Scilab Textbook Companion for Essentials of Materials Science and Engineering by D. R. Askeland and P. P. Phule[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 2

Atomic structure

Scilab code Exa 2.1 Nano particle

```
1 //Page 26
2 clc;funcprot(0);//EXAMPLE 2.1
3 // Initialisation of Variables
4 r=1.5*10^-7;.....//Radius of a particle in cm
5 rho=7.8;.....//Density of iron magnetic nano-
    particle in cm^3
6 //CALCULATIONS
7 v=(4/3)*%pi*(r)^3;.....//Volume of each Iron
    magnetic nano -particle in cm^3
8 m=rho*v;.....//Mass of each iron nano-particle in
    g
9 disp(v,"Volume of each Iron magnetic nano -particle
    in cm^3:")
10 disp(m,"Mass of each iron nano-particle in g:")
```

Scilab code Exa 2.4 Convalent bond

```
1 //Page 37
```

```
clc;funcprot(0);//EXAMPLE 2.4
// Initialisation of Variables
Es=1.8;........//Electro negativity of Silicon from
    fig.2-8
Eo=3.5;........//Electro negativity of Oxygen from
    fig.2-8
//CALCULATION
F=exp(-0.25*(Eo-Es)^2);........//Fraction covalent
    of   SiO2
disp(F,"Fraction covalent of   SiO2 :")
```

Chapter 3

Atomic and Ionic arrangements

Scilab code Exa 3.1 Lattice points

```
1 //page 53
2 clc;funcprot(0);//EXAMPLE 3.1
3 // Initialisation of Variables
4 Cn=8;.....//No. of Corners of the Cubic Crystal
    Systems
5 c=1;.....//No. of centers of the Cubic Crystal
    Systems in BCC unit cell
6 F=6;.....//No. of Faces of the Cubic Crystal
    Systems in FCC unit cell
7 //CALCULATIONS
8 N1=Cn/8;.....//No. of latice points per unit cell in
     SC unit cell
9 N2=(Cn/8)+c*1;....//No. of latice points per unit
    cell  in BCC unit cells
10 N3=(Cn/8)+F*(1/2);....//No. of latice points per
    unit cell  in FCC unit cells
11 disp(N1,"No. of latice points per unit cell in SC
    unit cell:")
12 disp(N2,"No. of latice points per unit cell  in BCC
    unit cells:")
13 disp(N3,"No. of latice points per unit cell  in FCC
```

```
unit cells:")
```

Scilab code Exa 3.3 Packing factor

```
1 //page 56
2 clc;funcprot(0);//EXAMPLE 3.14
3 // Initialisation of Variables
4 r=1;.....// one unit of radius of each atom of
    FCC cell
5 a0=(4*r)/sqrt(2);.....//Lattice constant for
    FCC cell
6 v=(4*%pi*r^3)/3;.....//volume of one atom in FCC
     cell
7 Pf=(4*v)/(a0)^3;.....//Packing factor in FCC cell
8 disp(Pf,"Packing factor in FCC cell")
```

Scilab code Exa 3.4 Density of BCC iron

```
1 //page 57
2 clc;funcprot(0);//EXAMPLE 3.4
3 // Initialisation of Variables
4 a0=2.866*10^-8;.....//Lattice constant for BCC
    iron cells in cm
5 m=55.847;.....//Atomic mass of iron in g/mol
6 Na=6.02*10^23;.....// Avogadros number in atoms/
    mol
7 n=2;.....//number of atoms per cell in BCC iron
8 //CALCULATIONS
9 v=a0^3;.....//Volume of unit cell for BCC iron in
     cm^3/cell
10 rho=(n*m)/(v*Na);.....//Density of BCC iron
11 disp(v,"Volume of unit cell for BCC iron in cm^3/
    cell:")
```

```
12 disp(rho,"Density of BCC iron in g/cm^3:")
```

Scilab code Exa 3.5 Volume change in polymorphs

```
1 clc;funcprot(0);//EXAMPLE 3.5
2 // Initialisation of Variables
3 a=5.156;........//The lattice constants for the
    monoclinic unit cells in Angstroms
4 b=5.191;........//The lattice constants for the
    monoclinic unit cells in Angstroms
5 c=5.304;........//The lattice constants for the
    monoclinic unit cells in Angstroms
6 beeta=98.9;.......//The angle fro the monoclinic
    unit cell
7 a2=5.094;........//The lattice constants for the
    tetragonal unit cells in Angstroms
8 c2=5.304;........//The lattice constants for the
    tetragonal unit cells in Angstroms
9 //CALCULATIONS
10 v2=(a2^2)*c2;........//volume of a tetragonal unit
    cell
11 v1=a*b*c*sin(beeta*%pi/180);........//volume of a
    monoclinic unit cell
12 Pv=(v1-v2)/(v1)*100;........//The percent change in
     volume in percent
13 disp(v2,"volume of a tetragonal unit cell in A^3:")
14 disp(v1,"volume of a monoclinic unit cell in A^3:")
15 disp(Pv,"The percent change in  volume in percent:")
16 //valu of pv is wrong in book
```

Scilab code Exa 3.8 Planar density and packing fraction

```
1 //page 64
```

```
clc;funcprot(0);//EXAMPLE 3.8
// Initialisation of Variables
r=1;.......//Radius of each atom in units
l=0.334;.......//Lattice parameter of (010) in nm
//CALCULATIONS
a1=2*r;........//Area of face for (010)
a2=l^2;..........//Area of face of (010) in cm^2
pd=1/a2;........//Planar density of (010) in atoms/
   nm^2
pf=%pi*r^2/(a1)^2;......//Packing fraction of (010)
disp(pd*10^14,"Planar density of (010) in atoms/cm
   ^2:")
disp(pf,"Packing fraction of (010):")
```

Scilab code Exa 3.11 Octahedral sites

```
//page 70
clc;funcprot(0);//EXAMPLE 3.11
// Initialisation of Variables
E=12;......//No. of Edges in the octahedral sites of
    the unit cell
S=1/4;.......//so only 1/4 of each site belongs
   uniquelyto each unit cell
N=E*S+1;.....//No.of site belongs uniquely to each
   unit cell
disp(N,"No.of octahedral site belongs uniquely to
   each unit cell:")
```

Scilab code Exa 3.12 Density

```
//page 72
clc;funcprot(0);//EXAMPLE 3.12
// Initialisation of Variables
```

```
4 r1=0.066;.....//Radius of Mg+2 from Appendix B in
    nm
5 r2=0.132;.....//Radius of O-2 from Appendix B in
    nm
6 Am1=24.312;.....//Atomic masses of Mg+2 in g/mol
7 Am2=16;.....//Atomic masses of O-2 in g/mol
8 Na=6.02*10^23;.....// Avogadros number
9 //CALCULATIONS
10 a0=2*r1+2*r2;.....//Lattice constant for MgO
    in nm
11 rho=((4*Am1)+(4*16))/((a0*10^-8)*Na);.....//Density
    of MgO in g/cm^3
12 disp(a0*10^-8,"Lattice constant for MgO in cm:")
13 disp(rho,"Density of MgO in g/cm^3:")
14 //Answer given in the book is wrong
```

Scilab code Exa 3.13 packing factor

```
1 //page 75
2 clc;funcprot(0);//EXAMPLE 3.13
3 // Initialisation of Variables
4 r=1;.....//Radius of each atom in units
5 n=8;.....//No. of atoms present in Diamond cubic
      Silicon per cell
6 //CALCULATIONS
7 v=(4/3)*%pi*r^3;.....// Volume of each atom in
    Diamond cubic Silicon
8 a0=(8*r)/sqrt(3);.....//Volume of unit cell in
    Diamond cubic Silicon
9 Pf=(n*v)/a0^3;.....//Packing factor of
    Diamond cubic Silicon
10 disp(Pf,"Packing factor of Diamond cubic Silicon:"
    )
```

Chapter 4

Inperfections of ionic and atomic arrangements

Scilab code Exa 4.1 Effect of temperature

```
1 //page 87
2 clc;funcprot(0);//EXAMPLE 4.1
3 // Initialisation of Variables
4 Lp=0.36151;.....//The lattice parameter of FCC
    copper in nm
5 T1=298;.....//Temperature of copper in K
6 Qv=20000;.....//Heat required to produce a
    mole of vacancies in copper in cal
7 R=1.987;.....//The gas constant in cal/mol-K
8 //CALCULATIONS
9 n=4/(Lp*10^-8)^3;.....//The number of copper
    atoms or lattice points per cm^3 in atoms/cm^3
10 nv1=n*exp(-Qv/(T1*R));.....//concentration of
    vacancies in copper at 25 degree celsius in
    vacancies /cm^3
11 nv2=nv1*1000;.....//concentration of vacancies in
    copper atoms at T2 temperature
12 T2=-Qv/(R*log(nv2/n));.....//temperature at which
    this number of vacancies forms in copper in K
```

```
13 disp(round(T2-273),"Temperature at which this number
       of vacancies forms in copper in Degree celsius:"
   )
```

