Scilab Textbook Companion for Mechanics of Materials by A. Pytel and J. Kiusalaas[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Stress

Scilab code Exa 1.1 Stress at section 1

```

clear//

//NOTE:The notation has been changed to simplify the
    coding process

//Variable Declaration
P_AB=4000 //Axial Force at section 1 in lb
P_BC=5000 //Axial Force at section 2 in lb
P_CD=7000 //Axial Force at section 3 in lb
A_1=1.2 //Area at section 1 in in^2
A_2=1.8 //Area at section 2 in in^2
A_3=1.6 //Area at section 3 in in^2

//Calculation
//S indicates sigma here
S_AB=P_AB/A_1 //Stress at section 1 in psi (T)
S_BC=P_BC/A_2 //Stress at section 2 in psi (C)
S_CD=P_CD/A_3 //Stress at section 3 in psi (C)

//Result
```

```
printf("\n The stress at the three sections is given as")
printf("\n Stress at section 1= %0.0f psi/in^2 section 2= %0.0f psi/in^2 section 3= %0.3f psi/in^2",S_AB,S_BC,S_CD)
```

Scilab code Exa 1.2 The Stress in member BD

```

clear//

//Variable Declaration
Ay=40 //Vertical Reaction at A in kN
Hy=60 //Vertical Reaction at H in kN
Hx=0 //Horizontal Reaction at H in kN
y=3 //Height in m
x=5 //Distance in m
p=4 //Panel distance in m
A=900 //Area of the member in mm^2
P_C=30 //Force at point C in kN

//Calculation
//Part 1
//Applying summation of forces in the x and y direction and equating to zero
P_AB=(-Ay)*(x*y**-1) //Force in member AB in kN
P_AC=-(p*x**-1*P_AB) //Force in member AC in kN
//Using stress=force/area
S_AC=(P_AC/A)*10**3 //Stress in member AC in MPa (T)

//Part 2
//Sum of moments about point E to zero
P_BD=(Ay*p*2-(P_C*p))*y**-1 //Force in memeber AB in kN (C)
S_BD=(P_BD/A)*10**3 //Stress in member in MPa (C)
```

```

//Result
printf("\n The Stress in member AC is %0.1f MPa (T)"
    ,S_AC)
printf("\n The Stress in member BD is %0.1f MPa (C)"
    ,S_BD)
```

Scilab code Exa 1.3 The maximum value of W allowable

```

clear//
//

//Variable Declaration
A_AB=800 //Area of member AB in m^2
A_AC=400 //Area of member AC in m^2
W_AB=110 //Safe value of stress in Pa for AB
W_AC=120 //Safe value of stress in Pa for AC
theta1=60*3.14*180**-1 //Angle in radians
theta2=40*3.14*180**-1 //Angle in radians

//Calculations
//Applying sum of forces
//Solving by matrix method putting W as 1
A =[-cos(theta1),cos(theta2);sin(theta1),sin(theta2)
    ]

B = [1;1]
C=inv(A)
D=C

//Using newtons third law
//Two values of W hence the change in the notation
W1=(W_AB*A_AB)*D(2,2)**-1 //Weight W in N
W2=(W_AC*A_AC)*D(1,2)**-1 //Weight W in N
```

```

//Result
printf("\n The maximum value of W allowable is %0.1f
    kN",W2*1000**-1)
```

Scilab code Exa 1.4 The maximum load that the joint can carry

```

clear//

//Variable Declaration
d=3*4**-1 //Rivet diameter in inches
t=7*8**-1 //Thickness of the plate in inches
tau=14000 //Shear stress limit in psi
sigma_b=18000 //Normal stress limit in psi

//Calculations
//Design Shear Stress in Rivets
V=tau*(d**2*(%pi/4))*4 //Shear force maximum
    allowable in lb
//Design for bearing stress in plate
Pb=sigma_b*t*d*4 //lb

//Result
printf("\n The maximum load that the joint can carry
    is %0.0f lb",V)
```

Chapter 2

Strain

Scilab code Exa 2.1 The elongation in the total structure

```

clear//

//Variable Declaration
//Axial Forces in lb in member AB, BC and CD
P_AB=2000
P_BC=2000
P_CD=4000
//Other Variables
E=29*10**6 //Modulus of Elasticity in psi
//Length of each member in inches
L_AB=5*12
L_BC=4*12
L_CD=4*12
//Diameter of each member in inches
D_AB=0.5
D_BC=0.75
D_CD=0.75

//Calculation
//Area Calculation of each member in square inches
```

```
A_AB=(%pi*D_AB**2)/4
A_BC=(%pi*D_BC**2)/4
A_CD=(%pi*D_CD**2)/4

//Using relation delta=(PL/AE) to compute strain
//As stress in Member CD is compression
delta=(E**-1)*((P_AB*L_AB*A_AB**-1)+(P_BC*L_BC*A_BC**-1)-(P_CD*L_CD*A_CD**-1))

//Result
printf("\n The elongation in the total structure is %0.5f in",delta)
```

Scilab code Exa 2.3 The displacement of point C

```

clear//

//Variable Decelration
A_AC=0.25 //Cross Sectional Area in square inch
Load=2000 //Load at point C in lb
E=29*10**6 //Modulus of elasticity in psi
theta=(%pi*40)/180 //Angle in radians
L_BC=8 //Length in ft

//Calculations
//Using sum of forces
P_AC=Load/sin(theta) //Force in cable AC in lb
L_AC=(L_BC*12)/cos(theta) //Length of cable AC in in

delta_AC=(P_AC*L_AC)/(E*A_AC) //elongation in inches

delta_C=delta_AC/sin(theta) //displacement of point C in inches

```

```
//Result
printf("\n The displacement of point C is %0.4f in",delta_C)
```

Scilab code Exa 2.4 The elongation in the bar

```

clear//

//Variable Declaration
d=0.05 //Diameter of the rod in mm
P=8000 //Load on the bar in N
E=40*10**6 //Modulus of elasticity in Pa
v=0.45 //Poisson Ratio
L=300 //Length of the rod in mm

//Calculation
A=((%pi*d**2)/4) //Area of the bar in mm^2
sigma_x=-P/A //Axial Stress in the bar in Pa
//As contact pressure resists the force
p=(v*sigma_x)/(1-v)
//Using Axial Strain formula
e_x=(sigma_x-(v*2*p))/E
//Corresponding change in length
delta=e_x*L //contraction in mm
//Without constrains of the wall
delta_w=(-P*(L*10**-3))/(E*A) //Elongation in m

//Result
printf("\n The elongation in the bar is %0.2f mm contraction",delta)
```

Scilab code Exa 2.5 The displacement of the rubber layer

```
clear//

//Variable Declaration
E=500 //Modulus of elasticity in psi
v=0.48 //Poisson ratio
V=600 //Force in lb
w=5 //Width of the plate in inches
l=9 //Length of the plate in inches
t=1.75 //Thickness of the rubber layer in inches

//Calculations
tau=V*(w*l)**-1 //Shear stress in rubber in psi
G=E/(2*(1+v)) //Bulk modulus in psi
gamma=tau/G //Shear Modulus
disp=t*gamma //Diplacement in inches

//Result
printf("\n The displacement of the rubber layer is
    %0.4f in",disp)
```

Scilab code Exa 2.6 The stress in steel and concrete

```
clear//

//Variable Declaration
P=10**6 //Force on the member in N
Es=200 //Modulus of elasticity of steel in GPa
Ec=14 //Modulus of elasticity concrete in GPa
As=900*10**-6 //Area of steel in m^2
Ac=0.3**2 //Area of concrete block in m^2

//Calculation
//Cross Sectional Areas
```

```
Ast=4*As //Cross Sectional Area in m^2 of Steel
Act=Ac-Ast //Cross Sectional Area of Concrete in m^2

//Applying equilibrium to the structure
//Using the ratio of stress and modulii of
    elasticity we obtain the following eq
sigma_ct=P/(((Es*Ec**-1)*Ast)+Act) //Stress in
    Concrete in Pa
sigma_st=sigma_ct*Es*Ec**-1 //Stress in Steel in Pa

//Result
printf("\n The stress in steel and concrete is as
    follows %0.1f MPa and %0.3f Mpa respectively",
    sigma_st*10**-6,sigma_ct*10**-6)
```

Scilab code Exa 2.7 The maximum allowable force

```

clear//

//Variable Declaration
//Say the ratio of stress in steel to concrete is R
R=14.286
sigma_co=6*10**6 //Stress in concrete in Pa
Ast=3.6*10**-3 //Area of steel in m^2
Aco=86.4*10**-3 //Area of Concrete in m^2

//Calculation
sigma_st=R*sigma_co //Stress in steel in Pa
//Here stress is below the allowable hence safe
P=sigma_st*Ast+sigma_co*Aco //Allowable force in N

//Result
printf("\n The maximum allowable force is %0.0f kN",
    P*10**-3)
```

Scilab code Exa 2.8 The safe load on the structure

```

clear//

//NOTE:The NOtation has been changed to ease coding
//Variable Declaration
d=0.005 //difference in length in inch
L=10 //Length in inch
//Area of copper and aluminium in sq.in
Ac=2 //Area of copper
Aa=3 //Area of aluminium
//Modulus of elasticity of copper and aluminium in
    psi
Ec=17000000 //Copper
Ea=10**7 //Aluminium
//Allowable Stress in psi
Sc=20*10**3 //Copper
Sa=10*10**3 //Aluminium

//Calculation
//Equilibrium is Pc+Pa=P
//Hookes Law is delta_c=delta_a+0.005
//Simplfying the solution we have constants we can
    directly compute
A=d*Ec*(L+d)**-1
B=Ec*Ea**-1
C=L*B*(L+d)**-1
sigma_a=(Sc-A)*C**-1

//Using equilibrium equation
P=Sc*Ac+sigma_a*Aa //Safe load in lb

//Result
```

```
printf("\n The safe load on the structure is %0.0f
   lb",P)
```

