

Scilab Textbook Companion for
Mechanical Metallurgy
by G. E. Dieter¹

Created by
Apurva Bhushan
B.Tech
Computer Engineering
KIIT University
College Teacher
None
Cross-Checked by
Spandana

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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.

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Chapter 1

Introduction

Scilab code Exa 1.1 Shear Stress

```
1 //Example 1.1
2 //Shear Stress
3 //Page No. 16
4 clc;clear;close;
5
6 y_b=2;           //in J/m^2
7 G=75;           //in Gpa
8 G=G*10^9;       //conversion to Pa
9 L=0.01;         //in mm
10 L=L*10^-3;     //conversion to m
11 nu=0.3;        //no unit
12 T=sqrt((3*%pi*y_b*G)/(8*(1-nu)*L));
13 T=T/10^6;
14 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

```
1 //Example 2.1
2 //State of Stress in two dimensions
3 //Page No. 25
4 clc;clear;close;
5
6 sigma_x=25;           //no unit
7 sigma_y=5;           //no unit
8 theta=45;            //in degrees
9 sigma_x_=50;         //in Mpa
10 T_x_y_=5;           //in Mpa
11 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)];
12 B=[sigma_x_;T_x_y_];
13 X=inv(A)*B;
14 p=X(1);
15 T_xy=X(2);
16 sigma_x1=sigma_x*p;
17 sigma_y1=sigma_y*p;
```

```

18 sigma_y_ = sigma_x1 + sigma_y1 - sigma_x_;
19 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

```

1 //Example 2.2
2 //State of Stress in three dimensions
3 //Page No. 29
4 clc; clear; close;
5
6 s = poly(0, 's');
7 A = [s-0, -240, 0; -240, s-200, 0; 0, 0, s+280]; //in
      Mpa
8 p = determ(A);
9 X = roots(p);
10 for i = 1:3
11     printf('\nsigma%i = %g MPa', i, X(i));
12 end
13 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

```

1 //Example 2.3
2 //Calculation of Stresses from elastic strains
3 //Page No. 52

```

```

4  clc; clear; close;
5
6  E=200;           //in GPa
7  nu=0.33;        //no unit
8  e1=0.004;       //no unit
9  e2=0.001;       //no unit
10 sigma1=E*(e1+nu*e2)/(1-nu^2);
11 sigma2=E*(e2+nu*e1)/(1-nu^2);
12 sigma1=sigma1*1000; //conversion to MPa
13 sigma2=sigma2*1000; //conversion to MPa
14 printf(' \nsigma1 = %g MPa\nsigma2 = %g MPa\n',sigma1
    ,sigma2);
15 printf(' \nNote: Slight calculation errors in Book')

```

Scilab code Exa 2.4 Elastic Anisotropy

```

1  //Example 2.4
2  //Elastic Anisotropy
3  //Page No. 60
4  clc; clear; close;
5
6  S11_Fe=0.8;           //in 1/Pa
7  S12_Fe=-0.28;        //in 1/Pa
8  S44_Fe=0.86;         //in 1/Pa
9  S11_W=0.26;          //in 1/Pa
10 S12_W=-0.07;         //in 1/Pa
11 S44_W=0.66;          //in 1/Pa
12 D_100_l=1;
13 D_100_m=0;
14 D_100_n=0;
15 D_110_l=1/sqrt(2);
16 D_110_m=1/sqrt(2);
17 D_110_n=0;
18 D_111_l=1/sqrt(3);
19 D_111_m=1/sqrt(3);

```

```

20 D_111_n=1/sqrt(3);
21
22 printf('\nFor Iron:\n\n');
23 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));
24 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));
25 printf('E_111 = %g x 10^11 Pa\nE_100 = %g x 10^11 Pa
      \n',Fe_E_111,Fe_E_100);
26 printf('\n\n\nFor Tungsten:\n\n');
27 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));
28 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));
29 printf('E_111 = %g x 10^11 Pa\nE_100 = %g x 10^11 Pa
      \n\nTherefore tungsten is elastically isotropic
      while iron is elastically 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

```
1 //Example 3.1
2 //True Stress and True Strain
3 //Page No. 76
4 clc; clear; close;
5
6 D_i=0.505; //in inches
7 L=2; //in inches
8 P_max=20000; //in lb
9 P_f=16000; //in lb
10 D_f=0.425; //in inches
11 E_St= P_max*4/(%pi*D_i^2);
12 T_fr_St= P_f*4/(%pi*D_f^2);
13 e_f=log(D_i^2/D_f^2);
14 e=exp(e_f)-1;
15 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

