation
```

Chapter 8

THE FIELD EFFECT TRANSISTOR

Scilab code Exa 8.1 CAPACITANCE C_{ox} AND C_o

```
1 clc
2 Nd=10^16
3 disp("Nd = "+string(Nd)+" /cm^3") //initializing
  value of donor ion concentration.
4 Er=3.9
5 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant .
6 Eo=8.854*10^-14
7 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
8 W=0.5*10^-4
9 disp("W = "+string(W)+" cm") //initializing value of
  width of p-substrate.
10 L=10^-4
11 disp("L = "+string(L)+" cm") //initializing value of
  length of p-substrate.
12 tox=400*10^-8
13 disp("tox = "+string(tox)+" cm") //initializing
  value of thickness of p-substrate.
```

```

14 E=Eo*Er
15 disp(" total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation
16 Cox=(E*W*L)/tox
17 disp(" Oxide capacitance ,Cox=(E*W*L)/tox="+string(
    Cox)+" F")//calculation
18 Co=(Cox/(W*L))
19 disp(" Capacitance per unit area ,Co=(Cox/(W*L))=" +
    string(Co)+" F/cm^2")//calculation

```

Scilab code Exa 8.2 MAXIMUM SPACE CHARGE WIDTH

```

1 clc
2 Na=10^17
3 disp("Na = "+string(Na)+" /cm^3") //initializing
    value of acceptor ion concentration.
4 Vt=0.0259
5 disp("Vt = "+string(Vt)+"V") //initializing value of
    thermal voltage.
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
8 ni=1.5*10^10
9 disp("ni = "+string(ni)+" /cm^3") //initializing
    value of intrinsic carrier concentration.
10 Er=11.9
11 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant
12 Eo=8.854*10^-14
13 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
14 Vs=Vt*log(Na/ni)
15 disp("Vs=Vt*log(Na/ni)="+string(Vs)+" V")//
    calculation
16 E=Eo*Er

```

```

17 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation
18 Wd=sqrt(4*E*Vs/(e*Na))
19 disp("maximum depletion width ,Wd(max)=Sqrt(4*E*Vs/(e
    *Na)))="+string(Wd)+" cm")//calculation

```

Scilab code Exa 8.3 MAXIMUM SPACE CHARGE WIDTH

```

1 clc
2 Nd=3*10^18
3 disp("Nd = "+string(Nd)+" /cm^3") //initializing
    value of acceptor ion concentration.
4 Vt=0.0259
5 disp("Vt = "+string(Vt)+"V") //initializing value of
    thermal voltage.
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
8 ni=1.5*10^10
9 disp("ni = "+string(ni)+" /cm^3") //initializing
    value of intrinsic carrier concentration.
10 Er=11.9
11 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant
12 Eo=8.854*10^-14
13 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
14 Vs=Vt*log(Nd/ni)
15 disp("Vs=Vt*log(Nd/ni)="+string(Vs)+" V")//
    calculation
16 E=Eo*Er
17 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation
18 Wd=sqrt(4*E*Vs/(e*Nd))
19 disp("maximum depletion width ,Wd(max)=Sqrt(4*E*Vs/(e

```

```
*Nd))=)+string(Wd)+" cm")//calculation
```

Scilab code Exa 8.5 METAL SEMICONDUCTOR WORK FUNCTION DIFFERENCE

```
1 clc
2 Vm=3.2
3 disp("Vm = "+string(Vm)+" V") //initializing value
  of modified metal work function.
4 X=3.25
5 disp("X = "+string(X)+" V") //initializing value of
  modified electron affinity.
6 Nd=2*10^16
7 disp("Nd = "+string(Nd)+" /cm^3") //initializing
  value of donor concentration.
8 ni=1.5*10^10
9 disp("ni = "+string(ni)+" V") //initializing value
  of intrinsic carrier concentration.
10 Vt=0.0259
11 disp("Vt = "+string(Vt)+"V") //initializing value of
  thermal voltage.
12 Eg=1.12
13 disp("Eg = "+string(Eg)+"V") //initializing value of
  energy gap.
14 Vfp=(Vt*log(Nd/ni))
15 disp("Vfp=(Vt*log(Nd/ni))="+string(Vfp)+" V")//
  calculation.
16 Vms=-(Vm+(Eg/2)+Vfp-Vm)
17 disp("Vms=-(Vm+(Eg/2)+Vfp-Vm)="+string(Vms)+" V")//
  calculation.
```

Scilab code Exa 8.7 CAPACITANCE Co AND FLAT BAND VOLTAGE

