Scilab Textbook Companion for Electrical And Electronics Engineering Materials by J. B. Gupta[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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List of Scilab Codes

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Chapter 1

Crystal Stucture Of Materials

Scilab code Exa 1.3 Density Of Copper Crystal

```
1  //Exa3
2  clc;
3  clear;
4  close;
5  //given data
6  //atomic radius
7  r=1.278; //in Angstrum
8  //atomic weight
9  aw=63.5;
10 //Avogadro's number
11 an=6.023*10^23;
12 //copper has FCC structure for which
13 a=(4*r)/sqrt(2);// in Angstrum
14 a=a*10^-10;//in m
15 //Mass of one atom
16 m=aw/an;//in gm
17 m=m*10^-3;//in kg
18 //volume of one unit cell of copper crystal,
19 V=a^3;//in meter cube
20 //Number of atoms present in one unit cell of Cu(FCC
        Structure),
```

```
21  n =4;
22  // Density of crystal
23  rho =(m*n)/V ;// in kg/m^3
24  disp ("Density of crystal is : "+string (rho)+"kg/m^3"
        );
```

Scilab code Exa 1.4 Interplanar Distance in a crystal

```
1   // Exa4
2   clc ;
3   clear ;
4   close ;
5   // given data :
6   // wavelength
7   lamda =1.539; // in Angstrum
8   // angle
9   theta =22.5; // in degree
10  n =1;// (first order)
11
12  // Formula n*lamda =2* d* sin (theta) , so
13  // interplaner distance ,
14  d= lamda /(2* sin (theta *% pi /180));
15  disp ("Interplaner distance is : "+string (d)+"
        Angstrum")
```

Scilab code Exa 1.5 Wavelength of X rays

```
1   // Exa5
2   clc ;
3   clear ;
4   close ;
5   // given data :
6   n =2;
```

```
7  d=0.4;// in nenometer
8  d=d*10^-9;// in meter
9  theta=16.8/2;// in degree
10 //using Bragg's equation we have n*lamda=2*d*sin(
       theta), so
11 lamda=(2*d*sin(8.4*%pi/180))/n;
12 disp("Wavelength of X-rays used is : "+string(lamda
       *10^10)+" Angstrum");
```

Scilab code Exa 1.6 Wavelength of X rays

```
1  //Exa6
2  clc;
3  clear;
4  close;
5  //given data :
6  a=3.15; //in Angstrum
7  a=a*10^-10;//in meter
8  //angle
9  theta=20.2;//in degree
10 n=1;//(first order)
11 //for BCC crystal
12 d110=a/sqrt(2);//in meter
13 //Formula n*lamda=2*d*sin(theta)
14 lamda=(2*d110*sin(theta*%pi/180))/n;//in meter
15 disp("Wavelength is : "+string(lamda*10^10)+"
       Angstrum")
```

Scilab code Exa 1.7 Angle of incidence

```
1  //Exa7
2  clc;
3  clear;
```

```scilab
4  close;
5  //given data :
6  lambda=0.842; //in Angstrum
7  lambda=lambda*10^-10; // in meter
8  //theta=8degree 35minutes
9  theta=8+35/60;//in degree
10 n=1;//(first order)
11 //Formula n*lamda=2*d*sin(theta)
12 d=n*lambda/(2*sind(theta))
13 //For third Order reflection :
14 //Formula n*lamda=2*d*sin(theta)
15 n=3;//order
16 theta=asind(n*lambda/(2*d));
17 disp(round(theta),"Angle of incidence for third
       order reflection in degree : ");
```

Chapter 2

Conductivity of metals

Scilab code Exa 2.1 Drift Velocity of Electrons

```
 1  //Exa2.1
 2  clc;
 3  clear;
 4  close;
 5  //given data :
 6  J=2.4; //in A/mm^2
 7  J=2.4*10^6; //in A/m^2
 8  n=5*10^28; //unitless
 9  e=1.6*10^-19; // in coulomb
10  //Formula : J=e*n*v
11  v=J/(e*n);//in m/s
12  disp("Drift velocity is : "+string(v)+" m/s or "+
         string(v*10^3)+" mm/s")
```

Scilab code Exa 2.2 Magnitude of current

```
 1  //Exa2
 2  clc;
```

```
3  clear;
4  close;
5  //given data :
6  //Electron density
7  n=1*10^24;//unit less
8  //Electron charge
9  e=1.6*10^-19; // in coulomb
10 //Drift velocity
11 v=1.5*10^-2; // in meter per second
12 //cross-sectional area
13 A=1; // in centimeter square
14 A=1*10^-4; // in meter square
15 I=e*n*v*A;// in ampere
16 disp("Magnitude of current is :"+string(I)+" A")
```

Scilab code Exa 2.3 Relaxation time and resistivity

```
1  //Exa2.3
2  clc;
3  clear;
4  close;
5  //given data :
6  miu_e=7.04*10^-3; //in m^2/V-s
7  n=5.8*10^28 ; // in /m^3
8  e=1.6*10^-19; // in coulomb
9  m=9.1*10^-31;//in kg
10 //(i) Relaxation time,
11 tau=miu_e/e*m;
12 disp("Relaxation time is : "+string(tau)+" second");
13 sigma=(n*e*miu_e);
14 //(ii) Resistivity of conductor,
15 rho=1/sigma;
16 disp("Resistivity of conductor is : "+string(rho)+"
       ohm-meter");
```

Scilab code Exa 2.4 Valance electron and mobility of electron

```
1  //Exa4
2  clc;
3  clear;
4  close;
5  //given data :
6  rho=1.73*10^-8;//in ohm-meter
7  toh=2.42*10^-14 ; //in second
8  e=1.6*10^-19; //in C
9  m=9.1*10^-31;//in kg
10 sigma=1/rho;
11 //(i) Number of free electrons per m^3
12 n=(m*sigma)/(e^2*toh);
13 disp("Number of free electrons per cube meter is : "
        +string(n));
14 //(ii) Mobility of electrons ,
15 miu_e=(e*toh)/m;
16 disp("Mobility of electrons is : "+string(miu_e)+" m
        ^2/V-s");
17 //Note: Answer in the book is wrong
```

Scilab code Exa 2.5 Mobility and relaxation time

```
1  //Exa5
2  clc;
3  clear;
4  close;
5  //given data :
6  rho=1.54*10^-8; //in ohm-meter
7  //since sigma=1/roh
8  sigma=1/rho;
```

```
 9  n=5.8*10^28 ; //unit less
10  e=1.6*10^-19; //in C (electron charge)
11  m=9.1*10^-31;//in kg (mass of electron)
12  //(i) Relaxation time
13  toh=(sigma*m)/(n*e^2);
14  disp(”(i) Relaxation time of electrons is : ”+string
        (toh)+” seconds”);
15  //(ii) Mobility of electrons ,
16  miu_e=(e*toh)/m;
17  disp(”(ii) Mobility of electrons is : ”+string(miu_e
        )+” m^2/V−s”);
```

Scilab code Exa 2.6 Relaxation time

```
 1  //Exa2.6
 2  clc;
 3  clear;
 4  close;
 5  //given data :
 6  rho=1.7*10^-8; //in ohm−meter
 7  //since sigma=1/roh
 8  sigma=1/rho;
 9  n=8.5*10^28 ; //unit less
10  e=1.6*10^-19; //in C (electron charge)
11  m=9.1*10^-31;//in kg
12  // Relaxation time
13  toh=(sigma*m)/(n*e^2);
14  disp(” Relaxation time of electrons is : ”+string(
        toh)+” seconds”);
```

Scilab code Exa 2.7 Relaxation time of conducting electrons

```
 1  //Exa2.7
```

```
2  clc;
3  clear;
4  close;
5  format('v',11);
6  //given data :
7  E=100;//in V/m
8  rho=1.5*10^-8; //in ohm-meter
9  //since sigma=1/roh
10 sigma=1/rho;
11 n=6*10^28 ; //unit less
12 e=1.601*10^-19; //in C
13 m=9.107*10^-31;//in kg
14 // Relaxation time
15 toh=(sigma*m)/(n*e^2);
16 disp("(i) Relaxation time of electrons is : "+string
       (toh)+" seconds");
17 //Drift velocity
18 v=(e*E*toh)/m;
19 disp("(ii) Drift velocity is : "+string(v)+" m/s");
```

