Scilab Textbook Companion for Engineering Physics by D. K. Bhattacharya[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.

Contents

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Chapter 1

ultrasonics

Scilab code Exa 1.1 To find depth of submerged submarine

```
// chapter 1 , Example1 1 , pg 20
v=1440        //velocity of ultrasonic waves(in m/s)
t=0.33        //time lapsed(in sec)
d=(v*t)       //distance travelled by ultrasonic waves
d1=d/2        //depth of submarine
disp (d, ' the velocity of ultrasonic waves ( in m)
   is ' )
disp (d1, ' the depth of submarine ( in m) is ' )
```

Scilab code Exa 1.2 To calculate the natural frequency

```
// chapter 1 , Example1 2 , pg 21
d=7.25*10^3      //density(in kg/m^3)
E=115*10^9       //youngs modulus(in N/m^2)
l=40*10^-3       //length of rod(in m)
n=sqrt(E/d)/(2*l)        //natural frequency of rod
disp (n*10^-3, 'the natural frequency of rod (in kHz
   ) is ')
```

```
printf("yes,the rod can be used for producing
   ultrasonic waves because its frequency lies in
   the ultrasonic  range")
```

Scilab code Exa 1.3 To calculate the natural frequency

```
// chapter 1 , Example1 3 , pg 21
l=10^-3//length(in m)
E=7.9*10^10//youngs modulus(in N/m^2)
d=2650//density(in kg/m^3)
p=1//fundamental mode
n= p*sqrt(E/d)/(2*l)  //natural frequency
printf("Fundamental  frequency of quartz crystal\n")
printf("n=%.2f Hz",n)
```

Scilab code Exa 1.4 compute the velocity of waves

```
// chapter 1 , Example1 4 , pg 22
lam=2*0.55*10^-3 //distance between 2 antinodes is
   lam/2 (in m)
n=1.45*10^6 //frequency of crystal(in Hz) (given)
              they have taken n=1.5 Hz in
   calculation
v=n*lam //velocity
printf("velocity of waves in sea water\n")
printf("v=%.1f m/s",v)


//sum is solved using n=1.5 Hz while the frequency
   given is n=1.45 Hz
```

Scilab code Exa 1.5 To calculate the natural frequency

```
// chapter 1 , Example1 5 , pg 22
l=50*10^-3//length of rod(in m)
d=7250//density(in  kg/m^3)
E=11.5*10^10//youngs modulus(in N/m^2)
n=sqrt(E/d)/(2*l)//natural frequency
printf("Natural frequency of rod\n")
printf("n=%.2f KHz",n*10^-3)
```

Scilab code Exa 1.6 To calculate the natural frequency

```
// chapter 1 , Example1 6 , pg 23
l=2*10^-3//length(in m)
d=2650//density(in kg/m^3)
E=7.9*10^10//youngs modulus(in N/m^2)
p=1
n=(p*sqrt(E/d))/(2*l)//natural frequency
printf("frequency of crystal\n")
printf("n=%.3f MHz",n*10^-6)
```

Scilab code Exa 1.7 To calculate the natural frequency

```
// chapter 1 , Example1 7 , pg 23
l=3*10^-3//length(in m)
d=2500//density(in kg/m^3)
E=8*10^10//youngs modulus(in N/m^2)
p=1
n=(p*sqrt(E/d))/(2*l)//natural frequency
printf("frequency of ultrasound\n")
printf("n=%.3f KHz",n*10^-3)
```

Scilab code Exa 1.8 To calculate the frequency

```
// chapter 1 , Example1 8 , pg 23
l=1.5*10^-3//length(in m)
d=2650//density(in kg/m^3)
E=7.9*10^10//youngs modulus(in N/m^2)
p=1
n=(p*sqrt(E/d))/(2*l)//natural frequency
printf("frequency of crystal\n")
printf("n=%.3f MHz",n*10^-6)
```

Scilab code Exa 1.9 To find depth of sea

```
// chapter 1 , Example1 9 , pg 24
v=1440      //velocity of ultrasonic waves(in m/s)
t=0.95      //time lapsed(in sec)
d=(v*t)     //distance travelled by ultrasonic waves
d1=d/2      //depth of sea
disp (d1, ' the depth of sea ( in m) is ' )
```

Scilab code Exa 1.10 To find depth of sea

```
// chapter 1 , Example1 10 , pg 24
v=1440      //velocity of ultrasonic waves(in m/s)
t=0.83      //time lapsed(in sec)
d=(v*t)     //distance travelled by sound
d1=d/2      //depth of submarine
disp (d, ' the velocity of ultrasonic waves ( in m) is ' )
disp (d1, ' the depth of submarine ( in m) is ' )
```

Scilab code Exa 1.11 To calculate reverberation time

```
// chapter 1 , Example1 11 , pg 24
aS=1050//total absorption inside hall(in Sabine)
//a=average absorption coefficient , S=area of
    interior surface
V=9000//volume of hall(in m^3)
T=(0.165*V)/aS//reverberation time
printf("Reverberation time of hall\n")
printf("T=%.4f sec",T)
```

Scilab code Exa 1.12 To find area of interior surface

```
// chapter 1 , Example1 12 , pg 25
V=13500//volume(in m^3)
T=1.2//reverberation time(in sec)
a=0.65//average absorption coefficient(in Sabine/m
    ^2)
S=(0.165*V)/(a*T)//area of interior surface
printf("Area of interior surface\n")
printf("S=%.1f m^2",S)
```

Scilab code Exa 1.13 To find reverberation time

```
// chapter 1 , Example1 13 , pg 25
V=15000//volume(in m^3)
T1=1.3//initial reverberation time(in sec)
aS=(0.165*V)/T1  //total absorption of hall (in
    Sabine)
```

```
T2=(0.165*V)/(aS+300)//revrberation time of hall after adding 300 chairs each having absorption of 1 Sabine
printf("Reverberation time of hall after adding 300 chairs\n")
printf("T2=%.3f sec",T2)
```

Scilab code Exa 1.14 To find depth of submarine

```
// chapter 1 , Example1 14 , pg 26
v=1440       //velocity of ultrasonic waves(in m/s)
t=0.5        //time lapsed(in sec)
d=(v*t)      //distance travelled by ultrasonic waves
d1=d/2       //depth of submarine
disp (d, ' the velocity of ultrasonic waves ( in m) is ' )
disp (d1, ' the depth of submarine ( in m) is ' )
```

Scilab code Exa 1.15 To find frequency of waves

```
// chapter 1 , Example1 15 , pg 26
lam=2*0.4*10^-3 //distance between 2 antinodes is lam/2 (in m)
n=1.5*10^6 //frequency of crystal(in Hz)
v=n*lam //velocity
printf("velocity of waves in sea water\n")
printf("v=%.1f m/s",v)
```

Scilab code Exa 1.16 To evaluate natural frequency

```
// chapter 1 , Example1 16 , pg 26
l=40*10^-3//length(in m)
E=11.5*10^10//youngs modulus(in N/m^2)
d=7250//density(in kg/m^3)
p=1//fundamental mode
n= p*sqrt(E/d)/(2*l)  //natural frequency
printf("Fundamental  frequency of quartz crystal\n")
printf("n=%.2f  KHz",n*10^-3)
```

Chapter 2

Lasers

Scilab code Exa 2.1 To calculate relative population

```
// chapter 2 , Example2 1 , pg 52
lam=590*10^-9//wavelength(in m)
T=250+273 //temperature(in kelvin)  (converting
   celsius into kelvin)
k=1.38*10^-23//boltzman constant (in (m^2*Kg)/(s^2*k
   ))
h=6.625*10^-34//plancks constant(in Js)
c=3*10^8//speed of light
N=exp(-(h*c)/(lam*k*T)) //N=(n2/n1)=relative
   population of atoms in the 1st excited state  and
    in ground state
//n1=number of atoms in ground state
//n2=number of atoms in excited state
printf("Relative population of Na atoms in the 1st
   excited state and in ground state\n")
disp(N)
```

Scilab code Exa 2.2 To calculate ratio of stimulated emission to spontaneous emission

```
// chapter 2 , Example2 2 , pg 53
T=250+273 //temperature(in kelvin)  (converting celsius into kelvin)
h=6.625*10^-34//plancks constant(in Js)
c=3*10^8//speed of light(in m/s)
lam=590*10^-9//wavelength(in m)
k=1.38*10^-23//boltzman constant (in (m^2*Kg)/(s^2*k))
N=1/(exp((h*c)/(lam*k*T))-1)  //N=((n21)'/(n21)) ratio of stimulated  emission to spontaneous emission
printf("Ratio of stimulated  emission to spontaneous emission is")
disp(N)


//answer given is wrong
```

Scilab code Exa 2.3 calculate number of photons emitted per minute

```
// chapter 2 , Example2 3 , pg 53
lam=632.8*10^-9//wavelength(in m)
Em=3.147*10^-3*60//energy emitted per minute(in J/min)
c=3*10^8//speed of light(in m/s)
h=6.625*10^-34//plancks constant(in Js)
n=c/lam  //frequency of emitted photons(in Hz)
E=h*n  //energy of each photon(in J)
N=Em/E  //number of photons emitted per minute
printf("Number of photons emitted per minute")
disp(N)
```

Chapter 3

Fibre optics and its applications

Scilab code Exa 3.1 To find NAand phi m and critical angle

```
// chapter 3 , Example 3.1 , pg 84
n1=1.5//core refractive index
n2=1.47//cladding refractive index
n0=1//refractive index of air
NA=sqrt(n1^2-n2^2)//numerical aperture
alpha_m =asin(NA/n0)//angle of acceptance  (in radian)
phi_m=asin((n0*sin(alpha_m))/n1)//  no*sin(alpha_m)=n1*sin(phi_m) (in radian)
phi_c=asin(n2/n1)  //critical angle  (in radian)
printf("NA=%.1f \n",NA)
printf("alpha_m=%.2f  degree\n",(alpha_m*180)/%pi)
printf("phi_m=%.2f degree\n",(phi_m*180)/%pi)
printf("phi_c=%.2f  degree",(phi_c*180)/%pi)


//data given is n2=1.97  which is not possible since refractive index of cladding should always be less than refractive index of core
//in calculation n2=1.47
```

Scilab code Exa 3.2 calculate pulse broadening per unit length

```
// chapter 3 , Example 3.2 , pg 85
n1=1.5//core refractive index
n2=1.47//cladding refractive index
c=3*10^8//speed of light(in m/s)
P=(n1*(n1-n2))/(n2*c)  //pulse broadening per unit length due to multiple dispersion
//P=(del_t/L)   where del_t=time interval  , L=distance  transversed by ray inside core
printf("pulse broadening per unit length due to multiple dispersion(in s/m)")
disp(P)
```

