Scilab Textbook Companion for Mechanical Metallurgy by G. E. Dieter[1]

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May 18, 2015

[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: Mechanical Metallurgy

Author: G. E. Dieter

Publisher: Tata McGraw-Hill

Edition: 3

Year: 2013

ISBN: 9781259064791

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 1

Introduction

Scilab code Exa 1.1 Shear Stress

```
//Example 1.1
//Shear Stress
//Page No. 16
clc;clear;close;

y_b=2;          //in J/m^2
G=75;          //in Gpa
G=G*10^9;          //conversion to Pa
L=0.01;              //in mm
L=L*10^-3;          //conversion to m
nu=0.3;          //no unit
T=sqrt((3*%pi*y_b*G)/(8*(1-nu)*L));
T=T/10^6;
printf('Shear Stress Required to nucleate a grain
   boundary crack in high temperature deformation =
   %g MPa',T)
```

Chapter 2

Stress and Strain Relationships for Elastic Behavior

Scilab code Exa 2.1 State of Stress in two dimensions

```
//Example 2.1
//State of Stress in two dimensions
//Page No. 25
clc;clear;close;

sigma_x=25;             //no unit
sigma_y=5;               //no unit
theta=45;                //in degrees
sigma_x_=50;             //in Mpa
T_x_y_=5;               //in Mpa
A=[(sigma_x+sigma_y)/2+(sigma_x-sigma_y)/2*cosd(2*
    theta),sind(2*theta);(sigma_y-sigma_x)/2*sind(2*
    theta),cosd(2*theta)];
B=[sigma_x_;T_x_y_];
X=inv(A)*B;
p=X(1);
T_xy=X(2);
sigma_x1=sigma_x*p;
sigma_y1=sigma_y*p;
```

```
sigma_y_=sigma_x1+sigma_y1-sigma_x_;
printf('\nsigma_x= %g MPa\nsigma_y= %g MPa\nT_xy= %g MPa\nsigma_y`= %g MPa',sigma_x1,sigma_y1,T_xy,sigma_y_);
```

Scilab code Exa 2.2 State of Stress in three dimensions

```
//Example 2.2
//State of Stress in three dimensions
//Page No. 29
clc;clear;close;

s=poly(0,'s')
A=[s-0,-240,0;-240,s-200,0;0,0,s+280];          //in Mpa
p=determ(A);
X=roots(p);
for i=1:3
    printf('\nsigma%i = %g MPa',i,X(i));
end
printf('\n\nLogic: The matrix provided in the book is a state of stress of a body which includes a combination of normal and shear stresses acting in a triaxial direction. So the determinant of the matrix results in the cubic equation in ""sigma"" which when solved gives the principal stresses');
```

Scilab code Exa 2.3 Calculation of Stresses from elastic strains

```
//Example 2.3
//Calculation of Stresses from elastic strains
//Page No. 52
```

```
clc;clear;close;

E=200;                    //in GPa
nu=0.33;                  //no unit
e1=0.004;                 //no unit
e2=0.001;                 //no unit
sigma1=E*(e1+nu*e2)/(1-nu^2);
sigma2=E*(e2+nu*e1)/(1-nu^2);
sigma1=sigma1*1000;       //conversion to MPa
sigma2=sigma2*1000;       //conversion to MPa
printf('\nsigma1 = %g MPa\nsigma2 = %g MPa\n',sigma1
   ,sigma2);
printf('\nNote: Slight calculation errors in Book')
```

Scilab code Exa 2.4 Elastic Anisotropy

```
//Example 2.4
//Elastic Anisotropy
//Page No. 60
clc;clear;close;

S11_Fe=0.8;               //in 1/Pa
S12_Fe=-0.28;             //in 1/Pa
S44_Fe=0.86;              //in 1/Pa
S11_W=0.26;               //in 1/Pa
S12_W=-0.07;              //in 1/Pa
S44_W=0.66;               //in 1/Pa
D_100_l=1;
D_100_m=0;
D_100_n=0;
D_110_l=1/sqrt(2);
D_110_m=1/sqrt(2);
D_110_n=0;
D_111_l=1/sqrt(3);
D_111_m=1/sqrt(3);
```

```
D_111_n=1/sqrt(3);

printf('\nFor Iron:\n\n');
Fe_E_111=1/(S11_Fe-2*((S11_Fe-S12_Fe)-S44_Fe/2)*(D_111_l^2*D_111_m^2+D_111_n^2*D_111_m^2+D_111_l^2*D_111_n^2));
Fe_E_100=1/(S11_Fe-2*((S11_Fe-S12_Fe)-S44_Fe/2)*(D_100_l^2*D_100_m^2+D_100_n^2*D_100_m^2+D_100_l^2*D_100_n^2));
printf('E_111 = %g x 10^11 Pa\nE_100 = %g x 10^11 Pa\n',Fe_E_111,Fe_E_100);
printf('\n\n\nFor Tungten:\n\n');
W_E_111=1/(S11_W-2*((S11_W-S12_W)-S44_W/2)*(D_111_l^2*D_111_m^2+D_111_n^2*D_111_m^2+D_111_l^2*D_111_n^2));
W_E_100=1/(S11_W-2*((S11_W-S12_W)-S44_W/2)*(D_100_l^2*D_100_m^2+D_100_n^2*D_100_m^2+D_100_l^2*D_100_n^2));
printf('E_111 = %g x 10^11 Pa\nE_100 = %g x 10^11 Pa\n\nTherefore tungsten is elastically isotropic while iron is elasitcally anisotropic',W_E_111,W_E_100);
```