```

1  clc
2  Nd=10^16
3  disp("Nd = "+string(Nd)+" /cm^3") //initializing
   value of donor ion concentration.
4  Vms=-1.12
5  disp("Vms = "+string(Vms)+" V") //initializing value
   of metal semiconductor work function difference.
6  Er=3.9
7  disp("Er = "+string(Er)) //initializing value of
   relative dielectric permittivity constant .
8  Eo=8.854*10^-14
9  disp("Eo = "+string(Eo)+" F/cm") //initializing
   value of permittivity of free space.
10 tox=200*10^-8
11 disp("tox = "+string(tox)+" cm") //initializing
   value of thickness of p-type substrate.
12 Qss=2.5*10^-8
13 disp("Qss = "+string(Qss)+" columbs/cm^2") //
   initializing value of charge density on
   semiconductor surface.
14 Eox=Eo*Er
15 disp("Total permittivity ,Eox=Eo*Er="+string(Eox)+" F
   /cm")//calculation
16 Co=(Eox/tox)
17 disp("Capacitance per unit area ,Co=(E/tox))="+string
   (Co)+" F/cm^2")//calculation
18 Vfb=(Vms-(Qss/Co))
19 disp("Flat band voltage ,Vfb=(Vms-(Qss/Co))="+string
   (Vfb)+" V")//calculation
20
21 //the answer for Co after calculation is provided
   wrong in the book.

```

Scilab code Exa 8.9 THRESHOLD VOLTAGE

```

1  clc
2  Na=3*10^16
3  disp("Na = "+string(Na)+" /cm^3") //initializing
    value of acceptor ion concentration.
4  Vms=-1.12
5  disp("Vms = "+string(Vms)+"V") //initializing value
    of metal semiconductor work function difference.
6  Er=11.9
7  disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
8  Eo=8.854*10^-14
9  disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
10 ni=1.5*10^10
11 disp("ni = "+string(ni)+"cm^-3") //initializing
    value of intrinsic concentration of electrons.
12 e=1.6*10^-19
13 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
14 tox=300*10^-8
15 disp("tox = "+string(tox)+" cm") //initializing
    value of thickness of p-type substrate.
16 Vfb=-1.12
17 disp("Vfb = "+string(Vfb)+" V") //initializing value
    of flat band voltage.
18 Qss=10^11
19 disp("Qss = "+string(Qss)+" electronic charge
    columns/cm^2") //initializing value of charge
    density on semiconductor surface.
20 Vt=0.0259
21 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
22 er=3.9
23 disp("er = "+string(er)) //initializing value of
    relative dielectric permittivity constant
24 Eox=Eo*Er
25 disp("total permittivity ,Eox=Eo*Er="+string(Eox)+" F
    /cm")//calculation

```

```

26 Vfp=Vt*(log(Na/(ni)))
27 disp(" Potential ,Vfp=Vt*(log(Na/(ni)))=" +string(Vfp)
    +" V")// calculation
28 Wd=sqrt((4*Eox*Vfp)/(e*Na))
29 disp(" Maximum depletion width ,Wd=sqrt((4*E*Vs)/(e*Nd
    )))=" +string(Wd)+" cm")// calculation
30 QDmax=(e*Na*Wd)
31 disp(" Over all maximum depletion width ,QDmax=(e*Na*
    Wd)=" +string(QDmax)+" columns/cm^2")//
    calculation
32 VT=(((QDmax-1.6*10^-8)*tox)/(er*Eo))+(2*Vfp+Vfb)
33 disp(" Thresold Voltage ,VT=(((QDmax-1.6*10^-8)*tox)/(
    er*Eo))+(2*Vfp+Vfb)=" +string(VT)+" V")//
    calculation

```

Scilab code Exa 8.10 VALUE OF Id

```

1 clc
2 L=1.25*10^-4
3 disp("L = " +string(L)+" cm") //initializing value of
    length of channel.
4 un=600
5 disp("un = " +string(un)+"cm^2/V-s") //initializing
    value of mobility of n-channel MOS transistor.
6 Co=6.9*10^-9
7 disp("Co = " +string(Co)+"F/cm^2") //initializing
    value of capacitance per unit area .
8 VT=0.60
9 disp("VT = " +string(VT)+" V") //initializing value
    of threshold Voltage.
10 Vgs=4
11 disp("Vgs = " +string(Vgs)+" V") //initializing value
    of gate to source voltage.
12 W=12*10^-4
13 disp("W = " +string(W)+" cm") //initializing value of

```