Scilab code Exa 2.8 Charge density current density and drift velocity

```
1  //Exa2.8
2  clc;
3  clear;
4  close;
5  //given data :
6  //Diameter of copper wire
7  d=2;//in milimeter
8  d=.002;//in meter
9  //conductivity of copper
10 nita=5.8*10^7;//in second per meter
11 //Electron mobility
12 miu_e=.0032;//in meter square per volt-second
13 //Applied electric field
```

```
14  E=20;//in mV/m
15  E=.02;  //in V/m
16  e=1.6*10^-19;
17  //(i) From eq. (2.13)
18  //charge density
19  n=nita/(e*miu_e);//in per meter cube
20  disp("(i) Charge density is : "+string(n)+" /meter
        cube");
21  //(ii) from eq. (2.9)
22  //current density
23  J=nita*E;// in A/m^2
24  disp("(ii) Current density is : "+string(J)+" A/m^2"
        );
25  //(iii) Current flowing in the wire I=J* Area of x-
        section of wire
26  // Area of x-section of wire= (%pi*d^2)/4
27  I=(J*%pi*d^2)/4;
28  disp("(iii) Current flowing in the wire is : "+
        string(I)+" A");
29  //(iv) form eq.2.14
30  //Electron drift velocity
31  v=miu_e*E;
32  disp("(iv) Electron drift velocity is :"+string(v)+"
        m/s");
```

Scilab code Exa 2.9 Drift velocity

```
1  //Exa2.9
2  clc;
3  clear;
4  close;
5  //given data
6  rho=0.5; // in ohm-meter
7  J=100; //in A/m^2
8  miu_e=0.4; //in m^2/V-s
```

```
9  E=J*rho; // since E=J/sigma
10 // Formula v=miu_e*E
11 v=miu_e*E;
12 disp(" Electron drift velocity is : "+string(v)+" m/
      s");
13 disp("Time taken by the electron to travel 10*10^-6
      m in crystal")
14 // let Time taken by the electron to travel 10*10^-6
       m in crystal = t
15 t=(10*10^-6)/v;
16 disp(string(t)+" second");
```

Scilab code Exa 2.10 Resistivity of silicon

```
1  //Exa10
2  clc;
3  clear;
4  close;
5  //given data
6  miu_e=0.17;//in m^2/V-s
7  miu_h=0.035;//in m^2/V-s
8  nita_i=1.1*10^16;  //in /m^3
9  e=1.6*10^-19;// in C (electron charge)
10 // Intrinsic conductivity,
11 sigma_i=(nita_i*e)*(miu_e+miu_h);
12 IntrinsicResistivity=1/sigma_i;
13 disp("Intrinsic resistivity is : "+string(
      IntrinsicResistivity)+" ohm-meter");
```

Scilab code Exa 2.11 Carrier density

```
1  //Exa11
2  clc;
```

```
 3 clear ;
 4 close ;
 5 // given data
 6 rho_i =2*10^-3; // in ohm−m ( there is miss printed in
       this line in the book )
 7 sigma_i =1/ rho_i ;
 8 miu_e =0.3; // in m^2/V−s
 9 miu_h =0.1; // in m^2/V−s
10 e =1.6*10^-19; // in C
11 // Formula sigma_i=nita_i∗e∗(miu_e+miu_h)
12 nita_i = sigma_i /( e *( miu_e + miu_h ) ) ;
13 disp (" Carrier density is : "+string ( nita_i ) +" /m^3")
      ;
```

Scilab code Exa 2.13 Temperature of coil

```
 1 // Exa2.13
 2 clc ;
 3 clear ;
 4 close ;
 5 // given data
 6 R_15 =250; // in ohm
 7 R_t2 =300 ; // in ohm
 8 alpha =0.0039; // in degree C
 9 t1 =15;
10 // Formula R_t2 = R_15 ∗ [1 + alpha1∗(t2 − t1)]
11 t2 =(( R_t2/R_15 ) -1)/ alpha + t1 ;
12 disp (" Temperature when its resistance is 300 ohms is
       : "+string ( t2 ) +" degree C") ;
```

Scilab code Exa 2.15 Resistance of the coil

```
 1 // Exa2.15
```

```
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  alpha0=0.0038;// in ohm/ohm/degree C
 7  t1=20; //in degree C
 8  alpha20=1/(1/alpha0+t1);
 9  R1=400;//in ohm
10  //Formula R2=R1*[1+alpha20*(t2-t1)]
11  R2=R1*[1+alpha20*(80-20)];
12  disp("Resistance of wire at 80 degree C si : "+
         string(R2)+" ohm")
```

Scilab code Exa 2.16 Temperature coefficient of resistance

```
 1  //Exa2.16
 2  clc;
 3  clear;
 4  close;
 5  disp("Let the temperature coefficient of resistance
         of material at 0 degree C be alpha0");
 6  disp("Resistance at 25 degree C, R1 = R0 * (1+25*
         alpha0)                    (i)");
 7  disp("Resistance at 70 degree C, R2 = R0 * (1+70*
         alpha0)                   (ii)");
 8  disp("Dividing Eq.(ii) by Eq.(i), we get");
 9  disp("R2/R1= (1+70*alpha0)/(1+25*alpha0)");
10  disp("or   57.2/50 = (1+70*alpha0)/(1+25*alpha0)");
11  disp("or alpha0 = 0.00348 ohm/ohm/degree C");
```

Scilab code Exa 2.17 Temperature coefficient of resistance

```
 1  //Exa2.17
```

```
 2 clc;
 3 clear;
 4 close;
 5 disp("Let the temperature coefficient of resistance
      of material coil at 0 degree C be alpha0,then");
 6 disp("Resistance at 25 degree C, R1 = R0 * (1+25*
      alpha0)                (i)");
 7 disp("Resistance at 75 degree C, R2 = R0 * (1+75*
      alpha0)                 (ii)");
 8 disp("Dividing Eq.(ii) by Eq.(i), we get");
 9 disp("R2/R1= (1+75*alpha0)/(1+25*alpha0)");
10 disp("or   49/45 = (1+75*alpha0)/(1+25*alpha0)");
11 disp("or  alpha0 = 0.00736 ohm/ohm/degree C");
```

Scilab code Exa 2.18 Resistance and temperature coefficient

```
 1 //Exa2.18
 2 clc;
 3 clear;
 4 close;
 5 disp("Let the temperature coefficient of resistance
      of platinum at 0 degree C be alpha0 and
      resistance of platinum coil at 0 degree C be R0,
      then");
 6 disp("Resistance at 40 degree C, R1 = R0 * (1+40*
      alpha0)                (i)");
 7 disp("Resistance at 100 degree C, R2 = R0 * (1+100*
      alpha0)                (ii)");
 8 disp("Dividing Eq.(ii) by Eq.(i), we have");
 9 disp("R2/R1= (1+100*alpha0)/(1+40*alpha0)");
10 disp("or   3.767/3.146 = (1+100*alpha0)/(1+40*alpha0)
      ");
11 disp("or  alpha0 = 0.00379 ohm/ohm/degree C");
12 alpha0=0.00379;// in ohm/ohm/degree C
13 disp("Temperature coefficient of resistance at 40
```

```
        degree C,")
14  alpha40 =1/(1/ alpha0 +40);
15  disp ( alpha40 );
16  disp ("Substituting R1=3.146 and alpha0 =0.00379 in Eq
        . ( i ) we have")
17  R1=3.146;// in ohm
18  //Formula R1 = R0 * (1+40* alpha0 )
19  R0=R1/(1+40* alpha0 );
20  disp ("Resistance of platinum coil at 0 degree C is :
        "+string (R0)+" ohm ");
```

Scilab code Exa 2.19 Mean temperature rise

```
1   //Exa2.19
2   clc ;
3   clear ;
4   close ;
5   disp ("Let R0 be the resistance of the coil at 0
        degree C and alpha0 be its temperature
        coefficient of resistance at 0 degree C");
6   disp ("Resistance at 20 degree C, 18 = R0 * (1+20*
        alpha0 )                    ( i )");
7   disp ("Resistance at 50 degree C, 20 = R0 * (1+50*
        alpha0 )                    ( ii )");
8   disp ("Dividing Eq.( ii ) by Eq.( i ), we have");
9   disp ("20/18= (1+50* alpha0 )/(1+20* alpha0 )");
10  disp ("or alpha0 = 1/250=0.004 ohm/ohm/ degree C");
11  disp ("If t degree C is the temperature of coil when
        its resistance is 21 ohm, then");
12  disp ("21=R0*(1+0.004* t )");
13  disp ("Dividing Eq.( iii ) by Eq.( ii ), we have");
14  disp ("21/20=(1+0.004* t )/(1+50*0.004)");
15  disp ("or t=65 degree C");
16  disp ("Temperature rise = t−surrounding temperature =
        65 − 15 = 50 degree C");
```