```
1 //Example 3.2
2 //Yielding Criteria for Ductile Metals
3 //Page No. 78
4 clc;clear;close;
5
6 sigma00=500;           //in MPa
7 sigma_z=-50;          //in MPa
8 sigma_y=100;          //in MPa
9 sigma_x=200;          //in MPa
10 T_xy=30;             //in MPa
11 T_yz=0;              //in MPa
12 T_xz=0;              //in MPa
13 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);
14 s=sigma00/sigma0;
15 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

```
1 //Example 3.3
2 //Tresca Criterion
3 //Page No. 81
4 clc;clear;close;
5
6 sigma00=500;           //in MPa
7 sigma_z=-50;          //in MPa
```

```

8 sigma_y=100;           //in MPa
9 sigma_x=200;           //in MPa
10 T_xy=30;              //in MPa
11 T_yz=0;               //in MPa
12 T_xz=0;               //in MPa
13 sigma0=sigma_x-sigma_z;
14 s=sigma00/sigma0;
15 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

```

1 //Example 3.4
2 //Levy-Mises Equation
3 //Page No. 91
4 clc;clear;close;
5
6 r_t=20;                //no unit
7 p=1000;                //in psi
8 sigma1=p*r_t;
9 sigma1=sigma1/1000;    //conversion
      to ksi
10 sigma=sqrt(3)*sigma1/2;
11 e=(sigma/25)^(1/0.25);
12 e1=sqrt(3)*e/2;
13 printf('\nPlastic Strain = %g',e1);

```

Chapter 4

Plastic Deformation of Single Crystals

Scilab code Exa 4.1 Critical Resolved Shear Stress for Slip

```
1 //Example 4.1
2 // Critical Resolved Shear Stress for Slip
3 //Page No. 125
4 clc;clear;close;
5
6 a=[1,-1,0];           //no unit
7 n=[1,-1,-1];        //no unit
8 s=[0,-1,-1];        //no unit
9 Tr=6;                //in MPa
10 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));
11 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));
12 sigma=Tr/(cos_fi*cos_lm);
13 printf('Tensile Stress applied = %g MPa',sigma);
```

Chapter 5

Dislocation Theory

Scilab code Exa 5.1 Forces Between Dislocations

```
1 //Example 5.1
2 //Forces Between Dislocations
3 //Page No. 166
4 clc;clear;close;
5
6 G=40; //in GPa
7 G=G*10^9; //conversion to N/m^2
8 b=2.5; //in angstrong
9 b=b*10^-10; //conversion to m
10 r=1200; //in angstrong
11 r=r*10^-10; //conversion to m
12 l=0.04; //in mm
13 l=l*10^-3; //conversion to m
14 F=G*b^2/(2*%pi*r);
15 Ft=F*l;
16 printf('The Total force on the dislocation is = %g N
    ',Ft);
```

Chapter 6

Strengthening Mechanisms

Scilab code Exa 6.1 Grain Size Measurement

```
1 //Example 6.1
2 //Grain Size Measurement
3 //Page No. 193
4 clc; clear; close;
5
6 sigma_i=150; //in MN/m2
7 k=0.7; //in MN/m(3/2)
8 n=6;
9 N_x=2(n-1);
10 N=N_x/(0.01)2; //in grains/in2
11 N=N*106/25.42; // in grains/m2
12 D=sqrt(1/N);
13 sigma0=sigma_i+k/D(1/2);
14 printf('\\nYield Stress = %g MPa',sigma0);
```

Scilab code Exa 6.2 Strengthening Mechanism

```
1 //Example 6.2
```

```

2 //Strengthening Mechanism
3 //Page No. 219
4 clc;clear;close;
5
6 sigma0=600;           //in MPa
7 G=27.6;              //in GPa
8 G=G*10^9             //conversion to Pa
9 b=2.5*10^-8;        //in cm
10 b=b*10^-2;         //conversion to m
11 T0=sigma0/2;
12 T0=T0*10^6;        //conversion to Pa
13 lambda=G*b/T0;
14 Cu_max=54;          //in %
15 Cu_eq=4;            //in %
16 Cu_min=0.5;        //in %
17 rho_al=2.7;        //in g/cm^3
18 rho_theta=4.43;    //in g/cm^3
19 wt_a=(Cu_max-Cu_eq)/(Cu_max-Cu_min);
20 wt_theta=(Cu_eq-Cu_min)/(Cu_max-Cu_min);
21 V_a=wt_a/rho_al;
22 V_theta=wt_theta/rho_theta;
23 f=V_theta/(V_a+V_theta);
24 r=(3*f*lambda)/(4*(1-f));
25 printf('\nParticle Spacing = %g m\nParticle Size =
    %g m',lambda,r);

```

Scilab code Exa 6.3 Fiber Strengthening

```

1 //Example 6.3
2 //Fiber Strengthening
3 //Page No. 222
4 clc;clear;close;
5
6 Ef=380;              //in GPa
7 Em=60;               //in GPa

```

```

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

```

Scilab code Exa 6.4 Load Transfer