Scilab code Exa 3.3 To calculate minimum and maximum number of total internal reflections per metre

```
// chapter 3 , Example 3.3 , pg 85
n1=1.5//core refractive index
n2=1.47//cladding refractive index
n0=1//refractive index of air
a=100*10^-6/2  //radius of core
NA=sqrt(n1^2-n2^2)//numerical aperture
alpha_m =asin(NA/n0)//angle of acceptance  (in radian)
phi_m=asin((n0*sin(alpha_m))/n1)//   no*sin(alpha_m)=n1*sin(phi_m)  (in radian)
L=a/tan(phi_m)  //(in m)
printf("Minimum number of reflections per metre=zero\n")  //since rays travelling with alpha=0 suffer no internal reflection
```

```
//for rays travelling with alpha=alpha_m ,1 internal
    reflection takes place for a transversed
   distance of 2*L
N=1/(2*L)  //Maximum number of reflections per metre
disp("Maximum number of reflections per metre(in m
   ^-1)=")
printf("N=%.0f",N)

//Answer varies as L is restricted to 2.45*10^-4 (m)
     instead of 2.462*10^-4 (m)
```

Chapter 4

Quantum physics

Scilab code Exa 4.1 calculate energy and momentum of photon

```
// chapter 4 , Example4 1 , pg 117
c=3*10^8 //speed of light(in m/sec)
h=6.625*10^-34//planck's constant(in  J s)
lam=1.2*10^-10//wavelength(in m)
E=(h*c)/(lam*1.6*10^-19)  //energy of photon(in eV)
p=h/lam  //momentum of photon
printf("Energy of photo\n")
printf("E=%.1f eV\n",E)
printf("momentum of photon(in Kg m/sec)\n")
disp(p)
```

Scilab code Exa 4.2 calculate number of photons emitted per second

```
// chapter 4 , Example 4.2 , pg 117
E1=10^4 //energy emitted per second(in J)
n=900*10^3  //frequency(in Hz)
h=6.625*10^-34 //plancks constant(in J s)
E=h*n//energy carried by 1 photon(in J)
```

```
N=E1/E//number of photons emitted per second
printf("number of photons emitted per second\n")
disp(N)
```

Scilab code Exa 4.3 determine number of photons emitted per second

```
// chapter 4 , Example 4.3 , pg 118
c=3*10^8//speed of light(in m/sec)
h=6.625*10^-34//plancks constant(in J s)
E1=100//energy emitted per second(in J)
lam=5893*10^-10//wavelength(in m)
E=(h*c)/lam  //energy carried by 1 photon
N=E1/E//number of photons emitted per second
printf("number of photons emitted per second\n")
disp(N)


//answer mentioned is wrong
```

Scilab code Exa 4.4 find the wavelength

```
// chapter 4 , Example 4.4 , pg 118
lam=2.8*10^-10//wavelength (in m)
theta=(30*%pi)/180//viewing angle(in radian)    (
    converting degree into radian)
c=3*10^8//speed of light(in m/sec)
h=6.625*10^-34//plancks constant(in J s)
m0=9.11*10^-31//rest mass of electron(in Kg)
lam1=lam+((2*h)*sin(theta/2)^2)/(m0*c) //wavelength
    of scattered radiation
printf("wavelength of scattered radiation(in m)\n")
disp(lam1)
```

```
printf("wavelength of scattered radiation(in Angstrom)\n")
disp(lam1*10^10)
//calculation is done assuming h=6.6*10^-34 Js in book
```

Scilab code Exa 4.5 calculate de Broglie wavelength

```
// chapter 4 , Example 4.5 , pg 119
m=0.04//mass(in Kg)
v=1000//speed(in m/sec)
h=6.625*10^-34//plancks constant(in J s)
p=m*v//momentum(in kg m/sec)
lam=h/p //wavelength
printf("de Broglie wavelength(in m)\n")
disp(lam)
printf("de Broglie wavelength(in A)\n")
disp(lam*10^10)
//calculation is done assuming h=6.6*10^-34 Js
```

Scilab code Exa 4.6 find energy of particle

```
// chapter 4 , Example 4.6 , pg 119
a=0.1 *10^-9 //width (in m)
n=1// lowest energy state of particle is obtained at n=1
h=6.625*10^-34 //plancks constant(in Js)
m=9.11*10^-31//mass of electron (in Kg)
```

```
E=(h^2)/(8*m*a^2)//energy of an electron
printf("Energy of electron in ground state(in J)\n")
disp(E)
printf("E=%.3f eV",E/(1.6025*10^-19))
```

Scilab code Exa 4.7 calculate minimum energy

```
// chapter 4 , Example 4.7 , pg 120
a=4*10^-9  //width  (in m)
n=1// lowest  energy state of particle is obtained
   at n=1
h=6.625*10^-34 //plancks constant(in Js)
m=9.11*10^-31//mass of electron (in Kg)
E=(h^2)/(8*m*a^2)//energy of an electron
printf("Energy of electron in ground state(in J)\n")
disp(E)
printf("E=%.5f eV",E/(1.6025*10^-19))
```

Scilab code Exa 4.8 calculate energy required to excite electron from ground state to 6th excited state

```
// chapter 4 , Example 4.8 , pg 120
a=0.1 *10^-9  //width  (in m)
n1=1// lowest  energy state of particle is obtained
   at n=1
n=6  //6th excited state hance n=6
h=6.625*10^-34 //plancks constant(in Js)
m=9.11*10^-31//mass of electron (in Kg)
//E=(n^2*h^2)/(8*m*a^2)    n=excited state of
   electron
E1=(n1^2*h^2)/(8*m*a^2)//energy of an electron in
   ground state (in J)
```

```
E6=(n^2*h^2)/(8*m*a^2)//energy at 6th excuted state(
    in J)
E=E6-E1//energy required to excite the electron from
     ground state  to the 6th excited state
printf("energy required to excite the electron from
    ground state  to the 6th excited state(in J)\n")
disp(E)
printf("E=%.2f eV",(E/(1.6025*10^-19)))
```

Scilab code Exa 4.9 find change in wavelength

```
// chapter 4 , Example 4.9 , pg 121
h=6.625*10^-34//planksconstant(in J s)
c=3*10^8//velocity of x-ray photon(in m/sec)
m0=9.11*10^-31//rest mass of electron(in Kg)
phi=(90*%pi)/180//angle of scattering (in radian)
    (converting degree into radian)
delta_H=(h*(1-cos(phi)))/(m0*c)//change in
    wavelength due to compton scattering
printf("change in wavelength of x-ray photon(in m)\n
    ")
disp(delta_H)
```

Chapter 5

Crystal physics

Scilab code Exa 5.1 determine miller indices

```
// chapter 5 , Example5 1 , pg 149
//plane has intercepts  a,2b,3c along the 3  crystal
    axes
//lattice points in 3−d lattice are given by r=p∗a+q
   ∗b+s∗c
//as p,q,r  are the basic vectors the proportion of
   intercepts  1:2:3
p=1
q=2
s=3
//therefore reciprocal
r1=1/1
r2=1/2
r3=1/3
//taking LCM
v=int32([1,2,3])
l=double(lcm(v))
m1=(l*r1)
m2=(l*r2)
m3=(l*r3)
printf("miler indices=")
```

```
disp(m3,m2,m1)
```

Scilab code Exa 5.2 calculate density of Si

```
// chapter 5 , Example5 2 , pg 150
a=5.43*10^-8//lattice constant(in cm)
M=28.1 //atomic weight (in g)
n=8// number of atoms/cell (for Si)
N=6.02*10^23 //Avogadro number
C=n/a^3 //atomic concentration =(number of atoms/
    cell)/cell volume (in atoms/cm^3)
D=(C*M)/N //Density
printf("Density of Si=")
printf("D=%.2f g/cm^3",D)
```

Scilab code Exa 5.3 calculate surface density of atoms

```
// chapter 5 , Example5 3 , pg 151
//(1 1 1) plane for a BCC crystal
a=5*10^-10//lattice constant (in m)
//height of equilaterl triangle (shaded area) =a*
    sqrt(3/2)
//hence area of shaded triangular portion is a*sqrt
    (2)*a*sqrt(3/2)/2 = a^2*sqrt(3)/2
//every corner atom contributes 1/6to the area
n111=(3/6)/(a^2*sqrt(3)/2) //planar concentration
printf("surface density of atoms in (1 1 1)plane of
    BCC structure (in atoms/m^2)")
disp(n111)
```

Scilab code Exa 5.4 calculate spacing of planes

```
// chapter 5 , Example5 2 , pg 150
a=4.049 //lattice constant(in Angstrom)
h=2
k=2
l=0  //since (h k l)=(2 2 0)   miller  indices
d=a/sqrt(h^2+k^2+l^2)  //spacing
printf("spacing of (2 2 0) planes=")
printf("d=%.3f  Angstrom",d)
```

Scilab code Exa 5.5 determine size of unit cell

```
// chapter 5 , Example5 5 , pg 152
d110=2.03//spacing of(1 1 0) planes   (in Angstrom)
h=1
k=1
l=0 //(h k l)=(1 1 0)
a=d110*sqrt(h^2+k^2+l^2)//size of unit cell
printf("size of unit cell=")
printf("a=%.2f angstrom",a)
```

Scilab code Exa 5.6 determine spacing between planes

```
// chapter 5 , Example5 6 , pg 152
a=5.64//lattice constant (in Angstrom)
h1=1
k1=0
l1=0 //(h1 k1 l1)=(1 0 0)
h2=1
k2=1
l2=0 //(h2 k2 l2)=(1 1 0)
h3=1
```

```
k3=1
l3=1//(h3 k3 l3)=(1 1 1)
d100=a/sqrt(h1^2+k1^2+l1^2)  //spacing of (1 0 0) planes
d110=a/sqrt(h2^2+k2^2+l2^2)  //spacing of (1 1 0) planes
d111=a/sqrt(h3^2+k3^2+l3^2)  //spacing of (1 1 1) planes
printf("spacing of (1 0 0) planes=")
printf("d100=%.2f  Angstrom\n",d100)
printf("spacing of (1 1 0) planes=")
printf("d110=%.2f  Angstrom\n",d110)
printf("spacing of (1 1 1) planes=")
printf("d111=%.2f  Angstrom",d111)
```

Scilab code Exa 5.7 find volume of unit cell

```
// chapter 5 , Example5 7 , pg 153
r=1.605 *10^-10 //radius of atom  (in m)
a=2*r//lattice constant  (for HCP structure)  (in m)
c=a*sqrt(8/3) //(in m)
V=(3*sqrt(3)*a^2*c)/2  //volume of unit cell
printf("volume of unit cell(in m^3)\n")
disp(V)
```

