

Scilab Textbook Companion for
Engineering Physics
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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

ultrasonics

Scilab code Exa 1.1 To find depth of submerged submarine

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

Scilab code Exa 1.2 To calculate the natural frequency

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

```
7 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

```
1 // chapter 1 , Example1 3 , pg 21
2 l=10^-3//length(in m)
3 E=7.9*10^10//youngs modulus(in N/m^2)
4 d=2650//density(in kg/m^3)
5 p=1//fundamental mode
6 n= p*sqrt(E/d)/(2*l) //natural frequency
7 printf("Fundamental frequency of quartz crystal\n")
8 printf("n=%0.2f Hz" ,n)
```

Scilab code Exa 1.4 compute the velocity of waves

```
1 // chapter 1 , Example1 4 , pg 22
2 lam=2*0.55*10^-3 //distance between 2 antinodes is
    lam/2 (in m)
3 n=1.45*10^6 //frequency of crystal(in Hz) (given)
    they have taken n=1.5 Hz in
    calculation
4 v=n*lam //velocity
5 printf("velocity of waves in sea water\n")
6 printf("v=%0.1f m/s" ,v)
7
8
9 //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

```
1 // chapter 1 , Example1 5 , pg 22
2 l=50*10^-3//length of rod(in m)
3 d=7250//density(in kg/m^3)
4 E=11.5*10^10//youngs modulus(in N/m^2)
5 n=sqrt(E/d)/(2*l)//natural frequency
6 printf("Natural frequency of rod\n")
7 printf("n=%0.2 f KHz" ,n*10^-3)
```

Scilab code Exa 1.6 To calculate the natural frequency

```
1 // chapter 1 , Example1 6 , pg 23
2 l=2*10^-3//length(in m)
3 d=2650//density(in kg/m^3)
4 E=7.9*10^10//youngs modulus(in N/m^2)
5 p=1
6 n=(p*sqrt(E/d))/(2*l)//natural frequency
7 printf("frequency of crystal\n")
8 printf("n=%0.3 f MHz" ,n*10^-6)
```

Scilab code Exa 1.7 To calculate the natural frequency

```
1 // chapter 1 , Example1 7 , pg 23
2 l=3*10^-3//length(in m)
3 d=2500//density(in kg/m^3)
4 E=8*10^10//youngs modulus(in N/m^2)
5 p=1
6 n=(p*sqrt(E/d))/(2*l)//natural frequency
7 printf("frequency of ultrasound\n")
8 printf("n=%0.3 f KHz" ,n*10^-3)
```

Scilab code Exa 1.8 To calculate the frequency

```
1 // chapter 1 , Example1 8 , pg 23
2 l=1.5*10^-3//length(in m)
3 d=2650//density(in kg/m^3)
4 E=7.9*10^10//youngs modulus(in N/m^2)
5 p=1
6 n=(p*sqrt(E/d))/(2*1)//natural frequency
7 printf("frequency of crystal\n")
8 printf("n=%0.3 f MHz" ,n*10^-6)
```

Scilab code Exa 1.9 To find depth of sea

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

Scilab code Exa 1.10 To find depth of sea

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

Scilab code Exa 1.11 To calculate reverberation time

```
1 // chapter 1 , Example1 11 , pg 24
2 aS=1050//total absorption inside hall(in Sabine)
3 //a=average absorption coefficient , S=area of
  interior surface
4 V=9000//volume of hall(in m^3)
5 T=(0.165*V)/aS//reverberation time
6 printf("Reverberation time of hall\n")
7 printf("T=%0.4f sec",T)
```

Scilab code Exa 1.12 To find area of interior surface

```
1 // chapter 1 , Example1 12 , pg 25
2 V=13500//volume(in m^3)
3 T=1.2//reverberation time(in sec)
4 a=0.65//average absorption coefficient(in Sabine/m
  ^2)
5 S=(0.165*V)/(a*T)//area of interior surface
6 printf("Area of interior surface\n")
7 printf("S=%0.1f m^2",S)
```

Scilab code Exa 1.13 To find reverberation time

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

```

5 T2=(0.165*V)/(aS+300)//reverberation time of hall
   after adding 300 chairs each having absorption of
   1 Sabine
6 printf("Reverberation time of hall after adding 300
   chairs\n")
7 printf("T2=%0.3f sec",T2)

```

Scilab code Exa 1.14 To find depth of submarine

```

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

```

Scilab code Exa 1.15 To find frequency of waves

```

1 // chapter 1 , Example1 15 , pg 26
2 lam=2*0.4*10^-3 //distance between 2 antinodes is
   lam/2 (in m)
3 n=1.5*10^6 //frequency of crystal(in Hz)
4 v=n*lam //velocity
5 printf("velocity of waves in sea water\n")
6 printf("v=%0.1f m/s",v)

```

Scilab code Exa 1.16 To evaluate natural frequency

```
1 // chapter 1 , Example 16 , pg 26
2 l=40*10^-3//length(in m)
3 E=11.5*10^10//youngs modulus(in N/m^2)
4 d=7250//density(in kg/m^3)
5 p=1//fundamental mode
6 n= p*sqrt(E/d)/(2*l) //natural frequency
7 printf("Fundamental frequency of quartz crystal\n")
8 printf("n=%0.2 f KHz",n*10^-3)
```

Chapter 2

Lasers

Scilab code Exa 2.1 To calculate relative population

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

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

```

1 // chapter 2 , Example2 2 , pg 53
2 T=250+273 //temperature(in kelvin) (converting
   celsius into kelvin)
3 h=6.625*10^-34//plancks constant(in Js)
4 c=3*10^8//speed of light(in m/s)
5 lam=590*10^-9//wavelength(in m)
6 k=1.38*10^-23//boltzman constant (in (m^2*Kg)/(s^2*k
   ))
7 N=1/(exp((h*c)/(lam*k*T))-1) //N=((n21)')/(n21))
   ratio of stimulated emission to spontaneous
   emission
8 printf("Ratio of stimulated emission to spontaneous
   emission is")
9 disp(N)
10
11
12 //answer given is wrong

```

Scilab code Exa 2.3 calculate number of photons emitted per minute

```

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

```

Chapter 3

Fibre optics and its applications

Scilab code Exa 3.1 To find NA and ϕ_m and critical angle

```
1 // chapter 3 , Example 3.1 , pg 84
2 n1=1.5//core refractive index
3 n2=1.47//cladding refractive index
4 n0=1//refractive index of air
5 NA=sqrt(n1^2-n2^2)//numerical aperture
6 alpha_m =asin(NA/n0)//angle of acceptance (in
    radian)
7 phi_m=asin((n0*sin(alpha_m))/n1)// no*sin(alpha_m)
    =n1*sin(phi_m) (in radian)
8 phi_c=asin(n2/n1) //critical angle (in radian)
9 printf("NA=%0.1f \n",NA)
10 printf("alpha_m=%0.2f degree\n", (alpha_m*180)/%pi)
11 printf("phi_m=%0.2f degree\n", (phi_m*180)/%pi)
12 printf("phi_c=%0.2f degree", (phi_c*180)/%pi)
13
14
15 //data given is n2=1.97 which is not possible since
    refractive index of cladding should always be
    less than refractive index of core
16 //in calculation n2=1.47
```

Scilab code Exa 3.2 calculate pulse broadening per unit length

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

Scilab code Exa 3.3 To calculate minimum and maximum number of total internal refl

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

```
        distance of 2*L
12 N=1/(2*L) //Maximum number of reflections per metre
13 disp("Maximum number of reflections per metre(in m
        ^-1)=")
14 printf("N=%0.0 f",N)
15
16 //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

```
1 // chapter 4 , Example4 1 , pg 117
2 c=3*10^8 //speed of light(in m/sec)
3 h=6.625*10^-34//planck 's constant(in J s)
4 lam=1.2*10^-10//wavelength(in m)
5 E=(h*c)/(lam*1.6*10^-19) //energy of photon(in eV)
6 p=h/lam //momentum of photon
7 printf("Energy of photo\n")
8 printf("E=%0.1f eV\n",E)
9 printf("momentum of photon(in Kg m/sec)\n")
10 disp(p)
```

Scilab code Exa 4.2 calculate number of photons emitted per second

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