Chapter 3

Elements of the Theory of Plasticity

Scilab code Exa 3.1 True Stress and True Strain

```
//Example 3.1
//True Stress and True Strain
//Page No. 76
clc;clear;close;

D_i=0.505;                //in inches
L=2;                  //in inches
P_max=20000;            //in lb
P_f=16000;               //in lb
D_f=0.425;               //in inches
E_St= P_max*4/(%pi*D_i^2);
T_fr_St= P_f*4/(%pi*D_f^2);
e_f=log(D_i^2/D_f^2);
e=exp(e_f)-1;
printf('\nEngineering Stress at maximum load = %g
   psi\nTrue Fracture Stress = %g psi\nTrue Strain
   at fracture = %g\nEngineering strain at fracture
   = %g',E_St,T_fr_St,e_f,e);
```

Scilab code Exa 3.2 Yielding Criteria for Ductile Metals

```
//Example 3.2
//Yielding Criteria for Ductile Metals
//Page No. 78
clc;clear;close;

sigma00=500;            //in MPa
sigma_z=-50;            //in MPa
sigma_y=100;            //in MPa
sigma_x=200;            //in MPa
T_xy=30;            //in MPa
T_yz=0;            //in MPa
T_xz=0;            //in MPa
sigma0=sqrt((sigma_x-sigma_y)^2+(sigma_y-sigma_z)^2+(sigma_z-sigma_x)^2+6*(T_xy^2+T_yz^2+T_xz^2))/sqrt(2);
s=sigma00/sigma0;
printf('\nSince the calculated value of sigma0 = %g MPa, which is less than the yield strength of the aluminium alloy\nThus safety factor is = %g',sigma0,s);
```

Scilab code Exa 3.3 Tresca Criterion

```
//Example 3.3
//Tresca Criterion
//Page No. 81
clc;clear;close;

sigma00=500;            //in MPa
sigma_z=-50;            //in MPa
```

```
sigma_y=100;              //in MPa
sigma_x=200;              //in MPa
T_xy=30;              //in MPa
T_yz=0;              //in MPa
T_xz=0;              //in MPa
sigma0=sigma_x-sigma_z;
s=sigma00/sigma0;
printf('\nSince the calculated value of sigma0 = %g
   MPa, which is less than the yield strength of the
    aluminium alloy\nThus safety factor is = %g',
   sigma0,s);
```

Scilab code Exa 3.4 Levy Mises Equation

```
//Example 3.4
//Levy-Mises Equation
//Page No. 91
clc;clear;close;

r_t=20;          //no unit
p=1000;          //in psi
sigma1=p*r_t;
sigma1=sigma1/1000;                          //conversion
    to ksi
sigma=sqrt(3)*sigma1/2;
e=(sigma/25)^(1/0.25);
e1=sqrt(3)*e/2;
printf('\nPlastic Strain = %g',e1);
```

Chapter 4

Plastic Deformation of Single Crystals

Scilab code Exa 4.1 Critical Resolved Shear Stress for Slip

```
//Example 4.1
//Critical Resolved Shear Stress for Slip
//Page No. 125
clc;clear;close;

a=[1,-1,0];                    //no unit
n=[1,-1,-1];                    //no unit
s=[0,-1,-1];                    //no unit
Tr=6;                        //in MPa
cos_fi=sum(a.*n)/(sqrt(a(1)^2+a(2)^2+a(3)^2)*sqrt(n
   (1)^2+n(2)^2+n(3)^2));
cos_lm=sum(a.*s)/(sqrt(a(1)^2+a(2)^2+a(3)^2)*sqrt(s
   (1)^2+s(2)^2+s(3)^2));
sigma=Tr/(cos_fi*cos_lm);
printf('Tensile Stress applied = %g MPa',sigma);
```

Chapter 5

Dislocation Theory

Scilab code Exa 5.1 Forces Between Dislocations

```
//Example 5.1
//Forces Between Dislocations
//Page No. 166
clc;clear;close;

G=40;                   //in GPa
G=G*10^9;               //conversion to N/m^2
b=2.5;                  //in angstrong
b=b*10^-10;               //conversion to m
r=1200;                   //in angstrong
r=r*10^-10;               //conversion to m
l=0.04;                    //in mm
l=l*10^-3;                 //conversion to m
F=G*b^2/(2*%pi*r);
Ft=F*l;
printf('The Total force on the dislocation is = %g N
    ',Ft);
```

Chapter 6

Strengthening Mechanisms

Scilab code Exa 6.1 Grain Size Measurement

```
//Example 6.1
//Grain Size Measurement
//Page No. 193
clc;clear;close;

sigma_i=150;                    //in MN/m^2
k=0.7;                          //in MN/m^(3/2)
n=6;
N_x=2^(n-1);
N=N_x/(0.01)^2;                  //in grains/in^2
N=N*10^6/25.4^2;                  // in grains/m^2
D=sqrt(1/N);
sigma0=sigma_i+k/D^(1/2);
printf('\nYield Stress = %g MPa',sigma0);
```

Scilab code Exa 6.2 Strengthing Mechanism

```
//Example 6.2
```

```
//Strengthing Mechanism
//Page No. 219
clc;clear;close;

sigma0=600;              //in MPa
G=27.6;                  //in GPa
G=G*10^9              //conversion to Pa
b=2.5*10^-8;                  //in cm
b=b*10^-2;               //conversion to m
T0=sigma0/2;
T0=T0*10^6;                //conversion to Pa
lambda=G*b/T0;
Cu_max=54;                //in %
Cu_eq=4;                  //in %
Cu_min=0.5;                //in %
rho_al=2.7;                //in g/cm^3
rho_theta=4.43;              //in g/cm^3
wt_a=(Cu_max-Cu_eq)/(Cu_max-Cu_min);
wt_theta=(Cu_eq-Cu_min)/(Cu_max-Cu_min);
V_a=wt_a/rho_al;
V_theta=wt_theta/rho_theta;
f=V_theta/(V_a+V_theta);
r=(3*f*lambda)/(4*(1-f));
printf('\nParticle Spacing = %g m\nParticle Size =
   %g m',lambda,r);
```

