

Scilab Textbook Companion for
Solid State Devices and Materials
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May 29, 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 and Materials

Author: R. K. Singh and D. S. Chauhan

Publisher: Wiley India Pvt. Ltd., New Delhi

Edition: 1

Year: 2011

ISBN: 978-81-265-2961-2

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 Semiconductor And Magnetic Materials	5
2 Physics Of Semiconductors	18
3 Junction Diode And Capacitance	43
4 Optoelectronic Devices	55
5 Frequency and High Power Devices	72
6 Bipolar Junction Transistor Fets And Mosfet	79
7 Voltage Regulator And Nonlinear Circuits	96

List of Scilab Codes

Exa 1.2	Conductivity and mobility	5
Exa 1.3	Hole and electron concentration	6
Exa 1.4	Conductivity and resistivity	6
Exa 1.5	Conductivity	7
Exa 1.6	Fraction of the total number of electrons	8
Exa 1.7	Ratio of electron to hole concentration	8
Exa 1.8	Charge density of free electrons	9
Exa 1.9	Time taken by the electron to travel	10
Exa 1.10	Horizontal component of the magnetic intensity	10
Exa 1.11	Current sending through the solenoid	11
Exa 1.12	Magnetic moment of the rod	11
Exa 1.13	Relative permeability	12
Exa 1.14	Flux density	12
Exa 1.15	Conductivity of a bar	13
Exa 1.16	Hole concentration and conductivity	13
Exa 1.17	Hole and electron concentration	14
Exa 1.18	Conductivity of the material	14
Exa 1.19	Conductivity of intrinsic Ge	15
Exa 1.20	Drift velocity of free electrons	15
Exa 1.21	Conductivity of Si material	16
Exa 1.22	Conductivity of Si material	16
Exa 2.1	Mobility and drift velocity	18
Exa 2.2	Value of intrinsic conductivities	19
Exa 2.3	Free electrons and hole mobilities	19
Exa 2.4	Conductivity of Si sample	20
Exa 2.5	Conductivity of copper	20
Exa 2.6	Conductivity of hole and electrons in an n type Si	21
Exa 2.7	Resistivity of Ge drops	21

Exa 2.8	Resistivity of intrinsic Si	22
Exa 2.9	The value of temperature at which the Fermi level coincides	23
Exa 2.10	Minority carrier concentration	23
Exa 2.11	Conductivity and resistivity of intrinsic sample of Si	24
Exa 2.12	Resistivity of Si	25
Exa 2.13	Total conduction current density	25
Exa 2.14	The minority carrier concentration at room temperature	26
Exa 2.15	Doping level and drift velocity	27
Exa 2.16	Relaxatime and drift velocity of electron in copper	28
Exa 2.17	Resistivity of the material	29
Exa 2.18	Conductivity of Si material	29
Exa 2.19	Electron hole concentration in the material	30
Exa 2.20	Resistivity	31
Exa 2.21	Conductivity and mobility for a copper wire	31
Exa 2.22	Conductivity and resistivity of an intrinsic Si	32
Exa 2.23	The value of intrinsic conductivity	32
Exa 2.24	Intrinsic carrier concentration of Ge	33
Exa 2.25	Conductivity of Si sample	33
Exa 2.26	Conductivity and resistivity of Ge	34
Exa 2.27	Conductivity of extrinsic semiconductor	34
Exa 2.28	Fraction of the total number of electrons	35
Exa 2.29	Ratio of electron to hole concentration	35
Exa 2.30	Charge density of free electrons	36
Exa 2.31	Drift velocity and time taken by the electron to travel	37
Exa 2.32	Conductivity of intrinsic Ge	37
Exa 2.33	Electron and hole drift velocity	38
Exa 2.34	Intrinsic carrier concentration in Si	39
Exa 2.35	Junction potential	39
Exa 2.36	Current flowing in the diode	40
Exa 2.37	Forward current for a Ge diode at room temperature	40
Exa 2.38	Dynamic resistance of Ge pn junction diode	41
Exa 2.39	AC resistance of a semiconductor diode	41
Exa 2.40	Magnitude of r for the Si pn junction	42
Exa 3.1	The transition capacitance of diode	43
Exa 3.2	The diffusion capacitance in pn junction diode	43
Exa 3.3	The diode current for the forward bias voltage	44
Exa 3.4	The constant n for the diode	45