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Scilab code Exa 2.20 Specific resistance and resistance temperature coefficient

```
1  //Exa2.20
2  clc;
3  clear;
4  close;
5  //given data
6  alpha20=1/254.5;// in ohm/ohm/degree C
7  t2=60;//degree C
8  t1=20;//degree C
9  rho0=1.6*10^-6;
10 alpha60=1/(1/alpha20+(t2-t1));
11 disp("Temperature coefficient of resistance at 60
       degree C is : "+string(alpha60)+" ohm/ohm/degree
      C");
12 //from alpha20=1/(1/alpha0+20)
13 alpha0=1/(1/alpha20-20);
14 //Formula rho60=rho0*(1+alpha0*t)
15 rho60=rho0*(1+alpha0*t2);
16 disp("Specific resistance at 60 degree C is : "+
       string(rho60)+" ohm-cm")
```

Scilab code Exa 2.21 Resistivity of the wire material

```
1  //Exa2.21
2  clc;
3  clear;
4  close;
5  //given data
6  R=95.5;//in ohm
```

```
 7  l=1;//in meter
 8  d=0.08;//in mm
 9  d=d*10^-3;//in meter
10  a=(%pi*d^2)/4;
11  //Formula R=rho*l/a
12  rho=R*a/l;
13  disp("Resistance of the wire material is : "+string(
       rho)+" ohm-meter")
```

Scilab code Exa 2.22 Resistance of the wire

```
 1  //Exa2.22
 2  clc;
 3  clear;
 4  close;
 5  //given data
 6  R=4;//in ohm
 7  d=0.0274;//in cm
 8  d=0.000274;//in meter
 9  rho=10.3;//in miu ohm-cm
10  rho=10.3*10^-8;//in ohm-m
11  a=(%pi*d^2)/4;
12
13  //Formula R=rho*l/a
14  l=R*a/rho;
15  disp("Lenght of wire is : "+string(l)+" meters")
```

Scilab code Exa 2.23 Current flowing

```
 1  //Exa2.23
 2  clc;
 3  clear;
 4  close;
```

```
5  //given data
6  V=220; // in V
7  W=100; //in watt
8  R100=V^2/W; //in ohm
9  alpha20=0.005;
10 t1=20;
11 t2=2000;
12 // since R100=R20*[1+alpha20*(t2-t1)]
13 R20=R100/(1+alpha20 * (t2-t1));
14 I20=V/R20;
15 disp("Current flowing at the instant of switching on
        a 100 W metal filament lamp is : "+string(I20)+"
        A")
```

Scilab code Exa 2.24 Resistance and temperature coefficient of combination

```
1  //Exa2.24
2  clc;
3  clear;
4  close;
5  //given data
6  t2=50; // in degree C
7  t1=20;  // in degree C
8  R1=600; // in ohm
9  R2=300; // in ohm
10
11 // Let resistance of 600 ohm resistance at 50 degree
        C = R_600
12 R_600=R1*(1+(t2-t1)*.001); // in ohm
13 // Let resistance of 300 ohm resistance at 50 degree
        C = R_300
14 R_300=R2*(1+(t2-t1)*.004); // in ohm
15 R_50=R_600+R_300; // in ohm
16 disp("Resistance of combination at 50degree C is : "
```

```
      +string(R_50)+ " ohm")
17 R_20=R1+R2;// in ohm
18 alpha_20=(R_50/R_20-1)/(t2-t1);
19 alpha_50=1/(1/(alpha_20)+(t2-t1));
20 disp("Effective temperature coefficient of
      combination at 50 degree C is : "+string(alpha_50
      )+" or 1/530 per degree C")
```

Scilab code Exa 2.25 Impurity percent

```
1 //Exa2.25
2 clc;
3 clear;
4 close;
5 //given data
6 toh=1.73//in micro-ohm-cm
7 tohDesh=1.74;//in micro-ohm-cm
8 sigma=1/toh;// conductivities of pure metal
9 sigmaDesh=1/tohDesh;//conductivities metal with
      impurity
10 PercentImpurity=((sigma-sigmaDesh)/sigma)*100;
11 disp(" Percent impurity in the rod is : "+string(
      PercentImpurity)+" %")
```

Scilab code Exa 2.26 Electronic contribution of thermal conductivity of aluminium

```
1 //Exa2.26
2 clc;
3 clear;
4 close;
5 //given data
6 ElectricalResistivity=2.86*10^-6;//in ohm-cm
```

```
7  sigma =1/ ElectricalResistivity ;
8  T =273+20; // in Kelvin ( Temperature )
9  // Formula K/( sigma*T)=2.44*10^-8
10 disp (" Thermal conductivity of Al ")
11 K =(2.44*10^ -8* T * sigma );
12 disp ( K );
```

Scilab code Exa 2.27 EMP developed per degree centigrade

```
1  // Exa2 .27
2  clc ;
3  clear ;
4  close ;
5  // given data
6  E_AC =16*10^ -6; // in V per degree C
7  E_BC = -34*10^ -6; // in V per degree C
8  // By law of successive contact ( or intermediate
       metals )
9  E_AB = E_AC - E_BC ; // in V/ degree C
10 E_AB = E_AB *10^6; // in miu V/ degree C
11 disp (" EMF of iron with respect to constantan is : "+
       string ( E_AB )+" micro V/ degree C")
```

Scilab code Exa 2.28 EMF developed in couple

```
1  // Exa2 .28
2  clc ;
3  clear ;
4  close ;
5  // given data
6  E_AC =7.4; // in miu V per degree C
7  E_BC = -34.4; // in miu V per degree C
```

```
8  //By law of successive contact (or intermediate
       metals)
9  E_AB=E_AC-E_BC;//in miu V/degree C
10 E_AB=E_AB*10^-6;// in  V/degree C
11 // Let Thermo-emf for a temperature difference of
       250 degree C = EMF_250
12 EMF_250=E_AB*250;// in V
13 EMF_250=EMF_250*10^3;//in mV
14 disp("Termo-emf for a temperature difference of 250
       degree C is "+string(EMF_250)+" mV");
```

Scilab code Exa 2.29 Thermo electric emf generated

```
1  //Exa2.29
2  clc;
3  clear;
4  close;
5  //given data
6  //Take iron as metal A and copper as metal B with
       respect to lead
7  //For metal A:
8  p_A=16.2;
9  q_A=-0.02;
10 //For metal B:
11 p_B=2.78;
12 q_B=+0.009;
13 p_AB=p_A-p_B;
14 q_AB=q_A-q_B;
15 T2=210;//in degree C
16 T1=10;// in degree C
17 E=p_AB*(T2-T1)+q_AB/2*(T2^2-T1^2);
18 disp("Thermo-electric emf is : "+string(E)+" micro V
       ");
19 Tn=-p_AB/q_AB;
20 disp("Neutral temperature is : "+string(Tn)+" degree
```

```
   C");
```

Scilab code Exa 2.30 Thermo emf neutral temperature temperature of inversion and max possible thermo electric emf

```
1  //Exa2.30
2  clc;
3  clear;
4  close;
5  //given data
6  p_A=17.34;
7  q_A=-0.0487;
8  p_B=1.36;
9  q_B=+0.0095;
10 p_AB=p_A-p_B;
11 q_AB=q_A-q_B;
12 T2=210;//in degree C
13 T1=10;// in degree C
14 E=p_AB*(T2-T1)+q_AB/2*(T2^2-T1^2);//in miu V
15 E=E*10^-3;//in m V
16 disp("Thermo-electric emf is : "+string(ceil(E))+" m
       V");
17 Tn=-p_AB/q_AB;
18 disp("Neutral temperature is : "+string(ceil(Tn))+"
        degree C");
19 Tc=10;// in degree C
20 Ti=Tn+(Tn-Tc);
21 disp("Temperature of inversion is : "+string(ceil(Ti
       ))+" degree C");
22 E_max=15.98*(275-10)-1/2*0.0582*[275^2-10^2];//in
       miu V
23 E_max=E_max*10^-3;// in mV
24 disp("Maximum possible thermo-electric emf at
        neutral temperature that is at 275 degree C is :
        "+string(E_max)+" mV");
```

Scilab code Exa 2.31 Potential difference

```
1  //Exa2.31
2  clc;
3  clear;
4  close;
5  //given data
6  rho=146*10^-6// in ohm-cm
7  a=1;//in cm^2
8  l=1;//in cm
9  // let current = i
10 i=0.06;//in amp
11 R=rho*l/a;//in ohm
12 // Let potential difference per degree centigrade =
       P
13 P=i*R;// By Ohm's law
14 disp("Potential difference per degree centigrade is
       : "+string(P)+" volt");
```