Scilab code Exa 6.3 Fiber Strengthing

```
//Example 6.3
//Fiber Strengthing
//Page No. 222
clc;clear;close;

Ef=380;             //in GPa
Em=60;                //in GPa
```

```
//Case 1
f_f=0.1;              //no unit
Ec=Ef*f_f+(1-f_f)*Em;
printf('\nEc for 10 vol%% = %g GPa\n',Ec);
//Case 2
f_f=0.6;                 //no unit
Ec=Ef*f_f+(1-f_f)*Em;
printf('\nEc for 60 vol%% = %g GPa\n',Ec);
```

Scilab code Exa 6.4 Load Transfer

```
//Example 6.4
//Load Transfer
//Page No. 225
clc;clear;close;

sigma_fu=5;                                   //in GPa
sigma_fu=sigma_fu*10^9;             //Conversion to Pa
sigma_m=100;                             //in MPa
sigma_m=sigma_m*10^6;             //Conversion to Pa
T0=80;                                     //in MPa
T0=T0*10^6;                               //Conversion to Pa
f_f=0.5;                                   //no unit
d=100;                                       //in um
d=d*10^-6;                         //conversion to m
B=0.5;                             //no unit
L=10;                                //in cm
L=L*10^-2;                           //conversion to m
Lc=sigma_fu*d/(2*T0);
sigma_cu=sigma_fu*f_f*(1-Lc/(2*L))+sigma_m*(1-f_f);
sigma_cu=sigma_cu*10^-9;
printf('\nsigma_cu = %g GPa for L=100um\n',sigma_cu)
   ;;

L=2;                           //in mm
```

```
L=L*10^-3;              //conversion to m
sigma_cu=sigma_fu*f_f*(1-Lc/(2*L))+sigma_m*(1-f_f);
sigma_cu=sigma_cu*10^-9;
printf('sigma_cu = %g GPa for L=2mm',sigma_cu);;
```

Chapter 7

Fracture

Scilab code Exa 7.1 Cohesive Strength

```
//Example 7.1
//Cohesive Strength
//Page No. 245
clc;clear;close;

E=95;                    //in GPa
E=E*10^9;                  //conversion to Pa
Ys=1000;                    //erg/cm^2
Ys=Ys*10^-3;                        //conversion to J/m^2
a0=1.6;                   //in angstrom
a0=a0*10^-10;                          //conversion to m
sigma_max=(E*Ys/a0)^(1/2)
sigma_max=sigma_max*10^-9;
printf('Cohesive strength of a silica fiber = %g GPa
    ',sigma_max);
```

Scilab code Exa 7.2 Fracture Stress

```
//Example 7.2
//Fracture Stress
//Page No. 246
clc;clear;close;

E=100;                          //in GPa
E=E*10^9;                     //conversion to Pa
Ys=1;                         //J/m^2
a0=2.5*10^-10;                   //in m
c=10^4*a0;
sigma_f=(E*Ys/(4*c))^(1/2);
sigma_f=sigma_f*10^-6;
printf('Fracture Stress = %g MPa',sigma_f);
```

Chapter 8

The Tension Test

Scilab code Exa 8.1 Standard properties of the material

```
//Example 8.1
//Standard properties of the material
//Page No. 281
clc;clear;close;

D=0.505;              //in inches
Lo=2;                   //in inches
Lf=2.53;              //in inches
Py=15000;            //in lb
Pmax=18500;           //in lb
Pf=16200;            //in lb
D_f=0.315;            //in inches
A0=%pi*D^2/4;
Af=%pi*D_f^2/4;
s_u=Pmax/A0;
s0=Py/A0;
s_f=Pf/A0;
e_f=(Lf-Lo)/Lo;
q=(A0-Af)/A0;
printf('\nUltimate Tensile Strength = %g psi\n0.2
   percent offset yield strength = %g psi\nBreaking
```

```
Stress = %g psi\nElongation = %g percent\nReduction of Area = %g percent\n\n\nNote: Slight Computational Errors in book',s_u,s0,s_f,e_f*100,q*100);
```

Scilab code Exa 8.2 True Strain

```
//Example 8.2
//True Strain
//Page No. 288
clc;clear;close;

//case 1
Af=100;                    //in mm^2
Lf=60;                     //in mm
A0=150;                    //in mm^2
L0=40;                     //in mm
ef1=log(Lf/L0);
ef2=log(A0/Af);
printf('\nTrue Strain to fracture using changes in length = %g\nTrue Strain to fracture using changes in area = %g',ef1,ef2);

//Case 2
Lf=83;                      //in mm
L0=40;                     //in mm
Df=8;                        //in mm
D0=12.8;                      //in mm
ef1=log(Lf/L0);
ef2=2*log(D0/Df);
printf('\n\n\nFor More ductile metals\nTrue Strain to fracture using changes in length = %g\nTrue Strain to fracture using changes in diameter = %g',ef1,ef2);
```

