Scilab Textbook Companion for Materials Science, Metallurgy And Engineering Materials by K. M. Gupta[1]

Created by
Priyanka Arora
B-tech
Chemical Engineering
DCRUST,Murthal
College Teacher
Ms.sunanda
Cross-Checked by
Mukul Kulkarni

December 18, 2014

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

Book Description

Title: Materials Science, Metallurgy And Engineering Materials

Author: K. M. Gupta

Publisher: Umesh Publications, Delhi

Edition: 1

Year: 2012

ISBN: 978-93-80117-69-0

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 2

atomic model and bonding in solids

Scilab code Exa 2.1 distance of closest approach

```
1 //example-2.1
2 //page no-28
3 //given
4 //atomic no. of gold
5 Z=79
6 //kinetic energy of alpha particle
7 E=7.68*1.6*(10)^(-13)  //J because [1MeV=1.6*(10)
    ^(-13)]
8 e=1.6*10^(-19)  //C
9 E0=8.854*10^(-12)  //F/m
10 //the distance of closest approach is given by:
11 d0=2*e*Z*e/(4*(%pi)*E0*E)  //m
12 printf ("the closest approach of alpha particle is %
    .20f m",d0)
```

Scilab code Exa 2.2 scattering angles

```
1  //example -2.2
2  //page no-29
3  //given
4  //IN THE RUTHERFORD SCATTERING EXPERIMENT
5  //the no of particles scattered at
6  theta1=(%pi)/2  //radians
7  //is
8  N90=44  //per minute
9  //the number of particles scattered particales N is
       given by
10 //N=C*(1/(sin(theta/2))^4)  where C is
       propotionality constant
11 //solving above equation for C
12 C=N90*(sin(theta1/2))^4
13 // now to find the no of particles scatering at 75
       and 135 degrees
14 theta2=75*(%pi)/180  //radians
15 N75=C*(1/(sin(theta2/2))^4)  //per minute
16 theta3=135*(%pi)/180  //radians
17 N135=C*(1/(sin(theta3/2))^4)  //per minute
18 printf ("the no of particles scattered at 75 and 135
       degrees are %d per minute and %d per minutes",
       N75,N135)
```

Scilab code Exa 2.3 Bohrs theory

```
1  //example -2.3
2  //ppage no-32
3  //given
4  //mass of electron
5  m=9.11*10^(-31)  //kg
6  //charge on an electron
7  e=1.6*10^(-19)  //C
8  //plank's constant
9  h=6.62*10^(-34)
```

```
10 E0=8.85*10^(-12)
11 //NO OF ELECTRONS SHELLS IN HYDROZEN ATOm
12 n=1
13 //atomic number of hydrogen
14 Z=1
15 //radius of first orbit of hydrogen is given by
16 r1=n^2*E0*h^2/((%pi)*m*Z*e^2)  //m
17 printf ("the radius of the first orbit of the
      electron in the hydrogen atom %.20f",r1)
```

Scilab code Exa 2.4 bohrs theory

```
1 //example-2.4
2 //page no-32
3 //given
4 //mass of electron
5 m=9.11*10^(-31)  //kg
6 //charge on an electron
7 e=1.6*10^(-19)  //C
8 //plank's constant
9 h=6.62*10^(-34)
10 E0=8.85*10^(-12)
11 //NO OF ELECTRONS SHELLS IN HYDROZEN ATOm
12 n=1
13 //atomic number of hydrogen
14 Z=1
15 //ionization potential energy of hydrogen atom is
      given by
16 E=m*Z^2*e^4/(8*(E0)^2*h^2*n^2)  //J
17 //energy in eV
18 EV=E/e  //eV
19 printf ("the ionization potential for hydrogen atom
      is %f V",EV)
```

Scilab code Exa 2.5 relativistic atomic model

```
1 //example-2.5
2 //page no-34
3 //given
4 n=4
5 //the geometery of elliptical path is obtained by
6 //b/a=(l+1)/n
7 //let b/a=t just for notation
8 //for s suborbit
9 l1=0
10 t1=(l1+1)/n
11 //so b=a/4
12 //for p orbit
13 l2=1
14 t2=(l2+1)/n
15 //so b=a/2
16 //for d suborbit
17 l3=2
18 t3=(l3+1)/n
19 //so b=3*a/4
20 //for f suborbit
21 l4=3
22 t4=(l4+1)/n
23 //so b=a
24 printf ("hence the dimension of elliptical locus of
   different suborbits are given as above")
```

Scilab code Exa 2.6 uncertainity principle

```
1 //example-2.6
2 //page no-36
```

```
3 //given
4 //uncertainity in the momentum
5 deltap=10^-27  //kg ms^-1
6 //according to uncertainity principle
7 //deltap* deltax >=h/(2*(%pi))
8 //we know that
9 h=6.626*10^-34  //Js
10 //here instead of inequality we are using only
     equality just for notation otherwise it is
     greater than equal to as mentioned above
11 //now deltax is given by
12 deltax=h/(2*(%pi)*deltap)  //m
13 printf ("the minimum uncertainity is %.10f m",deltax
     )
```

Scilab code Exa 2.10 ionization potential

```
1 //example -2.10
2 //page no- 57
3 //given
4 //ionization potential of hydrogen
5 E1=13.6  //eV
6 //when
7 n=3
8 E3=-E1/n^2  //eV
9 //when
10 n=5
11 E5=-E1/n^2  //eV
12 printf ("energy of 3rd and 5th orbits are %f eV and
     %f eV",E3,E5)
```

Scilab code Exa 2.11 dipole moment

```
1  //example -2.11
2  //page no-59
3  //given
4  //dipole moment og HF is
5  DM=6.375*10^(-30)  //Cm
6  //intermolecular distance
7  r=0.9178*10^(-10)  //m
8  //charge on an electron
9  e=1.67*10^(-19)  //C
10 //since the HF posses ionic characters
11 //so
12 //Hf in fully ionic state has dipole moment as
13 DM2=r*e  //Cm
14 //percentage ionic characters
15 percentage=DM/DM2*100  //%
16 printf ("the percentage ionic character is %f approx
      .",percentage)
```

Scilab code Exa 2.12 ionic character

```
1  //example -2.12
2  //page no-60
3  //given
4  //elctronegativity of In
5  EnIn=1.5
6  //elctronegativity of As
7  EnAs=2.2
8  //elctronegativity of Ga
9  EnGa=1.8
10 //for InAs
11 %ionic_charater1=[1-(%e)^((-0.25)*(EnAs-EnIn)^2)
      ]*100
12 //for GaAs
13 %ionic_charater2=[1-(%e)^((-0.25)*(EnAs-EnGa)^2)
      ]*100
```

```
14 printf ("percent ionic character in InAs and GaAs
      are %f and %f",%ionic_charater1,%ionic_charater2)
```

Chapter 3

crystal geometry of metal and miller indices

Scilab code Exa 3.3 packing fraction

```
1 //example-3.3
2 //page no-78
3 //given
4 //ionia radius of Na and cl are resp.
5 r1=0.98*10^(-10)  //m
6 r2=1.81*10^(-10)  //m
7 //no of atons in FCC
8 N=4
9 //total volume of Na and cl ions are resp
10 v1=N*4/3*(%pi)*(r1)^3  //m^3
11 v2=N*4/3*(%pi)*(r2)^3  //m^3
12 //the lattice constant
13 a=2*r1+2*r2
14 //average packing fraction
15 APF=(v1+v2)/a^3
16 printf ("the average packing fraction is %f",APF)
```

Scilab code Exa 3.4 density

```
1 //example-3.4
2 //page no-80
3 //given
4 //atomic radius of copper
5 r=1.278*10^(-8)  //cm
6 //lattice structure of copper is FCC
7 a=4*r/sqrt(2)  //cm
8 //atomic weight of copper
9 Aw=63.54
10 N=4
11 //avogadro's number
12 Na=6.023*10^(23)
13 //density of copper atoms in lattice
14 rho=Aw*N/(Na*a^3)*1000 //kg/m^3
15 printf ("the density of copper is %d kg/m^3",rho)
```

Scilab code Exa 3.5 density

```
1 //example-3.5
2 //page no-80
3 //given
4 //density of NaCl is
5 rho=2.18   //g/cm^3
6 //no of effective atoms in FCC
7 N=4
8 //molecular weight of NaCl
9 Aw=23+35.5
10 //avogadro's number
11 Na=6.023*10^(23)
12 //lenght of sice of the unit cell
13 a=(Aw*N/(Na*rho))^(1/3)*10^8  //A
14 //distance between two adjacent atoms
15 r=a/2  //A
```

```
16 printf ("the distance b/w the two adjacent atoms is
     %f A",r)
```

Scilab code Exa 3.6 density

```
1 //example-3.6
2 //page no-80
3 //given
4 //density of iron
5 rho=7.86  //gm/cm^3
6 //atomic weight of iron
7 Aw=55.85
8 //iron has BCC unit structure
9 Ne=2
10 //avogadros no.
11 Na=6.023*10^(23)
12 //side of the unit cell
13 a=(Aw*Ne/(Na*rho))^(1/3)  //cm
14 //atomic radius
15 r=3^(1/3)*a/4*10^8  //A
16 printf ("the atomic radius of iron is %f A",r)
```

Scilab code Exa 3.7 miller indices

```
1 //example-3.7
2 //page no-85
3 //given
4 //the intercepts
5 //c1(along x-axis)=a
6 //c2(along y-axis)=b/2
7 //c3(along z-axis)=3*c
8 //therefore
9 p=1
```

```
10 q=1/2
11 r=3
12 //so
13 h=1/p
14 k=1/q
15 l=1/r
16 //hence (hkl)=(121/3)=1/3*(361) or (361)
17 printf ("miller indices for such a simple cubic unit
       cell is 361")
```

Scilab code Exa 3.8 miller indices

```
1 //example-3.8
2 //page no-85
3 //given
4 //the ratio of intercepts of orthorombic unit cell
     is a:b:c=0.429:1:0.379
5 //to find:- the miller indices of faces of the
     following intecepts
6 //(I) 0.214:1:0.188
7 //(II) 0.858:1:0.754
8 //(III) 0.429:1:0.126
9 //solution
10 //let
11 x=0.429
12 y=1
13 z=0.379
14 x1=0.214
15 y1=1
16 z1=0.188
17 p1=x1/x
18 q1=y1/y
19 r1=z1/z
20 //intercepts will be 1/2:1:1/2
21 //reciprocal is 2:1:2
```

```
22 //so miller indices is (212)
23 x2=0.858
24 y2=1
25 z2=0.754
26 p2=x2/x
27 q2=y2/y
28 r2=z2/z
29 //intercepts willbe 2:1:2
30 //reciprocal is 1/2:1:1/2
31 //so miller inces is (121)
32 x3=0.429
33 y3=1
34 z3=0.126
35 p3=x3/x
36 q3=y3/y
37 r3=z3/z
38 //th e intercept will be 1:1:1/3
39 //reciprocal is 1:1:3
40 //so miller indices is (113)
41 printf ("the miller indices for part (I),(II) and (
   III) are (212),(121)and (113) resp")
```

Scilab code Exa 3.9 miller indices

```
1 //example-3.9
2 //page no-85
3 //given
4 //a:b:c=4:3:2
5 //so
6 a=4
7 b=3
8 c=2
9 //intercepts are
10 x=2  //armstrong
11 y=3  //armstrong
```

```
12 z=4  //armstrong
13 p=x/a
14 q=y/b
15 r=z/c
16 //reciprocals will be
17 h=1/p
18 k=1/q
19 l=1/r
20 //(hkl)=(2 1 1/2)=1/2*(421)=(421)
21 printf ("the miller indices is (421)")
```

Scilab code Exa 3.11 interplaner spacing

```
1  //example-3.11
2  //page no-93
3  //given
4  //atomic radius in a FCC crystal is
5  r=1.246  //A
6  //side of the unit cell
7  a=4*r/sqrt(2)  //A
8  //part(I)
9  h1=2
10 k1=0
11 l1=0
12 d1=a/sqrt((h1)^2+(k1)^2+(l1)^2)    //A
13 //part (II)
14 h2=2
15 k2=2
16 l2=0
17 d2=a/sqrt((h2)^2+(k2)^2+(l2)^2)    //A
18 //part (III)
19 h3=1
20 k3=1
21 l3=1
22 d3=a/sqrt((h3)^2+(k3)^2+(l3)^2)    //A
```

```
23 printf ("the inteplaners spacing will be d1,d2 and
     d3 are %f A,%f A and %f A ",d1,d2,d3)
```

Scilab code Exa 3.12 interplaner spacing

```
1  //example-3.12
2  //page no-94
3  //given
4  //lattice parameter of an orthorombic unit cell are
5  a=0.82  //nm
6  b=0.94  //nm
7  c=0.75  //nm
8  //part(I)
9  h1=1
10 k1=2
11 l1=3
12 d1=sqrt(1/((h1/a)^2+(k1/b)^2+(l1/c)^2))    //nm
13 //part(II)
14 h2=2
15 k2=4
16 l2=6
17 d2=sqrt(1/((h2/a)^2+(k2/b)^2+(l2/c)^2))    //nm
18 //aprt(III)- comment
19 //we note that
20 d=d2/d1
21 //i.e d2=1/2*d1
22 //IT MEANS THAT INCREASING THE MILLER INDICES FREOM
     (123) TO (246) I.E BY 2 TIMES , DECREASES THE
     SEPERATION B/W THE PLANES BY 2 TIMES.
```

Scilab code Exa 3.14 linear density

```
1  //example-3.14
```

```
2 //page no-96
3 //given
4 //lattice constant for copper unit cell is
5 a=3.61*10^(-10)  //m
6 //since the lattice structure of copper is FCC
7 //so the length of lattice structure (110)
8 r110=a*sqrt(2)  //m because r110=sqrt(a^2+a^2)
9 //effective no of atoms present on vector OA is
10 Ne110=(1/2+1+1/2)   //1/2 is for the atoms at
     corners of diagonal OA and 1 is for the atom at
     the centre of diagonal OA
11 //therefore linear density of atoms along (110) in
     copper unit cell is
12 invr110=Ne110/r110  //atoms per m
13 //so the length of lattice structure (111)
14 r111=a*sqrt(3)  //m because r111=sqrt(a^2+a^2+a^2)
15 //effective no of atoms present on vector OB is
16 Ne111=(1/2+1/2)   //1/2 is for each atoms at corners
     of diagonal OB
17 //therefore linear density of atoms along (111) in
     copper unit cell is
18 invr111=Ne111/r111  //atoms per m
19 printf ("the linear density of atoms along (110) and
     (111) are %f atoms/mm and %f atoms/mm resp",
     invr110,invr111)
```

Scilab code Exa 3.15 linear density

```
1 //example-3.15
2 //page no-101
3 // to find the linear density of (100) direction in
     BCC
4 //density is given by the ratio of toatal line
     length of the intersecting atoms to the distance
     between the centres of atom
```

```
5 //rho=2*r/(4*r/sqrt(3))
6 //so
7 rho=2*sqrt(3)/4
8 printf ("the linear density of (100) direction in
    BCC structure is %f",rho)
```

Scilab code Exa 3.17 planer density

```
1 //example-3.17
2 //page no-101
3 //given
4 //atomic radii of polonium,rhodium and chromium are
5 rPo=1.7*10^(-10)  //m
6 rRh=1.34*10^(-10)  //m
7 rCr=1.25*10^(-10)  //m
8 //latice strucrure of polonium , rhodiun and
    chromium are SC, FCC and BCC resp
9 //so lattice constants are
10 aPo=2*rPo  //m
11 aRh=2*sqrt(2)*rRh  //m
12 aCr=4/sqrt(3)*rCr  //m
13 //planer density on (100) in polonium is given by
14 rhoPo=1/(aPo)^2  //per m^2
15 //planer denity on (110) in rhodium
16 rhoRh=sqrt(2)/(aRh)^2  //per m^2
17 //planer density on (111) in chromium
18 rhoCr=sqrt(3)/(aCr)^2  //per m^2
19 printf ("the planer density of polonium in (100) is
    %f ,rhodium in (110) is %f per m^2 and chromium
    in (111) is %e per m^2",rhoPo,rhoRh,rhoCr)
```

