Scilab Textbook Companion for Mechanics Of Material by J. M. Gere[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

Tension Comprssion and Shear

Scilab code Exa 1.1 Determine the compressive stress and strain in the post

```
d_1 = 4 ; // inner diameter (inch)
d_2 = 4.5 ; //outer diameter (inch)
P = 26000 ; // pressure in pound
L = 16; // Length of cylinder (inch)
del = 0.012 ; // shortening of post (inch)
A = (%pi/4)*((d_2^2)-(d_1^2))  //Area (inch ^2)
s = P/A;  // stress
disp("psi",s,"compressive stress in the post is")
e = del / L;  // strain
disp(e,"compressive strain in the post is")
```

Scilab code Exa 1.2 Calculation of maximum stress

```
W = 1500; // weight (Newton)
d = 0.008 ; //diameter(meter)
g = 77000; // Weight density of steel
L = 40 ; // Length of bar (m)
```

```
A = (%pi/4)*(d^2) // Area
s_max = (1500/A) + (g*L) // maximum stress
disp("Pa",s_max,"Therefore the maximum stress in the
    rod is")
```

Scilab code Exa 1.3 Determination of various structural properties of the pipe

```
d1 = 4.5; // diameter in inch
d2 = 6 ; // diameter in inch
A = (%pi/4)*((d2^2)-(d1^2)) // Area
P = 140 ; // pressure in K
s = -P/A ; // stress (compression)
E = 30000 ; // young's modulus in Ksi
e = s/E ; // strain
// Part (a)
del = e*4*12  // del = e*L ;
disp(del,"Change in length of the pipe is")
// Part (b)
v = 0.30; // Poissio's ratio
e_ = -(v*e)
disp(e_,"Lateral strain in the pipe is")
// Part (c)
del_d2 = e_*d2 ;
del_d1 = e_*d1;
disp("inch",del_d1,"Increase in the inner diameter
    is ")
// Part (d)
t = 0.75;
del_t = e_*t ;
disp("inch",del_t,"Increase in the wall thicness is"
    )
del_t1 = (del_d2-del_d1)/2 ;
disp("del_t1 = del_t")
```

Scilab code Exa 1.4 Calculation of average shear and compressive stress in a punch

```
d = 0.02 ; // diameter in m
t = 0.008 ; // thickness in m
A = %pi*d*t ; // shear area
P = 110000 ; // prassure in Newton
A1 = (%pi/4)*(d^2); // Punch area
t_aver = P/A ; // Average shear stress
disp("Pa",t_aver,"Average shear stress in the plate
   is ")
s_c = P/A1 ; // compressive stress
disp("Pa",s_c,"Average compressive stress in the
   plate is ")
```

Scilab code Exa 1.5 Determination of various structural properties of the pin

```
P = 12; // Pressure in K
t = 0.375 ; // thickness of wall in inch
theta = 40 ; // angle in degree
d_pin = 0.75 ; // diameter of pin in inch
t_G = 0.625 ; // thickness of gusset in inch
t_B = 0.375 ; //thickness of base plate in inch
d_b = 0.50 ; // diameter of bolt in inch
//Part (a)
s_b1 = P/(2*t*d_pin); // bearing stress
disp("ksi",s_b1,"Bearing stress between strut and
   pin")
//Part (b)
t_pin = (4*P)/(2*%pi*(d_pin^2)); // average shear
   stress in the
```

```
disp("ksi",t_pin,"Shear stress in pin is ")
// Part (c)
s_b2 = P/(2*t_G*d_pin); // bearing stress between pin and gusset
disp("ksi",s_b2," Bearing stress between pin and gussets is")
// Part (d)
s_b3 = (P*cosd(40))/(4*t_B*d_b); // bearing stress between anchor bolt and base plate
disp("ksi",s_b3,"Bearing stress between anchor bolts and base plate")
// Part (e)
t_bolt = (4*cosd(40)*P)/(4*%pi*(d_b^2)); // shear stress in anchor bolt
disp("ksi",t_bolt,"Shear stress in anchor bolts is")
```

Scilab code Exa 1.7 Determination of allowable tensile load

```
b1 = 1.5 ; // width of rectangular crosssection in inch
t = 0.5 ; // thickness of rectangular crosssection in inch
b2 = 3 ; // width  of enlarged rectangular crosssection in inch
d = 1 ; // diameter in inch
// Part (a)
s_1 = 16000; // maximum allowable tensile stress in Psi
P_1 = s_1*t*b1 ;
disp("lb",P_1,"The allowable load  P1 is")
// Part (b)
s_2 = 11000; // maximum allowable tensile stress in Psi
P_2 = s_2*t*(b2-d) ;
disp("lb",P_2,"allowable load P2 at this section is"
```

```
)
//Part (c)
s_3 = 26000; // maximum allowable tensile stress in
    Psi
P_3 = s_3*t*d
disp("lb",P_3,"The allowable load based upon bearing
     between the hanger and the bolt is")
// Part (d)
s_4 = 6500; // maximum allowable tensile stress in
    Psi
P_4 = (%pi/4)*(d^2)*2*s_4 ;
disp("lb",P_4,"the allowable load  P4 based upon
    shear in the bolt is")
```

Scilab code Exa 1.8 Determination of required cross section area of the bar

```
// Horizontal component at A in N
R_ah = (2700*0.8 + 2700*2.6)/2 ;
// Horizontal component at C in N
R_ch = R_ah ;
// vertical component at C in N
R_cv = (2700*2.2 + 2700*0.4)/3 ;
// vertical component at A in N
R_av = 2700 + 2700 - R_cv ;
R_a = sqrt((R_ah^2)+(R_av^2))
R_c = sqrt((R_ch^2)+(R_cv^2))
Fab = R_a; // Tensile force in bar AB
Vc = R_c; // Shear force acting on the pin at C
s_allow = 125000000 ; // allowable stress in tension
t_allow = 45000000; // allowable stress in shear
Aab = Fab / s_allow;  // required area of bar
Apin = Vc / (2*t_allow);  // required area of pin
disp("m2",Apin,"Required area of bar is ")
d = sqrt((4*Apin)/%pi);   // diameter in meter
```

```
disp("m",d,"Required diameter of pin is")
```

Chapter 2

Axially Loaded Members

Scilab code Exa 2.1 Calculation of number of revolutions of the nut that are required to bring the pointer back to the mark

```
W = 2 ; //lb
b = 10.5; //inch
c = 6.4 ; //inch
k = 4.2; //inch
p = 1/16; //inch
n = (W*b)/(c*k*p); //inch
disp(n," No. of revolution required = ")
```

Scilab code Exa 2.2 Calculation of maximum allowable load

```
Fce_ = 2; //dummy variable
Fbd_ = 3; //dummy variable
Lbd = 480; //mm
Lce = 600; //mm
E = 205e6; //205Gpa
Abd = 1020; //mm
Ace = 520; //mm
```

```
Dbd_ = (Fbd_*Lbd)/(E*Abd); //dummy variable
Dce_ = (Fce_*Lce)/(E*Ace); //dummy variable
Da = 1; //limiting value
P = ( ( ((450+225)/225)*(Dbd_ + Dce_) - Dce_ )^(-1) ) * Da ;
Fce = 2*P; // Real value in newton
Fbd = 3*P; //real value in newton
Dbd = (Fbd*Lbd)/(E*Abd); //displacement in mm
Dce = (Fce*Lce)/(E*Ace); // displacement in mm
a = atand((Da+Dce)/675) ; //alpha in degree
disp("degree",a,"alpha = ")
```

Scilab code Exa 2.3 Calculation of vertical displacement at point C

```
P1 = 2100; //lb
P2 = 5600; //lb
b = 25; //inch
a = 28; //inch
A1 = 0.25; //inch^2
A2 = 0.15; //inch^2
L1 = 20; //inch
L2 = 34.8; //inch
E = 29e6; //29Gpa
P3 = (P2*b)/a ;
Ra = P3-P1;
N1 = -Ra ;
N2 = P1 ;
D = ((N1*L1)/(E*A1)) + ((N2*L2)/(E*A2)) ; //displacement
disp ("inch",D,"Downward displacement is = ")
```

Scilab code Exa 2.6 Calculation of the allowable load

```
//Numerical calculation of allowable load
d1 = 4; //mm
d2 = 3; //mm
A1 = (%pi*(d1^2))/4 ; //area
A2 = (%pi*(d2^2))/4 ; //area
L1 = 0.4; //meter
L2 = 0.3; //meter
E1 = 72e9 ; //Gpa
E2 = 45e9 ; //Gpa
f1 = L1/(E1*A1) * 1e6 ; // To cpmpensate for the mm
    ^2
f2 = L2/(E2*A2) * 1e6 ;
s1 = 200e6; //stress
s2 = 175e6; //stress
P1 = ( (s1*A1*(4*f1 + f2))/(3*f2) ) * 1e-6 // To
    cpmpensate for the mm^2
P2 = ( (s2*A2*(4*f1 + f2))/(6*f1) ) * 1e-6
disp( "Newton",P2,"Minimum allowable stress aomong
    the two P1 and P2 is smaller one, therefore MAS =
    ")
```

Scilab code Exa 2.10 Determination of state of stress in a bar

```
P = 90000; //newton
A = 1200e-6 // meter^2
s_x = -P/A ; //stress
t_1 = 25; //for the stresses on ab and cd plane
s_1 = s_x*(cosd(t_1)^2);
T_1 = -s_x*cosd(t_1)*sind(t_1) ;
t_2 = -65; //for the stresses on ad and bc plane
s_2 = s_x*(cosd(t_2)^2);
T_2 = -s_x*cosd(t_2)*sind(t_2) ;
disp("MPa respecively",s_1,T_1," The normal and
    shear stresses on the plane ab and cd are")
disp("MPa respecively",s_2,T_2," The normal and
```

```
shear stresses on the plane ad and bc are")
```

Scilab code Exa 2.11 Determination of minimum width of the bar

```
// Value of s_x based on allowable stresses on glued joint

s_t = -750; //psi
t = -50; //degree
T_t = -500; //psi
sg_x_1 = s_t/(cosd(t)^2)
sg_x_2 = -T_t/(cosd(t)*sind(t))

// Value of s_x based on allowable stresses on plastic

sp_x_1 = -1100; //psi
T_t_p =600; //psi
t_p = 45; //degree
sp_x_2 = -T_t_p/(cosd(t_p)*sind(t_p))

// Minimum width of bar

P = 8000; //lb
A = P/sg_x_2;
b_min = sqrt(A)  //inch
disp("inch",b_min,"The minimum width of the bar is")
```