Chapter 6

Conducting materials

Scilab code Exa 6.1 calculate Fermi energy

```
// chapter 6 , Example6 1 , pg 170
Vf=10^6      //Fermi velocity (in m/s)
m=9.11*10^-31      // mass of electron(in Kg)
Ef=(m*Vf^2)/2      //Fermi energy   (in J)
printf("Fermi energy for the electrons  in the metal
   =")
printf("Ef=%.1f  eV",(Ef/(1.6*10^-19)))        //
   converting J into  eV
```

Scilab code Exa 6.2 calculate Fermi energy

```
// chapter 6 , Example6 2 , pg 170
Ef0=7.04*1.6*10^-19    // Fermi energy at 0 K  (
   converting eV into J)
T=300      //temperature     (in K)
k=1.38*10^-23      //boltzmann  constant  (in (m^2*Kg)
   /(s^2*K^-1))
Ef=Ef0*(1-(%pi^2*(k*T)^2)/(12*Ef0^2))     //Fermi
   energy at 300 K  (in J)
```

```
printf("Fermi energy at 300 K =")
printf("Ef=%.4f  eV",(Ef/(1.6*10^-19)))   //
   converting J into eV
```

Scilab code Exa 6.3 calculate conductivity and relaxation time

```
// chapter 6 , Example6.3 , pg 171
d=2.7*10^3      //density     (in Kg/m^3)
Ma=27      //atomic weight
Me=9.11*10^-31      //mass of electron    (in Kg)
e=1.6*10^-19      //charge in electron    (in C)
T=10^-14      //relaxation time     (in s)
Na=6.022*10^23       //Avogadro  constant
N=3*10^3        //number of free electrons per atom
n=(d*Na*N)/Ma      //(in /m^3)
sigma=(n*e^2*T)/Me      //conductivity
printf("Conductivity of Al  (in /(ohm*m))")
disp(sigma)
```

Scilab code Exa 6.4 calculate Lorentz number

```
// chapter 6 , Example6 4 , pg 171
sigma=5.87*10^7     // electrical  conductivity   (in
    /(ohm m))
K=390       //thermal conductivity      (in W/(m K))
T=293      //temperature     (in K)
L=K/(sigma*T)     //Lorentz number        by wiedemann
   -Franz law
printf("Lorentz number    (in   W*ohm /K^2)")
disp(L)
```

Scilab code Exa 6.5 calculate electrical conductivity

```
// chapter 6 , Example6 5 , pg 172
d=8900      //density    (in Kg/m^3)
M=63.5      //atomic weight
T=10^-14    //relaxation time(in s)
N=6.022*10^23     //Avogadros  constant
N1=10^3          //number of free electrons per atom
e=1.6*10^-19     //electronic charge    (in  C)
me=9.11*10^-31     //mass of electron   (in Kg)

n=(N*d*N1)/M
sigma =(n*e^2*T)/me     //electrical  conductivity
printf("Electrical conductivity(in ohm m)=")
disp(sigma)
```

Scilab code Exa 6.6 calculate relaxation time and mobility and average drift velocity and mean free path

```
// chapter 6 , Example6 6 , pg 172
rho=1.54*10^-8     //resistivity    (in ohm*m)
Ef=5.5       //Fermi energy     (in eV)
E=100  //electric field intensity    (in V/m)
n=5.8*10^28      //concentration of electrons      (in
   atoms/m^3)
e=1.6*10^-19     //charge in electron     (in C)
Me=9.11*10^-31     //mass of electron   (in Kg)
T=Me/(rho*n*e^2)      //relaxation time
Un=(e*T)/Me      //mobility of electron
Vd=(e*T*E)/Me       //drift velocity
Vf=sqrt((2*Ef*e)/Me)      //Fermi velocity
lam_m=Vf*T     //mean free path

printf("Relaxation time of electron (in s)")
disp(T)
```

```
printf("Mobility of electron (in m^2/(V*s))")
disp(Un)
printf("Drift velocity of electron (in m/s)")
disp(Vd)
printf("Fermi velocity of electrons (in m/s)")
disp(Vf)
printf("Mean free path(in m)")
disp(lam_m)
```

Scilab code Exa 6.7 calculate thermal conductivity

```
// chapter 6 , Example6 6 , pg 174
L= 2.26*10^-8      //Lorentz number   (in W*m /K^2)
T=27+273        //temperature   (in K)   (converting celsius into kelvin)
rho=1.72*10^-8      //electrical resistivity   (in ohm *m)

//according to Wiedemann-Franz law
K=(L*T)/rho     //thermal  conductivity
printf("Thermal conductivity =")
printf("K=%.0f  W/(m*K)",K)
```

Scilab code Exa 6.8 calculate Lorentz number

```
// chapter 6 , Example6 8 , pg 174
sigma=5.87*10^7     // electrical conductivity  (in /(ohm m))
K=390        //thermal conductivity     (in W/(m K))
T=293      //temperature     (in K)
L=K/(sigma*T)     //Lorentz number        by wiedemann-Franz law
printf("Lorentz number   (in  W*ohm /K^2)")
```

```
disp(L)
```

Scilab code Exa 6.9 find F E

```
// chapter 6 , Example6 9 , pg 174
del_E=0.01*1.6*10^-19    //  del_E = E-Ef (in J)     (
    converting eV into J)
T=200    //temperature   (in K)
k=1.38*10^-23   //boltzmanns constant  (in J/K)
F_E=1/(1+exp(del_E/(k*T)))     //Fermi Dirac
    distribution function
printf("F_E=%.2f",F_E)
```

Scilab code Exa 6.10 calculate electrical conductivity

```
// chapter 6 , Example6.10 , pg 175
lam=4*10^-8     //maen free path of electrons    (in m
    )
n=8.4*10^28     //electron density     (in m^-3)
Vth=1.6*10^6     //average thermal velocity of
    electrons   (in m/s)
e=1.6*10^-19      //charge of electron    (in C)
Me=9.11*10^-31   //mass of electron     (in Kg)
sigma=(n*e^2*lam)/(Vth*Me)      //conductivity
printf("Electrical conductivity (in /(ohm*m))")
disp(sigma)
```

Scilab code Exa 6.11 calculate electrical and thermal conductivities

```
// chapter 6 , Example6.11 , pg 176
```

```
Tr=10^-14        //relaxation time  (in s)
T=300       //temperature      (in K)
n=6*10^28      //electron concentration     (in /m^3)
Me=9.11*10^-31      //mass of electron     (in Kg)
e=1.6*10^-19    //charge of electron    (in C)
k=1.38*10^-23      //Boltzmann constant     (in J/K)
sigma=(n*e^2*Tr)/(Me)      //Electrical conductivity
K=(3*n*k^2*Tr*T)/(2*Me)      //Thermal conductivity
L=K/(sigma*T)      //Lorentz number
printf("Electrical conductivity    (in /(ohm*m))")
disp(sigma)
printf("Thermal conductivity      (in W/(m*K))")
disp(K)
printf("Lorentz   number    (in(W*ohm)/K^2)")
disp(L)
```

Scilab code Exa 6.12 find relaxation time

```
// chapter 6 , Example6.12 , pg 177
n=5.8*10^28     //  electron concentration   (in /m^3)
e=1.6*10^-19      // charge of electron      (in C)
rho=1.54*10^-8      //resistivity of metal     (in ohm
   *m)
M=9.11*10^-31       //mass of electron     (in Kg)
T=M/(n*e^2*rho)    //relaxation time
printf("Relaxation time(in s)")
disp(T)
```

Scilab code Exa 6.13 calculate drift velocity and mobility and relaxation time

```
// chapter 6 , Example6.13 , pg 177
rho=1.54*10^-8     //resistivity     (in ohm*m)
```

```
E=100     //electric field intensity      (in V/m)
n=5.8*10^28      //electron concentration     (in /m
   ^3)
e=1.6*10^-19      //charge of electron      (in C)
Me=9.11*10^-31     //mass of electron     (in Kg)
T=Me/(rho*n*e^2)       //relaxation time
Vd=(e*E*T)/Me       //drift velocity
U=Vd/E      //mobility
printf("Relaxation time  (in s)")
disp(T)
printf("Drift veloity  (in m/s)")
disp(Vd)
printf("Mobility(in m^2/(V*s))")
disp(U)
```

Scilab code Exa 6.14 calculate drift velocity

```
// chapter 6 , Example6 14 , pg 178
T=300     //temperature    (in K)
l=2     //length    (in m)
R=0.02     //Resistance      (in ohm)
u=4.3*10^-3     //    (in m^2/(V*s))
I=15   //current    (in A)
V=I*R     //voltage drop across wire    (in V )
E=V/l      //electric field across wire   (in V/m)
Vd=u*E     //drift velocity    (in m/s)
printf("Drift velocity (in m/s)")
disp(Vd)
```

Scilab code Exa 6.15 calculate Fermi energy and Fermi temperature

```
// chapter 6 , Example6 15 , pg 179
m=9.11*10^-31     //mass of electron (in Kg)
```

```
k=1.38*10^-23    //boltzmann constant    (in J/K)
e=1.6*10^-19     //electronic charge(in C )
Vf=0.86*10^6    //Fermi velocity of electron   (in m/s)
Ef=(m*Vf^2)/(2*e)      //Fermi energy    (in eV)
Tf=(Ef*e)/k    //Fermi temperature
printf("Fermi energy=")
printf("Ef=%.1f   eV \n",Ef)
printf("Fermi temperature =")
printf("Tf=%.0f   K",Tf)
```

Scilab code Exa 6.16 calculate Fermi velocity

```
// chapter 6 , Example6 16 , pg 179
Tf=2460     //Fermi temperature    (in K)
m=9.11*10^-31     //mass of electron (in Kg)
k=1.38*10^-23    //boltzmann constant    (in J/K)
Vf=sqrt((2*k*Tf)/m)    //Fermi velocity
printf("Fermi velocity  (in m/s)=")
disp(Vf)
```

Chapter 7

Semiconducting materials

Scilab code Exa 7.1 Evaluate approximate donor binding energy

```
// chapter 7 , Example7.1 , pg 208
Er=13.2          // relative permittivity
Me=9.11*10^-31         //mass of electron    (in Kg)
Mnc=0.067*Me
h=6.625*10^-34      //plancks constant   (in Js)
Eo=8.85*10^-12
e=1.6*10^-19        //electronic charge of electron (
    in C)
E=(Mnc*e^4)/(8*(Er*Eo)^2*h^2)        //Donor binding
    energy   (in J)
printf("Donor binding energy (in J)=")
disp(E)
printf("E=%.4f    eV",(E/e))
```