Scilab code Exa 4.2 Vacancy concentrations in iron

```
1 //page 88
2 clc;funcprot(0);//EXAMPLE 4.2
3 // Initialisation of Variables
4 n1=2;.....//No. of Atoms in BCC iron Crystal
5 m=55.847;.....//Atomic mass of BCC iron crystal
6 a0=2.866*10^-8;.....//The lattice parameter of BCC
     iron in cm
7 Na=6.02*10^23;.....//Avogadros number in atoms/
     mol
8 rho1=7.87;.....//Required density of iron BCC in
     g/cm^3
9 //CALCULATIONS
10 rho2=(n1*m)/(a0^3*Na);.....//The expected
     theoretical density of iron BCC
11 X=(rho1*a0^3*Na)/m;.....//Number of iron atoms
     and vacancies that would be present in each unit
     cell for the required density
12 n2=n1-X;.....// no. of vacacies per unit cell
13 V=n2/a0^3;.....//The number of vacancies per cm
     ^3
14 disp(rho2,"The expected theoretical density of iron
     BCC ")
15 disp(X,"Number of iron atoms that would be present
     in each unit cell for the required density:")
16 disp(V,"The number of vacancies per cm^3 :")
```

Scilab code Exa 4.3 sites for carbon in iron

```
1  //page 90
2  clc;funcprot(0);//EXAMPLE 4.3
3  // Initialisation of Variables
4  a01=0.2866;.....//The Lattice parameter of
     BCC in nm
5  a02=0.3571;.....//The Lattice parameter of
     FCC in nm
6  r=0.071;.....//Radius of carbon atom in nm
7  ni1=12;.....//No. of interstitial sites per
     unit   cell for BCC
8  ni2=4;.....//No. of interstitial sites per
     unit   cell for FCC
9  //CALCULATIONS
10 Rb=(sqrt(3)*a01)/4;.....//Radius of iron atom in
     nm
11 Ri1=sqrt(0.3125*a01^2)-Rb;.....// Interstitial
     Radius  of iron atom in nm
12 Rf=(sqrt(2)*a02)/4;.....//the radius of the iron
     atom in nm
13 Ri2=(a02-(2*Rf))/2;.....//the radius of
     the interstitial site in nm
14 %C1=(ni1/(ni1+2))*100;.....//The atomic
     percentage  of carbon contained in the BCC iron
     in percent
15 %C2=(ni2/(ni2+4))*100;.....//The atomic
     percentage  of carbon contained in the FCC iron
     in percent
16 disp(Rb,"Radius of iron atom in nm")
17 disp(Ri1,"Interstitial Radius  of iron atom in nm:")
18 disp(Rf,"the radius of the iron atom in nm:")
19 disp(Ri2,"the radius of the interstitial site in nm:
     ")
20 disp(%C1,"The atomic percentage  of carbon contained
      in  BCC  iron in percent:")
21 disp(%C2,"The atomic percentage  of carbon contained
      in  FCC  iron in percent:")
```

Scilab code Exa 4.4 Dislocations in ciramic

```
1 //page 96
2 clc;funcprot(0);//EXAMPLE 4.4
3 // Initialisation of Variable
4 a0=0.396;.....//Lattice parameter of magnesium
      oxide
5 h=1;.....//Because b is a [110] direction
6 k=1;.....//Because b is a [110] direction
7 l=0;.....//Because b is a [110] direction
8 //CALCULATIONS
9 b=a0/sqrt(2);.....//The length of Burgers
    vector in nm
10 disp(b,"The length of Burgers vector in nm:")
```

Scilab code Exa 4.5 Burgers vector calculations

```
1 //page 97
2 clc;funcprot(0);//EXAMPLE 4.5
3 // Initialisation of Variables
4 a01=0.36151;.....//The lattice parameter of copper
    in nm
5 //CALCULATIONS
6 F=sqrt(2)*a01;.....//Face Diagonal of copperin nm
7 b=(1/2)*(F);.....//The length of the Burgers
    vector, or the repeat distance in nm
8 disp(F,"Face Diagonal of copperin nm:")
9 disp(b,"The length of the Burgers vector in nm:")
```

Scilab code Exa 4.6 Slip planes

```
1 //page 98
2 clc;funcprot(0);//EXAMPLE 4.6
3 // Initialisation of Variables
4 n=2;........//No. of Atoms present per cell in BCC
5 a0=2.866*10^-8;.....//The lattice parameter of BCC
    iron in cm
6 rho1=0.994*10^15;.......//Planar density of (112)BCC
     in atoms/cm^2
7 //CALCULATIONS
8 a=sqrt(2)*a0^2;.........//Area of BCC iron in cm^2
9 rho2=n/a;........//Planar density of (110)BCC in
    atoms/cm^2
10 d1=a0*10^-9/(sqrt(1^2+1^2+0));......//The
    interplanar spacings for (110)BCC in cm
11 d2=a0*10^-9/(sqrt(1^2+1^2+2^2));......//The
    interplanar spacings for (112)BCC in cm
12 disp(rho2,"Planar density of (110)BCC in atoms/cm^2:
    ")
13 disp(d1,"The interplanar spacings for (110)BCC in cm
    :")
14 disp(d2,"The interplanar spacings for (112)BCC in cm
    :")
```

Scilab code Exa 4.9 ASTN grain size number

```
1 //page 105
2 clc;funcprot(0);//EXAMPLE 4.10
3 // Initialisation of Variables
4 g=16;.......// No. of grains per square inch in a
    photomicrograph
5 M=250;.........//Magnification in a photomicrograph
6 N=(M/g)*100;........//The number of grains per
    square   inch
```

```
7 n=(log10(100)/log10(2))+1;.....//the ASTM grain
    size number
8 disp(n,"the ASTM grain size number:")
```

Chapter 5

Atoms and Ion movents in materials

Scilab code Exa 5.2 Activation energy

```
1 clc;funcprot(0);//EXAMPLE 5.2
2 //page 119
3 // Initialisation of Variables
4 R1=5*10^8;.....//The rate of moement of
    interstitial atoms in jumps/s 500 degree celsius
5 R2=8*10^10;.....//The rate of moement of
    interstitial atoms in jumps/s 800 degree celsius
6 T1=500;.....//Temperature at first jump in
    Degree celsius
7 T2=800;.....//Temperature at second jump in
    Degree celsius
8 R=1.987;.....//Gas constant in cal/mol-K
9 //CALCULATIONS
10 Q=log(R2/R1)/(exp(1/(R*(T1+273)))-exp(1/(R*(T2+273))
    ));.....//Activation Energy for Interstitial
    Atoms in cal/mol
11 disp(Q,"Activation Energy for Interstitial Atoms in
    cal/mol:")
12 //answer in book is wrong
```

Scilab code Exa 5.3 doping

```
clc;funcprot(0);//EXAMPLE 5.3
//page 124
// Initialisation of Variables
X=0.1;.....//Thickness of SIlicon Wafer in cm
n=8;.....//No. of atoms in silicon per cell
ni=1;.....//No of phosphorous atoms present for
    every 10^7 Si atoms
ns=400;.....//No of phosphorous atoms present for
   every 10^7 Si atoms
ci1=(ni/10^7)*100;.....//Initial compositions
   in atomic percent
cs1=(ns/10^7)*100;.....//Surface compositions
   in atomic percent
G1=(ci1-cs1)/X;.....//concentration gradient in
   percent/cm
a0=1.6*10^-22;.....//The lattice parameter of
   silicon
v=(10^7/n)*a0;.....//volume of the unit cell in cm
   ^3
ci2=ni/v;.....//The compositions in atoms/cm^3
cs2=ns/v;.....//The compositions in atoms/cm^3
G2=(ci2-cs2)/X;.....//concentration gradient in
   percent/cm^3.cm
disp(G1,"concentration gradient in percent/cm:")
disp(G2,"concentration gradient in percent/cm^3.cm:"
   )
```

Scilab code Exa 5.4 design of iron membrane

```
clc;funcprot(0);//EXAMPLE 5.4
//page 129
// Initialisation of Variables
N=1;.....//N0. of atoms on one side of iron bar
H=1;.....//No. of atoms onother side of iron
   bar
d=3;.....//Diameter of an impermeable cylinder in
   cm
l=10;.....//Length of an impermeable cylinder in cm
A1=50*10^18*N;.....// No. of gaseous Atoms per
   cm^3 on one side
A2=50*10^18*H;.....//No. of gaseous Atom per cm
   ^3 on one  side
B1=1*10^18*N;.....//No. of gaseous atoms per
   cm^3 on another side
B2=1*10^18*H;.....//No. of gaseous atoms per cm
   ^3 on another side
t=973;.....//The di usion coefficient of
   nitrogen in BCC iron at 700 degree celsius in K
Q=18300;.....//The activation energy for
   di usion of Ceramic
Do=0.0047;.....//The pre-exponential term of
   ceramic
R=1.987;.....//Gas constant in cal/mol.K
//CALCULATIONS
T=A1*(%pi/4)*d^2*l;....//The total number of
   nitrogen atoms in the container in N atoms
LN=0.01*T/3600;.....//The maximum number of atoms
   to be lost per second in N atoms per Second
JN=LN/((%pi/4)*d^2);.....//The Flux of ceramic
   in Natoms per cm^2. sec.
Dn=Do*exp(-Q/(R*t));.....//The di usion
   coefficient of Ceramic in cm^2/Sec
deltaX=Dn*(A1-B1)/JN;.....//minimum thickness of
    the membrane in cm
LH=0.90*T/3600;.....//Hydrogen atom loss per sec.
JH=LH/((%pi/4)*d^2);.....//The Flux of ceramic
   in Hatoms per cm^2. sec.
```

```
24 Dh=Do*exp(-Q/(R*t));.....//The di usion
     coeficient of Ceramic in cm^2/Sec
25 deltaX2=((1.86*10^-4)*(A2-B2))/JH;.....//Minimum
     thickness of  the membrane in cm
26 disp(deltaX,"Minimum thickness of  the membrane of
     Natoms in cm")
27 disp(deltaX2,"Minimum thickness of  the membrane of
     Hatoms in cm")
```