Scilab code Exa 2.15 Comparison of energy absorbing capacity of the three bolt

```
//Bolt with reduced shank diameter
g = 1.50; // inch
```

```
d = 0.5; //inch
t = 0.25; //inch
d_r = 0.406; //inch
L = 13.5; //inch
ratio = ( (g*(d^2)) / ( ((g-t)*(d_r^2))+(t*(d^2))) ) //U2/U1
disp(ratio,"The energy absorbing capacity of the bolts with reduced shank diameter")
// Long bolts
ratio_1 = ( (((L-t)*(d_r^2))+(t*(d^2))) / ((2*(g-t)*(d_r^2))+2*(t*(d^2))) ); //U3/2U1
disp(ratio_1,"The energy absorbing capacity of the long bolts")
```

Scilab code Exa 2.16 Calculation of maximum elongation and maximum tensile stress in a bar

```
// Maximum elongation
M = 20; //kg
g = 9.81; //m/s^2
L = 2; //meter
E = 210e9; //210Gpa
h = 0.15; //meter
diameter = 0.015; //milimeter
A = (%pi/4)*(diameter^2) ; //area
D_st = ((M*g*L)/(E*A)) ;
D_max = D_st*(1+(1+(2*h/D_st))^0.5) ;
D_max_1 = sqrt(2*h*D_st) // another approach to find D_max
i = D_max / D_st // Impact factor
disp("mm",D_max,"Maximum elongation is")
// Maximum tensile stress
s_max = (E*D_max)/L ; //Maximum tensile stress
s_st = (M*g)/A ;//static stress
i_1 = s_max / s_st //Impact factor
```

```
disp("Pa",s_max,"Maximum tensile stress is")
```

Scilab code Exa 2.18 Determination of displacement at the lower end of the bar under various conditions

```
P1 = 108000; //Newton
P2 = 27000; //Newton
L = 2.2; //meter
A = 480; //mm^2

// Displacement due to load P1 acting alone

s = (P1/A) //stress in MPa
e = (s/70000) + (1/628.2)*((s/260)^10) //strain
D_b = e*L*1e3 //elongation in mm
disp("mm",D_b,"elongation when only P1 load acting
    is = ")

// Displacement due to load P2 acting alone

s_1 = (P2/A) //stress in MPa
e_1 = (s_1/70000) + (1/628.2)*((s_1/260)^10) //
    strain
D_b_1 = e_1*(L/2)*1e3 //elongation in mm (no
    elongation in lower half)
disp("mm",D_b_1,"elongation when only P2 load acting
     is = ")

// Displacement due to both load acting
    simontaneously

//upper half
s_2 = (P1/A) //stress in MPa
e_2 = (s_2/70000) + (1/628.2)*((s_2/260)^10) //
    strain
```

```
//lower half
s_3 = (P1+P2)/A //stress in MPa
e_3 = (s_3/70000) + (1/628.2)*((s_3/260)^10) //
    strain
D_b_2 = ( (e_2*L)/2 + (e_3*L)/2 ) * 1e3 //
    elongation in mm
disp("mm",D_b_2,"elongation when P1 and P2 both
    loads are acting is = ")
```

Chapter 3

Torsion

Scilab code Exa 3.1 Calculation of maximum shear stress and permissible torque in the bar

```
d = 1.5; // diameter of bar in inch
L = 54 ; // Length of bar in inch
G = 11.5e06 ; // modulus of elasticity in psi
// Part (a)
T = 250 ; // torque
t_max = (16*T*12)/(%pi*(d^3)); // maximum shear stress in bar
Ip = (%pi*(d^4))/32 ; // polar miment of inertia
f = (T*12*L)/(G*Ip) ; // twist in radian
f_ = (f*180)/%pi ; // twist in degree
disp("psi",t_max,"Maximum shear stress in the bar is")
disp("degree",f_,"Angle of twist is")
//Part (b)
t_allow = 6000 ; // allowable shear stress
T1 = (%pi*(d^3)*t_allow)/16; //allowable permissible torque in lb-in
T1_ = T1*0.0831658 ; //allowable permissible torque in lb-ft
f_allow = (2.5*%pi)/180 ; // allowable twist in
```

```
radian
T2 = (G*Ip*f_allow)/L;  // allowable stress via a another method
T2_ = T2*0.0831658; //allowable permissible torque in lb−ft
T_max = min(T1_,T2_); // minimum of the two
disp("lb−ft",T_max,"Maximum permissible torque in the bar is")
```

Scilab code Exa 3.2 Calculation of required diameter for solid and hollow shaft

```
T = 1200 ; // allowable torque in N−m
t = 40e06 ; // allowable shear stress in Pa
f = (0.75*%pi)/180 ; // allowable rate of twist in rad/meter
G = 78e09; // modulus of elasticity
// Part (a) : Solid shaft
d0 = ((16*T)/(%pi*t))^(1/3)
Ip = T/(G*f) ; // polar moment of inertia
d01 = ((32*Ip)/(%pi))^(1/4); // from rate of twist definition
disp("m",d0,"The required diameter of the solid shaft is ")
// Part (b) : hollow shaft
d2 = (T/(0.1159*t))^(1/3) ; // Diamater of hollow shaft in meter
// The above equation comes from solving the following four equation
// t1 = 0.1*d2 ; thickness of shaft
// d1 = d2−(2*t1) ; // diameter of inner radius
// Ip = (%pi/32)*((d2^4)−(d1^4)); // Polar moment of inertia
// r = d2/2
// t = (T*r)/Ip ; // allowable shear stress
```

```
d2_ = (T/(0.05796*G*f))^(1/4) ; // Another value of d2 by definition of theta(allow), f = T/(G*Ip)
d1 = 0.8*d2_ ; // because rate of twist governs the design
disp("m",d2,"The required diameter of the hollow shaft is ")
// Part (c) : Ratio of diameter and weight
r1 = d2_/d01 ; // diameter ratio
r2 = ((d2_^2)-(d1^2))/(d01^2) ; // Weight Ratio
disp(r1,"Ratio of the diameter of the hollow and solid shaft is")
disp(r2,"Ratio of the weight of the hollow and solid shaft is")
```

Scilab code Exa 3.4 Determination of maximum shear stress in each part of the shaft and the angle of twist

```
d = 0.03 ; // diameter of the shaft in meter
T2 = 450 ; // Torque in N-m
T1 = 275 ; //
T3 = 175 ; //
Lbc = 0.5 ; // Length of shaft in meter
Lcd = 0.4 ; // Length of shaft in meter
G = 80e09 ; // Modulus of elasticity
Tcd = T2-T1 ; // torque in segment CD
Tbc = -T1 ; // torque in segment BC
tcd = (16*Tcd)/(%pi*(d^3)); // shear stress in cd segment
disp("Pa",tcd,"Shear stress in segment cd is")
tbc = (16*Tbc)/(%pi*(d^3)); // shear stress in bc segment
disp("Pa",tbc,"Shear stress in segment bc is")
Ip = (%pi/32)*(d^4); // Polar moment of inertia
fbc = (Tbc*Lbc)/(G*Ip); // angle of twist in radian
fcd = (Tcd*Lcd)/(G*Ip); // angle of twist in radian
```

```
fbd = fbc + fcd ; // angle of twist in radian
disp("radian",fbd,"Angles of twist in section BD")
```

Scilab code Exa 3.6 Calculation of various stress and strain in circular tube

```
d1 = 0.06 ; // Inner diameter in meter
d2 = 0.08 ; // Outer diameter in meter
r = d2/2; // Outer radius
G = 27e09 ; // Modulus of elasticity
T = 4000 ; // Torque in N-m
Ip = (%pi/32)*((d2^4)-(d1^4)); // Polar moment of inertia
t_max = (T*r)/Ip ; // maximum shear stress
disp("Pa",t_max,"Maximum shear stress in tube is ")
s_t = t_max ; // Maximum tensile stress
disp("Pa",s_t,"Maximum tensile stress in tube is ")
s_c = -(t_max); // Maximum compressive stress
disp("Pa",s_c,"Maximum compressive stress in tube is ")
g_max = t_max / G ; // Maximum shear strain in radian
disp("radian",g_max,"Maximum shear strain in tube is ")
e_t = g_max/2 ; // Maximum tensile strain in radian
disp("radian",e_t,"Maximum tensile strain in tube is ")
e_c = -g_max/2 ; // Maximum compressive strain in radian
disp("radian",e_c,"Maximum compressive strain in tube is ")
```

Scilab code Exa 3.7 Calculation of the required diameter d of the shaft

```
H = 40 ; // Power in hp
s = 6000 ; // allowable shear stress in steel in psi
// Part (a)
n = 500 ; // rpm
T = ((33000*H)/(2*%pi*n))*(5042/420); // Torque in
    lb-in
d = ((16*T)/(%pi*s))^(1/3); // diameter in inch
disp("inch",d,"Diameter of the shaft at 500 rpm")
// Part (b)
n1 = 3000 ; // rpm
T1 = ((33000*H)/(2*%pi*n1))*(5042/420); // Torque in
    lb-in
d1 = ((16*T1)/(%pi*s))^(1/3); // diameter in inch
disp("inch",d1,"Diameter of the shaft at 3000 rpm")
```

Scilab code Exa 3.8 Calculation of maximum shear stress tmax in the shaft and the angle of twist

```
d = 0.05 ; // diameter of the shaft
Lab = 1 ; // Length of shaft ab in meter
Lbc = 1.2 ; // Length of shaft bc in meter
Pa = 50000; // Power in Watt at A
Pb = 35000; // Power in Watt at B
Ip = (%pi/32)*(d^4) ; // Polar moment of inertia
Pc = 15000; // Power in Watt at C
G = 80e09; // Modulus of elasticity
f = 10 ; // frequency in Hz
Ta = Pa/(2*%pi*f) // Torque in N-m at A
Tb = Pb/(2*%pi*f) // Torque in N-m at B
Tc = Pc/(2*%pi*f) // Torque in N-m at B
Tab = Ta ; // Torque in N-m in shaft ab
Tbc = Tc ; // Torque in N-m in shaft bc
tab = (16*Tab)/(%pi*(d^3)) ; // shear stress in ab
    segment
fab = (Tab*Lab)/(G*Ip); // angle of twist in radian
```

```
tbc = (16*Tbc)/(%pi*(d^3)); // shear stress in ab
    segment
fbc = (Tbc*Lbc)/(G*Ip); // angle of twist in radian
fac = (fab+fbc)*(180/%pi);  // angle of twist in
    degree in segment ac
tmax = Tab;  // Maximum shear stress
disp("Nm",tmax,"The maximum shear stress tmax in the
     shaft")
disp("degree",fac,"Angle of twist in segment AC")
```