```

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

```

Scilab code Exa 4.3 determine number of photons emitted per second

```

1 // chapter 4 , Example 4.3 , pg 118
2 c=3*10^8//speed of light(in m/sec)
3 h=6.625*10^-34//plancks constant(in J s)
4 E1=100//energy emitted per second(in J)
5 lam=5893*10^-10//wavelength(in m)
6 E=(h*c)/lam //energy carried by 1 photon
7 N=E1/E//number of photons emitted per second
8 printf("number of photons emitted per second\n")
9 disp(N)
10
11
12 //answer mentioned is wrong

```

Scilab code Exa 4.4 find the wavelength

```

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

```

```

10 printf(" wavelength of scattered radiation (in
    Angstrom)\n")
11 disp(lam1*10^10)
12
13
14 //calculation is done assuming h=6.6*10^-34 Js in
    book

```

Scilab code Exa 4.5 calculate de Broglie wavelength

```

1 // chapter 4 , Example 4.5 , pg 119
2 m=0.04//mass(in Kg)
3 v=1000//speed(in m/sec)
4 h=6.625*10^-34//plancks constant(in J s)
5 p=m*v//momentum(in kg m/sec)
6 lam=h/p //wavelength
7 printf("de Broglie wavelength(in m)\n")
8 disp(lam)
9 printf("de Broglie wavelength(in A)\n")
10 disp(lam*10^10)
11
12
13
14 //calculation is done assuming h=6.6*10^-34 Js

```

Scilab code Exa 4.6 find energy of particle

```

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

```



```

6 E=(h^2)/(8*m*a^2)//energy of an electron
7 printf("Energy of electron in ground state(in J)\n")
8 disp(E)
9 printf("E=%0.3f eV",E/(1.6025*10^-19))

```

Scilab code Exa 4.7 calculate minimum energy

```

1 // chapter 4 , Example 4.7 , pg 120
2 a=4*10^-9 //width (in m)
3 n=1// lowest energy state of particle is obtained
   at n=1
4 h=6.625*10^-34 //plancks constant(in Js)
5 m=9.11*10^-31//mass of electron (in Kg)
6 E=(h^2)/(8*m*a^2)//energy of an electron
7 printf("Energy of electron in ground state(in J)\n")
8 disp(E)
9 printf("E=%0.5f eV",E/(1.6025*10^-19))

```

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

```

1 // chapter 4 , Example 4.8 , pg 120
2 a=0.1 *10^-9 //width (in m)
3 n1=1// lowest energy state of particle is obtained
   at n=1
4 n=6 //6th excited state hance n=6
5 h=6.625*10^-34 //plancks constant(in Js)
6 m=9.11*10^-31//mass of electron (in Kg)
7 //E=(n^2*h^2)/(8*m*a^2) n=excited state of
   electron
8 E1=(n1^2*h^2)/(8*m*a^2)//energy of an electron in
   ground state (in J)
9 E6=(n^2*h^2)/(8*m*a^2)//energy at 6th excuted state(
   in J)

```

```

10 E=E6-E1//energy required to excite the electron from
    ground state to the 6th excited state
11 printf("energy required to excite the electron from
    ground state to the 6th excited state(in J)\n")
12 disp(E)
13 printf("E=%0.2f eV" ,(E/(1.6025*10^-19)))

```

Scilab code Exa 4.9 find change in wavelength

```

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

```

Chapter 5

Crystal physics

Scilab code Exa 5.1 determine miller indices

```
1 // chapter 5 , Example5 1 , pg 149
2 //plane has intercepts a,2b,3c along the 3 crystal
   axes
3 //lattice points in 3-d lattice are given by r=p*a+q
   *b+s*c
4 //as p,q,r are the basic vectors the proportion of
   intercepts 1:2:3
5 p=1
6 q=2
7 s=3
8 //therefore reciprocal
9 r1=1/1
10 r2=1/2
11 r3=1/3
12 //taking LCM
13 v=int32([1,2,3])
14 l=double(lcm(v))
15 m1=(l*r1)
16 m2=(l*r2)
17 m3=(l*r3)
18 printf("miller indices=")
```

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

Scilab code Exa 5.2 calculate density of Si

```
1 // chapter 5 , Example5 2 , pg 150
2 a=5.43*10^-8//lattice constant(in cm)
3 M=28.1 //atomic weight (in g)
4 n=8// number of atoms/cell (for Si)
5 N=6.02*10^23 //Avogadro number
6 C=n/a^3 //atomic concentration =(number of atoms/
  cell)/cell volume (in atoms/cm^3)
7 D=(C*M)/N //Density
8 printf("Density of Si=")
9 printf("D=%0.2 f g/cm^3",D)
```

Scilab code Exa 5.3 calculate surface density of atoms

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

Scilab code Exa 5.4 calculate spacing of planes

```
1 // chapter 5 , Example5 2 , pg 150
2 a=4.049 //lattice constant(in Angstrom)
3 h=2
4 k=2
5 l=0 //since (h k l)=(2 2 0) miller indices
6 d=a/sqrt(h^2+k^2+l^2) //spacing
7 printf("spacing of (2 2 0) planes=")
8 printf("d=%0.3f Angstrom",d)
```

Scilab code Exa 5.5 determine size of unit cell

```
1 // chapter 5 , Example5 5 , pg 152
2 d110=2.03 //spacing of(1 1 0) planes (in Angstrom)
3 h=1
4 k=1
5 l=0 //(h k l)=(1 1 0)
6 a=d110*sqrt(h^2+k^2+l^2) //size of unit cell
7 printf("size of unit cell=")
8 printf("a=%0.2f angstrom",a)
```

Scilab code Exa 5.6 determine spacing between planes

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

```

10 k3=1
11 l3=1//(h3 k3 l3)=(1 1 1)
12 d100=a/sqrt(h1^2+k1^2+l1^2) //spacing of (1 0 0)
    planes
13 d110=a/sqrt(h2^2+k2^2+l2^2) //spacing of (1 1 0)
    planes
14 d111=a/sqrt(h3^2+k3^2+l3^2) //spacing of (1 1 1)
    planes
15 printf("spacing of (1 0 0) planes=")
16 printf("d100=%0.2f Angstrom\n",d100)
17 printf("spacing of (1 1 0) planes=")
18 printf("d110=%0.2f Angstrom\n",d110)
19 printf("spacing of (1 1 1) planes=")
20 printf("d111=%0.2f Angstrom",d111)

```

Scilab code Exa 5.7 find volume of unit cell

```

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

```

Chapter 6

Conducting materials

Scilab code Exa 6.1 calculate Fermi energy

```
1 // chapter 6 , Example6 1 , pg 170
2 Vf=10^6 //Fermi velocity (in m/s)
3 m=9.11*10^-31 // mass of electron (in Kg)
4 Ef=(m*Vf^2)/2 //Fermi energy (in J)
5 printf("Fermi energy for the electrons in the metal
   =")
6 printf("Ef=%0.1f eV", (Ef/(1.6*10^-19))) //
   converting J into eV
```

Scilab code Exa 6.2 calculate Fermi energy

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

```

6 printf("Fermi energy at 300 K =")
7 printf("Ef=%0.4f eV", (Ef/(1.6*10^-19))) //
   converting J into eV

```

Scilab code Exa 6.3 calculate conductivity and relaxation time

```

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

```

Scilab code Exa 6.4 calculate Lorentz number

```

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

```

Scilab code Exa 6.5 calculate electrical conductivity

```
1 // chapter 6 , Example6 5 , pg 172
2 d=8900 //density (in Kg/m^3)
3 M=63.5 //atomic weight
4 T=10^-14 //relaxation time(in s)
5 N=6.022*10^23 //Avogadros constant
6 N1=10^3 //number of free electrons per atom
7 e=1.6*10^-19 //electronic charge (in C)
8 me=9.11*10^-31 //mass of electron (in Kg)
9
10 n=(N*d*N1)/M
11 sigma =(n*e^2*T)/me //electrical conductivity
12 printf("Electrical conductivity(in ohm m)=")
13 disp(sigma)
```

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