```

1 //Example 6.4
2 //Load Transfer
3 //Page No. 225
4 clc;clear;close;
5
6 sigma_fu=5; //in GPa
7 sigma_fu=sigma_fu*10^9; //Conversion to Pa
8 sigma_m=100; //in MPa
9 sigma_m=sigma_m*10^6; //Conversion to Pa
10 T0=80; //in MPa
11 T0=T0*10^6; //Conversion to Pa
12 f_f=0.5; //no unit
13 d=100; //in um
14 d=d*10^-6; //conversion to m
15 B=0.5; //no unit
16 L=10; //in cm
17 L=L*10^-2; //conversion to m
18 Lc=sigma_fu*d/(2*T0);
19 sigma_cu=sigma_fu*f_f*(1-Lc/(2*L))+sigma_m*(1-f_f);
20 sigma_cu=sigma_cu*10^-9;
21 printf('\nsigma_cu = %g GPa for L=100um\n',sigma_cu)
22 ;;
23 L=2; //in mm

```

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

Chapter 7

Fracture

Scilab code Exa 7.1 Cohesive Strength

```
1 //Example 7.1
2 //Cohesive Strength
3 //Page No. 245
4 clc;clear;close;
5
6 E=95; //in GPa
7 E=E*10^9; //conversion to Pa
8 Ys=1000; //erg/cm^2
9 Ys=Ys*10^-3; //conversion to J/m^2
10 a0=1.6; //in angstrom
11 a0=a0*10^-10; //conversion to m
12 sigma_max=(E*Ys/a0)^(1/2)
13 sigma_max=sigma_max*10^-9;
14 printf('Cohesive strength of a silica fiber = %g GPa
        ',sigma_max);
```

Scilab code Exa 7.2 Fracture Stress

```
1 //Example 7.2
2 //Fracture Stress
3 //Page No. 246
4 clc;clear;close;
5
6 E=100; //in GPa
7 E=E*10^9; //conversion to Pa
8 Ys=1; //J/m^2
9 a0=2.5*10^-10; //in m
10 c=10^4*a0;
11 sigma_f=(E*Ys/(4*c))^(1/2);
12 sigma_f=sigma_f*10^-6;
13 printf('Fracture Stress = %g MPa',sigma_f);
```

Chapter 8

The Tension Test

Scilab code Exa 8.1 Standard properties of the material

```
1 //Example 8.1
2 //Standard properties of the material
3 //Page No. 281
4 clc; clear; close;
5
6 D=0.505;           //in inches
7 Lo=2;             //in inches
8 Lf=2.53;         //in inches
9 Py=15000;        //in lb
10 Pmax=18500;     //in lb
11 Pf=16200;      //in lb
12 D_f=0.315;     //in inches
13 A0=%pi*D^2/4;
14 Af=%pi*D_f^2/4;
15 s_u=Pmax/A0;
16 s0=Py/A0;
17 s_f=Pf/A0;
18 e_f=(Lf-Lo)/Lo;
19 q=(A0-Af)/A0;
20 printf(' \nUltimate Tensile Strength = %g psi\n0.2
    percent offset yield strength = %g psi\nBreaking
```



```

Stress = %g psi\nElongation = %g percent\n
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

```

1 //Example 8.2
2 //True Strain
3 //Page No. 288
4 clc;clear;close;
5
6 //case 1
7 Af=100; //in mm^2
8 Lf=60; //in mm
9 A0=150; //in mm^2
10 L0=40; //in mm
11 ef1=log(Lf/L0);
12 ef2=log(A0/Af);
13 printf('\nTrue Strain to fracture using changes in
length = %g\nTrue Strain to fracture using
changes in area = %g',ef1,ef2);
14
15 //Case 2
16 Lf=83; //in mm
17 L0=40; //in mm
18 Df=8; //in mm
19 D0=12.8; //in mm
20 ef1=log(Lf/L0);
21 ef2=2*log(D0/Df);
22 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

```
1 //Example 8.3
2 //Ultimate Tensile Strength
3 //Page No. 290
4 clc;clear;close;
5
6 deff('y=sigma(e)', 'y=200000*e^0.33');
7 E_u=0.33; //no unit
8 sigma_u=sigma(E_u);
9 s_u=sigma_u/exp(E_u);
10 printf('Ultimate Tensile Strength = %g psi',s_u);
```

Scilab code Exa 8.4 Effect of Strain Rate

```
1 //Example 8.4
2 //Effect of Strain Rate
3 //Page No. 298
4 clc;clear;close;
5
6 C_70=10.2; //in ksi
7 C_825=2.1; //in ksi
8 m_70=0.066; //no unit
9 m_825=0.211; //no unit
10 e1=1; //no unit
11 e2=100; //no unit
12 printf('\nAt 70deg F\n');
13 sigma_a=C_70*e1^m_70;
14 sigma_b=C_70*e2^m_70;
15
16 printf('sigma_a = %g ksi\nsigma_b = %g ksi\nsigma_b/
sigma_a = %g\n',sigma_a,sigma_b,sigma_b/sigma_a);
```