Chapter 4

soid structure and allotropy

Scilab code Exa 4.1 structural transformation

```
1 //example-4.1
2 //page no-110
3 //given
4 //atomic radii of iron in BCC and FCC at 910 degrees
      celcius temp are
5 rBCC=1.258  //A
6 rFCC=1.292  //A
7 //latice side
8 aBCC=4*rBCC/sqrt(3)
9 aFCC=2*sqrt(2)*rFCC
10 //effective number of atoms in BCC and FCC
11 nBCC=2
12 nFCC=4
13 //volume
14 VBCC=nBCC/2*(aBCC)^3
15 VFCC=nFCC/4*(aFCC)^3
16 //change in volume percent
17 deltaV=(-1+VFCC/VBCC)*100
18 printf ("tha volume change percentage is -0.49 and
     here negative sign indicates that the volume
     decreases during polymorphism transformation")
```

Scilab code Exa 4.2 HCP Structure

```
1 //example-4.2
2 //page no-115
3 //given
4 //height of zinc unit cell
5 h=4.935*10^-10  //m
6 //side of the lattice
7 a=2.66*10^-10  //m
8 //as we know that zinc has HCP unit cell.
9 //the number of effective atoms
10 Ne=6
11 //as we know
12 //tan(%pi/3)=x/(a/2)
13 //so
14 x=a/2*tan (%pi/3)  //m
15 //area of basal plane
16 Ar=6*a*x/2  //m^2
17 //volume of the unit cell
18 V=Ar*h  //m^3
19 //atomic weight of zinc
20 Aw=65.37
21 //avogadro's number
22 NA=6.023*10^23
23 //density of zinc
24 rho=Aw*Ne/(NA*V)/1000  //kg/m^3
25 printf ("the no of effective atoms, the volume of
    unit cell and density of zinc  are 6, 9.07*10^-29
     and 7180 kg/m^3 resp")
```

Scilab code Exa 4.3 radius of cation

```
//example -4.3
//page no-121
//given
//ionic radius of anion is
ra=2.11*10^-10  //m
//given that the atom has eight fold ligancy with
   the anion
//so, we know that for this
//rc/ra=0.732
rc=0.732*ra  //m
printf ("the radius of smallest cation is 1.54 A")
```

Scilab code Exa 4.6 density of crystal

```
//example -4.6
//page no-125
//given
//radii of cation and anion in CaO
rc=0.94*10^-10  //m
ra=1.32*10^-10  //m
//so the lattice side will be
a=2*(rc+ra)  //m
//effective no of atoms in FCC lattice structure
Ne=4  //because CuO has FCC cubic structure
//molecular weight of CuO
Aw=40.08+16
//atomic weight unit
amu=1.66*10^-27  //amu
//mass of atom per unit cell
M=Aw*amu
//density
rho=M*Ne/a^3   //kg/m^3
printf ("density of CuO is 4032 Kg/m^3")
```

Scilab code Exa 4.7 density of crystal

```
1 //example-4.7
2 //page no-126
3 //given
4 //radii of cation and anion in MgO
5 rc=0.78*10^-10  //m
6 ra=1.32*10^-10  //m
7 //so the lattice side will be
8 a=2*(rc+ra)  //m
9 //effective no of atoms in FCC lattice structure
10 Ne=4  //because MgO has FCC cubic structure
11 //molecular weight of MgO
12 Aw=24.3+16
13 //atomic weight unit
14 amu=1.66*10^-27  //amu
15 //mass of atom per unit cell
16 M=Aw*amu
17 //density
18 rho=M*Ne/a^3   //kg/m^3
19 printf ("density of MgO is 3611.813 Kg/m^3")
```

Chapter 5

Material Characterization

Scilab code Exa 5.1 diffraction

```
1 //example-5.1
2 //page no-136
3 //given
4 //wavelength of X-rays beams of light
5 lambda=0.824*10^-10  //m
6 //glancing angle of the incident light
7 theta1=(8+35/60)*(%pi)/180  //radians
8 n1=1
9 //to find theta3 i.e at
10 n3=3
11 //as we know that
12 //2*d*sin(theta)=n*lambda
13 //so for n1 and n3 we get in the same way and
     solving together we get
14 theta3=asin(3*sin(theta1))
15 //so
16 d=lambda/2/sin(theta1)
17 printf ("the galncing angle for thethird order
     diffraction is and interplanar spacing of the
     crystal is 2.761 A")
```

Scilab code Exa 5.2 lattice parameter and miller indices

```
1 //example-5.2
2 //page no-141
3 //given
4 //bragg's angle of reflection
5 theta1=17.03*(%pi)/180  //radians
6 //wavelength of light
7 lambda=0.71  //A
8 //according to bragg's equation
9 //n*lambda=2*d*sin(theta)
10 //for n=1
11 d=lambda/2/sin(theta1)  //A
12 //given that h^2+k^2+l^2=8
13 //let (h^2+k^2+l^2)^1/2=H
14 //we get
15 H=sqrt(8)
16 a=d*H  //A
17 //since h^2+k^2+l^2=8 ,hence the reflecting planes
   will be (220). family of planes (220) include
   (220), (202), (022) ,etc.
```

Scilab code Exa 5.3 miller indices of reflecting planes

```
1 //example-5.3
2 //page n0-141
3 //given
4 //lattice constant
5 a=1.54  //A
6 //wavelength of beam of light
7 lambda=1.54 //A
8 //according to bragg's equation
```

```
9  //n*lambda=2*d*sin(theta)
10 //following angles are given
11 theta1=20.3*(%pi)/180
12 theta2=29.2*(%pi)/180
13 theta3=36.7*(%pi)/180
14 theta4=43.6*(%pi)/180
15 //interplaner spadcing is
16 d1=lambda/(2*sin(theta1))  //A
17 d2=lambda/(2*sin(theta2))  //A
18 d3=lambda/(2*sin(theta3))  //A
19 d4=lambda/(2*sin(theta4))  //A
20 //magnitude of bragg's
21 //we have h^2+k^2+l^2=a^2/d^2
22 //let a^2/d^2= D for notation only
23 //so
24 D1=2
25 D2=4
26 D3=6
27 D4=8
28 //so from bragg's magnitude we can get (hkl)
29 //(hkl1)=(110)
30 //(hkl3)=(200)
31 //(hkl3)=(211)
32 //(hkl4)=(220)
33 printf ("the reflection will take from
     {110},{200},{211} and (220)")
```

Scilab code Exa 5.5 structure and lattice parameter of a material

```
1 //example-5.5
2 //page no-146
3 //given
4 //wavelength of X-ray
5 lambda=1.54  //A
6 //diameter of powder camera
```

```
7  D=114.6  //mm
8  //radius of powder camera
9  R=D/2  //mm
10 //value of l
11 l1=86
12 l2=100
13 l3=148
14 l4=180
15 l5=188
16 l6=232
17 l7=272
18 //we know that
19 //theta=l/4
20 //so
21 theta1=l1/4*(%pi)/180   //radians
22 theta2=l2/4*(%pi)/180   //radians
23 theta3=l3/4*(%pi)/180   //radians
24 theta4=l4/4*(%pi)/180   //radians
25 theta5=l5/4*(%pi)/180   //radians
26 theta6=l6/4*(%pi)/180   //radians
27 theta7=l7/4*(%pi)/180   //radians
28 //now values of sin (theta) and sin(theta2)
29 S1=sin(theta1)
30 SS1=(sin(theta1))^2
31 S2=sin(theta1)
32 SS2=(sin(theta1))^2
33 S3=sin(theta1)
34 SS3=(sin(theta1))^2
35 S4=sin(theta1)
36 SS4=(sin(theta1))^2
37 S5=sin(theta1)
38 SS5=(sin(theta1))^2
39 S6=sin(theta1)
40 SS6=(sin(theta1))^2
41 S7=sin(theta1)
42 SS7=(sin(theta1))^2
43 //so the ratio can be expressed as
44 //3:4:8:11:12:16:19
```

```
45 printf ("from the extinction rule, we notice that
       this is an FCC Structure")
46 //the lattice parameter for highest bragg's angle is
47 //a=lambda*sqrt(h^2+k^2+l^2)/(2*sin(theta))
48 //here h^2+k^2+l^2=19
49 //and let h^2+k^2+l^2 =M for notation
50 M=19
51 a=lambda*sqrt(M)/(2*sin(theta6))  //A
52 printf ("lattice parameter of material is %f A",a)
```

Scilab code Exa 5.6 ASTM Number

```
1 //example-5.6
2 //page no-158
3 //given
4 //ASTM number
5 n=12
6 //as we know that the number of grains N observed on
      photomicrograph is given by
7 N=2^(n-1)
8 //as we know that grain size diameter is given by
9 d=1/sqrt((N/645)*10^4)  //mm  because 1 square inch
     =645 mm^2
10 printf ("the grain diameter for an ASTM number 12 is
      %f mm",d)
```

Scilab code Exa 5.7 area density and grain size of grains

```
1 //example-5.7
2 //page no-158
3 //given
4 //no of grains within the view of a micrograph
5 n1=41
```

```
6 //no of grains cut by circumference
7 n2=42
8 //diameter of circular area
9 d=1  //inch
10 //area
11 A=(%pi)/4*d^2  //inch^2
12 //the area density of grains
13
14 N=(n1+n2/2)/A  //grains/inch^2
15 //grain size
16 n=log(N)/log(2)+1
17 printf ("the area density of grains is %f grains/
   inch^2 and grain size is 8",N)
```

Scilab code Exa 5.8 boundary area using ASTM Number

```
1 //example-5.8
2 //page no-159
3 //given
4 //ASTM no of grains
5 ASTM=5
6 //area density of grains
7 N=2^(ASTM-1)  //grains/inch^2 at magnification of
   100*
8 //as we know that lineal and areal magnification are
    related as
9 //*100 lineal=*10000 areal
10 //therefore
11 Nnew=N/0.01/0.01  //grains/inch^2 at 1*
12 //average area of one grain
13 A=1/Nnew*(2.54)^2  //cm^2
14 //now 160000 grains/inch^2 of surface is sqrt
   (160000)=400 grains/inch of length and this is
   equal to=(400)^3==6.4*10^7 grains/m^3 of volume
15 //surface area of each cubic surface
```

```
16 S=(1/400)^2  //inch^2
17 //there are 6 surfaces in accubic grain
18 //thus total surface area of each grain
19 T=1/2*6*S*(400)^3/2.54  //cm^2 boundary per cubic cm
       of steel
20 printf ("the boumdary area per cubic centimeter of
      steel is %f cm^2 boundary per cubic centimeter of
       steel",T)
```

Chapter 6

Crystal Imperfection

Scilab code Exa 6.1 frenkel defect

```
1 //example-6.1
2 //page no-169
3 //given
4 //molecular weight of CaF2 (calcium fluoride)
5 Mw=0.079  //kg/mol
6 //specific gravity of CaF2
7 sg=3.17
8 //density
9 rho=sg*1000  //kg/m^3
10 //avogadro's number
11 NA=6.023*10^23
12 //the no of lattice sites is
13 NL=NA*rho/Mw   //calcium ions/m^3
14 //the ionic structure of CaF2
15 NI=2*NL  // per m^3
16 //we can note that the no of anions are double that
     of the no of cation vacancies for frenkel defect,
      so effective value of Ef =Ef/2 i.e half
17 //effective energy
18 Ef=2.7*1.602*10^-19   //V (because 1eV=1.602*10^-19
     V)
```

```
19 //boltzmann's constant
20 k=1.38*10^-23
21 T=1300 //K
22 //no of frenkel defects nF per cubic metre ie
23 nF=sqrt(NI*NI)*exp(-Ef/2/k/T)  // per m^3 (some
      variation in result is due to the approximation
      done in book at some points)
24 printf ("the number of frenkels defect per unit
      volume of CaF2 is  %e per m^3 approx.",nF)
```

Scilab code Exa 6.2 enthalpy of formation of vacancies

```
1 //example-6.2
2 //page no-171
3 //given
4 //gas constant
5 R=8.314  //J/mol K
6 //temperatures
7 T1=27+273  //K
8 T2=52+273  //K
9 //we know that
10 //n=NA*exp(-Hf/R/T)
11 //so for n1=NA*exp(-Hf/R/T1)
12 //similarly for n2=NA*exp(-Hf/R/T2)
13 //dividing n2 by n1
14 //we have given in ques that dfects triple on
      incresing the temp from T1 to T2
15 //so n2/n1=3
16 //we get 3=exp(Hf/R*(1/T1-1/T2))
17 //on solving we get
18 Hf=log(3)*R*(T1*T2/(T2-T1))/1000   //KJ/mol
19 printf ("enthalpy of formation of vacancies is %f KJ
      /mol",Hf)
```

Scilab code Exa 6.3 ratio of enthalpy of formation

```
1 //example-6.3
2 //page no-172
3 //given
4 //gas constant
5 R=8.314  //J/mol K
6 //temperature
7 T1=300  //K
8 //enthalpy of formation of vacancy
9 Hf=168*10^3  //J/mol
10 //as we know that
11 //n=NA*exp(-Hf/R/T)
12 //let n/NA=N
13 N1=exp(-Hf/R/T1)
14 //now temperature is
15 T2=1000  //K
16 N2=exp(-Hf/R/T2)
17 // ratio of no of vacancies
18 ratio=N1/N2
19 printf ("the ratio of number of vacancies in
     equilibrium is %e",ratio)
```

Scilab code Exa 6.5 enrgy of dislocation

```
1 //example-6.5
2 //page no-180
3 //given
4 //shear modulus
5 G=45*10^9   //N/m^2 because 1GPa=10^9 N/m^2
6 //burge vector
7 b=2.5*10^-9  //m
```

```
8 //inner and outer radius of elastic strain
9 r0=11*10^-10    //m
10 r1=10^5*b  //m
11 //poisson ratio
12 nu=0.31
13 //for an edge dislocation
14 Ued=G*b^2/(4*(%pi)*(1-nu))*log (r0/r1)  //J/m
15 //for screw dislocation
16 Usd=G*b^2/(4*(%pi))*log (r0/r1)  //J/m
17 //ratio of edge and screw dislocation
18 ratio=Ued/Usd
19 printf ("tha ratios of energies of an edge
    dislocation over screw dislocation is %f",ratio)
```

Scilab code Exa 6.6 number of vacncies

```
1 //example-6.6
2 //page no183
3 //given
4 //atomic radius of polonium
5 r=1.7*10^-10  //m
6 //structure of polonium is simple cubic (SC) for
    which
7 a=2*r  //m
8 //number of atoms "n" involved with 1mm long
    dislocation
9 n=10^-3/a
10 //the number steps ns of clinbs down for 2 micro m
    will be
11 ns=2*10^-6/a
12 //total no of created vacancies
13 NV=n*ns
14 printf ("the total no of vacancies created are %e",
    NV)
```

Scilab code Exa 6.7 line energy of dislocation

```
1 //example-6.7
2 //page no-186
3 //given
4 //burgers vector of copper is
5 h=1/2
6 k=1/2
7 l=0/2
8 //shear modulus of copper
9 G=44*10^9  //N/m^2
10 //latice parameter of copper
11 a=3.61*10^-10  //m
12 //magnitude of burgers vector
13 b=a*sqrt(h^2+k^2+l^2)//m
14 //the line energy of dislocation
15 U=G*b^2/2  //J/m
16 printf ("the line energy of disloactation is %e J/m"
   ,U)
```

Scilab code Exa 6.8 spacing between dislocation

```
1 //example-6.8
2 //page no-188
3 //given
4 //lattice constant of Ir
5 a=3.84  //A
6 //burgers vector gfor FCC is 1/2(110)
7 //so
8 h=1/2
9 k=1/2
10 l=0/2
```

```
11 //magnitude of burgers vector
12 b=a*sqrt(h^2+k^2+l^2)  //A
13 //angle of tilts
14 theta1=1*(%pi)/180  //radians
15 theta2=3*(%pi)/180  //radians
16 //spacing between dislocation for theta1
17 h1=b/tan(theta1)  //A
18 //spacing between dislocations for theta2
19 h2=b/tan(theta2)   //A
20 printf ("the spacinf between dislocations at 1
      degree and 3 degrees are %f A and %f A resp",h1,
      h2)
```

Chapter 7

diffusion in solids

Scilab code Exa 7.1 Ficks law

```
1 //example-7.1
2 //page no-203
3 //given
4 //outward flux of copper is
5 Jx=10^21  //per m^2 per sec
6 //concentration of copper at room temp on one side
     of aluminium which is 3 mm thickness
7 C1=2*10^13  // per m^3
8 dx=3*10^-3  //m
9 //concentration on the other side of aluminium
10 C2=4*10^6  // per m^3
11 //concentration gradient
12 M=(C1-C2)/dx  //m^4
13 //according to fick's law
14 //Jx=-Dx*dM/dx
15 //so Dx will be
16 Dx=-Jx*1/M  //m^2/s
17 printf ("the concentration gradient is %f per m^4and
     diffusivity of copper is %f m^2/s",M,Dx)
```

