Scilab Textbook Companion for
A Textbook of Production Engineering
by P. C. Sharma[1]

Created by
Mayank Sahu
B.E.
Mechanical Engineering
M. I. T. S Gwalior, M.P
College Teacher
None
Cross-Checked by
Bhavani Jalkrish

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 2

Press Tool Design

Scilab code Exa 2.1 find total pressure and dimensions

```
1  clc
2  D = 50 // Diameter of washer in mm
3  t = 4 // thickness of material in mm
4  d = 24 // diameter of hole in mm
5  p = 360 // shear strength of material in N/mm^2
6  F1 = %pi*D*t*p // blanking pressure in N
7  F2 = %pi*d*t*p // piercing pressure in N
8  F = F1 + F2 // total pressure in N
9  d1 = d + 0.4 // piercing die diameter in mm
10 d2 = D - 0.4 // blank punch diameter in mm
11 c = 0.8*F // press capacity in N
12 printf("\n Blanking pressure = %d kN\n Piercing
       pressure = %0.3f KN\n Total pressure required =
       %0.1f KN" ,F1/1000,F2/1000,F/1000)
13 printf("\n piercing punch diameter = %0.2f cm\n
       blanking punch diametre = %0.2f cm \n press
       capacity = %0.2f KN\n", d1/10 , d2/10 , c/1000)
14 // Answers vary due to round off error
```

Scilab code Exa 2.2 To find number of draws

```
1  clc
2  h = 10 // height of cup in cm
3  d = 5 // diameter of cup in cm
4  D = sqrt(d^2 + 4*d*h) // blank diameter in cm
5  // height daimeter ratio is 2 . Therefore from table
        2.9 total reductions are 3
6  r1 = 0.45*D // first reduction is 45%
7  d1 = D - r1 // diameter at first draw in cm
8  r2 = d1*0.25 // second reduction is 25%
9  d2 = d1 - r2 // diameter at second draw in cm
10 r3 = d2*0.2 // third reduction is 20%
11 d3 = d2 - r3 // diameter at third draw in cm
12 printf("\n Diameter at first draw = %0.2f cm\n
        Diameter at second draw = %0.2f cm\n Diameter at
         third draw =%0.3f cm" , d1 , d2 , d3)
```

Scilab code Exa 2.3 To calculate bending force

```
1  clc
2  K = 1.20 // die-opening factor
3  L = 37.5 // Length of strip in cm
4  T = 2.5 // thickness of strip in mm
5  sigma_ut = 630 // tensile strength in N/mm^2
6  W = 16*T // width of die opening in mm
7  F = (K*L*10*sigma_ut*T^2)/W // bending force in N
8  printf("\n bending force = %0.1f KN" , F/1000)
```

Scilab code Exa 2.4 find blanking force and work done

```
1  clc
2  b = 25 // width of blank in mm
```

```
 3  l = 30 // length of blank in mm
 4  tau = 450 // ultimate shear stress of material in N/
        mm^2
 5  t = 1.5 // thickness of metal strip in mm
 6  p = 2*(l + b) // perimeter of blank in mm
 7  f = p*t*tau // blanking force in N
 8  Pt = 0.25*t // punch travel in mm
 9  w = f*Pt // work done in Nmm
10  printf("\n blanking force  = %0.2f KN\n work done  =
        %0.2f Nm", f/1000,w/1000)
```

Scilab code Exa 2.5 To find elastic recovery of material

```
 1  clc
 2  t = 1.5 // thickness in mm
 3  c = 0.05*t // clearance in mm
 4  D = 25.4 // outside diameter in mm
 5  D_o = D - 0.05 // blank die opening in mm
 6  B_s = D_o - 2*c // blanking punch size in mm
 7  d = 12.7 // internal diameter in mm
 8  P_s = d + 0.05 // piercing punch size in mm
 9  D_s = P_s + 2*c // piercing die size in mm
10  printf("\n clearance = %0.3f mm\n blank die opening
        size = %0.2f mm ",c  ,D_o)
11  printf("\n blanking punch size = %0.2f mm\n piercing
         punch size = %0.2f mm\n piercing die size = %0.2
        f mm",B_s,P_s,D_s )
```

Scilab code Exa 2.6 To find cutting forces

```
 1  clc
 2  D = 25.4 // outside diameter in mm
 3  d = 12.7 // internal diameter in mm
```

12

```
4  t = 1.5 // thickness in mm
5  tau = 280 // ultimate shearing strength in N/mm^2
6  F = %pi*(D + d)*t*tau // total cutting force in N
7  F_s = %pi*D*t*tau // cutting force when punches are
       staggered in N
8  k = 0.6 // penetration
9  i = 1 // shear of punch in mm
10 F_p = (t*k*F)/(k*t +i)// cutting force when both
       punches act together in N
11 printf ("\n shear force when both punch act at same
       time and no shear is applied = %0.2f kN" , F
       /1000)
12 printf("\n cutting force when punches are staggered
       = %0.1f kN", F_s/1000)
13 printf("\n cutting force when there is penetration
       and shear on punch = %0.1f kN",F_p/1000)
```

Scilab code Exa 2.7 To calculate amount of shear

```
1  clc
2  D = 60 // hole diameter in mm
3  tau = 450 // ultimate shear strength in N/mm^2
4  t = 2.5 // thickness in mm
5  F = %pi*D*t*tau // maximum punch force in N
6  w = F*0.4*t // work done in Nm
7  f = F/2 // punching force in N
8  k = 0.4 // penetration percentage
9  i = k*t*(F-f)/f // shear on punch in mm
10 printf("\n Amount of shear on punch = %d mm" , i)
```

Scilab code Exa 2.8 To find economy of material

```
1  clc
```

```
2  // from  fig  2.27
3  w = 2.5  // cm
4  t = 3.2  // strip  thickness  in mm
5  h = 10  // cm
6  a = t + 0.015*h*10  // back  scrap  and  front  scrap  in
      mm
7  b = t  // scrap  bridge  in mm
8  W = h + (2*a)/10  // width  of  strip  in cm
9  W = ceil(W)  // cm
10  s = w + b/10  // length  of  one  piece  of  stock  in cm
11  L = 240  // length  of  strip  in cm
12  N = (L-b)/s  // number  of  parts
13  y = L - (N*s + b/10)   // scrap  remaining  at  the  end
      in mm
14  printf("\n Value  of  back  scrap  = %0.1 f mm\n Value  of
        scrap  bridge  = %0.1 f mm " , a , b )
15  printf("\n Width  of  strip  = %0.2 f cm\n Length  of  one
         piece  of  stock  needed  to  produce  one  part  = %0.2
      f cm" , W , s)
16  printf("\n Number  of  parts  = %0.1 f blanks\n Scrap
      remaining  at  the  end = %0.2 f mm" , N , y)
17  // Answers  vary  due  to  round  off  error
```