Scilab code Exa 8.3 Ultimate Tensile Strength

```
//Example 8.3
//Ultimate Tensile Strength
//Page No. 290
clc;clear;close;

deff('y=sigma(e)','y=200000*e^0.33');
E_u=0.33;                //no unit
sigma_u=sigma(E_u);
s_u=sigma_u/exp(E_u);
printf('Ultimate Tensile Strength = %g psi',s_u);
```

Scilab code Exa 8.4 Effect of Strain Rate

```
//Example 8.4
//Effect of Strain Rate
//Page No. 298
clc;clear;close;

C_70=10.2;               //in ksi
C_825=2.1;                //in ksi
m_70=0.066;               //no unit
m_825=0.211;                //no unit
e1=1;                //no unit
e2=100;                //no unit
printf('\nAt 70deg F\n');
sigma_a=C_70*e1^m_70;
sigma_b=C_70*e2^m_70;

printf('sigma_a = %g ksi\nsigma_b = %g ksi\nsigma_b/
   sigma_a = %g\n',sigma_a,sigma_b,sigma_b/sigma_a);
```

```
printf('\n\nAt 825deg F\n');
sigma_a=C_825*e1^m_825;
sigma_b=C_825*e2^m_825;
printf('sigma_a = %g ksi\nsigma_b = %g ksi\nsigma_b/sigma_a = %g\n',sigma_a,sigma_b,sigma_b/sigma_a);
```

Chapter 11

Fracture Mechanics

Scilab code Exa 11.1 Fracture Toughness

```
//Example 11.1
//Fracture Toughness
//Page No. 354
clc;clear;close;

a=5;                    //in mm
a=a*10^-3;              //conversion to m
t=1.27;             //in cm
t=t*10^-2;          //conversion to m
K_Ic=24;            //in MPa*m^(1/2)
sigma=K_Ic/(sqrt(%pi*a)*sqrt(sec(%pi*a/(2*t))));
printf('Since Fracture Toughness of the material is
    = %g MPa\n and the applied stress is 172 MPa thus
     the flaw will propagate as a brittle fracture',
    sigma);
```

Scilab code Exa 11.2 Fracture Toughness

```
//Example 11.2
//Fracture Toughness
//Page No. 354
clc;clear;close;

K_Ic=57;                //in MPam^(1/2)
sigma0=900;              //in MPa
sigma=360;               //in MPa
Q=2.35;                   //no unit
a_c=K_Ic^2*Q/(1.21*%pi*sigma^2);
a_c=a_c*1000;                              //cpnversion
    to mm
printf('\nCritical Crack depth = %g mm\nwhich is
    greater than the thickness of the vessel wall, 12
   mm',a_c);
```

Scilab code Exa 11.3 Plasticity

```
//Example 11.3
//Plasticity
//Page No. 361
clc;clear;close;

a=10;                          //in mm
a=a*10^-3;                     //conversion to m
sigma=400;                      //in MPa
sigma0=1500;                    //in MPa
rp=sigma^2*a/(2*%pi*sigma0^2);
rp=rp*1000;                              //conversion to mm
K=sigma*sqrt(%pi*a);
K_eff=sigma*sqrt(%pi*a)*sqrt(a+%pi*rp);
printf('\nPlastic zone size = %g mm\nStress
    Intensity Factor = %g MPa m^(1/2)\n\n\nNote:
    Calculation Errors in book',rp,K_eff);
```

Chapter 12

Fatigue of Metals

Scilab code Exa 12.1 Mean Stress

```
//Example 12.1
//Mean Stress
//Page No. 387
clc;clear;close;

sigma_u=158;                 // in ksi
sigma0=147;                 // in ksi
sigma_e=75;                 // in ksi
l_max=75;                 // in ksi
l_min=-25;                 // in ksi
sf=2.5;                 //no unit
sigma_m=(l_max+l_min)/2;
sigma_a=(l_max-l_min)/2;
sigma_e=sigma_e/sf;
A=sigma_a/sigma_e+sigma_m/sigma_u;
D=sqrt(4*A/%pi);
printf('\nBar Diameter = %g in',D);
```

Scilab code Exa 12.2 Low Cycle Fatigue

```
//Example 12.2
//Low Cycle Fatigue
//Page No. 391
clc;clear;close;

sigma_b=75;                    //in MPa
e_b=0.000645;                   //no unit
e_f=0.3;                        //no unit
E=22*10^4;                      //in MPa
c=-0.6;                         //no unit
d_e_e=2*sigma_b/E;
d_e_p=2*e_b-d_e_e;
N=(d_e_p/(2*e_f))^(1/c)/2;
printf('\nd_e_e = %g\nd_e_p = %g\nNumber of Cycles =
    %g cycles',d_e_e,d_e_p,N);
```

Scilab code Exa 12.3 Fatigue Crack Proportion

```
//Example 12.3
//Fatigue Crack Proportion
//Page No. 401
clc;clear;close;

ai=0.5;                        //in mm
ai=ai*10^-3;                //conversion to m
sigma_max=180;                  //in MPa
Kc=100;                        //MPam^(1/2)
alpha=1.12;                     //no unit
p=3;                            //no unit
A=6.9*10^-12;                   //in MPam^(1/2)
af=(Kc/(sigma_max*alpha))^2/%pi;
Nf=(af^(1-(p/2))-ai^(1-(p/2)))/((1-p/2)*A*sigma_max
   ^3*%pi^(p/2)*alpha^p);
printf('Fatigue Cycles = %g cycles',Nf);
```