Scilab code Exa 2.9 `psi steel and bronze`

```

clear//
//

//Variable Declaration
P=50*10**3 //Load applied in N
x1=0.6 //Length in m
x2=1.6 //Length in m
L1=1 //Length of steel cable in m
L2=2 //Length of bronze cable in m
L=2.4 //Length in m
//Area in m^2
Ast=600*10**-6 //Steel
Abr=300*10**-6 //Bronze
//Modulus of elasticity in GPa
Est=200 //Steel
Ebr=83 //Bronze

//Calculations
//Applying the equilibrium and Hookes law we solve
   by matrix method
a=[x1,x2;1,-((x1*Est*Ast*L2)/(x2*Ebr*Abr))]
b=([L*P;0])
y=linsolve(a,b)

//Stresses in Pa
sigma_st=-y(1)*Ast**-1 //Stress in steel
sigma_br=-y(2)/Abr //Stress in bronze

//Result
```

```
printf("\n The stresses in steel and bronze are as follows")
printf("\n %0.1f MPa and %0.1f MPa respectively",sigma_st*10**-6,sigma_br*10**-6)
```

Scilab code Exa 2.10 The Stress in part 2 in the rod

```

clear//

//Variable Declaration
L=2.5 //Length in m
A=1200 //Cross sectional Area in mm^2
delta_T=40 //Temperature drop in degree C
delta=0.5*10**-3 //Movement of the walls in mm
alpha=11.7*10**-6 //Coefficient of thermal expansion in /degreeC
E=200*10**9 //Modulus of elasticity in Pa

//Calculation
//Part(1)
sigma_1=alpha*delta_T*E //Stress in the rod in Pa

//Part(2)
//Using Hookes Law
sigma_2=E*((alpha*delta_T)-(delta*L**-1)) //Stress in the rod in Pa

printf("\n The Stress in part 1 in the rod is %0.1f MPa",sigma_1*10**-6)
printf("\n The Stress in part 2 in the rod is %0.1f MPa",sigma_2*10**-6)
```

Scilab code Exa 2.11 psi steel and bronze

```

clear//

//Variable Declaration
delta=100 //Increase in the temperature in degreeF
Load=12000 //Load on the beam in lb
//Length in inch
Ls=2*12 //Steel
Lb=3*12 //Bronze
//Area in sq.in
As=0.75 //Steel
Ab=1.5 //Bronze
//Modulus of elasticity in psi
Es=29*10**6 //Steel
Eb=12*10**6 //Bronze
//Coefficient of thermal expansion in /degree C
alpha_s=6.5*10**-6 //Steel
alpha_b=10**-5 //Bronze

//Calculations
//Applying the Hookes Law and equilibrium we get two
    equations
a=([[Ls*(Es*As)**-1,-Lb*(Eb*Ab)**-1;2,1]])
b=([(alpha_b*delta*Lb-alpha_s*delta*Ls);Load])
y=linsolve(a,b)

//Stresses
sigma_st=-y(1)*As**-1 //Stress in steel in psi (T)
sigma_br=-y(2)*Ab**-1 //Stress in bronze in psi (C)

//Result
printf("\n The Stress in steel and bronze are as
    follows")
printf("\n %0.3f psi (T) and %0.3f psi(C)",sigma_st,
    sigma_br)
```

Scilab code Exa 2.12 The change in the Temperature

```

clear//

//Variable Declaration
P=6000 //Force in lb
Est=29*10**6 //Modulus of elasticity of steel in psi
L1=24 //Length in inches
L2=36 //Length in inches
alpha_1=6.5*10**-6 //coefficient of thermal
    expansion in /degree F of steel
alpha_2=10**-5 //coefficient of thermal expansion in
     /degree F of bronze
As=0.75 //Area os steel in sq.in

//Calculations
delta_T=((P*L1)/(Est*As))/(alpha_2*L2-alpha_1*L1) //
    Change in temperature in degree F

printf("\n The change in the Temperature is %0.1f F"
    ,delta_T)
```

Chapter 3

Torsion

Scilab code Exa 3.1 To satisfy both strength and rigidity conditions d

```

clear//

//Variable Declaration
P=20*10**3 //Power in W
f=2 //Frequency in Hz
t_max=40*10**6 //Maximum shear stress in Pa
G=83*10**9 //Bulk modulus in Pa
theta=(6*%pi)/180 //Angle of twist in radians
L=3 //Length in m

//Calculations
//Strength condition
T=P/(2*%pi*f) //Torque in N.m
d1=((16*T)/(%pi*t_max))**0.333 //Max allowable diameter in mm

//Applying torque-twist relationship
d2=((32*T*L)/(G*theta*%pi))**0.25 //Diameter in mm

d=max(d1,d2)
```

```
printf("\n To satisfy both strength and rigidity
    conditions d= %0.1f mm",d*1000)
```

Scilab code Exa 3.2 psi in Steel

```

clear//

//Variable Declaration
Ga=4*10**6 //Bulk modulus of Aluminium in psi
Gs=12*10**6 //Bulk Modulus of Steel in psi
T=10**4 //Torque in lb.in
L1=3 //Length in ft of the Steel bar
L2=6 //Length in ft of the Aluminium bar
d1=3 //Diameter of the Aluminium bar in inches
d2=2 //Diameter of the Steel bar in inches

//Calculations
//Using Compatibility and equlibrium conditions
a=([[1,1;(L1*32)/(Gs*%pi*d2**4),-((L2*32)/(Ga*d1**4*
    %pi))]])
b=([T;0])
y=linsolve(a,b)

//Stresses
t_max_st=(16*-y(1))/(%pi*d2**3) //Max shear Stress
    in Steel in psi
t_max_al=(16*-y(2))/(%pi*d1**3) //Max shear stress
    in aluminium in psi

printf("\n The maximum values of Shear Stresses are
    as follows")
printf("\n %0.1f psi in Steel and %0.1f psi in
    aluminium",(t_max_st),t_max_al)
```

Scilab code Exa 3.3 The angle of twist

```

clear//

//Variable Declaration
d=2 //Diameter in ft
G=12*10**6 //Bulk Modulus in psi
//Torque in lb.ft
T1=500 //Torque 1
T2=900 //Torque 2
T3=1000 //Torque 3
//Length in ft
L1=4
L2=3
L3=5

//Calculations
//Applying the sum of torques we get
Tab=T1 //Torque at section AB in lb.ft
Tbc=-T2+T1 //Torque at section BC in lb.ft
Tcd=T3-T2+T1 //Torque at Section CD in lb.ft

//Summing the angle of twists
theta_r=(((Tab*12*L3*12)+(Tbc*12*L2*12)+(Tcd*12*L1
    *12))*32)/(%pi*2**4*G)
theta=(theta_r*180)/%pi //Angle in degrees

printf("\n The angle of twist is %0.3f degrees",
    theta)
```

Scilab code Exa 3.4 The angle of twist in the shaft

```
clear//

//Variable Declaration
L=1.5 //Length of the shaft in m
t_B=200 //Torque per unit length in N.m/m
d=0.025 //Diameter of the shaft in m
G=80*10**9 //Bulk Modulus for steel in Pa


//Calculations
//Part(1)
//After carrying out the variable integration
T_A=0.5*t_B*L //Torque about point A in N.m
//Using equation of max stress
tau_Max=(16*T_A)*(%pi*d**3)**-1 //Maximum stress in the shaft in Pa

//Part(2)
J=(%pi*d**4)*32**-1 //Polar moment of inertia in m^4
//After carrying out the computation for angle of twist we get
theta_r=(t_B*L**2)*(3*G*J)**-1 //Angle of twist in radians
theta=theta_r*(180*%pi**-1) //Angle of twist in degrees

//Result
printf("\n Result for part (1)")
printf("\n Maximum Shear Stress in the shaft is %0.1f MPa",tau_Max/10**6)
printf("\n Result for part (2)")
printf("\n The angle of twist in the shaft is %0.2f degrees",theta)
```

Scilab code Exa 3.5 The shear stress in the wall

```

clear//

//Variable Declaration
L=6 //Length of the tube in ft
t=3*8**-1 //Constant wall thickness in inches
G=12*10**6 //Bulk modulus of the tube in psi
w1=6 //Width on the top in inches
w2=4 //Width at the bottom in inches
h=5 //Height in inches
theta=0.5 //Angle of twist in radians

//Calculations
//Part(1)
Ao=(w1+w2)*2**-1*h //Area enclosed by the median
    line in sq.in
S=w1+w2+2*(sqrt(1**2+h**2)) //Length of the median
    line in inches
//Using the torsional stifness formula we get
k=4*G*Ao**2*t*(L*12*S)**-1*(%pi*180**-1) //tortional
     Stiffness  in lb.in/rad

//Part(2)
T=k*theta //Torque required to produce an angle of
    twist of theta in lb.in
q=T*(2*Ao)**-1 //Shear flow in lb/in
tau=q/t //Shear stress in the wall in psi


//Result
printf("\n Part(1) results")
printf("\n Torsional stiffness is %0.0f lb.in/deg",k
    )
printf("\n Part(2) results")
printf("\n The shear stress in the wall is %0.0f psi
    ",tau)
```

Scilab code Exa 3.6 The angle of twist

```

clear//

//Variable Declaration
L=1.2 //Length of the tube in m
tau=40*10**6 //MAximum shear stress  in MPa
t=0.002 //Thickness in m
r=0.025 //Radius of the semicircle in m
G=28*10**9 //Bulk Modulus in Pa
t1=2 //Thickness in mm
t2=3 //thickness in mm

//Calculations
//Part(1)
q=tau*t //Shear flow causing the stress in N/m
Ao=%pi*r**2*0.5 //Area of the semi-circle in m^2
T=2*Ao*q //Torque causing the shear stress in N.m

//Part(2)
//After computing the median lines integration we get
S=(%pi*25*t1**-1)+(2*25*t2**-1) //Length of median line
theta_r=T*L*S*(4*G*Ao**2)**-1 //Angle of twist in radians
theta=theta_r*(180*%pi**-1) //Angle of twist in degrees

//Result
printf("\n Result for part(1)")
printf("\n The torque causing the stress of 40MPa is %0.2f N.m",T)
```

```
printf("\n Result for part (2)")
printf("\n The angle of twist is %0.1f degrees",
    theta)
```