Scilab code Exa 3.10 evaluation of the strain energy for different cases

```
Ta = 100 ; // Torque in N-m at A
Tb = 150; // Torque in N-m at B
L = 1.6 ; // Length of shaft in meter
G = 80e09 ; // Modulus of elasticity
Ip = 79.52e-09; // polar moment of inertia in m4
Ua = ((Ta^2)*L)/(2*G*Ip) // Strain energy at A
disp("joule",Ua,"Torque acting at free end")
Ub = ((Tb^2)*L)/(4*G*Ip)  // Strain energy at B
disp("joule",Ub,"Torque acting at mid point")
a = (Ta*Tb*L)/(2*G*Ip) // dummy variabble
Uc = Ua+a+Ub ; // Strain energy at C
disp("joule",Uc,"Total torque")
```

Scilab code Exa 3.11 Evaluation of the strain energy of a hollow shaft

```
t = 480 ; // Torque of constant intensity
L = 144 ; // Length of bar
G = 11.5e06; // Modulus of elasticity in Psi
Ip = 17.18 ; // Polar moment of inertia
U = ((t^2)*(L^3))/(G*Ip*6) // strain energy in in-lb
```

```
disp("in-lb",U,"The strain energu for the hollow
   shaft is")
```

Chapter 4

Shear Forces and Bending Moments

Scilab code Exa 4.3 Calculation of the shear force and the bending moment of the cross section

```
q = 0.2 ; // Uniform load intensity in K/ft
P = 14 ; // Concentrated load in k
Ra = 11 ; // Reaction at A from wquation of
    equilibrium
Rb = 9 ; // Reaction at B from wquation of
    equilibrium
V = 11 - 14 - (0.2*15) ; // shear force in k
disp("k",V,"Shear force at section D")
M = (11*15)-(14*6)-(0.2*15*7.5) ; // Bending moment
    in K-ft
disp("k-ft",M,"Bending moment at section D")
V1 = -9+(0.2*15); // Shear firce from alternative
    method in k
M1 = (9*9)-(0.2*7.5*15);  // Bending moment from
    alternative method in k-ft
```

Scilab code Exa 4.7 Shear force nd bending moment diagramme

```
q = 1 ; // Uniform load intensity in k/ft
M0 = 12 ; // Couple in k-ft
Rb = 5.25 ; // Reaction at B in k
Rc = 1.25 ; // Reaction at C in k
b = 4 ; // Length of section AB in ft
Mb = -(q*(b^2))/2 ; // Moment acting at B
disp("k-ft",Mb,"Bending moment at B")
```

Chapter 5

Stresses in Beams Basic Topics

Scilab code Exa 5.1 Determination of radius of curvature and deflection in a simply supported beam

```
L = 8 ; // length of beam in ft
h = 6 ; // Height of beam in inch
e = 0.00125 ; // elongation on the bottom surface of
    the beam
y = -3 ; // Distance of the bottom surface to the
   neutral surface of the beam in inch
r = -(y/e) ; // Radius of curvature
disp("ft",r,"radius of curvature is")
k = 1/r ; // curvature in in-1
disp("ft-1",k,"curvature")
theta = asind((L*12)/(2*r)) ; // angle in degree
disp("degree",theta,"Angle of twist")
del = r*(1-cosd(theta)); //Deflection in inch
```

Scilab code Exa 5.2 Determination of the bending moment M and maximum bending stress smax in the wire

```
d = 0.004 ; // thickness of wire in m
R0 = 0.5 ; // radius of cylinder in m
E = 200e09 ; // Modulus of elasticity of steel
s = 1200e06 ; // proportional limit of steel
M = (%pi*E*d^4)/(32*(2*R0+d)) ; // Bending moment in
    wire in N-m
disp("N-m",M,"Bending moment in the wire is ")
s_max = (E*d)/(2*R0+d) ; // Maximum bending stress
    in wire in Pa
disp("Pa",s_max,"Maximum bending stress in the wire
    is ")
```

Scilab code Exa 5.3 Determination of maximum tensile and compressive stresses in the beam due to bending

```
L = 22 ; // Span of beam in ft
q = 1.5; // Uniform load intensity in k/ft
P = 12 ; // Concentrated in k
b = 8.75 ; // width of cross section of beam in inch
h = 27 ; // height of cross section of beam in inch
Ra = 23.59; // Reaction at point A
Rb = 21.41; // Reacyion at point B
Mmax = 151.6 ; // Maximum bending moment
S = (b*h^2)/6 ; // Section modulus
s = (Mmax*12)/S  // stress in k
st = s*1000 ; // Tensile stress
disp("psi",st,"Maximum tensile stress in the beam")
sc = -s*1000 ; // Compressive stress
disp("psi",sc,"Maximum compressive stress in the
    beam")
```

Scilab code Exa 5.4 Determination the maximum tensile and compressive stresses in the beam due to the uniform load

```
q = 3200 ; // Uniform load intensity in N/m
b = 0.3; // width of beam in m
h = 0.08 ; // Height of the beam in m
t = 0.012 ; // thickness of beam in m
Ra = 3600 ; // Reaction at A in N
Rb = 10800 ; // Reaction at B in N
Mpos = 2025 ; // Moment in Nm
Mneg = -3600 ; // Moment in Nm
y1 = t/2;
A1 = (b-2*t)*t ;
y2 = h/2;
A2 = h*t ;
A3 = A2 ;
c1 = ((y1*A1)+(2*y2*A2))/((A1)+(2*A2));
c2 = h - c1 ;
Ic1 = (b-2*t)*(t^3)*(1/12);
d1 = c1-(t/2);
Iz1 = (Ic1)+(A1*(d1^2));
Iz2 = 956600e-12;
Iz3 = Iz2 ;
Iz = Iz1 + Iz2 + Iz3 ; // Moment of inertia of the beam cross section
// Section Modulli
S1 = Iz / c1 ; // for the top surface
S2 = Iz / c2 ; // for the bottom surface
// Maximum stresses for the positive section
st = Mpos / S2 ;
disp("Pa",st,"Maximum tensile stress in the beam in positive section is")
sc = -Mpos / S1 ;
disp("Pa",sc,"Maximum compressive stress in the beam in positive section is")
// Maximum stresses for the negative section
snt = -Mneg / S1 ;
disp("Pa",snt,"Maximum tensile stress in the beam in negative section is")
snc = Mneg / S2 ;
disp("Pa",snc,"Maximum compressive stress in the
```

```
    beam in negative section is")
// Conclusion
st_max = st;
sc_max = snc ;
```

Scilab code Exa 5.5 Selection of the suitable size for the beam

```
L = 12 ; // Length of beam in ft
q = 420 ; // Uniform load intensity in lb/ft
s = 1800 ; // Allowable bending stress in psi
w = 35 ; // weight of wood in lb/ft3
M = (q*L^2*12)/8 ; // Bending moment in lb-in
S = M/s ; // Section Modulli in in3
// From Appendix F
q1 = 426.8; // New uniform load intensity in lb/ft
S1 = S*(q1/q); // New section modulli in in3
// From reference to appendix F, a beam of cross
    section 3*12 inch is selected
disp("Beam of crosssection 3*12 is sufficient")
```

Scilab code Exa 5.6 Calculation of minimum required diameter in the wood and alluminium rod

```
P = 12000; // Lataeral load at the upper end in N
h = 2.5 ; // Height of post in m
Mmax = P*h ; // Maximum bending moment in Nm
// Part (a) : Wood Post
s1 = 15e06 ; // Maximum allowable stress in Pa
S1 = Mmax/s1 ;// Section Modulli in m3
d1 = ((32*S1)/%pi)^(1/3); // diameter in m
disp("m",d1,"the minimum required diameter d1 of the
    wood post is")
// Part (b) : Alluminium tube
```

```
s2 = 50e06 ; // Maximum allowable stress in Pa
S2 = Mmax/s2; // Section Modulli in m3
d2 = (S2/0.06712)^(1/3); // diameter in meter
    .....(1)
// Here equation (1) , comes from solving following
    three equation
// c = d2/2 (radius of tube)
// I2 = (%pi/64)*((d2^4)-((0.75*d2)^4)) (Moment of
    inertia)
// S2 = I2/c ;
disp("m",d2,"minimum required outer diameter d2 of
    the aluminum tube is")
```

Scilab code Exa 5.7 Selection of the steel beam

```
q = 2000 ; // Uniform load intensity in lb/ft
s = 18000 ; // Maximum allowable load in Psi
Ra = 18860 ; // Reaction at point  A
Rb = 17140 ; // Reaction at point  B
x1 = Ra/q ; // Distance in ft from left end to the
    point of zero shear
Mmax = (Ra*x1)-((q*(x1^2))/2) ; // Maximum bending
    moment in lb-ft
S = (Mmax*12)/s; // Section Modulli in in3
// Trial Beam
Ra_t = 19380 ; // Reaction at point  A
Rb_t = 17670 ; // Reaction at point  B
x1_t = Ra_t/q ; // Distance in ft from left end to
    the point of zero shear
Mmax_t = (Ra_t*x1_t)-((q*(x1_t^2))/2) ; // Maximum
    bending moment in lb-ft
S_t = (Mmax_t*12)/s; // Section Modulli in in3
// From table E beam 12*50 is selected
disp("in3",S_t,"Beam of crosssection 12*50 is
    selected with section modulli")
```

Scilab code Exa 5.8 Determination of the minimum required dimension b of the posts

```
g = 9810 ; // Specific weight of water in N/m3
h = 2; // Height of dam in m
s = 0.8 ; // Distance between square cross section
    in m
sa = 8e06 ; // Maximum allowable stress in Pa
b = ((g*(h^3)*s)/sa)^(1/3) ; // Dimension of
    croossection in m
disp("m",b,"the minimum required dimension b of the
    posts")
```

Scilab code Exa 5.11 Determination of the normal stress and shear stress at point C

```
L = 3 ; // Span of beam in ft
q = 160 ; // Uniform load intensity in lb/in
b = 1; // Width of cross section
h = 4; // Height of cross section
// Calculations from chapter 4
Mc = 17920 ; // Bending moment in ld-in
Vc = -1600 ; // Loading in lb
//
I = (b*(h^3))/12; // Moment of inertia in in4
sc = -(Mc*1)/I; // Compressive stress at point C in
    psi
Ac = 1*1 ; // Area of section C in inch2
yc = 1.5 ; // distance between midlayers od section
    C and cross section of beam
Qc = Ac*yc ; // First moment of C cross section in
    inch3
```

```
tc = (Vc*Qc)/(I*b); // Shear stress in Psi
disp("psi",sc,"Normal stress at C")
disp("psi",tc,"Shear stress at C")
```

Scilab code Exa 5.12 Determination of the maximum permissible value Pmax of the loads

```
s = 11e06 ; // allowable tensile stress in pa
t = 1.2e06 ; // allowable shear stress in pa
b = 0.1 ; // Width of cross section in m
h = 0.15 ; // Height of cross section in m
a = 0.5 ; // in m
P_bending = (s*b*h^2)/(6*a); // Bending stress in N
P_shear = (2*t*b*h)/3;  // shear stress in N
Pmax = P_bending; // Because bending stress governs the design
disp("N",Pmax,"the maximum permissible value Pmax of the loads")
```