Exa 3.5	Voltage to be applied across a pn junction	45
Exa 3.6	Voltage to be applied across a pn junction	46
Exa 3.7	Junction forward bias voltage	47
Exa 3.8	Voltage at which the reverse in a Ge diode	48
Exa 3.9	Factor by which the current will get multiplied	48
Exa 3.10	Forward and reverse resistance	49
Exa 3.11	Dynamic resistance	49
Exa 3.12	Forward and reverse dynamic resistance	50
Exa 3.13	Static and dynamic resistance	51
Exa 3.14	DC resistance levels	51
Exa 3.15	Junction dynamic resistance	52
Exa 3.16	Dynamic resistance of a diode	53
Exa 3.17	Dynamic resistance	53
Exa 4.1	The slope efficiency	55
Exa 4.2	Power efficiency of a VCSEL diode	56
Exa 4.3	Power radiated by an LED	56
Exa 4.4	Internal quantum efficiency and optical power generated	57
Exa 4.5	Photocurrent	57
Exa 4.6	Quantum efficiency of photo detector	58
Exa 4.7	Responsivity of an InGaAs photo diode	58
Exa 4.8	Responsivity	59
Exa 4.9	Currents in a circuit	60
Exa 4.10	Minimum and maximum values of LED current	60
Exa 4.11	Supply voltage	61
Exa 4.12	Smallest standard resistor value	62
Exa 4.13	Responsivity of the photo diode	62
Exa 4.14	Power radiated by an LED	63
Exa 4.15	Internal quantum efficiency	63
Exa 4.16	Quantum efficiency of photo detector	64
Exa 4.17	Responsivity of an InGaAs photo diode	64
Exa 4.18	Minimum and maximum values of LED current	65
Exa 4.19	Supply voltage	65
Exa 4.20	The value of current in the circuit	66
Exa 4.21	Responsivity and received optical power	67
Exa 4.22	Internal quantum efficiency and optical power generated	67
Exa 4.23	Power radiated by an LED	68
Exa 4.24	Minimum and maximum values of LED current	68
Exa 4.25	Smallest standard resistor value	69

Exa 4.26	The slope efficiency	69
Exa 4.27	Power efficiency of a VCSEL diode	70
Exa 4.28	Probability of exciting electron	70
Exa 4.29	Ratio of majority to minority charge carrier	71
Exa 5.1	Tuning range for the circuit	72
Exa 5.2	The value of CT	73
Exa 5.3	Space charge capacitance	73
Exa 5.4	The value of CT	74
Exa 5.5	The depletion layer capacitance	74
Exa 5.6	Decrease in capacitance	75
Exa 5.7	Diffusion capacitance for a Si diode	75
Exa 5.8	Transition capacitance	76
Exa 5.9	Decrease in capacitance	76
Exa 5.10	Tuning range for the circuit	77
Exa 5.11	Tuning range for the circuit	77
Exa 6.1	Transfer curve	79
Exa 6.2	Transfer curve	79
Exa 6.3	Value of V_{gs} and g_m	80
Exa 6.4	value of V_{gs}	81
Exa 6.5	The value of transconductance of a FET	81
Exa 6.6	The value of V_o and V_i	82
Exa 6.7	Drain to source voltage	82
Exa 6.8	Maximum transconductance of a certain n channel JFET	83
Exa 6.9	Transconductance	84
Exa 6.10	The value of V_{GS}	84
Exa 6.11	Minimum value of V_{DS}	85
Exa 6.12	Effective input impedance	85
Exa 6.13	q value of V_{DS}	86
Exa 6.14	The value of V_{GS} and V_{DS}	87
Exa 6.15	The value of V_{GS} and I_D	88
Exa 6.16	The value of V_{GS} and I_D	89
Exa 6.17	The value of I_{DS} g_{mo} and g_m	89
Exa 6.20	The value of V_{GS} and I_D	90
Exa 6.21	Drain source resistance	91
Exa 6.22	The value of I_d and V_{DS}	92
Exa 6.23	The value of R_D	92
Exa 6.24	Channel resistance	93
Exa 6.25	The value of V_{GS}	94

Exa 6.26	The value of I_{DSS}	94
Exa 6.27	Minimum value of V_{DS}	95
Exa 7.1	Base emitter and zener diode current	96
Exa 7.2	Base emitter and zener diode current	97
Exa 7.3	Base emitter and zener diode current	99
Exa 7.4	Resistance and current	100
Exa 7.5	Output voltage	101

Chapter 1

Semiconductor And Magnetic Materials

Scilab code Exa 1.2 Conductivity and mobility

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

```

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

```

Scilab code Exa 1.3 Hole and electron concentration

```

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

```

Scilab code Exa 1.4 Conductivity and resistivity

```

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

```

```

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

```

Scilab code Exa 1.5 Conductivity

```

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