Chapter 4

Shear and Moment in Beams

Scilab code Exa 4.6 The maximum Shear force

```

clear//

//Variable Declaration
P1=15 //Load in kN
P2=25 //Load in kN
P3=50 //Load in kN
R=90 //Load in kN
L1=3.5 //Length in m
L2=2 //Length in m
L3=3 //Length in m
L=12 //Total span in m

//Calculation
//Part 1
//Maximum Bending Moment at A
R1=R*L1*L**-1 //Reaction 1 in kN
M_A=R1*L1 //Moment about A in kN.m
//Maximum Bending Moment at B
R1_2=R*(L1+(L3-L2))*L**-1 //reaction 1 in kN
M_B=R1_2*(L1+(L3-L2))-P1*L2 //Moment at B in kN.m
```

```
//Maximum Moment at C
R2=(P2+P3)*(L2+L3)*L**-1 //Reaction 2 in kN
M_C=R2*(L2+L3) //Moment at C in kN.m

[M_max] = (max(M_A,M_B,M_C))

//Part 2
R2_2=R*(L-L3)*L**-1 //Reaction 2 in kN

[V_max] = (max(R1,R2,R1_2,R2_2))


//Result
printf("\n The maximum Shear force is %0.3f kN and the Maximum Bending Moment is %0.1f kN.m",V_max,M_max)
```

Chapter 5

Stresses in Beams

Scilab code Exa 5.2 `Maximum Compression`

```

clear//

//Variable Declaration
wf=6 //Width of the top flange in inches
df=0.8 //Depth of the top flange in inches
dw=8 //Depth of the web portion in inches
ww=0.8 //Width of the web portion in inches
Ra=1600 //Reation at point A in lb
Rb=3400 //Reaction at point B in lb
w=400 //Load on the beam in lb/ft
M_4=3200 //Moment at x=4 ft in lb.ft
M_10=4000 //Moment at x=10 ft in lb.ft

//Calculations
//Preliminary Calculations
//Area computation
A1=dw*ww //Area of the web portion in sq.in
A2=wf*df //Area of the top flange in sq.in
y1=dw*0.5 //Centroid from the bottom of the web
    portion in inches
```

```
y2=dw+df*0.5 //Centroid from the bottom of the flange portion in inches

//y_bar computation
y_bar=(A1*y1+A2*y2)/(A1+A2) //centroid of the section in inches from the bottom

//Moment of Inertia computation
I=(ww*dw**3*12**-1)+(A1*(y1-y_bar)**2)+(wf*df**3*12**-1)+(A2*(y2-y_bar)**2) //Moment of inertia in in^4

//Maximum Bending Moment
c_top=dw+df-y_bar //distance of top fibre in inches
c_bot=y_bar //Distance of bottom fibre in inches

//Stress at x=4 ft
sigma_top=-(12*M_4*c_top)*I**-1 //Stress at top fibre in psi
sigma_bot=12*M_4*c_bot*I**-1 //Stress at bottom fibre in psi

//Stress at x=10 ft
sigma_top2=M_10*12*c_top*I**-1 //Stress at the top fibre in psi
sigma_bot2=-M_10*12*c_bot*I**-1 //Stress at the bottom fibre in psi

//Maximum values
[sigma_t] = (max(sigma_bot,sigma_bot2,sigma_top,sigma_top2))
[sigma_c] = (min(sigma_top,sigma_top2,sigma_bot,sigma_bot2))

//Result
printf("\n The maximum values of stress are")
printf("\n Maximum Tension= %0.0f psi at x=4ft",sigma_t)
```

```
printf("\n Maximum Compression= %0.0f psi at x=10ft"
    ,-sigma_c)
```

Scilab code Exa 5.3 Sigmamax

```

clear//

//Variable Declaration
L=4 //Length of each section in ft
h_ab=4 //Thickness of the front section in inches
h_bd=6 //Thickness of the back section in inches
P=2000 //Point load acting at point A in lb
M_B=8000 //Moment at 4ft in lb.ft
M_D=16000 //Moment at x=8ft in lb.ft
b=2 //Breadth in inches

//Calculations
S_ab=b*h_ab**2*6**-1 //Sectional Modulus of section
    AB in in^3
S_bd=b*h_bd**2*6**-1 //Sectional Modulus of section
    BD in in^3
sigma_B=12*M_B*S_ab**-1 //Maximum bending stress in
    psi
sigma_D=12*M_D*S_bd**-1 //Maximum bending stress in
    psi

//Maximum stress
sigma_max=max(sigma_B,sigma_D) //Maximum stress in
    psi

//Result
printf("\n Comparing the two results we find that
    the maximum stress is")
printf("\n Sigma_max= %0.0f psi",sigma_max)
```

Scilab code Exa 5.4 The maximum Bending Stress in the section

```

clear//

//Variable Declaration
M=15000 //Maximum bending moment in absolute values in lb.ft
S=42 //Sectional Modulus in in^3

//Calculations
sigma_max=M*12*S**-1 //Maximum stress in the section in psi

//Result
printf("\n The maximum Bending Stress in the section is %0.0f psi",sigma_max)
```

Scilab code Exa 5.5 The section chosen

```

clear//

//Variable Declaration
M_max=60*10**3 //Maximum Bending Moment in kN.m
sigma_w=120*10**6 //Maximum Bending Stress allowed in Pa
M_max_2=61.52*10**3 //max bending moment computed in N.m

//Section details
```

```
mass=38.7 //Mass in kg/m
g=9.81 //Acceleration due to gravity in m/s^2
S=549*10**3 //Sectional modulus of the section in mm^3

//Calculations
S_min=M_max*sigma_w**-1*10**9 //Minimum Sectional Modulus required in mm^3

//We selecet section W310x39
w0=mass*g*10**-3 //Weight of the beam in kN/m
sigma_max=M_max_2*S**-1*10**3 //Maximum stress in MPa

//Result
printf("\n The section chosen is W310x39 with maximum stress as %0.1f MPa",sigma_max)
```

Scilab code Exa 5.6 The maximum stress

```

clear//

//Variable Declaration
V_max=24 //Maximum Shear in kN
b=0.160 //Width of the beam in m
h=0.240 //Depth of the beam in m

//Calculations
I=b*h**3*12**-1 //Moment of Inertia of the beam in m^4

//Part 1
Q=b*(h*3**-1)**2 //First moment of Area m^3
tau_max=(V_max*Q)*(I*b)**-1 //Maximum Shear Stress
```

```
    in glue in kPa

//Part 2
tau_max_2=(3.0/2.0)*(V_max/(b*h)) //Shear Stress in
    kPa
Q_1=b*h*0.5*h*0.25 //First moment about NA in m^3
tau_maxx=(V_max*Q_1)/(I*b) //Shear stress in kPa

//Result
printf("\n The Results agree in both parts")
printf("\n The maximum stress is %0.0f kPa",
    tau_max_2)
```

Scilab code Exa 5.7 The final shear stress in the web portion

```

clear//

//Variable Declaration
I=310 //Moment of inertia in in^4
V=160 //Shear Force in kips
//Dimension defination
tf=0.515 //Thickness of flange in inches
de=11.94 //Effective depth in inches
tw=0.295 //Thickness of web in inches
wf=8.005 //Width of lange in inches

//Calculations
//Part 1
Q=wf*tf*(de-tf)*0.5 //First moment about NA in inch
    ^3
tau_min=(V*Q*10**2)/(I*tw) //Minimum shear stress in
     web in psi

//Part 2
```

```
A_2=(de*0.5-tf)*tw //Area in in^3
y_bar_2=0.5*(de*0.5-tf) //Depth in inches

Q_2=Q+A_2*y_bar_2 //First Moment in inches^3

tau_max=(V*Q_2*10**2)/(I*tw) //Maximum Shear Stress
    in psi

//Part 3
V_web=10.91*tw*(tau_min+((2*3**-1)*(tau_max-tau_min)
    )) //Shear in the web in lb
perV=(V_web/V)*100 //Percentage shear force in web
    in %
t_max_final=V*10**3/(10.91*tw)

//result
printf("\n The final shear stress in the web portion
     is %0.0f psi",t_max_final)
```

Scilab code Exa 5.8 The maximum stress

```

clear//

//Variable Declaration
I=547 //Moment of inertia in inches^4
d=8.9 //NA deoth in inches
V=12 //Shear Force in kips
h=7.3 //Depth of NA
b=2 //Width in inches
t=1.2 //Thickness in inches
h2=7.5 //Depth in inches

//Calculations
//Shear Stress at NA
```

```
Q=(b*h)*(h*0.5) //First Moment about NA in in^3
tau=(V*10**3*Q)/(I*b) //Shear stress at NA in psi

//Shear Stress at a-a
Q_1=(t*h2)*(d-h2*0.5) //First moment about NA in in^3
tau1=(V*Q_1)/(I*t) //Shear Stress in psi

//Result
printf("\n Comparing two stresses")
printf("\n The maximum stress is %0.0f psi",max(tau,tau1))
```

Scilab code Exa 5.10 The maximum allowable P value

```

clear//

//Variable Declaration
sigma_w=1000 //Working Stress in Bending in psi
tau_w=100 //Working stress in shear in psi
//Dimensions
b_out=8 //Width in inches
h=10 //Depth in inches
b_in=6 //Width in inches

//Calculations
I=((b_out*h**3)-(b_in*b_out**3))*12**-1 //Moment of inertia in in^4
//Design for shear
Q=(b_out*h*0.5*0.25*h)-(b_in*b_out*0.5*0.25*b_out) //First Moment about NA in in^3

//Largest P
P=(tau_w*I*2)/(1.5*Q) //P in shear in lb
```

```

//Design for bending
P1=(sigma_w*I)/(60*5) //P in bending in lb

//Result
printf("\n The maximum allowable P value is %0.0f lb
    ",min(P,P1))
```

Scilab code Exa 5.11 The maximum spacing allowed

```

clear//

//Variable Declaration
A=2630 //Area in mm^2
y_bar=536.6 //Neutral Axis depth from top in mm
tau_w=100 //Allowable stress in MPa
sigma_b_w=280 //Allowable bending stress in MPa
d=0.019 //Diameter of the rivet in m
t_web=0.01 //Thickness of the web in m
I=4140 //Moment of inertia in m^4
V=450 //Max shear allowable in kN

//Calculations
Q=A*y_bar //first moment in mm^3
Fw=(%pi*d**2)*tau_w*10**6 //Allowable force in N
Fw_2=d*t_web*sigma_b_w*10**6*0.5 //Allowable force
    in N
e=Fw_2*I*(V*10**3*Q*10**-3)**-1 //Allowable spacing
    in m

//Result
printf("\n The maximum spacing allowed is %0.1f mm",
    e*1000)
```