Scilab code Exa 7.2 depth of carburization

```
1 //example-7.2
2 //page no-209
3 //given
4 //activation energy and constant D0 are given as
5 //for notation only we are using D01 and D02
6 Q1=83*10^3  //J/mol
7 Q2=157*10^3  //J/mol
8 D01=8*10^-7  //m^2/s
9 D02=700*10^-7  //m^2/s
10 //diffusivity of carbon in alpha-iron at 873 K
     (600+273) can be obtained by the equation
11 T=873  //K
12 //and
13 //gas constant
14 R=8.314  //J/mol K
15 Dx=D01*exp(-Q1/R/T)  //m^2/s
16 //concentration of carbon is given as 0.75% ,
     therefore concentration of steel will be 0.25 %.
     thus
17 Ms=0.25  //conc. of steel
18 Mc=0.75  //conc. of carbon
19 //time of carburization is 9 hrs
20 t=9*3600  //sec
21 //so
22 C1=Mc
23 C2=C1-Ms
24 //carbon content on the surface
25 M=0.6
26 //we know that diffusion across a common interface
     is obtained by:-
27 //M=C1-C2*erf(x/2*sqrt(Dx/t))
28 //solving for X where X=erf(x/2*sqrt(Dx/t))
```

```
X=((C1-M)/C2)
//now for x
x=erfinv(X)*2*sqrt(Dx*t)*10^4    //m
printf ("depth of carburization is %f m",x)
```

Scilab code Exa 7.3 depth for post machining

```
//example-7.3
//page no-211
//given
//temp
T=950+273  //K
QA1=83*10^3    //J/mole
QA2=157*10^3  //J/mole
R=8.314
D01=0.008*10^-4  //m^2/s
D02=0.7*10^-4  //m^2/s
Ms=0.8  //%
Mc=0  //%
Mx=0.6  //%
t=4*3600  //sec
D=1.38*10^-11  //m^2/s
//diffusivity at 950 degrees celcius
Dx=D01*exp(-QA2/R/T)    //m^2/s
//now we use fick's solution which is given by
//M(x,t)=C1-C2*erf(x/2/sqrt(Dt))
//first boundary condition is
//M(x,0)=0.8 for x<0
//on solving we get
//C1+C2=0.8
//second boundary condition is
//M(0,t)=0
//so we get
//C1-C2=0
//therefore we get
```

```
C1=0
C2=0.8
//so we get x as
x=erfinv((C1-Mx)/C2)*2*sqrt(D*t)
printf ("post machining is to be done upto %f mm",x)
```

Scilab code Exa 7.4 duration for which material is to kept at high temperature

```
//example-7.4
//page no-213
//given
D0=0.002*10^-6  //m^2/s
Q=120*10^3  //J/mol
T=550+273  //K
//the condition for diffusion are
//M(x,0)=4% for x>0
//M(x,0)=0% for x<0
x=(0.25-0.10)*10^-3  //m
Mx=0.4  //%
R=8.314 //gas constant
//diffusion at 550 degrees celcius is
Dx=D0*exp(-Q/R/T)  //m^2/s
//by using
//M(x,t)=C1-C2*erf(x/2/sqrt(Dx*t))
//putting boundary conditions in above equation we
   get
C1=2   //%
C2=2  //%
//solving for t
//we get
t=(erfinv((C1-Mx)/C2)*2*sqrt(Dx)/x)^-2 //sec
printf ("the duration for which he material is kept
   at 550 degrees celcius is %e sec",t)
```

Scilab code Exa 7.5 depth of material

```
1 //example-7.5
2 //page no-215
3 //given
4 Mx=10^22  //atoms/m^3
5 M0=10^24  //atoms/m^3
6 t=3*3600  //sec
7 T=1100+273  //K
8 D=7*10^-17   //m^2/s
9 //boundary cinditions are
10 //M(x,0)=0 for x>0 at t=0
11 //M(0,t)=10^24 atoms/m^3
12 //M(x,t)=C1-C2*erf(x/22/sqrt(D*t))
13 //putting boundary conditions in the above equation
14 //we get
15 C1=10^24  //atoms/m^3
16 C2=10^24  //atoms/m^3
17 //solving for x
18 //now for x we have
19 x=erfinv((C1-Mx)/C2)*2*sqrt(D*t)*10^3   //mm
20 printf ("depth below the surface at which the
   concentration is 10^22 atoms/m^3 is %f mm",x)
```

Scilab code Exa 7.6 diffusivity

```
1 //example-7.6
2 //page no-216
3 //given
4 //temp and pressure of Nitrogen gas
5 T=400  //K
6 P=15 //atm
```

```
7  //Nitrogen conc at the inner surface of the tank
8  M=12  //kg/m^3
9  //constant D0 and activation energy
10 D0=5*10^-7  // m^2/s
11 Q=75*10^3  //J/mol
12 //thickness of tank wall
13 x=6*10^-3  //m
14 D=M/x //kg/m^4  (calculation mistake in book)
15 //gas constant
16 R=8.314  //J/mol/K
17 //dufusing flux
18 //Jx=-Dx*m/x kg/m^2/s
19 //Dx can be determined as follows
20 Dx=D0*exp(-Q/R/T)  //m^2/s
21 //so //diffusing flux will be
22 Jx=Dx*D  //kg/m^2/s  (calculation mistake in book)
23 printf ("diffusing rate of nitrogen is %e kg/m^2/s",
     Jx)
```

Scilab code Exa 7.7 activation energy

```
1  //example-7.7
2  //page no-217
3  //given
4  //ratio of rate of diffusion at 1350 and 110 degree
     C is 8
5  //so
6  //dM/dt at 1350 degree C(1623K)/dM/dt at 110degree C
       (1373K)=8
7  //so
8  Ratio=8
9  //we know that
10 //Dx=D0*exp(-Q/R/T)
11 //so Dx (at 1623 K)/Dx (at 1373 K)= exp(-Q/R/T1-Q/R/
     T2)
```

```
12 //where
13 T1=1623  //K
14 T2=1373  //K
15 //gas constant
16 R=8.314  //J/mol/K
17 //so we get
18 //Ratio=exp(-Q/R*(1/T1-1/T2))
19 //so we get Q as
20 Q=-log(Ratio)*R/(1/T1-1/T2)/1000  //KJ/mol
21 printf ("the activation energy for sulphur diffusion
       is %d KJ/mol",Q)
```

Chapter 8

phase and phase diagrams

Scilab code Exa 8.1 gibbs phase rule

```
1 //example-8.1
2 //page no-227
3 //given
4 //according to reduced phase rule, we have
5 //D=C-P+2
6 C=2  // for two component system
7 P=1
8 for P=1:5
9       //no of variables
10     V=P*(C-1)+2
11     //degrees of freedom
12     D=C-P+2
13 end
14  printf ("we can see that for P=5 we have D=-1 i.e
      non existent so,two components cannot have more
      than 4 phases in equilibrium")
```

Scilab code Exa 8.2 composition of alloy

```
//example-8.2
//page no-235
//given
//density of alpha and beta phases
rhoalpha=10300  //kg/m^3
rhobeta=7300  //kg/m^3
//refer to fig-8.5 in book
//at point B, the composition of lead in alpha-phase is 82% and that of tin in alpha-phase is 18%
leadalpha=82
tinalpha=18
//so we get
//82/rholead+18/rhotin=100/rhoalpha  ----------(1)
//similarly at point E
//the composition of tin and lead resp are 97% and 3 %
leadbeta=3
tinbeta=97
//so we get
//3/rholead+97/rhotin=100/rhobeta  ------(2)
//solving 1 and 2
//we get
rholead=11364.1  //kg/m^3
rhotin=7220.14  //kg/m^3
//let density of eutectic composition is rhoe. knowing the compositions at point D, we can write
//38/rholead+62/rhotin=100/rhoe
//so
rhoe=100/(38/rholead+62/rhotin)  //kg/m^3
//it is given that there is 88% eutectic composition by volume. its conversion in weight proportions yeild
W=88/100*rhoe  //kgf
Wlead=38/100*W  //Kgf
Wtin=62/100*W  //kgf
//there is 12% beta phase by volume which on converion to weight proportion gives
Wdash=12/100*rhobeta  //Kgf
```

```
33 Wdashlead=3/100*Wdash  //kgf
34 Wdashtin=97/100*Wdash  //kgf
35 //total weight of lead and tin can be estimated now
      as
36 Wddashlead=Wlead+Wdashlead  //kgf
37 Wddashtin=Wtin+Wdashtin  //kgf
38 //percentafe of tin
39 percenttin=Wddashtin/(Wddashtin+Wddashlead)*100
40 printf ("percentace of tin is %f",percenttin)
```

Scilab code Exa 8.4 peritectic system

```
1 //example-8.4
2 //page no-242
3 //given
4 //melting point of A and B
5 MptA=1250   //degrees celcius
6 MptB=1900   //degrees celcius
7 //part(a)
8 //according to the conditions given in question
      phase diagram can be drawn as shown in fig 8.10
      given in book
9 //part(b)
10 //at 1250 degrees celcius , it is a peritectic
      solution
11 //equation representing the equilibrium is given in
      the book which denotes forward reaction as
      cooling and backward as heating
12 //part (c)
13 //we are just considering a tie line just above the
      peritectic line at temp 1251 degrees celcius
14 //at this point
15 Cs1=80
16 Cl1=30
17 C01=75
```

```
18 //point below peritectic line has temp as 1249
     degrees celcius
19 Cs2=80
20 Cl2=50
21 C02=75
22 //weight fraction of the phase present in the
     material of overall composition 75% B at 1251
     degrees celcius and 75% B at 1249 degrees
23 f_alpha1=(Cs1-C01)/(Cs1-Cl1)*100    //%
24 f_beta1=(C01-Cl1)/(Cs1-Cl1)*100    //%
25 f_alpha2=(Cs2-C02)/(Cs2-Cl2)*100    //%
26 f_beta2=(C02-Cl2)/(Cs2-Cl2)*100   //%
27 //part (d)
28 // 75% B at room temp
29 Cs3=90
30 Cl3=30
31 C03=75
32 f_alpha3=(Cs3-C03)/(Cs3-Cl3)*100    //%
33 f_beta3=(C03-Cl3)/(Cs3-Cl3)*100    //%
34 //the microstructure is also shown in book at page
     no 243
35 printf ("weight fraction of the phase present in the
     material of overall composition 75 percent B at
     1251 degrees celcius and 75percent B at 1249
     degrees are %d %d %f %f and at 75 percent
     concentration of B at room temp is %d %d",
     f_alpha1,f_beta1,f_alpha2,f_beta2,f_alpha3,
     f_beta3)
```

Scilab code Exa 8.5 eutectic system

```
1 //example-8.5
2 //page no-246
3 //given
4 //according to the given conditions in the ques the
```

```
    graph can be drawn as shown in fig 8.12
5 //the given temp 576.9 degees celcius is just below
    the eutectic temp 577 degres celcius
6 //from the graph, we can have the following values
7 C_beta_e=100
8 C_e=1.65
9 C_0=10
10 //hence weight fraction is given by
11 W_alpha=(C_beta_e-C_0)/(C_beta_e-C_e)
12 printf ("the weight fraction of alpha in an alloy
    containing 10percent Si at 576.9 degrees celcius
    is %f ",W_alpha)
```

Scilab code Exa 8.6 eutectic system

```
1 //example-8.6
2 //page no-247
3 //given
4 //weight percent of tin and lead are
5 W1=90
6 W2=10
7 //let the amount of tin that can be added to the
    crucible without changing the system's
    solidificarion is "m"
8 //eutectic arm extends to 97% tin
9 //therefore, with the addition of "m" gram of tin,
    the composition of alloy should not exceed 97%
    tin
10 //therefore
11 //(900+m)/(1000+m)=97/100
12 //so
13 m=(97/100*1000-900)/(1-97/100)/1000  //kg because 1
    kg=1000g
14 printf ("maximum %f kg of tin can be added without
    changing the systems temperature",m)
```

Scilab code Exa 8.7 eutectoid mixture of pearlite

```
1 //example-8.7
2 //page no-250
3 //given
4 //the eutectoidal mixture of pearlite consists of
    two phases viz. alpha (ferrite) and Fe3C (
    cementite). the eutectoid composition contains
    0.83% carbon. the lever rule is applied in which
    the lever arm has ferrite (=0% carbon) at one end
     and cementite  (6.67% carbon) at the other end.
    the fulcrum is taken at 0.83% carbon. hence by
    applying lever rule, we get
5 Walpha=(6.67-0.83)/(6.67-0.00)
6 WFe3C=(0.83-0.0)/(6.67-0.0)
7 printf ("the weight fractions of ferrite and
    cementite are %f and %f resp",Walpha,WFe3C)
```

Chapter 9

mechanical properties

Scilab code Exa 9.1 tensile strain and youngs modulus

```
1 //example-9.1
2 //page no-259
3 //given
4 //bonding characteristics of a material are
5 n=1
6 m=9
7 A=7.56*10^-29    //J m
8 //initial bond length
9 r_0=2.3*10^-10    //m
10 //this bond length exceed by 15 %
11 //so extension is
12 e=15/100*r_0    //m
13 //new bond length will be
14 r=r_0+e    //m
15 //the axial tensile starin is given by
16 epsilon_t=e/r_0    //(change in dimension /original
     dimension)
17 //according to P-r function we have
18 B=A*r_0^8/9    //J m^9
19 //we have double deravative of P as
20 double_derivative_P=-2*A/r_0^3+90*B/r_0^11    ///J/m
```

```
    ^2
21 //so youngs modulus will be given by
22 E=double_derivative_P/r_0*10^-9    //GPa  (some
    approximation is done in book)
23 printf ("the axial stain is %.2f \n and youngs
    modulus of elasticity is %e GPa ", epsilon_t,E)
```

Scilab code Exa 9.4 stress strain

```
1 //example-9.4
2 //page no-274
3 //given
4 //according to the data given in the question we can
    have the graph shown in the fig 9.11 in book
5 //part(a):- tangent modulus of elasticity at 200 MPa
6 E_tangent=(222-168)*10^9/(1.90-1.42)/10^9    //G Pa (
    values from graph)
7 //part(b):- secant modulus of elasticity at 180 MPa
8 E_secant= (180-0)*10^9/(1.46-0)/10^9    //G Pa  (
    values from graph)
9 //part(c):-youngs modulus of elasticity at 85 MPa
10 E=(85-0)*10^6/((0.68-0)*10^-3)/10^9    //G Pa  (
    values from graph)
11 printf ("tangent modulus of elasticity at 200 MPa is
    %f Pa\n secant modulus of elasticity at 180 MPa
    is %d Pa \n youngs modulus of elasticity at 85
    MPa is %d Pa",E_tangent,E_secant,E)
```

Scilab code Exa 9.5 stress

```
1 //example-9.5
2 //page no-280
3 //given
```

```
4 //stress
5 sigmamean=70  //MPa
6 //stress range
7 sigmarange=210  //MPa
8 //as we know that
9 //sigmamean=(sigmamax+sigmamin)/2
10 //from this we get
11 //sigmamax+sigmamin=140    ----------(1)
12 //also
13 //sigmarange=sigmamax-sigmamin
14 //so we get
15 //sigmamax-sigmamin=210  ----------(2)
16 //solving 1 and 2
17 //we get
18 sigmamax=(140+210)/2   //MPa
19 //and
20 sigmamin=140-sigmamax  //MPa
21 //stress ratio
22 R=sigmamin/sigmamax
23 //stress ranges from sigmamin to sigmamax
24 //so total sum will be
25 totalsum=-sigmamin+sigmamax  //MPa
26 printf ("the maximum and minimum stresses are %d MPa
       and %d MPa resp\n, stress rstio is %f\n and
     totalsum is %d MPa",sigmamax,sigmamin,R,totalsum)
```