```

Scilab code Exa 1.6 Fraction of the total number of electrons

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

Scilab code Exa 1.7 Ratio of electron to hole concentration

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

Scilab code Exa 1.8 Charge density of free electrons

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

Scilab code Exa 1.9 Time taken by the electron to travel

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

Scilab code Exa 1.10 Horizontal component of the magnetic intensity

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

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

Scilab code Exa 1.11 Current sending through the solenoid

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

Scilab code Exa 1.12 Magnetic moment of the rod

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



```

13 // Then  $I = \mu_r \mu_0 H / \mu_0 - H = (\mu_r - 1) H$ 
14 //  $H = n i$ 
15  $I = (\mu_r - 1) n i$ ; // in amp/meter
16  $\text{MagMoment} = I \cdot \text{vol}$ ; // in  $\text{Am}^2$ 
17 disp(round(MagMoment), "Magnetic moment in  $\text{Am}^2$  is :
      ")

```

Scilab code Exa 1.13 Relative permeability

```

1 // Exa 1.13
2 clc;
3 clear;
4 close;
5 format('v',13);
6 // Given data
7  $X_m = 9.48 \cdot 10^{-9}$ ;
8  $\mu_r = 1 + X_m$ ; //
9 disp( $\mu_r$ , "Relative permeability si : ")
10 disp("That is r is slightly greater than 1");

```

Scilab code Exa 1.14 Flux density

```

1 // Exa 1.14
2 clc;
3 clear;
4 close;
5 // Given data
6  $\phi_{e_B} = 2 \cdot 10^{-6}$ ; // in weber
7  $A = 10^{-4}$ ; // in  $\text{m}^2$ 
8  $N = 300$ ; // number of turns
9  $l = 30$ ; // in cm
10  $l = 1 \cdot 10^{-2}$ ; // in meter
11  $i = 0.032$ ; // in amp

```

```

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

```

Scilab code Exa 1.15 Conductivity of a bar

```

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

```

Scilab code Exa 1.16 Hole concentration and conductivity

```

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

```

```

8 ni= 2.4*10^19; // in /m^3
9 miu_n= 3500; // in cm^2/vs
10 miu_n= miu_n*10^-4; // in m^2/vs
11 // Formula n*p= ni^2
12 p= ni^2/n; // in m^-3
13 disp(p,"Hole concentration in m^-3 is : ")
14 sigma=q*n*miu_n; // in ( -m)^-1
15 disp(sigma,"The conductivity of the extrinsic
    semiconductor in ( m )^-1 is :")
16
17 // Note : There is miss print in the printed value
    of p and also calculation error in evaluating the
    value of p . So the answer in the book is wrong

```

Scilab code Exa 1.17 Hole and electron concentration

```

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

```

Scilab code Exa 1.18 Conductivity of the material

```

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

```

Scilab code Exa 1.19 Conductivity of intrinsic Ge

```

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

```

Scilab code Exa 1.20 Drift velocity of free electrons

```

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

```

Scilab code Exa 1.21 Conductivity of Si material

```

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

```

Scilab code Exa 1.22 Conductivity of Si material

```

1 // Exa 1.22
2 clc;

```

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

Chapter 2

Physics Of Semiconductors

Scilab code Exa 2.1 Mobility and drift velocity

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

Scilab code Exa 2.2 Value of intrinsic conductivities

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

Scilab code Exa 2.3 Free electrons and hole mobilities

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

Scilab code Exa 2.4 Conductivity of Si sample

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

Scilab code Exa 2.5 Conductivity of copper

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

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

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

Scilab code Exa 2.7 Resistivity of Ge drops

```

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

```

Scilab code Exa 2.8 Resistivity of intrinsic Si

```

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

```

```

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

```

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

```

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

```

Scilab code Exa 2.10 Minority carrier concentration

```

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

```

```

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

```

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

```

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

```

```

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

```

Scilab code Exa 2.12 Resistivity of Si

```

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

```

Scilab code Exa 2.13 Total conduction current density

```

1 // Exa 2.13
2 clc;
3 clear;
4 close;
5 // Given data
6 q=1.6*10^-19; // in C
7 rho=75; //in cm
8 N_D= 10^13; // in /cm^3
9 N_A= 5*10^12; //in /cm^3
10 E=3; // in V/cm
11 ni= 2.7*10^12; // in /cm^3
12 sigma= 1/rho; // in (cm)^-1
13 // miu_p/miu_n= 1/3 or miu_n=3*miu_p
14 // sigma= q*ni*(miu_n+miu_p) = q*ni*(3*miu_p+miu_p)
    = q*ni*(4*miu_p)
15 miu_p= sigma/(q*ni*4);
16 miu_n= 3*miu_p;
17 // n+N_A= p+N_D or n= p+N_D-N_A
18 // n*p= ni^2 or (p+N_D-N_A)*p= ni^2
19 // p^2 + (N_D-N_A)*p-ni^2 =0
20 // values= [1 (N_D-N_A) -ni^2];
21 p = roots([1 5*10^12 -7.29*10^24])
22 p=p(2); //discarding -ve value
23 n=p+N_D-N_A;
24 I= q*(n*miu_n+p*miu_p)*E // in A/m^2
25 disp(I,"The total conduction current in A/m^2 is : ")
    )
26
27 // Note: There is some difference between book
    answer and coding. The reason behind this is that
28 // The value of P is evaluated 1.8*10^12
    while accurate value is 1.179674*10^12