```

        width of channel.
14 Id=((Co*un*W)/(L)*((Vgs-VT)^2/(2)))
15 disp("Drain current ,Id=((Co*un*W)/(L)*((Vgs-VT)
    ^2/(2)))="+string(Id)+" A")// calculation.
16
17
18 //The answer provided in the book (for Id) is wrong
    as the value of mobility used for solution is
    different than provided in the question and also
    value of (Vgs-Vt) is put wrong in the solution
    than given in the book.
19 //I have used the value given in the question i.e.
    answer differ.

```

Scilab code Exa 8.13 MINIMUM CAPACITANCE AND FLAT BAND CAPACITANCE

```

1 clc
2 Na=2*10^17
3 disp("Na = "+string(Na)+" /cm^3") //initializing
    value of acceptor ion concentration.
4 Er=11.9
5 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
6 Eo=8.854*10^-14
7 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
8 ni=1.5*10^10
9 disp("ni = "+string(ni)+"cm^-3") //initializing
    value of intrinsic concentration of electrons.
10 e=1.6*10^-19
11 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
12 tox=400*10^-8
13 disp("tox = "+string(tox)+" cm") //initializing

```

```

    value of thickness of p-type substrate.
14 Vt=0.0259
15 disp("Vt = "+string(Vt)+" eV") //initializing value
    of thermal voltage.
16 er=3.9
17 disp("er = "+string(er)) //initializing value of
    relative dielectric permittivity constant
18 Vfp=Vt*(log(Na/(ni)))
19 disp(" Potential ,Vfp=Vt*(log(Na/(ni)))=" +string(Vfp)
    +" V")//calculation
20 Wd=sqrt((4*Er*Eo*Vfp)/(e*Na))
21 disp(" Depletion width ,Wd=sqrt((4*Er*Eo*Vs)/(e*Nd))="
    "+string(Wd)+" cm")//calculation
22 CTmin=(er*Eo/(((er/Er)*(Wd))+(tox)))
23 disp(" Minimum Capacitance ,CTmin=(er*Eo/((er/Er)*(Wd)
    +(tox)))=" +string(CTmin)+" F/cm^2")//calculation
24 CFB=((er*Eo)/(((er/Er)*sqrt(Vt*Er*Eo/(e*Na))))+(tox
    )))
25 disp(" Flat band capacitance ,CFB=((er*Eo)/(((er/Er)*
    sqrt(Vt*Er*Eo/(e*Na))))+(tox))=" +string(CFB)+" F/
    cm^2")//calculation
26
27 //the value of Na (acceptor ion concentration) and
    tox (thickness of p-type substrate) is provided
    different in the question than used in the
    solution.
28 //I have used the value provided in the solution.(i.
    e Na=2*10^17 and tox=400*10^8cm)

```

Scilab code Exa 8.14 VALUE OF Q_{ss}

```

1 clc
2 Vfb=-1.0
3 disp("Vfb = "+string(Vfb)+" V") //initializing value
    of flat band voltage.

```

```

4 Vms=-0.9
5 disp("Vms = "+string(Vms)+"V") //initializing value
    of metal semiconductor work function difference.
6 tox=200*10^-8
7 disp("tox = "+string(tox)+" cm") //initializing
    value of gate oxide thickness.
8 et=3.9
9 disp("et = "+string(et)) //initializing value of
    relative permittivity.
10 eo=8.85*10^-14
11 disp("eo = "+string(eo)+"F/cm") //initializing value
    of free space permittivity.
12 e=1.6*10^-19
13 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
14 eox=(eo*et)
15 disp("eox=(eo*et)="+string(eox)+" F/cm^2")//
    calculation
16 Cox=(eox/tox)
17 disp("Oxide capacitance ,Cox=(eox/tox)="+string(Cox)
    +" F/cm^2")//calculation
18 Qss=((Vms-Vfb)*Cox)
19 disp("charge density on semiconductor surface ,Qss=((
    Vms-Vfb)*Cox)="+string(Qss)+" C/cm^2")//
    calculation
20 Qss1=Qss/e
21 disp("charge density on semiconductor surface (in
    terms of number of charges) ,Qss*=Qss/e)="+string
    (Qss1)+" electrons/cm^2")//calculation

```

Scilab code Exa 8.15 VALUE OF Id