Scilab code Exa 2.32 EMF for a copper iron thermo couple

```
1  //Exa2.32
2  clc;
3  clear;
4  close;
5  //given data
6  T_lower=10;// in degree C
7  T_upper=150;// in degree C
8
9  // Thermo-electric power for iron at any temperature
       T degree C w.r.t. lead is given by (17.34-0.0487
```

```
         T)*10^-6 and that for copper by (1.36-.0095 T)
         *10^-6
10
11  // Thermo-electric power, P=dE/dT
12  // or dE=P*dT
13  // Thermo-emf for copper between temperature 10
         degree C and 150 degree C,
14  E_c= integrate('(1.36-0.0095*T)*10^-6','T',T_lower,
         T_upper);
15
16  // Thermo-emf for iron between temperature 10 degree
          C and 150 degree C,
17  E_i= integrate('(17.34-0.0487*T)*10^-6','T',T_lower,
         T_upper);
18
19  // Thermo-emp for copper-iron thermo-couple
20  E=E_i-E_c;
21
22  disp("Thermo-emf for iron between temperature 10
         degree C and 150 degree C is : "+string(E*10^6)+"
          micro V");
```

Scilab code Exa 2.34 Critical magnetic field

```
1  //Exa2.34
2  clc;
3  clear;
4  close;
5  //given data
6  Hc_0=8*10^5;//in A/m
7  Tc=7.26;//in K
8  T=4;//in K
9  Hc_T=Hc_0*[1-(T/Tc)^2]';
10 disp("The critical value of magnetic field at T=4 K
         is : "+string(Hc_T)+" A/m");
```

Scilab code Exa 2.35 Critical current

```
1  //Exa2.35
2  clc;
3  clear;
4  close;
5  //given data
6  Hc=7900;//in A/m
7  d=1;//in mm
8  r=d/2;//in mm
9  r=r*10^-3;//in m
10 Ic=2*%pi*r*Hc;
11 disp("Critical current is : "+string(Ic)+" A");
```

Scilab code Exa 2.36 Critical current density

```
1  //Exa2.36
2  clc;
3  clear;
4  close;
5  //given data
6  Hc_0=8*10^4;//in A/m
7  Tc=7.2;//in K
8  T=4.5;//in K
9  d=1;//in mm
10 r=d/2;//in mm
11 r=r*10^-3;//in m
12 Hc=Hc_0*[1-(T/Tc)^2]';
13 disp("The critical field at T=4.5 K is : "+string(Hc
       )+" A/m");
14 Ic=2*%pi*r*Hc;
15 disp("Critical current is : "+string(Ic)+" A");
```

31

Scilab code Exa 2.37 Diameter of copper wire

```
1  //Exa2.37
2  clc;
3  clear;
4  close;
5  format('v',5)
6  // Formula R=rho*l/a
7  //putting value for copper wire
8  R=2;// in ohm
9  l=100;//in meter
10 rho=1.7*10^-8;// (for copper)
11 a=rho*l/R;//in meter
12 a=a*10^6;// in mm
13 // Formula a=%pi/4*d^2
14 d_copper=sqrt(a*4/%pi); // (d_copper is diameter
      for copper)
15
16 // Formula R=rho*l/a
17 //putting value for Aluminium wire
18 R=2;// in ohm
19 l=100;//in meter
20 rho=2.8*10^-8;// (for aluminium)
21 a=rho*l/R;//in meter
22 a=a*10^6;// in mm
23 // Formula a=%pi/4*d^2
24 d_aluminium=sqrt(a*4/%pi); // (d_aluminium is
      diameter for aluminium)
25 DiaRatio=d_aluminium/d_copper; // (DiaRatio is
      ratio of diameter of aluminium and copper)
26 disp("The diameter of the aluminium wire is "+string
      (DiaRatio)+" times that of copper wire");
```

Scilab code Exa 2.38 Resistance of liquid resistor

```
1  //Exa2.38
2  clc;
3  clear;
4  close;
5  format('v',7)
6  //given data
7  l=60;// in cm
8  l=l*10^-2;//in meter
9  d=20;// in cm
10 d=d*10^-2;//in meter
11 D=35;// in cm;
12 D=D*10^-2;//in meter
13 r1=d/2;
14 r2=D/2;
15 rho=8000;// in ohm-cm
16 rho=80;// in ohm-m
17 // Let Insulation resistance of the liquid resistor
       = Ir
18 Ir=[rho/(2*%pi*l)]*log(r2/r1);
19 disp(" Insulation resistance of the liquid resistor
       is : "+string(Ir)+" ohm")
```

Scilab code Exa 2.39 Resistivity of dielectric in a cable

```
1  //Exa2.39
2  clc;
3  clear;
4  close;
5  format('v',11)
6  //given data
```

```
 7  R_desh=1820;// in M ohm
 8  R_desh=R_desh*10^6;// in ohm
 9  d1=1.5;// in cm
10  d1=d1*10^-2;// in meter
11  d2=5;// in cm
12  d2=d2*10^-2;// in meter
13  l=3000;// in meter
14  r1=d1/2;
15  r2=d2/2;
16
17  rho= (2*%pi*l*R_desh)/log(r2/r1);
18  disp("Resistivity of dielectric is : "+string(rho)+"
         ohm meter")
```

Scilab code Exa 2.40 Insulation resistance

```
 1  //Exa2.40
 2  clc;
 3  clear;
 4  close;
 5  format('v',9)
 6  // given data
 7  // First Case:
 8  r1=1.5/2;// in cm
 9  // let radius thickness of insulation = r1_t
10  r1_t=1.5;// in cm
11  r2=r1+r1_t;
12  R_desh=500;// in M ohm
13  R_desh=R_desh*10^6;// in ohm
14  // Second case:
15  r1_desh=r1;// in cm (as before)
16  // let radius thickness of insulation = r2_t
17  r2_t=2.5;// in cm
18  r2_desh=r1+r2_t;
19  // since Insulation resistance , R_desh= sigma/(2*
```

```
        %pi*l)*log(r2/r1) and
20  //                                              R1_desh= sigma/(2*
        %pi*l)*log(r2_desh/r1_desh)
21  // Dividing R1_desh by R1, We get
22  //  R1_desh/R_desh = log(r2_desh/r1_desh)/log(r2/r1)
23  // Let R = R1_desh/R_desh, Now
24  R= log(r2_desh/r1_desh)/log(r2/r1);
25  R1_desh=R*R_desh;
26  disp("New insulation resistance is : "+string(
        R1_desh*10^-6)+" M ohm");
```

Scilab code Exa 2.41 Insulation resistance and resistance of copper conductor

```
 1  //Exa2.41
 2  clc;
 3  clear;
 4  close;
 5  // given data
 6  t1=20;// in degree C
 7  t2=36;// in degree C
 8  alpha_20=0.0043;// in per degree C (Temperature
        Coefficient)
 9  InsulationResistance=480*10^6;// in ohm
10  copper_cond_res=0.7;// in ohm (copper conductor
        resistance)
11  l=500*10^-3;// in kilo meter (length)
12  R1_desh=InsulationResistance * l;// in ohm
13
14  // From Formula log(R2_desh)= log(R1_desh-K*(t2-t1))
15  // K= 1/(t2-t1)*log(R1_desh/R2_desh)
16  // since when t2-t1=10 degree C and R1_desh/R2_desh=
        2
17
18  K=1/10*log(2);
```

```
19
20  // (i) Insulation resistance at any temperature t2,
       R2_desh is given by
21     logR2_desh= log(R1_desh)-(t2-t1)/10* log(2);
22     R2_desh= %e^logR2_desh
23
24     disp(" (i) Insulation resistance at any temperature
          : "+string(R2_desh*10^-6)+" Mega ohm");
25
26  // (ii)
27       R_20= copper_cond_res/l;// in ohm
28       R_36=R_20*[1+alpha_20*(t2-t1)];
29
30       disp("Resistance at 36 degree C is : "+string(
          R_36)+" ohm")
```

Chapter 3

Semiconductor

Scilab code Exa 3.1 Velocity of electron

```
1  //Exa3.1
2  clc;
3  clear;
4  close;
5  // given data
6  E=2.1;//in eV
7  E=E*1.602*10^-19;// in J
8  m=9.107*10^-31;// in kg (mass of electron)
9  // Formula E=1/2*m*v^2
10 v=sqrt(2*E/m);
11 disp(" Velocity of electron at Fermi-level is : "+
       string(v)+" m/s")
```

Scilab code Exa 3.2 Relaxation time resistivity of conductor and velocity of electron

```
1  //Exa3.2
2  clc;
```

```
3  clear;
4  close;
5  // given data
6  E=5.5;// in eV; (Fermi energy)
7  E=E*1.6*10^-19;// in J
8  miu_e=7.04*10^-3;  //in m^2/V-s  (Mobility of
       electrons)
9  n=5.8*10^28 ; // in /m^3   (Number of conduction
       electrons/m^3)
10 e=1.6*10^-19; // in coulomb
11 m=9.1*10^-31;//in kg
12 //(i) Relaxation time,
13 tau=miu_e/e*m;
14 disp(”(i) Relaxation time is : ”+string(tau)+”
       second”);
15 sigma=(n*e*miu_e);
16 //(ii) Resistivity of conductor,
17 rho=1/sigma;
18 disp(”(ii) Resistivity of conductor is : ”+string(
       rho)+” ohm-meter”);
19 // (iii) Let Velocity of electrons with fermi energy
       = v
20 v=sqrt(2*E/m);
21 disp(”(iii) Velocity of electron with Fermi-level is
        : ”+string(v)+” m/s”);
```