```
17 printf('\n\nAt 825deg F\n');
18 sigma_a=C_825*e1^m_825;
19 sigma_b=C_825*e2^m_825;
20 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

```
1 //Example 11.1
2 //Fracture Toughness
3 //Page No. 354
4 clc;clear;close;
5
6 a=5; //in mm
7 a=a*10^-3; //conversion to m
8 t=1.27; //in cm
9 t=t*10^-2; //conversion to m
10 K_Ic=24; //in MPa*m^(1/2)
11 sigma=K_Ic/(sqrt(%pi*a)*sqrt(sec(%pi*a/(2*t))));
12 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

```

1 //Example 11.2
2 //Fracture Toughness
3 //Page No. 354
4 clc;clear;close;
5
6 K_Ic=57; //in MPam^(1/2)
7 sigma0=900; //in MPa
8 sigma=360; //in MPa
9 Q=2.35; //no unit
10 a_c=K_Ic^2*Q/(1.21*pi*sigma^2);
11 a_c=a_c*1000; //cpnversion
    to mm
12 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

```

1 //Example 11.3
2 //Plasticity
3 //Page No. 361
4 clc;clear;close;
5
6 a=10; //in mm
7 a=a*10^-3; //conversion to m
8 sigma=400; //in MPa
9 sigma0=1500; //in MPa
10 rp=sigma^2*a/(2*pi*sigma0^2);
11 rp=rp*1000; //conversion to mm
12 K=sigma*sqrt(pi*a);
13 K_eff=sigma*sqrt(pi*a)*sqrt(a+pi*rp);
14 printf('\nPlastic zone size = %g mm\nStress
    Intensity Factor = %g MPa m^(1/2)\n\nNote:
    Calculation Errors in book',rp,K_eff);

```

Chapter 12

Fatigue of Metals

Scilab code Exa 12.1 Mean Stress

```
1 //Example 12.1
2 //Mean Stress
3 //Page No. 387
4 clc;clear;close;
5
6 sigma_u=158;           // in ksi
7 sigma0=147;           // in ksi
8 sigma_e=75;           // in ksi
9 l_max=75;             // in ksi
10 l_min=-25;           // in ksi
11 sf=2.5;              //no unit
12 sigma_m=(l_max+l_min)/2;
13 sigma_a=(l_max-l_min)/2;
14 sigma_e=sigma_e/sf;
15 A=sigma_a/sigma_e+sigma_m/sigma_u;
16 D=sqrt(4*A/%pi);
17 printf('\nBar Diameter = %g in',D);
```

Scilab code Exa 12.2 Low Cycle Fatigue

```

1 //Example 12.2
2 //Low Cycle Fatigue
3 //Page No. 391
4 clc;clear;close;
5
6 sigma_b=75; //in MPa
7 e_b=0.000645; //no unit
8 e_f=0.3; //no unit
9 E=22*10^4; //in MPa
10 c=-0.6; //no unit
11 d_e_e=2*sigma_b/E;
12 d_e_p=2*e_b-d_e_e;
13 N=(d_e_p/(2*e_f))^(1/c)/2;
14 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

```

1 //Example 12.3
2 //Fatigue Crack Proportion
3 //Page No. 401
4 clc;clear;close;
5
6 ai=0.5; //in mm
7 ai=ai*10^-3; //conversion to m
8 sigma_max=180; //in MPa
9 Kc=100; //MPam^(1/2)
10 alpha=1.12; //no unit
11 p=3; //no unit
12 A=6.9*10^-12; //in MPam^(1/2)
13 af=(Kc/(sigma_max*alpha))^2/%pi;
14 Nf=(af^(1-(p/2))-ai^(1-(p/2)))/((1-p/2)*A*sigma_max
    ^3*%pi^(p/2)*alpha^p);
15 printf('Fatigue Cycles = %g cycles ',Nf);

```

Scilab code Exa 12.4 Stress Concentration of Fatigue

```
1 //Example 12.4
2 //Stress Concentration of Fatigue
3 //Page No. 404
4 clc;clear;close;
5
6 rho=0.0004;           //no unit
7 S_u=190;             //in ksi
8 S_u=S_u*1000;       //conversion to psi
9 M=200;              //in inches-lb
10 Pm=5000;           //in lb
11 D=0.5;             //in inches
12 dh=0.05;          //in inches
13 r=dh/2;
14 Kt=2.2;           //no unit
15 Kf=1+(Kt-1)/(1+sqrt(rho/r));
16 q=(Kf-1)/(Kt-1);
17 A=%pi/4*D^2;
18 sigma_m=Pm/A;
19 I=%pi/64*D^4;
20 sigma_a=Kf*((M*D)/(2*I));
21 sigma_max=sigma_a+sigma_m;
22 sigma_min=sigma_a-sigma_m;
23 sigma_e=S_u/2;
24 sigma_a1=sigma_e/Kf*(1-sigma_m/S_u);
25 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

```
1 //Example 12.5
2 //Infinite Life Design
3 //Page No. 422
4 clc;clear;close;
5
6 Kt=1.68;           //no unit
7 q=0.9;            //no unit
8 sigma_ed=42000;   //in psi
9 Cs=0.9;           //no unit
10 Cf=0.75;         //no unit
11 Cz=0.81;         //no unit
12 Kf=q*(Kt-1)+1;
13 sigma_e=sigma_ed*Cs*Cf*Cz;
14 sigma_en=sigma_e/Kf;
15 printf('\nFatigue Limit = %g psi',sigma_en);
```