Scilab code Exa 9.7 creep

```
1 //example-9.7
2 //page no-289
3 //given
4 //temp
5 T=600  //degree C
6 //tightenening stress
7 sigmai=750    //kgf/cm^2
```

```
8  //minimum creep rate
9  vcr=2.8*10^-8  //cm/cm/hour
10 //stress
11 sigma=300  //kgf/cm^2
12 //young's modulus
13 E=2*10^6   //kgf/cm^2
14 //constant
15 n=3
16 //we knnow that minimum creep rate
17 //vcr=A*sigma^n
18 //so
19 A=vcr/sigma^n
20 //total time involved in creep of bolt is 1 year
21 t=365*24  //hours
22 //the stress relaxation in bolt due to creep is
      expresed by:-
23 //1/(sigmaif)^(n-1)=1/(sigmai)^(n-1)+A*E*(n-1)*t
24 //we have to find sigmaif
25 //so
26 sigmaif={(1/(sigmai)^(n-1)+A*E*(n-1)*t)^(1/(n-1))
      }^-1
27 printf ("the stress relaxation in bolt to creep is
      %f kgf/cm^2",sigmaif)
```

Chapter 10

Mechanical Tests and Factors Affecting Mechanical Properties

Scilab code Exa 10.1 stress strain

```
1 //example-10.1
2 //page no-298
3 //given
4 //initial gauge length of the specimen
5 l0=50*10^-3    //m
6 //initia;l gauge diameter of the specimen
7 d0=12*10^-3   //m
8 //extended gauge length of fracture
9 lf=58*10^-3    //m
10 //reduced gauge diameter
11 df=7*10^-3   //m
12 //initial an final cross sectional areas are
13 A_i=3.14/4*d0^2    //m^2
14 A_f=3.14/4*df^2    //m^2
15 //various applied loads are in k N
16 P1=0
17 P2=5
```

```
18 P3=10
19 P4=15
20 P5=20
21 P6=25
22 P7=30
23 P8=32
24 P9=33
25 P10=32
26 P11=31
27 P12=35
28 P13=40
29 P16=130
30 //corresponding to these load we have recorded
      elongation as
31 delta1=0
32 delta2=0.011
33 delta3=0.022
34 delta4=0.035
35 delta5=0.048
36 delta6=0.059
37 delta7=0.073
38 delta8=0.088
39 delta9=0.100
40 delta10=0.125
41 delta11=0.150
42 delta12=0.230
43 delta13=0.400
44 delta16=8.000
45 //stress and strain corresponding to these loads and
      elongations are
46 sigma1=P1/A_i
47 strain1=delta1/l0
48 sigma2=P2/A_i
49 strain2=delta2/l0
50 sigma3=P3/A_i
51 strain3=delta3/l0
52 sigma4=P4/A_i
53 strain4=delta4/l0
```

```
54 sigma5=P5/A_i
55 strain5=delta5/l0
56 sigma6=P6/A_i
57 strain6=delta6/l0
58 sigma7=P7/A_i
59 strain7=delta7/l0
60 sigma8=P8/A_i
61 strain8=delta8/l0
62 sigma9=P9/A_i
63 strain9=delta9/l0
64 sigma10=P10/A_i
65 strain10=delta10/l0
66 sigma11=P11/A_i
67 strain11=delta11/l0
68 sigma12=P12/A_i
69 strain12=delta12/l0
70 sigma13=P13/A_i
71 strain13=delta13/l0
72 sigma16=P16/A_i
73 strain16=delta16/l0
74 //part(a)
75 //modulus of elasticity
76 E=(sigma4-sigma1)/(strain4-strain1)/10^3    //G Pa
77 //part(b)
78 //ultimate stress (maximum)
79 ultimate_sigma=P16/A_i*10^3/10^6    //M N/m^3
80 //part (c)
81 //upper yield point at C (shown in fig 10.3)
82 u_yield=P9/A_i*1000/10^6    //M N/m^2
83 //lower yield point at D (shown in fig 10.3)
84 l_yield=P11/A_i*1000/10^6    //M N/m^2
85 //part(d)
86 //percentage reduction in area
87 percent_A=(d0^2-df^2)/d0^2*100   //%
88 //part (e)
89 //percentage elongation
90 percent_l=(lf-l0)/l0*100   //%
91 //part(f)
```

```
92 //apparent breaking stress
93 app_breaking_stress=P16*1000/A_i/10^6    //M N/m^2
94 //actual breaking stress
95 actual_breaking_stress=P16*1000/A_f/10^6    //M N/m^2
96 printf ("the modulus of elasticity is %f G Pa \n the
       ultimate (maximum) stress is %f M n/m^2 \n,upper
       yield point is %f M N/m^2 \n lower yield point
      is %f M n/m^2\n percentage reduction in area is
      %f \n percentage elongation in length %f\n
      apparent breaking stress is %f M n/mm^2\n actual
      breaking point is %f M n/m^2",E,ultimate_sigma,
      u_yield,l_yield,percent_A,percent_l,
      app_breaking_stress,actual_breaking_stress)
```

Scilab code Exa 10.2 stress strain

```
1 //example-10.2
2 //page no-303
3 //given
4 //initial length of the specimen
5 h0=24.02*10^-3    //m
6 //initial gauge diameter of the specimen
7 d0=18.74*10^-3   //m
8 //final length of specimen
9 hf=18.70*10^-3    //m
10 //final diameter
11 df=21.54*10^-3   //m
12 //initial an final cross sectional areas are
13 A_i=3.14/4*d0^2    //m^2
14 A_f=3.14/4*df^2    //m^2
15 //various applied loads are in k N
16 P1=0
17 P2=5
18 P3=10
19 P4=15
```

```
20 P5=20
21 P6=25
22 P7=30
23 P8=35
24 P9=40
25 P10=45
26 P11=50
27 P12=55
28 P13=60
29 P14=65
30 P15=70
31 P16=75
32 P17=80
33 P18=85
34 P19=131
35 //corresponding to these load we have recorded
      contraction as
36 delta1=0
37 delta2=0.004
38 delta3=0.008
39 delta4=0.012
40 delta5=0.015
41 delta6=0.017
42 delta7=0.020
43 delta8=0.023
44 delta9=0.025
45 delta10=0.028
46 delta11=0.032
47 delta12=0.036
48 delta13=0.040
49 delta14=0.044
50 delta15=0.049
51 delta16=0.054
52 delta17=0.061
53 delta18=0.069
54 //stress and strain corresponding to these loads and
       elongations are
55 sigma1=P1/A_i
```

```
strain1=delta1/h0
sigma2=P2/A_i
strain2=delta2/h0
sigma3=P3/A_i
strain3=delta3/h0
sigma4=P4/A_i
strain4=delta4/h0
sigma5=P5/A_i
strain5=delta5/h0
sigma6=P6/A_i
strain6=delta6/h0
sigma7=P7/A_i
strain7=delta7/h0
sigma8=P8/A_i
strain8=delta8/h0
sigma9=P9/A_i
strain9=delta9/h0
sigma10=P10/A_i
strain10=delta10/h0
sigma11=P11/A_i
strain11=delta11/h0
sigma12=P12/A_i
strain12=delta12/h0
sigma13=P13/A_i
strain13=delta13/h0
sigma14=P14/A_i
strain14=delta14/h0
sigma15=P15/A_i
strain15=delta15/h0
sigma16=P16/A_i
strain16=delta16/h0
sigma17=P17/A_i
strain17=delta17/h0
sigma18=P18/A_i
strain18=delta18/h0
//part(a)
//modulus of elasticity
E=(sigma13-sigma1)/(strain13-strain1)/10^3    //G Pa
```

```
94 //part(b)
95 // yield stress at D (shown in fig 10.6)
96 yield=P15/A_i*1000/10^6    //M N/m^2
97 //part (c)
98 //ultimate stress (maximum)
99 ultimate_sigma=P19/A_i*10^3/10^6    //M N/m^3
100 //part (d)
101 //percentage contraction
102 percent_l=(h0-hf)/h0*100   //%
103 //part(e)
104 //percentage increase in area
105 percent_A=(df^2-d0^2)/d0^2*100   //%
106 //part(f)
107 //apparent breaking stress
108 app_breaking_stress=P19*1000/A_i/10^6    //M N/m^2
109 //actual breaking stress
110 actual_breaking_stress=P19*1000/A_f/10^6    //M N/m^2
111 printf ("the modulus of elasticity is %f G Pa \n ,
    yield stress is %f M n/m^2\nthe ultimate (maximum
    ) stress is %f M n/m^2 \n  percentage contraction
     in length %f\n percentage increase in area is %f
     \n apparent breaking stress is %f M n/mm^2\n
    actual breaking point is %f M n/m^2",E,yield,
    ultimate_sigma,percent_l,percent_A,
    app_breaking_stress,actual_breaking_stress)
```

Scilab code Exa 10.3 Mechanical properties

```
1 //example -10.3
2 //page no-307
3 //given
4 //length of glass piece
5 l=1.1*10^3   //mm
6 //width of glass piece
7 b=225    //mm
```

```
8 //height or thicness of plate
9 h=10  //mm
10 //load
11 P=250  //N
12 //for a simply supported beam subjected to
      concentrated load in the middle of its span,
13 M=P*l/4  //N mm
14 //and force
15 F=P/2  //N
16 //part(a)
17 //flexure strength
18 sigma=6*M/b/h^2  //N/mm^2
19 //part (b)
20 //shear strength
21 tau=3*F/2/b/h  //N/mm^2
22 //part (c)
23 P1=350  //N
24 M1=P1*l/4
25 //ineria
26 I=b*h^3/12  //mm^4
27 y=h/2  //mm
28 //the modulus of rupture is given by
29 sigmar=M1*y/I
30 printf ("the flexture strength, shear strength and
      modulus of rupture are %f N/mm^2, %f N/mm^2 and
      %f N/mm^2 resp",sigma, tau, sigmar)
```

Scilab code Exa 10.4 BHN Number

```
1 //example -10.4
2 //page no-313
3 //given
4 //diameter of ball
5 D=0.5*10   //mm
6 //indentation diameter
```

```
d=32.5/10  //mm (diveided by 10 because it is 10
    times magnified)
//from table- 10.3 of book , the load for steel
    specimen is
P=30*D^2  //kg f
//hardness
BHN=P/[(%pi)*D/2*{D-sqrt(D^2-d^2)}]
printf ("the hardness is %f" ,BHN)
```

Scilab code Exa 10.5 mechanical properties

```
//example-10.5
//page no-321
//given
//dimension of steel specimen
l=75  //mm
b=10  //mm
t=10  //mm
//depth of V-notch is t/5
//in the absence of specimen, frictional and windage
    loss
L1=0.1  //kg f.m
//in the presence ofspecimen, which is placed on
    support breaks
L2=5.9  //kg f m
//rupture energy
U=L2-L1  //kg f m
//since the depth of V-notch is t/5
//so t/5=2
te=t-2  //mm
//volume of specimen
Ve=l*b*te*10^-9  //m^3
//modulus of rupture
Ur=U/Ve  //kg f/m^2
//effective area of cross section
```

```
23 Ae=b*te*10^-6  //m^2
24 //notch impact strength
25 Is=U/Ae  //kg/m
26 //given that
27 Ui=30  //kg f.m
28 alpha=160*(%pi)/180  //radians
29 //swing diameter
30 D=1600  //mm
31 R=D/2*10^-3  //m
32 //weight of hammer
33 //as we know that
34 //Ut=W*R(1-cos(aplha))
35 //so
36 W=Ui/R/(1-cos(alpha))  //kg f.m
37 //capacity of izod impact testing machine
38 L3=30  //kg f.m
39 //so Uf will be
40 Uf=L3-L2  //kbg f.m
41 //we know that energy after rupture
42 //Uf=W*R(1-cos(beta))
43 bet=acos(1-Uf/W/R)  //radins
44 //beta in degrees
45 Beta=bet*180/(%pi)  //degrees
46 //also we know that Uf=W*hf
47 //so hf will be
48 hf=Uf/W  //m
49 printf ("rupture energy is %f kg f.m \n, modulus of
     rupture %f kg f/m^2 \n, notch impact strength %f
     kg/m \n, angle of hammer after striking %f
     degrees \n and height risen by hammer after
     breaking %f m",U,Ur,Is,Beta,hf)
```

Scilab code Exa 10.6 endurance stress

```
1 //example-10.6
```

```
2 //page no-323
3 //given
4 //diameter  of circular section of bean
5 d=60  //mm
6 //length of circular section of beam
7 l=500  //mm
8 //maximum and minimum load
9 Pmin= 20  //kN
10 Pmax= 50  //kN
11 //ultimate strength
12 sigmau=650  //MPa
13 //yoeld strength
14 sigmay=520  //MPa
15 //factor of safety
16 fos=1.8
17 //maximum bending moment
18 Mmax=Pmax*l/4  //kN mm
19 //minimum bending moment
20 Mmin=Pmin*l/4  //kN mm
21 //mean bending moment
22 Mm=(Mmax+Mmin)/2  //kN mm
23 //alerting (variable) bending moment
24 Ma=(Mmax-Mmin)/2  //kN mm
25 //section modulus of beam
26 Z=(%pi)*d^3/32  //mm^3
27 //mean bending stress
28 sigmam=Mm/Z*1000  //MPa
29 //variable bending stress
30 sigmaa=Ma/Z*1000    //MPa
31 //endurance stress from
32 //(i) gerber's parabolic relation
33 sigmae1=sigmaa/[1/fos-(sigmam/sigmau)^2*fos]  //MPa
34 //(ii) goodman's straight line relation
35 sigmae2=sigmaa/[1/fos-sigmam/sigmau]  //MPa
36 //(iii) soderberg's straight line realtion
37 sigmae3=sigmaa/[1/fos-sigmam/sigmay]  //MPa
38 printf ("sndurance strength of the material are \n
   Gerbers parabolic fomula %f MPa\n, goodmans
```

```
straight line formula %f MPa\n and sodergerbs
straight line relation %f MPa ",sigmae1,sigmae2,
sigmae3)
```

Scilab code Exa 10.7 yield strength

```
1  //example-10.7
2  //page no-329
3  //given
4  //yeild strength of polycrystalline material
      increases from sigmay1 to sigmay2
5  sigmay1=118  //MPa
6  sigmay2=207  //MPa
7  //decreasing grain diameter from d1 to d2
8  d1=0.253*10^-3   //m
9  d2=0.0224*10^-3  //m
10 //to find the yield strngth at
11 d=0.095*10^-3  //m
12 //as we know that according to hall and petch
      equation,
13 //sigmay=sigma0+C/sqrt(d)
14 //putting sigmay1,sigmay2,d1 and d2.. we get 2
      equations
15 //sigma0+C/sqrt(d1)=sigmay1  -------(1)
16 //and sigma0+C/sqrt(d2)=sigmay2    -----(2)
17 //solving equation 1 and 2 we get
18 sigma0=80.3  //MPa
19 //and
20 C=0.1896  //MN/m^(3/2)
21 //so the yield stress for the grain size
22 d=0.095*10^-3  //m
23 sigma=sigma0+C/sqrt(d)  //MPa
24 printf ("the yield stress for a grainof size of
      0.095 mm is %f MPa",sigma)
```

Scilab code Exa 10.8 ASTM Number

```
1 //example-10.8
2 //page no-330
3 //given
4 //ASTM number
5 n=12
6 //as we know that
7 N=2^(n-1)
8 //1 square inch=645 mm^2
9 //so grain diameter for ASTM number 12 will be
10 d=1/sqrt((N/645)*10^4)  //mm
11 printf ("the grain diameter of ASTM number 12 is %f
   mm",d)
```

Scilab code Exa 10.9 ASTM Number

```
1 //example-10.9
2 //page no-330
3 //given
4 //ASTM number of grain
5 n=5
6 //as we know that
7 N=2^(n-1) //grains/inche^2 at magnification 100*
8 // as lineal and areal magnifications are related as
    *100=10,000 areal
9 N1=N/0.01/0.01  //grains/inch^2 at 1*
10 //average area of one grain
11 A=2.54*2.54/N1  //cm^2
12 //now N1 grains/ inch^2 of surface is = sqrt
   (160,000)=400 grain/inch of length and this is
   equal to =(400)^3=6.4*10^7  grains/m^3 of volume
```

```
13 //surface area of eaxh cubic surface
14 S=(1/400)^2  //inch^2
15 //there are 6 surfaces in a cubic grain
16 //so total surface area of each grain
17 TS=6*S  //inch^2
18 //each boundary is composed of two grain surfaces,
     therefore , total boundary in the volume is
19 TotS=1/2*TS*(400)^3  //inch^2 boundary per cubic of
     steel
20 //total suface area in cm^2
21 TotalS=TotS/(2.54)  //cm^2 boundary per cubic cm of
     steel
22 printf ("total boundary in the volume is %f cm^2 per
     cm^3 of steel",TotalS)
```