Scilab code Exa 3.3 Electron and hole density

```
1  //Exa3.3
2  clc;
3  clear;
4  close;
5  // given data
6  n_i=2.5*10^13;// in /cm^3
7  rho=0.039;// in ohm-cm
```

```
 8  sigma_n =1/ rho ;
 9  e =1.602*10^ -19; // in C
10  miu_e =3600; // in cm^2/V−s
11  // since sigma_n = n∗e∗miu_e = N_D∗e∗miu_e
12  N_D = sigma_n /(e* miu_e );
13  n = N_D ; // ( approx )
14  disp (" Concentration of electrons is : "+ string (n)+"
        /cm^3");
15  p = n_i^2/n ;
16  disp (" Concentration of holes is : "+ string (p)+" /cm
        ^3");
```

Scilab code Exa 3.4 Donar atom concentration mobile electron concentration hole concentration and conductivity of doped silicon sample

```
 1  // Exa3 .4
 2  clc ;
 3  clear ;
 4  close ;
 5  // given data
 6  SiliconAtom =5*10^22; // unit less ( Number of silicon
        atom )
 7  DonorImpurity =1/10^6;
 8  n_i =1.45*10^10; // in cm^−3
 9  e =1.602*10^ -19; // in C
10  miu_e =1300; // taking miu_e for Si as 1300 cm^2/V−s
11  // (i) Donor atom concentraion
12  // Formula N_D= Number of silicon atoms /cm^3 ∗ donor
         impurity
13  N_D = SiliconAtom * DonorImpurity ;
14  disp ("(i) Donor atom concentration is : "+ string (N_D
        )+" per cm^3");
15
16  // (ii) Mobile electron concentration
17  n = N_D ; // ( approx .)
```

```
18  disp(" (ii) Mobile electron concentration is : "+
        string(n)+" per cm^3");
19
20  // (iii) Hole concentration
21  p=n_i^2/N_D;
22  disp(" (iii) Hole concentration is : "+string(p)+" /
        cm^3");
23
24  //(iv) conductivity of doped silicon sample
25  sigma=n*e*miu_e;
26  disp(" (iv) conductivity of doped silicon sample is :
        "+string(sigma)+" S/cm");
27
28  rho=1/sigma;
29  //(v) resistance of given semiconductor
30  l=0.5;// in cm
31  a=(50*10^-4)^2
32  R=rho*l/a;
33  disp(" Resistance of give semiconductor is : "+string
        (R)+" ohm");
```

Scilab code Exa 3.5 Concentration of hole in si

```
1  //Exa3.5
2  clc;
3  clear;
4  close;
5  // given data
6  n_i=1.4*10^18;// in m^3
7  N_D=1.4*10^24;// in m^3
8  n=N_D;// (approx)
9  p=n_i^2/n;
10 // let Ratio of electron to hole concentration = r
11 r=n/p;
12 disp(" Ratio of electron to hole concentration is : "
```

```
    + string ( r ) ) ;
```

Scilab code Exa 3.6 Conductivity and resitivity of an intrinsic semiconductor

```
 1  // Exa3 . 6
 2  clc ;
 3  clear ;
 4  close ;
 5  // given data
 6  n_i =2.5*10^13; // in cm^3
 7  e =1.6*10^ -19; // in coulomb
 8  miu_h =1800; // in cm^2/V-s
 9  miu_e =3800; // in cm^2/V-s
10  sigma_i=n_i*e*(miu_e+miu_h);
11  disp ( " Intrinsic conductivity is : " + string ( sigma_i )+
        " /ohm-cm " ) ;
12  rho_i =1/ sigma_i ;
13  disp ( " Intrinsic resistiviry is : " + string ( rho_i )+ "
        ohm-cm " )
```

Scilab code Exa 3.7 Density of electron and drift velocity of holes and electrons

```
 1  // Exa3 . 7
 2  clc ;
 3  clear ;
 4  close ;
 5  // given data
 6  rho_i =0.47; // in ohm-meter
 7  sigma_i =1/ rho_i ;
 8  miu_e =0.39; // in m^2/V-s
 9  miu_h =0.19; // in m^2/V-s
```

```
10  e=1.6*10^-19;// in C
11
12  // since sigma_i=n_i*e*(miu_e+miu_h);
13  n_i=sigma_i/(e*(miu_e+miu_h));
14  // so Density of electrons = Intrinsic Concentration
        ,n_i
15  disp("Density of electons is :"+string(n_i)+" /m^3")
        ;
16  E=10^4;// in V/m
17  v_n=miu_e*E;
18  disp("Drift velocity of electrons is : "+string(v_n)
        +" m/s");
19  v_h=miu_h*E;
20  disp("Drift velocity of holes is : "+string(v_h)+" m
        /s");
```

Scilab code Exa 3.8 Conductivity of Si

```
1  //Exa3.8
2  clc;
3  clear;
4  close;
5  // given data
6  n_i=1.5*10^10;// in /cm^3
7  miu_e=1300;// in cm^2/V-s
8  miu_h=450;// in cm^2/V-s
9  e=1.6*10^-19;// in C  (charge of electrons)
10  sigma_i=n_i*e*(miu_e+miu_h);
11  disp("Conductivity of silicon (intrinsic) is : "+
        string(sigma_i)+" /ohm-cm");
12  N_A=10^18;// in /cm^3
13  disp("conductivity of the resulting P-type silicon
        semiconductor")
14  sigma_p=e*N_A*miu_h;
15  disp(string(sigma_p)+" /ohm-cm");
```

Scilab code Exa 3.9 Find conductivity of intrinsic Ge

```
1  //Exa3.9
2  clc;
3  clear;
4  close;
5  // given data
6  n_i=2.5*10^13;// in /m^3
7  miu_e=3800;// in cm^2/V-s
8  miu_h=1800;// in cm^2/V-s
9  e=1.6*10^-19;// in C (charge of electrons)
10 sigma_i=n_i*e*(miu_e+miu_h);
11 disp("Intrinsic conductivity is : "+string(sigma_i)+
        " /ohm-cm");
12 // Let Number of germanium atoms/cm^3 = no_g
13 no_g=4.41*10^22;
14 // since Donor impurity = 1 donor atom / 10^7
        germanium atoms, so
15 DonorImpurity=10^-7;
16 N_D=no_g*DonorImpurity;
17 n=N_D; // (approx)
18 p=n_i^2/N_D;
19 // so
20 sigma_n=e*N_D*miu_e;
21 disp("conductivity in N-type germanium semiconductor
        is : "+string(sigma_n)+" /ohm-cm");
```

Scilab code Exa 3.10 Electron and hole drift velocity conductivity of intrinsic Ge and total current

```
1  //Exa3.10
```

```scilab
 2  clc;
 3  clear;
 4  close;
 5  // given data
 6  e=1.6*10^-19;//in C
 7  miu_e=.38;// in m^2/V-s
 8  miu_h=.18;// in m^2/V-s
 9  l=25;// in mm (length)
10  l=l*10^-3;// in m
11  w=4;// in mm (width)
12  w=w*10^-3;// in m
13  t=1.5;// in mm (thickness)
14  t=t*10^-3;// in m
15  V=10;// in V
16  l=25;// in mm
17  l=l*10^-3;//in m
18  E=V/l;
19  //(i)
20  v_e=miu_e*E;
21  v_h=miu_h*E;
22  disp("Electron drift velocity is : "+string(v_e)+" m
       /s");
23  disp("Hole drift velocity is : "+string(v_h)+" m/s")
       ;
24  n_i=2.5*10^19;//in /m^3
25  //(ii)
26  sigma_i=n_i*e*(miu_e+miu_h);
27  disp("Intrinsic conductiviry of Ge is : "+string(
       sigma_i)+" /ohm-cm");
28  //(iii)
29  a=w*t;
30  I=sigma_i*E*a;// in amp
31  I=I*10^3;// in m A
32  disp("Total current is : "+string(I)+" mA");
```

Scilab code Exa 3.11 Diffusion coefficient of electron and hole

```
1 //Exa3.11
2 clc;
3 clear;
4 close;
5 // given data
6 k_desh=1.38*10^-23;// in J degree^-1
7 e=1.602*10^-19;// in C
8 miu_e=3600;// in cm^2/V-s
9 miu_h=1700;// in cm^2/V-s
10 T=300;// in K
11 D_e=miu_e*k_desh*T/e;
12 disp("Diffusion constant of electrons is : "+string(
      D_e)+" cm^2/s");
13 D_h=miu_h*k_desh*T/e;
14 disp("Diffusion constant of holes is : "+string(D_h)
      +" cm^2/s");
```