```
1 // chapter 6 , Example6 6 , pg 172
2 rho=1.54*10^-8 //resistivity (in ohm*m)
3 Ef=5.5 //Fermi energy (in eV)
4 E=100 //electric field intensity (in V/m)
5 n=5.8*10^28 //concentration of electrons (in
atoms/m^3)
6 e=1.6*10^-19 //charge in electron (in C)
7 Me=9.11*10^-31 //mass of electron (in Kg)
8 T=Me/(rho*n*e^2) //relaxation time
9 Un=(e*T)/Me //mobility of electron
10 Vd=(e*T*E)/Me //drift velocity
11 Vf=sqrt((2*Ef*e)/Me) //Fermi velocity
12 lam_m=Vf*T //mean free path
13
14 printf("Relaxation time of electron (in s)")
15 disp(T)
16 printf("Mobility of electron (in m^2/(V*s))")
```

```

17 disp(Un)
18 printf("Drift velocity of electron (in m/s)")
19 disp(Vd)
20 printf("Fermi velocity of electrons (in m/s)")
21 disp(Vf)
22 printf("Mean free path(in m)")
23 disp(lam_m)

```

Scilab code Exa 6.7 calculate thermal conductivity

```

1 // chapter 6 , Example6 6 , pg 174
2 L= 2.26*10^-8 //Lorentz number (in W*m /K^2)
3 T=27+273 //temperature (in K) (converting
    celsius into kelvin)
4 rho=1.72*10^-8 //electrical resistivity (in ohm
    *m)
5
6 //according to Wiedemann–Franz law
7 K=(L*T)/rho //thermal conductivity
8 printf("Thermal conductivity =")
9 printf("K=%0.0 f W/(m*K)" ,K)

```

Scilab code Exa 6.8 calculate Lorentz number

```

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

```

Scilab code Exa 6.9 find F E

```
1 // chapter 6 , Example6 9 , pg 174
2 del_E=0.01*1.6*10^-19 // del_E = E-Ef (in J) (
    converting eV into J)
3 T=200 //temperature (in K)
4 k=1.38*10^-23 //boltzmanns constant (in J/K)
5 F_E=1/(1+exp(del_E/(k*T))) //Fermi Dirac
    distribution function
6 printf("F_E=%0.2 f", F_E)
```

Scilab code Exa 6.10 calculate electrical conductivity

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

Scilab code Exa 6.11 calculate electrical and thermal conductivities

```
1 // chapter 6 , Example6.11 , pg 176
2 Tr=10^-14 //relaxation time (in s)
```

```

3 T=300 //temperature (in K)
4 n=6*10^28 //electron concentration (in /m^3)
5 Me=9.11*10^-31 //mass of electron (in Kg)
6 e=1.6*10^-19 //charge of electron (in C)
7 k=1.38*10^-23 //Boltzmann constant (in J/K)
8 sigma=(n*e^2*Tr)/(Me) //Electrical conductivity
9 K=(3*n*k^2*Tr*T)/(2*Me) //Thermal conductivity
10 L=K/(sigma*T) //Lorentz number
11 printf("Electrical conductivity (in /(ohm*m))")
12 disp(sigma)
13 printf("Thermal conductivity (in W/(m*K))")
14 disp(K)
15 printf("Lorentz number (in (W*ohm)/K^2)")
16 disp(L)

```

Scilab code Exa 6.12 find relaxation time

```

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

```

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

```

1 // chapter 6 , Example6.13 , pg 177
2 rho=1.54*10^-8 //resistivity (in ohm*m)
3 E=100 //electric field intensity (in V/m)

```

```

4 n=5.8*10^28 //electron concentration (in /m
   ^3)
5 e=1.6*10^-19 //charge of electron (in C)
6 Me=9.11*10^-31 //mass of electron (in Kg)
7 T=Me/(rho*n*e^2) //relaxation time
8 Vd=(e*E*T)/Me //drift velocity
9 U=Vd/E //mobility
10 printf("Relaxation time (in s)")
11 disp(T)
12 printf("Drift velocity (in m/s)")
13 disp(Vd)
14 printf("Mobility(in m^2/(V*s))")
15 disp(U)

```

Scilab code Exa 6.14 calculate drift velocity

```

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

```

Scilab code Exa 6.15 calculate Fermi energy and Fermi temperature

```

1 // chapter 6 , Example6 15 , pg 179
2 m=9.11*10^-31 //mass of electron (in Kg)
3 k=1.38*10^-23 //boltzmann constant (in J/K)

```

```

4 e=1.6*10^-19 //electronic charge(in C )
5 Vf=0.86*10^6 //Fermi velocity of electron (in m/s
)
6 Ef=(m*Vf^2)/(2*e) //Fermi energy (in eV)
7 Tf=(Ef*e)/k //Fermi temperature
8 printf("Fermi energy=")
9 printf("Ef=%0.1f eV \n",Ef)
10 printf("Fermi temperature =")
11 printf("Tf=%0.0f K",Tf)

```

Scilab code Exa 6.16 calculate Fermi velocity

```

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

```

Chapter 7

Semiconducting materials

Scilab code Exa 7.1 Evaluate approximate donor binding energy

```
1 // chapter 7 , Example7.1 , pg 208
2 Er=13.2 // relative permittivity
3 Me=9.11*10^-31 //mass of electron (in Kg)
4 Mnc=0.067*Me
5 h=6.625*10^-34 //plancks constant (in Js)
6 Eo=8.85*10^-12
7 e=1.6*10^-19 //electronic charge of electron (
  in C)
8 E=(Mnc*e^4)/(8*(Er*Eo)^2*h^2) //Donor binding
  energy (in J)
9 printf("Donor binding energy (in J)=")
10 disp(E)
11 printf("E=%0.4f eV" ,(E/e))
```

Scilab code Exa 7.2 calculate equilibrium hole concentration and how is E_f located

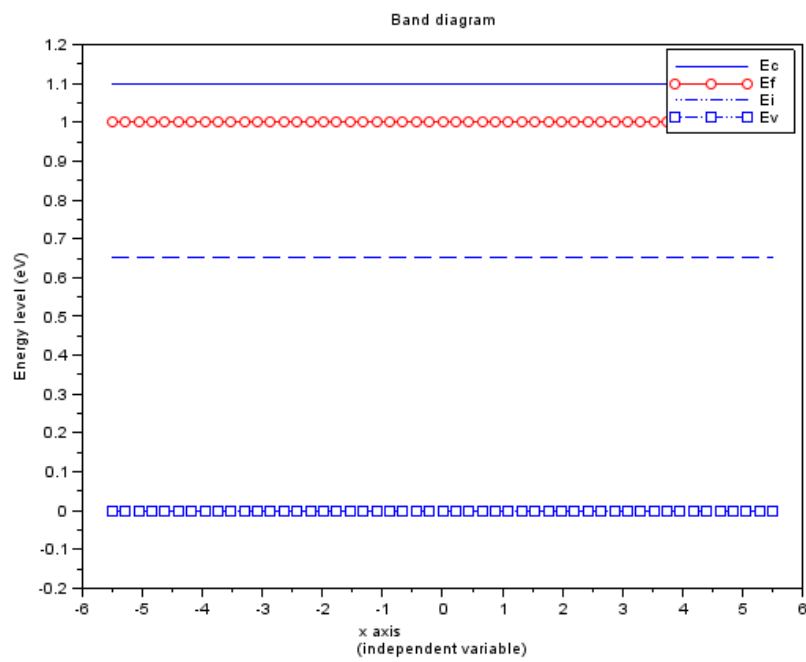


Figure 7.1: calculate equilibrium hole concentration and how is E_f located relative to E_i


