Scilab Textbook Companion for Advanced Strength and Applied Elasticity by A. C. Ugural and S. K. Fenster[1]

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July 31, 2019

[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: Advanced Strength and Applied Elasticity

Author: A. C. Ugural and S. K. Fenster

Publisher: Prentice Hall

Edition: 2

Year: 1981

ISBN: 0713134364

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

Analysis of Stress

Scilab code Exa 1.1 Find stress

```
//Mohr's circle

clc;
sigma=((40+80)/2)
disp(sigma,"center of the circle in MPa = ")

//solution a
x=((80-40)^2);
y=30^2;
sigma1=60+sqrt((.25*x)+y)
disp(sigma1,"maxi pricipal stress in MPa = ");//displaying result
sigma2=60-sqrt((.25*x)+y)
disp(sigma2,"mini pricipal stress in MPa = ");//displaying result
theta1=((atand(30/20))/2)
disp(theta1,"pricipal stresses in degree");//displaying result
theta2=(((atand(30/20))+180)/2)
disp(theta2,"pricipal stresses in degree");//displaying result
```

```
//solution b
tau=sqrt((.25*x)+y)
disp(tau,"maxi shearing stress in MPa = ");//
    displaying result
theta3=theta1+45
disp(theta3,"stress in MPa = ");// displaying result
theta4=theta2+45
disp(theta4,"stress in MPa = ");// displaying result

//final solution in matrix form
p=[80 30 ;30 40]
disp(p)
q=[sigma1 0 ; 0 sigma2]
disp(q)
r=[sigma -tau ; -tau sigma]
disp(r)
```

Scilab code Exa 1.2 Normal and shear stresses

```
//Mohr's circle

clc;
radius=((14+28)/2)
disp(radius,"radius of the circle in degree = ")
sigma1=(7+radius *cosd(60))
disp(sigma1," the circle in MPa = ")
sigma2=(7-radius *cosd(60))
disp(sigma2," the circle in MPa = ")
tau1=radius*sind(60)
disp(tau1," orientation of the stresses in MPa = ")
```

Chapter 2

Strain and stress strain relations

Scilab code Exa 2.1 Principal strains

```
clc;

radius=((sqrt(195^2+130^2))*10^(-6));
disp(radius,"radius of the circle in degree = ")
theta1=(atand(130/195))
disp(theta1,"pricipal stresses in degree");//
   displaying result
epsilonx=510*10^(-6)
epsilony=120*10^(-6)
epsilon=(epsilonx+epsilony)/2
disp(epsilon,"distance between O and c=")

//solution a
angle=60- theta1
disp(angle,"angle of ACA1 in degree = ")//
   displaying result
epsilonx1=epsilon+radius*cosd(26.3)
disp(epsilonx1,"strains in x axis= ")// displaying
   result
```

```
epsilony1=epsilon-radius*cosd(26.3)
disp(epsilony1,"strains in y axis= ")// displaying result
gammaxy=-2*(radius*sind(26.3))
disp(gammaxy,"shear strain")// displaying result

//solution b
epsilon1=epsilon+radius
disp(epsilon1,"strains in x axis= ")// displaying result
epsilon2=epsilon-radius
disp(epsilon2,"strains in x axis= ")// displaying result

//solution c
gammamax=-+468*10^(-6)
disp(gammamax,"maxi shear stress= ")
```

Scilab code Exa 2.2 Principal stresses and their directions

```
clc;

epsilon0=190*10^(-6)
epsilon60=200*10^(-6)
epsilon120=-300*10^(-6)
E=200// GPa
v=0.3
epsilonx=epsilon0
disp(epsilonx,"value of epsilonx is= ")

// epsilon60=((epsilonx+epsilony)/2)-((epsilonx-epsilony)/4)+(gammaxy*sqrt(3))/4 eqn 1
// epsilon120=((epsilonx+epsilony)/2)-((epsilonx-epsilony)/4)-(gammaxy*sqrt(3))/4 eqn 2

```

```
epsilony=(2*(epsilon60+epsilon120)-epsilon0)/3
disp(epsilony,"value of epsilony is= ")
gammaxy=(2/sqrt(3))*(epsilon60-epsilon120)// from eqn 1 and eqn 2
disp(gammaxy,"value of gammaxy is= ")
epsilon1=((epsilonx+epsilony)/2)+sqrt(((epsilonx-epsilony)/2)^2+(gammaxy/2)^2)// epsilony value is in negative so the sign changes in the eqn
disp(epsilon1,"value of epsilon1 is= ")
epsilon2=((epsilonx+epsilony)/2)-sqrt(((epsilonx-epsilony)/2)^2+(gammaxy/2)^2)//epsilony value is in negative so the sign changes in the eqn
disp(epsilon2,"value of epsilon2 is= ")

gammamax=(2*10^-6)*sqrt(((epsilonx-epsilony)/2)^2+(gammaxy/2)^2)
disp(gammamax,"max shear strain is= ")
thetap=atand(577/320)/2
disp(thetap,"orientations of principal axes is= ")// or
thetap1=atand(577/320)*2
disp(thetap1,"orientations of principal axes is= ")
sigma1=(200*10^9/(1-0.09))*(epsilon1+0.3*epsilon2)
disp(sigma1,"plane stresss is Pa= ")
sigma2=(200*10^3/(1-0.09))*(epsilon2+0.3*epsilon1)
disp(sigma2,"plane stresss is MPa= ")

taumax=(200*10^9/(2*(1+0.3)))*gammamax
disp(taumax,"plane stresss is MPa= ")
```