Scilab code Exa 10.16 ASTM Number

```
1 //example -10.16
2 //page no-332
3 //given
4 //ASTM number
5 n=4
6 //as we know that
7 N=2^(n-1)  //per inch^2 at a magnification of 100
8 //let r be the radius of grain
9 //so
10 //N*A=1/100 inch^2  where A=(%pi)*r^2
11 //so
12 r=sqrt(1/100/N/(%pi))  //inch
13 //radius of grain in mm
14 R=r*25.4  //mm
15 printf ("the radius of grain is %f mm", R)
```

Chapter 11

Theories of Inelastic Anelastic and Viscoelastic Deformations and Fractura

Scilab code Exa 11.1 shear stress

```
1 //example-11.1
2 //page no- 343
3 //given
4 //applied stress
5 sigmax=3.5  //MPa
6 //aluminium crystal slips from (111) plane in the
     direction [110] when the stess is applied to
     (1-11)
7 //so
8 h1=1
9 k1=1
10 l1=1
11 h2=1
12 k2=-1
13 l2=1
14 //magnitude of plane (111)
15 M1=sqrt(h1^2+k1^2+l1^2)
```

```
16 //magnitude of (1-11)
17 M2=sqrt(h2^2+k2^2+l2^2)
18 //direction [110]
19 h3=1
20 k3=1
21 l3=0
22 //magnitude of direction[110]
23 M3=sqrt(h3^2+k3^2+l3^2)
24 //the angle between the planes (111) and (1-11) is
25 cosphie=[{h1*h2+k1*k2+l1*l2}/(M1*M2)]
26 sinphie=sqrt(1-(cosphie)^2)
27 //similarly angle between the plane (111) and the
      direction [110] is given by
28 costheta=[(h1*h3+k1*k3+l1*l3)/(M1*M3)]
29 //critical resolved shear stress
30 taucr=sigmax*2*sinphie*cosphie*costheta/2  //MPa
31 printf ("the critical resolved shear stress is %f
      MPa",taucr)
```

Scilab code Exa 11.2 plastic deformation

```
1 //exaplme-11.2
2 //page no-351
3 //given
4 //shera stress
5 tau=715*10^6  //Pa
6 //shear modulus
7 G=25*10^9  //Pa
8 //atomic radius
9 b=4.05*10^-10  //m
10 //as we know that
11 //tau=G*b/l
12 //so
13 l=G*b/tau  //m
14 printf ("the length of frank- read source in
```

```
aluminium crystal is %.10f m",l)
```

Scilab code Exa 11.3 dislocation density

```
//example-11.2
//page no-351
//given
//shear modulous
G=25*10^9  //Pa
//shear stress
tau=50*10^6  //Pa
//lattice constant of aluminium is
a=4.05*10^-10  //m
//burger's vector for aluminium is 1/2(110)
h=1
k=1
l=0
//atomic radius of aluminium
b=a/sqrt(h^2+k^2+l^2) // m
//as we know that
//tau=G*b/L
//so
L=G*b/tau  //m
//disloaction density is rhoD (let)
rhoD =1/L^2  // per m^2  (calculation mistake,
   there in book formula written is correct but
   calculation is wrong)
printf ("the dislocation density is %e per m^2",rhoD
   )
```

Scilab code Exa 11.4 rate of straining

```
//example-11.4
```

```
2 //page no-352
3 //given
4 //burger vector
5 b=4*10^-10  //m
6 //density
7 N=10^13  //lines/m^2
8 //velocity
9 v=10^-5  //m/s
10 //rate of straining
11 epsilonP=N*b*v  //lines/sec
12 printf ("the rate of starining is %f lines/sec",
   epsilonP)
```

Scilab code Exa 11.5 stress and strain

```
1 //example-11.5
2 //page no-357
3 //given
4 //conventional stress
5 sigmac=98.9  //MPa
6 //conventional strain
7 epsilonc=0.35  //mm/mm
8 //as we know that
9 epsilont=log(1+epsilonc)   //mm/mm
10 //also
11 //sigmac=sigmat*exp(-epsilont)
12 //so
13 sigmat=sigmac/exp(-epsilont)  //MPa
14 printf ("the true strees is %f MPa\n and true strain
    is %f mm/mm",sigmat,epsilont)
```

Scilab code Exa 11.6 stress strain

```
1 //example-11.6
2 //page no-357
3 //given
4 //material constant
5 K=500  //MPa
6 //strain hardenening coefficient
7 n=0.20
8 //according to true stress-strain relation
9 //sigmat=d sigmat/d epsilont=d(Kepsilont^n)/d
     epsilont
10 //so we get
11 //sigmat=n*K*epsilont^(n-1)  -----(1)
12 //also we know that
13 //sigmat=K*epsilont^n  ------------(2)
14 //equating (1) and (2)
15 epsilont=n
16 //also we know that
17 //epsilont=log (1+epsilonc)
18 //so
19 epsilonc=exp(epsilont)-1
20 //now
21 sigmat=K*epsilont^n  //MPa
22 printf ("the maximum tensile strength %f \n and the
     linear strain are %f MPa ",epsilonc,sigmat)
```

Scilab code Exa 11.7 relaxation time

```
1 //exapmle-11.7
2 //page no-363
3 //given
4 //applied strain
5 epsilon=0.4
6 //immediate stress
7 sigmai=10*10^9  //Pa
8 //after 42 days stress is
```

```
sigma=5*10^9  //Pa
t=42  //days
//as we know that
//sigma=sigmai*exp(-t/tr)
//so
tr=t/log(sigmai/sigma)   //days
//stress after 90 days
t90=90 //days
sigma90=sigmai*exp(-t90/tr)*10^-9   //MPa
printf ("relaxation time for the tensile stress to
   decrease from 10 to 5 MPa is %fdays\n and the
   stress after 90 days is %f MPa",tr,sigma90)
```

Scilab code Exa 11.8 youngs modulus

```
//example-11.8
//page no-370
//given
//crack length of glass piece
l=3*10^-6/2  //m divided by 2 because min general we
    consider 2*l be the length of crack
//young modulus
E=70*10^9  //Pa
//specific surface energy
gammae=1.05  ///J/m^2
//fracture strength
sigmaf=sqrt(2*E*gammae/(%pi)/l) //N/m^2
//ratio of strength and young's modulus
R=sigmaf/E
printf ("fracture strength is %f N/m^2 \n and the
   ratio of strength and youngs modulus is %f ",
   sigmaf,R)
```

Scilab code Exa 11.9 surface energy

```
1 //exaple-11.9
2 //page no-370
3 //given
4 //young's modulus
5 E=71*10^9    //Pa
6 //fracture strength
7 sigmaf=115*10^6   //Pa
8 //lenght of crack
9 //2l=6 micro m
10 //so
11 l=6/2*10^-6   //m
12 //as we know that
13 //sigmaf=sqrt(2*E*sigmac/(%pi)/l)
14 //so
15 sigmac=(sigmaf)^2*(%pi)*l/2/E   //J/m^2
16 printf ("surface energy of the etched glass is %f J/
   m^2",sigmac)
```

Scilab code Exa 11.10 griffiths energy

```
1 //example-11.10
2 //page no-370
3 //given
4 E=70*10^9   //Pa
5 gammae=0.85   //J/m^2
6 l=2*10^-6   //m
7 //necessary stress to satisfy the griffith's energy
8 sigmaf=sqrt(2*E*gammae/(%pi)/l)/10^6 //Pa
9 printf ("the necessary stress is %f MPa",sigmaf)
```

Scilab code Exa 11.11 crack length

```
1  //example -11.11
2  //page 371
3  //given
4  E=72*10^9  //Pa
5  gammae=0.9  //J/m^2
6  sigmaf=17.5*10^6  //Pa
7  //as we know that
8  //sigmaf=sqrt(2*E*gammae/(%pi)/l) //N/m^2
9  //so
10 l=2*E*gammae/(%pi)/(sigmaf)^2*1000  //mm
11 //length of intenal crack
12 L=2*l  //m
13 printf ("length of crack on the outer surface is %f
     mm \n and length of crack internally %f mm",l,L)
```

Chapter 12

organic materials plastics rubber elastomers and wood

Scilab code Exa 12.1 polymers

```
1 //example -12.1
2 //page no-382
3 //given
4 //degree of polymerization of styrene
5 DOP=10000
6 //formula of styrene= C8H8
7 //molecular weight of styrene monomer
8 Mm=12*8+1*8
9 //molecular weight of polymer
10 Mp=DOP*Mm
11 printf ("the molecular weight of styrene polymer is
   %d",Mp)
```

Scilab code Exa 12.2 polymers

```
1 //example -12.2
```

```
2 //page no-382
3 //given
4 //degree of polymerization of teflon
5 DOP=100000
6 //chemical formula of teflon is C2F4
7 //molecular weight of monomer teflon
8 Mm=2*12+4*19
9 //molecular weight of teflon polymer
10 Mp=DOP*Mm
11 //molecular weight of polythene monomer i.ee C2H4
12 MmP=2*12+4*1
13 //molecular weight of polythene polymer
14 MpP=DOP*MmP
15 printf ("molecular weight of PTFE anf Polythene are
     %d and %d",Mm,MpP)
16 //ratio of molecular weight of PTFE and Polythene
17 R=Mp/MpP
18 printf ("the ration of molecular weight of PTFE and
     Polythene having same DOP is %f",R)
```

Scilab code Exa 12.3 natural rubber

```
1 //example-12.3
2 //page no-396
3 //given
4 //the molecular weight of polyisoprene monomer
5 Mm=68  //gm
6 //after vulcanisation with sulphur, it is
     observedthat the 2 molecules of isoprene monimer
     require 2 molecules of sulphur
7 //hence for full cross linking ,(68*2) gm of
     isoprene requires (32*2)gm of sulphur. therefore
     68kg of isoprene requires
8 M=32*2*68/68/2  //kg of sulphur
9 printf ("the weight of sulphur required for cross
```

```
    link polymerization of polyisoprene is %d of
    sulphur",M)
10 printf ("the fully cross linked product will be
    EBONITE")
```

Scilab code Exa 12.4 vulcanization of rubber

```
1  //example -12.4
2  //page no-396
3  //given
4  //molecular weight of butdiene,isoprene,sulhur and
       carbon black are
5  MB=4*12+6*1
6  MI=68
7  MS=32
8  MC=12
9  //percentages of diiferent constituents in rubber
10 PB=27/MB
11 PI=51/MI
12 PS=16/MS
13 PC=6/MC
14 //percentage of coss linking
15 percent=PS/(PI+PB)*100
16 printf ("the percentage of cross linking is %d",
       percent)
```

Chapter 14

composite material

Scilab code Exa 14.1 composite material

```
1 //example-14.1
2 //page no-429
3 //given
4 //part(a)
5 //thickness of GRPS sheet
6 ts=3  //mm
7 //depth of this skin
8 tc=24  //mm
9 //breadth of skin
10 b=100  //mm
11 d=(ts+tc)/2  //mm
12 //moduli of polyster skin and foamare
13 Es=7000  //N/mm^2
14 Ec=20  //N/mm^2
15 //values of Is and Ic are
16 Is=2*(b*ts^3/12+b*ts*d^2)   //mm^4
17 Ic=b*tc^3/12  //mmm^4
18 //as we know that flexure rigidity is D, flexure
     rigidity of skin is Ds and that of core is Dc
19 //D=Ds+Dc
20 D=2*Es*Is+Ec*Ic  //mm^2 for two skins
```

```
    ----------------(1)
21 //part(b)
22 ts1=6  //mm
23 //Ds1=Es*Is1
24 Ds1=Es*b*ts1^2/12  //Nmm^2  ----------------(2) (
       there is calculation mistake I myself have
       checked from calculator too)
25 //ratio of (1) and (2) is R (let)
26 R=D/Ds1
27 printf ("flexure rigidity of sandwich beam is %d
       times more",R)
```

Scilab code Exa 14.2 composite material

```
1  //example-14.2
2  //page no-441
3  //given
4  //young's modulus of aluminium, iron and boron are
       resp
5  //here we are representing a,b and c for aluminum,
       iron and boron resp.
6  Ea=71*10^9  //Pa
7  Eb=210*10^9  //Pa
8  Ec=440*10^9  //Pa
9  //as we know that Ec=Ef*Vf+Em*Vm where Ef and Em are
       the young's modulus of fibre and matrix resp.
10 //so we get
11 //210=71*Va+440*Vb  ----------------(1)
12 //assumin void volume is zero and we know that
13 //Va+Vb=1
14 //so Vb=1-Va  ----------------(2)
15 //on solving 1 and 2 we get
16 Va=31.8
17 Vb=68.2
18 //ratio of Va and Vb
```

```
19 R=Va/Vb
20 printf ("the volume ratio of aluminium and boron in
      aluminium boron composite %d",R)
```

Scilab code Exa 14.3 composite material

```
1 //example-14.3
2 //page no-442
3 //given
4 //elastic moduli of carbon fibre and epoxy resin
5 Ef=430  //GPa
6 E=3.6  ///GPa
7 //modular ratio
8 Pf=Ef/E
9 //part(a)
10 Vf1=0.15
11 Vm1=1-Vf1
12 R1=Vm1/Vf1
13 Pc1=Pf+R1
14 volume_fibre1=Pf/Pc1
15 //part(b)
16 Vf2=0.65
17 Vm2=1-Vf2
18 R2=Vm2/Vf2
19 Pc2=Pf+R2
20 volume_fibre2=Pf/Pc2
21 printf ("the fraction of load carried by fibre in
      carbon-epoxy matrix composite containing 15
      percent fibre by volume is %f\n and that by 65
      percent fibre by volume is %f",volume_fibre1,
      volume_fibre2)
```

Scilab code Exa 14.4 composite

```
1  //example -14.4
2  //page no-442
3  //given
4  Vf=.65
5  Vm=1-Vf
6  //part(a)
7  //longitudinal strength is determined by
8  //sigmac=sigmaf*Vf+sigmam*Vm
9  //here according to table given in question we have
10 sigmaf=2.8
11 sigmam=0.0025
12 sigmac=sigmaf*Vf+sigmam*Vm  //GPa
13 //part(b)
14 //longitudinal modulus is given by
15 //Ec=Ef*Vf+Em*Vm
16 //here according to table
17 Ef=130
18 Em=3.5
19 Ec=(Ef*Vf+Em*Vm)  //GPa
20 //part(c)
21 //transverse modulus is given by
22 //1/EC=Vf/Ef+Vm/Em
23 EC=(Vf/Ef+Vm/Em)^-1  //GPa
24 //part(d)
25 //poisson ratio
26 //nuLT=nuf*Vf+num*Vm
27 //here according to the table
28 nuf=0.34
29 num=0.36
30 nuLT=nuf*Vf+num*Vm
31 //part(e)
32 //shear modulus
33 //1/Glt=Vf/Gf+Vm/Gm
34 // here according to the table
35 Gf=2.2
36 Gm=1.2
37 GLT=(Vf/Gf+Vm/Gm)^-1  //GPa
38 printf ("the longitudinal strength is %f GPa\n, the
```

```
logitudinal modulus is %f GPa\n , the transvrse
modulus is %f GPa\n , the  poissons ratio is %f\n
 and sher modulus is %f GPa",sigmac,Ec,EC,nuLT,
GLT)
```