Scilab code Exa 12.6 Local Strain method

```
1 //Example 12.6
2 //Local Strain method
3 //Page No. 424
4 clc;clear;close;
5
6 funcprot(0);
7 K=189;            //in ksi
8 n=0.12;          //no unit
9 ef=1.06;         //no unit
10 sigma_f=190;     //in ksi
11 b=-0.08;         //no unit
12 c=-0.66;        //no unit
13 E=30*10^6;       //in psi
14 E=E/1000;       //conversion to ksi\
15 s=200;          //in ksi
```

```

16 sigma_m=167;           //in ksi
17 sigma_a=17;           //in ksi
18 se=s^2/E;
19 deff('y=f(ds)', 'y=(ds^2)/(2*E)+(ds^((1+n)/n))/(2*K)
      ^((1/n)-se/2)');
20 [ds,v,info]=fsolve(0,f);
21 de=se/ds;
22 deff('y=f1(N2)', 'y=N2^-b*(sigma_f/E)+ef*N2^-c-de/2')
      ;
23 [N2,v,info]=fsolve(0,f1);
24 N2=1/N2;
25 N_1=N2/2;
26 de_e2=sigma_a/E;
27 deff('y=f2(N2)', 'y=N2^-b*((sigma_f-sigma_m)/E)+ef*N2
      ^-c-de_e2');
28 [N2,v,info]=fsolve(0,f2);
29 N2=1/N2;
30 N_2=N2/2;
31 C_pd=2*60*60*8;
32 f=N_2/C_pd;
33 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

```
1 //Example 13.1
2 //Engineering Creep
3 //Page No. 461
4 clc;clear;close;
5
6 sf=3; //no unit
7 per=1/1000; //in %
8 T(1)=1100; //in Fahrenheit
9 T(2)=1500; //in Fahrenheit
10 C(1)=30000; //from fig 13-17 in book
11 C(2)=4000; //from fig 13-17 in book
12 W(1)=C(1)/sf;
13 W(2)=C(2)/sf;
14 W1(1)=W(1)*0.00689;
15 W1(2)=W(2)*0.00689;
16 printf('\n


---


n');
17 printf('Temperature\tCreep Strength, psi\tWorking
Stress, psi\tWorking Stress, MPa\n');
18 printf('
```

```

    ');
19 printf( '\n1100 F\t\t\t%i\t\t\t%i\t\t\t%g\n', C(1), W
    (1), W1(1));
20 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

```

1 //Example 13.2
2 //Engineering Creep
3 //Page No. 461
4 clc;clear;close;
5
6 deff( 'y=C(f)', 'y=(f-32)*(5/9)');
7 R=1.987; //in cal/mol K
8 T2=1300; //in Fahrenheit
9 T1=1500; //in Fahrenheit
10 T2=C(T2)+273.15;
11 T1=C(T1)+273.15;
12 e2=0.0001; //no unit
13 e1=0.4; //no unit
14 Q=R*log(e1/e2)/(1/T2-1/T1);
15 printf( '\nActivation Energy = %g cal/mol',Q)
16 printf( '\n\n\nNote: Calculation Errors in book');

```

Scilab code Exa 13.3 Prediction of long time properties

```

1 //Example 13.3
2 //Prediction of long time properties
3 //Page No. 464
4 clc;clear;close;
5

```

```
6 t=10^5;           //in hr
7 C1=20;           //in no unit
8 T1=1200;        //in Fahrenheit
9 T2=1600;        //in Fahrenheit
10 P_1200=(T1+460)*(log10(t)+C1);
11 P_1600=(T2+460)*(log10(t)+C1);
12 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

```
1 //Example 14.1
2 //Stress Corrosion Cracking
3 //Page No. 494
4 clc;clear;close;
5
6 cg=10; //in mm
7 cg=cg/1000; //conversion to m
8 gr=10^-8; //m/s
9 l=cg/(gr*3600*24);
10 printf('\nEstimated Life = %g days',l);
11 K_1_SCC=10; //in MN m^(-3/2)
12 a_sigma2=K_1_SCC^2/(1.21*%pi);
13 s=[500,300,100];
14 printf('\n\n\n-----\n
    nStress , MPa\tCrack Length , mm\n
    -----\n');
15 for i=1:3
16     printf('\t%g\t\t%g\n',s(i),a_sigma2*1000/s(i)^2)
    ;
```

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


---