Scilab code Exa 12.4 Stress Concentration of Fatigue

```
//Example 12.4
//Stress Concentration of Fatigue
//Page No. 404
clc;clear;close;

rho=0.0004;              //no unit
S_u=190;              //in ksi
S_u=S_u*1000;             //conversion to psi
M=200;                //in inches-lb
Pm=5000;              //in lb
D=0.5;                  //in inches
dh=0.05;                 //in inches
r=dh/2;
Kt=2.2;                 //no unit
Kf=1+(Kt-1)/(1+sqrt(rho/r));
q=(Kf-1)/(Kt-1);
A=%pi/4*D^2;
sigma_m=Pm/A;
I=%pi/64*D^4;
sigma_a=Kf*((M*D)/(2*I));
sigma_max=sigma_a+sigma_m;
sigma_min=sigma_a-sigma_m;
sigma_e=S_u/2;
sigma_a1=sigma_e/Kf*(1-sigma_m/S_u);
printf('\nMean Stress = %g psi\nFluctuating Bending
    Stress = %g psi\nEffective Maximum Stress = %g
    psi\nEffective Minimum Stress = %g psi\nsigma_a =
    %g psi\n\n\nNote: Calculation Errors in the book
    ',sigma_m,sigma_a,sigma_max,sigma_min,sigma_a1);
```

Scilab code Exa 12.5 Infinite Life Design

```
//Example 12.5
//Infinite Life Design
//Page No. 422
clc;clear;close;

Kt=1.68;                     //no unit
q=0.9;                       //no unit
sigma_ed=42000;               //in psi
Cs=0.9;                       //no unit
Cf=0.75;                     //no unit
Cz=0.81;                      //no unit
Kf=q*(Kt-1)+1;
sigma_e=sigma_ed*Cs*Cf*Cz;
sigma_en=sigma_e/Kf;
printf('\nFatigue Limit = %g psi',sigma_en);
```

Scilab code Exa 12.6 Local Strain method

```
//Example 12.6
//Local Strain method
//Page No. 424
clc;clear;close;

funcprot(0);
K=189;                    //in ksi
n=0.12;                   //no unit
ef=1.06;                   //no unit
sigma_f=190;                //in ksi
b=-0.08;                    //no unit
c=-0.66;                 //no unit
E=30*10^6;                 //in psi
E=E/1000;             //conversion to ksi\
s=200;                 //in ksi
```

```
sigma_m=167;            //in ksi
sigma_a=17;               //in ksi
se=s^2/E;
deff('y=f(ds)','y=(ds^2)/(2*E)+(ds^((1+n)/n))/(2*K)^(1/n)-se/2');
[ds,v,info]=fsolve(0,f);
de=se/ds;
deff('y=f1(N2)','y=N2^-b*(sigma_f/E)+ef*N2^-c-de/2');
[N2,v,info]=fsolve(0,f1);
N2=1/N2;
N_1=N2/2;
de_e2=sigma_a/E;
deff('y=f2(N2)','y=N2^-b*((sigma_f-sigma_m)/E)+ef*N2^-c-de_e2');
[N2,v,info]=fsolve(0,f2);
N2=1/N2;
N_2=N2/2;
C_pd=2*60*60*8;
f=N_2/C_pd;
printf('\nNumber of cycles = %g cycles\nFatigue damage per cycle = %g\nNumber of cycles with correction of mean stress= %g cycles\nFatigue damage per cycle  with correction of mean stress= %g damage per year\nShaft will fail in %g days',N_1,1/N_1,N_2,1/N_2,f);
```

Chapter 13

Creep and Stress Rupture

Scilab code Exa 13.1 Engineering Creep

```
//Example 13.1
//Engineering Creep
//Page No. 461
clc;clear;close;

sf=3;                      //no unit
per=1/1000;                //in %
T(1)=1100;                 //in Fahrenheit
T(2)=1500;                 //in Fahrenheit
C(1)=30000;                     //from fig 13-17 in book
C(2)=4000;                     //from fig 13-17 in book
W(1)=C(1)/sf;
W(2)=C(2)/sf;
W1(1)=W(1)*0.00689;
W1(2)=W(2)*0.00689;
printf('\n
   ----------------------------------------------------------------------------
   n');
printf('Temperature\tCreep Strength, psi\tWorking
   Stress, psi\tWorking Stress, MPa\n');
printf('
```

```
______________________________________________________________________________');
printf('\n1100 F\t\t\t%i\t\t\t%i\t\t\t%g\n',C(1),W(1),W1(1));
printf('\n1500 F\t\t\t%i\t\t\t%i\t\t\t%g\n',C(2),W(2),W1(2));
```

Scilab code Exa 13.2 Engineering Creep

```
//Example 13.2
//Engineering Creep
//Page No. 461
clc;clear;close;

deff('y=C(f)','y=(f-32)*(5/9)');
R=1.987;                    //in cal/mol K
T2=1300;                //in Fahrenheit
T1=1500;                //in Fahrenheit
T2=C(T2)+273.15;
T1=C(T1)+273.15;
e2=0.0001;                //no unit
e1=0.4;                 //no unit
Q=R*log(e1/e2)/(1/T2-1/T1);
printf('\nActivation Energy = %g cal/mol',Q)
printf('\n\n\nNote: Calculation Errors in book');
```

Scilab code Exa 13.3 Prediction of long time properties

```
//Example 13.3
//Prediction of long time properties
//Page No. 464
clc;clear;close;

```

```
t=10^5;                    //in hr
C1=20;                      //in no unit
T1=1200;                   //in Fahrenheit
T2=1600;                   //in Fahrenheit
P_1200=(T1+460)*(log10(t)+C1);
P_1600=(T2+460)*(log10(t)+C1);
printf('\nAt T = 1200 F, P = %g\nAt T = 1600 F, P =
    %g\nAnd from the master ploy of Astroploy,
    corresponding stress required are sigma = 78000
    psi and sigma = 11000 psi',P_1200,P_1600);
```