```

1 clc
2 L=3*10^-6
3 disp("L = "+string(L)+" meter") //initializing value

```

```

    of length of channel.
4 un=800
5 disp("un = "+string(un)+"cm^2/V-s") //initializing
    value of mobility of n-channel MOS transistor.
6 VT=1
7 disp("VT = "+string(VT)+" V") //initializing value
    of threshold Voltage.
8 Vgs=0
9 disp("Vgs = "+string(Vgs)+" V") //initializing value
    of gate to source voltage.
10 tox=500*10^-8
11 disp("tox = "+string(tox)+" cm") //initializing
    value of gate oxide thickness.
12 et=3.9
13 disp("et = "+string(et)) //initializing value of
    relative permittivity.
14 eo=8.85*10^-14
15 disp("eo = "+string(eo)+"F/cm") //initializing value
    of free space permittivity.
16 W=30*10^-6
17 disp("W = "+string(W)+"m") //initializing value of
    width of channel.
18 eox=(eo*et)
19 disp("eox=(eo*et)="+string(eox)+" F/cm^2")//
    calculation
20 Id=((eox*un*W)/(tox*L)*((Vgs-VT)^2/(2)))
21 disp("Drain current , Id=((eox*un*W)/(tox*L)*((Vgs-VT)
    ^2/(2)))="+string(Id)+" A")// calculation

```

Scilab code Exa 8.16 VALUE OF Id

```

1 clc
2 L=2.5*10^-6
3 disp("L = "+string(L)+" meter") //initializing value
    of length of channel.

```

```

4 un=800
5 disp("un = "+string(un)+"cm^2/V-s") //initializing
    value of mobility of n-channel MOS transistor.
6 VT=0.8
7 disp("VT = "+string(VT)+" V") //initializing value
    of threshold Voltage.
8 Vgs=1
9 disp("Vgs = "+string(Vgs)+" V") //initializing value
    of gate to source voltage.
10 tox=400*10^-8
11 disp("tox = "+string(tox)+" cm") //initializing
    value of gate oxide thickness.
12 et=3.9
13 disp("et = "+string(et)) //initializing value of
    relative permittivity.
14 eo=8.85*10^-14
15 disp("eo = "+string(eo)+"F/cm") //initializing value
    of free space permittivity.
16 eox=(eo*et)
17 disp("eox=(eo*et)="+string(eox)+" F/cm^2")//
    calculation
18 W=25*10^-6
19 disp("W = "+string(W)+"m") //initializing value of
    width of channel..
20 Id=((eox*un*W)/(tox*L)*((Vgs-VT)^2/(2)))
21 disp("Drain current ,Id=((eox*un*W)/(tox*L)*((Vgs-VT)
    ^2/(2)))="+string(Id)+" A")//calculation

```

Scilab code Exa 8.17 RATIO OF W AND L

```

1 clc
2 un=525
3 disp("un = "+string(un)+"cm^2/V-s") //initializing
    value of mobility of n-channel MOS transistor.
4 VT=0.75

```

```

5 disp("VT = "+string(VT)+" V") //initializing value
  of threshold Voltage.
6 Vgs=2
7 disp("Vgs = "+string(Vgs)+" V") //initializing value
  of gate to source voltage.
8 tox=400*10^-8
9 disp("tox = "+string(tox)+" cm") //initializing
  value of gate oxide thickness.
10 et=3.9
11 disp("et = "+string(et)) //initializing value of
  relative permittivity.
12 eo=8.85*10^-14
13 disp("eo = "+string(eo)+"F/cm") //initializing value
  of free space permittivity.
14 eox=(eo*et)
15 disp("eox=(eo*et)="+string(eox)+" F/cm^2")//
  calculation
16 Id=6*10^-3
17 disp("Id = "+string(Id)+"A") //initializing value of
  width of channel..
18 X=((Id*tox*2)/(eox*un*((Vgs-VT)^2)))
19 disp("width to length ratio ,W/L=((Id*tox*2)/(eox*un
  *((Vgs-VT)^2)))="+string(X))//calculation

```

Scilab code Exa 8.18 PINCH OFF VOLTAGE

```

1 clc
2 Nd=2*10^16
3 disp("Nd = "+string(Nd)+" /cm^3") //initializing
  value of donor ion concentration.
4 a=2*10^-4
5 disp("a = "+string(a)+" cm") //initializing value of
  height of channel at pinch off.
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columns") //initializing

```