```

Chapter 15

Fundamentals of Metalworking

Scilab code Exa 15.1 Mechanics of Metal Working

```
1 //Example 15.1
2 //Mechanics of Metal Working
3 //Page No. 506
4 clc;clear;close;
5
6 //For Bar which is double in length
7 L2=2;           //factor (no units)
8 L1=1;           //factor (no units)
9 e=(L2-L1)/L1;
10 e1=log(L2/L1);
11 r=1-L1/L2;
12 printf('\nEngineering Strain = %g\nTrue Strain = %g\n
    nReduction = %g',e,e1,r);
13
14 //For bar which is halved in length
15 L1=1;           //factor (no units)
16 L2=0.5;         //factor (no units)
17 e=(L2-L1)/L1;
18 e1=log(L2/L1);
19 r=1-L1/L2;
20 printf('\n\nEngineering Strain = %g\nTrue Strain = %g
```



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

Scilab code Exa 15.2 Mechanics of Metal Working

```
1 //Example 15.2
2 //Mechanics of Metal Working
3 //Page No. 511
4 clc;clear;close;
5
6 D0=25; //in mm
7 D1=20; //in mm
8 D2=15; //in mm
9 ep1=log((D0/D1)^2);
10 U1=integrate('200000*e^0.5','e',0,ep1);
11 ep2=log((D1/D2)^2);
12 U2=integrate('200000*e^0.5','e',ep1,ep1+ep2);
13 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

```
1 //Example 15.3
2 //Hodography
3 //Page No. 517
4 clc;clear;close;
5
6 alpha=60; //in degrees
7 mu=1/sind(alpha);
8 p_2k=mu*5/2;
9 printf('Pressure = %g',p_2k);
```

Scilab code Exa 15.4 Temperature in Metalworking

```
1 //Example 15.4
2 //Temperature in Metalworking
3 //Page No. 526
4 clc;clear;close;
5
6 Al_s=200;           //in MPa
7 Al_e=1;             //no unit
8 Al_p=2.69;         //in g/cm^3
9 Al_c=0.215;        //in cal/g * deg C
10 Ti_s=400;          //in MPa
11 Ti_e=1;            //no unit
12 Ti_p=4.5;          //in g/cm^3
13 Ti_c=0.124;        //in cal/g * deg C
14 J=4.186;           //in J/cal
15 b=0.95;            //no unit
16 Al_Td=Al_s*Al_e*b/(Al_p*Al_c*J);
17 Ti_Td=Ti_s*Ti_e*b/(Ti_p*Ti_c*J);
18 printf('\nTemperature Rise for aluminium = %g C\n
    nTemperature Rise for titanium = %g C\n',Al_Td,
    Ti_Td);
```

Scilab code Exa 15.5 Friction and Lubrication

```
1 //Example 15.5
2 //Friction and Lubrication
3 //Page No. 546
4 clc;clear;close;
5
6 Do=60;              //in mm
7 Di=30;              //in mm
```

```

8 def1=70; //in mm
9 def2=81.4; //in mm
10 h=10; //in mm
11 a=30; //in mm
12 di=sqrt((Do^2-Di^2)*2-def1^2);
13 pr=(Di-di)/Di*100;
14 m=0.27; //no unit
15 p_s=1+2*m*a/(sqrt(3)*h);
16 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);
17 di=sqrt(def2^2-(Do^2-Di^2)*2);
18 pr=(Di-di)/Di*100;
19 m=0.05; //no unit
20 p_s=1+2*m*a/(sqrt(3)*h);
21 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

```
1 //Example 16.1
2 //Forging in Plain Strain
3 //Page No. 574
4 clc;clear;close;
5
6 sigma=1000;           //in psi
7 mu=0.25;             //no unit
8 a=2;                 //in inches
9 b=6;                 //in inches
10 h=0.25;              //in inches
11 x=0;                 //in inches
12 p_max=2*sigma*exp(2*mu*(a-x)/h)/sqrt(3);
13 printf('\nAt the centerline of the slab = %g psi\n',
        p_max);
14 printf('\nPressure Distributon from the centerline:');
15 printf('\n-----\n');
16 printf('x\tp (ksi)\t\tt_i (ksi)\n');
17 printf('-----\n');
18 for x=0:h:a
19     p=2*sigma*exp(2*mu*(a-x)/h)/(1000*sqrt(3));
```

```

                                //in ksi
20     t_i=mu*p;
21     printf( '%g\t%g\t\t%g\n',x,p,t_i);
22 end
23 printf( '-----\n');
24 k=sigma/sqrt(3);
25 x=0;                                //in inches
26 p_max1=2*sigma*((a-x)/h+1)/sqrt(3);
27 printf( '\nFor sticking friction:\np_max = %g ksi',
        p_max1/1000);
28 x1=a-h/(2*mu)*log(1/(2*mu));
29 p=2*sigma*(a/(2*h)+1)/sqrt(3);
30 P=2*p*a*b;
31 P=P*0.000453;                        //conversion to
        metric tons
32 printf( '\n\nThe Forging load = %g tons',P);