Chapter 14

Brittle Fracture and Impact Testing

Scilab code Exa 14.1 Stress Corrosion Cracking

```
//Example 14.1
//Stress Corrosion Cracking
//Page No. 494
clc;clear;close;

cg=10;              //in mm
cg=cg/1000;           //conversion to m
gr=10^-8;           //m/s
l=cg/(gr*3600*24);
printf('\nEstimated Life = %g days',l);
K_l_SCC=10;                  //in MN m^(-3/2)
a_sigma2=K_l_SCC^2/(1.21*%pi);
s=[500,300,100];
printf('\n\n\n-----------------------------------------\
   nStress, MPa\tCrack Length, mm\n
   -----------------------------------------\n');
for i=1:3
    printf('\t%g\t\t%g\n',s(i),a_sigma2*1000/s(i)^2)
        ;
```

```
end
printf('--------------------------------------');
printf('\n\n\n\nNote: Calculation errors in book');
```

Chapter 15

Fundamentals of Metalworking

Scilab code Exa 15.1 Mechanics of Metal Working

```
//Example 15.1
//Mechanics of Metal Working
//Page No. 506
clc;clear;close;

//For Bar which is double in length
L2=2;                  //factor (no units)
L1=1;                  //factor (no units)
e=(L2-L1)/L1;
e1=log(L2/L1);
r=1-L1/L2;
printf('\nEnginering Strain = %g\nTrue Strain = %g\
   nReduction = %g',e,e1,r);

//For bar which is halved in length
L1=1;                  //factor (no units)
L2=0.5;                  //factor (no units)
e=(L2-L1)/L1;
e1=log(L2/L1);
r=1-L1/L2;
printf('\n\nEnginering Strain = %g\nTrue Strain = %g
```

```
\nReduction = %g',e,e1,r);
```

Scilab code Exa 15.2 Mechanics of Metal Working

```
//Example 15.2
//Mechanics of Metal Working
//Page No. 511
clc;clear;close;

D0=25;                  //in mm
D1=20;                  //in mm
D2=15;                  //in mm
ep1=log((D0/D1)^2);
U1=integrate('200000*e^0.5','e',0,ep1);
ep2=log((D1/D2)^2);
U2=integrate('200000*e^0.5','e',ep1,ep1+ep2);
printf('\nPlastic work done in 1st step = %g lb/in
   ^2\nPlastic work done in 2nd step = %g lb/in^2\n'
   ,U1,U2);
```

Scilab code Exa 15.3 Hodography

```
//Example 15.3
//Hodography
//Page No. 517
clc;clear;close;

alpha=60;                  //in degrees
mu=1/sind(alpha);
p_2k=mu*5/2;
printf('Pressure  = %g',p_2k);
```

Scilab code Exa 15.4 Temperature in Metalworking

```
//Example 15.4
//Temperature in Metalworking
//Page No. 526
clc;clear;close;

Al_s=200;                  //in MPa
Al_e=1;                 //no unit
Al_p=2.69;                  //in g/cm^3
Al_c=0.215;                  //in cal/g * deg C
Ti_s=400;                  //in MPa
Ti_e=1;                 //no unit
Ti_p=4.5;                  //in g/cm^3
Ti_c=0.124;                  //in cal/g * deg C
J=4.186;                  //in J/cal
b=0.95;                 //no unit
Al_Td=Al_s*Al_e*b/(Al_p*Al_c*J);
Ti_Td=Ti_s*Ti_e*b/(Ti_p*Ti_c*J);
printf('\nTemperature Rise for aluminium = %g C\
   nTemperature Rise for titanium = %g C\n',Al_Td,
   Ti_Td);
```

Scilab code Exa 15.5 Friction and Lubrication

```
//Example 15.5
//Friction and Lubrication
//Page No. 546
clc;clear;close;

Do=60;                  //in mm
Di=30;                  //in mm
```

```
def1=70;                    //in mm
def2=81.4;                    //in mm
h=10;                   //in mm
a=30;                   //in mm
di=sqrt((Do^2-Di^2)*2-def1^2);
pr=(Di-di)/Di*100;
m=0.27;                    //no unit
p_s=1+2*m*a/(sqrt(3)*h);
printf('\nFor OD after deformation being 70 mm, Di = %g mm\nPrecent change in inside diameter = %g percent\nPeak pressure = %g',di,pr,p_s);
di=sqrt(def2^2-(Do^2-Di^2)*2);
pr=(Di-di)/Di*100;
m=0.05;                    //no unit
p_s=1+2*m*a/(sqrt(3)*h);
printf('\n\n\n\nFor OD after deformation being 81.4 mm, Di = %g mm\nPrecent change in inside diameter = %g percent\nPeak pressure = %g',di,pr,p_s);
```

Chapter 16

Forging

Scilab code Exa 16.1 Forging in Plain Strain

```
//Example 16.1
//Forging in Plain Strain
//Page No. 574
clc;clear;close;

sigma=1000;                    //in psi
mu=0.25;                       //no unit
a=2;                           //in inches
b=6;                           //in inches
h=0.25;                           //in inches
x=0;                           //in inches
p_max=2*sigma*exp(2*mu*(a-x)/h)/sqrt(3);
printf('\nAt the centerline of the slab = %g psi\n',
   p_max);
printf('\nPressure Distributon from the centerline:'
   );
printf('\n————————————————————————————————————————\n');
printf('x\tp (ksi)\t\tt_i (ksi)\n');
printf('————————————————————————————————————————\n');
for x=0:h:a
    p=2*sigma*exp(2*mu*(a-x)/h)/(1000*sqrt(3));
```

```
                    //in ksi
    t_i=mu*p;
    printf('%g\t%g\t\t%g\n',x,p,t_i);
end
printf('----------------------------------\n');
k=sigma/sqrt(3);
x=0;                           //in inches
p_max1=2*sigma*((a-x)/h+1)/sqrt(3);
printf('\nFor sticking friction:\np_max = %g ksi',p_max1/1000);
x1=a-h/(2*mu)*log(1/(2*mu));
p=2*sigma*(a/(2*h)+1)/sqrt(3);
P=2*p*a*b;
P=P*0.000453;                           //conversion to metric tons
printf('\n\nThe Forging load = %g tons',P);
```