Chapter 6

Deflection of Beam

Scilab code Exa 6.1 The maximum Bending Stress

```

clear//

//Variable Declaration
wo=400 //loading in lb/ft
E=29*10**6 //Modulus of elasticity in psi
I=285 //Moment of inertia in in^4
S=45.6 //Sectional Modulus in in^3
L=8 //Span in ft

//Calculations
//Part 1
//Part1 is theoretical in nature hence not coded

//Part 2
delta_max=((wo*12**-1)*(L*12)**4)/(8*E*I) //maximum
    deflection in inches
M_max=(wo*12**-1)*(L*12)**2 //Maximum moment
sigma_max=M_max/(2*S) //Maximum bending stress in
    psi

```

```
//Result
printf("\n M_max")
printf("\n The maximum deflection is %0.4f in",
    delta_max)
printf("\n The maximum Bending Stress is %0.0f psi",
    sigma_max)
```

Scilab code Exa 6.3 The maximum angle

```

clear//

//Variable Declaration
P=300 //Point Load in N
R_a=100 //Reaction at A in N
R_c=200 //Reaction at C in N
E=12 //Youngs Modulus in GPa
L1=2 //Length of the load from A in m
L2=1 //Length of the load from C in m
b=0.04 //Width of the CS of the beam in m
h=0.08 //Depth of the CS of the beam in m

//Claculations
//Moment of inertia
I=b*h**3*12**-1 //Moment of Inertia in m^4
//Flexural Rigidity
FR=E*10**9*I //FLexural rigidity in N.m^2

//Moments in terms of x are
//Given
//After the variable Calculations we get
C1=-400/3 //Constant
C3=C1 //Constant
C2=0 //Constant
C4=0 //Constant
```

```
//to get max displacement x we have
x=(6.510/2.441)**0.5 //Length at which displacement is maximum in m
v=(0.8138*x**3-6.510*x) //Displacement in mm

//Largest slope
theta=(2.441*(L1+L2)**2-(7.324*(L1+L2-L1)**2)-6.150)*10**-3//Angle in radians

//Result
printf("\n The maximum displacement is %0.2f mm downwards",-v)
printf("\n The maximum angle is %0.3f degrees anticlockwise",theta*180*%pi**-1)
```

Scilab code Exa 6.4 `The maximum displacement`

```

clear//

//Variable Declaration
//The computation is mostly variable based hence values will be directly declared
C1=19.20*10**3 //lb.ft^2
C2=-131.6*10**3 //lb.ft^2
C3=14.7*10**3 //lb.ft^2
C4=-112.7*10**3 //lb.ft^2
EI=10**7 //Flexural Rigidity in psi

//Calculations
v=-(C2*12**3)/(EI*40) //Displacement in inches

//Result
printf("\n The maximum displacement is %0.3f in
```

```
downwards",v)
```

Scilab code Exa 6.6 The deflection at point E

```

clear//

//Variable Declaration
L1=3 //Length in m
L2=1 //Length in m
L3=8 //Length in m
L4=4 //Length in m
L5=6 //Length in m

//Calculations
//Deflection midway
EIv=250*3**-1*L1**3-(50*3**-1*(L1-L2)**4)
    -(3925*3**-1*L1) //Deflection in N.m^3

//Deflection at E
EIv_E=250*3**-1*L3**3-(50*3**-1*(L3-L2)**4)
    +(50*3**-1*(L3-L4)**4)+(650*3**-1*(L3-L5)**3)
    -(3925*3**-1*L3) //Deflection in N.m^3

//Result
printf("\n The deflection at midspan is %0.0f N.m^3
    downwards",-EIv)
printf("\n The deflection at point E is %0.0f N.m^3
    downwards",-EIv_E)
```

Scilab code Exa 6.8 The magnitude of force P

```

```

```
clear//

//Variable Declaration
x1=16*3**-1 //Centroid of the triangle in ft
x2=3 //Centroid of the lower parabola in ft
x3=6 //Centroid of the rectangle in ft
x4=20*3**-1 //Centroid of the triangle in ft
//Moment values
M1=4800 //Moment in lb.ft
M2=14400 //Moment in lb.ft

//Calcualtions
P=((3**-1*4*M1*x2)+(4*M1*x3)+(0.5*4*M1*2*x4))*(x1
    *8*8*0.5)**-1 //Force P in lb

//Result
printf("\n The magnitude of force P is %0.1f lb",P)
```

Scilab code Exa 6.9 The displacement in part 2

```

clear//

//Variable Declaration
P=300 //Force in N
L1=1 //Length in m
L2=2 //Length in m
R_a=100 //Reaction at A in N
R_c=200 //Reaction at C in N
EI=20.48*10**3 //Flexural Rigidity in N.m^2

//Calculations
//Part 1
tC_A=(0.5*(L1+L2)*P*L1-(0.5*L1*P*(L1+L2)**-1))*EI
    **-1 //First Moment in m
```

```
theta_A=tC_A/(L1+L2) //Angle in radians

//Part 2
tD_A=0.5*L1*R_a*(L1+L2)**-1*EI**-1 //First Moment in
    m
delta_D=(theta_A*L1-tD_A) //Displacement in m

//Result
printf("\n The angle in part 1 is %0.3f Degrees",
   theta_A*180*%pi**-1)
printf("\n The displacement in part 2 is %0.2f mm
   downward",delta_D*1000)
```

Scilab code Exa 6.10 The deflection

```

clear//

//Variable Declaration
P1=150 //Load in lb
P2=30 //Load in lb
R_A=78 //Reaction at A in lb
R_C=102 //Reaction at C in lb
L1=4 //Length in ft
L2=6 //Length in ft
M1=780 //Moment in lb.ft
M2=900 //Moment in lb.ft
M3=120 //Moment in lb.ft

//Calculations
EI_AC=0.5*(L1+L2)*M1*(2*3**-1)*(L1+L2)-(0.5*L2*M2*(
   L1+(2*3**-1)*L2)) //Deflection in lb.ft^3
EI_thetaC=EI_AC/(L1+L2) //Deflection in lb.ft^2

EI_DC=-0.5*L1*M3*2*3**-1*L1 //Deflection in lb.ft^3
```

```
EI_deltaD=EI_thetaC*L1-(-EI_DC) //Deflection in lb.
    ft^2

//Result
printf("\n The deflection is %0.0f lb.ft^2 upwards",
    EI_deltaD)
```

Scilab code Exa 6.11 The deflection at midspan

```

clear//

//Variable Declaration
P1=80 //Load in lb
P2=100 //Load in lb
b1=3 //Distance of load from end in ft
b2=2 //Distance of load from end in ft
L=9 //Span of the beam in ft

//Calcualtions
EI_delta1=(P1*b1*48**-1)*(3*L**2-4*b1**2) //
    Deflection in lb.ft^3
EI_delta2=(P2*b2*48**-1)*(3*L**2-4*b2**2) //
    Deflection in lb.ft^3
EI_delta=EI_delta1+EI_delta2 //Deflection at modspan
     in lb.ft^3

//Result
printf("\n The deflection at midspan is %0.0f  lb.ft
    ^3 downward",EI_delta)
```

Scilab code Exa 6.12 The total Deflection at midpsan

```

clear//

//Variable Declaration
wo=600 //Load in N/m
L=6 //Span of the beam in m
b=2 //Distance of the load from end in m
a=1 //Distance of the load from end in m

//Calulations
EI_delta1=wo*384**-1*(5*L**4-12*L**2*b**2+8*b**4) //Deflection in N.m^3
EI_delta2=wo*96**-1*a**2*(3*L**2-2*a**2) //Deflection in N.m^3

EI_delta=EI_delta1-EI_delta2 //Total Delfection at midspan in N.m^3

//Result
printf("\n The total Deflection at midpsan is %0.0f N.m^3 downwards",EI_delta)
```

Chapter 7

Statically Indeterminate Beams

Scilab code Exa 7.4 Ra

```

clear//
//

//Variable Declaration
w=60 //Continous Load in lb/ft
L1=3 //Length in ft
L2=9 //Length in ft

//Calculations
//After carrying out the variable computations we
    get
A=([[1,1,0,0;(L1+L2),0,1,1;0.5*(L1+L2)**2,0,-(L1+L2)
    ,0;6**-1*(L1+L2)**3,0,-0.5*(L1+L2)**2,0]])
B=([w*L2;w*L2*0.5*L2;L2**3*10;L2**4*2.5])
C=linsolve(A,B)

//Result
printf("\n The values are as follows")
printf("\n Ra= %0.0f lb Ma= %0.0f lb.ft Rb= %0.0f lb
     and Mb= %0.0f lb.ft",-C(1),-C(2),-C(3),-C(4))
```

Chapter 8

Stresses due to Combined Loading

Scilab code Exa 8.1 Change in radius of end cap

```

clear//

//Variable Declaration
p=125 //Pressure in psi
r=24 //Radius of the vessel in inches
t=0.25 //Thickness of the vessel in inches
E=29*10**6 //Modulus of Elasticity in psi
v=0.28 //poisson ratio

//Calcualtions
//Part 1
sigma_c=p*r*t**-1 //Circumferential Stress in psi
sigma_l=sigma_c/2 //Longitudinat Stress in psi
e_c=E**-1*(sigma_c-(v*sigma_l)) //Circumferential
    Strain using biaxial Hooke's Law
delta_r=e_c*r //Change in the radius in inches

//Part 2
```

```
sigma=(p*r)*(2*t)**-1 //Stress in psi
e=E**-1*(sigma-(v*sigma)) //Strain using biaxial
    Hooke's Law
delta_R=e*r //Change inradius of end-cap in inches

//Result
printf("\n Part 1 Answers")
printf("\n Stresses are sigma_c= %0.0f psi and
    sigma_l= %0.0f psi",sigma_c,sigma_l)
printf("\n Change of radius of cylinder= %0.5f in",
    delta_r)
printf("\n Part 2 Answers")
printf("\n Stresses are sigma= %0.0f psi",sigma)
printf("\n Change in radius of end cap= %0.5f in",
    delta_R)
```

Scilab code Exa 8.3 `The maximum Stress`

```

clear//

//Variable Declaration
b=6 //Width in inches
h=10 //Depth in inches
P1=6000 //Force in lb
P2=3000 //Force in lb
L=4 //Length in ft
P=-13400 //Load in lb
M=6000 //Moment in lb.ft
y=5 //Depth in inches
P2=-9800 //Load in lb
M2=-12000 //Moment in lb.ft

//Calculations
A=b*h //Area in in^2
```

```
I=b*h**3*12**-1 //Moment of inertia in in^4
T=(P1*L+P2*L*3)*(6)**-1 //Tension in the cable in lb

//Computation of largest stress
sigma_B=(P*A**-1)-(M*y*12*I**-1) //Maximum
    Compressive Stress caused by +ve BM in psi
sigma_C=(P2*A**-1)-(M2*-y*12*I**-1) //Maximum
    Compressive Stress caused by -ve BM in psi

sigma_max=max(-sigma_B,-sigma_C) //Maximum
    Compressive Stress in psi

//Result
printf("\n The maximum Stress is %0.0f psi",
    sigma_max)
```