```

1 // chapter 7 , Example 7.2 , pg 208
2 ni=1.5*10^10 //intrinsic concentration (in cm
   ^-3)
3 Nd=10^16 //donor concentration (in atoms/cm^3)
4 T=300 //temperature (in K)
5 e=1.6*10^-19 //charge of electron (in C)
6 k=1.38*10^-23 //Boltzmann constant (in J/K)
7 n0=Nd //Assuming n0=Nd (since Nd >&
   gt; ni)
8 p0=ni^2/n0 //hole concentration
9 E=k*T*log(n0/ni) // E=(Ef-Ei) location of Ef
   relative to Ei
10 printf("Hole concentration (in cm^-3)")
11 disp(p0)
12 printf("Location of Ef relative to Ei (in eV)")
13 disp(E/e)
14 x = linspace(-5.5,5.5,51);
15 y = ones(length(x),1);
16
17 scf(2);
18 clf(2);
19 plot(x,y+0.1);
20
21 plot(x,y,'ro-');
22 plot(x,y-0.347,'--');
23 plot(x,y*0,'bs:');
24 xlabel(["x axis";"(independent variable)"]);
25 ylabel("Energy level (eV)");
26 title("Band diagram");
27 set(gca(),"data_bounds",matrix([-6,6,-0.1,1.1],2,-1)
   );

```

Scilab code Exa 7.3 calculate resistivity of sample

```

1 // chapter 7 , Example7.3 , pg 208

```

```

2 Nd=10^14 //Donor density (in atoms/cm^3)
3 e=1.6*10^-19 //electronic charge of electron (
  in C)
4 Un=3900 // electron mobility (in cm^2/(V*s))
  for Ge at 300 K
5 sigma=Nd*e*Un //conductivity
6 rho=1/sigma //resistivity
7 printf(" Resistivity=\n")
8 printf(" rho=%0.2f ohm*cm",rho)

```

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

```

1 // chapter 7 , Example7 4 , pg 209
2 e=1.6*10^-19 //charge in electron (in C)
3 Ix=2*10^-3 //current (in A)
4 d=200*10^-4 //thickness (in cm)
5 Bz=5*10^-5 //magnetic induction (in Wb/cm^2)
6 Un=800 //electron mobility (in cm^2/(V*s))
7 n=5*10^16 //doping concentration (in atoms/cm
  ^3)
8
9 sigma=n*e*(Un) // electrical conductivity
10 rho=1/sigma //resistivity
11 Rh=-1/(e*n) //Hall coefficient
12 Vh=-(Ix*Bz)/(d*e*n) //Hall voltage
13 printf(" Resistivity(in ohm*cm)")
14 disp(rho)
15 printf(" Hall coefficient(in cm^3/C)")
16 disp(Rh)
17 printf(" Hall voltage (in V)")
18 disp(Vh)

```

Scilab code Exa 7.5 calculate intrinsic carrier concentration and intrinsic conduct

```

1 // chapter 7 , Example 7.5 , pg 210
2 T=300 //temperature (in K)
3 Un=0.4 //electron mobility (in m^2/(V*s))
4 Up=0.2 //hole mobility (in m^2/(V*s))
5 e=1.6*10^-19 //charge of electron (in C)
6 h=6.625*10^-34 //plancks constant (in m^2*Kg*S
    ^-1)
7 Eg=0.7 //bandgap (in eV)
8 k=1.38*10^-23 //Boltzmann constant (in J/K)
9 Me=9.11*10^-31 //mass of electron (in Kg)
10 Mn=0.55*Me //electron effective mass
11 Mp=0.37*Me //hole effective mass
12 ni=2*((2*pi*k*T)/h^2)^(3/2)*(Mn*Mp)^(3/4)*exp(-(Eg*
    e)/(2*k*T)) //intrinsic concentration
13 sigma=ni*e*(Un+Up) //intrinsic conductivity
14 rho=1/sigma //intrinsic resistivity
15 printf("Intrinsic concentration (in m^-3)")
16 disp(ni)
17 printf("Intrinsic conductivity (in /(ohm*m)")
18 disp(sigma)
19 printf("Intrinsic resistivity (in ohm*m)")
20 disp(rho)
21
22
23 //answer given is wrong

```

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

```

1 // chapter 7 , Example 7.6 , pg 211
2 Nd=10^16 //donor concentration (in cm^-3)
3 ni=1.45*10^10 //intrinsic concentration (in cm
    ^-3)
4 T=300 //temperature (in K)
5 e=1.6*10^-19 //charge of electron (in C)
6 k=1.38*10^-23 //Boltzmann constant (in J/K)

```

```

7 E=k*T*log(Nd/ni) //E=(Efd-Ei) Fermi energy
  with respect to Fermi energy in intrinsic Si
8 printf("Fermi energy with respect to Fermi energy
  in intrinsic Si(in eV)")
9 disp(E/e)

```

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

```

1 // chapter 7 , Example 7.7 , pg 211
2 rho=2300 //resistivity (in ohm*m) for Si
  (value given in book is wrong)
3 ni=1.6*10^16 //intrinsic concentration (in m
  ^-3)
4 Ue=0.15 //electron mobility (in m^2/(V*s))
5 e=1.6*10^-19 //charge of electron (in C)
6 // assuming 1*1*1 (in cm) dimension of Si
  crystal
7 l=10^-2 //length (in m)
8 b=10^-2 //breadth (in m)
9 w=10^-2 //width (in m)
10 Nsi=5*10^28 // (in atoms/m^3)
11 x=1/10^9 //doping concentration
12 A=l*b //area (in m^2)
13 R1=(rho*l)/A //resistance of pure Si crystal
  (in ohm)
14 Nd=Nsi*x //donor concentration (in m^-3)
15 p=ni^2/Nd //concentration of hole (in m^-3)
16 sigma=Nd*Ue*e //conductivity of doped Si (in ohm
  ^-1*m^-1)
17 R=1/(sigma*A) //resistance of doped Si crystal
  (in ohm)
18 printf("Resistance of pure Si crystal (in ohm)")
19 disp(R1)
20 printf("Resistance of doped Si crystal (in ohm)")
21 disp(R)

```

22
23
24 //answer given is wrong

Scilab code Exa 7.8 compute forbidden energy gap

```
1 // chapter 7 , Example 7.8 , pg 212
2 rho=2.12 //resistivity (in ohm*m)
3 T=300 //temperature (in K)
4 Un=0.36 //electron mobility (in m^2/(V*s))
5 Up=0.17 //hole mobility (in m^2/(V*s))
6 h=6.625*10^-34 //plancks constant (in m^2*Kg*S
    ^-1)
7 k=1.38*10^-23 //Boltzmann constant (in J/K)
8 e=1.6*10^-19 //charge in electron (in C)
9 Me=9.11*10^-31 //mass of electron (in Kg)
10 Mn=0.5*Me //electron effective mass
11 Mp=0.37*Me //hole effective mass
12 ni=1/(rho*e*(Un+Up)) //intrinsic concentration
    (in m^-3)
13 Nc=2*((2*pi*k*T)/h^2)^(3/2)*(Mn)^(3/2) //
    effective density of states in conduction band (
    in m^-3)
14 Nv=2*((2*pi*k*T)/h^2)^(3/2)*(Mp)^(3/2) //
    effective density of states in valence band (in m
    ^-3)
15 Eg=2*k*T*log(sqrt(Nc*Nv)/ni) //Forbidden
    energy gap
16 printf("Forbidden energy gap=")
17 printf("Eg=%0.3f eV",Eg/e)
```

Scilab code Exa 7.9 calculate conductivity of sample

```

1 // chapter 7 , Example7.9 , pg 213
2 ni=2.4*10^19 //intrinsic carrier density(in m
   ^-3)
3 Un=0.39 //electron mobility (in m^2/(V*s))
4 up=0.19 //hole mobility (in m^2/(V*s))
5 e=1.6*10^-19 //charge in electron (in C)
6 sigma=ni*e*(Un+up) // electrical conductivity
7 printf("Electrical conductivity\n")
8 printf("sigma=%0.3f (ohm*m)^-1",sigma)

```

Scilab code Exa 7.10 find the new position of Fermi level