Scilab code Exa 5.13 Determination of the maximum shear stress in the pole and diameter d0 of a solid circular pole

```
d2 = 4; // Outer diameter in inch
d1 = 3.2; // Inner diameter in inch
r2 = d2/2; // Outer radius in inch
r1 = d1/2; // inner radius in inch
P = 1500 ; // Horizontal force in lb
// Part (a)
t_max = ((r2^2+(r2*r1)+r1^2)*4*P)/(3*%pi*((r2^4)-(r1^4))) ; // Mximum shear stress in Psi
disp("psi",t_max,"Maximum shear stress in the pole is")
// Part (b)
```

```
d0 = sqrt((16*P)/(3*%pi*t_max)) ; // Diameter of solid circular cross section in meter
disp("m",d0,"Diameter of solid circular cross section is ")
```

Scilab code Exa 5.14 Determination of the maximum shear stress minimum shear stress and total shear force in the web

```
b = 0.165 ; // in m
h = 0.320 ; // in m
h1 = 0.290 ; // in m
t = 0.0075; //  in m
V = 45000; // Vertical force in N
I = (1/12)*((b*(h^3))-(b*(h1^3))+(t*(h1^3))) // Moment of inertia of the cros section
t_max = (V/(8*I*t))*((b*(h^2))-(b*(h1^2))+(t*(h1^2))); // Maximum shear stress in Pa
t_min = ((V*b)/(8*I*t))*(h^2-h1^2); // Minimum shear stress in Pa
T = ((t*h1)/3)*(2*t_max + t_min); // Total shear force in Pa
t_avg = V/(t*h1) ; // Average shear stress in Pa
disp("Pa",t_max,"Maximum shear stress in the web is")
disp("Pa",t_min,"Minimum shear stress in the web is")
disp("Pa",T,"Total shear stress in the web is")
```

Scilab code Exa 5.15 Determination of the shear stress t1 at the top of the web and the maximum shear stress tmax

```
V = 10000; // Vertical shear force in lb
b = 4; // in inch
```

```
t = 1; // in inch
h = 8; // in inch
h1 = 7; // in inch
A = b*(h-h1) + t*h1 ;// Area of cross section
Qaa = ((h+h1)/2)*b*(h-h1) + (h1/2)*(t*h1); // First
    moment of cross section
c2 = Qaa/A ; // Position of neutral axis in inch
c1 = h-c2 ; // Position of neutral axis in inch
Iaa = (b*h^3)/3 - ((b-t)*h1^3)/3 ; // Moment of
    inertia about the line aa
I = Iaa - A*c2^2 // Moment of inertia of
    crosssection
Q1 = b*(h-h1)*(c1-((h-h1)/2)) ; // First moment of
    area above the line nn
t1 = (V*Q1)/(I*t)  // Shear stress at the top of web
     in Psi
Qmax = (t*c2)*(c2/2); // Maximum first moment of
    inertia below neutral axis
t_max = (V*Qmax)/(I*t);  // Maximum Shear stress in
    Psi
disp("psi",t1,"Shear stress at the top of the web is
    ")
disp("Psi",t_max,"Maximum Shear stress in the web is
    ")
```

Scilab code Exa 5.16 determination of the maximum permissible longitudinal spacing of the screws

```
Af = 40*180; // Area of flange in mm2
V = 10500 ; // Shear force acting on cross section
F = 800 ; // Allowable load in shear
df = 120 ; // Distance between centroid of flange
    and neutral axis in mm
Q = Af*df ; // First moment of cross section of
    flange
```

```
I = (1/12)*(210*280^3) - (1/12)*(180*200^3) ; // Moment of inertia of entire cross section in mm4
f = (V*Q)/I; // Shear flow
s = (2*F)/f  // Spacing between the screw
disp("mm",s,"The maximum permissible longitudinal spacing s of the screws is")
```

Scilab code Exa 5.17 Determination of the maximum tensile and compressive stresses in the beam due to a load

```
L = 60 ; // Length of beam in inch
d = 5.5 ; // distance from the point of application of the load P to the longitudinal axis of the tube in inch
b = 6 ; // Outer dimension of tube in inch
A = 20 ; // Area of cross section of tube in inch
I = 86.67 ; // Moment of inertia in in4
P = 1000; // in lb
theta = 60 ; // in degree
Ph = P*sind(60); // Horizontal component
Pv = P*cosd(60); // Vertical component
M0 = Ph*d ; // Moment in lb-in
y = -3 ; // Point at which maximum tensile stress occur in inch
N = Ph ; // Axial force
M = 9870 ; // Moment in lb-in
st_max = (N/A)-((M*y)/I) ; // Maximum tensile stress in Psi
yc = 3 ; // in inch
M1 = 5110 ; // moment in lb-in
sc_left = (N/A)-((M*yc)/I) ; // Stress at the left of point C in Psi
sc_right = -(M1*yc)/I ; // Stress at the right of point C in Psi
sc_max = min(sc_left,sc_right) ; // Because both are
```

```
    negative quantities
disp("psi",sc_max,"The maximum compressive stress in
    the beam is")
disp("psi",st_max,"The maximum tensile stress in the
    beam is")
```

Chapter 6

Stresses in Beams Advanced Topics

Scilab code Exa 6.1 Calculation of stresses in wood and steel

```
// 4*6 inch wood beam dimension
// 4*0.5 inch steel beam dimension
M = 60 ; // Moment in k-in
E1 = 1500 ; // in Ksi
E2 = 30000; // in Ksi
h1 = 5.031 ; // Distance between top surface and
    neutral axis of the beam in inch by solving
    1500*(h1-3)*24 + 30000*(h1-6.25)*2 = 0
h2 = 6.5 - h1 ;
I1 = (1/12)*(4*6^3) + (4*6)*(h1-3)^2 ; // Momeny of
    inertia of the wooden cross section
I2 = (1/12)*(4*0.5^3) + (4*0.5)*(h2-0.25)^2 ; //
    Momeny of inertia of the steel cross section
I = I1 + I2 ; // Moment of inertia of whole cross
    section
// Material 1
s1a = -(M*h1*E1)/((E1*I1)+(E2*I2)) ; // Maximum
    compressive stress in ksi where y = h1
s1c = -(M*(-(h2-0.5))*E1)/((E1*I1)+(E2*I2)) ; //
```

```
Maximum tensile stress in ksi where y = -(h2-0.5)
disp("ksi",s1a," Maximum compressive stress in wood is")
disp("ksi",s1c," Maximum tensile stress in wood is")
// Material 2
s2a = -(M*(-h2)*E2)/((E1*I1)+(E2*I2)); // Maximum tensile stress in ksi where y = -h2
s2c = -(M*(-(h2-0.5))*E2)/((E1*I1)+(E2*I2)); // Minimum tensile stress in ksi where y = -(h2-0.5)
disp("ksi",s2a," Maximum tensile stress in steel is")
disp("ksi",s2c," Minimum tensile stress in steel is")
```

Scilab code Exa 6.2 Determination of the maximum tensile and compressive stresses in the faces and the core

```
M = 3000 ; // moment in N-m
t = 0.005 ; // thickness of alluminiun in m
E1 = 72e09 ; // Modulus of elasticity of alluminium in Pa
E2 = 800e06 ; // Modulus of elasticity of Plastic core in Pa
b = 0.2 ; // Width of cross section in m
h = 0.160 ; // Height of cross section in m
hc = 0.150 ; // Height of Plastic core cross section in m
I1 = (b/12)*(h^3 - hc^3) ; // Moment of inertia of alluminium cross section
I2 = (b/12)*(hc^3) ; // Moment of inertia of Plastic core cross section
f = (E1*I1) + (E2*I2) ; // Flexural rigidity of the cross section
s1_max = (M*(h/2)*E1)/f ;
s1c = -s1_max ; // Maximum compressive stress in
```

```
allu minium core in Pa
s1t = s1_max ;  // Maximum tensile stress in allu minium core in Pa
disp("Pa",s1c," Maximum compressive stress on allu minium face by the general theory for composite beams is")
disp("Pa",s1t," Maximum tensile stress on allu minium face by the general theory for composite beams is")
s2_max = (M*(hc/2)*E2)/f ;
s2c = -s2_max ; // Maximum compressive stress in Plastic core in Pa
s2t = s2_max ;  // Maximum tensile stress in Plastic core in Pa
disp("Pa",s2c," Maximum compressive stress in plastic core by the general theory for composite beams is")
disp("Pa",s2t," Maximum tensile stress in plastic core by the general theory for composite beams is")
// Part (b) : Calculation from approximate theory of sandwitch
s1_max1 = (M*h)/(2*I1) ;
s1c1 = -s1_max1 ; // Maximum compressive stress in allu minium core in Pa
s1t1 = s1_max1 ;  // Maximum tensile stress in allu minium core in Pa
disp("Pa",s1c1," Maximum compressive stress on allu minium core by approximate theory of sandwitch is")
disp("Pa",s1t1," Maximum tensile stress on allu minium core by approximate theory of sandwitch is")
```

Scilab code Exa 6.3 Calculation of stresses in wood and steel

```
// 4*6 inch wood beam dimension
// 4*0.5 inch steel beam dimension
M = 60 ; // Moment in k-in
E1 = 1500 ; // in Ksi
E2 = 30000; // in Ksi
b = 4; // width of crosssection in inch
// Transformed Section
n = E2/E1 ; // Modular ratio
b1 = n*4 ; // Increased width of transformed cross
    section
// Neutral axis
h1 = ((3*4*6)+(80*0.5*6.25))/((4*6)+(80*0.5)); //
    Distance between top surface and neutral axis of
    the beam in inch
h2 = 6.5 - h1 ; // in inch
// Moment of inertia
It = (1/12)*(4*6^3) + (4*6)*(h1-3)^2 + (1/12)
    *(80*0.5^3) + (80*0.5)*(h2-0.25)^2 ; // Moment of
     inertia of transformed cross section
// Material 1
s1a = -(M*h1)/It;  // Maximum tensile stress in ksi
    where y = h1
s1c = -(M*(-(h2-0.5)))/It;  // Maximum compressive
    stress in ksi where y = -(h2-0.5)
disp("psi",s1a*1000,"Maximum tensile stress in wood
    is")
disp("psi",s1c*1000,"Maximum compressive stress in
    wood is")
// Material 2
s2a = -(M*(-h2)*n)/It ; // Maximum tensile stress in
     ksi where y = -h2
s2c = -(M*(-(h2-0.5)*n))/It ; // Minimum tensile
    stress in ksi where y = -(h2-0.5)
disp("psi",s2a*1000," Maximum tensile stress in
    steel")
disp("psi",s2c*1000," Minimum tensile stress in
    steel")
```