Scilab code Exa 5.5 diffusion couple

```
1  clc;funcprot(0);//EXAMPLE 5.6
2  // Initialisation of Variables
3  n=2;.....//no of atoms/ cell in BCC Tungsten
4  a0=3.165;.....//The lattice parameter of BCC
     tungsten in Angstromes
5  W=n/(a0*10^-8)^3;.....//The number of tungsten
     atoms per cm^3
6  Cth=0.01*W;.....//The number of thorium atoms per
     cm^3
7  Cg=-Cth/0.01;.....//The concentration gradient of
     Tungsten in atoms/cm^3.cm
8  Q=120000;.....//The activation energy for
     diffusion of Tungsten
9  Q2=90000;.....//The activation energy for
     diffusion of Tungsten
10 Q3=66400;.....//The activation energy for
     diffusion of Tungsten
11 Do=1.0;.....//The pre-exponential term of Tungsten
12 Do2=0.74;.....//The pre-exponential term of
     Tungsten
13 Do3=0.47;.....//The pre-exponential term of
     Tungsten
14 R=1.987;.....//Gas constant in cal/mol.K
15 t=2273;.....//The diffusion coefficient of
```

```
    nitrogen in BCC iron at 2000 degree celsius in K
//CALCULATIONS
D1=Do*exp(-Q/(R*t));........//The diffusion
    coeficient  of Tungsten in cm^2/Sec
J1=-D1*Cg;............//Volume Diffusion in Th atoms
    /cm^2.sec.
D2=Do2*exp(-Q2/(R*t));........//The diffusion
    coeficient  of Tungsten in cm^2/Sec
J2=-D2*Cg;............//Grain boundary Diffusion in
    Th atoms/cm^2.sec.
D3=0.47*exp(-66400/(1.987*2273));........//The
    diffusion coeficient  of Tungsten in cm^2/Sec
J3=-D3*Cg;............//Surfae Diffusion in Th atoms
    /cm^2.sec.

disp(W,"The number of tungsten atoms per cm^3:")
disp(Cth,"The number of thorium atoms per cm^3:")
disp(Cg,"The concentration gradient of Tungsten in
    atoms/cm^3.cm:")
disp(D1,"The diffusion coeficient  of Tungsten in cm
    ^2/Sec:")
disp(J1,"Volume Diffusion in Th atoms/cm^2.sec.:")
disp(D2,"The diffusion coeficient  of Tungsten in cm
    ^2/Sec:")
disp(J2,"Grain boundry Diffusion in Th atoms/cm^2.
    sec.:")
disp(D3*10^7,"The Surface diffusion coeficient of
    Tungsten in cm^2/Sec:")
disp(J3,"Surface Diffusion in Th atoms/cm^2.sec.:")
```

Scilab code Exa 5.6 carburizing treatment

```
//Example 5.6
//page 155
clc
```

```
4 T=[1173 1273 1373 1473]
5 //in K
6
7 //for loop t
8
9 for i=1:1:4
10 t(i)=0.0861/exp(-16558/T(i))
11 end
12 disp(t,"The combination temp in second is")
```

Scilab code Exa 5.7 Economical heat treatment

```
1 //Example 5.6
2 //page 155
3 clc
4 T=[1173 1273 1373 1473]
5 //in K
6
7
8 //for loop t
9
10 for i=1:1:4
11 t(i)=0.0861/exp(-16558/T(i))
12 end
13 disp(t,"The combination temp in second is")
```

Scilab code Exa 5.8 Tensile testing

```
1 clc;funcprot(0);//EXAMPLE 5.8
2 // Initialisation of Variables
3 H=10;.....//Required time to successfully
    carburize a batch of 500 steel gears
```

```
t1=1173;.....//Temperature at carburizing a batch
   of   500 steel gears in K
t2=1273;.....//Temperature at carburizing a batch
   of   500 steel gears in K
Q=32900;.....//The activation energy for
   diffusion  of BCC steel
R=1.987;.....//Gas constant in cal/mol.K
c1=1000;.....//cost per hour to operate the
   carburizing furnace at 900degree centigrades
c2=1500;.....//Cost per hour to operate the
   carburizing furnace at 1000 degree centigrade
H2=(exp(-Q /(R*t1))*H*3600)/exp(-Q /(R*t2));.....
   // Time requried to  successfully carburize a
   batch of 500 steel gears at 1000 degree
   centigrade
Cp1=c1*H/500;.....//The cost per Part of steel
   rods  at 900 degree centigrade
Cv=(c2*3.299)/500;.....//The cost per Part of
   steel rods  at 1000 degree centigrade
disp(H2/3600,"Time requried to  successfully
   carburize a batch of 500 steel gears at 1000
   degree centigrade:")
disp(Cp1,"The cost of carburizing per Part of steel
   rods  at 900 degree centigrade")
disp(Cv,"The cost of carburizing per Part of steel
   rods  at 1000 degree centigrade")
```

Chapter 6

Mechanical properties

Scilab code Exa 6.1 Tensile testing

```
1 //page 152
2 clc
3 F=1000//in lb
4 Ao=(%pi/4)*(0.505)^2//in^2
5 rho=F/Ao
6 delta_I=0.001//in
7 I_o=2//in
8 e=delta_I/I_o
9 disp(rho,"The value in psi is=")
10 disp(e,"The value of epselon")
```

Scilab code Exa 6.2 suspension rod

```
1 clc;funcprot(0);//EXAMPLE 6.2
2 //page 152
3 // Initialisation of Variables
4 F=45000;.....//Force applied on an aluminum rod in
    lb
```

```
e=25000;.....//the maximum allowable stress on the
    rod in psi
l2=150;.....//the minimum length of the rod in in
e1=0.0025;.....//The strain appiled on rod
sigma=16670;.....//Stress applied on rod in psi
L=0.25;.....//The maximum allowable elastic
   deformation in in
//CALCULATIONS
Ao1=F/e;.....//The required crosssectional area
   of the rod
d=sqrt((Ao1*4)/%pi);.....//Diameter of rod in in
l1=e1*L;.....//The maximum length of the rod
   in in
e2=L/e1;.....//The minimum strain allowed on
   rod
Ao2=F/sigma;.....//The minimum cross-sectional
   area in in^2
disp(Ao1,"The required crosssectional area of the
   rod in in^2:")
disp(d,"Diameter of rod in in:")
disp(l1,"The maximum length of the rod in in:")
disp(e2,"The minimum strain allowed on rod:")
disp(Ao2,"The minimum cross-sectional area in in^2:"
   )
```

Scilab code Exa 6.3 Elasticity and strain

```
clc;funcprot(0);//EXAMPLE 6.3
// Initialisation of Variables
sigma1=35000;.....//Stress applied of aluminum
   alloy in psi from table 6-1
e1=0.0035;.....//Strain applied of aluminum alloy
    from table 6-1
sigma2=30000;.....//Stress applied of aluminum
   alloy  in psi
```

```
Lo=50;.....//initial length of  aluminum alloy
//CALCULATIONS
E=sigma1/e1;.....//Modulus of elasticity  of
   aluminum alloy
e2=sigma2/E;.....//Strain applied of aluminum
   alloy
L=Lo+(e2*Lo);.....//The length after deformation of
    bar in in
disp(E,"Modulus of elasticity  of aluminum alloy
   from table 6-1:")
disp(L,"The length after deformation of bar in in")
disp(e2,"Strain applied of aluminum alloy:")
```

Scilab code Exa 6.4 `Final length`

```
clc;funcprot(0);//EXAMPLE 6.4
// Initialisation of Variables
Lf=2.195;.....//Final length after failure
d1=0.505;.....//Diameter of alluminum alloy in in
d2=0.398;.....//Final diameter of alluminum alloy
   in in
Lo=2;.....//Initial length of alluminum alloy
//CALCULATIONS
A0=(%pi/4)*d1^2;.....//Area of original of
   alluminum alloy
Af=(%pi/4)*d2^2;.....//Area of final of alluminum
    alloy
%E=((Lf-Lo)/Lo)*100;.....//Percentage of Elongation
%R=((A0-Af)/A0)*100;.....//Percentage of Reduction
   in area
disp(%E,"Percentage of Elongation:")
disp(%R,"Percentage of Reduction in area:")
printf("The final length is less than 2.205 in
   because, after fracture, the elastic strain is
   recovered.")
```