Scilab code Exa 14.5 longitudinal strength and modulus

```
1  //example-14.5
2  //page no-444
3  //given
4  //content of polyster
5  Vm=0.45
6  Vf=1-Vm
7  //longitudinal strength and modulus are calculated
      using following formulas
8  //sigmac=nu*sigmaf*Vf+singmam*Vm
9  //Ec=nu*Ef*Vf+Em*Vm
10 //according to the table given in the ques
11 Ef=240  //GPa
12 Em=4.5  //GPa
13 sigmaf=1.7  //GPa
14 sigmam=0.0029  //GPa
15 Gf=1.7
16 Gm=1.4
17 nuf=0.28
18 num=0.32
19 //values of nu
20 nu1=1
21 nu2=1/2
22 nu3=1/4
23 nu4=3/8
24 nu5=1/6
25 //now longitudinal strength for differnt nu
26 sigmac1=nu1*(sigmaf*Vf+sigmam*Vm)     //GPa
27 sigmac2=nu2*(sigmaf*Vf+sigmam*Vm)     //GPa
```

```
28 sigmac3=nu3*(sigmaf*Vf+sigmam*Vm)     //GPa
29 sigmac4=nu4*(sigmaf*Vf+sigmam*Vm)     //GPa
30 sigmac5=nu5*(sigmaf*Vf+sigmam*Vm)     //GPa
31 //liongitudina modulus for differnt nu
32 EC1=nu1*(Ef*Vf+Em*Vf)     //GPa
33 EC2=nu2*(Ef*Vf+Em*Vf)     //GPa
34 EC3=nu3*(Ef*Vf+Em*Vf)     //GPa
35 EC4=nu4*(Ef*Vf+Em*Vf)     //GPa
36 EC5=nu5*(Ef*Vf+Em*Vf)     //GPa
37 printf ("longitudinal strength and longitudinal
      modulus for nu=1     is %f GPa     and     %f GPa
      \n longitudinal strength and longitudinal modulus
       for nu=1/2     is %f GPa     and     %f GPa\n
      longitudinal strength and longitudinal modulus
      for nu=1/4     is %f GPa     and     %f GPa\n
      longitudinal strength and longitudinal modulus
      for nu=3/8     is %f GPa     and     %f GPa\n
      longitudinal strength and longitudinal modulus
      for nu=1/6     is %f GPa     and     %f     GPa\
      n",sigmac1,EC1,sigmac2,EC2,sigmac3,EC3,sigmac4,
      EC4,sigmac5,EC5)
```

Chapter 15

Phase Transformation

Scilab code Exa 15.1 arrhenius concept

```
1  //example-15.1
2  //page no-461
3  //given
4  //reaction comlete in 500 mins at 10 degree celcius
     and in 1 min at 80 degrees celcius
5  //so
6   t1=1   //min
7   t2=500   //min
8   T1=273+80   //kelvin
9   T2=273+10   //Kelvin
10  //gas constant
11  R=8.314
12  //as we know that phie=1/t*
13  //so
14  //log(phie1/phie2)=log(t2/t1)
15  //so we get
16  //log(t2/t1)=Ea/2.303*(1/T1-1/T2)
17  //so Ea is given by
18  Ea=2.303*log(t2/t1)*(1/(1/T1-1/T2))*R
19  //to find the reaction completion time when
      temperature is 40 degrees celcius
```

```
20  //so
21  T3=273+40    //Kelvin
22  t3=t1*exp(Ea/2.303/R*(1/T1-1/T3))   //min
23  printf ("the reaction completion tym at 40 degree
       celcius is %f min",t3)
```

Scilab code Exa 15.2 homogeneous nucleation

```
1  //example-15.2
2  //page no-463
3  //given
4  //temp
5  T=983+273   //K
6  Tm=1083+273   //K
7  deltaT=Tm-T   //K
8  //given that
9  //latent heat of fusion of copper
10 deltaHm=1.88*10^9   //J/m^3
11 //interface energy/unit area
12 gammasL=0.144   //J/m^2
13 //change in free energy of vapour
14 deltaGv=deltaHm*deltaT/Tm     //J/m^3
15 //critical radius of copper during solidification
16 //for notation only we are using r*=R
17 R=2*gammasL/deltaGv*10^10   //A
18 printf ("the critical radius of copper during
       solidification is %f A",R)
```

Scilab code Exa 15.3 homogenous nucleation

```
1  //example-15.3
2  //page no-463
3  //given
```

```
4 //latent heat of fusion of pure gold
5 deltaHf=-1.16*10^9  //J/m^2
6 //surface free energy
7 gama=0.132  //J/m^2
8 //melting point of gold
9 Tm=1064+273  //K
10 //supercooling value
11 deltaT=230  //K
12 //critical radius is given by R intead of r* just
     for notation
13 R=(-2*gama*Tm/deltaHf)*(1/deltaT)*10^9  //nm
14 printf ("critical radius of pure gold at 230 degree
     celcius is %f nm",R)
15 //change in free energy of vapours is
16 deltaGv=deltaHf*deltaT/Tm  //J/m^3
17 //activation free energy
18 //for notation deltaG* we  use deltaG
19 deltaG=16*(%pi)*(gama)^3/3/(deltaGv)^2  //J
20 printf ("the activation free energy is %e J",deltaG)
```

Scilab code Exa 15.5 strengthening

```
1 //example -15.5
2 //page no-472
3 //given
4 //diameter of hard inert particle
5 D=2  //m
6 //average centre to centre distance between the
     particles
7 l=20*10^-6   //m becaus 1 micro m=10^-6 m
8 //shear modulus of copper
9 G=41*10^9  //Pa
10 //burgers vector
11 b=0.64*10^-9  //m
12 //contribution of these particles on the yeild
```

```
    strength of material
13 tau=G*b/l/10^6  //MPa
14 printf ("the contribution of these particles on the
    yeild strength of material is %f MPa",tau)
```

Scilab code Exa 15.7 recovery

```
1  //example-15.7
2  //page no-474
3  //given
4  //heat for recovery of yeild point in zinc
5  Q=83.14*10^3  //J/mole
6  //gas constant
7  R=8.314*10^3  //J/mol K
8  //temperature
9  T1=0+273  //K
10 T2=27+273  //K
11 //recovery time at 0 degree celcius
12 t2=5  //min
13 //the recovery time for the two different temp is
    given by
14 //1/t1=A*exp(-Q/R/T1)  ---------------(1)
15 //1/t2=A*exp(-Q/R/T2)  ------------(2)
16 //taking ratio of (1) to (2)
17 //we get
18 t1=t2*exp(Q/R*(1/T1-1/T2))  //min (there is
    calculation mistake I myself have checked from
    calculator too)
19 printf ("the recovery time at 27 degree celcius is
    %f min",t2)
```

Chapter 16

Heat Treatment

Scilab code Exa 16.1 allotropy

```
1 //example -16.1
2 //page no- 484
3 //given
4 //atomic radiii of gamma-iron having FCC lattice
5 rFCC=1.26  //A
6 //atomic radius of alpha-iron having BCC lattica
7 rBCC=1.24  //A
8 //as we know that FCC and BCC has effective no of
    atoms 4 and 2 resp
9 //so
10 aBCC=4/sqrt(3)*rBCC  //A
11 aFCC=2*sqrt(2)*rFCC  //A
12 //volume of lattice for FCC and BCC
13 VFCC=(aFCC)^3  //A^3
14 VBCC=(aBCC)^3  //A^3
15 //percentage change in volume during phase
    transformation of gamma-iron to alpha-iron is
    given by
16 percent_vol_change=(VFCC/4-VBCC/2)/(VFCC/4)*100
17 printf("the percentage volume change during phase
    transformation of gamma-iron to alpha-iron is %f"
```

```
,percent_vol_change)
```

Scilab code Exa 16.3 annealing

```
1 //example-16.3
2 //page no-495
3 //given
4 //young's modulus
5 E=51*10^9  //Pa
6 //poisson's ratio
7 nu=0.22
8 //magnitude of burger's vector
9 b=2*10^-10  //m
10 //we know that shear modulus is given by
11 G=E/2/(1-nu)  //Pa
12 //elastic strain energy of dislocation in cold
    worked tin
13 Ue=1/2*G*b^2*10^12  //Pa m
14 //the strain energy in tin before cold working may
    be neglected as it is smaller by three orders of
    magnitude.
15 printf ("the change in energy during
    recrystallization is %f Pa m",Ue)
```

Chapter 17

corrosion and oxidation

Scilab code Exa 17.1 oxidation of nickel

```
1 //example -17.1
2 //page no-511
3 //given
4 //density of nickel and nickel oxide (NiO)
5 rhom=8900  //kg/m^3
6 rhoc=7080  //kg/m^3
7 //molecular weight of nickel and nickel oxide
8 Mm=58.51
9 Mc=74.71
10 //molar volumes are
11 Vm=Mm/rhom  //m^3/mol
12 Vc=Mc/rhoc  //m^3/mol
13 printf ("it is clear that Vc>Vm, so a protective
    film will form over nickel")
```

Scilab code Exa 17.2 laws of corrosion

```
1 //example -17.2
```

```
2 //page no-513
3 //given
4 //oxidation loss on the copper surface is 0.1 mm in
     25 hours
5 t1=25  //hours
6 x1=0.1  //mm
7 //to find the loss in 300 hours
8 t2=300  //hours
9 // as we know that oxidation loss is given by
10 //x^2=Cp*t
11 //for t1 and t2 we have following equations
12 //x1^2=Cp*t1  -------(1)
13 //x2^2=Cp*t2  ----------(2)
14 //dividing equation 1 by 2
15 //we get
16 x2=x1*sqrt(t2/t1)  //mm
17 printf ("loss in 300 hours is %f mm",x2)
```

Scilab code Exa 17.3 protection against corrosion

```
1 //example-17.3
2 //page no-515
3 //given
4 //atomic weight  and density of magnesium
5 MMg=24.3  //gm
6 rhoMg=1.740  //g/cm^3
7 //molecular weight and density of MgO
8 MMgO=40.3  //gm
9 rhoMgO=3.650  //g/cm^3
10 //volume of Mg and Mgo
11 VMg=MMg/rhoMg  //cm^3
12 VMgO=MMgO/rhoMgO  //cm^3
13 //we know that pilling-bedworth ratio is given by
14 PBR=VMgO/VMg
15 printf ("since PBR is less than 1 so the film formed
```

```
    is not protective ")
```

Scilab code Exa 17.4 protection against corrosion

```
1  //example-17.4
2  //page no-526
3  //given
4  //one mole of magnesium weighs
5  MMg=0.0243  //Kg
6  //current density
7  I=20*10^-3   //A/m^2
8  //design life of 15 years
9  t=15*365*24*3600  //sec
10 //charge= 2 faradya
11 Q=2*96490  //C
12 //charge needed per m^2 of structure's for design
       life
13 q=I*t  //A s
14 //the amount of magnesium needed
15 AMg=MMg*q/Q  //kg/m^2
16 printf("the amount of magnesiun meeded is %f kg/m?^2
       ",AMg)
```

Chapter 18

electron theories and conducting materialproperties behaviour and application

Scilab code Exa 18.1 energy

```
1 //example-18.1
2 //page no-535
3 //given
4 //side of cube
5 l=20*10^-3  //m
6 //plank's constant
7 h=6.626*10^-34   //Js
8 //mass of electron
9 m=9.109*10^-31  //kg
10 // lower energy level
11 nx1=1
12 ny1=1
13 nz1=1
14 //higher energy level
15 nx2=2
16 ny2=1
17 nz2=1
```

```
18 //energy in the lower level
19 E1=h^2*(nx1^2+ny1^2+nz1^2)/(8*m*l^2)  //J
20 //energy in the higher level
21 E2=h^2*(nx2^2+ny2^2+nz2^2)/(8*m*l^2)  //J
22 //difference in energies of the two levels
23 deltaE=E2-E1  //J
24 printf ("since deltaE is very small, so the
      assumption that E varies continuously with k, is
      justified")
```

Scilab code Exa 18.2 electric field

```
1 //example-18.2
2 //page no-537
3 //given
4 //distance between the plates
5 d=5*10^-3  //m
6 //voltage difference between the plates
7 V=230  //Volts
8 //electric field is given by
9 E=-V/d  //V/m
10 printf ("electric field between the plates is %f V/m
      ",E)
```

Scilab code Exa 18.3 drift velocity

```
1 //example-18.3
2 //page no- 537
3 //given
4 //conductivity of material
5 sigma=0.018  // per ohm m
6 //no of electrons
7 n=10^19  //electrons/m^3
```

```
8 //voltage
9 V=0.16  //V
10 //thickness of material
11 t=0.29*10^-3  //m
12 //mass and charge of electron
13 m=9.1*10^-31  //kg
14 e=1.602*10^-19  //C
15 //electric feilf gradient
16 kie=V/t  //V/m
17 //as we know that
18 //sigma=n*e*vd/kie
19 //so v
20 vd=sigma*kie/n/e  //m/s
21 printf ("drift velocity of carriers is %f m/s",vd)
```

Scilab code Exa 18.4 specific resistance

```
1 //example -18.4
2 //page no-547
3 //given
4 //resistance of wire
5 R=21  //ohm
6 //length of wire
7 l=200  //m
8 //diameter of wire
9 d=0.44*10^-3  //m
10 //area of cross section of wire
11 A=(%pi)/4*d^2  //m^2
12 //as we know that
13 //R=rho*l/A
14 //so
15 rho=R*A/l  //ohm m
16 printf ("the specific resistance of wire is %e ohm m
   ",rho)
```

Scilab code Exa 18.5 temp coefficient of resistance

```
1 //example-18.5
2 //page no-548
3 //given
4 //resistance of wire at 70 degree celcius is 57.2
    ohm and at 25 degrees celcius 50 ohm
5 R25=50  //ohm
6 R70=57.2  //ohm
7 T1=25    //degree C
8 T2=70  //degree C\
9 //as we know that
10 //Rt=R0*(1+t*alpha)
11 //putting above values in the above given equation
    we get
12 //R25=R0*(1+25*alpha)  -------(1)
13 //R70=R0*(1+70*alpha)  --------(2)
14 //applying R70/R25
15 //we get
16 //R70/R25=(1+70*alpha)/(1+25*alpha)
17 //solving for alpha we get equation as follows
18 alpha=(R70-R25)/(T2*R25-T1*R70)  //K^-1
19 printf ("the temperature coefficient of resistance
    is %f K^-1",alpha)
```

Scilab code Exa 18.6 resistivity

```
1 //example-18.6
2 //page no-550
3 //given
4 //resistivity of copper , nickel and silver are
5 rhoCu=0.015*10^-6  //ohm m
```

```
6  rhoNi=0.012*10^-6   //ohm m
7  rhoAg=0.016*10^-6   //ohm m
8  //atomic percent of nickle and silver
9  CNi=0.25
10 CAg=0.40
11 //the resistivity of Cu-Ni-Ag alloy at 300 K
12 rho=rhoCu+(rhoNi*CNi)+(rhoAg*CAg)   //ohm m
13 printf ("the resistivity of Cu=Ni-Ag alloy is %e ohm
       m",rho)
```

Chapter 19

semiconducting materials properties behaviour and applications

Scilab code Exa 19.1 fermi energy

```
1  //example-19.1
2  //page no-561
3  //given
4  pE=0.05
5  //let E-Ef=EE
6  EE=0.4  //eV
7  k=8.614*10^-5
8  //we know that
9  //p(E)=1/exp((E-EF)/k/T)
10 //putting above values in above equation we get
11 T=EE/k/log(1/pE-1)  //K
12 printf ("the temperature at which there is a
       probability of 5 percent for an electron to
       occupy energy state which is 0.4 eV above the
       fermi level is %f K",T)
```

Scilab code Exa 19.2 intrinsic charge carriers

```
1 //example -19.2
2 //page no-563
3 //given
4 //resistivity of pure silicon is
5 rho= 3000  //ohm m
6 //conductivity of pure silicon is reciproca of
     resistivity
7 sigma=1/rho  //(ohm m)^-1
8 //mobility of electrons and holes
9 muh=0.05  //m^2/V s
10 mue=0.14  //m^2/V s
11 //charge on elctron
12 e=1.602*10^-19  //C
13 // we know that
14 //sigme=ne*ee*mue+nh*eh*muh
15 //here we have ne=nh=n and ee=eh=e
16 //so we have sigma=n*e*muh+n*e*mue
17 //so
18 n=sigma/(e*muh+e*mue)  //ohm m^2/(C V s)
19 printf ("the density of intrensic carriers is %e /m
     ^3",n)
```

Scilab code Exa 19.3 resistivity

```
1 //example -19.3
2 //page no-563
3 //given
4 //mobility of silicon
5 mue=0.17  //m^2/V s
6 //mobility of holes
```

```
7 muh=0.035  //m^2/V s
8 //carrier density
9 n=1.1*10^16  //per m^3 (here ne=nh=n)
10 //electronic charge
11 e=1.602*10^-19  //C (here ee=eh)
12 //as we know that
13 //sigma=ne*ee*mue+nh*eh*muh
14 //so we get
15 sigma=n*e*(mue+muh)  //per ohm m
16 //resistivity
17 rho=1/sigma  //ohm m
18 printf ("the resistivity of silicon is %f ohm m
     approx.",rho)
```

Scilab code Exa 19.4 extrinsic semiconductor

```
1 //example-19.4
2 //page no-565
3 //given
4 //resistivity
5 rho=2*10^-3  //ohm m
6 //conductivity
7 sigma=1/rho  //per ohm m
8 //electrons and holes mobility
9 mue=0.3  //m^2/V s
10 muh=0.1  //m^2/V s
11 //charge on holes and electrons are same so
12 e=1.602*10^-19  //C
13 //we know that
14 //sigma=ne*e*mue+nh*e*muh
15 //here ne=nh=n
16 //so
17 n=sigma/(e*(mue+muh))  //per m^3  (some
     approximation is done in book)
18 printf ("the carrier density is %e per m^3",n)
```