Chapter 17

Rolling of Metals

Scilab code Exa 17.1 Forces in rolling

```
//Example 17.1
//Forces in rolling
//Page No. 596
clc;clear;close;

mu=0.08;                            //no unit
R=12;                                //in inches
alpha=atand(mu);
dh=mu^2*R;
printf('\nMaximum possible reduction when mu is 0.08
    = %g in\n',dh);
mu=0.5;                            //no unit
dh=mu^2*R;
printf('Maximum possible reduction when mu is 0.5 =
   %g in',dh);
```

Scilab code Exa 17.2 Rolling Load

```
//Example 17.2
//Rolling Load
//Page No. 598
clc;clear;close;

h0=1.5;                       //in inches
mu=0.3;                       //no unit
D=36;                       //in inches
s_en=20;                       //in ksi
s_ex=30;                       //in ksi
h1=h0-0.3*h0;
dh=h0-h1;
h_=(h1+h0)/2;
Lp=sqrt(D/2*dh);
Q=mu*Lp/h_;
sigma0=(s_en+s_ex)/2;
P=sigma0*(exp(Q)-1)*s_ex*Lp/Q;
printf('\nRolling Load = %g kips',P);
P=sigma0*(Lp/(4*dh)+1)*s_ex*Lp;
printf('\nRolling Load  if sticking friction occurs
   = %g kips',P);
```

Scilab code Exa 17.3 Rolling Load

```
//Example 17.3
//Rolling Load
//Page No. 599
clc;clear;close;

h0=1.5;                       //in inches
mu=0.3;                       //no unit
D=36;                       //in inches
s_en=20;                       //in ksi
s_ex=30;                       //in ksi
C=3.34*10^-4;                       //in inches^2/ton
```

```
P_=1357;                    //in tons
h1=h0-0.3*h0;
dh=h0-h1;
h_=(h1+h0)/2;
R=D/2;
R1=R*(1+C*P_/(s_ex*(dh)));
Lp=sqrt(R1*dh);
Q=mu*Lp/h_;
sigma0=(s_en+s_ex)/2;
P2=sigma0*(exp(Q)-1)*s_ex*Lp/Q;
P2=P2*0.45359                         ///conversion
   to tons
R2=R*(1+C*P2/(s_ex*(dh)));
printf('\nP2 = %g tons\nR2 = %g in',P2,R2);
```

Scilab code Exa 17.4 Torque and Horsepower

```
//Example 17.4
//Torque and Horsepower
//Page No. 614
clc;clear;close;

w=12;                       //in inches
hi=0.8;                       //in inches
hf=0.6;                       //in inches
D=40;                       //in inches
N=100;                       //in rpm
R=D/2;
dh=abs(hf-hi);
e1=log(hi/hf);
r=(hi-hf)/hi;
sigma=20*e1^0.2/1.2;
Qp=1.5;                            //no unit
P=2*sigma*w*(R*(hi-hf))^(1/2)*Qp/sqrt(3);
a=0.5*sqrt(R*dh);
```

```
a=a/12;                                        //conversion to
    ft
hp=4*%pi*a*P*N*1000/33000;
printf('\nRolling Load = %g\nHorsepower = %g',P,hp);
```

Chapter 18

Extrusion

Scilab code Exa 18.1 Extrusion Process

```
//Example 18.1
//Extrusion Process
//Page No. 629
clc;clear;close;

Db=6;                         //in inches
Df=2;                         //in inches
L=15;                         //in inches
v=2;                         //in inches/s
alpha=60;                         //in degrees
mu=0.1;                         //no unit
R=Db^2/Df^2;
e=6*v*log(R)/Db
sigma=200*e^0.15;
B=mu*cotd(alpha);
p_d=sigma*((1+B)/B)*(1-R^B);
p_d=abs(p_d);
t_i=sigma/sqrt(3);
p_e=p_d+4*t_i*L/Db;
p_e=p_e*145.0377;                         //conversion to
    psi
```

```
A=%pi*Db^2/4;
P=p_e*A;
P=P*0.000453;                       //conversion to
    metric tons
printf('\nForce required for the Operation = %g
    metric tons\n\n\nNote: Slight calculation errors
    in book',P);
```

Chapter 19

Drawing of Rods Wires and Tubes

Scilab code Exa 19.1 Analysis of Wiredrawing

```
//Example 19.1
//Analysis of Wiredrawing
//Page No. 640
clc;clear;close;

Ab=10;                          //in mm
r=0.2;                          //in %
alpha=12;                          //in degrees
mu=0.09;                          //no unit
n=0.3;                          //no unit
K=1300;                          //in MPa
v=3;                          //in m/s
B=mu*cotd(alpha/2);
e1=log(1/(1-r));
sigma=K*e1^0.3/(n+1);
Aa=Ab*(1-r);
sigma_xa=sigma*((1+B)/B)*[1-(Aa/Ab)^B];
Aa=%pi*Aa^2/4;
Pd=sigma_xa*Aa;
```

```
Pd=Pd/1000;                          //conversion to
    kilo units
P=Pd*v;
H=P/0.746;
printf('\nDrawing Stress = %g MPa\nDrawing Force =
    %g kN\nPower = %g kW\nHorsepower = %g hp',
    sigma_xa,Pd,P,H);
```