Scilab code Exa 6.5 Stress and strain

```
clc;funcprot(0);//EXAMPLE 6.5
// Initialisation of Variables
F=8000;.....//Load applied for the aluminum alloy
    in lb
F2=7600;.....//Load applied for the aluminum alloy
    in lb at fracture
dt1=0.505;.....//diameter of for the aluminum
    alloy in in
dt2=0.497;.....//The diameter at maximum load
Lt=2.120;.....//Final length at maxium load
Lot=2;.....//Initial length of alluminum
    alloy
Ff=7600;.....//Load applied for the aluminum
    alloy after fracture in lb
df=0.398;.....//The diameter at maximum load after
     fracture
Lf=0.205;.....//Final length at fracture
//CALCULATIONS
Es=F/((%pi/4)*dt1^2);.....//Engineering stress in
    psiAt the tensile or maximum load
Ts=F/((%pi/4)*dt2^2);.....//True stress in psi At
    the tensile or maximum load
Ee=(Lt-Lot)/Lot;.....//Engineering strain At the
    tensile or maximum load
Te=log(Lt/Lot);.....//True strain At the tensile
    or maximum load
Es2=F2/((%pi/4)*dt1^2);.....//Engineering stress At
     fracture:
Ts2=F2/((%pi/4)*df^2);.....//True stress At
    fracture:
Ee2=Lf/Lot;.....//Engineering strain At
    fracture:
```

```
20 Te2=log(((%pi/4)*dt1^2)/((%pi/4)*df^2));.....//
   True strain At fracture:
21 disp(Es,"Engineering stress in psiAt the tensile or
   maximum load")
22 disp(Ts,"True stress in psi At the tensile or
   maximum load")
23 disp(Ee,"Engineering strain At the tensile or
   maximum load")
24 disp(Te,"True strain At the tensile or maximum load"
   )
25 disp(Es2,"Engineering stress At fracture:")
26 disp(Ts2,"True stress At fracture")
27 disp(Ee2,"Engineering strain At fracture:")
28 disp(Te2,"True strain At fracture:")
```

Scilab code Exa 6.6 Deflection

```
1 clc;funcprot(0);//EXAMPLE 6.6
2 // Initialisation of Variables
3 Fs=45000;.....//The flexural strength of a
   composite material in psi
4 Fm=18*10^6;.....//The flexural modulus of
   composite material in psi
5 w=0.5;.....//wide of sample in in
6 h=0.375;.....//Height of sample in in
7 l=5;.....//Length of sample in in
8 //CALCULATIONS
9 F=Fs*2*w*h^2/(3*l);.....//The force required to
   fracture the material in lb
10 delta=(l^3)*F/(Fm*4*w*h^3);.....//The deflection
   of the sample at fracture
11 disp(F,"The force required to fracture the material
   in lb:")
12 disp(delta,"The deflection of the sample at
   fracture in in")
```

Chapter 7

Fracture mechanics fatigue and creep behaviour

Scilab code Exa 7.1 Design of a nondestructive test

```
1 clc;funcprot(0);//EXAMPLE 7.1
2 //page 181
3 // Initialisation of Variables
4 f=1.12;.....//Geometry factor for the specimen and
      flaw
5 sigma=45000;.....//Applied stress on Steel in psi
6 K=80000;.....//The stress intensity factor
7 //CALCULATIONS
8 a=(K/(f*sigma))^2/%pi;.....//Depth of crank in in
9 disp(a,"Depth of crank that will propagate in the
     steel in in:")
```

Scilab code Exa 7.2 properties of siAion ceramics

```
1 clc;funcprot(0);//EXAMPLE 7.2
2 //page 183
```

```
3 // Initialisation of Variables
4 T=60000;.....//Tensile strength Of Sialon (
    acronym  for silicon aluminum oxynitride) in psi
5 sigma=500;.....//The stress at which the part
    unexpectedly fails in psi
6 a=0.01;.....//Depth of thin crack in in
7 //CALCULATIONS
8 r=a/(T/(2*sigma))^2;.....//The radius of the crack
    tip  in in
9 disp(r*2.54*10^8,"The radius of the crack tip in
    Angstroms")
```

Scilab code Exa 7.3 Design of ceramic support

```
1 clc;funcprot(0);//EXAMPLE 7.3
2 //page 184
3 // Initialisation of Variables
4 F=40000;.....// Maximum Tensile load in lb
5 K=9000;.....//Fracture toughness of Ceramic
6 w=3;.....// plate made of Sialon width
7 //CALCULATIONS
8 A=F*sqrt(%pi)/K;.....//Area of ceramic
9 T=A/w;.....// Thickness of Ceramic
10 disp(T,"THickness of ceramic :")
```

Scilab code Exa 7.8 Strength of ceramic

```
1 clc;funcprot(0);//EXAMPLE 7.8
2 //page 193
3 // Initialisation of Variables
4 m=9;.....//Weibull modulus of an ceramic
5 sigma1=250;.....//The flexural strength in MPa
6 F1=0.4;.....//probability of failure
```

```
7 F2=0.1;.....//Expected the probability of failure
8 //CALCULATIONS
9 sigma2=exp(log(sigma1)-(log(log(1/(1-F1)))/m ))
    ;.....// The characteristic strength of the
    ceramic
10 sigma3=exp((log(log(1/(1-F2)))/m)+log(sigma2))
    ;.....//Expected level of stress that can be
    supported in MPa
11 disp(sigma2,"The characteristic strength of the
    ceramic in MPa:")
12 disp(sigma3,"Expected level of stress that can be
    supported in MPa:")
```

Scilab code Exa 7.9 parameter determination

```
1 //page 195
2 clc;funcprot(0);//EXAMPLE 7.9
3 // Initialisation of Variables
4 Ln1=0.5
5 Ln2=-2.0
6
7 sigma1=52;.....//the maximum allowed stress level
    on ceramic at one point in MP.
8 sigma2=23.5;.....//the maximum allowed stress
    level on ceramic at another point in MP.
9 //CALCULATIONS
10 m=(Ln1-Ln2)/(log(sigma1)-log(sigma2));.....//
    Weibull modulus of ceramic
11 disp(m,"Weibull modulus of ceramic:")
```

Scilab code Exa 7.11 Design of rotating shaft

```
1 clc;funcprot(0);//EXAMPLE 7.11
```

```
2 //page 199
3 // Initialisation of Variables
4 N=5.256*10^5;.....//No. of cycles that the shaft
     will  experience in one year
5 F=12500;.....//applied load  on shaft in lb
6 L=96;.....//Length of Kliin produced from tool
     steel in in.
7 sigma1=72000;.....//the applied stress on
     Shaft
8 f=2;.....//Factor of saftey of shaft
9 sigma2=sigma1/f;.....//the maximum allowed stress
     level
10 //CALCULATIONS
11 d1=(16*F*L/(sigma1*%pi))^(1/3);.....//The
     Diameter of Shaft in in.
12 d2=(16*F*L/(sigma2*%pi))^(1/3);.....//The minimum
     diameter required to prevent failure
13 disp(d1,"The Diameter of Shaft in in.:")
14 disp(d2,"The minimum diameter required to prevent
     failure in in.:")
```

Chapter 8

Strain hardening and annealing

Scilab code Exa 8.1 Cold working a copper plate

```
1 clc;funcprot(0);//EXAMPLE 8.1
2 //page 221
3 // Initialisation of Variables
4 t0=1;.......//Thickness of Copper plate in cm
5 tf=0.50;.....//Cold reducetion of coopper in cm in
     step1
6 tf2=0.16;.....// Further Cold reduction of cooper in
     cm in step2
7 //CALCULATIONS
8 %CW1=((t0-tf)/t0)*100;......//Amount of Cold work
     accomplished in step1
9 %CW2=((tf-tf2)/tf)*100;.....//Amount of Cold work
     accomplished in step2
10 %CW=((t0-tf2)/t0)*100;.......//Actual Total Cold
     work in percent
11 disp(%CW1,"Amount of Cold work accomplished in step1
     :")
12 disp(%CW2,"Amount of Cold work accomplished in step2
     :")
13 disp(%CW,"Actual Total Cold work in percent:")
```

Scilab code Exa 8.2 Cold working process

```
clc;funcprot(0);//EXAMPLE 8.2
//page 222
// Initialisation of Variables
tf=0.1;.....//Thickness of cooper to produce in cm
%CW1=40;.....//cold work to produce a tensile
   strengthof 65,000 psi
%CW2=45;.....//cold work to produce a tensile
   strengthof 60,000 psi
//CALCULATIONS
Tmax=(tf/(1-(%CW1/100)));.....//Maximum
   thicknessproduced in step1 in cm
Tmin=(tf/(1-(%CW2/100)));.....//Minimum
   thicknessproduced in step2 in cm
disp(Tmax,"Maximum thicknessproduced  in cm:")
disp(Tmin,"Minimum thicknessproduced  in cm:")
```

Scilab code Exa 8.5 Wire drawing process

```
//EXAMPLE 8.5
//page 228
clc;
// Initialisation of Variables
D0=0.40;.....// Lets assume that the starting
   diameter of the copper wire in in.
Df=0.20;.....// Diameter of the copper wire to be
    produced in in.
sigma1=22000;.....//Yeidl strength at 0% cold
   work
//CALCULATIONS
```

```
CW=((D0^2-Df^2)/D0^2)*100;.....//The fianal Cold
    Work in percent
F=sigma1*(%pi/4)*D0^2;.....//The draw force
   required to deform the initial wire in lb
sigma2=F/((%pi/4)*Df^2);.....// The stress acting on
    the wire after passing through the die in psi
disp(CW,"The fianal Cold Work in percent:")
disp(F,"The draw force required to deform the
   initial wire in lb:")
disp(sigma2,"The stress acting on the wire after
   passing through the die in psi:")
```