Scilab code Exa 19.5 extrinsic semiconductor

```
1 //example-19.5
2 //page no-566
3 //given
4 //current density
5 Id=1000  //A/m^2
6 //resistivity
7 rho=0.05  //ohm m
8 //conductivity
9 sigma=1/rho  //per ohm m
10 //electron mobility
11 mue=0.4  //m^2/V m
12 //length of crystal
13 l=100*10^-6  //m
14 //charge on electron
15 e=1.602*10^-19  //C
16 //in n-type semiconductor ne>>>nh
17 //so
18 n=sigma/e/mue  //per m^3
19 //also we know that
20 //Ie=n*e*vd
21 //so
22 vd=Id/n/e  //m/s
23 //the distance l travelled in time t at drift
     velocity vd, by an electron is given by
24 //l=t*vd
25 //so
26 t=l/vd*10^6  //micro sec
27 printf ("the velocity and time taken by the electron
     to travel 100 m in the crystal is %d m/s and %d
    micro sec",vd,t)
```

Scilab code Exa 19.6 extrinsic semiconductor

```
1 //example-19.6
2 //page no-567
3 //given
4 //electronic charge
5 e=1.602*10^-19  //C
6 //lengthof rod
7 l=10*10^-3  //m
8 //diameter of rod
9 d=1*10^-3  //m
10 //area of cross section
11 A=(%pi)/4*d^2  //m^2
12 //resistance of wire
13 R=100  //ohm
14 //mobility of holes
15 muh=0.19  //m^2/V s
16 //resistivity of wire
17 rho=R*A/l  //ohm m
18 //conductivity
19 sigma=1/rho  //per ohm m
20 //we know that i p-type semiconductore nh>>>ne and
     eh=e
21 //so
22 //sigma=nh*e*muh
23 //so
24 nh=sigma/e/muh  //per m^3
25 printf ("the impurity conc in the rod is %e per m^3"
     ,nh)
```

Scilab code Exa 19.7 density of state

```
1 //example -19.7
2 //page no569
3 //given
4 //hole density
5 n=10^19  //per m^3
6 //intrinsic carriers concentration
7 ni=1.5*10^16  // per m^3
8 //no of conduction electrons are given by
9 p=(ni)^2/n  //per m^3
10 printf ("the no of intrinsic carrier are %e per m^3"
    ,p)
```

Scilab code Exa 19.8 density of state

```
1 //example -19.8
2 //page no-569
3 //given
4 //hole density in silicon
5 ND=10^17  //per cm^3
6 //intrinsic carrier concentretion
7 ni=1.5*10^10  //per cm^3
8 //since ND>>>> ni, so ne=ND
9 ne=ND
10 //the holes concentration
11 nh=(ni)^2/ne  //per cm^3
12 printf ("the hole concentration is %f per cm^3",nh)
13 //relative location of EF and Ei are found from
14 //EF-Ei=k*Tlog (ne/ni)
15 //let us assume for notation
16 //EF-Ei=EE
17 //temp
18 T=300  //K
19 k=8.614*10^-5  //eV
20 //so now
21 EE=k*T*log(ne/ni)  //eV
```

```
22 printf ("EF is located at %f eV away from Ei,
      toeards Ec side as denoted in book",EE)
```

Scilab code Exa 19.9 hall effect

```
1  //example -19.9
2  //page no-582
3  //given
4  //deimension of aluminium piece
5  t=15*10^-3  //m (thickness)
6  b=60*10^-3  //m (width)
7  l=180*10^-3  //m (length)
8  //magnetic field
9  betaz=0.6  //T (tesla)
10 //current
11 I=25  //A
12 //hole mobility
13 sigmah=0.0012
14 //electrical conductivity
15 sigma=3.8*10^7  // per ohm m
16 //part(a)
17 //hall coefficient
18 HC=sigmah/sigma  //Vm/AT
19 //part(b)
20 //hall voltage
21 VAB=HC*I*betaz/t  //V
22 //part(c)
23 //resistance
24 R=l/sigma/b/t  //ohm
25 printf ("the hall coefficient is %.12f Vm/AT\n, hall
       voltage is %.9f V\n and resistance is %.6f ohm",
      HC,VAB,R)
```

Scilab code Exa 19.13 hall effect

```
1 //example-19.13
2 //page no-583
3 //given
4 //electron mobility
5 mue=1.065*10^-3  //m^2/V s
6 //relaxation time
7 tau=6*10^-15  //s
8 //charge on electron
9 e=1.6*10^-19  //C
10 //no of electrons
11 n=1
12 //mass of electron
13 me=9.1*10^-31  //kg
14 //as we know that
15 //mue=sigma*HC and sigma=n*e^2*tau/me
16 //so
17 //mue=n*e^2*tau*HC/me
18 //from above equation we can get
19 HC=mue*me/n/e^2/tau   //V m^3/A Wb
20 //condustivity
21 sigma=mue/HC  //per ohm m   (calculation mistake in
   book)
22 printf ("the hall coefficient is %e V m^3/A Wb and
   conductivity is %e per ohm m",HC,sigma)
```

Scilab code Exa 19.14 hall effect

```
1 //example-19.14
2 //page no-583
3 //given
4 //electron mobility
5 mue=1.065*10^-3   //m^2/Vs
6 //relaxation time
```

```
7 tau=6*10^-15  //sec
8 //charge on an electron
9 e=1.6*10^-19  //C
10 //mass of electron
11 me=9.1*10^-31  //Kg
12 n=1
13 //as we know that
14 //mue=sigma*Hc and sigma=n*e^2*tau/me
15 //so
16 //mue=n*e^2*tau*Hc/me
17 //upon rearrangement
18 Hc=mue*me/n/e^2/tau
19 //and
20 sigma=mue/Hc   //(ohm m)^-1  //(ohm m)^-1  (
   calulation mistake is there in book)
21 printf ("the hall coefficent is %e \n and
   conductivity of Al sample is %e (ohm m)^-1 ",Hc,
   sigma)
```

Scilab code Exa 19.15 hall angle

```
1 //example-19.15
2 //page no-584
3 //given
4 //magnetic flux density
5 betaz=0.5  //T or Wb/m^2
6 //hall coefficient
7 HC=3.66*10^-4  //m^3/C
8 //resistivity of semiconductors
9 rho=0.00893  //ohm m
10 //hall angle
11 thetaH={atan(HC*betaz/rho)}*180/(%pi)   //degrees
12 printf ("the hall angle is %f degrees",thetaH)
```

Scilab code Exa 19.18 fermienergy

```
1 //example -19.18
2 //page no-585
3 //given
4 //fermi velocity of electron
5 VF=0.85*10^6  //m/s
6 //rest mass of electron
7 m0=9.109*10^-31  //kg
8 //charge on an electron
9 e=1.602*10^-19  //C
10 //fermi energy is
11 EF=1/2*m0*(VF)^2  // J
12 //energy in eV
13 E=EF/e //eV
14 printf ("the fermi energy value indicate that the
     metal is potassium")
15 //speed of light
16 c=3*10^8  //m/s
17 //varying mass of electron can bee calculated as
18 m=m0*sqrt(1-(VF/c)^2)  //kg
19 //fermi energy
20 EF=1/2*m*(VF)^2  //J
21 //energy in eV
22 E=EF/e  //eV
23 printf ("the fermi energy value indicate that the
     metal is potassium")
```

Scilab code Exa 19.19 band gap

```
1 //example -19.19
2 //page no-586
```

```
3 //given
4 //wavelength of the edge of the absorption edge of a
      semiconductor material is
5 lambda=1771*10^-9  //m
6 //plank's constant
7 h=6.626*10^-34
8 //speed of light
9 c=3*10^8  //m/s
10 //band gap energy
11 Eg=h*c/lambda  //J
12 //charge on electron
13 e=1.602*10^-19  //C
14 //energy in eV
15 E=Eg/e  //eV
16 printf ("the band gap energy is %f eV",E)
```

Chapter 20

dielectric ferroelectric piezoelastic and pyroelastic materials

Scilab code Exa 20.1 dielectric strength

```
1 //example-20.1
2 //page no-593
3 //given
4 //dielecric strength of natural rubber
5 DS=40000  //volts/mm
6 //current
7 I=33*10^3  //V
8 //required thickness of insulation
9 t=I/DS  //mm
10 printf ("the thickness of wire required for
    insulation is %f mm",t)
```

Scilab code Exa 20.2 dielectric loss

```
1 //example -20.2
2 //page no-594
3 //given
4 //capacitance of capacitor
5 C=0.025*10^-6  //F
6 //power factor
7 //tan delta=0.0005
8 //for notation let tan delta=delta
9 delta=0.0005
10 //current
11 I=200  //A
12 //frequency
13 f=25*10^3  //Hz
14 //volatge across a capacitor is
15 V=I/(2*(%pi)*f*C)  //V
16 //dielectric loss
17 P=V*I*delta  // W
18 printf ("the dielectric loss is %f Watt",P)
```

Scilab code Exa 20.3 polarization

```
1 //example -20.3
2 //page no-596
3 //given
4 //electric field
5 E=600  //V/m
6 //dielectric constant
7 Er=6.1
8 E0=8.85*10^-12
9 //polarization is given by
10 P=E*E0*(Er-1)  //V/m
11 printf ("the polarization produced is %e V/m",P)
```

Scilab code Exa 20.4 measurement of polarization

```
1 //example-20.4
2 //page no-596
3 //given
4 //charge
5 Q=10*10^-6  //C
6 //voltage
7 V=10*10^3  //V
8 //seperation betweemn the plates
9 d=5*10^-4  //m
10 //dielectric eonstant
11 Er=10
12 E0=8.854*10^-12
13 //we know that
14 //Q=C*V
15 //so
16 C=Q/V  //F
17 //also we know that
18 //C=Er*E0*A/d
19 //so
20 A=C*d/Er/E0  //m^2
21 printf ("area between the plates is %f m^2",A)
```

Scilab code Exa 20.5 measurement of polarization

```
1 //example-20.5
2 //page no-597
3 //given
4 //area of plate
5 A=10*10*10^-6  //m^2
6 //capacitance
7 C=10^-9  //F
8 //distance between the plates
9 d=2*10^-3  //m
```

```
10 //contant
11 E0=8.854*10^-12  //F/m
12 //dielectric constant
13 Er=C*d/(E0*A)
14 printf ("the cielectric constant of the crystal is
      %f",Er)
```

Scilab code Exa 20.6 measurement of polarization

```
1  //example-20.6
2  //page no-597
3  //given
4  //dielectric constant
5  Er1=6.0
6  Er2=3.0
7  //thickness of plates
8  d1=0.25*10^-3  //m
9  d2=0.1*10^-3  //m
10 //taking A1=A2
11 //we know that
12 //C=Er*E0*A/d
13 //for plate1
14 //C1=Er1*E0*A1/d1      ----------(1)
15 //for plate 2
16 //C2=Er1*E0*A2/d2    ----------(2)
17 //dividing 1 and 2
18 //we get
19 //C1/C2=Er1*d2/(Er2*d1)
20 //let C1/C2=c
21 C=Er1*d2/(Er2*d1)
22 //so we get
23 //C1=0.8*C2
24 printf ("the plastic film wil hold more charge")
```

Scilab code Exa 20.7 potential differnce

```
1 //example-20.7
2 //page no-609
3 //given
4 //thickness of BaTiO3 wafer
5 t=0.15*10^-3  //m
6 //compressive strength
7 sigma=25*10^6  //N/m^2
8 //young's modulus of elasticity
9 Y=70*10^9  //N/m^2
10 //electric field E produced by the stress sigma is
     related as
11 //E=sigma*lambda  where lambda is constant known as
     voltage output coefficient
12 lambda=1*10^-10  //m/V
13 //and modulus of elasticity is gven by
14 //Y=1/(lambda*t)
15 //so we get from 1 and 2
16 //E=sigma/(Y*t)
17 //also E=V/t
18 //so
19 V=sigma*t/(lambda*Y)  //V
20 printf ("potential difference producd across tha
     wafer is %f V",V)
```

Scilab code Exa 20.8 thickness of crystal

```
1 //example-20.8
2 //page no-613
3 //given
4 //vibration frequency
```

```
5 f=434*10^3 //Hz
6 //young's modulus of elasticity
7 E=80*10^9   //Pa
8 //density
9 rho=2655  //kg/m^3
10 //and fundamental overtones may be 1,2,3.....
11 //so
12 n=1
13 //we konow tha
14 //f=n/(2*t)*sqrt(E/rho) wher t is the thickness of
     crystal
15 //so
16 t=n/(2*f)*sqrt(E/rho)*10^3  //mm
17 printf ("the thickness of crystal is %f mm",t)
```

Scilab code Exa 20.9 capacitor

```
1 //example=20.9
2 //page no-613
3 //given
4 //capacitance of paper capacitance
5 C=0.02*10^-6  //F
6 //thickness of capacitor
7 d=1*10^-3  //m
8 //relative permitivity
9 Er=2.6
10 E0=8.85*10^-12
11 //dielectric strength
12 k=1.8*10^7   //V/m
13 //area of capacitor is given by
14 A=C*d/(Er*E0)*10^4  //cm^2
15 //breakdown volatage
16 Vbreakdown=k*d  //V
17 printf ("the area of capacitor is %f am^2 \n and
     breakdown volatage is %f V",A,Vbreakdown)
```

Scilab code Exa 20.10 capacitor

```
1 //example-20.10.sce
2 //page no-614
3 //given
4 //capacitance of capacitor
5 C=0.2*10^-6  //F
6 //loss factor
7 //tan delta=0.004
8 // for notation let us use tan delta=delta
9 delta=0.004
10 //voltage
11 V=240  //V
12 //frequency
13 f=50  //Hz
14 //and
15 omega=2*(%pi)*f
16 //power loss is given by
17 P=V^2*omega*C*delta  //W
18 printf ("power loss in the capacitor is %f W",P)
```

Chapter 21

magnetic materials properties behaviour and application

Scilab code Exa 21.1 magnetic field

```
1 //example-21.1
2 //page no-621
3 //given
4 //magnetic field
5 H=2400  //A/m
6 //susceptibilty
7 kie=1500
8 //part(a)
9 //relative permeability is given by
10 mur=1+kie
11 //part(b)
12 //intensity of magnetization
13 M=kie*H  //A/m
14 //part(c)
15 //permeability
16 mu0=4*(%pi)*10^-7
17 //remanance
18 B=mu0*mur*H  //T
19 printf ("the realative permeability is %f \n, the
```

```
intensity of magnetisation is %f A/m \n and the
remanance is %f",mur,M,B)
```

Scilab code Exa 21.2 magnetic field

```
1 //example -21.2
2 //page no-621
3 //given
4 //relative permeability of superalloy
5 mur=200000
6 mu0=4*(%pi)*10^-7  //henry/m
7 //intensity of magnetisation
8 M=6000  //A/m
9 //magnetic field is given by
10 H=M/(mur-1)  //A/m
11 //strength of magnet
12 B=mu0*mur*H  //tesla
13 printf ("the strength of magnet is %f T",B)
```

Scilab code Exa 21.3 magnetic field

```
1 //example -21.3
2 //page no-621
3 //given
4 //magnetic moment is 0.6 times bohr magneton and we
   know that beta is 9.27*10^-24 Am^2
5 beta=9.27*10^-24  //A/m^2
6 M=0.6*beta  //A/m^2
7 //attice constant
8 a=0.35*10^-9  //m
9 //no of atoms per unit cell is given by
10 Ne=4
```

```
11 //saturation magnetisation for FCC unit cell is
      given by
12 Ms=Ne*M/a^3  //A/m
13 printf ("he saturation magnetisation is %f A/m",Ms)
```

Scilab code Exa 21.4 B H curve

```
1 //example -21.4
2 //page no-632
3 //given
4 //refer to fig -21.6
5 //width of loop
6 //W=(OA+OB)
7 //so
8 W=80*2  //A/m
9 //height of loop
10 //H=(OC+OD)  //wb/m^2
11 //so
12 H=0.15*2  //Wb/m^2
13 //area of loop
14 A=W*H  //T A/m or J
15 printf ("the energy loss per ubitvolume of the
      magnetic material during one cycle is %f J",A)
```