Scilab code Exa 2.9 Calculations for designing drawing die

```
1  clc
2  // from  figure  2.73
3  t = 0.8  // thickness  in mm
4  d = 50  // shell  diameter  in mm
5  r = 1.6  // radius  of  bottom  corner  in mm
6  h = 50  // height  in mm
7  D = sqrt(d^2 + 4*d*h)  // shell  blank  size  in mm
8  el = 6.4  // extra  length  required  to  add  in  shell
      blank  size
9  D = D + el  // mm
```

```scilab
10  pr = 100*(1-(d/D)) // percentage reduction
11  ratio = h/d
12  n = 2 // number of draws
13  R1 = 45 // first reduction
14  D1 = D - R1*D/100 // diameter at first reduction in
       mm
15  R2 = 100*(1-(d/D1)) // second reduction
16  PR = 4*t // punch radius in mm
17  PR = ceil(PR)
18  DR = 6 // die radius in mm
19  DC1 = 0.87 // die clearance for first draw in mm
20  DC2 = 0.88 // die clearance for second draw in mm
21  PD2 = d - 2*t // punch diameter for second draw in
       mm
22  DD2 = PD2 + 2*DC2 // Die opening diameter for second
        draw in mm
23  PD1 = D1 - 2*t // punch diameter for first draw in
       mm
24  DD1 = D1 + 2*DC1 // Die opening diameter for first
        draw in mm
25  // Drawing pressure
26  c = 0.65 // constant
27  sigma = 427 // N/mm^2
28  F = %pi*d*t*sigma*(D/d-c) // Drawing pressure in mm
29  Bhp = 30.8 // blanking holding pressure in kN
30  pc = 150 // press capacity in kN
31  printf("\n (i) size of blank = %0.2f mm \n (ii)
       Percentage reduction = %0.1f percent \n (iii)
       Number of draws = %d \n (iv) Radius on punch = %d
        mm \n    Die Radius = %d mm \n (v) Die clearance
        for first draw = %0.2f mm \n    die clearance
       for second draw = %0.2f mm" , D , pr,n,PR,DR,DC1,
       DC2)
32  printf("\n    Punch diameter for second draw = %0.1f
       mm \n    Die opening diameter for second draw = %0
       .2f mm \n    Punch diameter for first draw  = %0.3
       f mm \n    Die opening diameter for first draw =
       %0.3f mm\n (vi) Drawing pressure = %0.2f mm \n (
```

```
      vii ) Blank  holding  pressure = %d kN \n ( viii )
      Press  capacity = %d kN" , PD2 , DD2 ,PD1 ,DD1 , F
      /1000 ,Bhp , pc )
33 // Answers vary due to round off error
```

Scilab code Exa 2.10 Determine developed length

```
1  clc
2  // from figure 2.74
3  l1 = 76 - ( 2.3 + 0.90) // length1 in mm
4  l2 = 115 - (2.3 + 0.90) // length2 in mm
5  t = 2.3 // mm
6  r = 0.90 // inner radius in mm
7  k = t/3 // mm
8  B = 0.5*%pi*(r + k) // bending allowance in mm
9  d = l1 + l2 + B // developed length in mm
10 printf("\n Developed length = %0.2f mm" , d)
11 // Answers vary due to round off error
```

Scilab code Exa 2.11 To calculate bending force

```
1  clc
2  t = 3.2 // thickness of blank in mm
3  l = 900 // bending length in mm
4  sigma = 400 // ultimate tensile strength in N/mm^2
5  k = 0.67 // die opening factor
6  r1 = 9.5 // punch radius in mm
7  r2 = 9.5 // die edge radius in mm
8  c = 3.2 // clearance in mm
9  w = r1 + r2 + c // width between contact points
      batween die and punch in mm
10 F= (k*l*sigma*t^2)/w // bending force in N
11 F=floor(F/10)*10 // N
```

```
12 printf(" \n bending force = %0.2f kN" ,F/1000)
```

Scilab code Exa 2.12 To calculate bending force

```
1 clc
2 k = 1.33 // die opening factor
3 l = 1200 // bend length in mm
4 sigma = 455 // ultimate tensile strength in N/mm^2
5 t = 1.6 // blank thickness in mm
6 w = 8*t // width of die opening in mm
7 F = k*l*sigma*t^2/w // bending force in N
8 printf(" \n bending force = %0.2f kN", F/1000)
```

Scilab code Exa 2.13 calculate capacity of double bending die

```
1 clc
2 c = 1.25 // clearance in mm
3 r1 = 3 // die radius in mm
4 r2 = 1.5 // punch radius in mm
5 sigma = 315 // ultimate tensile strength in MPa
6 t = 1 // thickness in mm
7 l = 50 // width at bend in mm
8 w = r1 + r2 +c // width between contact points on
      die and punch in mm
9 F = 0.67*l*sigma*t^2/w // bending force in N
10 F_p = 0.67*sigma*l*t // pad force in N
11 sigma_c = 560 // setting pressure in MPa
12 b1 = 2 // beads on punch
13 b = b1*r1 // mm
14 F_b = sigma_c*l*b // bottoming force in N
15 F_o = F_p + F_b // Force required when bottoming is
      used in N
```

```
16  F_n = F +F_p // Force required when bottoming is not
         used in N
17  printf("\n Force required when bottoming is used =
         %0.1f tonnes" ,F_o/(9.81*1000))
18  printf("\n Force required when bottoming is not used
         = %0.3f tonnes" , F_n/(9.81*1000))
```

Scilab code Exa 2.14 To calculate cutting force

```
1  clc
2  w = 2 // width in mm
3  t = 5 // thickness in mm
4  theta=6 // shear in degrees
5  tau = 382.5 // ultimate shear stress in MPa
6  F = w*t*tau*1000 // cutting force in N
7  l = t/sin(theta*%pi/180) // length to be cut in mm
8  F_i = l*t*tau // cutting force in N
9  printf("\n cutting force with parallel cutting edges
         = %0.3f MN\n cutting force when shear is
         considered = %0.2f kN ",F/10^6 ,F_i/1000)
```

Scilab code Exa 2.15 Determine blank and punch diameter

```
1  clc
2  d1 = 105 // inside diameter in mm
3  h = 90 // depth in mm
4  t = 1 // thickness in mm
5  D = sqrt(d1^2+4*d1*h) // blank diameter in mm
6  tr = t*100/D // thickness ratio
7  // from table safe drawing ratio is 1.82
8  r = 1.82 // draw ratio
9  d2 = D/r // diameter for first draw in mm
10 d = 130 // Let diameter for first draw in mm
```