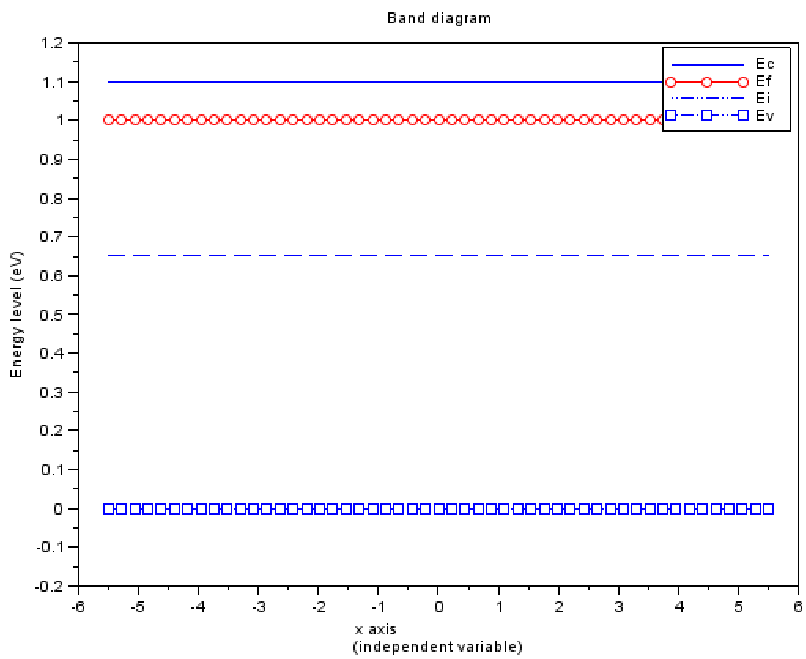

Figure 7.1: calculate equilibrium hole concentration and how is Ef located relative to Ei

Scilab code Exa 7.2 calculate equilibrium hole concentration and how is Ef located relative to Ei

```
// chapter 7 , Example 7.2 , pg 208
ni=1.5*10^10        //intrinsic concentration   (in cm
   ^-3)
Nd=10^16     //donor concentration    (in atoms/cm^3)
T=300      //temperature     (in K)
e=1.6*10^-19     //charge of electron     (in C)
k=1.38*10^-23       //Boltzmann constant     (in J/K)
n0=Nd      //Assuming n0=Nd        ( since    Nd >> ni
   )
p0=ni^2/n0      //hole concentration
E=k*T*log(n0/ni)      // E=(Ef-Ei)     location of Ef
   relative to Ei
printf("Hole concentration (in cm^-3)")
disp(p0)
printf("Location of Ef relative to Ei   (in eV)")
disp(E/e)
x = linspace(-5.5,5.5,51);
y = 1 ;

scf(2);
clf(2);
plot(x,y+0.1);

plot(x,y,'ro-');
plot(x,y-0.347,'--');
plot(x,y*0,'bs:');
xlabel(["x axis";"(independent variable)"]);
ylabel("Energy level (eV)");
title("Band diagram");
legend(["Ec";"Ef";"Ei";"Ev"]);
set(gca(),"data_bounds",matrix([-6,6,-0.1,1.1],2,-1)
   );
```

Scilab code Exa 7.3 calculate resistivity of sample

```
// chapter 7 , Example7.3 , pg 208
Nd=10^14      //Donor density   (in atoms/cm^3)
e=1.6*10^-19      //electronic charge of electron   (
   in C)
Un=3900        // electron mobility (in cm^2/(V*s))
        for Ge at 300 K
sigma=Nd*e*Un      //conductivity
rho=1/sigma        //resistivity
printf("Resistivity=\n")
printf("rho=%.2f      ohm*cm",rho)
```

Scilab code Exa 7.4 calculate resistivity and Hall coefficient and Hall voltage

```
// chapter 7 , Example7 4 , pg 209
e=1.6*10^-19     //charge in electron (in C)
Ix=2*10^-3     //current (in A)
d=200*10^-4      //thickness   (in cm)
Bz=5*10^-5     //magnetic induction   (in Wb/cm^2)
Un=800     //electron mobility   (in cm^2/(V*s))
n=5*10^16      //doping concentration    (in atoms/cm
   ^3)

sigma=n*e*(Un)     // electrical conductivity
rho=1/sigma     //resistivity
Rh=-1/(e*n)     //Hall coefficient
Vh=-(Ix*Bz)/(d*e*n)     //Hall  voltage
printf("Resistivity(in ohm*cm)")
disp(rho)
printf("Hall coefficient(in cm^3/C)")
```

```
disp(Rh)
printf("Hall voltage (in V)")
disp(Vh)
```

Scilab code Exa 7.5 calculate intrinsic carrier concentration and intrinsic conductivity and relativity

```
// chapter 7 , Example 7.5 , pg 210
T=300     //temperature     (in K)
Un=0.4    //electron mobility     (in m^2/(V*s))
Up=0.2    //hole mobility     (in m^2/(V*s))
e=1.6*10^-19      //charge of electron (in C)
h=6.625*10^-34     //plancks constant     (in m^2*Kg*S
   ^-1)
Eg=0.7      //bandgap    (in eV)
k=1.38*10^-23      //Boltzmann constant     (in J/K)
Me=9.11*10^-31    //mass of electron     (in Kg)
Mn=0.55*Me      //electron effective mass
Mp=0.37*Me      //hole effective mass
ni=2*((2*%pi*k*T)/h^2)^(3/2)*(Mn*Mp)^(3/4)*exp(-(Eg*
   e)/(2*k*T))      //intrinsic concentration
sigma=ni*e*(Un+Up)      //intrinsic conductivity
rho=1/sigma      //intrinsic resistivity
printf("Intrinsic concentration (in m^-3)")
disp(ni)
printf("Intrinsic conductivity (in /(ohm*m)")
disp(sigma)
printf("Intrinsic resistivity  (in ohm*m)")
disp(rho)


//answer given is wrong
```

Scilab code Exa 7.6 calculate Fermi energy with respect to Fermi energy

```
// chapter 7 , Example 7.6 , pg 211
Nd=10^16      //donor concentration (in cm^-3)
ni=1.45*10^10      //intrinsic concentration  (in cm
   ^-3)
T=300      //temperature     (in K)
e=1.6*10^-19     //charge of electron     (in C)
k=1.38*10^-23      //Boltzmann constant     (in J/K)
E=k*T*log(Nd/ni)        //E=(Efd-Ei)    Fermi energy
   with respect to  Fermi energy in intrinsic Si
printf("Fermi energy  with respect to  Fermi energy
   in intrinsic  Si(in eV)")
disp(E/e)
```

Scilab code Exa 7.7 find resistance of pure and doped Si crystal

```
// chapter 7 , Example 7.7 , pg 211
rho=2300    //resistivity   (in ohm*m)    for Si
              (value given in book is wrong)
ni=1.6*10^16      //intrinsic concentration    (in m
   ^-3)
Ue=0.15       //electron mobility    (in m^2/(V*s))
e=1.6*10^-19     //charge of electron    (in C)
//    assuming  1*1*1 (in cm)  dimension of Si
   crystal
l=10^-2     //length     (in m)
b=10^-2      //breadth     (in m)
w=10^-2       //width    (in m)
Nsi=5*10^28     //    (in atoms/m^3)
x=1/10^9       //doping concentration
A=l*b      //area     (in m^2)
R1=(rho*l)/A       //resistance of pure Si crystal
   (in ohm)
Nd=Nsi*x       //donor concentration     (in m^-3)
```

```
p=ni^2/Nd    //concentration of hole    (in m^-3)
sigma=Nd*Ue*e    //coductivity of doped Si    (in ohm
    ^-1*m^-1)
R=1/(sigma*A)     //resistance of doped Si crystal
    (in ohm)
printf("Resistance of pure Si crystal  (in ohm)")
disp(R1)
printf("Resistance of doped Si crystal (in ohm)")
disp(R)


//answer given is wrong
```

Scilab code Exa 7.8 compute forbidden energy gap

```
// chapter 7 , Example 7.8 , pg 212
rho=2.12     //resistivity    (in ohm*m)
T=300    //temperature    (in K)
Un=0.36     //electron mobility    (in m^2/(V*s))
Up=0.17      //hole mobility      (in m^2/(V*s))
h=6.625*10^-34     //plancks constant     (in m^2*Kg*S
    ^-1)
k=1.38*10^-23      //Boltzmann constant     (in J/K)
e=1.6*10^-19      //charge in electron   (in C)
Me=9.11*10^-31    //mass of electron     (in Kg)
Mn=0.5*Me      //electron effective mass
Mp=0.37*Me      //hole effective mass
ni=1/(rho*e*(Un+Up))      //intrinsic concentration
      (in m^-3)
Nc=2*((2*%pi*k*T)/h^2)^(3/2)*(Mn)^(3/2)       //
    effective density of states in conduction band (
    in m^-3)
Nv=2*((2*%pi*k*T)/h^2)^(3/2)*(Mp)^(3/2)       //
    effective density of states in valence band (in m
    ^-3)
```

```
Eg=2*k*T*log(sqrt(Nc*Nv)/ni)          //Forbidden
   energy gap
printf("Forbidden energy gap=")
printf("Eg=%.3f  eV",Eg/e)
```

Scilab code Exa 7.9 calculate conductivity of sample

```
// chapter 7 , Example7.9 , pg 213
ni=2.4*10^19      //intrinsic  carrier  density(in m
   ^-3)
Un=0.39      //electron  mobility   (in m^2/(V*s))
up=0.19      //hole mobility   (in m^2/(V*s))
e=1.6*10^-19     //charge in electron (in C)
sigma=ni*e*(Un+up)     // electrical conductivity
printf("Electrical conductivity\n")
printf("sigma=%.3f    (ohm*m)^-1",sigma)
```

Scilab code Exa 7.10 find the new position of Fermi level

```
// chapter 7 , Example 7.10 , pg 214
T1=300      //temperature     (in K)
e=1.6*10^-19     //charge of electron     (in C)
k=1.38*10^-23      //Boltzmann constant     (in J/K)
T2=330      //temperature    (in K)
E1=0.3      // E1=(Ec-Ef_300)     (in eV)
E2=(E1*T2)/T1     //E2=(Ec-Ef_330)     (in eV)
printf("At 330 K the Fermi energy kevel lies ")
disp(E2)
printf("(in eV) below conduction band")
```