```

Chapter 17

Rolling of Metals

Scilab code Exa 17.1 Forces in rolling

```
1 //Example 17.1
2 //Forces in rolling
3 //Page No. 596
4 clc;clear;close;
5
6 mu=0.08; //no unit
7 R=12; //in inches
8 alpha=atand(mu);
9 dh=mu^2*R;
10 printf('\nMaximum possible reduction when mu is 0.08
    = %g in\n',dh);
11 mu=0.5; //no unit
12 dh=mu^2*R;
13 printf('Maximum possible reduction when mu is 0.5 =
    %g in ',dh);
```

Scilab code Exa 17.2 Rolling Load

```

1 //Example 17.2
2 //Rolling Load
3 //Page No. 598
4 clc;clear;close;
5
6 h0=1.5; //in inches
7 mu=0.3; //no unit
8 D=36; //in inches
9 s_en=20; //in ksi
10 s_ex=30; //in ksi
11 h1=h0-0.3*h0;
12 dh=h0-h1;
13 h_=(h1+h0)/2;
14 Lp=sqrt(D/2*dh);
15 Q=mu*Lp/h_;
16 sigma0=(s_en+s_ex)/2;
17 P=sigma0*(exp(Q)-1)*s_ex*Lp/Q;
18 printf('\nRolling Load = %g kips ',P);
19 P=sigma0*(Lp/(4*dh)+1)*s_ex*Lp;
20 printf('\nRolling Load if sticking friction occurs
    = %g kips ',P);

```

Scilab code Exa 17.3 Rolling Load

```

1 //Example 17.3
2 //Rolling Load
3 //Page No. 599
4 clc;clear;close;
5
6 h0=1.5; //in inches
7 mu=0.3; //no unit
8 D=36; //in inches
9 s_en=20; //in ksi
10 s_ex=30; //in ksi
11 C=3.34*10^-4; //in inches^2/ton

```

```

12 P_=1357; //in tons
13 h1=h0-0.3*h0;
14 dh=h0-h1;
15 h_=(h1+h0)/2;
16 R=D/2;
17 R1=R*(1+C*P_/(s_ex*(dh)));
18 Lp=sqrt(R1*dh);
19 Q=mu*Lp/h_;
20 sigma0=(s_en+s_ex)/2;
21 P2=sigma0*(exp(Q)-1)*s_ex*Lp/Q;
22 P2=P2*0.45359 //conversion
    to tons
23 R2=R*(1+C*P2/(s_ex*(dh)));
24 printf('\nP2 = %g tons\nR2 = %g in ',P2,R2);

```

Scilab code Exa 17.4 Torque and Horsepower

```

1 //Example 17.4
2 //Torque and Horsepower
3 //Page No. 614
4 clc;clear;close;
5
6 w=12; //in inches
7 hi=0.8; //in inches
8 hf=0.6; //in inches
9 D=40; //in inches
10 N=100; //in rpm
11 R=D/2;
12 dh=abs(hf-hi);
13 e1=log(hi/hf);
14 r=(hi-hf)/hi;
15 sigma=20*e1^0.2/1.2;
16 Qp=1.5; //no unit
17 P=2*sigma*w*(R*(hi-hf))^(1/2)*Qp/sqrt(3);
18 a=0.5*sqrt(R*dh);

```



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

Chapter 18

Extrusion

Scilab code Exa 18.1 Extrusion Process

```
1 //Example 18.1
2 //Extrusion Process
3 //Page No. 629
4 clc;clear;close;
5
6 Db=6; //in inches
7 Df=2; //in inches
8 L=15; //in inches
9 v=2; //in inches/s
10 alpha=60; //in degrees
11 mu=0.1; //no unit
12 R=Db^2/Df^2;
13 e=6*v*log(R)/Db
14 sigma=200*e^0.15;
15 B=mu*cotd(alpha);
16 p_d=sigma*((1+B)/B)*(1-R^B);
17 p_d=abs(p_d);
18 t_i=sigma/sqrt(3);
19 p_e=p_d+4*t_i*L/Db;
20 p_e=p_e*145.0377; //conversion to
    psi
```

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

Chapter 19

Drawing of Rods Wires and Tubes

Scilab code Exa 19.1 Analysis of Wiredrawing

```
1 //Example 19.1
2 //Analysis of Wiredrawing
3 //Page No. 640
4 clc;clear;close;
5
6 Ab=10; //in mm
7 r=0.2; //in %
8 alpha=12; //in degrees
9 mu=0.09; //no unit
10 n=0.3; //no unit
11 K=1300; //in MPa
12 v=3; //in m/s
13 B=mu*cotd(alpha/2);
14 e1=log(1/(1-r));
15 sigma=K*e1^0.3/(n+1);
16 Aa=Ab*(1-r);
17 sigma_xa=sigma*((1+B)/B)*[1-(Aa/Ab)^B];
18 Aa=%pi*Aa^2/4;
19 Pd=sigma_xa*Aa;
```

```

20 Pd=Pd/1000;                                //conversion to
    kilo units
21 P=Pd*v;
22 H=P/0.746;
23 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