Chapter 3

Two dimensional problems in elasticity

Scilab code Exa 3.5 Size of the contact area and maxi contact pressure

```
clc;

E=210 //GPa
v=0.3
r1=0.4 //m radius
r2=0.3 //m cross radius
P=90 //kN compression load
1/r1'==1/r2'==0

m=4/((1/r1)+(1/r2))
disp(m)
A=(1/2)*((1/r1)+(1/r2))
disp(A)
B=(1/2)*((1/r1)-(1/r2))
disp(B)
coss=(((1/r1)-(1/r2))/((1/r1)+(1/r2)))
disp(coss,"cos aplha is= ")
n=(4*E*10^9)/(3*(1-v^2))
disp(n,"n is ")
```

```
s=acosd(coss)
disp(s," s is alpha value = ") // ans is 81.79degree
    but here since cosa is in negative we get ans as
    98.21
ca=1.1040 // from the interpolating table
cb=0.9112 // from the interpolating table
a=ca*(90000*m/n)^(0.33)
disp(a,"semiaxes of the elliptical contact area in
   meter is= ")
b=cb*(90000*m/n)^(0.33)
disp(b,"semiaxes of the elliptical contact area in
   meter is= ")
sigmac=1.5*(90000/(%pi*a*b))
disp(sigmac,"max contact pressure in Pa is= ") //
   text book ans is wrong
```

Chapter 4

Mechanical behaviour of materials

Scilab code Exa 4.1 `Calculate diameter`

```
clc;

sigmayp=350 //MPa
sigma3=0
M=8 //kN
Mt=24 //kNm
N=2
v=0.3

// sigma= My/I ==32M/%pid^3
// tau= Mt*r/J ==16Mt/%pid^3
//sigma1=(16*(M+sqrt(M^2+Mt^2)))/(%pi*d^3)
//sigma2=(16*(M-sqrt(M^2+Mt^2)))/(%pi*d^3)

//solution a: max principal stress theory
//(16*(M+sqrt(M^2+Mt^2)))/(%pi*d^3)=sigmayp/N

a=(16*(M+sqrt(M^2+Mt^2)))/%pi
disp(a)
```

```
b=sigmayp*10^6/N
disp(b)
d=(a/b)^(1/3)
disp(d,"diameter of the bar in meter is= ")

//solution b:max shearing stress theory

c=(32*sqrt(M^2+Mt^2))/%pi
disp(c)
d=(c/b)^(1/3)
disp(d,"diameter of the bar in meter is= ")

//solution c:max principal strain theory
//epsilon1=(sigma1-v(sigma2+sigma3))/E=epsilonyp/N=sigmayp/EN    Or
//sigma1-v(sigma2+sigma3)=b    given
//sigma1=b+v(sigma2+sigma3)    substituting the values of the sigma 1,2 and 3 we get
//(16*(M+sqrt(M^2+Mt^2)-vM-v*sqrt(M^2+Mt^2)))/(%pi*d^3)=b
e=(16*(M+sqrt(M^2+Mt^2)-v*M-v*sqrt(M^2+Mt^2)))/%pi
disp(e)
d=(e/b)^(1/3)
disp(d,"diameter of the bar in meter is= ")

//solution d:max energy of distortion theory

f=(16*sqrt(4*M^2+3*Mt^2))/%pi
disp(f)
d=(f/b)^(1/3)
disp(d,"diameter of the bar in meter is= ")
```

Scilab code Exa 4.3 Calculate limiting torque

```
clc
```

```
sigmau1=300  //MPa
sigmau2=700  //MPa
b=0.105 //m outer diameter
a=0.100 //m inner diameter

//sigma1==(-sigma2)==tau

sigma3=0

//Mt=J*tau/r= (%pi*(b^2-a^2))/2*b
//Mt=((%pi*(b^4-a^4))/(2*b))*tau          equation a
q=(%pi*(b^4-a^4))/(2*b)

//solution a: max principal stress theory
tau=sigmau1
Mt=q*tau*10^6
disp(Mt,"max principal stress in Nm is= ")

//solution b:max shearing stress theory
// |sigma1-sigma2|=sigmau1
// 2*sigma1==sigmau1==2*tau  or

Mt=q*tau*10^6
disp(Mt,"max shearing stress in Nm is= ")

//solution c:Coulomb- mohr theory
//(tau/sigmau1)-(-tau/sigmau2)=1
tau=1*((sigmau1*sigmau2)/(sigmau1+sigmau2))
disp(tau,"tau in MPa is= ")
Mt=q*tau*10^6
disp(Mt,"Coulomb- mohr in Nm is= ")
```

Scilab code Exa 4.4 `Determine reversed axial load`

```
clc

a=0.05 // m
Fm=90 //kN
sigmacr=210 // MPa
sigmayp=280 // MPa

//sigmaa=Ma*c/I          equation 1
//Ma=0.025*Fa
c=0.025
I=(a^4)/12
disp(I)
//sigmaa=((0.025*Fa)*c)/I  substituting the values


//sigmam=Fm/A             equation 2
sigmam=Fm/(a*a)
disp(sigmam,"in kilo Pa is= ")

//(((1200*Fa)/sigmacr)+(sigmam/sigmayp))=1
Fa=(1-(sigmam/sigmayp))*(sigmacr/1200)
disp(Fa,"load Fa in N is= ")                            //wrong ans in textbook
```