Scilab code Exa 7.11 calculate concentration in conduction band

```
// chapter 7 , Example 7.11 , pg 214
T=300    //temperature    (in K)
e=1.6*10^-19     //charge of electron (in C)
h=6.625*10^-34    //plancks constant    (in m^2*Kg*S
    ^-1)
Eg=1.1      //bandgap    (in eV)
k=1.38*10^-23      //Boltzmann constant    (in J/K)
Me=9.11*10^-31    //mass of electron    (in Kg)
Mn=0.31*Me      //electron effective mass
ni=2*((2*%pi*k*T*Mn)/h^2)^(3/2)*exp(-(Eg*e)/(2*k*T))
        //intrinsic concentration
printf("Intrinsic concentration (in m^-3)")
disp(ni)
```

Scilab code Exa 7.12 calculate drift mobility of electron

```
// chapter 7 , Example7.12 , pg 214
T=300    //temperature    (in K)
Rh=0.55*10^-10      //Hall coefficient    (in  m^3/(
    A*s))
sigma=5.9*10^7    //conductivity       (in ohm^-1 *
    m^-1)
DM= Rh*sigma      //drift mobility
printf("Drift mobility  (in m^2/(V *s))=")
disp(DM)
```

Scilab code Exa 7.13 calculate concentration of conduction electrons in Cu

```
// chapter 7 , Example 7.13 , pg 215
```

```
Ud=3.2*10^-3     //electron drift mobility (in m^2/(V*s))
sigma=5.9*10^7     //conductivity (in /(ohm*m))
e=1.6*10^-19     //charge of electron (in C)
Na=6.022*10^23     //Avogadro constant (in mol^-1)
ni=sigma/(Ud*e)     //intrinsic concentration (in m^-3)
Aw=63.5     //atomic weight
d=8960   //density (in Kg/m^3)
n=10^3  //number of free electrons per atom
N=(Na*d*n)/Aw     //concentration of free electrons in pure Cu
Avg_N=ni/N     //Average number of electrons contributed per Cu atom
printf("concentration of free electrons in pure Cu (in m^-3)")
disp(N)
printf("Average number of electrons contributed per Cu atom\n")
printf("Avg_N=%.2f ",Avg_N)
```

Scilab code Exa 7.14 calculate charge carrier density and electron mobility

```
// chapter 7 , Example7.14 , pg 215
RH=3.66*10^-11     //Hall coefficient (in m^3/(A*s))
e=1.6*10^-19     //charge in electron (in C)
sigma=112*10^7     //conductivity (in (oh*m)^-1)
n=1/(RH*e)    //charge carrier density
Un=sigma/(n*e)     //electron mobility
printf("charge carrier density(in m^-3)=")
disp(n)
printf("Electron mobility=")
printf("Un=%.3f   m^2/(A*s)",Un)
```

Scilab code Exa 7.15 calculate magnitude of Hall voltage

```
// chapter 7 , Example7.15 , pg 216
I=50    //current   (in A)
B=1.5    //magnetic field    (in T)
d=0.2*10^-2    //width of slab    (in m)
n=8.4*10^28     //concentration of electrons (in m^-3)
e=1.6*10^-19     // charge    (in C)
VH=(B*I)/(n*e*d)     //Hall  voltage
printf("Hall voltage(in V)=")
disp(VH)




//Answer given is wrong
```

Scilab code Exa 7.16 find resistance of intrinsic Ge

```
// chapter 7 , Example7.16 , pg 216
ni=2.5*10^19      //intrinsic  carrier  density(in m^-3)
Un=0.39      //electron mobility    (in m^2/(V*s))
up=0.19      //hole mobility    (in m^2/(V*s))
e=1.6*10^-19     //charge in electron (in C)
l=10^-2        //length    (in m)
A=10^-3*10^-3      //area (in m^2)
sigma=ni*e*(Un+up)     // electrical conductivity    (in  (ohm*m)^-1)
R=l/(sigma*A)       //Resistance
```

```
printf("Resistance of intrinsic Ge rod\n")
printf("R=%.0f    ohm",R)
```

Scilab code Exa 7.17 determine the position of Fermi level

```
// chapter 7 , Example7.17 , pg 216
Eg=1.12     //bandgap    (in eV)
T=300    //temperature    (in K)
Me=9.11*10^-31     //mass of electron    (in Kg)
Mn=0.12*Me
Mp=0.28*Me
k=1.38*10^-23     //Boltzmann constant    (in (m^2*Kg)/(s^2*K))
Ef=(Eg/2)+((log(Mp/Mn)*3*k*T)/(4*1.6*10^-19))
printf("position of Fermi level")
printf("Ef=%.3f    eV",Ef)
```

Scilab code Exa 7.18 calculate electrical conductivity

```
// chapter 7 , Example7.18 , pg 217
ni=1.5*10^16      //intrinsic carrier density(in m^-3)
Un=0.13      //electron mobility    (in m^2/(V*s))
up=0.05      //hole mobility    (in m^2/(V*s))
e=1.6*10^-19     //charge in electron (in C)
sigma=ni*e*(Un+up)     // electrical conductivity
printf("Electrical conductivity\n")
printf("sigma=%.6f    (ohm*m)^-1",sigma)
```

Scilab code Exa 7.19 find intrinsic resistivity

```
// chapter 7 , Example7.19 , pg 217
ni=2.15*10^13       //intrinsic  carrier  density(in
    cm^-3)
Un=3900     //electron mobility   (in cm^2/(V*s))
up=1900      //hole mobility   (in cm^2/(V*s))
e=1.6*10^-19     //charge in electron (in C)
sigma_I=ni*e*(Un+up)     // electrical conductivity
     (in  (ohm*cm)^-1)
rho_I=1/sigma_I     //intrinsic resistivity
printf("Intrinsic resistivity\n")
printf("rho_I=%.0f    ohm*cm",rho_I)




//Intrisic carrier density is given as 2.15*10^-13
    instead of 2.15*10^13
```

Scilab code Exa 7.20 find electrical conductivity before and after addition of B atoms

```
// chapter 7 , Example7.20 , pg 217
ni=2.1*10^19       //intrinsic  carrier  density(in m
    ^-3)
Un=0.4       //electron mobility   (in m^2/(V*s))
up=0.2       //hole mobility   (in m^2/(V*s))
e=1.6*10^-19     //charge in electron (in C)
sigma=ni*e*(Un+up)     // electrical conductivity
printf("Electrical conductivity\n")
printf("sigma=%.3f     (ohm*m)^-1",sigma)
```

Scilab code Exa 7.21 find Hall coefficient and electron mobility

```
// chapter 7 , Example 7.21 , pg 218
e=1.6*10^-19    // charge of electron   (in C)
I=5*10^-3     // current  (in mA)
V=1.35   // voltage   (in V)
Vh=20*10^-3    //Hall voltage   (in V)
B=0.45    //magnetic induction   (in T)
l=10^-2   //length   (in m)
b=5*10^-3    //breadth   (in m)
d=10^-3     //thickness    (in m)
R=V/I     //resistance    (in ohm)
A=b*d    //area   (in m^2)
rho= (R*A)/l    //resistivity    (in ohm*m)
E=Vh/d     //Hall electric field  (in V/m)
J=I/A     //current density   (in A/m^2)
Rh=E/(B*J)    //Hall coefficient
Un=Rh/rho    //electron mobility   (in m^2/(V*S))
printf("Hall coefficient =")
printf("Rh=%.3f  m^3/C \n",Rh)
printf("Electron mobility=")
printf("Un=%.2f m^2/(V*S)",Un)
```

Scilab code Exa 7.22 find Hall potential difference

```
// chapter 7 , Example7.22 , pg 218
Ix=200   //current  (in A)
Bz=1.5   //magnetic field   (in T)
d=10^-3   //width of slab   (in m)
p=8.4*10^28    //concentration of electrons (in m
   ^-3)
e=1.6*10^-19    // charge   (in C)
VH=(Bz*Ix)/(p*e*d)    //Hall  voltage
printf("Hall voltage(in V)=")
disp(VH)
```

Chapter 8

Magnetic materials

Scilab code Exa 8.1 Determine magnitude and direction of magnetic moment

```
// chapter 8 , Example 8.1 , pg 238
I=12 // current(in A)
A=7.5*10^-4 //area(in m^2)
M=I*A    //magnetic moment associated  with  the
   loop
printf("Magnetic moment associated with  the loop(in
   A m^2)=")
disp(M)
printf("M is directed away from  the observer  and
   is perpendicular  to the plane  of the loop")
```

Scilab code Exa 8.2 Determine magnetic moment

```
// chapter 8 , Example 8.2 , pg 238
r=0.5*10^-10   //radius of orbit   (in m)
e= 1.6*10^-19   //charge on electron  (in C)
n=10^16    //frequency of revolution of electron  (
   in  rps)
```

```
I=e*n       //current   (in A)
A=%pi *r^2   //area   (in  m^2)
M=I*A  //magnetic moment associated with  motion of
   electron
printf("Magnetic moment associated with  motion of
   electron (in  A m^2)")
disp(M)
```

Scilab code Exa 8.3 calculate magnetic susceptibility

```
// chapter 8 , Example 8.3 , pg 239
ur=5000   //relative permeability
xm=ur-1   //magnetic susceptibility
printf("Magnetic  susceptibility=")
disp(xm)
```

Scilab code Exa 8.4 calculate permeability

```
// chapter 8 , Example 8.4 , pg 239
H=1800  //magnetizing field  (in  A/m)
phi=3*10^-5   //magnetic  flux   (in Wb)
A=0.2 *10^-4  //area  (in m^2)
B=phi/A     //magnetic flux density   (in Wb/m^2)
u=B/H    //permeability     (in H/m)
printf("permeability (in  H/m )=")
disp(u)
```

Scilab code Exa 8.5 calculate magnetic moment

```
// chapter 8 , Example 8.5 , pg 239
```

```
B=0.65       //magnetic induction    (in T)
d=8906       //density     (in Kg/m^3)
M=58.7     //atomic weight
e=1.6*10^-19      //charge of electron     (in C)
h=6.625*10^-34     //plancks constant     (in m^2*Kg*S^-1)
m=9.11*10^-31      //mass of electron    (in Kg)
Uo=4*%pi*10^-7      //vacuum permeability
Na=6.023*10^26     //Avogadro constant
Ub=(e*h)/(4*%pi*m)       //Bhor magneton    (in A*m^2)
N=(d*Na)/M      //number of atoms per unit volume
Ur=B/(N*Uo)      //relative permeability     (in A/m^2)
M=Ur/(Ub)       //magnetic moment
printf("Magnetic moment")
printf("M=%.2f    A*m^2",M)
```

Chapter 9

Superconducting materials

Scilab code Exa 9.1 calculate critical magnetic field intensity

```
// chapter 9 , Example9.1 , pg 255
H0=6.5*10^4      //magnetic field intensity at 0K  (
    in  A/m)
T=4.2       //temperature   (in K)
Tc=7.18      //critical temperature  (in K)
Hc=H0*(1-(T^2/Tc^2))     // critical magnetic field
    intensity
printf("critical magnetic field intensity\n")
printf("Hc=%.0f    A/m",Hc)
```