Scilab code Exa 6.4 Determination of the maximum tensile and compressive stresses in the beam and locating the neutral axis

```
q = 3000 ; // Uniform load intensity in N/m
a = 26.57 ; // tilt of the beam in degree
b = 0.1; // width of the beam
h = 0.15; // height of the beam
L = 1.6 ; // Span of the beam
qy = q*cosd(a) ; // Component of q in y direction
qz = q*sind(a) ; // Component of q in z direction
My = (qz*L^2)/8 ; // Maximum bending moment in y
    direction
Mz = (qy*L^2)/8 ; // Maximum bending moment in z
    direction
Iy = (h*b^3)/12; // Moment of inertia along y
Iz = (b*h^3)/12; // Moment of inertia alon z
s = ((3*q*L^2)/(4*b*h))*((sind(a)/b)+(cosd(a)/h));
sc = -s ; // Maximum compressive stress
st = s; // Maximum tensile stress
disp("Pa",sc,"Maximum compressive stress in the beam
     is")
disp("Pa",st,"Maximum tensile stress in the beam is"
    )
// Neutral axis
l = (h/b)^2;
t = sind(a)/cosd(a);
j = l*(sind(a)/cosd(a));
be = atand(j); // Inclination of Neutral axis to z
    axis
disp("degree",be,"Inclination of Neutral axis to z
    axis is")
```

Scilab code Exa 6.5 Determination of the maximum bending stresses in the beam

```
L = 12 ; // Length of the beam in ft
P = 10 ; // Load in k acting in vertical direction
//Part (a)
h = 24 ; // Height of beam in inch
Iz = 2100 ; // Moment of inertia along z axis in in4
Iy = 42.2 ; // Moment of inertia along y axis in in4
s_max = (P*(h/2)*L*12)/Iz ; // Maximum stress in Ksi
disp("psi",s_max*1000,"Maximum tensile stress in the beam at the top of the beam")
disp("psi",-s_max*1000,"Maximum compressive stress in the beam at the bottom of the beam")
//Part (b)
a = 1 ; // Angle between y axis and the load
My = -(P*sind(a))*L*12 ; // Moment along y-axis in K-in
Mz = -(P*cosd(a))*L*12 ; // Moment along z-axis in K-in
ba = atand((My*Iz)/(Mz*Iy)); // Orientation of neutral axis
z = -3.5; y = 12 ; // Coordinates of the point A and B where maximum stress occur
s = ((My*z)/Iy)-((Mz*y)/Iz) ; // Stress in Ksi
sa = s ; // Tensile stress at A
sb = -s ; // Compressive stress in B
disp("psi",sa*1000,"The tensile stress at A is")
disp("psi",sb*1000,"The compressive stress at B is")
```

Scilab code Exa 6.6 Calculation of the bending stresses and location of neutral axis

```
M = 15 ; // Bending moment in k-in
t = 10 ; // Angle between line of action of moment
```

```
and z-axis
// Properties of cross section
c = 0.634 ; // Location of centroid on the axis of symmetry
Iy = 2.28; // Moment of inertia in y-direction in in4
Iz = 67.4; // Moment of inertia in z-direction in in4
ya = 5 ; za = -2.6+0.634 ; // Coordinates of point A
yb = -5 ; zb = 0.634 ; // Coordinates of point B
My = M*sind(t); // Moment along y-axis
Mz = M*cosd(t); // Moment along z-axis
sa = ((My*za)/Iy)-((Mz*ya)/Iz) ; // Bending stress at point A in ksi
sb = ((My*zb)/Iy)-((Mz*yb)/Iz) ; // Bending stress at point B in ksi
disp("psi",sa*1000,"The bending stress at point A is ")
disp("psi",sb*1000,"The bending stress at point B is ")
// Neutral axis
j = (Iz/Iy)*(sind(t)/cosd(t));
be = atand(j); // Inclination of neutral axis to z-axis in degree
disp("degree",be,"Inclination of neutral axis to z-axis is")
```

Scilab code Exa 6.9 Determination of the magnitude of the moment

```
b = 5 ; // in inch
b1 = 4 ; // in inch
h = 9 ; // in inch
h1 = 7.5 ; // in inch
sy = 33 ; // stress along y axis in ksi
M = (sy/12)*((3*b*h^2)-(b+(2*b1))*(h1^2)) ; //
```

```
   Bending moment acting in k-in
disp("k-in",M,"the magnitude of the moment M is")
```

Chapter 7

Analysis of Stress and Strain

Scilab code Exa 7.1 Determination of the stresses acting on an inclined element

```
// Let x1, y1 be the transformed direction inclined
   at 45 deegree to the original
sx = 16000; // Direct stress in x-direction in psi
sy = 6000; // Direct stress in y-direction ""
txy = 4000; // Shear stress in y-direction ""
tyx = txy ; // Shear stress in x-direction ""
t = 45 ; // Inclination pf plane in degree
sx1 = (sx+sy)/2 + ((sx-sy)*(cosd(2*t))/2) + txy*sind
   (2*t);   // Direct stress in x1-direction in psi
sy1 = (sx+sy)/2 - ((sx-sy)*(cosd(2*t))/2) - txy*sind
   (2*t);   // Direct stress in y1-direction in psi
tx1y1 =  - ((sx-sy)*(sind(2*t))/2) + txy*cosd(2*t)
     // Shear stress in psi
disp("psi",sx1,"The direct stress on the element in
   x1-direction is")
disp("psi",sy1,"The direct stress on the element in
   y1-direction is")
disp("psi",tx1y1,"The shear stress on the element")
```

Scilab code Exa 7.2 Determination of stresses acting on inclined element

```
// Let x1, y1 be the transformed direction inclined
   at 15 deegree to the original
sx = -46e06; // Direct stress in x-direction in Pa
sy = 12e06; // Direct stress in y-direction ""
txy = -19e06; // Shear stress in y-direction ""
t = -15 ; // Inclination of plane in degree
sx1 = (sx+sy)/2 + ((sx-sy)*(cosd(2*t))/2) + txy*sind
   (2*t)   // Direct stress in x1-direction in Pa
sy1 = (sx+sy)/2 - ((sx-sy)*(cosd(2*t))/2) - txy*sind
   (2*t)   // Direct stress in y1-direction in Pa
tx1y1 =  - ((sx-sy)*(sind(2*t))/2) + txy*cosd(2*t)
      // Shear stress in Pa
disp("Pa",sx1,"The direct stress on the element in
   x1-direction is")
disp("Pa",sy1,"The direct stress on the element in
   y1-direction is")
disp("Pa",tx1y1,"The shear stress on the element")
```

Scilab code Exa 7.3 Determination of stresses acting on inclined element

```
sx = 90e06; // Direct stress in x-direction in Pa
sy = 20e06; // Direct stress in y-direction in Pa
t = 30 ; // Inclination of element in degree
savg = (sx+sy)/2 ; // Average in-plane direct stress
txy = 0 ;
R = sqrt(((sx-sy)/2)^2+(txy)^2) // Radius of mohr
   circle
// Point D ; at 2t = 60
sx1 = savg + R*cosd(2*t) ; // Direct stress at point
    D
```

```
tx1y1 = -R*sind(2*t) ;   // shear stress at point D
disp("Pa",sx1,"The direct stress at point D is")
disp("Pa",tx1y1,"The shear stress at point D is")
// Point D' ; at 2t = 240
sx2 = savg + R*cosd(90 + t);   // Direct stress at point D
tx2y2 = R*sind(90 + t);    // shear stress at point D
disp("Pa",sx2,"The direct stress at point D_desh is")
disp("Pa",tx2y2,"The shear stress at point D_desh is")
```

Scilab code Exa 7.4 Determination of stresses acting on inclined element using mohrs circle

```
sx = 90e06; // Direct stress in x-direction in Pa
sy = 20e06; // Direct stress in y-direction in Pa
t = 30 ; // Inclination of element in degree
savg = (sx+sy)/2 ; // Average in-plane direct stress
txy = 0 ;
R = sqrt(((sx-sy)/2)^2+(txy)^2) // Radius of mohr circle
// Point D ; at 2t = 60
sx1 = savg + R*cosd(2*t) ; // Direct stress at point D
tx1y1 = -R*sind(2*t) ;   // shear stress at point D
// Point D ; at 2t = 240
sx2 = savg + R*cosd(90 + t);   // Direct stress at point D
tx2y2 = R*sind(90 + t);    // shear stress at point D
```

Scilab code Exa 7.5 Determination of stresses acting on inclined element using Mohrs circle

```
sx = 15000; // Direct stress in x-direction in psi
sy = 5000; // Direct stress in y-direction ""
txy = 4000 ; // Shear stress in y-direction ""
savg = (sx+sy)/2 ; // Average in-plane direct stress
sx1 = 15000; tx1y1 = 4000; // Stress acting on face at theta = 0 degree
sx1_ = 5000; tx1y1_ = -4000; // Stress acting on face at theta = 0 degree
R = sqrt(((sx-sy)/2)^2+(txy)^2) // Radius of mohr circle
// Part (a)
t = 40 ; // Inclination of the plane in degree
f1 = atand(4000/5000) ; // Angle between line CD and x1-axis
f2 = 80 - f1 ; // Angle between line CA and x1-axis
// Point D ;
sx1 = savg + R*cosd(f2);  // Direct stress at point D
tx1y1 = -R*sind(f2);   // shear stress at point D
disp("psi",sx1,"The direct stres at point D")
disp("psi",tx1y1,"The shear stress at point D")
// Point D' ;
sx2 = savg - R*cosd(f2)  // Direct stress at point D'
tx2y2 = R*sind(f2)   // shear stress at point D'
disp("psi",sx2,"The direct stres at point D_desh")
disp("psi",tx2y2,"The shear stress at point D_desh")
//Part (b)
sp1 = savg + R ; // Maximum direct stress in mohe circle (at point P1)
tp1 = f1/2 ; // Inclination of plane of maximum direct stress
disp("degree",tp1,"with angle","psi",sp1,"The maximum direct stress at P1 is ")
sp2 =  savg - R ; // Minimum direct stress in mohe circle (at point P2)
tp2 = (f1+180)/2 ; // Inclination of plane of minimum direct stress
```

```
disp("degree",tp2,"with angle","psi",sp2,"The maximum direct stress at P2 is ")
// Part (c)
tmax = R ;  // Maximum shear stress in mohe circle
ts1 = -(90 - f1)/2 // Inclination of plane of maximum shear stress
disp("degree",ts1,"with plane incilation of","psi",tmax,"The Maximum shear stress is ")
```