Scilab code Exa 4.5 Compute the value of p

```
clc

r=0.04 //m
t=5 //mm
sigmae=250 //MPa
sigmay=300 //MPa

//sigmathetamax=(p*r)/t =8*p          max values of tangential stresses
```

```
//sigmathetamin=((-p/4)*r)/t =-2*p    min values of tangential stresses
//sigmazamax=(p*r)/2*t =4*p          axial principal stresses
//sigmazmin=((-p/4)*r)/2*t =-p

//sigmathetaa=(sigmathetamax-sigmathetamin)/2= 5p    alternating and mean stresses
//sigmathetam=(sigmathetamax+sigmathetamin)/2= 3p
//sigmaza=(sigmazamax-sigmazmin)/2 =2.5p
//sigmazm=(sigmazamax+sigmazmin)/2 =1.5p

//sqrt(sigmathetaa^2-sigmathetaa*sigmaza+sigmaza^2)=sigmaea
//sqrt(sigmathetam^2-sigmathetam*sigmazm+sigmazm^2)=sigmaem

//sqrt(25p^2-12.3p^2+6.25p^2)=sigmaea
//sqrt(9p^2-4.5p^2+2.25p^2)=sigmaem    solving this equation we get
sigmaea=4.33 //p
sigmaem=2.60 //p

p=1/((sigmaea/sigmae)+(sigmaem/sigmay))
disp(p,"the value of p in MPa is= ")
```

Scilab code Exa 4.6 Determine fatigue

```
clc

a=[700 14 0; 14 -350 0; 0 0 -350]
disp(a)
c=[-660 -7 0; -7 -350 0; 0 0 -350]
disp(c)
sigmau=2400 //MPa
```

```
K=1
sigmae=800 //MPa
Nf=1 //cycles for SAE
Nff=10^3 //cycles for Gerber
Ne=10^8 //cycles

sigmaxa=(700+660)/2
disp(sigmaxa,"alternating and mean values of stresses in MPa is= ")
sigmaxm=(700-660)/2
disp(sigmaxm,"alternating and mean values of stresses in MPa is= ")
sigmaya=(-350+350)/2
disp(sigmaya,"alternating and mean values of stresses in MPa is= ")
sigmaym=(-350-350)/2
disp(sigmaym,"alternating and mean values of stresses in MPa is= ")
sigmazm=(-350-350)/2
disp(sigmazm,"alternating and mean values of stresses in MPa is= ")
tauxya=(14+7)/2
disp(tauxya,"alternating and mean values of stresses in MPa is= ")
tauxym=(14-7)/2
disp(tauxym,"alternating and mean values of stresses in MPa is= ")

sigmaea=sqrt(((sigmaxa-sigmaya)^2+(sigmaya-sigmaxa)^2+6*(tauxya)^2)/2)
disp(sigmaea,"in MPa is =")
sigmaem=sqrt(((sigmaxm-sigmaym)^2+(sigmaym-sigmaxm)^2+6*(tauxym)^2)/2)
disp(sigmaem,"in MPa is= ")

//solution a:
sigmacr=sigmaea/(1-(sigmaem/2400))
disp(sigmacr)
```

```
b=log(sigmau/sigmae)/log(1/Ne)
disp(b)

Ncr=1*(sigmacr/2400)^(1/b)
disp(Ncr,"in cycles is= ")

//solution b:
sigmacr=sigmaea/(1-(sigmaem/sigmau)^2)
disp(sigmacr,"in MPa is= ")
b=log(0.9*2400/sigmae)/log(Nff/Ne)
disp(b)

Ncr=Nff*(sigmacr/(0.9*2400))^(-11.587)
disp(Ncr,"in cycles is= ")
```

Scilab code Exa 4.7 Determine instantaneous maxi deflection

```
clc

W=180 //N
h=0.1 //m
L=1.16 //m
w=0.025 //m
d=0.075 //m
E=200 //GPa
k=180 //kN/m

I=w*d^3
disp(I)
//deltast=(W*L^3)/(48*E*I)          equation 1
deltast=(W*L^3*12)/(48*E*10^9*I)
disp(deltast,"deflection of a point in meter is= ")

//deltastmax=Mc/I                    equation 2
deltastmax=(W*L*12*0.0375)/(4*I)
```

```
disp(deltastmax,"deflection of a point in Pa is= ")

//solution a:
a=1+sqrt(1+((2*h)/deltast))
disp(a,"imapct factor is= ")
deltamax=deltast*a
disp(deltamax,"in meter is =")
sigmamax=deltastmax*a
disp(sigmamax,"in Pa is= ")

//solution b:
deltast=deltast+(90/180000)
disp(deltast,"static deflection of the beam in meter
    is= ")
a=1+sqrt(1+((2*h)/deltast))
disp(a,"imapct factor is= ")
deltamax=deltast*a
disp(deltamax,"in meter is =")
sigmamax=deltastmax*a
disp(sigmamax,"in Pa is= ")
```

Chapter 5

Bending of beams

Scilab code Exa 5.1 Determine neutral axis

```
clc

Mz=11000 //Nm
A1=0.13*0.02 //m
A2=0.15*0.02 //m
z1=0.01 //m
z2=0.075 //m
yA=0.043 //m
zA=-0.106 //m
yB=-0.063 //m
zB=0

//location of the centroid
z=(A1*z1+A2*z2)/(A1+A2)
disp(z,"in meter is= ")

Iz=(0.02*(0.13)^3)/12+ (0.13*0.02*(0.04)^2)
   +(0.15*(0.02)^3)/12+ (0.15*0.02*(0.035)^2)
disp(Iz,"Iz in meter^4 is= ")
Iy=(0.02*(0.13)^3)/12+ (0.13*0.02*(0.04)^2)
   +(0.15*(0.02)^3)/12+ (0.15*0.02*(0.035)^2)
```

```
disp(Iy,"Iy in meter^4 is= ")
Iyz=0+A1*0.04*(-0.035)+0+A2*(-0.035)*0.03
disp(Iyz,"Iyz in meter^4 is= ")
//thetap=(atand((-2*Iyz)/(Iz-Iy)))/2
//disp(thetap)
I1=(Iz+sqrt(0+(6.79*10^-6)^2))
disp(I1,"I1 in meter^4 is= ")
I2=(Iz-sqrt(0+(6.79*10^-6)^2))
disp(I2,"I2 in meter^4 is= ")
My1=11000*sind(45)
disp(My1,"My1 in Nm is")
Mz1=11000*sind(45)
disp(Mz1,"Mz1 in Nm is")

sigmaxA=((My1*(zA))/I1)-((Mz1*yA)/I2)
disp(sigmaxA,"sigmaxA in MPa is")
sigmaxB=0-((My1*yB)/I2)
disp(sigmaxB,"sigmaxB in MPa is")

My=0
y=((Mz*Iyz)*z)/(Mz*Iy) //.......equal to z=-1.71y
disp(y)
```