Scilab code Exa 8.4 And tauxy

```

clear//

//Variable Declaration
theta=(60*%pi)/180 //Angle in radians (Twice as
    declared)
sigma_x=30 // Stress in x in MPa
sigma_y=60 //Stress in y in MPa
tau_xy=40 //Stress in MPa

//Calcualtions
sigma_xdash=0.5*(sigma_x+sigma_y)+0.5*(sigma_x-
    sigma_y)*cos(theta)+tau_xy*sin(theta) //Stress at
     x' axis in MPa
sigma_ydash=0.5*(sigma_x+sigma_y)-0.5*(sigma_x-
    sigma_y)*cos(theta)-tau_xy*sin(theta) //Stress at
     y' axis in MPa
```

```
tau_x_y=-0.5*(sigma_x-sigma_y)*sin(theta)+tau_xy*cos(theta) //Stress at x'y' in shear in MPa
//Result
printf("\n The new stresses at new axes are as follows")
printf("\n sigma_x= %0.1f MPa sigma_y= %0.1f MPa",sigma_xdash,sigma_ydash)
printf("\n And tau_xy= %0.0f MPa",tau_x_y)
```

Scilab code Exa 8.5 `Theta1`

```

clear//

//Variable Declaration
sigma_x=8000 //Stress in x in psi
sigma_y=4000 //Stress in y in psi
tau_xy=3000 //Stress in xy in psi

//Calculations
R=sqrt(((sigma_x-sigma_y)*0.5)**2+tau_xy**2) //Resultant Stress in psi

//Principal Stresses
sigma1=(sigma_x+sigma_y)*0.5+R //Principal Stress in psi
sigma2=(sigma_x+sigma_y)*0.5-R //Principal Stress in psi

//Principal Direction
theta1=atan(2*tau_xy*(sigma_x-sigma_y)**-1)*0.5*180*%pi**-1 //Principal direction in degrees
theta2=theta1+90 //Second pricnipal direction in degrees

```

```
//Normal Stress
sigma_xdash=0.5*(sigma_x+sigma_y)+0.5*(sigma_x-sigma_y)*cos(2*theta1*%pi*180**-1)+tau_xy*sin(2*theta1*%pi*180**-1)

//Result
printf("\n The principal stresses are as follows")
printf("\n sigma1= %0.0f psi and sigma2= %0.0f psi",sigma1,sigma2)
printf("\n The corresponding directions are")
printf("\n Theta1= %0.1f degrees and Theta2= %0.1f degrees",theta1,theta2)
```

Scilab code Exa 8.6 `The maximum in plane Shear`

```

clear//

//Variable Declaration
sigma_x=40 //Stress in x in MPa
sigma_y=-100 //Stress in y in MPa
tau_xy=-50 //Shear stress in MPa

//Calculations
tau_max=sqrt(((sigma_x-sigma_y)*0.5)**2+tau_xy**2) //Maximum in-plane shear in MPa

//Orientation of Plane
theta1=atan(-((sigma_x-sigma_y)*(2*tau_xy)**-1))*180*%pi**-1*0.5 //Angle in Degrees
theta2=theta1+90 //Angle in degrees

//Plane of max in-plane shear
tau_x_y=-0.5*(sigma_x-sigma_y)*sin(2*theta1*%pi*180**-1)+tau_xy*cos(2*theta1*%pi*180**-1)
```

```

//Normal Stress
sigma=(sigma_x+sigma_y)*0.5 //Stress in MPa

//Result
printf("\n The maximum in-plane Shear is %0.0f MPa",
    tau_x_y)
```

Scilab code Exa 8.7 Tauxy

```

clear//

//Vairable Declaration
sigma_x=40 //Stress in x in MPa
sigma_y=20 //Stress in y in MPa
tau_xy=16 //Shear in xy in MPa

//Calculations
sigma=(sigma_x+sigma_y)*0.5 //Normal Stress in MPa
R=sqrt(((sigma_x-sigma_y)*0.5)**2+tau_xy**2) //
    Resultant Stress in MPa

//Part 1
sigma1=sigma+R //Principal Stress in MPa
sigma2=sigma-R //Principal Stress in MPa
theta=atan(tau_xy*((sigma_x-sigma_y)*0.5)**-1)*180*
    %pi**-1*0.5 //Orientation in degrees

//Part 2
tau_max=18.87 //From figure in MPa

//Part 3
sigma_xdash=sigma+tau_max*cos((100-theta*2)*%pi
    *180**-1) //Stress in MPa
```

```
sigma_ydash=sigma-tau_max*cos((100-theta*2)*%pi*180**-1) //Stress in MPa
tau_x_y=tau_max*sin((100-2*theta)*%pi*180**-1) //Shear stress in MPa

//Result
printf("\n The principal Stresses are")
printf("\n Sigma1= %0.1f MPa and Sigma2= %0.1f MPa",sigma1,sigma2)
printf("\n The Principal Plane is at %0.0f degrees",theta)
printf("\n The  Maximum Shear Stress is %0.3f MPa",tau_max)
printf("\n Sigma_x= %0.0f MPa and Sigma_y= %0.2f MPa",sigma_xdash,sigma_ydash)
printf("\n Tau_xy= %0.2f MPa",tau_x_y)
```

Scilab code Exa 8.9 `The diameter of the shaft to be selected`

```

clear//

//Variable Declaration
sigma_w=120 //Working Stress in MPa
tau_w=70 //Working Shear in MPa

//Calcualtions
//Section a-a
M=3750 //Applied moment at section a-a in N.m
T=1500 //Applied Torque at section a-a in N.m

//After carrying out the variable based computation we compute d
d1=((124.62)/(sigma_w*10**3*%pi))**0.3333 //Diameter of the shaft in m
```

```
d2=((65.6)/(tau_w*10**3*%pi))**0.3333 //Diameter of the shaft in m
d=max(d1,d2) //Diameter of the shaft to be selected in m

//Result
printf("\n The diameter of the shaft to be selected is %0.1f mm",d*1000)
```

Scilab code Exa 8.10 The largest allowable Torque

```

clear//

//Variable Declaration
t=0.01 //Thickness of the shaft in m
p=2 //Internal Pressure in MPa
r=0.45 //Mean radius of the vessel in m
tw=50 //Working shear stress in MPa

//Calculation
sigma_x=(p*r)/(2*t) //Stress in MPa
sigma_y=(p*r)/t //Stress in MPa

R=100-67.5 //From the diagram in MPa
tau_xy=sqrt((R**2-(sigma_y-67.5)**2)) //Stress in MPa

J=2*%pi*r**3*t //Polar Moment of inertia in mm^4

T=1000*(tau_xy*J)/r //Maximum allowable Torque in kN.m

//Result
printf("\n The largest allowable Torque is %0.0f kN.
```

```
m",T)
```

Scilab code Exa 8.11 The Maximum normal stress in case 2

```

clear//

//Variable Declaration
L=15 //Length of the shaft in inches
r=3.0/8.001 //Radius of the shaft in inches
T=540 //Torque applied in lb.in

//Calculations
V=30 //Transverse Shear Force in lb
M=15*V //Bending Moment in lb.in
I=(%pi*r**4)/4.0 //Moment of Inertia in in^4
J=2*I //Polar Moment Of Inertia in in^4

//Part 1
sigma=(M*r)/I //Bending Stress in psi
tau_t=10**-3*(T*r)/J //Shear Stress in ksi

sigma_max1=13.92 //From the Mohr Circle in ksi

//Part 2
Q=(2*r**3)/3.0 //First Moment in in^3
b=2*r // in

tau_V=10**-3*(V*Q)/(I*b) //Shear Stress in ksi
tau=tau_t+tau_V //Total Shear in ksi

sigma_max2=tau //Maximum stress in ksi

//Result
printf("\n The maximum normal stress in case 1 is %0
```

```
.3f ksi",sigma_max1)
printf("\n The Maximum normal stress in case 2 is %0.2f ksi",sigma_max2)
```

Scilab code Exa 8.12 ex

```

clear//

//Variable Declaration
ex=800*10**-6 //Strain in x (no units)
ey=200*10**-6 //Strain in y(no units)
y_xy=-600*10**-6 //Strain in xy(no units)

//Calculations
e_bar=(ex+ey)*0.5 //Strain
R=sqrt(2*300**2)*10**-6 //Resultant

//Part 1
e1=e_bar+R //Strain in Principal Axis(no units)
e2=e_bar-R //Strain in Principal Axis(no units)

//Part 2
alpha=15*180**-1*%pi //From the Mohr Circle in degrees
e_xbar=e_bar-(R*cos(alpha)) //Strain in x (no units)
e_ybar=e_bar+(R*cos(alpha)) //Strain in y(no units)

shear_strain=2*R*sin(alpha) //Shear follows

//Result
printf("\n The principal Strains are")
printf("\n e1= %0.6f e2= %0.6f ",e1,e2)
printf("\n The follows components are")
printf("\n ex= %0.6f ey= %0.6f y_xy= %0.6f ",e_xbar,
```

```
e_ybar,shear_strain)
```

Scilab code Exa 8.13 Sigma1

```

clear//

//Variable Declaration
e_x=800*10**-6 //Strain in x
e_y=200*10**-6 //Strain in y
y_xy=-600*10**-6 //Strain in xy
v=0.30 //Poissons Ratio
E=200 //Youngs Modulus in GPa
R_e=424.3*10**-6 //Strain
e_bar=500*10**-6 //Strain

//Calculations
//Part 1
R_sigma=10**-6*R_e*(E*10**9/(1+v)) //Stress in MPa
sigma_bar=10**-6*e_bar*(E*10**9/(1-v)) //Stress in MPa

//Part 2
sigma1=sigma_bar+R_sigma //Principal Stress in MPa
sigma2=sigma_bar-R_sigma //Principal Stress in MPa

//Result
printf("\n The principal Stresses are as follows")
printf("\n Sigma1= %0.0f MPa and Sigma2= %0.1f MPa",sigma1,sigma2)
```