18

```
11  ratio1 = D/d // D/d for first draw
12  ratio2 = d/d1 // D/d for second draw
13  h1 =((D)^2-(d)^2)/(4*d) // Depth of first draw in mm
14  sigma = 415 // N/mm^2
15  c = 0.65 // constant
16  pc = %pi*d*t*sigma(D/d - c) // press capacity in kN
17  printf("\n Blank diameter = %d mm \n Thickness ratio
        = %0.3f \n Diameter for first draw = %d mm \n
      Depth of first draw = %0.2f mm \n Press capacity
      = %0.2f kN" ,D,tr,d2,h1,pc/1000)
18  // Answers vary due to round off error
```

Scilab code Exa 2.16 To find drawing operations and force

```
1  clc
2  d = 80 // diameter in mm
3  h = 250 // height in mm
4  D = sqrt((d^2+4*d*h))/10 // blank diameter in cm
5  D1 = 0.5*D // diameter after first draw in cm
6  // let reduction be 40% in second draw
7  D2 = D1-0.4*D1 // diameter after scond draw in cm
8  R = (1 - (d/(10*D2)))*100 // percentage reduction
      for third draw
9  l1 = ((D)^2-(D1)^2)/(4*D1) // height of cup after
      first draw in cm
10 l2 = ((D)^2-(D2)^2)/(4*D2) // height of cup after
      first draw in cm
11 l3 = ((D)^2-(d/10)^2)/(4*d/10) // height of cup
      after first draw in cm
12 t = 3 // mm
13 sigma = 250 // N/mm^2
14 C = 0.66
15 F = %pi*d/10*t*sigma*((D*10/d)-C) // drawing force
      in kN
16 printf("\n Diameter after first draw = %0.1f \n
```

```
        Diameter after second draw = %0.2f \n Percentage
        reduction after third draw = %d percent",D1,D2,R)
17 printf("\n Height of cup after first draw = %0.2f cm
        \n Height of cup after second draw = %0.2f cm\n
        Height of cup after third draw = %0.2f cm", l1,l2
        ,l3)
18 printf("\n Drawing force = %0.3f kN",F/1000)
19 // Answers vary due to round off error
```

Scilab code Exa 2.17 Determine developed length

```
1 clc
2 // from figure 2.75 (a)
3 r1 = 30 // radius in mm
4 t = 10 // thickness in mm
5 h1 = 300 // height in mm
6 ir1 = r1-t // inner radius of bends in mm
7 L1 = h1-(ir1+t) // mm
8 alpha1 = 90 // degree
9 r2 = 2*t // mm
10 k = 0.33*t // mm
11 L2 = alpha1*2*%pi*(r2+k)/360 // mm
12 w = 200 // mm
13 L3 = w-2*(t+ir1)// mm
14 L4 = L2 //mm
15 h2 = 100 // mm
16 L5 = h2 -(t+ir1) // mm
17 r3 = 150 //mm
18 ir2 = r3 - t // inner radius in mm
19 alpha2 = 180 // degree
20 L6 = alpha2*2*%pi*(ir2+k)/360 // mm
21 dl = L1+L2+L3+L4+L5+L6 // Total developed length in
        mm
22 printf("\n Total developed length = %0.2f mm" , dl)
23 // Answers vary due to round off error
```

Chapter 4

Cost Estimating

Scilab code Exa 4.1 To calculate total cost and SP

```
1  clc
2  d_m = 5500 // cost of direct material in Rs
3  d_l = 3000 // manufacturing wages in Rs
4  // factory overhead is 100% 0f manufacturing wages
5  f_o = (100*d_l)/100 // factory overheads in Rs
6  FC = d_m + d_l + f_o // factory cost in Rs
7  nm_o = 15*FC/100 // non-manufacturing overheads in
      Rs
8  tc = FC+nm_o // total cost in Rs
9  p = 12*tc/100 // profit in Rs
10 sp = tc+p // selling price in Rs
11 printf(" \n Total cost = Rs %d\n Selling price = Rs
      %d" , tc,sp)
```

Scilab code Exa 4.2 To find selling price

```
1  clc
2  // given
```

```
 3  OS_RM = 20000 // opening stock of raw materials in
        Rs
 4  CS_RM = 30000 // closing stock of raw materials in
        Rs
 5  TP_RM = 170000 // total purchase in year in Rs
 6  OS_FG = 10000 // opening stock of finished goods in
        Rs
 7  CS_FG = 15000 // closing stock of finished goods in
        Rs
 8  sales = 489500 // sales of finished goods in Rs
 9  D_W = 120000 // direct wages in Rs
10  F_E1 = 120000 // factory expenses in Rs
11  NM_E = 50000 //  non-manufacturing expenses in Rs
12  DMC = OS_RM + TP_RM - CS_RM // direct material cost
13  FC = DMC + D_W + F_E1 // factory cost
14  TC = FC + NM_E // total cost
15  FG_S = OS_FG + TC - CS_FG // cost of finished goods
        sold in Rs
16  P = sales - FG_S // profit in Rs
17  F_E2 = (F_E1)/D_W*100 // factory expenses in percent
18  NM_C = (NM_E)/FC*100 // non-manufacturing expenses
        to factory cost
19  P_C = (P/FG_S)*100 // profit to cost of sales
20  dm = 20000 // direct material in Rs
21  dw = 30000 // direct wages in Rs
22  fe = dw // factory expenses
23  fc = dm+dw+fe // factory cost in Rs
24  nme = NM_C*fc/100 // non-manufacturing expenses in
        Rs
25  tc = fc+nme // total cost in Rs
26  p = (P_C*tc)/100 // profit in Rs
27  sp = tc+p // selling price in Rs
28  printf("\n Selling price = Rs %d" , sp)
```

Scilab code Exa 4.3 To find factory cost

```
1  clc
2  d = 38 // diameter of bar in mm
3  l = 25 // length of bar in mm
4  p = 8.6 // density gm/cm^3
5  g = 9.81 // acceleration due to gravity in m/s^2
6  w = (%pi*d^2*l*p*g)/(4*10^6) // weight of material
       in N
7  mc = w*1.625 // material cost in Rs
8  lc = (2*90)/60 // labour cost in Rs
9  fo = 0.5*lc // factory overheads in Rs
10 fc = mc + lc + fo // factory cost in Rs
11 printf("\n factory cost = Rs %0.2f ", fc )
12 // Answers vary due to round off error
```

Scilab code Exa 4.4 find production cost and time taken

```
1  clc
2  sp = 65 // selling price in Rs
3  profit = 0.2*sp // profit in Rs
4  tc = sp - profit // total cost in Rs
5  P = (sp - profit)/1.4 // production cost in Rs
6  DM = 15 // cost of direct material in Rs
7  W = (P - DM)/ 1.4 // direct labour cost in Rs
8  tt = W/2 // time taken in hours
9  printf("\n Time taken = %0.3f Hours" , tt )
10 // Answers vary due to round off error
```