Scilab code Exa 8.6 Process to produce copper strip

```
clc;funcprot(0);//EXAMPLE 8.6
//page 235
// Initialisation of Variables
t0=5;.....//Assming we are able to purchase only
   5-cm thick stock
t02=1;.....//Thickness of strip in cm
tf=0.182;.....//Final thickness of strip in cm
%CW2=80;.....//cold work  of a strip in percent
M=1085;.....// The melting point of copper in
   degree celsius
//CALCULATIONS
%CW=((t0-tf)/t0)*100;.....//Cold work between from
    5 to 0.182 cm in percent
tf2=(1-(%CW2/100))*t0;.....// Final Thickness of
   strip in cm
Tr=0.4*(M+273);...// Recrystallization temperature
   By using 0.4Tm relationship in degree celsius
%CW3=((t02-tf)/t02)*100;.....//Cold work of the
   strip of 1 cm thickness
disp(%CW,"Cold work between from 5 to 0.182 cm in
   percent:")
```

```
15 disp(tf2,"1. Final Thickness of strip in cm")
16 disp(Tr-273,"2. Recrystallization temperature By
      using 0.4Tm relationship in degree celsius:")
17 disp(%CW3,"3. Cold work of the strip of 1 cm
      thickness :")
```

Scilab code Exa 8.7 Process to produce copper strip

```
1 clc;funcprot(0);//EXAMPLE 8.7
2 //page 237
3 // Initialisation of Variables
4 t0=5;.........//We are able to purchase strip of 5cm
      thickness in cm
5 tf=0.182;.....//Thickness to be produced in cm
6 tf2=0.167;.......//Thickness to procedure in cm
7 //CALCULATIONS
8 %HW=((t0-tf)/t0)*100;.....//Hot work for a strip
      from 5cm to 0.182 cm in percent
9 %HW2=((t0-tf2)/t0)*100;......//Hot work for a strip
      from 5cm to 0.167 cm in percent
10 disp(%HW,"Hot work for a strip from 5cm to 0.182 cm
      in percent:")
11 disp(%HW2,"Hot work for a strip from 5cm to 0.167 cm
      in percent")
```

Chapter 9

Principles and applications of solidification

Scilab code Exa 9.1 Critical radius

```
1 clc;funcprot(0);//EXAMPLE 9.1
2 //page 250
3 // Initialisation of Variables
4 deltaT=236;.....//Typical Undercooling for
    HomogeneousNucleation from the table 9-1 for
    cooper
5 Tm=1358;.....//Freezing Temperature from the table
    9-1 for cooper in degree celsius
6 deltaH=1628;.....// Latent Heat of Fusion from the
    table 9-1 for cooper in J/cm^3
7 sigma1=177*10^-7;.....//Solid-Liquid Interfacial
    Energyfrom the table 9-1 for cooper in J/cm^2
8 a0=3.615*10^-8;.....//The lattice parameter for FCC
    copper in cm
9 //CALCULATIONS
10 r=(2*sigma1*Tm)/(deltaH*deltaT);.....//Critical
    Radius of copper in cm
11 V=a0^3;....//Volume of FCC unit cell of copper in cm
    ^3
```

```
12 V2=(4/3)*%pi*r^3;....//Critical volume of FCC copper
13 N=V2/V;......//The number of unit cells in the
      critical nucleus
14 Nc=4*round(N);......//Since there are four atoms in
      each unit cell of FCC metals
15 disp(r*10^8,"Critical Radius of copper in cm:")
16 disp(V,"Volume of FCC unit cell of copper in cm^3:")
17 disp(V2,"Critical volume of FCC copper :")
18 disp(round(N),"The number of unit cells in the
      critical nucleus :")
19 disp(Nc,"Since there are four atoms in each unit
      cell of FCC metals:")
```

Scilab code Exa 9.2 Casting for improved strength

```
1 clc;funcprot(0);//EXAMPLE 9.2
2 //page 255
3 // Initialisation of Variables
4 d=18;//Diameter of the casting in in
5 x=2;//Thickness  of the casting in in
6 B=22//Mold constant of casting
7 V=(%pi/4)*d^2;//Volume of the casting in in^3
8 A=2*(%pi/4)*d^2+%pi*d*x;//The surface area of the
      casting in contact with the mold
9 x=(0.708*A)/V
10 disp(x,"The thickness in inches=")
```

Chapter 10

Solid solutions and phase equilibrium

Scilab code Exa 10.6 `Gibbs rule`

```
1 clc;funcprot(0)//EXAMPLE 10.6
2 //page 293
3 //INITIALISATION OF VARIABLES
4 c1=2;.....//NO. of independent Chemical
    components at 1300 celsius
5 p1=1;.....//No. of phases at 1300 celsius
6 c2=2;.....//NO. of independent Chemical components
     at 1250 celsius
7 p2=2;.....//No. of phases at 1250 celsius
8 c3=2;.....//NO. of independent Chemical
    components at 1200 celsius
9 p3=1;.....//No. of phases at 1200 celsius
10 //CALCULATIONS
11 f1=1+c1-p1;.....//Degrees of freedom of both
    Copper and NIckel at 1300 celsius
12 f2=1+c2-p2;.....//Degrees of freedom of both
    Copper and NIckel at 1250 celsius
13 f3=1+c3-p3;.....//Degrees of freedom of both
    Copper and NIckel at 1200 celsius
```

```
14 disp(f1,"Degrees of freedom of both Copper and
     NIckel at 1300 celsius ")
15 disp(f2,"Degrees of freedom of both Copper and
     NIckel at 1250 celsius ")
16 disp(f3,"Degrees of freedom of both Copper and
     NIckel at 1200 celsius ")
```

Scilab code Exa 10.8 Application of lever rule

```
1 clc;funcprot(0);//EXAMPLE 10.8
2 //page 295
3 // Initialisation of Variables
4 %Nia=40;.....//no, of grams of nickel in alloy at
     alla temperature
5 %NiL=32;.....//Mass of Nickel present in Liquid
6 %Nialpha=45;.....//Mass of NIckel present in alpha
7 //CALCULATIONS
8 x=(%Nia-%NiL)/(%Nialpha-%NiL);.....//Mass fraction
     of alloy in percent
9 disp(x,"Mass fraction of alloy in percent:")
10 printf("By converting 62percent alpha and 38percent
     Liquid are present.:")
```

Scilab code Exa 10.9 Alloy

```
1 clc;funcprot(0);//EXAMPLE 10.9
2 //page 296
3 // Initialisation of Variables
4 %NiL=37;.....// percentage of NI the Liquid
     contains at 1270 degree celsius
5 %NiS=50;.....//percentage of NI the Solid
     contains at 1270 degree celsius
```

```
%NiL2=32;........//percentage of NI the
   Liquidcontains at 1250 degree celsius
%NiS2=45;........//percentage of NI the Solid
   contains at 1250 degree celsius
%NiS3=40;........//percentage of NI the Solid
   contains at 1200 degree celsius
%NiL3=40;.......//percentage of NI the Liquid
   contains at 1300 degree celsius
//CALCULATIONS
%L=((%NiS-%NiL3)/(%NiS-%NiL))*100;......//Percentage
    of Liquid at 1270 degree celsius
%S=((%NiS3-%NiL)/(%NiS-%NiL))*100;.......//
   Percentage of Solid qt 1270 degree celsius
%L2=((%NiS2-%NiL3)/(%NiS2-%NiL2))*100;....//
   Percentage of Liquid at 1250 degree celsius
%S2=((%NiS3-%NiL2)/(%NiS2-%NiL2))*100;....//
   Percentage of Solid qt 1250 degree celsius
printf("At 1300 degree celsius only one phase so 100
    percent Liquid")
disp(round(%L),"Percentage of Liquid at 1270 degree
   celsius :")
disp(round(%S),"Percentage of Solid qt 1270 degree
   celsius:")
disp(round(%L2),"Percentage of Liquid at 1250 degree
    celsius :")
disp(round(%S2),"Percentage of Solid at 1250 degree
   celsius:")
printf("At 1200 degree celsius only one phase so 100
    percent Solid ")
```

Chapter 11

Dispersion strengthening and electric phase diagrams

Scilab code Exa 11.2 Phases in lead

```
1 clc;funcprot(0);//EXAMPLE 11.2
2 //page 319
3 // Initialisation of Variables
4 %Sn=2;.....//Amount of Tin Dissolved in alpha solid
     solution
5 %Sn2=10;.....//Amount of Tin Dissolved in alpha+
    beeta   solid solution at 0 degree celsius
6 m=100;.....//Total mass of the Pb-Sn alloy in gm
7 Pbm=90;.....//Total mass of the Pb in Pb-Sn alloy
    in gm
8 //CALCULATIONS
9 B=((%Sn2-%Sn)/(m-%Sn))*100;.....//The amount of
    beeta Sn  that forms if a Pb-10% Sn alloy is
    cooled to 0 Degree celsius
10 B2=100-B;.....//The amount of alpha Sn that forms
    if a Pb-10% Sn alloy is cooled to 0 Degree
    celsius
11 Sn1=(%Sn/100)*(B2);.....//The mass of Sn in the
    alpha phase in g
```

```
12 Sn2=%Sn2-Sn1;.....//The mass of Sn in beeta phase in
       g
13 Pb1=B2-Sn1;....//The mass of Pb in the alpha phase
      in g
14 Pb2=Pbm-Pb1;.........//The mass of Pb in the beeta
      phase in g
15 disp(B,"c.Amount of beeta forms of Pb-Sn in gm:")
16 disp(Sn1,"d.The mass of Sn in the alpha phase in g:"
      )
17 disp(Sn2,"d.The mass of Sn in beeta phase in g:")
18 disp(Pb1,"e.The mass of Pb in the alpha phase in g:"
      )
19 disp(Pb2,"e.The mass of Pb in the beeta phase in g:"
      )
```