Scilab code Exa 9.2 calculate isotopic mass

```
// chapter 9 , Example9.2 , pg 255
M1=199.5     //isotopic mass
Tc1=4.185     //critical temperature for M1   (in K)
Tc2=4.133     //critical temperature for M2   (in K)
alpha=0.5

```

```
//M^alpha * Tc=constant
M2=((M1^alpha*Tc1)/Tc2)^(1/alpha)
printf("Isotopic mass at critical temperature 4.133K \n")
printf("M2=%.3f ",M2)
```

Chapter 10

Dielectric materials

Scilab code Exa 10.1 calculate electronic polarizability

```
// chapter 10 , Example10 1 , pg 289
Er=1.0000684     //Dielectric constant
N=2.7*10^25      //(in atoms/m^3)
E0=8.85*10^-12   //permittivity of free space (in F/m)
Alpha_e=(E0*(Er-1))/N    //electronic polarization
printf("Electronic polarization (in F*m^2)\n")
disp(Alpha_e)
```

Scilab code Exa 10.2 calculate electronic polarizability

```
// chapter 10 , Example10 2 , pg 290
Er=1.0024     //Dielectric constant
N=2.7*10^25      //(in atoms/m^3)
E0=8.85*10^-12   //permittivity of free space    (in F/m)
Alpha_e=(E0*(Er-1))/N    //electronic polarization
printf("Electronic polarization (in F*m^2)\n")
disp(Alpha_e)
```

Chapter 12

Additional solved examples

Scilab code Exa 12.1 calculate relative population

```
// Additional solved examples , Example 1 , pg 330
lam=590*10^-9//wavelength(in m)
T=270+273  //temperature(in kelvin)   (converting
   celsius into kelvin)
k=1.38*10^-23//boltzman constant (in (m^2*Kg)/(s^2*k
   ))
h=6.625*10^-34//plancks constant(in Js)
c=3*10^8//speed of light
N=exp(-(h*c)/(lam*k*T)) //N=(n2/n1)=relative
   population of atoms in the 1st excited state  and
    in ground state
//n1=number of atoms in ground state
//n2=number of atoms in excited state
printf("Relative population of Na atoms in the 1st
   excited state and in ground state\n")
disp(N)
```

Scilab code Exa 12.2 determine relative population

```
// Additional solved examples , Example 2 , pg 330
lam=500*10^-9//wavelength(in m)
T=250+273  //temperature(in kelvin)  (converting celsius into kelvin)
k=1.38*10^-23//boltzman constant (in (m^2*Kg)/(s^2*k))
h=6.625*10^-34//plancks constant(in Js)
c=3*10^8//speed of light
N=exp(-(h*c)/(lam*k*T)) //N=(n2/n1)=relative population of atoms in the 1st excited state  and in ground state
//n1=number of atoms in ground state
//n2=number of atoms in excited state
printf("Relative population of Na atoms in the 1st excited state and in ground state\n")
disp(N)
```

Scilab code Exa 12.3 calculate ratio of stimulated emission to spontaneous emission

```
// Additional solved examples , Example 3 , pg 331
T=260+273 //temperature(in kelvin)  (converting celsius into kelvin)
h=6.625*10^-34//plancks constant(in Js)
c=3*10^8//speed of light(in m/s)
lam=590*10^-9//wavelength(in m)
k=1.38*10^-23//boltzman constant (in (m^2*Kg)/(s^2*k))
N=1/(exp((h*c)/(lam*k*T))-1)  //N=((n21)'/(n21)) ratio of stimulated  emission to spontaneous emission
printf("Ratio of stimulated  emission to spontaneous emission is")
disp(N)
```

Scilab code Exa 12.4 calculate number of photons emitted per minute

```
// Additional solved examples , Example 4 , pg 331
lam=632.8*10^-9//wavelength(in m)
Em=3.16*10^-3*60//energy emitted per minute(in J/min)
c=3*10^8//speed of light(in m/s)
h=6.625*10^-34//plancks constant(in Js)
n=c/lam  //frequency of emitted photons(in Hz)
E=h*n  //energy of each photon(in J)
N=Em/E  //number of photons emitted per minute
printf("Number of photons emitted per minute")
disp(N)
```

Scilab code Exa 12.5 calculate number of photons emitted per minute

```
// Additional solved examples , Example 5 , pg 332
lam=540*10^-9//wavelength(in m)
Em=5*10^-3*60//energy emitted per minute(in J/min)
c=3*10^8//speed of light(in m/s)
h=6.625*10^-34//plancks constant(in Js)
n=c/lam  //frequency of emitted photons(in Hz)
E=h*n  //energy of each photon(in J)
N=Em/E  //number of photons emitted per minute
printf("Number of photons emitted per minute")
disp(N)
```

Scilab code Exa 12.6 find NA and critical angle and alpha m

```
// Additional solved examples , Example 6 , pg 332
n1=1.5//core refractive index
n2=1.45//cladding refractive index
n0=1//refractive index of air
NA=sqrt(n1^2-n2^2)//numerical aperture
alpha_m =asin(NA/n0)//angle of acceptance (in radian)
phi_m=asin((n0*sin(alpha_m))/n1)// no*sin(alpha_m)=n1*sin(phi_m) (in radian)
phi_c=asin(n2/n1) //critical angle (in radian)
printf("NA=%.2f \n",NA)
printf("alpha_m=%.2f degree\n",(alpha_m*180)/%pi)
printf("phi_m=%.2f degree\n",(phi_m*180)/%pi)
printf("phi_c=%.2f degree",(phi_c*180)/%pi)
```

Scilab code Exa 12.7 find NA and critical angle and alpha m

```
// Additional solved examples , Example 7 , pg 333
n1=1.5//core refractive index
n2=1.45//cladding refractive index
n0=1.1//refractive index of medium
NA=sqrt(n1^2-n2^2)//numerical aperture
alpha_m =asin(NA/n0)//angle of acceptance (in radian)
phi_m=asin((n0*sin(alpha_m))/n1)// no*sin(alpha_m)=n1*sin(phi_m) (in radian)
phi_c=asin(n2/n1) //critical angle (in radian)
printf("NA=%.2f \n",NA)
printf("alpha_m=%.2f degree\n",(alpha_m*180)/%pi)
printf("phi_m=%.2f degree\n",(phi_m*180)/%pi)
printf("phi_c=%.2f degree",(phi_c*180)/%pi)
```

Scilab code Exa 12.8 calculate pulse broadening per unit length

```
// Additional solved examples , Example 8 , pg 334
n1=1.5//core refractive index
n2=1.45//cladding refractive index
c=3*10^8//speed of light(in m/s)
P=(n1*(n1-n2))/(n2*c)  //pulse broadening per unit
   length due to multiple dispersion
//P=(del_t/L)    where del_t=time interval  , L=
   distance  transversed by ray inside core
printf("pulse broadening per unit length due to
   multiple dispersion(in s/m)")
disp(P)
```

Scilab code Exa 12.9 calculate pulse broadening per unit length

```
// Additional solved examples , Example 9 , pg 334
n1=1.55//core refractive index
n2=1.48//cladding refractive index
c=3*10^8//speed of light(in m/s)
P=(n1*(n1-n2))/(n2*c)  //pulse broadening per unit
   length due to multiple dispersion
//P=(del_t/L)    where del_t=time interval  , L=
   distance  transversed by ray inside core
printf("pulse broadening per unit length due to
   multiple dispersion(in s/m)")
disp(P)
```

Scilab code Exa 12.10 calculate minimum and maximum number of total internal reflections per metre

```
// Additional solved examples , Example 10 , pg 335
n1=1.5//core refractive index
n2=1.45//cladding refractive index
n0=1//refractive index of air
```

```
NA=sqrt(n1^2-n2^2)//numerical aperture
alpha_m =asin(NA/n0)//angle of acceptance  (in radian)
a=100*10^-6/2  //radius of core
phi_m=asin((n0*sin(alpha_m))/n1)//   no*sin(alpha_m)=n1*sin(phi_m)  (in radian)
L=a/tan(phi_m)  //(in m)
printf("Minimum number of reflections per metre=zero\n")   //since rays travelling with alpha=0 suffer no internal reflection
//for rays travelling with alpha=alpha_m ,1 internal reflection takes place for a transversed distance of 2*L
N=1/(2*L)  //Maximum number of reflections per metre
disp("Maximum number of reflections per metre(in m^-1)=")
printf("N=%.0f",N)

//Answer varies as L is restricted to 1.86*10^-4 (m) instead of 1.888*10^-4 (m)
```

Scilab code Exa 12.11 calculate energy and momentum of photon

```
// Additional solved examples , Example 11 , pg 335
c=3*10^8 //speed of light(in m/sec)
h=6.625*10^-34//planck's constant(in  J s)
lam=1.4*10^-10//wavelength(in m)
E=(h*c)/(lam*1.6*10^-19)  //energy of photon(in eV)
p=h/lam  //momentum of photon
printf("Energy of photo\n")
printf("E=%.1f eV\n",E)
printf("momentum of photon(in Kg m/sec)\n")
disp(p)
```

Scilab code Exa 12.12 calculate number of photons emitted per second

```
// Additional solved examples , Example 12 , pg 336
E1=2*10^4 //energy emitted per second(in J)
n=1000*10^3  //frequency(in Hz)
h=6.625*10^-34 //plancks constant(in J s)
E=h*n//energy carried by 1 photon(in J)
N=E1/E//number of photons emitted per second
printf("number of photons emitted per second\n")
disp(N)
```

Scilab code Exa 12.13 calculate de Broglie wavelength

```
// Additional solved examples , Example 13 , pg 336
m=0.05//mass(in Kg)
v=2000//speed(in m/sec)
h=6.625*10^-34//plancks constant(in J s)
p=m*v//momentum(in kg m/sec)
lam=h/p //wavelength
printf("de Broglie wavelength(in m)\n")
disp(lam)
printf("de Broglie wavelength(in A)\n")
disp(lam*10^10)
```

Scilab code Exa 12.14 find change in wavelength

```
// Additional solved examples , Example 14 , pg 336
h=6.625*10^-34//planckconstant(in J s)
c=3*10^8//velocity of x-ray photon(in m/sec)
```

```
m0=9.11*10^-31//rest mass of electron(in Kg)
phi=(85*%pi)/180//angle of scattering (in radian)(converting degree into radian)
delta_H=(h*(1-cos(phi)))/(m0*c)//change in wavelength due to compton scattering
printf("change in wavelength of x-ray photon(in m)\n")
disp(delta_H)
```