Scilab code Exa 4.5 To find profit

```
1  clc
2  mp = 6000 // market price of machine in Rs
3  d = 0.2*mp // discount in Rs
4  sp = mp - d // selling price of factory in Rs
```

```
5  mc = 400 // material cost in Rs
6  lc = 1600 // labour cost in Rs
7  fo = 800 // factory overheads in Rs
8  F = mc + lc + fo // factory cost in Rs
9  se = 0.5*F // selling expenses in Rs
10 profit = sp - (F + se ) // Rs
11 printf("\n profit =  Rs %d" , profit)
```

Scilab code Exa 4.6 To find lot size and time

```
1  clc
2  a = 1500 // requirements of components
3  s = 30 // cost of each set up in Rs
4  k = 0.2 // charge factor
5  c = 5 // cost of each part in Rs
6  N = 5*sqrt(a*s)/(k*c) // economic lot size
7  printf("\n Economic lot size = %d pieces", N)
8  S = (N*s)/a // time for each set up in hours
9  printf("\n Time for each set up = %0.2f hours", S )
10 // Answers vary due to round off error
```

Scilab code Exa 4.7 To find time to change cutter

```
1  clc
2  Tc = 2 // time taken by cutter per cycle in minutes
3  Tk = 10 // time taken to change cutter in minutes
4  T = 240 // tool life in minutes
5  t = (Tc*Tk)/T // time to change the cutter in min.
6  printf("\n Unit time to change the cutter = %0.3f
      min" , t )
7  // Error in textbook
```

Scilab code Exa 4.8 To find tool change time

```
1 clc
2 Tk = 360 // time taken by tool to cut before
     sharpening in min.
3 Tc = 20 // time taken to change the tool in min.
4 T = 4320 // time taken before it is discarded in min
     .
5 t = (Tc*Tk)/T //  tool change time per cycle in min.
6 printf("\n Unit tool change time per cycle = %0.2 f
     min" , t )
```

Scilab code Exa 4.9 To calculate measuring time allowance

```
1 clc
2 Tc = 10 // time taken to check hole in secs
3 F = 2 // frequency of checking dimension
4 tc = Tc*F // time taken to check one piece in secs
5 N = 200 // number of pieces
6 Tc = tc*(N + 1) // Total time in sec
7 printf("\n Total time taken to check dimensions = %d
      min" , Tc/60)
```

Scilab code Exa 4.10 To find direct labour cost

```
1 clc
2 forgings = 40
3 setup = 4
4 Tc = 12 // machining time in min. per forging
```

```
5  nmt = 21 // non−machining in min. per forging
6  st = 45 // set up time per set up
7  ts = 5 // total sharpening in min. per forging
8  f = 20 // fatigue in percent
9  f = f/100
10 pn = 5 // personal needs in percent
11 pn = pn/100
12 Tk = 10 // tool chanhe time in min.
13 T = 8 // tool life in hours
14 ct = 15 // checking time with 5 checks in 15 secs
15 R = 1.4 // performance factor
16 dlc = 5 // direct labour cost in Rs per hour
17 tt = Tc+nmt // machining and non−machining time in
       min.
18 ft = f*tt // fatigue time in min.
19 pnt = pn*tt // personal needs in min.
20 t = (Tc*Tk)/(T*60) // total sharpening time in min.
        per forging
21 mct = (ts*ct)/60 // measuring and checking time in
       min.per forging
22 su = Tc + nmt+ pnt + ft + t + mct // sum of times in
        min.
23 tf = su*forgings // time for 40 forgings in min.
24 tst = st*setup // total set up time in min.
25 Te = tf+tst // total estimated time in min.
26 Ta = Te*R // total actual time in min.
27 lc = (Ta*dlc)/60 // direct labour cost in Rs
28 printf("\n Direct labour cost = Rs %0.1f" , lc)
```

Scilab code Exa 4.11 To find machining time

```
1 clc
2 // from figure 4.4
3 v = 100 // cutting speed in m/min
4 D = 50 // mm
```

```
5  l1 = 76  // mm
6  f = 7.5  // feed in mm/rev.
7  // Case 1 , time to turn 38 mm diameter by 76 mm
        length of cut
8  N1 = (1000*v)/(%pi*D)// r.p.m
9  tm1 = l1*10/(f*N1)  // min.
10 // Case 2 , time to turn 25 mm by 38 mm length
11 N2 = (1000*v)/(%pi*38)  // r.p.m
12 l2 = 38  // mm
13 tm2 = l2*10/(f*N2)  // min
14 tt = tm1 + tm2  // total time in min
15 printf(" \n Total time = %0.2 f min." , tt)
```

Scilab code Exa 4.12 To find time to turn relief

```
1  clc
2  // from figure 4.5
3  v = 60  // cutting speed m/min.
4  f = 0.375  // feed in mm/rev
5  D = 38  // mm
6  N = (1000*60)/(%pi*D)  // rev/min
7  l = 32  // mm
8  Tm = l/(f*N)  // min
9  printf(" \n Time to turn external relief = %0.2 f min.
        " , Tm )
```

Scilab code Exa 4.13 calculate time to face on lathe

```
1  clc
2  // from figure 4.11
3  l = 7.5  // cm
4  Dave = (25+ 10)/2  // average diameter in cm
5  v = 27  // cutting speed in m/min
```

28

```
6  f = 0.8 // feed in mm/rev
7  N = (1000*v)/(%pi*Dave*10) // r.p.m.
8  tm = l*10/(f*N) // min.
9  printf("\n The machining time to face on lathe = %0
       .2f min." , tm)
```

Scilab code Exa 4.14 To find time to drill hole

```
1  clc
2  D = 12.7 // diameter in mm
3  d = 50 // depth in mm
4  v = 75 // cutting speed in m/min.
5  f = 0.175 // feed in mm/rev
6  l = d + 2*0.29*D // lemgth of drill travel in mm
7  N = (1000*v)/(%pi*D) // r.p.m.
8  tm = l/(f*N) // min
9  printf("\n Time taken to drill hole = %0.3f min." ,
       tm)
```

Scilab code Exa 4.15 To find time to complete cut

```
1   clc
2   k = 1/4 // return time to cutting ratio
3   l = 900 + 2*75 // length of stroke in mm
4   v = 6 // cutting stroke in m/min
5   f = 2 // feed mm/stroke
6   w = 600 // breadth in mm
7   N = (v*1000)/(l*1.25) // r.p.m
8   N = round(N)
9   time =  w/(f*N) // min
10  printf("\n Time required for shaper to complete one
        cut = %d min" ,time )
```

Scilab code Exa 4.16 To find time to broach

```
1  clc
2  l = 70 // length of stroke in cm
3  cs = 11 // cutting speed in m/min
4  rs = 24 // return speed in m/min
5  tm = (l/(100*cs)) + (l/(100*rs)) // min
6  printf("\n Time taken to broach a four spline brass
       = %0.4f min" , tm)
7  // Answers vary due to round off error
```