Scilab code Exa 3.12 Hall effect in semiconductor

```
1 //Exa3.12
2 clc;
3 clear;
4 close;
5 // given data
6 e=1.6*10^-19;// in coulomb
7 Resistivity=9*10^-3;// in ohm-m
8 R_H=3.6*10^-4;// in m^3 coulomb^-1 (Hall
      Coefficient)
9 sigma=1/Resistivity;
10 rho=1/R_H;
11 n=rho/e;
12 disp("Density of charge carriers is : "+string(n)+"
      /m^3");
```

```
13  miu=sigma*R_H;
14  disp("Mobility is : "+string(miu)+" m^2/V-s");
```

Scilab code Exa 3.13 Current density

```
1   //Exa3.13
2   clc;
3   clear;
4   close;
5   // given data
6   E_x=100;// in V/m
7   e=1.6*10^-19;// in C
8   R_H=0.0145;// in m^3/coulomb
9   miu_n=0.36;// in m^2/volt-second
10  // Formula R_H=1/(n*e)
11  n=1/(R_H*e);
12  sigma=n*e*miu_n;
13  J=sigma*E_x;
14  disp("Current density is : "+string(J)+" A per m^2")
        ;
```

Scilab code Exa 3.14 Value of hall coefficient

```
1   //Exa3.14
2   clc;
3   clear;
4   close;
5   // given data
6   Resistivity=9;// in milli-ohm-m
7   Resistivity=9*10^-3;// in ohm-m
8   miu=0.03;// in m^2/V-s
9   sigma=1/Resistivity;
10  R_H=miu/sigma;
```

```
11  disp("Half  coefficient  is  :  "+string(R_H)+"  m^3/C");
```

Scilab code Exa 3.15 Magnitude of Hall voltage

```
1  //Exa3.15
2  clc;
3  clear;
4  close;
5  // given data
6  E_x=5;// in V/cm
7  miu_e=3800;// in cm^2/V-s
8  B_z=0.1;// in Wb/m^2
9  d=4;// in mm
10  d=d*10^-3;// in m
11  v=miu_e*E_x;//in cm/second
12  v=v*10^-2;// in m/second
13  V_H=B_z*v*d;// in V
14  V_H=V_H*10^3;// in m V
15  disp("Hall  voltage  is  :  "+string(V_H)+"  mV");
```

Scilab code Exa 3.16 Mobility of holes

```
1  //Exa3.16
2  clc;
3  clear;
4  close;
5  // given data
6  rho=200;// in Kilo ohm-cm
7  rho=rho*10^-2;// in kilo ohm m
8  rho=rho*10^3;// in ohm meter
9  sigma=1/rho;
10  V_H=50;// in mV
11  V_H=V_H*10^-3;//in V
```

```
12  I=10;// in miu A
13  I=I*10^-6;//in A
14  B_z=0.1;// in Wb/m^2
15  w=3;//in mm
16  w=w*10^-3;//in meter
17  R_H=V_H*w/(B_z*I);
18  disp("Mobility of holes in p-type silicon bar is : "
        )
19  miu_h=sigma*R_H;
20  disp(string(miu_h)+" m^2/V-s");
```

Scilab code Exa 3.17 Hall voltage

```
1  //Exa3.17
2  clc;
3  clear;
4  close;
5  // given data
6  N_D=1*10^21;// in /m^3
7  B_Z=0.2;// in T
8  J=600;// in A/m^2
9  n=N_D;
10 d=4;//in mm
11 d=d*10^-3;// in meterr
12 e=1.6*10^-19;// in C (electron charge)
13 // Formula  V_H*w/(B_Z*I) = 1/(n*e) , hence V_H=B_Z*
        I/(n*e*w)
14 // where I=J*w*d
15 // putting I=J*w*d in V_H=B_Z*I/(n*e*w), we get
16 V_H=B_Z*J*d/(n*e);// in V
17 V_H=V_H*10^3;// in mV
18 disp("Hall Voltage is : "+string(V_H)+" mV");
```

Scilab code Exa 3.18 Hall voltage

```
1  //Exa3.18
2  clc;
3  clear;
4  close;
5  // given data
6  w=0.1;// in mm
7  B_Z=0.6;// in T
8  R_H=3.8*10^-4;// in m^3/C
9  I=10;// in mA
10 I=I*10^-3;//in A
11 V_H=R_H*B_Z*I/w;// in V
12 V_H=V_H*10^6;// in V
13 disp("Hall voltage is : "+string(V_H)+" micro volt")
       ;
```

Scilab code Exa 3.19 Density and mobility of carrier

```
1  //Exa3.19
2  clc;
3  clear;
4  close;
5  // given data
6  Resistivity=9.23*10^-3;// in ohm-m
7  R_H=3.84*10^-4;//in m^3/C    (Hall Coefficient)
8  sigma=1/Resistivity;
9  rho=1/R_H;
10 e=1.6*10^-19;// in C (electron charge)
11 n=rho/e;
12 disp("Density of charge carriers is : "+string(n)+"
       /m^2");
13 miu=sigma*R_H;
14 disp("Mobility is : "+string(miu)+" m^2/V-s")
```

Scilab code Exa 3.20 Hll angle

```
1  //Exa3.20
2  clc;
3  clear;
4  close;
5  // given data
6  B=0.48;// in Wb/m^2
7  R_H=3.55*10^-4;// in m^3/C
8  Resistivity=.00912;// in ohm
9  sigma=1/Resistivity;
10 theta_H=atand(sigma*B*R_H);
11 disp("Hall angle is : "+string(theta_H)+" degree")
```

Scilab code Exa 3.21 New position of fermi level

```
1  //Exa3.21
2  clc;
3  clear;
4  close;
5  // given data
6  T=27;// in degree C
7  T=T+273;// in K
8  // Let E_C - E_F =E_CF
9  E_CF=0.3;// in eV
10 // Formula E_C - E_F = k*T*log(n_C/N_D)
11 // Let log(n_C/N_D) = L, so
12 L=E_CF/T;
13 T_desh=55;// in degree C
14 T_desh=T_desh+273;// in K
15 //At temperature T_desh
16 new_fermi_level= T_desh*L;   // where L=log(n_C/N_D)
```

```
17 disp("The new position of Fermi Level is : "+string(
      new_fermi_level)+" V");
```

Scilab code Exa 3.22 Potential barrier

```
1 //Exa3.22
2 clc;
3 clear;
4 close;
5 // given data
6 N_A=8*10^14;// in /cm^3
7 N_D=N_A;
8 n_i=2*10^13;// in /cm^3
9 k=8.61*10^-5;// in eV/K
10 T=300;// in K
11 V_0=k*T*log(N_D*N_A/n_i^2);
12 disp("Potential barrier is : "+string(V_0)+" V");
```

Scilab code Exa 3.23 Resistance level

```
1 //Exa3.23
2 clc;
3 clear;
4 close;
5 // given data
6 // (i) when
7 I_D=2;// in mA
8 I_D=I_D*10^-3;// in A
9 V_D=0.5;// in V
10 R1=V_D/I_D;
11 disp("Resistace is : "+string(R1)+" ohm");
12 // (ii) when
13 I_D=20;// in mA
```

```
14  I_D=I_D*10^-3;// in A
15  V_D=0.8;// in V
16  R2=V_D/I_D;
17  disp("Resistace is : "+string(R2)+" ohm");
18  // (ii) when
19  I_D=-1;// in miu A
20  I_D=I_D*10^-6;// in A
21  V_D=-10;// in V
22  R3=V_D/I_D;// in ohm
23  R3=R3*10^-6;// in M ohm
24  disp("Resistace is : "+string(R3)+" M ohm");
```

Scilab code Exa 3.24 Fraction of the total number of electron

```
1  //Exa3.24
2  clc;
3  clear;
4  close;
5  format('v',12)
6  // given data
7  E_G=0.72;// in eV
8  E_F=E_G/2;// in eV
9  k=8.61*10^-5; // in eV/K
10 T=300;// in K
11 // Formula n_C/n = 1/1+%e^(E_G-E_F)/k*T
12 // Let n_C/n = N
13 N=1/(1+%e^((E_G-E_F)/(k*T)));
14
15 disp("Fraction of the total number of electrons (
        conduction band as well as valence band) : "+
        string(N));
```

Scilab code Exa 3.25 Current flowing

52

```
1 //Exa3.25
2 clc;
3 clear;
4 close;
5 format('v',3)
6 // given data
7 I_0=.15;// in micro amp
8 I_0=I_0*10^-6;// in A
9 V=0.12;// in V
10 V_T=26;// in mV
11 V_T=V_T*10^-3;// in V
12 I=I_0*(%e^(V/V_T)-1);// in amp
13 I=I*10^6;// in micro amp
14 disp("Large reverse bias current is : "+string(I)+"
       micro amp");
```