Scilab code Exa 5.4 Determine flange

```
clc

t=1.25 //mm
y=15.87 //mm
z=5.28 //mm
Iy=4765.62 //mm^4
Iz=21054.69 //mm^4
Iyz=3984.37 //mm^4
thetap=13.05 //degree
Iy1=3828.12 //mm^4
```

```
Iz1=21953.12//mm^4
s=12.5

//tau=(Vy/Iz1*t)*s*t(19.55+s*asind(13.05)/2).... equation 1
//F1=integrate((tau*t)ds)
x=integrate('(0)','s',0,1)
//F1=0.0912*Vy1                    substituting the value of tau we get F1
//Vy1*ez1=37.5*F1                  substituting the value of F1 we get ez1
ez1=37.5*0.0912
disp(ez1,"the distance in mm is= ")

//tau=(Vz1/Iy1*t)*s*t(12.05-s*asind(13.05)/2).... equation 2
//F1=integrate((tau*t)ds)
x=integrate('(0)','s',0,1)
//F1=0.204*Vz1                    substituting the value of tau we get F1
//Vz1*ey1=37.5*F1                  substituting the value of F1 we get ez1
ey1=37.5*0.204
disp(ey1,"the distance in mm is= ")
```

Scilab code Exa 5.5 Determine area and tangential stress

```
clc

P=70 //kN
c=0.05//m
c1=c
c2=c
R=0.1+0.05
A=0.005
```

```
//m=(-1/(2*c))*integrate((y/R+y)dy)
x=integrate('(-c)','c',0,1)
m=-1+(R/2*c)*log((R+c)/(R-c))
disp(m)
//m=(-1/(2*c))*integrate((y/R)-(y^2/R^2)+(y^3/R^3)-(y^4/R^4)+.....)dy)
m=-1+(3/2)*log(2)
disp(m)

M=P*R
disp(M)
sigmatheta1=(-P*c2)/(m*A*(R-c1))
disp(sigmatheta1,"stress in Pa is= ")
sigmatheta2=(P*c2)/(m*A*(R+c2))
disp(sigmatheta2,"stress in Pa is= ")
```

Chapter 6

Torsion of prismatic bars

Scilab code Exa 6.2 Shearing stress and angle of twist

```
clc

G=28 //GPa
t1=0.012
t2=0.006
t3=0.01
t4=0.006
A=0.125
h=226000 //N/m
Mt=2*A*h
disp(Mt,"applied torque in Nm is=")

tau1=(h/t1)
disp(tau1,"shearing stress in Pa is= ")
tau2=(h/t2)
disp(tau2,"shearing stress in Pa is= ")
tau3=(h/t3)
disp(tau3,"shearing stress in Pa is= ")
tau4=(h/t4)
disp(tau4,"shearing stress in Pa is= ")

```

```
//theta=(h/2*G*A)intc((1/t)ds)
theta=(h/(2*G*10^9*A))*((0.25/t1)+2*(0.5/t2)+(0.25/t3))
disp(theta,"angle of twist per unit length in rad/m is= ")
```

Scilab code Exa 6.4 Maxi longitudinal stress and angle of twist

```
clc

G=80 //GPa
E=200 //GPa
tf=10 //mm
tw=0.007 //m
t1=tw
t2=0.01
h=0.2 //m
b=0.1 //m
b2=b
b1=0.19
L=2.4 //m
If=0.01*0.1^3
Mt=1200
L=2.4

//solution a:
//C=Mt/theta
//C=(b1*t1^3+2*b2*t2^3)*(G/3)
C=((b1*t1^3+2*b2*t2^3)/3)//    without substituting the value of G we get C
disp(C,"torsional rigidity of the beam is= ")

//a=(If*E)/12
a=If/12//                  without substituting the value of E we get a
```

```
disp(a)
//alpha=1/(h*sqrt((E*If)/(2*C)))
y=sqrt((2.5*a)/(2*C))//   without substituting the
   value of h
disp(y)
//(1/alpha)==y
//sigmafmax=(Mfmax*x)/If
sigmafmax=(3.43*Mt*0.05)/a
disp(sigmafmax,"maxi longitudinal bending stress in
   the flange in MPa is= ")

//soluton b:
si=(Mt/(C*G*10^9))*(L-y*h)
disp(si,"the angle of twist at the free end in
   radian is =")
si1=(Mt*L)/(C*G*10^9)
disp(si1,"total angle of twist in radians is= ")
```

Chapter 7

Numerical methods

Scilab code Exa 7.3 Find shearing stress

```
clc
a=15 //mm
b=10 //mm
h=5 //mm
h1=4.4 //mm
h2=2.45 //mm
h3=3 //mm

x=[2 0 0 0 2 -4;0 2 0 1 -4 1;0 0 2 -4 1 0;-4 2 0 0 0
    1;1 -4.27 1 0 1.06 0;0 1.25 -7.41 1.34 0 0]
disp(x)
y=[-2 ;-2; -2; -2; -2; -2]
disp(y)
z=inv(x)*y
printf('fi=%f G*h^2*theta \n',z)

dfi=2.075
d3fi=-0.001
d2fi=-1.383
d4fi=0.002