Scilab code Exa 4.17 find feed cutter travel and time

```
1  clc
2  v = 50 // cutting speed in m/min
3  D = 150 // diameter of face cutter in mm
4  N = (1000*v)/(%pi*D) // r.p.m.
5  f = 0.25 // feed mm/tooth
6  n = 10 //number of tooth
7  tf = N*f*n // table feed in mm/min
8  l = 200 // length of work piece in mm
9  d = 25 // depth of slot in mm
10 tot = sqrt(D*d - d^2) // total overtravel in mm
11 tct = l + tot // total cutter travel in mm
12 time = tct/tf // min.
13 printf("\n Table feed = %d mm/min. \n Total cutter
        travel = %0.1f mm\n Time required to machine the
        slot = %0.3f min." , tf , tct ,time )
```

Scilab code Exa 4.18 To find cutting time

```
1  clc
2  D = 63.5 // diameter of plain milling cutter in mm
3  w = 30 // width of block in mm
4  l = 180 // length of block in mm
5  f = 0.125 // feed in mm/tooth
6  n = 6 // no. of teeth
7  N = 1500 // spindle speed in r.p.m
8  tot = (D - sqrt(D^2 - w^2))/2 // total over travel
       in mm
9  tct = l + tot // total cutter travel in mm
10 Tm = tct/(f*n*N) // cutting time in min
11 printf(" Cutting time = %0.3f min." , Tm)
12 // Answers vary due to round off error
```

Scilab code Exa 4.19 To find milling time

```
1  clc
2  // from figure 4.17
3  d = 19 // depth of cut in mm
4  D1 = 5 // diameter of round bar in cm
5  v = 50 // cutting speed in m/min
6  n = 8 // number of teeth
7  f = 0.2 // feed in mm/tooth
8  l = 2*sqrt(d*D1*10 - d^2) // length of chord in mm
9  D2 = 10 // daimeter of cutter in cm
10 overrun = sqrt(D2*10*d+D1*10*d-d^2) - sqrt(D1*10*d-d
       ^2)// mm
11 tt = l + overrun // table travel in mm
12 N = (1000*v)/(%pi*D2*10) // r.p.m
13 tm = tt/(f*n*N) // time in min.
14 printf("\n The milling time = %0.2f min." , tm )
```

Scilab code Exa 4.20 To find time to grind shaft

```
1  clc
2  w = 50 // width of grinding wheep in mm
3  f = w/2 // feed in mm
4  t = 0.25 // toatal stock in mm
5  d = 0.025 // depth of cut in mm
6  n = t/d // number of cuts
7  v = 15 // cutting speed in m/min
8  D = 38 // diameter in mm
9  N = (1000*v)/(%pi*D) // r.p.m.
10 l = 200 // length of part in mm
11 Tm = (l*10)/(f*N) // min.
12 printf("Time required to grind the shaft = %0.2f min
       ." , Tm)
```

Scilab code Exa 4.21 To find time to cut threads

```
1  clc
2  v = 6 // cutting speed in m/min
3  n = 5 // number of cuts
4  D = 44 // diameter in mm
5  N = (1000*v)/(%pi*D) // r.p.m
6  f = 0.5 // feed in cm
7  l = 8.9 // length of cut in cm
8  Tm = (l*n)/(f*N) // time in min
9  printf("\n Time to cut the threads = %0.2f min" , Tm
       )
10 // Answers vary due to round off error
```

Scilab code Exa 4.22 find time to produce one piece

```
 1  clc
 2  vt = 40 // cutting speed for turning in m/min
 3  vs = 8 // cutting speed for cutting and knurling in
        m/min
 4  ft = 0.4 // feed for turning in mm/rev.
 5  ff = 0.2 // feed for forming in mm/rev
 6  d1 = 25 // diameter in mm
 7  l1 = 50 // mm
 8  N1 = 1000*vt/(%pi*d1) // spindle speed in rev./min.
 9  time1 = l1/(ft*N1) // min.
10  tt = 2*time1 // total time in min.
11  d2 = 15 // mm
12  N2 = 1000*vt/(%pi*d2)// rev/min.
13  l2 = 30 // mm
14  time2 = l2/(ft*N2) // min.
15  eft = 0.15 // end forming time in min.
16  d3 = 10 // mm
17  N3 = 1000*vs/(%pi*d3) // rev./min.
18  l3 = 15 // mm
19  f = 1.5 // feed in min.
20  time3 = l3/(f*N3) // min.
21  N4 = 1000*vs/(%pi*d1) // rev./min.
22  l4 = 10 // mm
23  time4 = l4/(ft*N4) // min.
24  time5 = 0.15 // time for chamfering in min.
25  Dave = d1/2 // mm
26  N5 = 1000*vt/(%pi*Dave) // r.p.m.
27  time6 = Dave/(N5*ff) // min,
28  tmt = tt+time2+time3+time4+time5+time6+eft // total
        machining time in min.
29  t = 0.05 // min.
30  ht = time5+6*time6+4*t+3*t // handling time in min.
31  tot = ht+tmt // total handling time in min.
32  ct = 15*tot/100 // contingency in min.
33  tct = tot+ct // total cycle time in min.
34  st = 60 // set up time for turret lathe
```

```
35  p = 100 // total pieces
36  stp = st/p // set up time per piece in min.
37  tpt = tct+stp // Total production timr per piece in
        min.
38  printf("\n Total production timr per piece = %0.2 f
        min" , tpt)
39  //Answers vary due to round off error
```

Chapter 5

Economics of tooling

Scilab code Exa 5.1 To find value of machine tool

```
1  clc
2  Co = 250000 // original value of machine tool in Rs
3  Cs = 25000 // salvage value in Rs
4  n = 20 //useful life in years
5  d = (Co-Cs)/n // depreciation per year in Rs
6  v1 = Co - 10*d // value of machine tool at the end
      of 10 years in Rs
7  s = Co - Cs // sum at the end of useful life in Rs
8  i = 8/100 // annual interst rate
9  D = (s*i)/((1 + i)^n-1) // annual deposit
10 a  = D*((1+i)^10-1)/i //amount at the end of 10
      years in Rs
11 v2 = Co - a // value at the end of 10 years
12 printf("\n Value of machine at the end of 10 years
      through straight line depreciation method = Rs %d
      " , v1)
13 printf("\n Value of machine at the end of 10 years
      through sinking fund method = Rs %d" , v2)
14 // Answers vary due to round off error
```

Scilab code Exa 5.2 To find annual investment

```
1  clc
2  p = 200000 // present worth in Rs
3  i = 10 // annual interest rate
4  i = 10/100
5  n = 20 // number of years
6  a1 = (p*i)/((1+i)^n-1) // annual investment using
       sinking fund factor in Rs
7  a2 = (p*i*(i+1)^n)/((i+1)^n-1)// annual investment
       using capital recovery factor in Rs
8  printf("\nAnnual investment using sinking fund
       factor = Rs %d /- per year" , a1)
9  printf("\nAnnual investment using capital recovery
       factor = Rs %d /- per year" , a2)
10 // Answers vary due to round off error
```