```

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

```

Scilab code Exa 7.11 calculate concentration in conduction band

```

1 // chapter 7 , Example 7.11 , pg 214
2 T=300 //temperature (in K)
3 e=1.6*10^-19 //charge of electron (in C)
4 h=6.625*10^-34 //plancks constant (in m^2*Kg*S
   ^-1)
5 Eg=1.1 //bandgap (in eV)
6 k=1.38*10^-23 //Boltzmann constant (in J/K)
7 Me=9.11*10^-31 //mass of electron (in Kg)

```

```

8 Mn=0.31*Me //electron effective mass
9 ni=2*((2*%pi*k*T*Mn)/h^2)^(3/2)*exp(-(Eg*e)/(2*k*T))
//intrinsic concentration
10 printf("Intrinsic concentration (in m^-3)")
11 disp(ni)

```

Scilab code Exa 7.12 calculate drift mobility of electron

```

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

```

Scilab code Exa 7.13 calculate concentration of conduction electrons in Cu

```

1 // chapter 7 , Example 7.13 , pg 215
2 Ud=3.2*10^-3 //electron drift mobility (in m^2/(
V*s))
3 sigma=5.9*10^7 //conductivity (in /(ohm*m))
4 e=1.6*10^-19 //charge of electron (in C)
5 Na=6.022*10^23 //Avogadro constant (in mol^-1)
6 ni=sigma/(Ud*e) //intrinsic concentration (in
m^-3)
7 Aw=63.5 //atomic weight
8 d=8960 //density (in Kg/m^3)
9 n=10^3 //number of free electrons per atom
10 N=(Na*d*n)/Aw //concentration of free electrons
in pure Cu

```

```

11 Avg_N=ni/N      //Average number of electrons
    contributed per Cu atom
12 printf("concentration of free electrons in pure Cu
    (in m-3)")
13 disp(N)
14 printf("Average number of electrons contributed per
    Cu atom\n")
15 printf("Avg_N=%0.2 f ",Avg_N)

```

Scilab code Exa 7.14 calculate charge carrier density and electron mobility

```

1 // chapter 7 , Example7.14 , pg 215
2 RH=3.66*10-11 //Hall coefficient (in m3/(A*s
    ))
3 e=1.6*10-19 //charge in electron (in C)
4 sigma=112*107 //conductivity (in (oh*m)-1)
5 n=1/(RH*e) //charge carrier density
6 Un=sigma/(n*e) //electron mobility
7 printf("charge carrier density(in m-3)=")
8 disp(n)
9 printf("Electron mobility=")
10 printf("Un=%0.3 f m2/(A*s)",Un)

```

Scilab code Exa 7.15 calculate magnitude of Hall voltage

```

1 // chapter 7 , Example7.15 , pg 216
2 I=50 //current (in A)
3 B=1.5 //magnetic field (in T)
4 d=0.2*10-2 //width of slab (in m)
5 n=8.4*1028 //concentration of electrons (in m
    -3)
6 e=1.6*10-19 // charge (in C)
7 VH=(B*I)/(n*e*d) //Hall voltage

```



```

8 printf("Hall voltage(in V)=")
9 disp(VH)
10
11
12
13
14 //Answer given is wrong

```

Scilab code Exa 7.16 find resistance of intrinsic Ge

```

1 // chapter 7 , Example7.16 , pg 216
2 ni=2.5*10^19 //intrinsic carrier density(in m
   ^-3)
3 Un=0.39 //electron mobility (in m^2/(V*s))
4 up=0.19 //hole mobility (in m^2/(V*s))
5 e=1.6*10^-19 //charge in electron (in C)
6 l=10^-2 //length (in m)
7 A=10^-3*10^-3 //area (in m^2)
8 sigma=ni*e*(Un+up) // electrical conductivity (
   in (ohm*m)^-1)
9 R=1/(sigma*A) //Resistance
10 printf("Resistance of intrinsic Ge rod\n")
11 printf("R=%0.0f ohm",R)

```

Scilab code Exa 7.17 determine the position of Fermi level

```

1 // chapter 7 , Example7.17 , pg 216
2 Eg=1.12 //bandgap (in eV)
3 T=300 //temperature (in K)
4 Me=9.11*10^-31 //mass of electron (in Kg)
5 Mn=0.12*Me
6 Mp=0.28*Me

```

```

7 k=1.38*10^-23 //Boltzmann constant (in (m^2*Kg)
  /(s^2*K))
8 Ef=(Eg/2)+((log(Mp/Mn)*3*k*T)/(4*1.6*10^-19))
9 printf("position of Fermi level")
10 printf("Ef=%0.3f eV",Ef)

```

Scilab code Exa 7.18 calculate electrical conductivity

```

1 // chapter 7 , Example7.18 , pg 217
2 ni=1.5*10^16 //intrinsic carrier density(in m
  ^-3)
3 Un=0.13 //electron mobility (in m^2/(V*s))
4 up=0.05 //hole mobility (in m^2/(V*s))
5 e=1.6*10^-19 //charge in electron (in C)
6 sigma=ni*e*(Un+up) // electrical conductivity
7 printf("Electrical conductivity\n")
8 printf("sigma=%0.6f (ohm*m)^-1",sigma)

```

Scilab code Exa 7.19 find intrinsic resistivity

```

1 // chapter 7 , Example7.19 , pg 217
2 ni=2.15*10^13 //intrinsic carrier density(in
  cm^-3)
3 Un=3900 //electron mobility (in cm^2/(V*s))
4 up=1900 //hole mobility (in cm^2/(V*s))
5 e=1.6*10^-19 //charge in electron (in C)
6 sigma_I=ni*e*(Un+up) // electrical conductivity
  (in (ohm*cm)^-1)
7 rho_I=1/sigma_I //intrinsic resistivity
8 printf("Intrinsic resistivity\n")
9 printf("rho_I=%0.0f ohm*cm",rho_I)
10
11

```

```

12
13
14 //Intrinsic carrier density is given as  $2.15 \times 10^{-13}$ 
    instead of  $2.15 \times 10^{13}$ 

```

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

```

1 // chapter 7 , Example7.20 , pg 217
2 ni=2.1*10^19 //intrinsic carrier density(in m
    ^-3)
3 Un=0.4 //electron mobility (in m^2/(V*s))
4 up=0.2 //hole mobility (in m^2/(V*s))
5 e=1.6*10^-19 //charge in electron (in C)
6 sigma=ni*e*(Un+up) // electrical conductivity
7 printf("Electrical conductivity\n")
8 printf("sigma=%0.3f (ohm*m)^-1",sigma)

```

Scilab code Exa 7.21 find Hall coefficient and electron mobility

```

1 // chapter 7 , Example 7.21 , pg 218
2 e=1.6*10^-19 // charge of electron (in C)
3 I=5*10^-3 // current (in mA)
4 V=1.35 // voltage (in V)
5 Vh=20*10^-3 //Hall voltage (in V)
6 B=0.45 //magnetic induction (in T)
7 l=10^-2 //length (in m)
8 b=5*10^-3 //breadth (in m)
9 d=10^-3 //thickness (in m)
10 R=V/I //resistance (in ohm)
11 A=b*d //area (in m^2)
12 rho= (R*A)/l //resistivity (in ohm*m)
13 E=Vh/d //Hall electric field (in V/m)
14 J=I/A //current density (in A/m^2)

```

```

15 Rh=E/(B*J) //Hall coefficient
16 Un=Rh/rho //electron mobility (in m^2/(V*S))
17 printf("Hall coefficient =")
18 printf("Rh=%0.3f m^3/C \n",Rh)
19 printf("Electron mobility=")
20 printf("Un=%0.2f m^2/(V*S)",Un)

```

Scilab code Exa 7.22 find Hall potential difference

```

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

```

Chapter 8

Magnetic materials

Scilab code Exa 8.1 Determine magnitude and direction of magnetic moment