Scilab code Exa 11.3 alloy

```
1 clc;funcprot(0);//EXAMPLE 11.3
2 //page 321
3 // Initialisation of Variables
4 M=200;........//Mass of alpha phase of alloy in gm
5 %Sn=61.9;......//Percentage of the Sn in the
      eutectic alloy in percent
6 %Pb=19;.......//Percentage of the Pb in the alpha
      phase in percent
7 %Pb2=97.5;.....//Percentage of the Sn in the beeta
      phase in percent
8 //CALCULLATIONS
9 W1=(%Pb2-%Sn)/(%Pb2-%Pb);.....//Weight fraction of
      alpha phase
10 W2=(%Sn-%Pb)/(%Pb2-%Pb);.......//Weight fraction of
      beeta phase
11 Ma=M*W1;......//The mass of the alpha phase in 200g
      in g
12 Mb=M-Ma;......//The amount of the beeta phase in g
```

```
    at  182 degree celsius
13 MPb1=Ma*(1-(%Pb/100));.......//Mass of Pb in the
    alpha phase in g
14 MSn1=Ma-MPb1;......//Mass of Sn in alpha phase
15 MPb2=Mb*(1-(%Pb2/100));.....//Mass of Pb in beeta
    phase
16 MSn2=123.8-MSn1;.....//mass of Sn in beeta Phase
17 disp(W1,"Weight fraction of alpha phase")
18 disp(W2,"Weight fraction of beeta phase")
19 disp(Ma,"The mass of the alpha phase in 200g in g:")
20 disp(Mb,"The amount of the beeta phase in g at  182
    degree celsius:")
21 disp(MPb1,"Mass of Pb in the alpha phase in g:")
22 disp(MSn1,"Mass of Sn in alpha phase")
23 disp(MPb2,"Mass of Pb in beeta phase:")
24 disp(MSn2,"mass of Sn in beeta Phase:")
```

Scilab code Exa 11.5 Microconstituent amount

```
1 clc;funcprot(0);//EXAMPLE 11.3
2 //page 325
3 // Initialisation of Variables
4 %Sn=61.9;......//Percentage of the Sn in the
    eutectic alloy in percent
5 %Pb=19;.......//Percentage of the Pb in the alpha
    phase in percent
6 %Sn2=30;....//Percentage of the Sn in the eutectic
    alloy in percent
7 //CALCULATIONS
8 %Pa=(%Sn-%Sn2)/(%Sn-%Pb);......//The amount of
    compositions of primary alpha in Pb-Sn
9 %L=(%Sn2-%Pb)/(%Sn-%Pb);......//The amount of
    composition of eutectic in Pb-Sn
10 disp(round(%Pa*100),"The amount of compositions of
    primary alpha in Pb-Sn:")
```

```
11 disp(round(%L*100),"The amount of composition of
      eutectic in Pb-Sn:")
```

Scilab code Exa 11.6 Wiping solder

```
1 //Example 11.6
2 //page 330
3 clc
4 per_L_200=((40-18)/(55-18))*100
5 Per_L_210=((40-17)/(50-17))*100
6 disp(per_L_200,"L200 in percentage")
7 disp(Per_L_210,"L210 in percentage")
8 //answer variation is due to round off
```

Chapter 12

Dispersion strengthening by phase transformations and heat treatment

Scilab code Exa 12.1 Activation energy

```
1 clc;funcprot(0);//EXAMPLE 12.1
2 //page 347
3 // Initialisation of Variables
4 r1=0.111;.....//Rate of copper in min^-1 at 135
    degree celsius
5 r2=0.004;.....//Rate of copper in min^-1 at 88
    degree celsius
6 T1=408;.....//Temperature in K
7 T2=361;.....//Temperature in K
8 R=1.987;.....//Gas constant
9 Q=20693;.....//Change in Rates
10 slope=(log(r1)-log(r2))/((1/T1)-(1/T2));....//Slope
    of the straight line ploted ln(Growth rate) as a
    function of 1=T,
11 A=r1/(exp(-Q/(R*T1)));.....//Constant
12 disp(A,"Constant A=")
13 disp(slope,"Slpoe of the straight line -Q/R")
```

Scilab code Exa 12.3 Phases and composition od pearlite

```
clc;funcprot(0);//EXAMPLE 12.5
//page 357
// Initialisation of Variables
%Fe=6.67;.....//Carbon percentage in Cementite
%G=0.77;.....//Carbon percentage in peralite in
    composition
%A=0.0218;.....//Carbon percentage in Ferrite
//CALCULATIONS
%ferrite=((%Fe-%G)/(%Fe-%A))*100;.....//Amount of
    ferrite present in peralite
%C=((%G-%A)/(%Fe-%A))*100;.....//Amount of
    Cementite present in peralite
disp(%ferrite,"Amount of ferrite present in peralite
    :")
disp(%C,"Amount of Cementite present in peralite:")
```

Scilab code Exa 12.7 Phases in hypoeutectiod plain carbon steel

```
clc;funcprot(0);//EXAMPLE 12.7
//page 359
// Initialisation of Variables
%A=0.0218;.....//Carbon percentage in primary
    alpha in percent
%Fe=6.67;.....//Carbon percentage in Cementite in
    percent
%G=0.77;.....//Carbon percentage in eutectoid
    composition at 727 degree celsius
%C=0.60;...//Carbon percentage in Pearlite in
    percent
```

```
8 //CALCULATIONS
9 %alpha=((%Fe-%C)/(%Fe-%A))*100;.......// Composition
      of Phase Ferrite in alloy
10 %Ce=((%C-%A)/(%Fe-%A))*100;.......//Composition of
     Cementite in percent in alloy
11 %PF=((%G-%C)/(%G-%A))*100;......//Percentage of
     microconstituents Primary Ferrite in alloy
12 %P=((%C-%A)/(%G-%A))*100;.......//Percentage of
     microconstituents Pearlite in alloy
13 disp(%alpha,"Composition of Phase Ferrite in alloy :
     ")
14 disp(%Ce,"Composition of Cementite in percent in
     alloy:")
15 disp(%PF,"Percentage of microconstituents Primary
     Ferrite in alloy:")
16 disp(%P,"Percentage of microconstituents Pearlite in
      alloy:")
```

Scilab code Exa 12.8 Heat treatment

```
1 clc;funcprot(0);//EXAMPLE 12.8
2 //page 364
3 // Initialisation of Variables
4 d=0.001;........//Actual distence between one alpha
     plate to next alpha plate
5 S=14;.........//Spacings between between one alpha
     plate to next alpha plate
6 //CALCULATIONS
7 lamida=d/S;......//The interlamellar spacing between
      one alpha plate to next alpha plate in Pearlite
     Microstructure
8 disp(lamida,"The interlamellar spacing between one
     alpha plate to next alpha plate in Pearlite
     Microstructure:")
```

Scilab code Exa 12.10 Heat treatment in dual phase steel

```
1 clc;funcprot(0);//EXAMPLE 12.10
2 //page 366
3 // Initialisation of Variables
4 %M=0.60;.......//Percentage of Carbon in Martensite
    at 750 degree celsius
5 %a=50;......//Percentage of Carbon in Austenite at
    750 degree celsius
6 %c=0.02;......//Percentage of Carbon atoms in Steel
7 X=(%a/100)*(%M-%c)+%c;......//The carbon content of
    Steel in percentage
8 disp(X,"The carbon content of hypoeutectoid Steel
    in percentage:")
```

Chapter 13

Heat Treatment of steels and cast irons

Scilab code Exa 13.1 AISI number

```
clc;funcprot(0);//EXAMPLE 13.1
//page 380
// Initialisation of Variables
%Fe=6.67;.....//Carbon percentage in Cementite by
   weight
%G=0.77;.....//Carbon percentage in eutectoid
   composition in steel by weight
%A=0.0218;.....//Carbon percentage in Ferrite
%Fe3C=16;....//Percentage of alpha ferrite in steel
%P=95;.....//Percentage of Pearlite in Steel
//CALCULATIONS
X1=((%Fe3C/100)*(%Fe-%A))+%A;.....//Carbon content
   present in Steel
X2=%Fe-((%P/100)*(%Fe-%G));.....//Carbon content
   present in Steel
disp(X1,"Carbon content present in Steel:")
disp(X2,"Carbon content present in Steel:")
printf("The carbon content is on the order of 1.065
   to 1.086 percent, consistent with a 10110 steel")
```

Scilab code Exa 13.3 Heat treating temperatures

```
1 //page 385
2 clc
3 primary_alpha=((0.77-.5)/(0.77-0.0218))*100
4 pearlite=((0.5-0.0218)/(0.77-0.0218))*100
5 disp(primary_alpha,"primary alpha in percentage =")
6 disp(pearlite,"pearlite in percentage =")
7 //Answer difference is due to roundoff
```