```

```
//tauB=derivative(fi,y)B
tauB=(dfi+(d2fi/2)-(d3fi/3)+(d4fi/4))
printf('tauB=%f G*thetab\n',tauB)

dfi=1.536
d2fi=-0.613
d3fi=-0.002
d4fi=0.001
d5fi=0.001
d6fi=-0.002

//tauA=derivative(fi,x)A
tauA=(dfi+(-d2fi/2)-(d3fi/3)-(d4fi/4)+(d5fi/5)+(d6fi/6))
printf('tauA=%f G*thetaa\n',tauA)
```

Scilab code Exa 7.6 Determine moments of the supports of the beam

```
clc

p=15
P=45
a=3
b=1.5
L1=3
L2=4.5
MfAB=-(p*L1^2)/12
disp(MfAB,"in kNm is= ")
MfBA=(11.25)
disp(MfBA,"in kNm is= ")
MfBC=-(P*a*b^2)/L2^2
disp(MfBC,"in kNm is= ")
MfCB=(P*b*a^2)/L2^2
disp(MfCB,"in kNm is= ")
B=MfBA+MfBC
```

```
disp(B,"effective fem at joint B in kNm is= ")
AB=0.429*-B     //                    joint rotates until a change in moment is +3.75
disp(AB,"the change of moment in beam segment AB in kN is=")
BC=0.571*-B
disp(BC,"the change of moment in beam segment AB in kN is=")
```

Scilab code Exa 7.7 Determine stiffness matrix and nodal force matrix

```
clc

p=14 //MPa
t=0.3 //cm
E=200 //GPa
v=0.3
gamma1=77 //kN/m^3
alpha=12*10^-6 // per degree celcius
A=2
T=50 //degree celcius

D=[3.33 0.99 0;0.99 3.3 0;0 0 1.16]
disp(D)
//[D*]=(t*[D])/4*A
[D1]=(10^6*[D])/4*A
disp(D1)

//solution a: stiffness matrix
xi=0
x1=0
xj=4
x2=4
xm=0
x3=0
```

```
yi=-1
y1=-1
yj=-1
y2=-1
ym=1
y3=1

ai=0-4
a1=0-4
disp(ai,a1)
aj=0-0
a2=0-0
disp(aj,a2)
am=4-0
a3=4-0
disp(am,a3)

bi=-1-1
b1=-1-1
disp(bi,b1)
bj=1+1
b2=1+1
disp(bj,b2)
bm=-1+1
b3=-1+1
disp(bm,b3)

k11=(10^6/8)*(3.3*4+1.16*16)
printf('k11=%f\n',k11)
k12=(10^6/8)*(3.3*2*-2+0)
printf('k12=%f\n',k12)
k13=(10^6/8)*(0+1.16*4*-4)
printf('k13=%f\n',k13)
k22=(10^6/8)*(3.3*4+0)
printf('k22=%f\n',k22)
k23=0
printf('k23=%f\n',k23)
k32=0
```

```
printf('k32=%f\n',k32)
k21=(10^6/8)*(3.3*2*-2+0)
printf('k21=%f\n',k21)
k31=(10^6/8)*(0+1.16*4*-4)
printf('k31=%f\n',k31)
k33=(10^6/8)*(0+1.16*16)
printf('k33=%f\n',k33)

kuu=[k11 k12 k13;k21 k22 k23;k31 k32 k33]
disp(kuu)
kuv=10^6*[2.15 -1.16 -0.99;-0.99 0 0.99;-1.16 1.16 0]
disp(kuv)
kvv=10^6*[7.18 -0.58 -6.6;-0.58 0.58 0;-6.6 0 6.6]
disp(kvv)
kvu=[2.15 -0.99 -1.16;-1.16 0 1.16;-0.99 0.99 0]
disp(kvu)

ke=[kuu kuv;kvu kvv]
disp(ke)

//solution b:
Fx=0
Fy=0.077 //N/cm^2
Qbe={0,0,0,-0.0308,-0.0308,-0.0308}//N
disp(Qbe)
stp=(sqrt(20)*0.3)*{-2*(1400/sqrt(20)),-4*(1400/sqrt(20))}
disp(stp)
Qp3={0,-420,-420,0,-840,-840}
disp(Qp3)

epsilon=alpha*T
printf('epsilon=%f\n\n',epsilon)
//Qte=[B']*[D]*epsilon*At
Qte=(1/8)*[-2 0 -4;2 0 0;0 0 4;0 -4 -2;0 0 2;0 4 0]*((200*10^5)/0.91)*[1 0.3 0;0.3 1 0;0 0 0.35]*[0.0006;0.0006;0]*(1.2)
```

```
printf('Qte=%f in N\n',Qte)

Qe={-5142.85;4742.85;-400;-10285.71;-840.03;9445.67}
disp(Qe,"in N is=")
```