```

    value of charge of electrons.
8 Er=11.9
9 disp("Er = "+string(Er)) //initializing value of
    relative permittivity.
10 Eo=8.85*10^-14
11 disp("Eo = "+string(Eo)+"F/cm") //initializing value
    of free space permittivity.
12 E=(Eo*Er)
13 disp("E=(Eo*Er)="+string(E)+" F/cm^2")//calculation
14 Vp=((e*Nd*a^2)/(2*E))
15 disp("Pinch off Voltage ,Vp=((e*Nd*a^2)/(2*E))="+
    string(Vp)+" V")//calculation

```

Scilab code Exa 8.20 VALUE OF rDS

```

1 clc
2 a=2*10^-4
3 disp("a = "+string(a)+" cm") //initializing value of
    height of channel at pinch off.
4 Er=11.9
5 disp("Er = "+string(Er)) //initializing value of
    relative dielectric permittivity constant .
6 Eo=8.854*10^-14
7 disp("Eo = "+string(Eo)+" F/cm") //initializing
    value of permittivity of free space.
8 un=1350
9 disp("un = "+string(un)+"cm^2/V-s") //initializing
    value of mobility of n-type silicon Mosfet.
10 W=8*10^-4
11 disp("W = "+string(W)+" cm") //initializing value of
    width of p-substrate.
12 L=10*10^-4
13 disp("L = "+string(L)+" cm") //initializing value of
    length of p-substrate.
14 e=1.6*10^-19

```

```

15 disp("e = "+string(e)+" columns") //initializing
    value of charge of electrons.
16 Vp=4
17 disp("Vp = "+string(Vp)+" V") //initializing value
    of thickness of p-substrate.
18 Vgs=0
19 disp("Vgs = "+string(Vgs)+" V") //initializing value
    of gate to source voltage.
20 E=Eo*Er
21 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
    )//calculation
22 Nd=((Vp*2*E)/(e*a^2))
23 disp("Donor ion concentration ,Nd=((Vp*2*E)/(e*a^2))
    =" +string(Nd)+" /cm^3")//calculation
24 rds=(L/(W*a*e*un*Nd))
25 disp("On Drain resistance ,rds=(L/(W*a*e*un*Nd))=" +
    string(rds)+" ohm")//calculation

```

Chapter 10

SILICON CONTROLLED RECTIFIER

Scilab code Exa 10.2 VALUE OF PUNCH THROUGH VOLTAGE

```
1 clc
2 Nd=10^14
3 disp("Nd = "+string(Nd)+" /cm^-3") //initializing
  value of donor ion concentration.
4 Er=11.9
5 disp("Er = "+string(Er)) //initializing value of
  relative dielectric permittivity constant .
6 e=1.6*10^-19
7 disp("e = "+string(e)+" columns") //initializing
  value of charge of electrons.
8 Eo=8.854*10^-14
9 disp("Eo = "+string(Eo)+" F/cm") //initializing
  value of permittivity of free space.
10 W=100*10^-4
11 disp("W = "+string(W)+" cm") //initializing value of
  width of SCR.
12 E=Eo*Er
13 disp("total permittivity ,E=Eo*Er="+string(E)+" F/cm"
  )//calculation
```

```

14 Vpt=(e*Nd*W^2)/(2*E)
15 disp("Punch trough voltage ,Vpt=(e*Nd*W^2)/(2*E))="+
    string(Vpt)+" V")//calculation

```

Scilab code Exa 10.3 VALUE OF THE DIFFERENTIAL TERM

```

1  clc
2  Ia=2*10^-3
3  disp("Ia = "+string(Ia)+" A") //initializing value
    of forward current of thyristor.
4  x=0.9
5  disp("(ap+an) = "+string(x)) //initializing value of
    sum of current gain of n,ptype semiconductor [
    value is get in by variable x,but represented on
    console window through ap +an].
6  a=0.45
7  disp("a = "+string(a)) //initializing value of
    current gain of both n,p type semiconductor (as
    it is assume that ap[current gain of n type
    semiconductor]=an[current gain of ptype
    semiconductor]in the question).
8  Ico=Ia*(1-(2*a))
9  disp("Ico=Ia*(1-(2*an))="+string(Ico)+" A")//
    calculation
10 y=1/2*Ico*((Ia)^-2)
11 disp("(da/dt)=1/2*Ico*((Ia)^-2)="+string(y)+" /A")
    //calculation
12
13 //The answer for (da/dt) after doing calculation is
    provided wrong in the book.

```