```
1 // chapter 8 , Example 8.1 , pg 238
2 I=12 // current(in A)
3 A=7.5*10^-4 //area(in m^2)
4 M=I*A //magnetic moment associated with the
    loop
5 printf("Magnetic moment associated with the loop(in
    A m^2)=")
6 disp(M)
7 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

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

```

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

```

Scilab code Exa 8.3 calculate magnetic susceptibility

```

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

```

Scilab code Exa 8.4 calculate permeability

```

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

```

Scilab code Exa 8.5 calculate magnetic moment

```

1 // chapter 8 , Example 8.5 , pg 239

```

```

2 B=0.65 //magnetic induction (in T)
3 d=8906 //density (in Kg/m^3)
4 M=58.7 //atomic weight
5 e=1.6*10^-19 //charge of electron (in C)
6 h=6.625*10^-34 //plancks constant (in m^2*Kg*S
^-1)
7 m=9.11*10^-31 //mass of electron (in Kg)
8 Uo=4*pi*10^-7 //vacuum permeability
9 Na=6.023*10^26 //Avogadro constant
10 Ub=(e*h)/(4*pi*m) //Bhor magneton (in A*m^2)
11 N=(d*Na)/M //number of atoms per unit volume
12 Ur=B/(N*Uo) //relative permeability (in A/m
^2)
13 M=Ur/(Ub) //magnetic moment
14 printf("Magnetic moment")
15 printf("M=%0.2 f A*m^2",M)

```

Chapter 9

Superconducting materials

Scilab code Exa 9.1 calculate critical magnetic field intensity

```
1 // chapter 9 , Example9.1 , pg 255
2 H0=6.5*10^4 //magnetic field intensity at 0K (
   in A/m)
3 T=4.2 //temperature (in K)
4 Tc=7.18 //critical temperature (in K)
5 Hc=H0*(1-(T^2/Tc^2)) // critical magnetic field
   intensity
6 printf("critical magnetic field intensity\n")
7 printf("Hc=%0.0f A/m" ,Hc)
```

Scilab code Exa 9.2 calculate isotopic mass

```
1 // chapter 9 , Example9.2 , pg 255
2 M1=199.5 //isotopic mass
3 Tc1=4.185 //critical temperature for M1 (in K)
4 Tc2=4.133 //critical temperature for M2 (in K)
5 alpha=0.5
6
```



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

Chapter 10

Dielectric materials

Scilab code Exa 10.1 calculate electronic polarizability

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

Scilab code Exa 10.2 calculate electronic polarizability

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


Chapter 12

Additional solved examples

Scilab code Exa 12.1 calculate relative population

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

Scilab code Exa 12.2 determine relative population

```

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

```

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

```

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

```

Scilab code Exa 12.4 calculate number of photons emitted per minute

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

Scilab code Exa 12.5 calculate number of photons emitted per minute

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

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

```

1 // Additional solved examples , Example 6 , pg 332
2 n1=1.5//core refractive index
3 n2=1.45//cladding refractive index
4 n0=1//refractive index of air
5 NA=sqrt(n1^2-n2^2)//numerical aperture
6 alpha_m =asin(NA/n0)//angle of acceptance (in
    radian)
7 phi_m=asin((n0*sin(alpha_m))/n1)// no*sin(alpha_m)
    =n1*sin(phi_m) (in radian)
8 phi_c=asin(n2/n1) //critical angle (in radian)
9 printf("NA=%0.2 f \n",NA)
10 printf("alpha_m=%0.2 f degree\n", (alpha_m*180)/%pi)
11 printf("phi_m=%0.2 f degree\n", (phi_m*180)/%pi)
12 printf("phi_c=%0.2 f degree", (phi_c*180)/%pi)

```

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

```

1 // Additional solved examples , Example 7 , pg 333
2 n1=1.5//core refractive index
3 n2=1.45//cladding refractive index
4 n0=1.1//refractive index of medium
5 NA=sqrt(n1^2-n2^2)//numerical aperture
6 alpha_m =asin(NA/n0)//angle of acceptance (in
    radian)
7 phi_m=asin((n0*sin(alpha_m))/n1)// no*sin(alpha_m)
    =n1*sin(phi_m) (in radian)
8 phi_c=asin(n2/n1) //critical angle (in radian)
9 printf("NA=%0.2 f \n",NA)
10 printf("alpha_m=%0.2 f degree\n", (alpha_m*180)/%pi)
11 printf("phi_m=%0.2 f degree\n", (phi_m*180)/%pi)
12 printf("phi_c=%0.2 f degree", (phi_c*180)/%pi)

```

Scilab code Exa 12.8 calculate pulse broadening per unit length

```

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

```

Scilab code Exa 12.9 calculate pulse broadening per unit length

```

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

```

Scilab code Exa 12.10 calculate minimum and maximum number of total internal reflection

```

1 // Additional solved examples , Example 10 , pg 335
2 n1=1.5//core refractive index
3 n2=1.45//cladding refractive index
4 n0=1//refractive index of air
5 NA=sqrt(n1^2-n2^2)//numerical aperture

```



```

6 alpha_m =asin(NA/n0)//angle of acceptance (in
   radian)
7 a=100*10^-6/2 //radius of core
8 phi_m=asin((n0*sin(alpha_m))/n1)// no*sin(alpha_m)
   =n1*sin(phi_m) (in radian)
9 L=a/tan(phi_m) //(in m)
10 printf("Minimum number of reflections per metre=zero
   \n") //since rays travelling with alpha=0
   suffer no internal reflection
11 //for rays travelling with alpha=alpha_m ,1 internal
   reflection takes place for a transversed
   distance of 2*L
12 N=1/(2*L) //Maximum number of reflections per metre
13 disp("Maximum number of reflections per metre(in m
   ^-1)=")
14 printf("N=%0.0 f" ,N)
15
16 //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

```

1 // Additional solved examples , Example 11 , pg 335
2 c=3*10^8 //speed of light(in m/sec)
3 h=6.625*10^-34//planck's constant(in J s)
4 lam=1.4*10^-10//wavelength(in m)
5 E=(h*c)/(lam*1.6*10^-19) //energy of photon(in eV)
6 p=h/lam //momentum of photon
7 printf("Energy of photo\n")
8 printf("E=%0.1 f eV\n",E)
9 printf("momentum of photon(in Kg m/sec)\n")
10 disp(p)

```

Scilab code Exa 12.12 calculate number of photons emitted per second

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

Scilab code Exa 12.13 calculate de Broglie wavelength

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

Scilab code Exa 12.14 find change in wavelength

```
1 // Additional solved examples , Example 14 , pg 336
2 h=6.625*10^-34//plancksconstant(in J s)
3 c=3*10^8//velocity of x-ray photon(in m/sec)
4 m0=9.11*10^-31//rest mass of electron(in Kg)
5 phi=(85*%pi)/180//angle of scattering (in radian)
   (converting degree into radian)
```

```

6 delta_H=(h*(1-cos(phi)))/(m0*c)//change in
    wavelength due to compton scattering
7 printf("change in wavelength of x-ray photon(in m)\n
    ")
8 disp(delta_H)

```

Scilab code Exa 12.15 find miller indices

```

1 // Additional solved examples , Example 15 , pg 337
2 //plane has intercepts 2a,2b,3c along the 3
    crystal axes
3 //lattice points in 3-d lattice are given by r=p*a+q
    *b+s*c
4 //as p,q,r are the basic vectors the proportion of
    intercepts 2:2:3
5 p=2
6 q=2
7 s=3
8 //therefore reciprocal
9 r1=1/2
10 r2=1/2
11 r3=1/3
12 //taking LCM
13 v=int32([2,2,3])
14 l=double(lcm(v))
15 m1=(l*r1)
16 m2=(l*r2)
17 m3=(l*r3)
18 printf("miller indices=")
19 disp(m3,m2,m1)

```

Scilab code Exa 12.16 find miller indices