```

Scilab code Exa 2.14 The minority carrier concentration at room temperature

```

1 // Exa 2.14
2 clc;
3 clear;
4 close;
5 // Given data
6 N_D= 10^20; // in /cm^3
7 ni= 2.5*10^12; // in /cm^3
8 kT=26; // in meV
9 kT=kT*10^-3; // in eV
10 n= N_D; // as N_D>>ni
11 p= ni^2/n; //in /cm^3
12 disp(p,"The minority carrier concentration per cm^3
    is :")
13
14 // Part (b)
15 LocationOfFermiLevel= kT*log(N_D/ni); // in eV
16 disp("The Fermi Level will be "+string(
    LocationOfFermiLevel)+" eV above Fermi level")
17
18 //Note: The value of Minority carrier concentration
    of part(a) is calculated wrong because the value
    of (2.5*10^12)^2/(10^20) will be 62500 not
    2.5*10^4

```

Scilab code Exa 2.15 Doping level and drift velocity

```

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

```



```

10 L=8; // in cm
11 A=0.8*0.8; // in cm^2
12 I=4*10^-3; // in A
13 // R= rho*L/A = V/I
14 R= V/I; // in
15 sigma= L/(R*A); // in ( cm )^-1
16 // sigma= q*n*miu_n
17 n= sigma/(q*miu_n);
18 N_D= n;
19 disp(N_D,"The value of N_D is :")
20 // Part (b)
21 d=L;
22 E= V/d;
23 vd=miu_n*E; // in cm/s
24 disp(vd,"Drift velocity in cm/s is : ")

```

Scilab code Exa 2.16 Relaxation time and drift velocity of electron in copper

```

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

```

Scilab code Exa 2.17 Resistivity of the material

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

Scilab code Exa 2.18 Conductivity of Si material

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

```

17
18 // Part (c)
19 p= 5*10^28/10^8;
20 sigma= q*p*miu_p;// in ( m )^-1
21 disp(sigma,"The conductivity with acceptor impurity
    in ( m )^-1 is : ")
22
23 // Part (d)
24 p_desh= p-n;// in /m^3
25 sigma= q*p_desh*miu_p;// in ( m )^-1
26 disp(sigma,"The conductivity with donar and acceptor
    impurity in ( m )^-1 is : ")
27
28 // Note : Answer in the book of part (a) may be miss
    printed or wrong

```

Scilab code Exa 2.19 Electron hole concentration in the material

```

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

```

Scilab code Exa 2.20 Resistivity

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

Scilab code Exa 2.21 Conductivity and mobility for a copper wire

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

Scilab code Exa 2.22 Conductivity and resistivity of an intrinsic Si

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

Scilab code Exa 2.23 The value of intrinsic conductivity

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

Scilab code Exa 2.24 Intrinsic carrier concentration of Ge

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

Scilab code Exa 2.25 Conductivity of Si sample

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

Scilab code Exa 2.26 Conductivity and resistivity of Ge

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

Scilab code Exa 2.27 Conductivity of extrinsic semiconductor

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

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

Scilab code Exa 2.28 Fraction of the total number of electrons

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

Scilab code Exa 2.29 Ratio of electron to hole concentration

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



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

Scilab code Exa 2.30 Charge density of free electrons

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

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

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

Scilab code Exa 2.32 Conductivity of intrinsic Ge

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

```

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

```

Scilab code Exa 2.33 Electron and hole drift velocity

```

1 // Exa 2.33
2 clc;
3 clear;
4 close;
5 // Given data
6 e=1.6*10^-19; // in C
7 a= 0.004*0.0015; // in m^2
8 ni= 2.5*10^19; // per m^3
9 miu_e= 0.38; // in m^2/v-s
10 miu_p= 0.18; // in m^2/v-s
11 V=10; // in V
12 i= 25; // in mm
13 i=i*10^-3; // in m
14 E= V/i; // in V/m
15 // Part (a)
16 ve= miu_e*E; // in m/sec
17 disp(ve,"Electric drift velocity in m/sec is : ")
18 vp= miu_p*E; // in m/sec
19 disp(vp,"Hole drift velocity in m/sec is : ")
20
21 // Part (b)

```

```

22 sigma_i= ni*e*(miu_e+miu_p);// in ( cm )^-1
23 disp(sigma_i,"Intrinsic carrier conductivity of Ge
    in ( cm )^-1 is : ")
24
25 // Part (c)
26 I= sigma_i*E*a;// in A
27 I=I*10^3;// in mA
28 disp(I,"Total current in mA is : ")