Scilab code Exa 8.14 The plane orientation

```

clear//

//Variable Declaration
e_a=100*10**-6 //Strain
e_b=300*10**-6 //Strain
e_c=-200*10**-6 //Strain
E=180 //Youngs Modulus in GPa
v=0.28 //Poissons Ratio

//Calculations
y_xy=(e_b-(e_a+e_c)*0.5) //Strain in xy
e_bar=(e_a+e_c)*0.5 //Strain
R_e=sqrt(y_xy**2+(150*10**-6)**2) //Resultant Strain

//Corresponding Parameters from Mohrs Diagram
sigma_bar=(E/(1-v))*e_bar*10**3 //Stress in MPa
R_sigma=(E/(1+v))*R_e*10**3 //Resultant Stress in MPa

//Principal Stresses
sigma1=sigma_bar+R_sigma //MPa
sigma2=sigma_bar-R_sigma //MPa

theta=atan(y_xy/(150*10**-6))*180*%pi**-1*0.5 //Degrees

//Result
printf("\n The Principal Stresses are as follows")
printf("\n Sigma1= %0.1f MPa and Sigma2= %0.2f MPa",sigma1,sigma2)
printf("\n The plane orientation is %0.2f degrees",theta)
```

Chapter 9

Composite Beams

Scilab code Exa 9.1 The Maximum Allowable moment that the beam can support

```

clear//

//Variable Declaration
n=20 //Modular Ratio
sigma_wd=8*10**6 //Maximum bending stress in wood in
    Pa
sigma_st=120*10**6 //Maximum bending stress in steel
    in Pa

//Cross Sectional Details
Awd=45 //Area of wood in mm^2
y_wd=160 //Neutral Axis of from bottom of the wooden
    section in mm
Ast=15 //Area of steel in mm^2
y_st=5 //Neutral Axis of the Steel section in mm
//Dimensions
ww=150 //width of wooden section in mm
dw=300 //depth of wooden section in mm
ws=75 //width of steel section in mm
ds=10 //depth of steel section in mm
```

```
//Calculations
y_bar=(Awd*y_wd+Ast*y_st)*(Ast+Awd)**-1 //Location
    of Neutral axis from the bottom in mm
//Moment of inertia
I=(ww*dw**3*12**-1)+(ww*dw*(y_wd-y_bar)**2)+(n*ws*ds
    **3*12**-1)+(n*ws*ds*(y_bar-y_st)**2) //mm^4
c_top=dw+ds-y_bar //Distance from NA to top fibre in
    mm
c_bot=y_bar //Distance from NA to bottom fibre in mm

//The solution will be in different order
M1=sigma_wd*I*10**-12*c_top**-1 //Maximum Bending
    Moment in N.m
M2=sigma_st*I*10**-12*c_bot**-1 //Maximum Bending
    Moment in N.m
M=min(M1,M2) //Maximum allowable moment in N.m

//Result
printf("\n The Maximum Allowable moment that the
    beam can support is %0.1f kN.m",M)
```

Scilab code Exa 9.2 The deflection at the mid span

```

clear//

//Variable Declaration
dw=8 //Depth of wooden section in inches
da=0.4 //Depth og aluminium section in inches
w=2 //Width of the section in inches
n=40*3**-1 //Modular Ratio
Ewd=1.5*10**6 //Youngs modulus of wood in psi
Eal=10**7 //Youngs Modulus of aluminium in psi
V_max=4000 //Maximum shear in lb
```

```
b=24 //Inches
L=72 //Length in inches
P=6000 //Load on the beam in lb

//Calculations
I=w*dw**3*12**-1+2*(n*w*da**3*12**-1+n*da*4.2**2) //Moment of Inertia in in^4

//Part 1
Q=(w*dw*0.5)*2+(n*da)*(dw*0.5+da*0.5) //First Moment in in^3
tau_max=V_max*Q*I**-1*w**-1 //Maximum Shear Stress in psi

//Part 2
delta_mid=(P*b)*(48*Ewd*I)**-1*(3*L**2-4*b**2)

//Result
printf("\n The maximum shear stress allowable is %0.0f psi",tau_max)
printf("\n The deflection at the mid-span is %0.4f in",delta_mid)
```

Scilab code Exa 9.4 Area of steel

```

clear//

//Variable Declaration
sigma_co_w=12 //Maximum stress in compression in MPa
sigma_st_w=140 //Maximum stress in steel in MPa
M=90 //Moment in kN.m
n=8 //Modular Ratio

//Calculations
```

```
//h=0.4068d
//bd^2=0.04266
b=(0.04266/(1.5**2))**0.3333 //Breadth in m
d=1.5*b //Depth in m
h=0.4068*d //Height in m

//Area of steel
Ast=((M*10**3)/((d-h*3**-1)*sigma_st_w*10**3))*10**3
    //Area of steel in mm^2

//Result
printf("\n The dimensions of the beam are")
printf("\n b= %0.0f mm and d= %0.0f mm",b*1000,d
  *1000)
printf("\n Area of steel= %0.0f mm^2",Ast)
```

Chapter 10

Columns

Scilab code Exa 10.1 From the above computation we select W250x58 section

```

clear//

//Variable Declaration
Le=7 //Effective length in m
P=450 //Applied axial Load in kN
FOS=3 //Factor of safety
sigma_pl=200*10**6 //Stress allowable in Pa
E=200*10**9 //Youngs Modulus in Pa
end_cond=0.7 //End Condition factor to be multiplied

//Calculations
Pcr=P*FOS //Critical Load in kN
A=Pcr*sigma_pl**-1*10**9 //Area in mm^2

//Part 1
I1=10**15*(Pcr*Le**2)*(%pi**2*E)**-1 //Moment of Inertia Required in mm^4
//From table selecting appropriate Section W250x73

//Part 2
```

```
I2=10**15*(Pcr*end_cond**2*Le**2)*(%pi**2*E)**-1 //
    Moment of Inertia Required in mmˆ4
//From table selecting appropriate Section W200x52

//Lightest Section that meets these criterion is
    W250x58 section


//Result
printf("\n From the above computation we select
    W250x58 section")
```

Scilab code Exa 10.2 `Maximum Allowable Load P`

```

clear//

//Variable Declaration
E=200*10**9 //Youngs Modulus in Pa
sigma_yp=380*10**6 //Stress allowable in Pa
Le=10 //Length in m
end_cond=0.5 //Support condition factor to be ,
    ultiplied to length
A=15.5*10**-3 //Area in mˆ2

//Calculations
Cc=sqrt((2*%pi**2*E)*sigma_yp**-1) //Slenderness
    Ratio

//Part 1
S_R1=142.9 //Slenderness ratio
sigma_w=(12*%pi**2*E)/(23*S_R1**2) //Allowable
    Working Stress in Pa
P=sigma_w*A //Maximum Allowable Load in kN

```

```
//Part 2
S_R2=79.37 //Slenderness ratio
N=5*3**-1+((3*S_R2)/(8*Cc))-(S_R2**3*(8*Cc**3)**-1)
    //Factor Of Safety

sigma_w2=(1-(S_R2**2*0.5*Cc**-2))*(sigma_yp*N**-1)
    //Allowable working Stress in Pa
P2=sigma_w2*A //Allowable Load in kN

//Part 3
S_R3=55.56 //Slenderness Ratio
N3=5*3**-1+((3*S_R3)/(8*Cc))-(S_R3**3*(8*Cc**3)**-1)
     //Factor Of Safety

sigma_w3=(1-(S_R3**2*0.5*Cc**-2))*(sigma_yp*N3**-1)
    //Allowable working Stress in Pa
P3=sigma_w3*A //Allowable Load in kN

//Result
printf("\n The results for Part 1 are")
printf("\n Maximum Allowable Load P= %0.0f kN",P
    *10**-3)
printf("\n Part 2")
printf("\n Maximum Allowable Load P= %0.0f kN",P2
    *10**-3)
printf("\n Part 3")
printf("\n Maximum Allowable Load P= %0.0f kN",P3
    *10**-3)
```

Scilab code Exa 10.3 `The maximum lateral dfelection`

```

clear//
//

```

```
//Variable Declaration
E=29*10**6 //Youngs Modulus in psi
sigma_yp=36*10**3 //Stress in psi
L=25 //Length in ft
A=17.9 //Area in in^2
Iz=640 //Moment of inertia in in^4
Sz=92.2 //Sectional Modulus in in^3
P=150*10**3 //Load in lb
e=4 //Eccentricity in inches

//Calculations

//Part 1
a=1.09836
sigma_max=P*A**-1+(P*e*Sz**-1)*a //Maximum Stress in
    psi

//Part 2
//After simplification we get the equation to
   compute N
N=2.19 //Trial and Error yields

//Part 3
v_max=e*((cos(sqrt((P*L**2*12**2)*(4*E*Iz)**-1)))
   **-1-1)

//Result
printf("\n The maximum compressive stress in the
   Column is %0.2f psi",sigma_max)
printf("\n The factor of safety is %0.3f ",N)
printf("\n The maximum lateral dfelection is %0.3f
   in",v_max)
```

Scilab code Exa 10.4 `The factor of safety`

```
clear//

//Variable Declaration
Le=7 //Effective Length in m
N=2 //Factor of Safety
h_max=400 //Maximum depth in mm
E=200 //Youngs Modulus in GPa
sigma_yp=250 //Maximum stress in yielding in MPa
P1=400 //Load 1 in kN
P2=900 //Load 2 in kN
x1=75 //Distance in mm
x2=125 //Distance in mm

//Calculations
e=(P2*x2-P1*x1)*(P1+P2)**-1 //Eccentricity in mm
P=N*(P1+P2) //Applied load after factor of safety is considered in kN

//Part 1 is not computable
I=415*10**-6 //Moment of inertia from the table in mm^4

//Part 2
P_cr=%pi**2*E*10**9*I*Le**-2 //Critical load for buckling in kN
FOS=P_cr*10**-3/(P1+P2) //Factor of safety against buckling in y-axis


//Result
printf("\n The critical load for buckling is %0.0f kN",P_cr*10**-3)
printf("\n The factor of safety is %0.1f ",FOS)
```