```

1 // Additional solved examples , Example 16 , pg 337
2 //plane has intercepts 4a,2b,4c along the 3
   crystal axes
3 //lattice points in 3-d lattice are given by r=p*a+q
   *b+s*c
4 //as p,q,r are the basic vectors the proportion of
   intercepts 2:2:3
5 p=4
6 q=2
7 s=4
8 //therefore reciprocal
9 r1=1/4
10 r2=1/2
11 r3=1/4
12 //taking LCM
13 v=int32([4,2,4])
14 l=double(lcm(v))
15 m1=(l*r1)
16 m2=(l*r2)
17 m3=(l*r3)
18 printf("miller indices=")
19 disp(m3,m2,m1)

```

Scilab code Exa 12.17 find size of unit cell

```

1 // Additional solved examples , Example 17 , pg 338
2 d110=1.96 //spacing of(1 1 0) planes (in Angstrom)
3 h=1
4 k=1
5 l=0 //(h k l)=(1 1 0)
6 a=d110*sqrt(h^2+k^2+l^2) //size of unit cell
7 printf("size of unit cell=")
8 printf("a=%.2f angstrom",a)

```

Scilab code Exa 12.18 find volume of unit cell

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

Scilab code Exa 12.19 calculate Fermi energy

```
1 // Additional solved examples , Example 19 , pg 339
2 Vf=7*10^5 //Fermi velocity (in m/s)
3 m=9.11*10^-31 // mass of electron(in Kg)
4 Ef=(m*Vf^2)/2 //Fermi energy (in J)
5 printf("Fermi energy for the electrons in the metal
   =")
6 printf("Ef=%0.1f eV", (Ef/(1.6*10^-19))) //
   converting J into eV
7
8
9
10
11 //Answer is given wrong
```

Scilab code Exa 12.20 calculate relaxation time and average drift velocity and vel

```
1 // Additional solved examples , Example 20 , pg 339
```

```

2 rho=1.8*10^-8 //resistivity (in ohm*m)
3 Ef=4.8 //Fermi energy (in eV)
4 E=100 //electric field intensity (in V/m)
5 n=6.2*10^28 //concentration of electrons (in
atoms/m^3)
6 e=1.6*10^-19 //charge in electron (in C)
7 Me=9.11*10^-31 //mass of electron (in Kg)
8 T=Me/(rho*n*e^2) //relaxation time
9 Un=(e*T)/Me //mobility of electron
10 Vd=(e*T*E)/Me //drift velocity
11 Vf=sqrt((2*Ef*e)/Me) //Fermi velocity
12 lam_m=Vf*T //mean free path
13
14 printf("Relaxation time of electron (in s)")
15 disp(T)
16 printf("Mobility of electron (in m^2/(V*s))")
17 disp(Un)
18 printf("Drift velocity of electron (in m/s)")
19 disp(Vd)
20 printf("Fermi velocity of electrons (in m/s)")
21 disp(Vf)
22 printf("Mean free path(in m)")
23 disp(lam_m)

```

Scilab code Exa 12.21 evaluate value of F E

```

1 // Additional solved examples , Example 21 , pg 341
2 del_E=0.02*1.6*10^-19 // del_E = E-Ef (in J) (
converting eV into J)
3 T=220 //temperature (in K)
4 k=1.38*10^-23 //boltzmanns constant (in J/K)
5 F_E=1/(1+exp(del_E/(k*T))) //Fermi Dirac
distribution function
6 printf("F_E=%0.3 f" ,F_E)

```

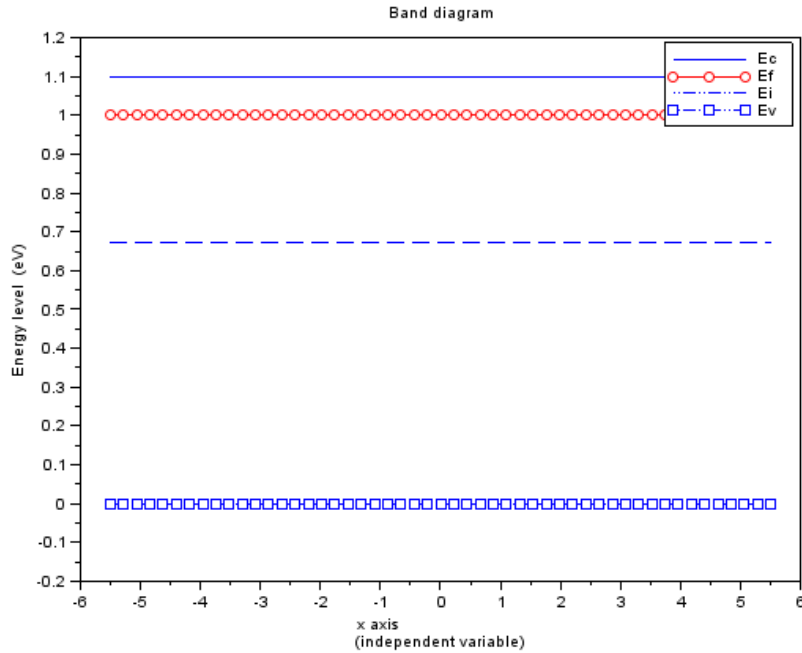


Figure 12.1: calculate how is E_f located relative to E_i

Scilab code Exa 12.22 calculate how is E_f located relative to E_i

```

1 // Additional solved examples , Example 22 , pg 341
2 ni=1.5*10^10 //intrinsic concentration (in cm
   ^-3)
3 Nd=5*10^15 //donor concentration (in atoms/cm
   ^3)
4 T=300 //temperature (in K)

```

```

5 e=1.6*10^-19 //charge of electron (in C)
6 k=1.38*10^-23 //Boltzmann constant (in J/K)
7 n0=Nd //Assuming n0=Nd (since Nd >&
    gt; ni)
8 p0=ni^2/n0 //hole concentration
9 E=k*T*log(n0/ni) // E=(Ef-Ei) location of Ef
    relative to Ei
10 printf("Hole concentration (in cm^-3)")
11 disp(p0)
12 printf("Location of Ef relative to Ei (in eV)")
13 disp(E/e)
14 x = linspace(-5.5,5.5,51);
15 y = ones(length(x),1);
16
17 scf(2);
18 clf(2);
19 plot(x,y+0.1);
20
21 plot(x,y,'ro-');
22 plot(x,y-0.329,'--');
23 plot(x,y*0,'bs:');
24 xlabel(["x axis";"(independent variable)"]);
25 ylabel("Energy level (eV)");
26 title("Band diagram");
27 set(gca(),"data_bounds",matrix([-6,6,-0.1,1.1],2,-1)
    );

```

Scilab code Exa 12.23 find magnitude of Hall voltage

```

1 // Additional solved examples , Example 23 , pg 342
2 I=40 //current (in A)
3 B=1.4 //magnetic field (in T)
4 d=2*10^-2 //width of slab (in m)
5 n=8.4*10^28 //concentration of electrons (in m
    ^-3)

```



```

6 e=1.6*10^-19 // charge (in C)
7 VH=(B*I)/(n*e*d) //Hall voltage
8 printf("Hall voltage(in V)=")
9 disp(VH)

```

Scilab code Exa 12.24 calculate Hall voltage and Hall coefficient

```

1 // Additional solved examples , Example 24 , pg 342
2 e=1.6*10^-19 //charge in electron (in C)
3 Ix=2*10^-3 //current (in A)
4 d=220*10^-4 //thickness (in cm)
5 Bz=5*10^-5 //magnetic induction (in Wb/cm^2)
6 Un=800 //electron mobility (in cm^2/(V*s))
7 n=9*10^16 //doping concentration (in atoms/cm
^3)
8
9 sigma=n*e*(Un) // electrical conductivity
10 rho=1/sigma //resistivity
11 Rh=-1/(e*n) //Hall coefficient
12 Vh=-(Ix*Bz)/(d*e*n) //Hall voltage
13 printf("Resistivity(in ohm*cm)")
14 disp(rho)
15 printf("Hall coefficient(in cm^3/C)")
16 disp(Rh)
17 printf("Hall voltage (in V)")
18 disp(Vh)

```

Scilab code Exa 12.25 determine magnitude and direction of magnetic moment