Scilab code Exa 7.6 Determination of stresses acting on inclined element using mohrs circle

```
sx = -50e06; // Direct stress in x-direction in psi
sy = 10e06; // Direct stress in y-direction ""
txy = -40e06 ; // Shear stress in y-direction ""
savg = (sx+sy)/2 ; // Average in-plane direct stress
sx1 = -50e06; tx1y1 = -40e06; // Stress acting on face at theta = 0 degree
sx1_ = 10e06; tx1y1_ = 40e06; // Stress acting on face at theta = 0 degree
R = sqrt(((sx-sy)/2)^2+(txy)^2); // Radius of mohr circle
// Part (a)
t = 45 ; // Inclination of the plane in degree
f1 = atand(40e06/30e06)  // Angle between line CD and x1-axis
f2 = 90 - f1 ; // Angle between line CA and x1-axis
// Point D ;
sx1 = savg - R*cosd(f2);  // Direct stress at point D
tx1y1 = R*sind(f2);   // shear stress at point D
disp("Pa",sx1,"The direct stres at point D")
disp("Pa",tx1y1,"The shear stress at point D")
// Point D' ;
sx2 = savg + R*cosd(f2);  // Direct stress at point
```

```
    D'
tx2y2 = -R*sind(f2);   // shear stress at point D'
disp("Pa",sx2,"The direct stres at point D_desh")
disp("Pa",tx2y2,"The shear stress at point D_desh")
//Part (b)
sp1 =  savg + R ;  // Maximum direct stress in mohe
    circle (at point P1)
tp1 =(f1+180)/2 ; // Inclination of plane of maximum
     direct stress
disp("degree",tp1,"with angle","Pa",sp1,"The maximum
     direct stress at P1 is ")
sp2 =  savg - R ; // Minimum direct stress in mohe
    circle (at point P2)
tp2 = f1/2 ; // Inclination of plane of minimum
    direct stress
disp("degree",tp2,"with angle","Pa",sp2,"The maximum
     direct stress at P2 is ")
// Part (c)
tmax = R ;  // Maximum shear stress in mohe circle
ts1 = (90 + f1)/2 ;// Inclination of plane of
    maximum shear stress
disp("degree",ts1,"with plane incilation of","Pa",
    tmax,"The Maximum shear stress is ")
```

Scilab code Exa 7.7 Determination of various strain on inclined element

```
ex = 340e-06; // Strain in x-direction
ey = 110e-06; // Strain in y-direction
txy = 180e-06 ; // shear strain
// Part (a)
t = 30 ; // Inclination of the element in degree
ex1 = (ex+ey)/2 + ((ex-ey)/2)*cosd(2*t) + (txy/2)*(
    sind(2*t)); // Strain in x1 direction (located at
     30 degree)
tx1y1 = 2*( -((ex-ey)/2)*sind(2*t) + (txy/2)*(cosd
```

```
(2*t)) ); // Shear starin
ey1 = ex+ey-ex1 ; // Strain in y1 direction (located at 30 degree)
disp(ex1," Strain in x1 direction (located at 30 degree) is")
disp(tx1y1,"shear strain is")
disp(ey1," Strain in y1 direction (located at 30 degree) is")
// Part (b)
e1 = (ex+ey)/2 + sqrt(((ex-ey)/2)^2 + (txy/2)^2); // Principle stress
e2 = (ex+ey)/2 - sqrt(((ex-ey)/2)^2 + (txy/2)^2); // Principle stress
tp1 = (0.5)*atand(txy/(ex-ey)); // Angle to principle stress direction
tp2 = 90 + tp1 ; // Angle to principle stress direction
e1 = (ex+ey)/2 + ((ex-ey)/2)*cosd(2*tp1) + (txy/2)*(sind(2*tp1)); // Principle stress via another method
e2 = (ex+ey)/2 + ((ex-ey)/2)*cosd(2*tp2) + (txy/2)*(sind(2*tp2)); // Principle stress via another method
disp("degree",tp1,"with angle",e1,"The Principle stress is ")
disp("degree",tp2,"with angle",e2,"The Principle stress is ")
// Part (c)
tmax = 2*sqrt(((ex-ey)/2)^2 + (txy/2)^2); // Maxmum shear strain
ts = tp1 + 45 ; // Orientation of element having maximum shear stress
tx1y1_ =  2*( -((ex-ey)/2)*sind(2*ts) + (txy/2)*(cosd(2*ts)) );  // Shear starin assosiated with ts direction
disp("degree",ts,"with angle",tx1y1_,"The Maximum shear strain is ")
eavg = (e1+e2)/2 ; // Average atrain
```

```
disp(eavg,"The average strain is")
```

Chapter 8

Applications of Plane Stress Pressure Vessels Beams and Combined Loadings

Scilab code Exa 8.1 Calculation of maximum permissible pressure under various conditions

```
d = 18 ; // inner idameter of the hemisphere in inch
t = 1/4 ; // thickness of the hemisphere in inch
// Part (a)
sa = 14000 ; // Allowable tensile stress in Psi
Pa = (2*t*sa)/(d/2); // Maximum permissible air
   pressure in Psi
disp("psi",Pa," Maximum permissible air pressure in
   the tank (Part(a)) is")
// Part (b)
sb = 6000 ; // Allowable shear stress in Psi
Pb = (4*t*sb)/(d/2) ; // Maximum permissible air
   pressure in Psi
disp("psi",Pb," Maximum permissible air pressure in
   the tank (Part(b)) is")
// Part (c)
e = 0.0003 ; // Allowable Strain in Outer sufrface
```

```
    of the hemisphere
E = 29e06 ; // Modulus of epasticity of the steel in
     Psi
v = 0.28 ; // Poissions's ratio of the steel
Pc = (2*t*E*e)/((d/2)*(1-v)) ; // Maximum
    permissible air pressure in Psi
disp("psi",Pc," Maximum permissible air pressure in
    the tank (Part(c)) is")
// Part (d)
Tf = 8100 ; // failure tensile load in lb/in
n = 2.5 ; // Required factor of safetty against
    failure of the weld
Ta = Tf / n ; // Allowable load in ld/in
sd = (Ta*(1))/(t*(1)); // Allowable tensile stress
    in Psi
Pd = (2*t*sd)/(d/2); // Maximum permissible air
    pressure in Psi
disp("psi",Pd," Maximum permissible air pressure in
    the tank (Part(d)) is")
// Part (e)
Pallow = Pb ; // Because Shear stress in the wall
    governs allowable pressure inside the tank
disp("Because Shear stress in the wall governs
    allowable pressure inside the tank","psi",Pallow,
    " Maximum permissible air pressure in the tank (
    Part(e)) is")
```

Scilab code Exa 8.2 Calculation of various stresses and strain in cylindrical part of the vessel

```
a = 55 ; // Angle made by helix with longitudinal
    axis in degree
r = 1.8 ; // Inner radius of vessel in m
t = 0.02 ; // thickness of vessel in m
E = 200e09 ; // Modulus of ealsticity of steel in Pa
```

```
v = 0.3 ; // Poission's ratio of steel
P = 800e03 ; // Pressure inside the tank in Pa
// Part (a)
s1 = (P*r)/t ; // Circumferential stress in Pa
s2 = (P*r)/(2*t) ; // Longitudinal stress in Pa
// Part (b)
t_max_z = (s1-s2)/2 ; // Maximum inplane shear stress in Pa
t_max = s1/2 ; // Maximum out of plane shear stress in Pa
// Part (c)
e1 = (s1/(2*E))*(2-v) ; // Strain in circumferential direction
e2 = (s2/E)*(1-(2*v)); // Strain in longitudinal direction
// Part (d)
// x1 is the direction along the helix
theta = 90 - a ;
sx1 = ((P*r)/(4*t))*(3-cosd(2*theta)); // Stress along x1 direction
tx1y1 = ((P*r)/(4*t))*(sind(2*theta)); // Shear stress in x1y1 plane
sy1 = s1+s2-sx1 ; // Stress along y1 direction
// Mohr Circle Method
savg = (s1+s2)/2 ; // Average stress in Pa
R = (s1 - s2 )/2 ; // Radius of Mohr's Circle in Pa
sx1_ = savg - R*cosd(2*theta) ; // Stress along x1 direction
tx1y1_ = R*sind(2*theta); // Shear stress in x1y1 plane
```

Scilab code Exa 8.3 Investigation of the principal stresses and maximum shear stresses at cross section mn

```
L = 6 ; // Span of the beam in ft
```

```
P = 10800 ; // Pressure acting in lb
c = 2 ; // in ft
b = 2; // Width of cross section of the beam in inch
h = 6; // Height of the cross section of the beam in inch
x = 9 ; // in inch
Ra = P/3 ; // Reaction at point at A
V = Ra ; // Shear force at section mn
M = Ra*x ; // Bending moment at the section mn
I = (b*h^3)/12  // Moment of inertia in in4
y = -3:0.1:3 ; // Variation along height
sx = -(M/I)*y; // Normal stress on  crossection  mn
Q = (b*(h/2-y)).*(y+((((h/2)-y)/2))) ; // First moment of rectangular cross section
txy = (V*Q)/(I*b);// Shear stress acting on x face of the stress element
s1 = (sx/2)+sqrt((sx/2).^2+(txy).^2) ; // Principal Tesile stress on the cross section
s2 = (sx/2)-sqrt((sx/2).^2+(txy).^2) ; // Principal Compressive stress on the cross section
tmax = sqrt((sx/2).^2+(txy).^2); // Maximum shear stress on the cross section
plot(sx,y,'o')
plot(txy,y,'+')
plot(s1,y,'--')
plot(s2,y,'<')
plot(tmax,y)
disp("psi",s1,"Principal Tesile stress on the cross section")
disp("psi",s2," Principal Compressive stress on the cross section")
// Conclusions
s1_max = 14400 ; // Maximum tensile stress in Psi
txy_max = 900 ; // Maximum shear stress in Psi
t_max = 14400/2 ; // Largest shear stress at 45 degree plane
```

Scilab code Exa 8.4 Determination of stresses in the shaft

```
d = 0.05 ; // Diameter of shaft in m
T = 2400 ; // Torque transmitted by the shaft in N-m
P = 125000; // Tensile force
s0 = (4*P)/(%pi*d^2) // Tensile stress in
t0 = (16*T)/(%pi*d^3)  // Shear force
// Stresses along x and y direction
sx = 0 ;
sy = s0;
txy = -t0 ;
s1 = (sx+sy)/2 + sqrt(((sx-sy)/2)^2 + (txy)^2) ; // Maximum tensile stress
s2 = (sx+sy)/2 - sqrt(((sx-sy)/2)^2 + (txy)^2) ; // Maximum compressive stress
tmax =  sqrt(((sx-sy)/2)^2 + (txy)^2) ; // Maximum in plane shear stress
disp("Pa",s1,"Maximum tensile stress")
disp("Pa",s2,"Maximum compressive stress")
disp("Pa",tmax,"Maximum in plane shear stress")
```