Scilab code Exa 7.8 Calculate deflections

```
clc

t=0.3 //cm
E=200 //GPa
v=0.3
i=2
j=4
m=3
L=5000 //N

a1=0-4
a2=0-4
disp(a1,a2)
aj=4-0
a4=4-0
disp(aj,a4)
am=4-4
a3=4-4
disp(am,a3)

bi=1-1
b2=1-1
disp(bi,b2)
bj=1+1
b4=1+1
disp(bj,b4)
bm=-1-1
b3=-1-1
```

```
disp(bm,b3)

k22=(10^6/8)*(3.3*0+1.16*16)
printf('k22=%f\n',k22)
k44=(10^6/8)*(3.3*4*+1.16*16)
printf('k44=%f\n',k44)
k24=(10^6/8)*(3.3*0+1.16*4*-4)
printf('k24=%f\n',k24)
k42=(10^6/8)*(3.3*0+1.16*4*-4)
printf('k42=%f\n',k42)
k23=0
printf('k23=%f\n',k23)
k32=0
printf('k32=%f\n',k32)
k43=(10^6/8)*(3.3*2*-2+1.16*0)
printf('k43=%f\n',k43)
k34=(10^6/8)*(3.3*2*-2+1.16*0)
printf('k34=%f\n',k34)
k33=(10^6/8)*(3.3*4+1.16*0)
printf('k33=%f\n',k33)


kuu=[k22 k23 k24;k32 k33 k34;k42 k43 k44]
disp(kuu)
kuv=10^6*[0 1.16 -1.16;0.99 0 -0.99;-0.99 -1.16 2.15]
disp(kuv)
kvv=10^6*[6.6 0 -6.6;0 0.58 -0.58;-6.6 -0.58 7.18]
disp(kvv)
kvu=10^6*[0 0.99 -0.99;1.16 0 -1.16;-1.16 -0.99 2.15]
disp(kvu)

ke=[kuu kuv;kvu kvv]
disp(ke)

k1=[3.97 -1.65 -2.32 0;-1.65 1.65 0 0;-2.32 0 2.32 0;0 0 0 0]
```

```
disp(k1)
k2=[2.15 -1.16 -0.99 0;-0.99 0 0.99 0;-1.16 1.16 0 0;0 0 0 0]
disp(k2)
k3=[2.15 -0.99 -1.16 0;-1.16 0 1.16 0;-0.99 0.99 0 0;0 0 0 0]
disp(k3)
k4=[7.18 -0.58 -6.6 0;-0.58 0.58 0 0;-6.6 0 6.6 0;0 0 0 0]
disp(k4)

ka=[k1 k2 ;k3 k4]
disp(ka)

k5=[0 0 0 0;0 2.32 0 -2.32;0 0 1.65 -1.65;0 -2.32 -1.65 3.97]
disp(k5)
k6=[0 0 0 0;0 0 1.16 -1.16;0 0.99 0 -0.99;0 -0.99 -1.16 2.15]
disp(k6)
k7=[0 0 0 0;0 0 0.99 -0.99;0 1.16 0 -1.16;0 -1.16 -0.99 2.15]
disp(k7)
k8=[0 0 0 0;0 6.6 0 -6.6;0 0 0.58 -0.58;0 -6.6 -0.58 7.18]
disp(k8)

kb=[k5 k6 ;k7 k8]
disp(kb)

K=[ka+kb]
disp(K)

Qy4=((3*(-5000))/4*1)*{(1/2)*(1+1)+0.33*[-0.25*(1-1+1)-0.75]}
printf('Qy4=%f N\n',Qy4)                              // textbook ans is wrong
```

```
Qy2=((3*(-5000))/4*1)*{(1/2)*(1+1)-0.33*[1+0.75*(1-1+1)-0.75]}
printf('Qy2=%f N\n',Qy2)                                    // textbook ans is wrong

Q=[0 0 0 0 0 Qy4 0 Qy2]
disp(Q)
u1=0
u3=0
v1=0
v3=0

Z=[3.97 -2.32 0 -1.16;-2.32 3.97 -0.99 2.15;0 -0.99 7.18 -6.6;-1.16 2.15 -6.6 7.18]
disp(Z)
z=inv(Z)
disp(z)
X=(z*[0;0;-2512.5;-2512.5])
disp(X)
X1= X*10**-6
disp(X1,"u2 u4 v2 v4 is= ")

Y=[-2 2 0 0 0 0;0 0 0 -4 0 4;-4 0 4 -2 2 0]
disp(Y)
W=(Y*[0;-0.0012;0;0;-0.0068;0])
disp(W)
W1=W*(1/8)
disp(W1,"espx epsy gammaxy is= ")

y=[1 0.3 0;0.3 1 0;0 0 0.35]*W1
disp(y)
u=(200*10^9/0.91)
disp(u)
U=u*y
disp(U,"sigmax sigmay tauxy in Pa is= ")
```

Scilab code Exa 7.9 Calculate finite element

```
clc

L=76.2 //mm
h=50.8 //mm
t=25.4 //mm
p=6895 //kPa
E=207 //GPa
v=0.15

//solution a: exact solution
//p=Mh/I
//sigmax=-(y/h)*p
sigmay=0
tauxy=0
//derivative(u,x)=-(yp/Eh)
//derivative(v,y)=(v*y*p)/(Eh)
//derivative(u,y)+derivative(v,x)=0
//u=-(p/E*h)*x*y                              // for u(0,0)=v(0,0)=0 and u(L,0)=0
//v=-(p/2*E*h)*(x^2+v*y^2)
//sigmax=-(1/0.0508)*(y*p)
sigmaxmax=6895 //kPa
//u(0.0762,-0.0254)=25.4*10^-6 //m
//v(0.0762,0)=1.905*10^-6 //m

//solution b:
Qx10=((0.0254*0.0254)/6)*((2*sigmaxmax)+3447.5)
disp(Qx10,"in mN is= ")
Qx11=((0.0254*0.0254)/6)*(2*3447.5+sigmaxmax)+((0.0254*0.0254)/6)*(2*3447.5+0)
disp(Qx11,"in mN is= ")
Qx12=((0.0254*0.0254)/6)*(0+3447.5)
```

```
disp(Qx12,"in mN is= ")
```