Chapter 11

Additional Beam Topics

Scilab code Exa 11.1 The Maximum Shear Flow

```

clear//

//Variable Declaration
V=1000 //Force acting on he section in lb
t=0.5 //Thickness in inches
//Dimensions
d=8 //Depth of the section in inches
wf=12 //Width of the flange in inches
wbf=8 //Width of the bottom flange in inches

//Calculations
y_bar=((d*t*0)+wbf*t*4+wf*t*8)/(d*t+wbf*t+wf*t) //Location of Neutral Axis in inches
I=d*t*y_bar**2+t*d**3*12**-1+d*t*(d*t-y_bar)**2+wf*t*(8-y_bar)**2 //Moment of Inertia in in^4

//Top Flange
q1=V*t*t*wf*(8-y_bar)*I**-1 //Shear flow in lb/in
//Bottom Flange
q2=V*t*t*d*y_bar*I**-1 //Shear Flow in lb/in
```

```
//Web
qB=2*q1 //Shear Flow in lb/in
qF=2*q2 //Shear Flow in lb/in

//Max Shear Flow
qMAX=qB+V*t*(8-y_bar)**2*0.5*I**-1 //Maximum Shear Flow in lb/in

//Result
printf("\n The Maximum Shear Flow is %0.0f lb/in",qMAX)
```

Scilab code Exa 11.2 The eccentricity

```

clear//

//Variable Declaration
V=1000 //Shear Force in lb
t=0.5 //Thickness in inches
wf=12 //Width of the flange in inches
d=8 //Depth of the section in inches
//Rest ALL DATA is similar to previous problem

//Calcualtions
I=t*wf**3*12**-1+t*d**3*12**-1 //Moment of Inertia

//Part 1
q1=V*t*t*wf*3*I**-1 //Shear Flow in lb/in
q2=V*t*t*d*2*I**-1 //Shear FLow in lb/in
V1=2*3**-1*q1*wf //Shear force carried in lb
V2=2*3**-1*q2*d //Shear force carried in lb

//Part 2
e=8*V2*V**-1 //Eccentricity in inches
```

```

//Result
printf("\n The Shear Force carried by Flanges is")
printf("\n Top Flange= %0.1f lb Bottom Flange= %0.1f lb",V1,V2)
printf("\n The eccentricity is %0.3f in",e)
```

Scilab code Exa 11.3 The maximum Bending Moment

```

clear//
//

//Variable Declaration
M=32 //Moment in kN.m
Iy=4.73*10**6 //Moment of inertia in y-axis in mm^4
Iz=48.9*10**6 //Moment of inertia in z-axis in mm^4
Sy=64.7*10**3 //Sectional Modulus in y-axis in mm^3
Sz=379*10**3 //Sectional Modulus in z-axis in mm^3
theta=16.2 //Angle between moment and z-axis in degrees

//Calculations
//Part 1
alpha=atan((Iz*Iy**-1)*tan(theta*%pi*180**-1))*180*%pi**-1 //Angle between NA and z-axis in degrees

//Part 2
My=-M*sin(theta*%pi*180**-1) //Bending Moment in y in kN.m
Mz=-M*cos(theta*%pi*180**-1) //Bending Moment in z in kN.m

sigma_max=My*Sy**-1+Mz*Sz**-1 //Largest Bending Stress in MPa
```

```
//Result
printf("\n The angle between the  Neutral Axis and Z-Axis is %0.1f degrees",alpha)
printf("\n The maximum Bending Moment is %0.0f MPa",-sigma_max*10**6)
```

Scilab code Exa 11.4 The maximum Bedning Stress

```

clear//

//Variable Declaration
A=4.75 //Area in inches^2
Iy_dash=6.27 //Moment of inertia in in^4
Iz_dash=17.4 //Moment of inertia in in^4
ry=0.87 //Radius of Gyration in inches
tan_theta=0.44
P=1 //Force in kips
L=48 //Length in inches
y_dash_B=-4.01 //Y coordinate of point B in inches
z_dash_B=-0.487 //Z coordinate of point B in inches

//Calcualtions
theta=atan(tan_theta) //Angle in radians
Iy=A*ry**2 //Moment of inertia in y in in^4
Iz=Iy_dash+Iz_dash-Iy //Moment of inertia in y in in^4

//Part 1
alpha=atan(Iz*Iy**-1*tan_theta)*180*%pi**-1 //Angle in radians
beta=alpha-(theta*180*%pi**-1) //Angle in degrees

//Part 2
```

```
M=P*L*4**-1 //Moment in kip.in
My=M*sin(theta) //Moment in y in kip.in
Mz=M*cos(theta) //Moment in z in kip.in

y_B=y_dash_B*cos(theta)+z_dash_B*sin(theta) //Y coordinate  in inches
z_B=z_dash_B*cos(theta)-y_dash_B*sin(theta) //Z coordinate in inches

//Maximum Bending Stress
sigma_max=My*z_B*Iy**-1-Mz*y_B*Iz**-1 //Maximum Bending Stress in ksi

//Result
printf("\n The angle of inclination of the Neutral axis to the z-axis is %0.1f degrees",beta)
printf("\n The maximum Bending Stress is %0.2f ksi",sigma_max)
```

Scilab code Exa 11.5 The maximum allowable load

```

clear//

//Variable Declaration
A1=4 //Area in in^2
A2=6 //Area in in^2
r1=7.8 //Radius in inches
r2=14.8 //Radius in inches
t=0.5 //Thickness in inches
d=4 //Depth in inches
sigma_w=18 //Maximum allowable stress in kips

//Calculations
A=A1+A2 //Area in in^2
```

```
r_bar=(A1*(r1+t)+A2*(r2+d))*(A1+A2)**-1 //Centroidal
    Axis in inches
//Simplfying the computation
a=(r1+2*t)/r1
b=r2/(r1+t*2)
integral=d*log(a)+2*t*log(b) //
R=A/integral //Radius of neutral Surface in inches

//Maximum Stress
//Answers are in variable terms hence not computable

P=sigma_w/0.7847 //Maximum Allowable load in kips

//Result
printf("\n The maximum allowable load is %0.1f kips"
    ,P)
```

Chapter 12

Special Topics

Scilab code Exa 12.1 The displacement of point A

```

clear//

//Variable Declaration
W=24*10**3 //Load in kips
E=29*10**6 //Youngs Modulus in psi
L=72 //length in inches
theta=30 //Angle in degrees

//Calculations
L_ab=L/sin(theta*%pi*180**-1) //Length of AB in
    inches
L_ac=L/sin((90-theta)*%pi*180**-1) //Length of AC in
     inches

//Applying the forces in x and y sum to zero
//Applying the follows energy formula
//Applying Castiglinos theorem
delta_A=91.16*W*E**-1 //Displacement in inches

//Result
```

```
printf("\n The displacement of point A is %0.4f in",
    delta_A)
```

Scilab code Exa 12.4 The maximum force

```

clear//
//

//NOTE:The figure mentions the unit of length as ft
    which is incorrect
//Variable Declaration
L=30 //Length in m
m=2000 //Mass in kg
v=2 //Velocity in m/s
E=10**5 //Youngs Modulus in MPa
A=600 //Area in mm^2
g=9.81 //Acceleration due to gravity in m/s^2

//Calculations
k=E*A*L**-1 //Stifness of the cable in N/m

//Applying the Work-Energy principle
delta_max=sqrt((0.5*m*v**2)*(0.5*k)**-1) //Maximum
    Displacement in m

P_max=k*delta_max+m*g //Maximum force in N

//Result
printf("\n The maximum force is %0.1f kN",P_max
    *10**-3)
```

Scilab code Exa 12.5 The maximum dynamic Bending Moment

```
clear//

//Variable Declaration
b=0.060 //Breadth of the section in mm
d=0.03 //Depth of the section in mm
L=1.2 //Length in m
m=80 //Mass in kg
g=9.81 //Acceleration due to gravity in m/s^2
E=200*10**9 //Youngs Modulus in Pa
e=0.015
h=0.01 //height in m

//Calculations
//Part 1
I=b*d**3*12**-1 //Moment of Inertia in m^4
delta_st=m*g*L**3/(48*E*I) //Mid-span Displacement in m
n=1+sqrt(1+(2*h/delta_st)) //Impact Factor

//Part 2
P_max=n*m*g //Maximum dynamic load in N at midspan
M_max=P_max*0.5*L*0.5 //Maximum moment in N.m
sigma_max=M_max*e/I //Maximum dynamic Bending Stress in Pa

//Result
printf("\n The impact factor is %0.3f ",n)
printf("\n The maximum dynamic Bending Moment is %0.1f MPa",sigma_max*10**-6)
```

Scilab code Exa 12.7 Using the maximum sitrotion energy theory T

```
clear//
```

```

//Variable Declaration
M=2.21 //Applied moment in kip.ft
d=3 //Diameter of the bar in inches
sigma_y=40 //Yield strength of the of steel in ksi

//Calculations
//Part 1
sigma=32*M*12*(%pi*d**3)**-1 //Maximum Bending Stress in ksi
T1=sqrt((sigma_y*0.5)**2-5**2)/(12*0.18863) //Maximum Allowable torque in kip.ft

//Part 2
R=sqrt((sigma_y**2-5**2)*3**-1) //Maximum shear stress in ksi
T2=sqrt(R**2-5**2)/(12*0.18863) //Maximum safe torque in kpi.ft

//Result
printf("\n Using the maximum shear stress theory T= %0.2f kip.ft",T1)
printf("\n Using the maximum sitrotion energy theory T= %0.2f kip.ft",T2)
```

Scilab code Exa 12.8 The maximum value of P

```

clear//

//Variable Declaration
D=250 //Wideness in mm
b=20 //Thickness of the plate in mm
r=50 //Radius of the hole in mm
e=50 //Eccentricity in mm
```

```
sigma_max=150 //Maximum normal stress at the hole in
    MPa
kb=2 //Stress Concentraion factor

//Calculations
A=b*(D-2*r)*10**-6 //Area in m^2
I=10**-12*(b*D**3*12**-1-(b*2**3*r**3*12**-1)) //
    Moment of inertia in m^4
//Simplfying computation
a=2*r*D**-1
kt=3-3.13*a+3.66*a**2-1.53*a**3 //Stress
    Concentration factor
//Simplfying computation
b=kt*A**-1
c=kb*r*r*10**-6*I**-1
P=10**3*sigma_max*(b+c)**-1 //Maximum Load in N

//Result
printf("\n The maximum value of P is %0.1f kN",P)
```