Scilab code Exa 21.5 eddy current

```
1 //example -21.5.
2 //page no-633
3 //given
4 //volume
5 V=0.01  //m^3
6 //frequency
7 f=50  //Hz
```

```
8 //area of loop
9 A=600    //J/m^2
10 //as we know that
11 //A=mu*Bmax^16
12 //also power loss is given by
13 //P=mu*Bmax^16*f*V
14 //so
15 P=A*f*V   //watt
16 printf ("the power loss due to hysteresis is %f W",P
   )
```

Scilab code Exa 21.6 eddy current

```
1 //example-21.6
2 //page no-633
3 //given
4 //hysteresis loss is
5 W1=300   //W
6 //max flux density is
7 Bmax1=0.9   //Wb/m^2
8 Bmax2=1.1   //Wb/m^2
9 //frequency
10 f1=50   //Hz
11 f2=40   //Hz
12 //we know that
13 //W=nu*(Bmax)^1.7*f*V
14 //s0
15 //W1=nu*(Bmax1)^1.7*f1*V    ----------(1)
16 //W2=nu*(Bmax2)^1.7*f*V    --------(2)
17 //from one and 2 we get
18 W2=W1*(Bmax2)^1.7*f2/((Bmax1)^1.7*f1)   //W
19 printf ("The hysteresis loss at 40 Hz frequency is
   %f W",W2)
```

Scilab code Exa 21.7 hysteresis loss

```
1 //example-21.7
2 //page no=634
3 //given
4 //flux density
5 Bm=1.10  //Wb/m^2
6 //frequency
7 f=50  //Hz
8 //thickness of sheet
9 t=0.5*10^-3  //m
10 //resistivity
11 rho=30*10^-8  //per ohm m
12 //density
13 rhodash=7800  //kg/m^3
14 //mass
15 m=1  //kg
16 //volume of material
17 V=m/rhodash  //m^3
18 //and
19 k=1.11
20 //hysteresis loss in each cycle
21 Wh=380  //W s/m^3
22 //loss per kg of specimen is given by
23 We=4/3*(Bm*f*t*k)^2*V/(rho)   //watt/kg
24 printf ("the loss is %f watt/kg",We)
```

Scilab code Exa 21.8 hysteresis loss

```
1 //example-21.8
2 //page no-634
3 //given
```

```
4 //frequency
5 f=50  //Hz
6 //mass
7 m=50  //kg
8 //density
9 rho=7500  //kg/m^3
10 //volume of material
11 V=m/rho  //m^3
12 //hysteresis loop area
13 A=150  //m^2
14 //scale factor
15 //1 cm=0.008 Wb/m^2 on y-axis and 1cm=20 A/m on x-
     axis
16 //energy lost during each cycle
17 E=A*0.008*20*10^4  //J/m^3
18 //poer loss due to hysteresis
19 P=E*f*V  //J/s
20 //energy lost in one hour
21 Wh=P*(60*60)  //J
22 printf ("the energy lost in one hour is %e J",Wh)
```

Scilab code Exa 21.11 eddy current loss

```
1 //example-21.11
2 //page no-650
3 //given
4 //frequency
5 f=50  //Hz
6 //eddy current loss in transformer
7 We=100  //W
8 //to find eddy current loss at frequencies
9 f1=60  //Hz
10 f2=100  //Hz
11 //as we know that
12 //We is directly proportional to f^2
```

```
13 We1=f1^2*We/f^2  //W
14 //similarly
15 We2=f2^2*We/f^2  //W
16 printf ("the eddy current loss at 60 Hz is %f W \n
      and at 100 Hz is %f W",We1,We2)
```

Scilab code Exa 21.15 magnetic field strength and flux density

```
1 //example-21.15
2 //page no-651
3 //given
4 //length of wire
5 l=250*10^-3  //m
6 //no of turns
7 N=400
8 //current
9 I=15  //A
10 //permeability in vaccum
11 mu0=1.2457*10^-6  //H/m
12 //relative permeability
13 mur=1
14 //magnetic field strength
15 H=N*I/l  //AT/m
16 //flux density is
17 B=mu0*mur*H  //Wb/m^2
18 printf ("the magnetic field strength is %f AT/m and
      flux density is %f Wb/m",H,B)
```

Chapter 22

superconducting materials properties behaviour and application

Scilab code Exa 22.2 critical field

```
1 //example-22.2
2 //page no-660
3 //given
4 //critical  temp of Pb
5 T0=7.17  //K
6 //critical field
7 H0=0.0803  //A/m
8 //to find the critical field at
9 T1=3 //K
10 T2=10  //K
11 //critical field at T1
12 Hc1=H0*(1-T1^2/T0^2)  //A/m
13 //critical field at T2
14 Hc2=H0*(1-T2^2/T0^2)  //A/m
15 printf ("the critical field at 3K temp is %f A/m and
    at 10K ia %f A/m",Hc1,Hc2)
```

Scilab code Exa 22.3 critical current

```
1 //example -22.3
2 //page no-660
3 //given
4 //critical magnetic field
5 Hc=7.9*10^3  //A/m
6 //diameter of aluminium wire
7 d=1*10^-3   //m
8 //critical current is give by
9 Ic=2*(%pi)*d*Hc  //A
10 printf ("the critical current which can pass through
    a long thin superconducting wire of aluminium is
    %f A",Ic)
```

Scilab code Exa 22.4 superconducting material

```
1 //example -22.4
2 //page no-667
3 //given
4 //specific density of lead
5 sd=11.4
6 //density of lead
7 rho=sd*10^3  //kg/m^3
8 //atomic weight of lead
9 Aw=207.2  //kg/kg-mol
10 //velocity of sound in lead
11 v=1200  //m/s
12 NA=6.023*10^26  //particles/kg-mol (avogadro's
    number)
13 e=1.602*10^-19  //C/electrons  (charge on an
    electron)
```

```
14 m=9.1*10^-31  //kg  (mass of electron)
15 mu0=4*(%pi)*10^-7  //H/m  (permeability)
16 //since lead is type I superconductor, so  London's
      theory of superconductivity is applicable
17 //so
18 ne=2*rho*NA/Aw  //electrons/m^3
19 //critical current density
20 Ied=ne*e*v  //A/m^2
21 //depth of penetration at the surface of lead
22 dp=sqrt(m/(mu0*ne*e^2))*10^10  //A
23 printf ("the electron density is %e electrons/m^3\n,
       the critical current density is %e A/m^2\n and
      the depth of penetration is %e A",ne,Ied,dp)
```

Scilab code Exa 22.9 magnetic field

```
1 //example-22.9
2 //page no-673
3 //given
4 //magnetic field at 0K temp
5 H0=65*10^3  //A/m
6 //critical temp
7 Tc=7.18  //K
8 //diameter of wire
9 d=1*10^-3  //m
10 //radius of wire
11 r=d/2  //m
12 //area of cross section
13 A=(%pi)*r^2  //m^2
14 //to find the current density at 4.2 K
15 //since it is given that Hc is parabolicaly
      dependent on T, so
16 T=4.2  //K
17 Hc=H0*(1-T^2/Tc^2)  //A/m
18 //critical current
```

```
19 Ic=2*(%pi)*r*Hc  //A
20 //critical current density Jc
21 Jc=Ic/A  //A/m^2
22 printf ("the critical current density of lead is %e
     A/m^2",Jc)
```

Scilab code Exa 22.10 superconductors

```
1 //example-22.10
2 //page no-673
3 //given
4 //critical field at 3K and 14 K are 21 A/m and 10 A/
     m
5 T1=7  //K
6 T2=14  //K
7 Hc1=21  //A/m
8 Hc2=10  //A/m
9 //DETERMINING CRITICAL TEMP
10 //as we know that H=H0*(1-T^2/Tc^2)
11 //so we get
12 //71=H0*(1-7^2/Tc^2)  ----(1)
13 //10=H0*(1-14^2/Tc^2) --(2)
14 //dividing 1 and 2 we get
15 //71/10=(Tc^2-7^2)/(Tc^2-14^2)
16 //on solving we get
17 Tc=sqrt(3626/11)  //K
18 //DETERMINING CRITICAL FIELD AT 0K
19 H0=Hc1/(1-T1^2/Tc^2)  //A/m
20 //DETERMINING CRITICAL FIELD AT
21 T=4.2  //K
22 Hc=H0*(1-T^2/Tc^2)  //A/m
23 printf ("the critical temp is %f K\n, the critical
     field at 0K is %f A/m and critical field at 4.2 K
      is %f A/m",Tc,H0,Hc)
```

Scilab code Exa 22.11 superconductors

```
1 //example-22.11
2 //page no-674
3 //given
4 //depth of penetration at 3K is 39.8 nm and at 7.1 K
      is 1730 A
5 T1=3  //K
6 T2=7.1  //K
7 dp1=39.6*10^-9  //m
8 dp2=1730*10^-10  //m
9 //as we know that depth of penetration and temp are
     related as
10 //(dp(T)/dp(T0))=1/(1-t^4/Tc^4)
11 //so we get
12 //at 3K
13 //let dp(T0)=dp0
14 //dp0=sqrt(dp1^2*(1-T1^4/Tc^4))  -(1)
15 //also
16 //dp0=sqrt(dp2^2*(1-T2^4/Tc^4))  .----(2)
17 //solving 1 and 2 we get
18 //((Tc^4-81)/(Tc^4-(7.1)^4))=(173)^2/(39.6)^2
19 //so we get
20 Tc=(48417.9/18.085)^(1/4)  //K\
21 //depth of penetration at absolute zero willbe
22 dp0=sqrt(dp1^2*(1-T1^4/Tc^4))*10^9  //nm
23 printf ("critica temp is %f K\n and depth of
     penetration at critica zero is %f nm",Tc,dp0)
```

Chapter 23

thermal properties and materials

Scilab code Exa 23.1 coefficient of linear expansion

```
1 //example-23.1
2 //page no-681
3 //given
4 //length of glass rod and steel rod is equal at 273
    K and differ by 1.2 mm at 373 K
5 T1=273  //K
6 T2=373  //K
7 //coefficients of linear expansion af glass and
    steel are
8 alphaG=8*10^-6  //per degree C
9 alphaS=12*10^-6   //per degrees C
10 //we know that
11 //lT2=lT1*(1+alpha(T2-T1))
12 //so for glass rod
13 //l100G=l0*(1+(alpha1)*(T2-T1))
14 //similarly for steel rod
15 //l100G=1.0008*l0   ----(1)
16 //l100S=lo*(1+(alpha2)*(T2-T1))
17 //l100S=1.0012*l0  ----------(2)
```

```
18 //we have given that
19 //l100S-l100G=1.2 mm  ---(3)
20 //from 1 and 2 put in 3, we get
21 //1.0012*l0-1.0008*l0=1.2
22 //so
23 l0=1.2*10^-3/(0.0012-.0008)  //m
24 printf ("the length of rod at 0 degrees celcius is
     %f m",l0)
```

Scilab code Exa 23.2 stress strain

```
1 //example-23.2
2 //page no-684
3 //given
4 //coefficient of linear expansion of Cu and steel
     are
5 alphaCu=18*10^-6  //cm/cm/degree C
6 alphaSteel=14*10^-6  //cm/cm/degree C
7 //young's modulus of elasticity
8 ECu=106*10^9  //Pa
9 ESteel=200*10^9  //Pa
10 //part(a)
11 //since alphaCu>alphaSteel
12 //so steel will contract less.
13 printf ("Hence strip will bend in the direction of
     copper")
14 //part(b)
15 //annealing temp
16 T2=530  //degrees celcius
17 //room temp
18 T1=30  //degrees celcius
19 //difference in temp
20 T=T2-T1  //degrees celcius
21 //differnce in values of coefficient of linear
     expansion
```

```
22 alpha=alphaCu-alphaSteel  //cm/cm/degrees celcius
23 //differential contraction
24 contraction=T*alpha  //cm/cm
25 //since the two metals in the strip have equal
      dimension
26 //sigmaCu=sigmaSteel=sigma
27 //strain in copper
28 //eCu=sigma/Ecu    -----(1)
29 //strain in steel
30 //eSteel=sigma/ESteel   ---(2)
31 //sum of strains given by equation 1 and 2
32 sigma=contraction*ESteel*ECu/(ESteel+ECu)*10^-6  //
      MPa
33 printf ("the stresses in each metal is %f MPa",sigma
      )
```

Chapter 26

optical properties of materials and materials for opto electronic devices

Scilab code Exa 26.1 energy of photon

```
1 //example-26.1
2 //page no-769
3 //given
4 //wavelength of light
5 lambda=5.893*10^-7  //m
6 //plank's constant
7 h=6.626*10^-34  //J s
8 //velocity of light
9 c=3*10^8  //m/s
10 //energy of photon
11 Ephoton=h*c/lambda  //J
12 //we know that 1eV=1.6*10^-19 J
13 //so
14 EPhoton=Ephoton/(1.6*10^-19)  //eV
15 printf ("the energy of photon is %.23f J or %f eV",
   Ephoton,EPhoton)
```

Scilab code Exa 26.2 absorption

```
1 //example-26.2
2 //page no-769
3 //given
4 ////thickness of sample
5 t=0.45*10^-4  //cm
6 //energy of light
7 E1=3  //eV
8 //absorption coefficient
9 alpha=50000  //per cm
10 //incident power on the sample
11 I0=15*10^-3  //W
12 //we know that
13 //intensity of transmitted light is given by
14 It=I0*exp(-alpha*t)  //W or J/s
15 //thus total energy absorbed is
16 Iabsorbed=I0-It  //W or J/s
17 printf ("total energy absorbed is %e J/s",Iabsorbed)
18 //plank's constant
19 h=6.626*10^-34  //J s
20 //energy of outgoing radiation
21 E2=2.35  //eV
22 //fraction of each photon energy unit which is
      converted ton heat
23 E=(E1-E2)/E1
24 //therefore total amount of energy converted to heat
      per second is
25 EC=E*Iabsorbed  //J/s
26 printf ("total amount of energy coverted to heat is
      %e J/s",EC)
27 //charge on an electron
28 e=1.6*10^-19  //C
29 //no of photons = nphoton
```

```
30 nphoton=Iabsorbed/(e*E1)  //photons/sec  (
     calculation mistake is there in book)
31 printf ("the no of photon given off from
     recombination is %e photons/sec",nphoton)
```

Scilab code Exa 26.3 energy of photon

```
1 //example -26.3
2 //page no-783
3 //given
4 //energy of photon
5 E=1.5*10^-19  //J
6 //quantum eficiency
7 muquantam=0.6
8 //photon current
9 Iopc=3*10^-6  //A
10 //speed of light
11 c=3*10^8  //m/s
12 //plank's constant
13 h=6.626*10^-34  //J s
14 //wavelength at which the photodiode is operatng
15 lambda=h*c/E*10^6  //micro m
16 //responsivity of diode
17 R=0.64
18 //incident optical power is given by
19 Piop=Iopc/R*10^6  //micro W
20 printf ("wavelength at which photodiode is operating
     is %f micro m \n and incident optical power is
     %f micro W",lambda,Piop)
```

Scilab code Exa 26.4 optical fibre

```
1 //example -26.4
```

```
2 //page no-784
3 //given
4 //refractive index of core and cladding
5 mucladding=1.47
6 mucore=1.50
7 //critocal angle at the core cladding interface
8 thetac=asin(mucladding/mucore) *180/(%pi) //degrees
9 printf ("the critical angle at core cladding
    interface is %f degrees",thetac)
```

Scilab code Exa 26.5 energy of absorbed light

```
1 //example-26.5
2 //page no-784
3 //given
4 //energy band gap
5 Eg=0.75*1.6*10^-19  //J
6 //plank's constant
7 h=6.626*10^-34  //Js
8 //speed of light
9 c=3*10^8  //m/s
10 //wavelength of light
11 lambda=h*c/Eg*10^10  //A
12 printf ("wavelength of light is %f A",lambda)
```

Scilab code Exa 26.7 energy of photoelectron

```
1 //example-26.7
2 //page no-784
3 //given
4 //frequency of light
5 f=1.5*10^9*10^6  //Hz
6 //pank's constant
```

```
7  h=6.626*10^-34  //J s
8  //threshold frequency is
9  f0=1.2*10^9*10^6  //Hz
10 //maximum energy of emitted photoelectron is
11 Emax=h*(f-f0)/(1.6*10^-19)  //eV
12 printf ("the maximum enery of the emitted photoe;
      lectron is %f eV",Emax)
```