Scilab code Exa 3.26 Forward voltage

```
1 //Exa3.26
2 clc;
3 clear;
4 close;
5 format('v',5)
6 // given data
7 I=.01;// in A
8 I_0=2.5*10^-6;// in   amp
9 nita=2;// for silicon
10 V_T=26;// in mV
11 V_T=V_T*10^-3;// in V
12 // Formula  I=I_0*(%e^(V/(nita*V_T))-1);
13 V=nita*V_T*log(I/I_0+1);
14 disp("Forward voltage is : "+string(V)+" V") ;
```

Scilab code Exa 3.27 Reverse saturation current density

```
1  //Exa3.27
2  clc;
3  clear;
4  close;
5  // given data
6  N_D=10^21;// in m^-3
7  N_A=10^22;// in m^-3
8  D_e=3.4*10^-3;// in m^2/s
9  D_h=1.2*10^-3;// in m^2/s
10 L_e=7.1*10^-4;// in m
11 L_h=3.5*10^-4;// in m
12 n_i=1.602*10^16;// in /m^3
13 e=1.6*10^-19;// in C (electron charge)
14 // Formula   I_0=a*e*[D_h/(L_h*N_D) + D_e/(L_e*N_A)]*
      n_i^2
15 //and
16 // Reverse saturation current density = I_0/a = [D_h
      /(L_h*N_D) + D_e/(L_e*N_A)]*e*n_i^2 , So
17 CurrentDensity= [D_h/(L_h*N_D) + D_e/(L_e*N_A)]*e*
      n_i^2;// in A
18 CurrentDensity=CurrentDensity*10^6;// in micro A
19 disp("Reverse saturation current density is : "+
      string(CurrentDensity)+"  micro amp");
```

Scilab code Exa 3.28 Junction width

```
1  //Exa3.28
2  clc;
3  clear;
4  close;
5  // given data'
6  format('v',13)
7  N_D=10^17*10^6;// in m^-3
```

```
 8  N_A =0.5*10^16*10^6; // in atoms/m^3
 9  epsilon_r =10; // in F/m
10  epsilon_o =8.85*10^-12; // in F/m
11  epsilon = epsilon_r * epsilon_o ;
12  e =1.602*10^-19; // in C ( electron charge )
13  // (i) when no external voltage is applied i.e.
14  V =0;
15  V_B =0.7; // in V
16  W=sqrt (2* epsilon * V_B /e *(1/ N_A +1/ N_D ));
17  disp (" Junction width is : "+ string (W)+" m");
18  // ( ii ) when external voltage of -10 V is applied i.
        e.
19  V = -10; // in V
20  V_o =0.7; // in V
21  V_B = V_o -V;
22  W=sqrt (2* epsilon * V_B /e *(1/ N_A +1/ N_D ));
23  disp (" Junction width is : "+ string (W)+" m");
24
25  // Note: Answer in the book is wrong
```

Chapter 4

Bipolar Junction And Field Effect Transistors

Scilab code Exa 4.1 Resistance between gate and source

```
1  //Exa 4.1
2  clc;
3  clear;
4  close;
5  //given data :
6  format('v',11)
7  VGS=10;//in Volt
8  IG=0.001;//in uAmpere
9  IG=IG*10^-6;//in Ampere
10 RGS=VGS/IG;//in Ohm
11 disp(RGS*10^-6,"Resistance between gate and source
      in Mohm : ");
```

Scilab code Exa 4.2 AC drain resistance of the JFET

```
1  //Exa 4.2
```

```
2 clc;
3 clear;
4 close;
5 //given data :
6 delVDS=1.5;//in Volt
7 delID=120;//in uAmpere
8 delID=delID*10^-6;//in Ampere
9 rd=delVDS/delID;//in Ohm
10 disp(rd*10^-3,"AC drain Resistance of JFET in Kohm :
      ");
```

Scilab code Exa 4.3 Transconductance

```
1 //Exa 4.3
2 clc;
3 clear;
4 close;
5 //given data :
6 ID2=1.5;//in mAmpere
7 ID1=1.2;//in mAmpere
8 delID=ID2-ID1;//in Ampere
9 VGS1=-4.25;//in Volt
10 VGS2=-4.10;//in Volt
11 delVGS=VGS2-VGS1;//in Volt
12 gm=delID/delVGS;//in Ohm
13 disp(gm,"Transconductance in mA/V : ");
14 disp(gm*10^3,"Transconductance in uS : ");
```

Scilab code Exa 4.4 AC drain resistance transconductance and amplification factor

```
1 //Exa 4.4
2 clc;
```

```
3  clear;
4  close;
5  //given data :
6  VDS1=5;//in Volt
7  VDS2=12;//in Volt
8  VDS3=12;//in Volt
9  VGS1=0;//in Volt
10 VGS2=0;//in Volt
11 VGS3=-0.25;//in Volt
12 ID1=8;//in mAmpere
13 ID2=8.2;//in mAmpere
14 ID3=7.5;//in mAmpere
15 //AC drain resistance
16 delVDS=VDS2-VDS1;//in Volt
17 delID=ID2-ID1;//in mAmpere
18 rd=delVDS/delID;//in Kohm
19 disp(rd,"AC Drain resistance in Kohm : ");
20 //Transconductance
21 delID=ID3-ID2;//in mAmpere
22 delVGS=VGS3-VGS2;//in Volt
23 gm=delID/delVGS;//in mA/V or mS
24 disp(gm,"Transconductance in mA/V : ");
25 //Amplification Factor
26 meu=rd*1000*gm*10^-3;//unitless
27 disp(meu,"Amplification Factor : ");
```

Scilab code Exa 4.5 Transconductance

```
1  //Exa 4.5
2  clc;
3  clear;
4  close;
5  //given data :
6  VP=-4.5;//in Volt
7  IDSS=10;//in mAmpere
```

```
8  IDS =2.5; //in  mAmpere
9  //Formula  :  IDS=IDSS*[1-VGS/VP]^2
10 VGS=VP*(1-sqrt(IDS/IDSS)); //in  Volt
11 gm=(-2*IDSS*10^-3)*(1-VGS/VP)/VP; //in  mA/V  or  mS
12 disp(gm*1000,"Transconductance  in  mA/V  :  ");
```

Scilab code Exa 4.6 Calculate VGS

```
1  //Exa  4.6
2  clc;
3  clear;
4  close;
5  //given  data  :
6  gm=10; //in  mS
7  gm=gm*10^-3; //in  S
8  IDSS=10; //in  uAmpere
9  IDSS=IDSS*10^-6; //in  Ampere
10 //VGS(OFF):VGS=VP
11 //Formula  :  gm=gmo=-2*IDSS/VP=-2*IDSS/VG(Off)
12 VGS_OFF=-2*IDSS/gm; //in  Volt
13 disp(VGS_OFF*1000,"VGS(OFF)  in  mV  :  ");
```

Scilab code Exa 4.7 Minimum value of VDS

```
1  //Exa  4.7
2  clc;
3  clear;
4  close;
5  //given  data  :
6  VP=-4; //in  Volt
7  VGS=-2; //in  Volt
8  IDSS=10; //in  mAmpere
9  IDSS=IDSS*10^-3; //in  Ampere
```

```
10  //Formula : ID=IDSS*[1-VGS/VP]^2
11  ID=IDSS*[1-VGS/VP]^2;//in Ampere
12  disp(ID*1000,"Drain Current in mA : ");
13  disp("The minimum value of VDS for pinch-off region
        is equal to VP. Thus the minimum value of VDS :
        VDS(min) = "+string(VP)+" Volt");
```

Scilab code Exa 4.8 ID gmo and gm

```
1   //Exa 4.8
2   clc;
3   clear;
4   close;
5   //given data :
6   IDSS=8.7;//in mAmpere
7   IDSS=IDSS*10^-3;//in Ampere
8   VP=-3;//in Volt
9   VGS=-1;//in Volt
10  //ID
11  ID=IDSS*[1-VGS/VP]^2
12  disp(ID*1000,"Drain current ID in mA : ");
13  //gmo
14  gmo=-2*IDSS/VP;//in S
15  disp(gmo*1000,"Transconductance for VGS=0V in mA/V
        or mS : ");
16  //gm
17  gm=gmo*(1-VGS/VP);//in S
18  disp(gm*1000,"Transconductance in mA/V or mS : ");
```