Scilab code Exa 12.15 find miller indices

```
// Additional solved examples , Example 15 , pg 337
//plane has intercepts  2a,2b,3c along the 3 crystal axes
//lattice points in 3-d lattice are given by r=p*a+q*b+s*c
//as p,q,r  are the basic vectors the proportion of intercepts  2:2:3
p=2
q=2
s=3
//therefore reciprocal
r1=1/2
r2=1/2
r3=1/3
//taking LCM
v=int32([2,2,3])
l=double(lcm(v))
m1=(l*r1)
m2=(l*r2)
m3=(l*r3)
printf("miler indices=")
disp(m3,m2,m1)
```

Scilab code Exa 12.16 find miller indices

```
// Additional solved examples , Example 16 , pg 337
//plane has intercepts  4a,2b,4c along the 3
    crystal axes
//lattice points in 3-d lattice are given by r=p*a+q
    *b+s*c
//as p,q,r  are the basic vectors the proportion of
    intercepts  2:2:3
p=4
q=2
s=4
//therefore reciprocal
r1=1/4
r2=1/2
r3=1/4
//taking LCM
v=int32([4,2,4])
l=double(lcm(v))
m1=(l*r1)
m2=(l*r2)
m3=(l*r3)
printf("miler indices=")
disp(m3,m2,m1)
```

Scilab code Exa 12.17 find size of unit cell

```
// Additional solved examples , Example 17 , pg 338
d110=1.96//spacing of(1 1 0) planes   (in Angstrom)
h=1
k=1
l=0 //(h k l)=(1 1 0)
```

```
a=d110*sqrt(h^2+k^2+l^2)//size of unit cell
printf("size of unit cell=")
printf("a=%.2f angstrom",a)
```

Scilab code Exa 12.18 find volume of unit cell

```
// Additional solved examples , Example 18 , pg 339
r=1.575 *10^-10 //radius of atom (in m)
a=2*r//lattice constant (for HCP structure) (in m)
c=a*sqrt(8/3) //(in m)
V=(3*sqrt(3)*a^2*c)/2 //volume of unit cell
printf("volume of unit cell(in m^3)\n")
disp(V)
```

Scilab code Exa 12.19 calculate Fermi energy

```
// Additional solved examples , Example 19 , pg 339
Vf=7*10^5 //Fermi velocity (in m/s)
m=9.11*10^-31 // mass of electron(in Kg)
Ef=(m*Vf^2)/2 //Fermi energy (in J)
printf("Fermi energy for the electrons in the metal
   =")
printf("Ef=%.1f eV",(Ef/(1.6*10^-19))) //
   converting J into eV




//Answer is given wrong
```

Scilab code Exa 12.20 calculate relaxation time and average drift velocity and velocity of electron and mean free path

```
// Additional solved examples , Example 20 , pg 339
rho=1.8*10^-8     //resistivity   (in ohm*m)
Ef=4.8       //Fermi energy     (in eV)
E=100   //electric field intensity    (in V/m)
n=6.2*10^28      //concentration of electrons     (in atoms/m^3)
e=1.6*10^-19     //charge in electron     (in C)
Me=9.11*10^-31     //mass of electron   (in Kg)
T=Me/(rho*n*e^2)      //relaxation time
Un=(e*T)/Me      //mobility of electron
Vd=(e*T*E)/Me       //drift velocity
Vf=sqrt((2*Ef*e)/Me)      //Fermi velocity
lam_m=Vf*T     //mean free path

printf("Relaxation time of electron (in s)")
disp(T)
printf("Mobility of electron  (in m^2/(V*s))")
disp(Un)
printf("Drift velocity of electron (in m/s)")
disp(Vd)
printf("Fermi velocity of electrons (in m/s)")
disp(Vf)
printf("Mean free path(in m)")
disp(lam_m)
```

Scilab code Exa 12.21 evaluate value of F E

```
// Additional solved examples , Example 21 , pg 341
del_E=0.02*1.6*10^-19    //   del_E = E-Ef (in J)     (converting eV into J)
T=220    //temperature    (in K)
k=1.38*10^-23    //boltzmanns constant   (in J/K)
```

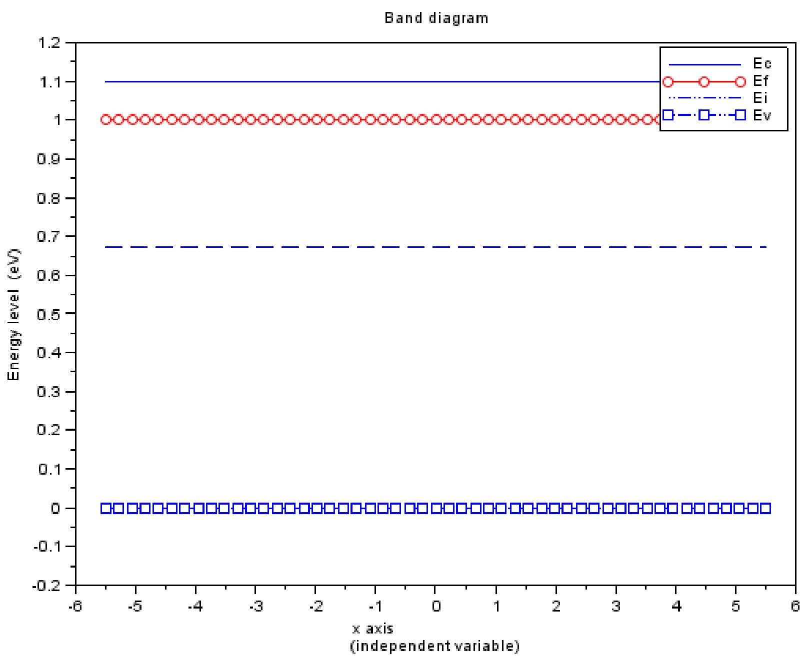

Figure 12.1: calculate how is Ef located relative to Ei

```
F_E=1/(1+exp(del_E/(k*T)))      //Fermi Dirac
    distribution function
printf("F_E=%.3f",F_E)
```

Scilab code Exa 12.22 calculate how is Ef located relative to Ei

```
// Additional solved examples , Example 22 , pg 341
ni=1.5*10^10        //intrinsic concentration   (in cm
    ^-3)
```

```
Nd=5*10^15    //donor concentration   (in atoms/cm
   ^3)
T=300     //temperature    (in K)
e=1.6*10^-19    //charge of electron    (in C)
k=1.38*10^-23    //Boltzmann constant    (in J/K)
n0=Nd     //Assuming  n0=Nd      ( since    Nd >> ni
   )
p0=ni^2/n0     //hole concentration
E=k*T*log(n0/ni)     // E=(Ef-Ei)    location of Ef
   relative to Ei
printf("Hole concentration (in cm^-3)")
disp(p0)
printf("Location of Ef relative to Ei   (in eV)")
disp(E/e)
x = linspace(-5.5,5.5,51);
y = 1 ;

scf(2);
clf(2);
plot(x,y+0.1);

plot(x,y,'ro-');
plot(x,y-0.329,'--');
plot(x,y*0,'bs:');
xlabel(["x axis";"(independent variable)"]);
ylabel("Energy level  (eV)");
title("Band diagram");
legend(["Ec";"Ef";"Ei";"Ev"]);
set(gca(),"data_bounds",matrix([-6,6,-0.1,1.1],2,-1)
   );
```

Scilab code Exa 12.23 find magnitude of Hall voltage

```
// Additional solved examples , Example 23 , pg 342
I=40   //current  (in A)
```

```
B=1.4    //magnetic field    (in T)
d=2*10^-2    //width of slab    (in m)
n=8.4*10^28     //concentration of electrons (in m^-3)
e=1.6*10^-19     // charge    (in C)
VH=(B*I)/(n*e*d)     //Hall  voltage
printf("Hall voltage(in V)=")
disp(VH)
```

Scilab code Exa 12.24 calculate Hall voltage and Hall coefficient

```
// Additional solved examples , Example 24 , pg 342
e=1.6*10^-19     //charge in electron (in C)
Ix=2*10^-3     //current (in A)
d=220*10^-4     //thickness    (in cm)
Bz=5*10^-5     //magnetic induction    (in Wb/cm^2)
Un=800     //electron mobility    (in cm^2/(V*s))
n=9*10^16     //doping concentration    (in atoms/cm^3)

sigma=n*e*(Un)     // electrical conductivity
rho=1/sigma     //resistivity
Rh=-1/(e*n)     //Hall coefficient
Vh=-(Ix*Bz)/(d*e*n)     //Hall  voltage
printf("Resistivity(in ohm*cm)")
disp(rho)
printf("Hall coefficient(in cm^3/C)")
disp(Rh)
printf("Hall voltage (in V)")
disp(Vh)
```

Scilab code Exa 12.25 determine magnitude and direction of magnetic moment

```
// Additional solved examples , Example 25 , pg 343
I=10 // current(in A)
A=8*10^-4 //area(in m^2)
M=I*A    //magnetic moment associated  with  the
   loop
printf("Magnetic moment associated with  the loop(in
      A m^2)=")
disp(M)
printf("M is directed away from  the observer  and
   is perpendicular  to the plane  of the loop")
```

Scilab code Exa 12.26 determine magnitude and direction of magnetic moment

```
// Additional solved examples , Example 26 , pg 343
I=22 // current(in A)
A=9*10^-3 //area(in m^2)
M=I*A    //magnetic moment associated  with  the
   loop
printf("Magnetic moment associated with  the loop(in
      A m^2)=")
disp(M)
printf("M is directed towards the observer  and is
   perpendicular  to the plane  of the loop")
```

Scilab code Exa 12.27 determine magnetic moment

```
// Additional solved examples , Example 27 , pg 344
r=0.62*10^-10   //radius of orbit   (in m)
e= 1.6*10^-19   //charge on electron  (in C)
n=10^15    //frequency of revolution of electron  (
   in  rps)
I=e*n      //current   (in A)
```

```
A=%pi *r^2    //area    (in   m^2)
M=I*A  //magnetic moment associated with  motion of
   electron
printf("Magnetic moment associated with  motion of
   electron (in  A m^2)")
disp(M)
```

Scilab code Exa 12.28 calculate permeability

```
// Additional solved examples , Example 28 , pg 344
H=2000  //magnetizing field  (in  A/m)
phi=5*10^-5   //magnetic  flux   (in Wb)
A=0.2 *10^-4  //area  (in m^2)
B=phi/A    //magnetic flux density   (in Wb/m^2)
u=B/H    //permeability     (in H/m)
printf("permeability (in  H/m )=")
disp(u)
```

Scilab code Exa 12.29 calculate susceptibility

```
// Additional solved examples , Example 29 , pg 345
ur=4000    //relative permeability
xm=ur-1    //magnetic susceptibility
printf("Magnetic  susceptibility=")
disp(xm)
```