Chapter 14

Nonferrous alloys

Scilab code Exa 14.1 Strength to weight ratio

```
clc;funcprot(0);//EXAMPLE 14.1
//page 427
// Initialisation of Variables
d1=0.5;.....//Diameter of a steel Cable in in.
rhoy=70000;.....//Yield Strength of Steel Cable
    in psi
rhoa1=36000;.....//Yield Strength of Aluminum in
    psi
rhos=0.284;.....//Density of Steel in lb/in^3
rhoa2=0.097;.....//Density of Aluminum in lb/in
    ^3
//CALCULATIONS
F=rhoy*((%pi/4)*(d1^2));.....//Load applied on
    Aluminum in lb
d2=sqrt((F/rhoa1)*(4/(%pi)));.....//Diameter of
    Aluminum in in.
Ws=(%pi/4)*(d1^2)*12*rhos;.....//Weight of
    Steel  in lb/ft
Wa=(%pi/4)*(d2^2)*12*rhoa2;.....//Weight of
          Aluminum in lb/ft
disp(F,"a. Load applied on Aluminum in lb:")
```

```
15 disp(d2,"b. Diameter of Aluminum in in.: ")
16 disp(Ws,"c.  Weight of Steel  in lb/ft:")
17 disp(Wa,"Weight of Aluminum in lb/ft:")
```

Chapter 15

Ceramic materials

Scilab code Exa 15.1 silicon carbide ceramic

```
1 clc;funcprot(0);//EXAMPLE 15.1
2 //page 459
3 // Initialisation of Variables
4 rho=3.2;.....//Specific Gravity of SiC in g/
    cm^2
5 Ww=385;.....//Weight of Ceramic when dry in
    g
6 Wd=360;.....//Weight of Ceramic after
    Soaking in water in g
7 Ws=224;.....//Weight of Ceramic Suspended in
       water in g
8 //CALCULATIONS
9 A=((Ww-Wd)/(Ww-Ws))*100;.....//Apparent
    Porosity in percent
10 B=(Wd)/(Ww-Ws);.....//Bulk Density of Ceramic
11 T=((rho-B)/rho)*100;.....//True Porosity of
    Ceramic  in Percent
12 C=T-A;.....//Closed pore percent of ceramic
13 F=C/T;.....//Fraction Closed Pores of
    Ceramic
14 disp(A,"Apparent Porosity in percent:")
```

```
15 disp(B,"Bulk Density of Ceramic:")
16 disp(T,"True Porosity of Ceramic  in Percent:")
17 disp(F,"Fraction Closed Pores of Ceramic:")
```

Scilab code Exa 15.2 Design of glass

```
1  clc;funcprot(0);//EXAMPLE 15.2
2  //page 462
3  // Initialisation of Variables
4  R=2.5;.....//Ratio of O to Si in SiO2
5  W1=69.62;.....//Weight of B2O3 in g/ml
6  W2=60.08;.....//Weight of SiO2 in g/ml
7  //CALCULATIONS
8  Fb1=(R-2)/3.5;.....//Mole Fraction of B2O3
9  Fb2=1-Fb1;.....//Mole fraction of SiO2
10 Wp=((Fb1*W1)/((Fb1*W1)+(Fb2*W2)))*100;.....//
     Weight Percent of B2O3
11 disp(Fb1,"Mole Fraction of B2O3:")
12 disp(Wp,"Weight Percent of B2O3:")
```

Chapter 16

Polymers

Scilab code Exa 16.2 calculation of initiator required

```
1 clc;funcprot(0);//EXAMPLE 16.2
2 //page 482
3 // Initialisation of Variables
4 W=28;..............//Molecular weight of Ethylene
    in g/mol
5 W1=200000;..........//Molecular weight of Benzoyl
    Peroxide in g/mol
6 W2=1000;...........//Weight of Polyethylene in gm
7 W3=242;............//Molecular Weight of Benzoyl
    Peroxide in g/mol
8 //Calculations
9 DP=W1/W;............// Degree of Polymerization
10 n=(W2*6.02*10^23)/W;............//No. of Monomers
    present
11 M=n/DP;.....................//NO. of Benzoyl
    Peroxide Molecules to be present
12 Ai=(M*W3)/6.02*10^23;..........//Amount of
    Initiator needed in gm
13 disp(DP,"Degree of Polymerization :")
14 disp(n,"No. of Monomers present :")
15 disp(M,"NO. of Benzoyl Peroxide Molecules to be
```

```
    present:")
16 disp(Ai,"Amount of Initiator needed in gm:")
```

Scilab code Exa 16.3 polymerization

```
1  clc;funcprot(0);//EXAMPLE 16.3
2  //page 484
3  // Initialisation of Variables
4  W1=116;.....//Molecular Weight of
       Hexamethylene Diamine in g/mol
5  W2=146;.....//Molecular Weight of Adipic
       Acid in g/mol
6  W3=18;.....//Molecular Weight of Water
       in g/mol
7  W=1000;.....//Weight of Hexamethylene
       Diamine in gm
8  //Calculations
9  N=W/W1;.....//No. of Moles of
       Hexamethylene Diamine
10 X=N*W2;.....//Weight of Adipic Acid
       required
11 Y=N*W3;.....//Weight of Water in gm
12 N2=W+X-2*Y;.....//Amount of Nylon Produced
13 disp(N2,"Amount of Nylon Produced:")
```

Scilab code Exa 16.4 Degree of polymerization

```
1  clc;funcprot(0);//EXAMPLE 16.4
2  //page 486
3  // Initialisation of Variables
4  W1=116;.....//Molecular Weight of
       Hexamethylene Diamine in g/mol
```

```
5 W2=146;.....//Molecular Weight of Adipic
    Acid in g/mol
6 W3=18;.....//Molecular Weight of Water
    in g/mol
7 W4=120000;.....//Molecular Weight of 6,6-
    nylon in g/mol
8 //alculations
9 M=W1+W2-2*W3;.....//Molecular Weight of the
    repeated unit
10 DOP=W4/M;.....//Degree of Polymerization
    of 6,6-nylon
11 disp(DOP,"Degree of Polymerization of 6,6-nylon:")
```

Scilab code Exa 16.7 Impact resistant polethylene

```
1 clc;funcprot(0);//EXAMPLE 16.7
2 //page 499
3 // Initialisation of Variables
4 M=56;.....//Molecular Weight of Polyethylene
5 P=0.88;.....//Measured density of
    PolyethyleneInitial
6 P1=0.915;.....//Measured density of Polyethylene
      Final
7 Pa=0.87;.....//Density of Amorphous Polyethylene
8 //Caluculations
9 Pc=M/(7.42*4.95*(2.55*10^-24)*6.02*10^23)
    ;.....//Density of complete Crystalline
    polymer
10 Cp1= ((Pc/P)*((P-Pa)/(Pc-Pa)))
    *100;.....//Crystallinity of
    Polyethylene initial
11 Cp2= ((Pc/P1)*((P1-Pa)/(Pc-Pa)))
    *100;.....//Crystallinity of
    Polyethylene final
12 disp(Pc,"Density of Crystalline polymer:")
```

```
13 disp(Cp1,"Crystall. of Polyethylene initial:")
14 disp(Cp2,"Crystall. of Polyethylene final:")
```

Scilab code Exa 16.9 Design of initial stress in polymer

```
1  clc;funcprot(0);//EXAMPLE 16.7
2  //page 500
3  //INITIALISATION OF VAREIABLES
4  sig1=980;..............//Initial Stress of
       POlyisoprene in psi
5  sig2=1000;.............//Fnal Stress of POlyisoprene
       in psi
6  sig3=1500;.............// Stress of POlyisoprene
       after one year in psi
7  t1=6;.................//time in weeks
8  t2=52;.............//time in weeks
9  //CALCULATIONS
10 Rt=-t1/(log(sig1/sig2));.....//Relaxation time in
       weeks
11 sig=sig3/(%e^(-t2/Rt));........//Initial Stress to
       be placed in psi
12 disp(round(Rt),"Relaxation time in weeks:")
13 disp(round (sig),"Initial Stress to be placed in psi
       :")
```

Chapter 17

Composites Teamwork and synergy in materials

Scilab code Exa 17.1 TD nickel composite

```
clc;funcprot(0);//EXAMPLE 17.1
//page 527
// Initialisation of Variables
per1=2;.....//Percent weight of ThO2
per2=98;.....//Percentage weight of Nickle
rho1=9.69;.....//Density of ThO2 in g/cm^3
rho2=8.9;.....//Density of Nickel in g/cm^3
r=0.5*10^-5;.....//Radius of ThO2 particle in cm
//calculations
f=(2/rho1)/((per1/rho1)+(per2/rho2));.....//
   Volume fraction of ThO2 per cm^3 of composite
v=(4/3)*(%pi)*r^3;.....//Volume of ech ThO2
   sphere in cm^3
c=f/v;.....//Concentration of ThO2
   particles in particles/cm^3
disp(c,"Concentration of ThO2 in particles/cm^3:")
```