Scilab code Exa 8.5 Determination of the maximum allowable internal pressure

```
P = 12 ; // Axial load in K
r = 2.1 ; // Inner radius of the cylinder in inch
t = 0.15 ; // Thickness of the cylinder in inch
ta = 6500 ; // Allowable shear stress in Psi
// From in plane sg=hear stress
p1 = (ta - 3032)/3.5 ; // allowable internal pressure
```

```
// Above equation comes from solving the following
   equation
// sx = (p*r)/(2*t) - (P)/(2*%pi*r*t) ;
// sy = (p*r)/t ;
// s1 = sy
// s2 = sx
// ta = (s1-s2)/2

// From out of the plane shear stress
// ta = s1/2
p2 = (ta + 3032)/3.5 ; // allowable internal
   pressure
// ta = s2/2
p3 = 6500/7 ;  // allowable internal pressure

p_allow = min(p1,p2,p3); // Minimum pressure would
   govern the design
disp("Becausem inimum pressure would govern the
   design","psi",p_allow,"Maximum allowable internal
    pressure ")
```

Scilab code Exa 8.6 Determination of stresses due to wind pressure

```
d1 = 0.18 ; // Inner diameter of circular pole in m
d2 = 0.22 ; // Outer diameter of circular pole in m
P = 2000; // Pressure of wind in Pa
b = 1.5 ; // Distance between centre line of pole
   and board in m
h = 6.6 ; // Distance between centre line of board
   and bottom of the ploe in m
W = P*(2*1.2) ; // Force at the midpoint of sign
V = W ; // Load
T = W*b ; // Torque acting on the pole
M = W*h ; // Moment at the bottom of the pole
I = (%pi/64)*(d2^4-d1^4) ; // Momet of inertia of
```

```
cross section of the pole
sa = (M*d2)/(2*I); // Tensile stress at A
Ip = (%pi/32)*(d2^4-d1^4) ; // Polar momet of inertia of cross section of the pole
t1 = (T*d2)/(2*Ip); // Shear stress at A and B
r1 = d1/2 ; // Inner radius of circular pole in m
r2 = d2/2 ; // Outer radius of circular pole in m
A = %pi*(r2^2-r1^2); // Area of the cross section
t2 = ((4*V)/(3*A))*((r2^2 + r1*r2 +r1^2)/(r2^2+r1^2)) ; // Shear stress at point B
// Principle stresses
sxa = 0 ; sya = sa ; txya = t1;
sxb = 0 ; syb = 0 ; txyb = t1+t2 ;
// Stresses at A
s1a = (sxa+sya)/2 + sqrt(((sxa-sya)/2)^2 + (txya)^2) ;  // Maximum tensile stress
s2a = (sxa+sya)/2 - sqrt(((sxa-sya)/2)^2 + (txya)^2) ; // Maximum compressive stress
tmaxa =  sqrt(((sxa-sya)/2)^2 + (txya)^2);  // Maximum in plane shear stress
disp("Pa",s1a,"Maximum tensile stress at point A is")
disp("Pa",s2a,"Maximum compressive stress at point A is")
disp("Pa",tmaxa,"Maximum in plane shear stress at point A is")
// Stress at B
s1b = (sxb+syb)/2 + sqrt(((sxb-syb)/2)^2 + (txyb)^2) ;  // Maximum tensile stress
s2b = (sxb+syb)/2 - sqrt(((sxb-syb)/2)^2 + (txyb)^2) ; // Maximum compressive stress
tmaxb =  sqrt(((sxb-syb)/2)^2 + (txyb)^2);  // Maximum in plane shear stress
disp("Pa",s1b,"Maximum tensile stress at point B is")
disp("Pa",s2b,"Maximum compressive stress at point B is")
disp("Pa",tmaxb,"Maximum in plane shear stress at
```

```
point B is")
```

Scilab code Exa 8.7 Determination of stresses due to loads

```
b = 6 ; // Outer dimension of the pole in inch
t = 0.5 ; // thickness of the pole
P1 = 20*(6.75*24); // Load acting at the midpoint of the platform
d = 9 ; // Distance between longitudinal axis of the post and midpoint of platform
P2 = 800; // Load in lb
h = 52 ; // Distance between base and point of action of P2
M1 = P1*d; // Moment due to P1
M2 = P2*h; // Moment due to P2
A = b^2 - (b-2*t)^2; // Area of the cross section
sp1 = P1/A ; // Comoressive stress due to P1 at A and B
I = (1/12)*(b^4 - (b-2*t)^4); // Moment of inertia of the cross section
sm1 = (M1*b)/(2*I);// Comoressive stress due to M1 at A and B
Aweb = (2*t)*(b-(2*t)); // Area of the web
tp2 = P2/Aweb ; // Shear stress at point B by lpad P2
sm2 = (M2*b)/(2*I);// Comoressive stress due to M2 at A
sa = sp1+sm1+sm2 ; // Total Compressive stress at point A
sb = sp1+sm1; // Total compressive at point B
tb = tp2; // Shear stress at point B
// Principle stresses
sxa = 0 ; sya = -sa ; txya = 0;
sxb = 0 ; syb = -sb ; txyb = tp2 ;
// Stresses at A
```

```
s1a = (sxa+sya)/2 + sqrt(((sxa-sya)/2)^2 + (txya)^2); // Maximum tensile stress
s2a = (sxa+sya)/2 - sqrt(((sxa-sya)/2)^2 + (txya)^2); // Maximum compressive stress
tmaxa =  sqrt(((sxa-sya)/2)^2 + (txya)^2);  // Maximum in plane shear stress
disp("Psi",s1a,"Maximum tensile stress at point A is")
disp("Psi",s2a,"Maximum compressive stress at point A is")
disp("Psi",tmaxa,"Maximum in plane shear stress at point A is")
// Stress at B
s1b = (sxb+syb)/2 + sqrt(((sxb-syb)/2)^2 + (txyb)^2); // Maximum tensile stress
s2b = (sxb+syb)/2 - sqrt(((sxb-syb)/2)^2 + (txyb)^2); // Maximum compressive stress
tmaxb =  sqrt(((sxb-syb)/2)^2 + (txyb)^2);  // Maximum in plane shear stress
disp("Psi",s1b,"Maximum tensile stress at point B is")
disp("Psi",s2b,"Maximum compressive stress at point B is")
disp("Psi",tmaxb,"Maximum in plane shear stress at point B is")
```

Chapter 11

Columns

Scilab code Exa 11.1 Determination of the allowable load using a factor of safety with respect to Euler buckling of the column

```
E = 29000; // Modulus of elasticity in ksi
spl = 42 ; // Proportional limit in ksi
L = 25 ; // Total length of coloum in ft
n = 2.5 ; // factor of safety
I1 = 98 ; // Moment of inertia on horizontal axis
I2 = 21.7 ; // Moment of inertia on vertical axis
A = 8.25 ; // Area of the cross section
Pcr2 = (4*%pi^2*E*I2)/((L*12)^2) ; // Criticle load
   if column buckles in the plane of paper
Pcr1 = (%pi^2*E*I1)/((L*12)^2) ; // Criticle load if
    column buckles in the plane of paper
Pcr = min(Pcr1,Pcr2) ; // Minimum pressure would
   govern the design
scr = Pcr/A ; // Criticle stress
Pa = Pcr/n ; // Allowable load in k
disp("k",Pa,"The allowable load is ")
```

Scilab code Exa 11.2 Determine the minimum required thickness t of the columns wrt Eular bucking of column

```
L = 3.25 ; // Length of alluminium pipe in m
d = 0.1 ; // Outer diameter of alluminium pipe
P = 100000; // Allowable compressive load in N
n =3 ; // Safety factor for eular buckling
E = 72e09 ; // Modulus of elasticity in Pa
l = 480e06 ; // Proportional limit
Pcr = n*P ; // Critic;e load
t = (0.1 - (55.6e-06)^(1/4) )/2 ; // Required thickness
// Above formula comes from solving following equation
// d2 = d ; d1 = d-2*t ; Pcr = n*P ; I = (%pi/64)*(d2^4-d1^4); Pcr = (2.406*%pi^2*E*I)/((L)^2) ;
tmin = t ;
disp("mm",tmin*1000,"The minimum required thickness of the coloumn is")
// Supplimentry calculatios
I = (%pi/64)*(d^4-(d-2*t)^4) ; // Moment of inertia
A = (%pi/4)*(d^2-(d-2*t)^2) ; // Area of cross section
r = sqrt(I/A);
s = L/r // slenderness ratio
scr = Pcr/A ; // Criticle stress
```

Scilab code Exa 11.3 Determination of longest permissible length of rod

```
P = 1500 ; // Load in lb
e = 0.45 ; // ecentricity in inch
h = 1.2 ; // Height of cross section in inch
b = 0.6 ; // Width of cross section in inch
E = 16e06 ; // Modulus of elasticity
del = 0.12 ; // Allowable deflection in inch
```

```
L = asec(1.2667)/0.06588 ; // Maximum allowable
    length possible
// Above formula comes from solving following
    equation
// Pcr = (%pi^2*E*I)/(4*(L)^2); I = (h*b^3)/12; del
    = e*(sec((%pi/2)*sqrt(P/Pcr))-1)
disp("inch",L,"The longest permissible length of the
     bar is")
```

Scilab code Exa 11.4 Calculation of compressive stress and factor of safety

```
L = 25 ; // Length of coloum in ft
P1 = 320 ; // Load in K
P2 = 40 ; // Load in K
E = 30000 ; // Modulus of elasticity of steel in Ksi
P = 360 ; // Euivalent load
e = 1.5 ; // Ecentricity of compressive load
A = 24.1 ; // Area of the Cross section
r = 6.05 ; // in inch
c = 7.155 ; // in inch
sy = 42 ;// Yeild stress of steel in Ksi
smax = (P/A)*(1+(((e*c)/r^2)*sec((L/(2*r))*sqrt(P/(E
    *A))))); // Maximum compressive stress
disp("ksi",smax,"The Maximum compressive stress in
    the column ")
// Bisection method method to solve for yeilding
function [x] = stress(a,b,f)
  N = 100;
  eps = 1e-5;
  if((f(a)*f(b))>0) then
    error('no root possible f(a)*f(b)>0');
    abort;
  end;
  if(abs(f(a))<eps) then
    error('solution at a');
```

```
    abort;
  end
  if(abs(f(b))<eps) then
    error('solution at b');
    abort;
  end
  while(N>0)
    c = (a+b)/2
    if(abs(f(c))<eps) then
      x = c ;
      x;
      return;
    end;
    if((f(a)*f(c))<0 ) then
      b = c ;
    else
      a = c ;
    end
    N = N-1;
  end
  error('no convergence');
  abort;
endfunction

deff('[y]=p(x)',['y = x + (0.2939*x*sec(0.02916*sqrt(x))) - 1012 '])
x = stress(710,750,p);
Py = x ; // Yeilding load in K
n = Py/P; // Factor of safety against yeilding
disp(n,"The factor of safety against yeilding is")
```