```

Scilab code Exa 2.34 Intrinsic carrier concentration in Si

```

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

```

Scilab code Exa 2.35 Junction potential

```

1 // Exa 2.35

```

```

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

```

Scilab code Exa 2.36 Current flowing in the diode

```

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

```

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

```

1  // Exa 2.37
2  clc;
3  clear;
4  close;
5  // Given data

```

```

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

```

Scilab code Exa 2.38 Dynamic resistance of Ge pn junction diode

```

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

```

Scilab code Exa 2.39 AC resistance of a semiconductor diode

```

1 // Exa 2.39
2 clc;
3 clear;

```

```

4 close;
5 // Given data
6 T=300; // in K
7 n=1;
8 V_T= 26; // in mV
9 V_T=V_T*10^-3; // in V
10 V_F= 200; // in mV
11 V_F=V_F*10^-3; // in V
12 Io= 1; // in A
13 Io= Io*10^-6; // in A
14 r_F= n*V_T/(Io*%e^(V_F/(n*V_T))); // in
15 disp(r_F,"The ac resistance of a semiconductor diode
      in      ")

```

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

```

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

```

Chapter 3

Junction Diode And Capacitance

Scilab code Exa 3.1 The transition capacitance of diode

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

Scilab code Exa 3.2 The diffusion capacitance in pn junction diode

```
1 // Exa 3.2
```



```

2  clc;
3  clear;
4  close;
5  // Given data
6  toh= 10-6; // in sec
7  I=10; // in mA
8  I=I*10-3; // in A
9  n=1;
10 V_T= 26; // in mV
11 V_T= V_T*10-3; // in V
12 C_D= toh*I/(n*V_T); // in F
13 disp(C_D*109, "The diffusion capacitance in p-n
      junction diode in nF")
14
15 // Note: There are two mistake in the book. First
      one is this that they put the wrong value of I to
      evaluating the value of C_D because the value of
      I is given 10mA (i.e. 10*10-3= 10-2 amp) but
      they put 10-3 at place
16 //           of 10-2 and second one is calculation
      error. So the answer in the book is wrong.

```

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

```

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

```

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

Scilab code Exa 3.4 The constant n for the diode

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

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

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

```

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

```

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

```

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

```

```

1
16 V= n*k*T*log(J/Jo)/e;
17 disp(V,"Voltage to be applied across the junction in
    volt is")
18
19 // Note:- In the book, the value of T (i.e. 300) has
    not been putted to evaluate the value of V. So
    if we'll not put the value of T to evaluate the
    value of V, then the answer of coding will be
    same as book. Hence the
20 // the answer in the book is wrong.

```

Scilab code Exa 3.7 Junction forward bias voltage

```

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

```

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

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

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

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

```

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

```

Scilab code Exa 3.10 Forward and reverse resistance

```

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

```

Scilab code Exa 3.11 Dynamic resistance

```

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

```

Scilab code Exa 3.12 Forward and reverse dynamic resistance

```

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

```

```

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

```

Scilab code Exa 3.13 Static and dynamic resistance

```

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

```

Scilab code Exa 3.14 DC resistance levels

```

1 // Exa 3.14
2 clc;
3 clear;

```



```

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

```

Scilab code Exa 3.15 Junction dynamic resistance

```

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

```

```

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

```

Scilab code Exa 3.16 Dynamic resistance of a diode

```

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

```

Scilab code Exa 3.17 Dynamic resistance

```

1 // Exa 3.17
2 clc;
3 clear;
4 close;
5 // Given data
6 I= 30; // in A
7 I=I*10^-6; // in A
8 T=125+273; // in K
9 r_F= T/(11600*I*%e^(-0.32/T)*11600); // in
10 disp(r_F*10^3,"The dynamic resistance in m is : ")
11
12 // Note: There are two error in this example in the
    book. First one is this that putted value of T in
    first term of calculation (i.e 3.98/11600) is
    wrong (correct value is 398 not 3.98).
13 // and second one error is this that
    calculaiton is also wrong for putted value

```

Chapter 4

Optoelectronic Devices

Scilab code Exa 4.1 The slope efficiency

```
1 // Exa 4.1
2 clc;
3 clear;
4 close;
5 // Given data
6 Ep= 0.0153*10^-17; //in J
7 lamda= 1300; // in nm
8 nita_ext= 0.1;
9 e = 1.6*10^-19; //in C
10 Eg= 1.42*e; // in eV
11 S= nita_ext*Eg/e; // in W/A (where S= deltaP/deltaI
    )
12 disp(S,"Slope of efficiency in W/A is : ")
13
14 // Note: In the book, the evaluated value of Eg/e is
    wrong because the value of 1.42*e/e = 1.42 not
    equal to 0.956 , Hence the answer in the book is
    wrong
```