Scilab code Exa 5.3 find project is economical or not

```
1  clc
2  // cash in flows
3  a = 21240 // annual revenue in Rs
4  i = 10 // annual interest rate
5  i = 10/100
6  n = 5 // perod in years
7  f1 = 8000 // salvage value in Rs
8  p1 =  (a*((i+1)^n-1))/(i*(i+1)^5)// annual revenue
       in Rs
9  p2 = f1/(i+1)^5 //present worth in Rs
10 t1 = p1 + p2 // total cash in flows in Rs
11 // cash out flows
12 I = 40000 // investment in Rs
```

```
13  f2 = 12000 // annual payment in Rs
14  p3 = (f2*((1+i)^5-1))/(i*(1+i)^5) // annual payments
        in Rs
15  t2 = I + p3 // total cash out flows in Rs
16  printf("\nTotal cash in flows = Rs %0.2f\nTotal cash
        out flows = Rs %0.2f",t1 ,t2)
17  disp("Since cash out flows are more than cash in
        flows therefore project is not economical")
18  // Answers vary due to round off error
```

Scilab code Exa 5.4 selection of economical machine

```
 1  clc
 2  //Machine A
 3  f1 = 2000 // annual benefit from better production
        quality in Rs
 4  i = 10 // interest rate
 5  i = 10/100
 6  f2 = 12000 // salvage value in Rs
 7  f3 = 8000 // operating and maintenance cost in Rs
 8  I1 = 100000 // initial cost in Rs
 9  n = 5 // years
10  p1 = (f1*((1+i)^n-1))/(i*(i+1)^n)
11  p2 = f2/(1+i)^n
12  c1 = p1 + p2 // cash in flows in Rs
13  p3 = (f3*((1+i)^n-1))/(i*(i+1)^n)
14  c2 = I1 + p3 // cash out flows in Rs
15  Pa = c1 - c2 // net P.W. in Rs
16  //Machine B
17  I2 = 60000 // initial cost in Rs
18  f4 = 16000 // operating and maintenance cost in Rs
19  f5 = 14000 // reconditioning at the end of third
        year in Rs
20  p4 = (16000*((1+i)^5-1))/(i*(1+i)^5)
21  p5 = f5/(1+i)^5
```

```
22  Pb = -I2 - p4 - p5 // net P.W. in Rs
23  printf("\n Net P.W. of Machine A= Rs %0.2f\n Net P.W.
        of Machine B = Rs%0.2f" , Pa ,Pb)
24  disp("It is clear that Net P.W of Machine A is less
        nagative as compared to that of Machine B ,
        therefore Machine A is economcal.")
25  // Answers vary due to round off error
```

Scilab code Exa 5.5 selection of machine

```
1   clc
2   //machine A
3   c1 = 20000 // manual cost in Rs
4   c2 = 40000 // operating cost in Rs
5   n1 = 2 // machine life in years
6   i = 10 // interest rate
7   i = 10/100
8   crf1 = ((1+i)^n1-1)/(i*(i+1)^n1) // capital recovery
        factor
9   pw1 = c1+c2*crf1 // present worth in Rs
10  // machine B
11  c3 = 50000 // manual cost in Rs
12  c4 = 30000 // operating cost in Rs
13  n2 = 4 // machine life in years
14  i = 10/100 // interest rate
15  crf2 = ((1+i)^n2-1)/(i*(i+1)^n2) // capital recovery
        factor
16  pw2 = c3+c4*crf2 // present worth in Rs for 4 years
17  pw3 = (pw2*crf1)/crf2 // present worth in Rs for 2
        years
18  printf("\n P.W. of expenses for A = Rs %d\n P.W. of
        expenses for B = Rs %0.2f" ,pw1,pw3)
19  disp("As the expenses of machine B are less , so
        this is economical")
20  // Answers vary due to round off error
```

Scilab code Exa 5.6 `selection of economical machine`

```
1  clc
2  //Machine A
3  i = 8 // // interest rate
4  i = i/100 // interest rate
5  n1 = 10 // economic life in years
6  CRF1 = i*(1+0.08)^n1/((1+i)^n1-1) // capital
       recovery factor
7  p1 = 46000 // first cost in Rs
8  s1 = 8000 // salvage value in Rs
9  o1 = 10000 // operating charges in Rs
10 AC1 = (p1-s1)*CRF1 + s1*i + o1 // annual cost in Rs
11 //Machine B
12 n2 = 15 // economic life in years
13 CRF2 = i*(1+0.08)^n2/((1+i)^n2-1) // capital
       recovery factor
14 p2 = 60000 // first cost in Rs
15 s2 = 10000 // salvage value in Rs
16 o2 = 9200 // operating charges in Rs
17 AC2 = (p2-s2)*CRF2 + s2*i + o2 // annual cost in Rs
18 printf("\n Annual cost of machine A = Rs %0.2f\n
       Annual cost of Machine B = Rs %0.2f" ,AC1, AC2 )
19 disp("Machine B will be economical")
20 // Error in textbook
```

Scilab code Exa 5.7 `find ERR and economicality of project`

```
1  clc
2  a = 100000 // Ej(p/f,e%,j) in Rs
3  n = 5 // life in years
```

```
4  e = 20 // M.A.R.R.
5  e = e/100 // M.A.R.R.
6  i = e
7  A = 32000 // savings in Rs
8  s = 20000 // salvage value in Rs
9  b = ((A*(((i+1)^n)-1)/i)+s)/a // (F/p,I,5)
10 i2 = (b)^(1/n)-1 // internal rate of return
11 printf("\n ERR = %0.4f\n Internal rate of return =
      %0.2f percent" , b , i2*100)
12 disp("Since Internal rate of return is > M.A.R.R ,
      therefore project is feasible")
```

Scilab code Exa 5.9 find ERR and economicality of project

```
1  clc
2  e = 20 // M,A.R.R.
3  i = e // interest rste
4  i = i/100
5  n = 5 // life in years
6  s = 32000 // annual net savings in Rs
7  p = 100000 // present worth in Rs
8  S = 20000 // salvage value in Rs
9  a = (p-S)*(i/((1+i)^n-1)) // (p-s)(A/F,e%,n)
10 E = (s-a)/p // E.R.R.R
11 printf("\n ERRR = %0.2f percent", E*100)
12 disp("Since E.R.R.R is > M.A.R.R. therefore project
      is feasible .")
```