```

1 //Example 19.2
2 //Analysis of Wiredrawing
3 //Page No. 645
4 clc;clear;close;
5
6 alpha=12;                                    //in degrees
7 r=0.2;                                       //in %
8 mu=0.09;                                    //no unit
9 n=0.3;                                       //no unit
10 K=1300;                                     //in MPa
11 v=3;                                        //in m/s
12 B=mu*cotd(alpha/2);
13 e1=log(1/(1-r));
14 sigma_xa=K*e1^0.3/(n+1);
15 r1=1-((1-(B/(B+1)))^(1/B));
16 e=log(1/(1-r1));
17 sigma0=1300*e^0.3;
18 r2=1-(1-((sigma0/sigma_xa)*(B/(B+1)))^(1/B));
19 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

```
1 //Example 20.1
2 //Deep Drawing
3 //Page No. 672
4 clc;clear;close;
5
6 le=0.3;           //factor (no unit)
7 wd=-0.16;        //factor (no unit)
8 l_10=1+le;
9 w_w0=1+wd;
10 R=log(1/w_w0)/log((w_w0)*l_10);
11 printf('\nLimiting ratio = %g',R);
```

Scilab code Exa 20.2 Forming Limit Criteria

```
1 //Example 20.2
2 //Forming Limit Criteria
3 //Page No. 675
4 clc;clear;close;
```

```
5
6 d=0.1; //in inches
7 mj_d=0.18; //in inches
8 mn_d=0.08; //in inches
9 e1=(mj_d-d)/d;
10 e2=(mn_d-d)/d;
11 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

```
1 //Example 21.1
2 //Mechanics of Machining
3 //Page No. 685
4 clc;clear;close;
5
6 a=6; //in degrees
7 sigma_s=60000; //in psi
8 su_s=91000; //in psi
9 sigma_c=10000; //in psi
10 su_c=30000; //in psi
11 deff('y=s(fi)', 'y=cosd(fi-a)*sind(fi)-sigma_s/su_s*(
    cosd(45-a/2)*sind(45+a/2))');
12 deff('y=c(fi)', 'y=cosd(fi-a)*sind(fi)-sigma_c/su_c*(
    cosd(45-a/2)*sind(45+a/2))');
13 [fi,v,info]=fsolve(0,s);
14 printf('\nShear Plane Angle for 1040 steel= %g deg',
    fi)
15 [fi,v,info]=fsolve(0,c);
16 printf('\nShear Plane Angle for Copper = %g deg',fi)
```

Scilab code Exa 21.2 Mechanics of Machining

```
1 //Example 21.2
2 //Mechanics of Machining
3 //Page No. 687
4 clc; clear; close;
5
6 v=500; //in ft/min
7 alpha=6; //in degrees
8 b=0.4; //in inches
9 t=0.008; //in inches
10 Fv=100; //in lb
11 Fh=250; //in lb
12 L=20; //in in
13 rho=0.283; //in lb/in^2
14 m=13.36; //in gm
15 m=m/454; //conversion to lb
16
17 tc=m/(rho*b*L);
18 r=t/tc;
19 fi=atand(r*cosd(alpha)/(1-r*sind(alpha)));
20 mu=(Fv+Fh*tand(alpha))/(Fh-Fv*tand(alpha));
21 be=atand(mu);
22 Pr=sqrt(Fv^2+Fh^2);
23 Ft=Pr*sind(be);
24 p_fe=Ft*r/Fh;
25 Fs=Fh*cosd(fi)-Fv*sind(fi);
26 vs=v*cosd(alpha)/cosd(fi-alpha);
27 p_se=Fs*vs/(Fh*v);
28 U=Fh*v/(b*t*v);
29 U=U/33000; //conversion to hp
30 U=U/12; //conversion of ft
    units to in units
31 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/in3,fi,p_fe*100,p_se*100,U);

```

Scilab code Exa 21.3 Tool Materials and Tool Life

```

1 //Example 21.3
2 //Tool Materials and Tool Life
3 //Page No. 698
4 clc;clear;close;
5
6 d=0.5; //in %
7 t=(1/d)^(1/0.12);
8 printf('\nFor High Speed steel tool, increase in
  tool life is given by: t2 = %g t1',t);
9 t=(1/d)^(1/0.3);
10 printf('\nFor Cemented carbide tool, increase in
  tool life is given by: t2 = %g t1',t);

```

Scilab code Exa 21.4 Grinding Processes

```

1 //Example 21.4
2 //Grinding Processes
3 //Page No. 703
4 clc;clear;close;
5
6 U=40; //in GPa
7 uw=0.3; //in m/s
8 b=1.2; //in mm
9 v=30; //in m/s
10 d=0.05; //in mm
11 b=b*10^-3; //conversion to m

```

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