Scilab code Exa 4.2 Power efficiency of a VCSEL diode

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

Scilab code Exa 4.3 Power radiated by an LED

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

wrong

Scilab code Exa 4.4 Internal quantum efficiency and optical power generated

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

Scilab code Exa 4.5 Photocurrent

```

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

```

Scilab code Exa 4.6 Quantum efficiency of photo detector

```

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

```

Scilab code Exa 4.7 Responsivity of an InGaAs photo diode

```

1 // Exa 4.7
2 clc;
3 clear;
4 close;

```

```

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

```

Scilab code Exa 4.8 Responsivity

```

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

```



```
is : ")
22
23 // Note : There is a calculation error in evaluating
    the value of n (number of received photons) , so
    the answer in the book is wrong
```

Scilab code Exa 4.9 Currents in a circuit

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

Scilab code Exa 4.10 Minimum and maximum values of LED current

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

```

9 R1= 470; // in
10 Imax= (Vs-VDmin)/R1; // in A
11 Imin= (Vs-VDmax)/R1; // in A
12 disp(Imax*103,"The maximum value of current in mA
    is : ")
13 disp(Imin*103,"The minimum value of current in mA
    is : ")

```

Scilab code Exa 4.11 Supply voltage

```

1 // Exa 4.11
2 clc;
3 clear;
4 close;
5 // Given data
6 VDmin= 1.8; // in V
7 VDmax= 3; // in V
8 // Case first
9 Vs= 24; // in V
10 R1= 820; // in
11 Imin= (Vs-VDmax)/R1; // in A
12 Imax= (Vs-VDmin)/R1; // in A
13 disp(Imax*103-Imin*103,"The variation in current
    in first case in mA is : ")
14 // Case second
15 Vs= 5; // in V
16 R1= 120; // in
17 Imin= (Vs-VDmax)/R1; // in A
18 Imax= (Vs-VDmin)/R1; // in A
19 disp(Imax*103-Imin*103,"The variation in current
    in first case in mA is : ")
20 disp("The variation in current in first case is
    smaller than in second case , So the brightness in
    the first case will remain constant , whereas in
    the second case it will be changing.")

```

Scilab code Exa 4.12 Smallest standard resistor value

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

Scilab code Exa 4.13 Responsivity of the photo diode

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

```

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

```

Scilab code Exa 4.14 Power radiated by an LED

```

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

```

Scilab code Exa 4.15 Internal quantum efficiency

```

1 // Exa 4.15
2 clc;
3 clear;
4 close;
5 // Given data
6 toh_r= 35;// in ns
7 toh_nr= 110;// in ns
8 toh= toh_r*toh_nr/(toh_r+toh_nr);// in ns
9 nita_int= toh/toh_r;

```

```

10 disp(nita_int,"The internal quantum efficiency is :
    ")
11
12 // Note : There is a calculation error (or miss
    printed ) in evaluating the value of nita_int (
    internal quantum efficiency ) so the answer in
    the book is wrong

```

Scilab code Exa 4.16 Quantum efficiency of photo detector

```

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

```

Scilab code Exa 4.17 Responsivity of an InGaAs photo diode

```

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

```

```

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

```

Scilab code Exa 4.18 Minimum and maximum values of LED current

```

1 // Exa 4.18
2 clc;
3 clear;
4 close;
5 // Given data
6 V_Dmin= 1; // in V
7 V_Dmax= 2; // in V
8 Vs= 20; // in V
9 R1= 470; // in
10 Imax= (Vs-V_Dmin)/R1; // in A
11 Imin= (Vs-V_Dmax)/R1; // in A
12 disp(Imax*10^3,"The maximum value of current in mA")
13 ;
14 disp(Imin*10^3,"The maximum value of current in mA")
15 ;

```

Scilab code Exa 4.19 Supply voltage

```

1 // Exa 4.19
2 clc;
3 clear;
4 close;
5 // Given data
6 V_Dmin= 2.5; // in V
7 V_Dmax= 5; // in V

```

```

8 // Case First
9 Vs= 25;// in V
10 Rs= 250;// in
11 Imax= (Vs-VDmin)/Rs;// in A
12 Imin= (Vs-VDmax)/Rs;// in A
13 disp(Imax*103-Imin*103,"The variation in current
    in first case in mA is : ")
14 // Case sec
15 Vs= 10;// in V
16 Rs= 130;// in
17 Imax= (Vs-VDmin)/Rs;// in A
18 Imin= (Vs-VDmax)/Rs;// in A
19 disp(Imax*103-Imin*103,"The variation in current
    in second case in mA is : ")
20 disp("Hence for the 25-V supply, the brightness of
    LED will be constant and for 10 V , it will be
    change")

```

Scilab code Exa 4.20 The value of current in the circuit

```

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