Scilab code Exa 12.30 determine critical current

```
// Additional solved examples , Example 30 , pg 345
```

```
H0=6*10^4      //magnetic field intensity at 0K   (in
     A/m)
T=4.2       //temperature    (in K)
Tc=8      //critical temperature   (in K)
Hc=H0*(1-(T^2/Tc^2))     // critical magnetic field
   intensity
printf("critical magnetic field intensity\n")
printf("Hc=%.0f    A/m",Hc)
```

Scilab code Exa 12.31 calculate critical current

```
// Additional solved examples , Example 31 , pg 346
H0=7*10^4      //magnetic field intensity at 0K   (in
     A/m)
T=4.2       //temperature    (in K)
Tc=8.2      //critical temperature   (in K)
Hc=H0*(1-(T^2/Tc^2))     // critical magnetic field
   intensity
printf("critical magnetic field intensity\n")
printf("Hc=%.0f    A/m",Hc)
```

Scilab code Exa 12.32 calculate isotopic mass

```
// Additional solved examples , Example 32 , pg 346
M1=198.5     //isotopic mass
Tc1=4.175     //critical temperature for M1   (in K)
Tc2=4.213     //critical temperature for M2   (in K)
alpha=0.5

//M^alpha * Tc=constant
M2=((M1^alpha*Tc1)/Tc2)^(1/alpha)
printf("Isotopic mass at critical temperature 4.133K
   \n")
```

```
printf("M2=%.3f ",M2)
```

Scilab code Exa 12.33 calculate isotopic mass

```
// Additional solved examples , Example 33 , pg 346
M1=199    //isotopic mass
Tc1=4.18    //critical temperature for M1   (in K)
Tc2=4.14    //critical temperature for M2   (in K)
alpha=0.5

//M^alpha * Tc=constant
M2=((M1^alpha*Tc1)/Tc2)^(1/alpha)
printf("Isotopic mass at critical temperature 4.133K
   \n")
printf("M2=%.4f ",M2)
```

Chapter 13

Additional solved short answers

Scilab code Exa 13.1.2 find fundamental frequency

```
// Additional solved numerical questions , Example(set 1) 2 , pg 348
l=0.7*10^-3//length(in m)
E=8.8*10^10//youngs modulus(in N/m^2)
d=2800//density(in kg/m^3)
p=1//fundamental mode
n= p*sqrt(E/d)/(2*l) //natural frequency
printf("Fundamental frequency of quartz crystal)\n")
printf("n=%.2f Hz",n)
```

Scilab code Exa 13.1.6 calculate critical angle

```
// Additional solved numerical questions , Example(set 1) 6 , pg 348
n1=1.5    //refractive index of core
n2= 1.47    // cladding refractive index
theta_c=asin(n2/n1)   //critical angle (in radian)
```

```
printf("critical angle=\n")
printf("theta_c=%.2f degree",(theta_c*180)/%pi)
```

Scilab code Exa 13.1.10 calculate interplanar spacing

```
// Additional solved numerical questions , Example(
    set 1) 10 , pg 349
a=4.938 //lattice constant(in Angstrom)
h=2
k=2
l=0 //since (h k l)=(2 2 0) miller indices
d=a/sqrt(h^2+k^2+l^2) //spacing
printf("spacing of (2 2 0) planes=")
printf("d=%.3f Angstrom",d)
```

Scilab code Exa 13.1.12 find the wavelength

```
// Additional solved numerical questions , Example(
    set 1) 12_b_3 , pg 349
Eg=0.8*1.6*10^-19 //bandgap (in J) (
    converting eV into J)
h=6.625*10^-34 //plancks constant (in J s)
c=3*10^8 //speed of light (in m/s)
lam=(h*c)/Eg //wavelength
printf("wavelength of light emitted (in m)is=")
disp(lam)
```

Scilab code Exa 13.1.14 calculate energy of scattered photon

```
// Additional solved numerical questions , Example(
    set 1) 14_a_3 , pg 350
lam=1.24*10^-13     //wavelength   (in m)
h=6.625*10^-34//planckconstant(in J s)
c=3*10^8//velocity of x-ray photon(in m/sec)
m0=9.11*10^-31//rest mass of electron(in Kg)
phi=(90*%pi)/180//angle of scattering (in radian)
    (converting degree into radian)
delta_H=(h*(1-cos(phi)))/(m0*c)//change in
    wavelength due to compton scattering      (in m)
LAM=lam+delta_H     //wavelength      (in m)
E=(h*c)/LAM        //energy of scattered photon   (
    in J)
printf("Energy of scattered photon   (in J)=")
disp(E)
```

Scilab code Exa 13.1.15 calculate number of unit cells

```
// Additional solved numerical questions , Example(
    set 1) 15_b_3 , pg 352
a=2.88*10^-8   //lattice constant   (in cm)
d=7200   //density (in  Kg/m^3)
C=8/a^3    // atomic  concentration
n=8       //number of atoms/cell
n1=C/n     //unit cell concentration

//since  density =7200 Kg/m^3
//7200 Kg  =  10^6 cc
//hence 1Kg = (10^6)/7200   cc
N=(n1*10^6)/7200      //number of unit  cells
    present in 1 Kg of metal
printf("Number of unit cells present in 1 Kg of
    metal=")
disp(N)
printf("unit cells")
```

Scilab code Exa 13.2.1 calculate the frequency

```
// Additional solved numerical questions , Example(
    set 2) 1 , pg 352
l=4*10^-2    //length(in m)
E=207 *10^6   //youngs modulus(in N/m^2)
d=8900   //density(in kg/m^3)
p=1//fundamental mode
n= p*sqrt(E/d)/(2*l)  //natural frequency
printf("Fundamental frequency of quartz crystal)\n"
    )
printf("n=%.2f   Hz",n)
```

Scilab code Exa 13.2.7 calculate wavelength of scattered radiation

```
// Additional solved numerical questions , Example(
    set 2) 7 , pg 353
lam=0.5*10^-9    //wavelength   (in m)
h=6.625*10^-34//planckscostant(in J s)
c=3*10^8//velocity of x-ray photon(in m/sec)
m0=9.11*10^-31//rest mass of electron(in Kg)
phi=(45*%pi)/180//angle of scattering (in radian)
    (converting degree into radian)
delta_H=(h*(1-cos(phi)))/(m0*c)//change in
    wavelength due to compton scattering     (in m)
LAM=lam+delta_H    //wavelength     (in m)
printf("wavelength of scattered radiation (im m)=")
disp(LAM)
```

Scilab code Exa 13.2.13 calculate Na and acceptance angle

```
// Additional solved numerical questions , Example(set 2) 13_b , pg 354
n1=1.5//core refractive index
n2=1.447//cladding refractive index
n0=1//refractive index of air
NA=sqrt(n1^2-n2^2)//numerical aperture
alpha_m =asin(NA/n0)//angle of acceptance (in radian)
printf("NA=%.1f \n",NA)
printf("alpha_m=%.2f degree\n",(alpha_m*180)/%pi)
```

Scilab code Exa 13.3.11 calculate mean free time

```
// Additional solved numerical questions , Example(set 3) 11_a , pg 355
Un=3*10^-3    //electron mobility  (in m^2/(V*s))
e=1.6*10^-19    //charge in electron   (in C)
Me=9.11*10^-31     //mass of electron   (in Kg)
T=(Me*Un)/e    //mean free time
printf("Mean free time(in S)")
disp(T)
```

Scilab code Exa 13.3.12 calculate the resistivity

```
// Additional solved numerical questions , Example(set 3) 12_b , pg 356
ni=1.5*10^16     //intrinsic  carrier  density(in m^-3)
Un=1.35     //electron mobility   (in m^2/(V*s))
up=0.48     //hole mobility   (in m^2/(V*s))
e=1.6*10^-19    //charge in electron (in C)
```

```

Ix=10^-3     //current (in A)
d=100*10^-6      //thickness    (in m)
Bz=0.1     //magnetic induction    (in T)
Un1=0.07     //electron mobility    (in m^2/(V*s))
n=10^23      //doping concentration     (in atoms/m^3)

sigma=ni*e*(Un+up)     // electrical conductivity
rho=1/sigma     //resistivity
Vh=-(Ix*Bz)/(d*e*n)    //Hall  voltage
printf("Resistivity(in ohm*m)")
disp(rho)
printf("Hall voltage (in V)")
disp(Vh)
```

Scilab code Exa 13.3.13 calculate energy loss per hour and intensity of magnetization and flux density

```
// Additional solved numerical questions  , Example(set 3) 13_b , pg 357
A=250     //area of B-H loop
f=50      //frequency    (in Hz)
d=7.5*10^3      //density     (in Kg/m^3)
M=10     //mass of core    (in Kg)

H=2000     //magnetic field intensity   (in A/m)
Xm=1000     //susceptibility
U0=4*%pi*10^-7       // relative permeability

V=M/d     //volume of sample    (in m^3)
N=60*60*f     //number of cycles per hour
EL=A*V*N     //energy loss per hour
I=H*Xm      //intensity of magnetization
Ur=1+Xm
B=Ur*U0*H       //magnetic  flux density
```

```
printf("Energy loss per hour (in J)")
disp(EL)
printf("Intensity of magnetization (in Wb/m^3)")
disp(I)
printf("Magnetic flux density(in T)")
disp(B)
```

Scilab code Exa 13.3.14 find capacitance and electric flux density

```
// Additional solved numerical questions , Example(
    set 3) 14 , pg 358
Er1=1.0000684      //Dielectric constant   (for sum
    14_a_2)
N=2.7*10^25      //(in atoms/m^3)
E0=8.85*10^-12    //permittivity of free space   (in
    F/m)
Er2=6       //dielectric constant  (for sum 14_a_3)
E=100     //electric field intensity  (in V/m)     (
    for sum  14_a_3)
A=200*10^-4     //area   (in m^2)
Er3=3.7     //dielectric constant      (for sum 14_b_2
    )
d=10^-3     //thickness    (in m)
V=300    //electric potential    (in V)
Alpha_e=(E0*(Er1-1))/N     //electronic polarization
R=(Alpha_e/(4*%pi*E0))^(1/3)    //radius of atom
P=E0*(Er2-1)*E     //polarization
C=(E0*Er3*A)/d     //capacitance
E1=V/d        //electric flux density
printf("Electronic polarization (in F*m^2)")
disp(Alpha_e)
printf("Radius of He atom(in m)")
disp(R)
printf("polarization(in C/m^2)")
disp(P)
```

```
printf("capacitance(in F)")
disp(C)
printf("Electric flux density (in V/m)")
disp(E1)
```