Scilab code Exa 19.2 Analysis of Wiredrawing

```
//Example 19.2
//Analysis of Wiredrawing
//Page No. 645
clc;clear;close;

alpha=12;                      //in degrees
r=0.2;                      //in %
mu=0.09;                      //no unit
n=0.3;                      //no unit
K=1300;                      //in MPa
v=3;                      //in m/s
B=mu*cotd(alpha/2);
e1=log(1/(1-r));
sigma_xa=K*e1^0.3/(n+1);
r1=1-((1-(B/(B+1)))^(1/B));
e=log(1/(1-r1));
sigma0=1300*e^0.3;
r2=1-(1-((sigma0/sigma_xa)*(B/(B+1)))^(1/B));
printf('\nBy First Approximation, r = %g\nBy Second
    Approximation, r = %g',r1,r2);
```

Chapter 20

Sheet Metal Forming

Scilab code Exa 20.1 Deep Drawing

```
//Example 20.1
//Deep Drawing
//Page No. 672
clc;clear;close;

le=0.3;                    //factor (no unit)
wd=-0.16;                    //factor (no unit)
l_l0=1+le;
w_w0=1+wd;
R=log(1/w_w0)/log((w_w0)*l_l0);
printf('\nLimiting ratio = %g',R);
```

Scilab code Exa 20.2 Forming Limit Criteria

```
//Example 20.2
//Forming Limit Criteria
//Page No. 675
clc;clear;close;
```

```
d=0.1;                          //in inches
mj_d=0.18;                          //in inches
mn_d=0.08;                          //in inches
e1=(mj_d-d)/d;
e2=(mn_d-d)/d;
printf('\nMajor Strain = %g percent \nMinor Strain =
    %g percent',e1*100,e2*100);
```

Chapter 21

Machining of Metals

Scilab code Exa 21.1 Mechanics of Machining

```
//Example 21.1
//Mechanics of Machining
//Page No. 685
clc;clear;close;

a=6;                          //in degrees
sigma_s=60000;                //in psi
su_s=91000;                   //in psi
sigma_c=10000;                //in psi
su_c=30000;                   //in psi
deff('y=s(fi)','y=cosd(fi-a)*sind(fi)-sigma_s/su_s*(
   cosd(45-a/2)*sind(45+a/2))');
deff('y=c(fi)','y=cosd(fi-a)*sind(fi)-sigma_c/su_c*(
   cosd(45-a/2)*sind(45+a/2))');
[fi,v,info]=fsolve(0,s);
printf('\nShear Plane Angle for 1040 steel= %g deg',
   fi)
[fi,v,info]=fsolve(0,c);
printf('\nShear Plane Angle for Copper = %g deg',fi)
```

Scilab code Exa 21.2 Mechanics of Machining

```
//Example 21.2
//Mechanics of Machining
//Page No. 687
clc;clear;close;

v=500;                          //in ft/min
alpha=6;                          //in degrees
b=0.4;                          //in inches
t=0.008;                          //in inches
Fv=100;                          //in lb
Fh=250;                          //in lb
L=20;                          //in in
rho=0.283;                          //in lb/in^2
m=13.36;                          //in gm
m=m/454;                //conversion to lb

tc=m/(rho*b*L);
r=t/tc;
fi=atand(r*cosd(alpha)/(1-r*sind(alpha)));
mu=(Fv+Fh*tand(alpha))/(Fh-Fv*tand(alpha));
be=atand(mu);
Pr=sqrt(Fv^2+Fh^2);
Ft=Pr*sind(be);
p_fe=Ft*r/Fh;
Fs=Fh*cosd(fi)-Fv*sind(fi);
vs=v*cosd(alpha)/cosd(fi-alpha);
p_se=Fs*vs/(Fh*v);
U=Fh*v/(b*t*v);
U=U/33000;                          //conversion to hp
U=U/12;                          //conversion of ft
   units to in units
printf('\nSlip plane angle = %g deg\nPercentage of
```

```
total energy that goes into friction = %g percent
\nPercentage of total energy that goes into shear
 = %g percent\nTotal energy per unit volume = %g
hp min/in^3',fi,p_fe*100,p_se*100,U);
```

Scilab code Exa 21.3 Tool Materials and Tool Life

```
//Example 21.3
//Tool Materials and Tool Life
//Page No. 698
clc;clear;close;

d=0.5;                        //in %
t=(1/d)^(1/0.12);
printf('\nFor High Speed steel tool, increase in
   tool life is given by: t2 = %g t1',t);
t=(1/d)^(1/0.3);
printf('\nFor Cemented carbide tool, increase in
   tool life is given by: t2 = %g t1',t);
```

Scilab code Exa 21.4 Grinding Processes

```
//Example 21.4
//Grinding Processes
//Page No. 703
clc;clear;close;

U=40;                         //in GPa
uw=0.3;                         //in m/s
b=1.2;                         //in mm
v=30;                         //in m/s
d=0.05;                         //in mm
b=b*10^-3;                         //conversion to m
```

```
d=d*10^-3;                              //conversion to m
U=U*10^9;                               //conversion to Pa
M=uw*b*d;
P=U*M;
F=P/v;
printf('Tangential force = %g N',F);
```