Scilab code Exa 4.9 Id and gm

```
1   //Exa 4.9
2   clc;
```

```
3  clear;
4  close;
5  //given data :
6  IDSS=8.4;//in mAmpere
7  IDSS=IDSS*10^-3;//in Ampere
8  VP=-3;//in Volt
9  VGS=-1.5;//in Volt
10 //ID
11 ID=IDSS*[1-VGS/VP]^2
12 disp(ID*1000,"Drain current ID in mA : ");
13 //gmo
14 gmo=-2*IDSS/VP;//in S
15 disp(gmo*1000,"Transconductance for VGS=0V in mA/V
       or mS : ");
16 gm=gmo*(1-VGS/VP);//in S
17 disp(gm*1000,"Transconductance in mA/V or mS : ");
```

Scilab code Exa 4.10 gm at IDS

```
1  //Exa 4.10
2  clc;
3  clear;
4  close;
5  //given data :
6  VP=-4.5;//in Volt
7  IDSS=9;//in mAmpere
8  IDSS=IDSS*10^-3;//in Ampere
9  IDS=3;//in mAmpere
10 IDS=IDS*10^-3;//in Ampere
11 //Formula : IDS=IDSS*[1-VGS/VP]^2
12 VGS=VP*(1-sqrt(IDS/IDSS));//in Volt
13 disp(VGS,"ID=3mA at VGS in Volt :");
14 gm=(-2*IDSS)*(1-VGS/VP)/VP;//in mA/V or mS
15 disp(gm*1000,"Transconductance in mA/V or mS: ");
```

Scilab code Exa 4.11 Drain current

```
1  //Exa 4.11
2  clc;
3  clear;
4  close;
5  //given data :
6  ID_on=5;//in mAmpere
7  VGS_on=8;//in Volt
8  VGS=6;//in Volt
9  VGST=4;//in Volt
10 k=ID_on/(VGS_on-VGST)^2;//in mA/V^2
11 ID=k*(VGS-VGST)^2;//in mA
12 disp(ID,"Drain current in mA : ");
```

Chapter 5

Magnetic Properties Of Materials

Scilab code Exa 5.1 Hysteresis loss

```
1  //Exa 5.1
2  clc;
3  clear;
4  close;
5  // given data
6  Area_hysteresis_curve=9.3;//in cm^2
7  Cordinate1_1cm=1000;//in AT/m
8  Cordinate2_1cm=0.2;//in T
9  //Part (i)
10 hysteresis_loss=Area_hysteresis_curve*Cordinate1_1cm
       *Cordinate2_1cm;//in J/m^3/cycle
11 disp(hysteresis_loss,"Hysteresis loss/m^3/cycle in J
       /m^3/cycle: ");
12 //Part (ii)
13 f=50;//in Hz
14 H_LossPerCubicMeter=hysteresis_loss*f;//in Watts
15 disp(H_LossPerCubicMeter*10^-3,"Hysteresis loss Per
       Cubic Meter in KWatts :");
```

Scilab code Exa 5.2 Hysteresis loss

```
1  //Exa 5.2
2  clc;
3  clear;
4  close;
5  format('v',11)
6  // given data
7  Area_hysteresis_loop=93;//in cm^2
8  scale1_1cm=0.1;//in Wb/m^2
9  scale2_1cm=50;//in AT/m
10
11 hysteresis_loss=Area_hysteresis_loop*scale1_1cm*
      scale2_1cm;//in J/m^3/cycle
12 disp(hysteresis_loss,"Hysteresis loss/m^3/cycle in J
      /m^3/cycle: ");
13
14 f=65;//unit less
15 V=1500*10^-6;// in m^3
16 P_h=hysteresis_loss*f*V;
17 disp("Hysteresis loss is : "+string(P_h)+" W");
```

Scilab code Exa 5.3 Loss of energy

```
1  //Exa 5.3
2  clc;
3  clear;
4  close;
5  format('v', 11)
6  // given data
7  nita=628;// in J/m^3
8  B_max=1.3;// in Wb/m^2
```

```
 9  f=25;// in Hz
10  ironMass=50;// in kg
11  densityOfIron=7.8*10^3;// in kg/m^3
12  V=ironMass/densityOfIron;
13  x=12.5;// in AT/m
14  y=0.1;// in T
15  // formula Hysteresis loss/second = nita*B_max^1.6*f
        *V
16  H_Loss_per_second = nita*B_max^1.6*f*V ;// in J/s
17  H_Loss_per_second=floor(H_Loss_per_second);
18  H_Loss_per_hour= H_Loss_per_second*60*60;// in J
19  disp("Hysteresis Loss per hour is : "+string(
        H_Loss_per_hour)+" J");
20  // Let Hysteresis Loss per m^3 per cycle = H1
21  H1=nita*B_max^1.6;
22  // formula  hysteresis loss/m^3/cycle = x*y*area of
        B–H loop
23  Area_of_B_H_loop=H1/(x*y);
24  Area_of_B_H_loop=floor(Area_of_B_H_loop);
25  disp("Area of B–H loop is : "+string(
        Area_of_B_H_loop)+" cm^2");
```

Scilab code Exa 5.4 Loss per kg in a specimen

```
 1  //Exa 5.4
 2  clc;
 3  clear;
 4  close;
 5  // given data
 6  H_L_per_M_Cube_per_C=380;// in W–S
 7  f=50;// unit less
 8  density=7800;// in kg/m^3
 9  V=1/density;// in m^3
10  // formula Hysteresis loss = Hysteresis loss/m^3/
        cycle * f * V
```

```
11  P_h = H_L_per_M_Cube_per_C * f * V;
12  disp ( " Hysteresis  loss  is  :  " + string ( P_h ) + " W " ) ;
```

Scilab code Exa 5.5 Eddy current loss

```
1  // Exa  5.5
2  clc ;
3  clear ;
4  close ;
5  //  given  data
6  P_e1 =1600; //  in  watts
7  B_max1 =1.2; //  in  T
8  f1 =50; //  in  Hz
9  B_max2 =1.5; //  in  T
10 f2 =60; //  in  Hz
11 //  P_e  propotional  to  B_max^2*f^2,  so
12 P_e2 = P_e1 *( B_max2 / B_max1 )^2*( f2 / f1 )^2
13 disp ( " Eddy  current  loss  is  :  " + string ( P_e2 ) + " watts "
       ) ;
```

Chapter 6

Dielectric Properties Of Materials

Scilab code Exa 6.1 Element of parallel RC circuit

```
1  //Exa 6.1
2  clc;
3  clear;
4  close;
5  // given data
6  epsilon_r=2.5;
7  epsilon_o=8.854*10^-12;
8  d=.2*10^-3;// in m
9  A=20*10^-4;// in m^2
10 omega=2*%pi*10^6;// in radians/s
11 f=10^6;
12 tan_delta=4*10^-4;
13 C=epsilon_o*epsilon_r*A/d;// in F
14 disp("Capicitance is : "+string(C*10^12)+" miu miu F
       ");
15 // Formula P=V^2/R, so
16 // R=V^2/P and P= V^2*2*%pi* f * C * tan delta ,
       putting the value of P, we get
17 R=1/(2*%pi*f*C*tan_delta);// in ohm
```

```
18  disp("The element of parallel R-C circuit is : "+
        string(R*10^-6)+" M ohm");
```

Scilab code Exa 6.2 Charge sensitivity

```
1  //Exa 6.2
2  clc;
3  clear;
4  close;
5  // given data
6  g=0.055;// in V-m/N
7  t=2*10^-3;// in m
8  P=1.25*10^6;// in N/m^2
9  epsilon=40.6*10^-12;// in F/m
10 V_out=g*t*P;
11 disp("Output voltage is : "+string(V_out)+" V");
12 // Formula Charge Sensivity=epsilon_o*epsilon_r*g=
        epsilon*g
13 ChargeSensivity=epsilon*g;
14 disp("Charge Sensivity is : "+string(ChargeSensivity
        )+" C/N");
```

Scilab code Exa 6.3 Force required to develop a voltage

```
1  //Exa 6.3
2  clc;
3  clear;
4  close;
5  // given data
6  V_out=150;// in V
7  t=2*10^-3;// in m
8  g=0.05;// in V-m/N
9  A=5*5*10^-6;// in m^2
```

```
10  F=V_out*A/(g*t);// in N
11  disp("Force applied is : "+string(F)+" N")
```

Scilab code Exa 6.4 Charge and its capacitance

```
1  //Exa 6.4
2  clc;
3  clear;
4  close;
5  // given data
6  g=12*10^-3;// in V–m/N
7  t=1.25*10^-3;// in m
8  A=5*5*10^-6;// in m^2
9  F=3;// in N
10  ChargeSensitivity=150*10^-12;// in C/N
11  P=F/A;
12  V_out=g*t*P;// in V
13  Q=ChargeSensitivity*F;
14  disp("Total charge developed is : "+string(Q)+" C");
15  // Formula C=Q/V;
16  C=Q/V_out;
17  disp("Capacitance is : "+string(C*10^12)+" miu miu F
       ");
18
19  // Note: Answer in the Book is wrong
```