Chapter 8

Axisymmetrically loaded members

Scilab code Exa 8.1 Determine maxi internal and external pressure

```
clc

di=0.3 //m
de=0.4 //m
v=0.3
sigmathetamax=250*10^6 //Pa
p0=0
pi=0

//solution a:
a=0.15
b=0.2
r=a
//sigmathetamax=pi*((b^2+a^2)/(b^2-a^2))
pi=sigmathetamax*((b^2-a^2)/(b^2+a^2))
disp(pi,"in Pa is= ")

//solution b:
r=a
```

```
//sigmathetamax=-2*p0*(b^2/(b^2-a^2))
p0=-(-sigmathetamax)*((b^2-a^2)/(2*b^2))
disp(p0,"in Pa is= ")

//solution c:
u=((a^3*pi)/(b^2-a^2))*(0.7+1.3*(b^2/a^2))
disp(u,"in per E meter is= ")
sigmaz=(pi*a^2-p0*b^2)/(b^2-a^2)
disp(sigmaz,"for longitudinal stress is")
```

Scilab code Exa 8.2 `Calculate internal pressure`

```
clc

sigmayp=340 //MPa
tauyp=sigmayp/2 //MPa
disp(tauyp,"in MPa is=")
a=0.1 //m
b=0.15 //m
v=0.3
//pi=4*p0
//sigmatheta=(pi*(a^2+b^2)-2*p0*b^2)/(b^2-a^2)
//sigmatheta=1.7*pi

//slloution a: maxi principal stress theory
sigmatheta=1.7
pi=sigmayp/sigmatheta
disp(pi,"in MPa is= ")

//slloution b: maxi shearing stress theory
//(sigmatheta-sigmar)/2=1.35*pi
pi=tauyp/1.35
disp(pi,"in MPa is= ")

//solution c: energy of distortion theory
```

```
sigmar=-1
sigmayp1=sqrt(sigmatheta^2+sigmar^2-sigmatheta*sigmar)//*pi
disp(sigmayp1)
pi=sigmayp/sigmayp1
disp(pi,"in MPa is=")

//solution d: maxi principal strain theory
//(sigmatheta-v*sigmar)/E=sigmayp/E
pi=sigmayp/(sigmatheta-v*sigmar)
disp(pi,"in MPa is= ")

//solution e: octahedral shearing stress theory:
pi=(sqrt(2)*sigmayp)/sqrt((sigmatheta-sigmar)^2+sigmar^2+(-sigmatheta)^2)
disp(pi,"in MPa is= ")
```

Scilab code Exa 8.3 Distribution of tangential stress

```
clc

a=0.15 //m
b=0.2 //m
c=0.25 //m
E=200*10^9 //Pa
delta=0.0001 //m
140 //MPa

p=((E*delta)/8)*(((b^2-a^2)*(c^2-b^2))/(2*(b^2)*(c^2-a^2)))
disp(p,"the contact pressure in Pa is= ") //textbook ans is wrong

p=12.3*10^6
sigmatheta=p*((b^2+c^2)/(c^2-b^2)) // where r=0.2
```

```
disp(sigmatheta,"tangential stresses in the outer cylinder in Pa is= ")
sigmatheta1=(2*p*b^2)/(c^2-b^2) // where r=0.25
disp(sigmatheta1,"tangential stresses in the outer cylinder in Pa is= ")
sigmatheta3=-(2*p*b^2)/(b^2-a^2) // where r=0.15
disp(sigmatheta3,"tangential stresses in the inner cylinder in Pa is= ")
sigmatheta4=-p*((b^2+a^2)/(b^2-a^2)) // where r=0.2
disp(sigmatheta4,"tangential stresses in the inner cylinder in Pa is= ")
```

Scilab code Exa 8.4 Determine shrinking allowance and maxi stress

```
clc

dn=0.1 //m
do=0.5 //m
t=0.08 //m
w=6900*(2*%pi/60) //rpm
row=7.8*10^3//Ns^2/m^4
E=200*10^9 //Pa
v=0.3
b=0.05
c=0.25


//solution a:
//ud=((0.05*3.3*0.7)*(0.0025+0.0625-(1.3/3.3)*0.0025+(1.3/0.7)*0.0625)*row*w^2)/(8*E)
ud=((0.05*3.3*0.7)*(b^2+c^2-(1.3/3.3)*b^2+(1.3/0.7)*c^2))/(8)
disp(ud,"radial displacement of the disk in meter is = ")

```

```
//us=((0.05*0.7)*(3.3*0.0025-1.3*0.0025)*row*w^2)/(8*E)
us=((0.05*0.7)*(3.3*b^2-1.3*b^2))/(8)
disp(us,"radial displacement of the shaft in meter is= ")
delta=(ud-us)*row*w^2/E
disp(delta)

//solution b:
//p=E*delta*(c^2-b^2)/(2*b*c^2)
p=E*delta*(c^2-b^2)/(2*b*c^2)
disp(p,"in Pa is= ")
sigmathetamax=p*(c^2+b^2)/(c^2-b^2)
disp(sigmathetamax,"in Pa is= ")

//solution c:
sigmathetamax=3.3*(b^2+c^2-(1.9/3.3)*b^2+c^2)*row*w^2/8
disp(sigmathetamax,"in Pa is= ")
```