Chapter 13

Inelastic Action

Scilab code Exa 13.1 The ratio ML by Myp

```
clear//

//Variable Declaration
d=150 //Depth of the web in mm
wf=100 //Width of the flange in mm
df=20 //Depth of the flange in mm
t=20 //Thickness of the web in mm

//Calculations
y_bar=10**-3*(((wf*df*(d+df*0.5))+(d*t*d*0.5))/(wf*
   df+d*t)) //Distance of Neutral Axis in m
//Simplfying the computation
a=wf*df**3*12**-1
b=wf*df*((d+df*0.5)-y_bar*10**3)**2
c=t*d**3*12**-1
f=t*d*((d*0.5)-y_bar*10**3)**2
I=(a+b+c+f)*10**-12 //Moment of inertia in mm^3

//Limit Moment
yp=(wf*df+d*t)/(2*t) //Plastic Neutral Axis in mm
```

```
Myp=I/y_bar //Yielding will start at moment without the stress term to ease computation
mom=10**-9*((t*yp**2*0.5)+(wf*df*(d-yp+10))+(t*25**2*0.5)) //Sum of 1st moments
Ml_Myp=mom*Myp**-1 //Ratio

//Result
printf("\n The ratio ML/Myp= %0.3f ",Ml_Myp)
```

Scilab code Exa 13.2 Sigmast

```

clear//
//

//Variable Declaration
E_st=200 //Youngs Modulus of Steel in GPa
sigma_st_yp=290 //Yielding Stress in MPa
E_al=70 //Youngs Modulus of Aluminium in GPa
sigma_al_yp=330 //Yielding Stresss of Aluminium in MPa
A_st=900 //Area of steel rod in mm^2
A_al=600 //Area of Aluminium rod in mm^2
L_st=350 //Length of the steel rod in mm
L_al=250 //Length of the aluminium rod in mm

//Calculations
//Limit Load
P_st=sigma_st_yp*A_st*10**-3 //Load in limiting condition in kN
P_al=sigma_al_yp*A_al*10**-3 //Load in limiting condition in kN
P_L=P_st+2*P_al //Total Loading in kN

//Elastic Unloading
```

```
//Solving for Pst and Pal using matri approach
A=([[1,2;L_st*(E_st*A_st)**-1,-L_al*(E_al*A_al)**-1]])
B=([P_L;0])
C=linsolve(A,B) //Loading in kN

//Residual Stresses
P_res_st=-C(1)-P_st //Residual Load in kN
P_res_al=-C(2)-P_al //Residual Load in kN
sigma_st=P_res_st/A_st //residual Stress in Steel in MPa
sigma_al=P_res_al/A_al //residual Stress in Aluminium in MPa


//Result
printf("\n The Residual stresses are as follows")
printf("\n Sigma_st= %0.1f MPa and sigma_al= %0.1f MPa",sigma_st*10**3,sigma_al*10**3)
```

Chapter 14

Review of Properties of Plane Area

Scilab code Exa 14.1 The moment of inertia along u axis

```

clear//

//Variable Declaration
A=2000 //Area of the plane in mm^2
Ix=40*10**6 //Momnet of Inertia in mm^4
d1=90 //Distance in mm
d2=70 //Distance in mm

//Calculations
Ix_bar=Ix-(A*d1**2) //Moment of Inertia along x_bar
    axis in mm^4
Iu=Ix_bar+A*d2**2 //Moment of Inertia along U-axis
    in mm^4

//Result
printf("\n Ix_bar")
printf("\n The moment of inertia along u-axis is %0
    .1f mm^4",Iu)
```

Scilab code Exa 14.2 `Moment of inertia about the centroidal axis`

```

clear//

//Variable Declaration
R=45 //Radius of the circle in mm
r=20 //Radius of the smaller circle in mm
h=100 //Depth of the straight section in mm

//Calculations
//Part 1

//Triangle
b=2*R //Breadth in mm
A_t=b*h*0.5 //Area in mm^2
Ix_bar_t=b*h**3*36**-1 //Moment of inertia in mm^4
y_bar1=2*3**-1*h //centroidal axis in mm
Ix_t=Ix_bar_t+A_t*y_bar1**2 //moment of inertia in mm^4

//Semi-circle
A_sc=%pi*R**2*0.5 //Area of the semi-circle in mm^2
Ix_bar_sc=0.1098*R**4 //Moment of inertia in mm^4
y_bar2=h+(4*R*(3*%pi)**-1) //Distance of centroid in mm
Ix_sc=Ix_bar_sc+A_sc*y_bar2**2 //Moment of inertia in mm^4

//Circle
A_c=%pi*r**2 //Area of the circle in mm^2
Ix_bar_c=%pi*r**4*4**-1 //Moment of inertia in mm^4
y_bar3=h //Distance of centroid in mm
Ix_c=Ix_bar_c+A_c*y_bar3**2 //Moment of inertia in
```

```
mm^4

//Composite Area
A=A_t+A_sc-A_c //Total area in mm^2
Ix=Ix_t+Ix_sc-Ix_c //Moment of inertia in mm^4

//Part 2
y_bar=(A_t*y_bar1+A_sc*y_bar2-A_c*y_bar3)/(A) //Location of centroid in mm
Ix_bar=Ix-A*y_bar**2 //Moment of inertia in mm^4

//Result
printf("\n Moment of inertia about x-axis is %0.0f mm^4",Ix)
printf("\n Moment of inertia about the centroidal axis is %0.0f mm^4",Ix_bar)
```

Scilab code Exa 14.3 `The Product of inertia`

```

clear//

//Variable Declaration
t=20 //Thickness in mm
h=140 //Depth in mm
w=180 //Width in mm

//Calculations
Ixy_1=0+(h*t*t*0.5*h*0.5) //product of inertia in mm^4
Ixy_2=0+((w-t)*t*(w+t)*0.5*t*0.5) //Product of inertia in mm^4
Ixy=Ixy_1+Ixy_2 //Product of inertia in mm^4

//Result
```

```
printf("\n The Product of inertia is %0.0f mm^4",Ixy
  )
```

Scilab code Exa 14.4 The moment of inertia along the uv axis

```

clear//

//Variable Declaration
t=30 //Thickness in mm
h=200 //Depth of the section in mm
w=160 //Width in mm
the=50 //Angle in degrees


//Calculations
A1=t*h //Area of the web portion in mm^2
A2=(w-t)*t //Area of the flange portion in mm^2
x_bar=(A1*t*0.5+A2*(t+(w-t)*0.5))/(A1+A2) //Location
    of x_bar in mm
y_bar=(A1*h*0.5+A2*t*0.5)/(A1+A2) //Location of
   y_bar in mm

//Simplfying the computation
a=t*h**3*12**-1
b=A1*(200*0.5-y_bar)**2
c=(w-t)*t**3*12**-1
d=A2*(t*0.5-y_bar)**2
Ix_bar=a+b+c+d //Moment of inertia about x-axis in
   mm^4

//Simplifying the computation
p=h*t**3*12**-1
q=A1*(t*0.5-x_bar)**2
r=t*(w-t)**3*12**-1
```

```
s=A2*((w-t)*0.5+t-x_bar)**2
Iy_bar=p+q+r+s //Moment of inertia about y−axis in
   mmˆ4

//Simplfying the computation
a1=(t*0.5-x_bar)*(h*0.5-y_bar)
a2=(t*0.5-y_bar)*((w-t)*0.5+t-x_bar)
Ixy_bar=A1*a1+A2*a2 //Moment of inertia in mmˆ4

//Part 1
//Simplfying the computation
a3=(Ix_bar+Iy_bar)*0.5
a4=(0.5*(Ix_bar-Iy_bar))**2
a5=Ixy_bar**2
I1=a3+sqrt(a4+a5) //Moment of inertia in mmˆ4
I2=a3-sqrt(a4+a5) //Moment of inertia in mmˆ4

ThetaRHS=-(2*Ixy_bar)/(Ix_bar-Iy_bar) //RHS of the
   tan term
theta1=atan(ThetaRHS)*0.5*180*%pi**-1 //Angle in
   degrees
theta2=theta1+90 //Angle in degrees

//Part 2
Iu=a3+sqrt(a4)*cos(2*the*%pi*180**-1)-(Ixy_bar)*sin
   (2*the*%pi*180**-1) //Moment of inertia in mmˆ4
Iv=a3-sqrt(a4)*cos(2*the*%pi*180**-1)+(Ixy_bar)*sin
   (2*the*%pi*180**-1) //Moment of inertia in mmˆ4
Iuv=sqrt(a4)*sin(2*the*%pi*180**-1)+(Ixy_bar)*cos(2*
   the*%pi*180**-1) //Moment of inertia in mmˆ4


//Result
printf("\n The Principal Moment of inertias are as
   follows")
printf("\n I1= %0.0f mmˆ4 and I2= %0.0f mmˆ4",I1,I2)
printf("\n Princial direction are theta1= %0.1f
   degrees theta2= %0.1f degrees",theta1,theta2)
```

```
printf("\n The moment of inertia along the uv-axis is %0.0f mm^4" ,Iuv)
```

Scilab code Exa 14.5 The moment of inertia along the uv axis

```

clear//

//Variable Declaration
Ix_bar=37.37*10**6 //Moment of inertia in mm^4
Iy_bar=21.07*10**6 //Moment of inertia in mm^4
Ixy_bar=-16.073*10**6 //Moment of inertia in mm^4

//Calculations
b=(Ix_bar+Iy_bar)*0.5 //Parameter for the circle in mm^4
R=sqrt(((Ix_bar-Iy_bar)*0.5)**2+Ixy_bar**2) //Radius of the Mohr's Circle in mm^4

//Part 1
I1=b+R //MI in mm^4
I2=b-R //MI in mm^4
theta1=asin(abs(Ixy_bar)/R)*180*%pi**-1*0.5 //Angle in degrees
theta2=theta1+90 //Angle in degrees

//Part 2
alpha=(100-theta1*2)*0.5 //Angle in degrees
Iu=(b)+R*(cos(alpha*%pi*180**-1)) //MI in mm^4

Iv=(b)-R*(cos(alpha*%pi*180**-1)) //MI in mm^4

Iuv=R*sin(2*alpha*%pi*180**-1) //MI in mm^4

//Result
```

```
printf("\n The Principal Moment of inertias are as
   follows")
printf("\n I1= %0.0f mm^4 and I2= %0.0f mm^4",I1,I2)
printf("\n Princial direction are theta1= %0.1f
   degrees theta2= %0.1f degrees" ,theta1,theta2)
printf("\n The moment of inertia along the uv-axis
   is %0.0f mm^4"  ,Iuv)
```