```

Scilab code Exa 4.21 Responsivity and received optical power

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

Scilab code Exa 4.22 Internal quantum efficiency and optical power generated

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



```

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

```

Scilab code Exa 4.23 Power radiated by an LED

```

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

```

Scilab code Exa 4.24 Minimum and maximum values of LED current

```

1 // Exa 4.24
2 clc;
3 clear;
4 close;
5 // Given data
6
7 V_Dmin= 2; // in V
8 V_Dmax= 4; // in V

```

```

9 Vs= 15; // in V
10 R1= 470; // in
11 Imax= (Vs-VDmin)/R1; // in A
12 Imin= (Vs-VDmax)/R1; // in A
13 disp(Imax*103, "The maximum value of current in mA
    is : ")
14 disp(Imin*103, "The minimum value of current in mA
    is : ")

```

Scilab code Exa 4.25 Smallest standard resistor value

```

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

```

Scilab code Exa 4.26 The slope efficiency

```

1 // Exa 4.26
2 clc;
3 clear;
4 close;
5 // Given data
6 Ep= 0.0153*10-17; // in J
7 lamda= 1300; // in nm

```

```

8 nita_ext= 0.1;
9 e = 1.6*10^-19; //in C
10 Eg= 1.42*e; // in eV
11 S= nita_ext*Eg/e; // in W/A (where S= deltaP/deltaI
    )
12 disp(S,"Slope of efficiency in W/A is : ")
13
14 // Note: In the book, the evaluated value of Eg/e is
    wrong because the value of 1.42*e/e = 1.42 not
    equal to 0.956 , Hence the answer in the book is
    wrong

```

Scilab code Exa 4.27 Power efficiency of a VCSEL diode

```

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

```

Scilab code Exa 4.28 Probability of exciting electron

```

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

```

Scilab code Exa 4.29 Ratio of majority to minority charge carrier

```

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

```

Chapter 5

Frequency and High Power Devices

Scilab code Exa 5.1 Tuning range for the circuit

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

Scilab code Exa 5.2 The value of CT

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

Scilab code Exa 5.3 Space charge capacitance

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

Scilab code Exa 5.4 The value of CT

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

Scilab code Exa 5.5 The depletion layer capacitance

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

Scilab code Exa 5.6 Decrease in capacitance

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

Scilab code Exa 5.7 Diffusion capacitance for a Si diode

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

Scilab code Exa 5.8 Transition capacitance

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

Scilab code Exa 5.9 Decrease in capacitance

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

```

10 C_T2= C_T1* sqrt(V1/V2);
11 disp(C_T2,"The capacitance for 1-V increase in bias
    in pF is : ")
12 disp(C_T1-C_T2,"Therefore , the decrease in
    capacitance in pF is :")
13
14 // NOTE: The answer in the book is wrong due to
    calculation error to evalaute the value of C_T2.

```

Scilab code Exa 5.10 Tuning range for the circuit

```

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

```

Scilab code Exa 5.11 Tuning range for the circuit

```

1 // Exa 5.11

```

```

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

```

Chapter 6

Bipolar Junction Transistor Fets And Mosfet

Scilab code Exa 6.1 Transfer curve

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

Scilab code Exa 6.2 Transfer curve

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

Scilab code Exa 6.3 Value of Vgs and gm

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

```

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

```

Scilab code Exa 6.4 value of Vgs

```

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

```

Scilab code Exa 6.5 The value of transconductance of a FET

```

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

```

Scilab code Exa 6.6 The value of V_o and V_i

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

Scilab code Exa 6.7 Drain to source voltage

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

```

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

```

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

```

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

```

Scilab code Exa 6.9 Transconductance

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

Scilab code Exa 6.10 The value of VGS

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

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

Scilab code Exa 6.11 Minimum value of VDS

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

Scilab code Exa 6.12 Effective input impedance

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

```

11 Rs= 4; // k
12 Rs= Rs*10^3; // in
13 // Part (a)
14 I_DSS= 1; // in mA
15 I_DSS= I_DSS*10^-3; // in A
16 V_P= -1; // in V
17 V_D= 10; // in V
18 I_D= (V_DD-V_D)/R_D; // in A
19 // I_D= I_DSS*(1-V_GS/V_P)^2; // in A
20 V_GS= V_P*(1-sqrt(I_D/I_DSS)); // in V
21 R1= abs(V_GS)/I_D; // in
22 disp(R1*10^-3,"The value of R1 in k is : ")
23
24 // Part (b)
25 gmo= -2*I_DSS/V_P; // A/V
26 gm= gmo*(1-(V_GS)/V_P); // A/V;
27 Ri= R_G/(1-gm*Rs/(1+gm*Rs)*Rs/(Rs+R1)); // in
28 disp(Ri*10^-6,"The effective input impedance in M
    is :")