Scilab code Exa 17.2 Comented carbides

```
clc;funcprot(0);//EXAMPLE 17.2
//page 528
// Initialisation of Variables
per1=75;.............//Percent Weight of WC
per2=15;.............//Percent Weight of TiC
per3=5;..............//Percent Weight of TaC
per4=5;..............//Percent Weight of Co
rho1=15.77;..........//Density of WC in g/cm^3
rho2=4.94;...........//Density of TiC in g/cm^3
rho3=14.5;...........//Density of TaC in g/cm^3
rho4=8.90;...........//Density of Co in g/cm^3
//Calculations
f1=(per1/rho1)/((per1/rho1)+(per2/rho2)+(per3/rho3)
   +(per4/rho4));.....//Volume fraction of WC
f2=(per2/rho2)/((per1/rho1)+(per2/rho2)+(per3/rho3)
   +(per4/rho4));.....//Volume fraction of Tic
f3=(per3/rho3)/((per1/rho1)+(per2/rho2)+(per3/rho3)
   +(per4/rho4));.....//Volume fraction of Tac
f4=(per4/rho4)/((per1/rho1)+(per2/rho2)+(per3/rho3)
   +(per4/rho4));.....//Volume fraction of Co
rho=(f1*rho1)+(f2*rho2)+(f3*rho3)+(f4*rho4);.......
   //Density of composite in g/cm^3
disp(rho,"Density of composite in g/cm^3:")
```

Scilab code Exa 17.3 Silver tungsten composite

```
clc;funcprot(0);//EXAMPLE 17.3
//page 530
// Initialisation of Variables
rho1=19.3;..........//Density of pure Tungsten in g
   /cm^3
rho2=10.49;..........//Density of pure Silver in g
   /cm^3
```

```
f1=0.75;.............//Volume fraction of Tungsten
f2=0.25;...........//Volume fraction of Silver and
    pores
//Calculations
per=((f2*rho2)/((f2*rho2)+(f1*rho1)))*100;........
    //Percentage weight of silver
disp(per,"Percentage Weight of Silver:")
```

Scilab code Exa 17.4 Mixture

```
clc;funcprot(0);//EXAMPLE 17.4
//page 531
// Initialisation of Variables
rho1=0.95;..........//Density of polyethylene in g/
    cm^3
rho2=2.4;...........//Density of clay in g/cm^3
f1=0.65;.............//Volume fraction of
    Polyethylene
f2=0.35;.............//Volume fraction of Clay
f3=1.67;............//Volume fraction of
    polyethylene after sacrifice
f4=1.06;............//Volume fraction of Clay after
     sacrifice
pa1=650;...........// No. of parts of polyethylene
    in 1000cm^3 composite  in cm^3
pa2=350;...........// No. of parts of clay in 1000
    cm^3 composite  in cm^3
//Calculations
pa3=(pa1*rho1)/454;.........//No. of parts of
    Polyethylene in 1000cm^3 composite  in lb
pa4=(pa2*rho2)/454;.........//No. of parts of clay
    in 1000cm^3 composite  in lb
co1=pa3* 0.05;.............//Cost of material
    Polyethylenein Dollars
co2=pa4* 0.05;.............//Cost of materials
```

```
    clay in Dollars
17 c0=co1+co2;.....//Cost of materials in
    Dollars
18 rho3=(f1*rho1)+(f2*rho2);.....//Composite
    density in g/cm^3
19 co3=f3* 0.05;.....//Cost of material
    polyethylene after savings in Dollars
20 co4=f4* 0.05;.....//Cost of material clay
    after savings in Dollars
21 c1=co3+co4;.....//Cost of materials
    after savings in Dollars
22 rho4=(0.8*rho1)+(0.2*rho2);.....//Density
    of composite after saving in g/cm^3
23 disp(rho3,"Composite density in g/cm^3:")
24 disp(rho4,"Composite densityafter saving in g/cm^3:"
    )
```

Scilab code Exa 17.7 Boron Alumunium composite

```
1 clc;funcprot(0);//EXAMPLE 17.7
2 // Initialisation of Variables
3 //page 536
4 f1=0.4;.....//Volume fraction of Fiber
5 f2=0.6;.....//Volume fraction of Aluminium
6 rho1=2.36;.....//Density of Fibers in g/cm^3
7 rho2=2.70;.....//Density of Aluminium in g/cm
    ^3
8 psi1=55*10^6;.....//Modulus of elasticity
    of Fiber in psi
9 psi2=10*10^6;.....//Modulus of elasticity
    of Aluminium in psi
10 ts1=400000;.....//Tensile strength of fiber
    in psi
11 ts2=5000;.....//Tensile strength of
    Aluminium in psi
```

```
12 //Calculations
13 rho=(f1*rho1)+(f2*rho2);.....//Density of mixture
       in g/cm^3
14 Ec1=(f1*psi1)+(f2*psi2);.....//Modulus of
       elasticity of mixture in psi
15 TSc=(f1*ts1)+(f2*ts2);.....//Tensile Strength of
       mixture in psi
16 Ec2=1/((f1/psi1)+(f2/psi2));.....//Modulus of
       elasticity  perpendicular to fibers in psi
17 disp(rho,"Density of mixture in g/cm^3:")
18 disp(Ec1,"Modulus of elasticity of mixture in psi:")
19 disp(TSc,"Tensile Strength of mixture in psi:")
20 disp(Ec2,"Modulus of elasticity  perpendicular to
       fibers in psi:")
```

Scilab code Exa 17.8 Nylon glass fiber

```
1 clc;funcprot(0);//EXAMPLE 17.8
2 //page 534
3 // Initialisation of Variables
4 psi1=10.5*10^6;.....//Modulus of elasticity
       of Glass in psi
5 psi2=0.4*10^6;.....//Modulus of elasticity
       of Nylon in psi
6 a1=0.3;.....//area of glass in cm^3
7 a2=0.7;.....//area of Nylon in cm^3
8 //Calculations
9 psi=psi1/psi2;.....//Fraction of elasticity
10 fo=a1/(a1+(a2*(1/psi)));.....//Fraction of
       applied force carried by Glass fiber
11 disp(fo,"Fraction of applied force carried by Glass
       fiber :")
12 printf("      Almost all of the load is carried by
       the glass fibers.")
```

Scilab code Exa 17.9 Design od composite

```
clc;funcprot(0);//EXAMPLE 17.9
//page 542
// Initialisation of Variables
psi=10*10^6;.............//Modulus of elasticity of
    7075-T6 in psi
psi1=55*10^6;.............//Modulus of elasticity
   of Boron fiber in psi
psi2=11*10^6;.............//Modulus of elasticity
   of Typical AL-LI in psi
f1=0.6;..............//Volume fraction of Boron
   Fiber
f2=0.4;..............//Volume fraction of typical
   AL-LI
rho1=0.085;..........//Density of  Boron Fibers in
   lb/in*3
rho2=0.09;..........//Density of typical AL-LI in
   lb/in^3
//Calculations
sm1=psi/(((2.7*(2.54)^3))/454);.........//Specific
   Modulus of current alloy in in.
rho=(f1*rho1)+(f2*rho2);........//Density of
   composite in lb/in^3
Ec=(f1*psi1)+(f2*psi2);........//Modulus of
   elasticity of mixture in psi
sm2=Ec/rho;..........//Specific Modulus of composite
    in in.
disp(sm1,"Specific Modulus of current alloy in in.:"
   )
disp(rho,"Density of composite in lb/in^3:")
disp(Ec,"Modulus of elasticity of mixture in psi:")
disp(sm2,"Specific Modulus of composite in in.:")
```

Scilab code Exa 17.10 Design of composite strut

```
1  clc;funcprot(0);//EXAMPLE 17.10
2  //page 554
3  // Initialisation of Variables
4  psi=500000;.....//Modulus Elasticity of
       Epoxyin psi
5  f=500;.....//Force applied on Epoxy
       in pounds
6  q=0.10;.....//Stretchable distence in
        in.
7  rho=0.0451;.....//Density of Epoxy in
       lb/in^3
8  d=1.24;.....//Diameter of Epoxy in in
9  e=12000;.....//Yeild Strngth of Epoxy
        in psi
10 E2=77*10^6;.....//Modulus of high Carbon
       Fiber in psi
11 Fc=0.817;.....//Volume fraction of
       Epoxy remaining
12 Fc2=0.183;.....//Min volume Faction of
       Epoxy
13 rho2=0.0686;.....//Density of high Carbon
       Fiber in lb/in^3
14 emax=q/120;.....//MAX. Strain of Epoxy
15 E=psi*emax;.....//Max Modulus of
       elasticity in psi
16 A=f/E;.....//Area of Structure in in
       ^2
17 W=rho*%pi*((d/2)^2)*120;.....//Weight of
       Structure in ib
18 c=W*0.80;.....//Cost of
       Structure in Dollars
19 Ec=e/emax;.....//Minimum Elasticity of
```

```
    composite in psi
20 A2=f/e;.....//Area of Epoxy in in^2
21 At=A2/Fc;.....//Total Volume of Epoxy
22 V=At*120;.....//Volume of Structure in in
    ^3
23 W2=((rho2*Fc2)+(rho*Fc))*V;.....//Weight of
    Structure in lb
24 Wf=(Fc2*1.9)/((Fc2*1.9)+(Fc*1.25));.....//
    Weight Fraction of Carbon
25 Wc=Wf*W2;.....//Weight of Carbon
26 We=0.746*W2;.....//Weight of Epoxy
27 c2=(Wc*30)+(We*0.80);.....//Cost of Each
    Struct.
28  disp(c2,"Cost of Each Struct.:")
```