Scilab code Exa 5.10 To determine acceptance of machine

```
1  clc
2  // machine A
3  r_e1 = 9600 //cash flow in Rs
```

```
4  p1 = 46000 // intial cost in Rs
5  s = 0 // salvage value
6  e = 8 // M.A.R.R
7  e = e/100
8  i = 8 // investment rate
9  i = i/100
10 n = 6 // life in years
11 x = i/((1+i)^n-1)
12 ERRR1 = (r_e1 - (p1-s)*x)/p1
13 //machine B
14 r_e2 = 7200 //cash flow in Rs
15 p2 = 32000 // intial cost in Rs
16 ERRR2 = (r_e2 - (p2-s)*x)/p2
17 printf("\n ERRR1 = %0.2f percent \n ERRR2 = %0.2f
      percent" , ERRR1*100 ,ERRR2*100)
18 disp("Only machine B is accepteble")
```

Scilab code Exa 5.11 find investment cost and unamortized value

```
1  clc
2  pmv = 15000 // present market value in Rs
3  ss = 6000 // sum needed to make it serviceable in Rs
4  ic = ss + pmv //  investment cost in Rs
5  pbv = 30000 // present book value in Rs
6  sv = 15000 // salvage value in Rs
7  ui = pbv - sv // unamortized investment in Rs
8  printf("\n Investment cost = Rs %d\n Unamortized
      investment = Rs %d" , ic , ui)
```

Scilab code Exa 5.13 To make decision of machines replacement

```
1  clc
2  // Existing machine
```

```
3  pmp = 100000 // present market price in Rs
4  io = 50000 // immediate overhauling in Rs
5  asl = 5 // additional service life in years
6  aoc = 50000 // annual operating cost in Rs
7  svo = 10000 // salvage value after overhauling in Rs
8  pc = io + pmp // present cost in Rs
9  i = 10 // interest rate
10 i = 10/100
11 crf1 = (i*(1+i)^asl)/((1+i)^asl - 1) // capital
      recovery factor
12 AC1 = (pc - svo)*crf1 + svo*i + aoc // average cost
      in Rs
13 // proposed machine
14 n = 10 // expected economic life in years
15 ic = 300000 // initial cost in Rs
16 sv = 100000 // salvage value in Rs
17 o = 30000 // annual operating cost in Rs
18 crf2 = (i*(1+i)^10)/((1+i)^10 - 1)
19 AC2 = (ic - sv)*crf2 + sv*i + o // average cost in
      Rs
20 printf("Existing machine = Rs %0.3f \n Proposed
      machine = Rs %0.2f" , AC1 , AC2)
21 disp("Since the equivalent annual cost of proposed
      machine is less than that of the existing machine
       , therefore , the replacement is justified .")
22 // Answers vary due to round off error
```

Scilab code Exa 5.15 Determine economic repair life

```
1 clc
2 c = 20000 // first cost of machine in Rs
3 s = 1000 // scrap value in machine in Rs
4 b = 180 // annual increase in cost of repairs in Rs
5 n = sqrt(2*(c-s)/b) // years
6 printf("\n Number of years of economic repair life =
```

```
    %0.2 f  years"  , n)
```

Scilab code Exa 5.16 find time to pay for itself

```
 1  clc
 2  Cn = 72000 // cost of new machine installed and
        tooled in Rs
 3  Co = 28000 // cost of new machime installed and
        tooled in Rs
 4  p = 16 // hourly pieces
 5  Nn = 2200*p // estimated annual production on new
        machine
 6  Ko = 17200 // present book value of old machine in
        Rs
 7  So = 6400 // scrap value of old machine in Rs
 8  Sn = 8000 // probable scrap value of old machine in
        at the end of its useful life Rs
 9  oco = 2.5 // opreator cost per hour
10  mco= 48 // machine cost
11  ro = 10 // production rate per hour
12  ocn = 2 // opreator cost per hour
13  mcn= 62 // machine cost
14  rn = 16 // production rate per hour
15  Po = (oco+mco)/ro // labour and machine cost per
        unit on old machine in Rs
16  Pn = (ocn+mcn)/rn // labour and machine cost per
        unit on new machine in Rs
17  i = 6 // interest on investment
18  i = i/100
19  t = 6 // annual taxes
20  t = t/100
21  d = 10 // annual allowance for depreciation
22  d = d/100
23  m = 3 // annual allowance for maintenance
24  m = m/100
```

```
25  n = ((Cn-Sn)+(Ko-So))/((Nn*(Po-Pn)) - Cn*(i+t+d+m))
26  printf("\n The number of years in which the new
        machine will pay for itself = %0.3f years" , n)
```

Scilab code Exa 5.17 selection of machine for job

```
 1  clc
 2  C = 80000 // cost of new machine installed and
        tooled in Rs
 3  nel = 2 // number of engine lathes
 4  c = 32000*nel // first cost of engine lathe
 5  N = 4000 // annual production of turret lathe
 6  n = 3800 // annual production in engine lathe
 7  nhp1 = 4 // hp motor
 8  L = 2256*nhp1 // annual labour cost of turret lathe
 9  w = 5 // wage in per hour
10  time = 2300 // hours
11  l = time*nel*w // labour cost of engine lathe
12  nhp2 = 2.5 // hp motor
13  pr = 0.35 // power rate in kwh
14  p = (nel*nhp2*746*time*pr)/1000 // power cost
15  P = (nhp1*746*time*pr)/1000 // power cost
16  F = 480 //saving
17  I  = 6/100 // interest rate
18  T = 4/100 // tax rate
19  D = 10/100 // allowance for depreciation in engine
        lathe
20  M = 6/100 // allowance for maintenance in engine
        lathe
21  B = 55/100 // labour burden in engine lathe
22  i  = 6/100 // interest rate
23  t = 4/100 // tax rate
24  d = 10/100 // allowance for depreciation in turret
        lathe
25  m = 6/100 // allowance for maintenance in turret
```

```
      lathe
26  X = (L + B*L + P +C*(I+T+D+M) - F)/N
27  x = (l+l*B + p + c*(i+t+d+m))/n
28  printf("\n Unit production cost on turret lathe = Rs
        %0.2f per piece\n Unit production cost on engine
        lathe = Rs %0.2f per piece" , X , x)
29  disp("Turret lathe will be more economical than two
        engine lathe")
30  // Answers vary due to round off error
```

Scilab code Exa 5.18 Calculate maximum investment on turret lathe

```
 1  clc
 2  X = 9.16 // production cost on turret lathe
 3  N = 4000 // annual requirement
 4  c = X*N // cost for 4000 pieces on turret lathe
 5  n = 3800 // production of engine lathe
 6  l = 23000 // labour cost
 7  p = 3002 // power cost
 8  i = 6 // interest rate
 9  i = i/100
10  t = 4 // tax rate
11  t = t/100
12  d = 10 // allowance for depreciation in turret lathe
13  d = d/100
14  m = 6 // allowance for maintenance in turret lathe
15  m = m/100
16  b = 55/100 //labour burden
17  a = i+t+d+m
18  tc = 64000 // first cost of engine lathe
19  c1 =(N*(l*(1+b)+p))/n+(tc*a) // cost for engine
        lathe
20  s = c1-c // savings
21  amt = s/a // amount invested in turret lathe over
        the cost of engine lathe
```

```
22 printf(" \n Amount invested in turret lathe over the
      cost of engine lathe = Rs %d" , amt)
23 // Answers vary due to round off error
```