```

Scilab code Exa 6.13 q value of VDS

```

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

```

```

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

```

Scilab code Exa 6.14 The value of VGS and VDS

```

1 // Exa 6.14
2 clc;
3 clear;
4 close;
5 // Given data
6 I_DSS= 4; // in mA
7 I_DSS= I_DSS*10^-3; // in A
8 V_P= -2; // in V
9 V_DD= 10; // in V
10 V_SS= V_DD; // in V
11 V_GS2=0; // in V
12 I_D= I_DSS*(1-V_GS2/V_P)^2; // in A
13 // since I_D= I_DSS
14 V_GS= 0; // in volt
15 // Formula V_SS= V_DS-V_GS

```

```

16 V_DS= V_SS-V_GS;// in volt
17 disp(I_D*10^3,"The value of I_D in mA is :")
18 disp(V_GS,"The value of V_GS in volt is : ")
19 disp(V_DS,"The value of V_DS in volts is :")
20
21 if V_DS > V_GS-V_P then
22     disp("The active region operation of the upper
           JFET is confirmed ")
23 end

```

Scilab code Exa 6.15 The value of VGS and ID

```

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

```

```

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

```

Scilab code Exa 6.16 The value of VGS and ID

```

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

```

Scilab code Exa 6.17 The value of IDS gmo and gm

```

1 // Exa 6.17

```

```

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

```

Scilab code Exa 6.20 The value of VGS and ID

```

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

```

```

        mA is : ")
18
19 // Part (ii)
20 // At I_DS= 3mA
21 I_DS= 3*10^-3; // in A
22 V_GS= V_P*(1-sqrt(I_DS/I_DSS));
23 disp(V_GS,"At I_DS= 3mA, the value of V_GS in volts
        is :")
24 // At I_DS= 5.5mA
25 I_DS= 5.5*10^-3; // in A
26 V_GS= V_P*(1-sqrt(I_DS/I_DSS));
27 disp(V_GS,"At I_DS= 5.5mA, the value of V_GS in
        volts is :")
28
29 // Note: There is calculation error in the second
        part to find the value of V_GS in both the
        condition . So the answer in the book is wrong

```

Scilab code Exa 6.21 Drain source resistance

```

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

```



```

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

```

Scilab code Exa 6.22 The value of Id and VDS

```

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

```

Scilab code Exa 6.23 The value of RD

```

1 // Exa 6.23

```

```

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

```

Scilab code Exa 6.24 Channel resistance

```

1  // Exa 6.24
2  clc;
3  clear;
4  close;
5  // Given data
6  ro=9; // in k
7  ro= ro*10^3; // in
8  V_P= -6; // in V
9  V_GS = -3; // in V
10 r= ro/(1-V_GS/V_P)^2; // in
11 disp(r*10^-3,"The value of channel resistance in k
    is : ")
12

```

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

Scilab code Exa 6.25 The value of VGS

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

Scilab code Exa 6.26 The value of IDSS

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

Scilab code Exa 6.27 Minimum value of VDS

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

Chapter 7

Voltage Regulator And Nonlinear Circuits

Scilab code Exa 7.1 Base emitter and zener diode current

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

```

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

```

Scilab code Exa 7.2 Base emitter and zener diode current

```

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

```

```

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

```

the Example 7.1
 44 // (i.e. I_{B1}= 19.8 mA and bita= 50)
 whereas in this example the value of bita is
 given 100 and the value of
 45 // of I_{B1} is calculated as 10 mA. So the
 answer of the last part of this example is wrong.

Scilab code Exa 7.3 Base emitter and zener diode current

```

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

```



```

27 //I2= .042;
28 I_C2= I2-I_B1;// in A
29 I_B1= (I1+I_L)/(1+bita);// in A
30 disp(I_B1*10^3,"The base current of T1 in mA is : ")
31 I_C2= I2-I_B1;// in A
32 I_E2= I_C2;// in A
33 disp(I_E2*10^3,"The emitter current of T2 in mA is :
    ")
34
35 // part (iii)
36 I3= (V2-V_Z)/R1;// in A
37 I_Z= I3+I_E2;// in A
38 disp(I_Z*10^3,"Current through zener diode in mA is
    : ")
39 V_CE= V2-V1;// in V
40 I_C1= bita*I_B1;// in A
41 T1= V_CE*I_C1;// in W
42 disp(T1,"Power dissipation in watt is : ")
43
44 // Note: In the book, the evaluated value of emitter
    current of T2 i.e. I_E2 and current through
    zener diode i.e I_Z is wrong because
45 //           there is a calculation error to evaluate
    the value of I2 ( (20-9)/500 = 42 mA is wrong,
    correct value is 22 mA)

```

Scilab code Exa 7.4 Resistance and current

```

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

```

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

Scilab code Exa 7.5 Output voltage

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