```

1 // Additional solved examples , Example 25 , pg 343
2 I=10 // current(in A)
3 A=8*10^-4 //area(in m^2)

```

```

4 M=I*A    //magnetic moment associated with the
    loop
5 printf("Magnetic moment associated with the loop(in
    A m^2)=")
6 disp(M)
7 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

```

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

```

Scilab code Exa 12.27 determine magnetic moment

```

1 // Additional solved examples , Example 27 , pg 344
2 r=0.62*10^-10 //radius of orbit (in m)
3 e= 1.6*10^-19 //charge on electron (in C)
4 n=10^15 //frequency of revolution of electron (
    in rps)
5 I=e*n //current (in A)
6 A=%pi *r^2 //area (in m^2)
7 M=I*A //magnetic moment associated with motion of
    electron

```

```
8 printf("Magnetic moment associated with motion of
    electron (in A m^2)")
9 disp(M)
```

Scilab code Exa 12.28 calculate permeability

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

Scilab code Exa 12.29 calculate susceptibility

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

Scilab code Exa 12.30 determine critical current

```
1 // Additional solved examples , Example 30 , pg 345
2 H0=6*10^4 //magnetic field intensity at 0K (in
    A/m)
3 T=4.2 //temperature (in K)
4 Tc=8 //critical temperature (in K)
```

```

5 Hc=H0*(1-(T^2/Tc^2))    // critical magnetic field
   intensity
6 printf("critical magnetic field intensity\n")
7 printf("Hc=%0.0f    A/m",Hc)

```

Scilab code Exa 12.31 calculate critical current

```

1 // Additional solved examples , Example 31 , pg 346
2 H0=7*10^4    //magnetic field intensity at 0K    (in
   A/m)
3 T=4.2    //temperature    (in K)
4 Tc=8.2    //critical temperature    (in K)
5 Hc=H0*(1-(T^2/Tc^2))    // critical magnetic field
   intensity
6 printf("critical magnetic field intensity\n")
7 printf("Hc=%0.0f    A/m",Hc)

```

Scilab code Exa 12.32 calculate isotopic mass

```

1 // Additional solved examples , Example 32 , pg 346
2 M1=198.5    //isotopic mass
3 Tc1=4.175    //critical temperature for M1    (in K)
4 Tc2=4.213    //critical temperature for M2    (in K)
5 alpha=0.5
6
7 //M^alpha * Tc=constant
8 M2=((M1^alpha*Tc1)/Tc2)^(1/alpha)
9 printf("Isotopic mass at critical temperature 4.133K
   \n")
10 printf("M2=%0.3f ",M2)

```

Scilab code Exa 12.33 calculate isotopic mass

```
1 // Additional solved examples , Example 33 , pg 346
2 M1=199 //isotopic mass
3 Tc1=4.18 //critical temperature for M1 (in K)
4 Tc2=4.14 //critical temperature for M2 (in K)
5 alpha=0.5
6
7 //M^alpha * Tc=constant
8 M2=((M1^alpha*Tc1)/Tc2)^(1/alpha)
9 printf("Isotopic mass at critical temperature 4.133K
   \n")
10 printf("M2=%.4f ",M2)
```

Chapter 13

Additional solved short answers

Scilab code Exa 13.1.2 find fundamental frequency

```
1 // Additional solved numerical questions , Example(  
  set 1) 2 , pg 348  
2 l=0.7*10^-3//length(in m)  
3 E=8.8*10^10//youngs modulus(in N/m^2)  
4 d=2800//density(in kg/m^3)  
5 p=1//fundamental mode  
6 n= p*sqrt(E/d)/(2*l) //natural frequency  
7 printf("Fundamental frequency of quartz crystal)\n"  
  )  
8 printf("n=%0.2 f Hz",n)
```

Scilab code Exa 13.1.6 calculate critical angle

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

```
5 printf("critical angle=\n")
6 printf("theta_c=%0.2f degree", (theta_c*180)/%pi)
```

Scilab code Exa 13.1.10 calculate interplanar spacing

```
1 // Additional solved numerical questions , Example(
   set 1) 10 , pg 349
2 a=4.938 //lattice constant(in Angstrom)
3 h=2
4 k=2
5 l=0 //since (h k l)=(2 2 0) miller indices
6 d=a/sqrt(h^2+k^2+l^2) //spacing
7 printf("spacing of (2 2 0) planes=")
8 printf("d=%0.3f Angstrom", d)
```

Scilab code Exa 13.1.12 find the wavelength

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

Scilab code Exa 13.1.14 calculate energy of scattered photon

```

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

```

Scilab code Exa 13.1.15 calculate number of unit cells

```

1 // Additional solved numerical questions , Example(
   set 1) 15_b_3 , pg 352
2 a=2.88*10^-8 //lattice constant (in cm)
3 d=7200 //density (in Kg/m^3)
4 C=8/a^3 // atomic concentration
5 n=8 //number of atoms/cell
6 n1=C/n //unit cell concentration
7
8 //since density =7200 Kg/m^3
9 //7200 Kg = 10^6 cc
10 //hence 1Kg = (10^6)/7200 cc
11 N=(n1*10^6)/7200 //number of unit cells
   present in 1 Kg of metal
12 printf("Number of unit cells present in 1 Kg of
   metal=")
13 disp(N)
14 printf("unit cells")

```

Scilab code Exa 13.2.1 calculate the frequency

```
1 // Additional solved numerical questions , Example(
   set 2) 1 , pg 352
2 l=4*10^-2 //length(in m)
3 E=207 *10^6 //youngs modulus(in N/m^2)
4 d=8900 //density(in kg/m^3)
5 p=1//fundamental mode
6 n= p*sqrt(E/d)/(2*1) //natural frequency
7 printf("Fundamental frequency of quartz crystal)\n"
   )
8 printf("n=%0.2 f Hz",n)
```

Scilab code Exa 13.2.7 calculate wavelength of scattered radiation

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

Scilab code Exa 13.2.13 calculate Na and acceptance angle

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

Scilab code Exa 13.3.11 calculate mean free time

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

Scilab code Exa 13.3.12 calculate the resistivity

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

```

6
7 Ix=10^-3 //current (in A)
8 d=100*10^-6 //thickness (in m)
9 Bz=0.1 //magnetic induction (in T)
10 Un1=0.07 //electron mobility (in m^2/(V*s))
11 n=10^23 //doping concentration (in atoms/m^3)
12
13 sigma=ni*e*(Un+up) // electrical conductivity
14 rho=1/sigma //resistivity
15 Vh=-(Ix*Bz)/(d*e*n) //Hall voltage
16 printf("Resistivity(in ohm*m)")
17 disp(rho)
18 printf("Hall voltage (in V)")
19 disp(Vh)

```

Scilab code Exa 13.3.13 calculate energy loss per hour and intensity of magnetizat

```

1 // Additional solved numerical questions , Example(
   set 3) 13_b , pg 357
2 A=250 //area of B-H loop
3 f=50 //frequency (in Hz)
4 d=7.5*10^3 //density (in Kg/m^3)
5 M=10 //mass of core (in Kg)
6
7 H=2000 //magnetic field intensity (in A/m)
8 Xm=1000 //susceptibility
9 U0=4*pi*10^-7 // relative permeability
10
11 V=M/d //volume of sample (in m^3)
12 N=60*60*f //number of cycles per hour
13 EL=A*V*N //energy loss per hour
14 I=H*Xm //intensity of magnetization
15 Ur=1+Xm
16 B=Ur*U0*H //magnetic flux density
17 printf("Energy loss per hour (in J)")

```

```

18 disp(EL)
19 printf("Intensity of magnetization (in Wb/m^3)")
20 disp(I)
21 printf("Magnetic flux density(in T)")
22 disp(B)

```

Scilab code Exa 13.3.14 find capacitance and electric flux density

```

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

```

```
23 disp(C)
24 printf("Electric flux density (in V/m)")
25 disp(E1)
```