Scilab code Exa 11.5 Calculation of allowable axial load and maximum permissible length

```
E = 29000; // Modulus of elasticity in ksi
```

```
sy = 36 ; // Yeilding stress in ksi
L = 20 ; // Length of coloumn in ft
r = 2.57 ; // radius of gyration of coloumn
K = 1 ; // Effetive Length factor
s = sqrt((2*%pi^2*E)/sy) // Criticle slenderness ratio (K*L)/r
s_ = (L*12)/r; // Slenderness ratio
// Part(a)
n1 = (5/3)+((3/8)*(s_/s))-((1/8)*((s_^3)/(s^3)));// Factor of safety
sallow = (sy/n1)*(1-((1/2)*((s_^2)/(s^2)))); // Allowable axial load
A = 17.6; // Cross sectional area from table E1
Pallow = sallow*A ; // Allowable axial load
disp("k",Pallow,"Allowable axial load is")
// Part (b)
Pe = 200 ; // Permissible load in K
L_ = 25 ; // Assumed length in ft
s__ = (L_*12)/r; // Slenderness ratio
n1_ = (5/3)+((3/8)*(s__/s))-((1/8)*((s__^3)/(s^3))); // Factor of safety
sallow_ = (sy/n1_)*(1-((1/2)*((s__^2)/(s^2)))); // Allowable axial load
A = 17.6 ; // Area of the cross section in^2
Pallow = sallow_*A // Allowable load
L1 = [24 24.4 25];
P1 = [201 194 190];
L_max = interpln([P1;L1],Pe); // Interpolation for getting the length correspondong to permissible load
disp("ft",L_max,"The maximum permissible length is")
```

Scilab code Exa 11.6 Finding the minimum required thickness for a steel pipe column

```
L = 3.6 ; // Length of steel pipe coloumn
d = 0.16 ; // Outer diameter in m
P = 240e03; // Load in N
E = 200e09; // Modulus of elasticity in Pa
sy = 259e06 ; // yeilding stress in Pa
Le = 2*L ; // As it in fixed-free condition
sc = sqrt((2*%pi^2*E)/sy); // Critical slenderness
    ratio
K = 2;
// First trial
t = 0.007; // Assumed thick ness in m
I = (%pi/64)*(d^4-(d-2*t)^4) // Moment of inertia
A = (%pi/4)*(d^2-(d-2*t)^2)  // Area of cross
    section
r = sqrt(I/A) ; // Radius of gyration
sc_ = (K*L)/r ; // Slender ness ratio
n2 = 1.98 ; // From equation 11.80
sa = (sy/(2*n2))*(sc^2/sc_^2) // Allowable stress
Pa = sa*A ; // Allowable axial load in N
// Interpolation
t = [7 8 9];
Pa = [196 220 243];
t_min = interpln([Pa;t],240) ; // Interpolation for
    getting the minimum length
disp("mm",t_min,"The minimum required thickness of
    the steel pipe is")
```

Scilab code Exa 11.7 Determination of the minimum required outer diameter of aluminium tube

```
L = 16 ; // Effective length in inch
P = 5 ; // axial load in K
// Bisection method for solvong the quaderatic
function [x] = stress(a,b,f)
  N = 100;
```

```
  eps = 1e-5;
  if((f(a)*f(b))>0) then
    error('no root possible f(a)*f(b)>0');
    abort;
  end;
  if(abs(f(a))<eps) then
    error('solution at a');
    abort;
  end
  if(abs(f(b))<eps) then
    error('solution at b');
    abort;
  end
  while(N>0)
    c = (a+b)/2
    if(abs(f(c))<eps) then
      x = c ;
      x;
      return;
    end;
    if((f(a)*f(c))<0 ) then
      b = c ;
    else
      a = c ;
    end
    N = N-1;
  end
  error('no convergence');
  abort;
endfunction

deff('[y]=p(x)',['y = 30.7*x^2 - 11.49*x -17.69 '])
x = stress(0.9,1.1,p);
d = x; // Diameter in inch
sl = 49.97/d ; // Slenderness ration L/r
dmin = d ; // Minimum diameter

// The above equation comes from solving the
```

```
    following equationd for d
// S_allow = 13.7 - 0.23*(L/r) = P/ A ;
// A = (%pi/4)*(d^2-(d-2t)^2)
// I = (%pi/64)*(d^4-(d-2t)^4)
// r = sqrt(I/A)
disp("inch",dmin,"The minimum required outer
    diameter of the tube is")
```

Scilab code Exa 11.8 Determination of allowable axial load maximum allowable length and minimum width of the cross section

```
Fc = 11e06 ; // Compressive desing stress in Pa
E = 13e09 ; // Modulus of elasticity in Pa
// Part (a)
Kce = 0.3 ;
c = 0.8;
A = 0.12*0.16 ; // Area of cross section
Sl = 1.8/0.12 ; // Slenderness ratio
fi = (Kce*E)/(Fc*Sl^2) ; // ratio of stresses
Cp = ((1+fi)/(2*c)) - sqrt(((1+fi)/(2*c))^2-(fi/c));
     // Coloumn stability factor
Pa = Fc*Cp*A ; // Allowable Axial load
disp("N",Pa,"The allowable axial load is")
// Part (b)
P = 100000; // Allowable Axial load
Cp_ = P/(Fc*A) ; // Coloumn stability factor
// Bisection method method to solve for fi
function [x] = stress(a,b,f)
  N = 100;
  eps = 1e-5;
  if((f(a)*f(b))>0) then
    error('no root possible f(a)*f(b)>0');
    abort;
  end;
  if(abs(f(a))<eps) then
```

```
    error('solution at a');
    abort;
  end
  if(abs(f(b))<eps) then
    error('solution at b');
    abort;
  end
  while(N>0)
    c = (a+b)/2
    if(abs(f(c))<eps) then
      x = c ;
      x;
      return;
    end;
    if((f(a)*f(c))<0 ) then
      b = c ;
    else
      a = c ;
    end
    N = N-1;
  end
  error('no convergence');
  abort;
endfunction

deff('[y]=p(x)',['y = ((1+x)/(2*c)) - sqrt(((1+x)/(2*c))^2-(x/c)) - Cp_ '])
x = stress(0.1,1,p);
fi_ = x
d_ = 0.12 ; // Diameter in m
L_max = d_*sqrt((Kce*E)/(fi_*Fc)); // Maximum length in m
disp("m",L_max,"The minimum allowable length is")
// Part (c)
b1 = [0.130 0.131 0.132]; // Two choices
Sl1 = 2.6./b1 // slenderness ratio
fi1 =  (Kce*E)./(Fc*Sl1^2)  // Ratio
Cp1 = ((1+fi1)/(2*c)) - sqrt(((1+fi1)/(2*c)).^2-(fi1
```

```
/c)); // Coloumn stability factor
P1 = 11000.*Cp1.*b1^2 ;  // Allowable atress
Pa1 = 125; // Given allowable stress
// Does not require display of result analysis has been shown for b = 0.131
```

Chapter 12

Review of Centroids and Moments of Inertia

Scilab code Exa 12.2 Locating centroid C of the cross sectional area

```
A1 = 6*0.5 ; // Partial Area in in2
A2 = 20.8 ; // from table E1 and E3
A3 = 8.82 ; // from table E1 and E3
y1 = (18.47/2) + (0.5/2) ; // Distance between
    centroid C1 and C2
y2 = 0 ; // Distance between centroid C2 and C2
y3 = (18.47/2) + 0.649 ; // Distance between
    centroid C3 and C2
A = A1 + A2 + A3 ; // Area of entire cross section
Qx = (y1*A1) + (y2*A2) - (y3*A3) ; // First moment
    of entire cross section
y_bar = Qx/A ; // Distance between x-axis and
    centroid of the cross section
disp("inch",-y_bar,"The distance between x-axis and
    centroid of the cross section is ")
```

Scilab code Exa 12.5 Determination of the moment of inertia Ic with respect to the horizontal axis

```
// Following variables are obtained from example 12.2
A1 = 6*0.5; // Partial Area in in2
A2 = 20.8; // from table E1 and E3
A3 = 8.82; // from table E1 and E3
y1 = (18.47/2) + (0.5/2); // Distance between centroid C1 and C2
y2 = 0 ; // Distance between centroid C2 and C2
y3 = (18.47/2) + 0.649; // Distance between centroid C3 and C2
A = A1 + A2 + A3; // Area of entire cross section
Qx = (y1*A1) + (y2*A2) - (y3*A3); // First moment of entire cross section
y_bar = Qx/A; // Distance between x-axis and centroid of the cross section
c_bar = -(y_bar);
//////////////////////////
I1 = (6*0.5^3)/12; // Moment of inertia of A1
I2 = 1170; // Moment of inertia of A2 from table E1
I3 = 3.94; // Moment of inertia of A3 from table E3
Ic1 = I1 + (A1*(y1+c_bar)^2); // Moment of inertia about C-C axis of area C1
Ic2 = I2 + (A2*(y2+c_bar)^2); // Moment of inertia about C-C axis of area C2
Ic3 = I3 + (A3*(y3-c_bar)^2); // Moment of inertia about C-C axis of area C3
Ic = Ic1 + Ic2 + Ic3 ; // Moment of inertia about C-C axis of whole area
disp("in^4",Ic,"The moment of inertia of entire cross section area about its centroidal axis C-C")
```

Scilab code Exa 12.7 Determination of the orientations of the principal centroidal axes and the magnitudes of the principal centroidal moments of inertia for the cross sectional area

```
Ix = 29.29e06; // Moment of inertia of crosssection about x-axis
Iy = 5.667e06; // Moment of inertia of crosssection about y-axis
Ixy = -9.336e06; // Moment of inertia of crosssection
tp1 = (atand(-(2*Ixy)/(Ix-Iy)))/2 ; // Angle definig a Principle axix
tp2 = 90 + tp1  // ""
disp("degree",tp1,"The Principle axis is inclined at an angle")
disp("degree",tp2,"Second angle of inclination of Principle axis is")
Ix1 = (Ix+Iy)/2 + ((Ix-Iy)/2)*cosd(tp1) - Ixy*sind(tp1) ; // Principle Moment of inertia corresponding to tp1
Ix2 = (Ix+Iy)/2 + ((Ix-Iy)/2)*cosd(tp2) - Ixy*sind(tp2) ; // Principle Moment of inertia corresponding to tp2
disp("mm^4",Ix1,"Principle Moment of inertia corresponding to tp1")
disp("mm^4",Ix2,"Principle Moment of inertia corresponding to tp2")
```