Scilab code Exa 8.5 Determine maxi stress and radial displacement

```
clc

ti=0.075 //m
to=0.015//m
a=0.05//m
b=0.25//m
delta=0.05 //mm
w=6900*(2*%pi/60) //rpm
s=1
row=7.8*10^3//Ns^2/m^4
E=200 //GPa

//solution a:
```

```
t1=ti*a^s
disp(t1,"t1 is=")
t1=to*b^2
disp(t1,"t1 is=")
//(ti/to)=(t1*a^-s)/(t1*b^-s)=(b/a)^s
c=(b/a)^s

(ti/to)==c
disp(ti/to,"ti/t0 is=")
m1=-0.5+sqrt((0.5)^2+(1+0.3*1))
disp(m1,"m1 is=")
m2=-0.5-sqrt((0.5)^2+(1+0.3*1))
disp(m2,"m2 is=")

//sigmar=0=(c1/t1)*(0.05)^m1+(c2/t1)*(0.05)^(m2)
    -0.00176*row*w^2        // r=0.05
//sigmar=0=(c1/t1)*(0.25)^m1+(c2/t1)*(0.25)^(m2)
    -0.0439*row*w^2         // r=0.25

c1=t1*0.12529*row*w^2
disp(c1,"c1 is=")
c2=t1*-6.272*10^-5*row*w^2
disp(c2,"c2 is=")

r=0.05
sigmar=(0.12529*r^0.745-6.272*10^-5*r^(-1.745)-0.70*
    r^2)//*row*w^2
disp(sigmar,"sigmar is= ")

sigmatheta=(0.09334*r^0.745+1.095*10^-4*r^(-1.745)
    -0.40*r^2)//*row*w^2
disp(sigmatheta,"sigmatheta is= ")

//solution b:
r=0.05
//ur=(r*sigmatheta)/E
ur=(r*sigmatheta)
disp(ur,"ur is= ")
```

Scilab code Exa 8.6 Distribution stress and disk profile

```
clc

b=0.25 //m
w=6900*(2*%pi/60) //rpm
t1=0.075 //m
t2=0.015 //m
row=7.8*10^3//Ns^2/m^4
c1=t1

x=t2/t1
disp(x)

//(t2/t1)==(c1*exp(-(row*w^2/2*sigma)*b^2))/c1
//exp(-(row*w^2/2*sigma)*b^2)=x
//log(x)=-(row*w^2*b^2/2*sigma)
y=2*log(x)
disp(y)
sigma=-(row*w^2*b^2)/y
disp(sigma,"in Pa is= ")

//t=c1*exp(-row*(w^2/2*sigma)*r^2)
z=row*(w^2/(2*sigma))
disp(z)
```

Chapter 9

Beams on elastic foundations

Scilab code Exa 9.1 Calculate maxi deflections and force per unit length

```
clc

w=0.1 //m
d=0.115 //m
l=4 //m
p=175 //kN/m
k=14*10^6 //Pa
E=200*10^9 //Pa
I=(0.1*(0.15)^3)

//deltav=(p/2*k)*derivative(x)*beta*exp^(betax)*(cos
    beta(x)+sin beta(x))
//vA=(p/2k)*(2-exp^(betaa)*cos betaa - exp^(betab)*
    cos betab)

beta=(k/(4*E*I/12))^(0.25)
disp(beta,"in meter inverse is= ")

vmax=(p*(2-(-0.0345)-(0.0345)))/(2*14000)
disp(vmax,"in meter is= ")
z=k*vmax
```

```
disp(z,"maxi force per unit of length between beam &
    foundation in kN/m is= ")

// Ans varies due to round of error
```

Scilab code Exa 9.4 Find maxi moment and deflection

```
clc

a=1.5 //m
E=206.8*10^9 //Pa
K=10000 //N/m
I=6*10^-6 //m^4
P=6700 //N
c=0.05

k=K/a
disp(k,"foundation modulus of the equivalent
   continuous elastic support in Pa is=")

beta=(k/(4*E*I))^(1/4)
disp(beta)

//sigmamax=(M*c/I)=(P*c/4*beta*I)
sigmamax=((P*c)/(4*beta*I))
disp(sigmamax,"in Pa is=")

vmax=(P*beta)/(2*k)
disp(vmax,"in meter is=")
```

Chapter 11

Elastic stability

Scilab code Exa 11.1 Buckling load of the column

```
clc

E=210*10^9 //Pa
d=100 //mm
t=50 //mm
A=0.005
Iz=0.05*(0.1^3)/12
disp(Iz)
Iy=0.1*(0.05^3)/12
disp(Iy)
//r=sqrt(Iy/A)
r= sqrt(Iy/A)
disp(r)//mm
L=2.75

//P=W/tand(15)=3.732
Pcr=(%pi^2*E*Iz)/L^2
disp(Pcr,"into W is= ")
W=Pcr/3.732
disp(W,"in N is= ")

```

```
Pcr=(%pi^2*E*Iy)/L^2
disp(Pcr,"into W is= ")
W=Pcr/3.732
disp(W,"in N is= ")

// Ans varies due to round of error
```

Chapter 12

Plastic behavior of solids

Scilab code Exa 12.1 Determine maxi plastic stress and strain

```
clc

alpha=45
sigmayp=35*10^6 //Pa
k=840//MPa
n=0.2
L0=3 //m
Aad=10*10^-5 //m^2
Acd=10*10^-5 //m^2
Abd=15*10^-5 //m^2

P=sigmayp*Abd+2*sigmayp*Aad*cosd(45)
disp(P,"plastic yeilding in N is= ")
sigma=k*n^n
disp(sigma,"maxi allowable stress in MPa is= ")
epsilon1=n
disp(epsilon1,"axial stress is= ")
epsilon2=-0.1
disp(epsilon2,"transverse stress is= ")
epsilon3=-0.1
disp(epsilon3,"transverse stress is= ")
```

```
z=3*n
disp(z,"total elongation for stability in meter is=
   ")
```