Scilab code Exa 5.19 To find years for new machine

```
1 clc
2 Cn = 60000 // cost of new machine
3 Sn = 5000 // scrap value of new machine
4 So = 1000 // scrap value of old machine
5 Nn = 200000 //annual production
6 I = 10 // interest rate
7 I = I/100
8 M = 7 // allowance for maintenane
9 M = M/100
10 T = 6 // annual taxes
11 T = T/100
12 D = 1/10 // allowance for depreciation
13 lco = 300 // labour charges for old machine
14 m = 12 // months
15 rco = 15000 // running charges for old machine
16 pro = 50000 // production rate for old machine
17 lcn = 500 // labour charges for new machine
18 rcn = 10000 // running charges for old machine
19 prn = 200000// production rate f
20 Po = (lco*m + rco)/pro // labour and machine cost on
       old machine
21 Pn = (lcn*m + rcn)/prn // labour and machine cost on
      new machine
22 n =((Cn-Sn)-So)/((Nn*(Po-Pn))-Cn*(I+T+D+M)) //years
23 printf(" \n Years in which new machine will pay for
      itself = %0.2f years" , n)
```

Scilab code Exa 5.20 `To find cost and pieces`

```
1  clc
2  a = 1.50 //saving in labour
3  b=55/100 // burden applied on labour
4  T = 4/100 // allowance for taxes
5  M = 5/100 // allowance for maintenance
6  I = 8/100 // interest rate
7  D = 50/100 // allowance for depreciation
8  H = 2 // years to amortize the investment
9  S = 50 // yearly cost for set up
10 C = 3000 // first cost
11 N1 = (C*(I+T+M+D)+S)/(a*(1+b)) // annual production
      when 1 run is made
12 r = 5 // number of runs
13 N2 = (C*(I+T+M+D)+S*r)/(a*(1+b)) // annual
      production when 1 run is made
14 D1 = 100/100 // allowance for depreciation
15 N3 = (C*(I+T+M+D1)+S)/(a*(1+b)) // production when D
      = 100
16 n1 = 1530 // pieces
17 C1 = (n1*(a*(1+b))-S)/(I+T+M+D1) // economical
      investment
18 n2 = 950 // pieces
19 a1 = 2 // labour cost
20 r1 = 6 // number of runs
21 S1 = r1*S // yearly cost
22 V = n2*a1*(1+b)-C*(I+T+M+D)-S1 //profit
23 printf("\n Number of pieces when one run is made and
       cost is Rs 3000 = %d pieces",N1)
24 printf("\n Annual production when 5 runs are made
      per year = %d pieces" , N2)
25 printf("\nAnnual production when fixture pay for
      itself = %d pieces" , N3)
26 printf("\nEconomical investment when 1530 pieces for
       single run with savings Rs 1.50 per piece = Rs
      %d",C1)
27 printf("\nAnnual profit when 950 pieces made per
```

```
      year in 6 runs and saving in labour cost Rs 2 per
          piece = Rs %d per year" , V)
28 //   'Answers vary due to round off error '
```

Scilab code Exa 5.21 `To find number of components`

```
1 clc
2 a = 0.125 //saving in labour cost per unit
3 b = 0.4 // overhead applied on direct labour saved
4 D = 1/2 // allowance for depreciation
5 C = 2400 // first cost
6 I = 6/100 // interest rate
7 T = 4/100 // allowance for taxes
8 M = 10/100 // allowance for maintenance
9 S = 80 // cost of set up
10 N = (C*(I+T+D+M)+S)/(a*(1+b)) // pieces per year
11 t = N*2 // total number of pieces
12 printf("\n Total number of pieces produced = %d" , t
     )
13 // Answers vary due to round off error
```

Scilab code Exa 5.22 `To find number of components`

```
1 clc
2 a = 0.125 // saving in labour cost per unit
3 b = 0.4 // overhead applied on direct labour saved
4 D = 1/2 // allowance for depreciation
5 C = 2400 // first cost
6 I = 6/100 // interst rate
7 T = 4/100 // allowance for taxes
8 M = 10/100 // allowance for maintenance
9 n = 6 // number of baches
10 S = 80 // cost of set up
```

```
11  s1 = S*n // total set up cost
12  N = (C*(I+T+D+M)+s1)/(a*(1+b)) // pieces
13  t = N*2 // total number of pieces
14  printf("\n Total number of pieces produced = %d" , t
      )
15  // Answers vary due to round off error
```

Scilab code Exa 5.23 To find time and profit

```
1  clc
2  C1 = 2000 // first cost  small tool in Rs
3  N = 5000 // parts per year
4  n = 5 // number of batches
5  S = 50*n // cost of set up
6  a = 0.15 // saving in labour cost per unit
7  b = 50/100 // burden applied on direct labour saved
8  I = 10/100 // interest rate
9  T = 5/100 // allowance for tax
10  M = 10/100 // allowance for maintenance
11  H = C1/((N*a*(1+b))-(C1*(I+T+M))-S) // years
12  C2 = 1600 // cost of fixture
13  D = 1/H // allowance for depreciation
14  V = N*a*(1+b)-C2*(I+T+D+M)-S // profit
15  printf("\n Number of years taken by fixture of Rs
      2000 = %0.2f years\n profit made when fixture of
      Rs 1600 = Rs %d" , H ,V)
```

Scilab code Exa 5.24 To find minimum number of components

```
1  clc
2  c1 = 3 //  machine cost per component using existing
      euipment in Rs
3  c2 = 1 // machine cost using fixture in Rs
```

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```
4  s = c1 - c2 // saving in machine cost per piece
5  f= 1000 // cost of fixture in Rs
6  N = f/2 // components
7  printf ("\n Minimum number of components to be
       produced if cost of fixture to be recovered = %d"
        ,N)
```

Scilab code Exa 5.25 To calculate number of pieces

```
1  clc
2  C = 1000 // cost of fixture
3  Co = 700 // cost of old fixture
4  Cs = 250 // scrap value
5  a = 10 //saving per piece in paisa
6  a = a/100
7  b = 30 // overhead applied on direct labour saved
8  b = b/100
9  I = 8 // interest rate
10 I = I/100
11 M = 3 // allowance for maintenance
12 M = M/100
13 T = 12 // allowance for tax
14 T = T/100
15 H = 3/2 // amortization
16 D = 1/H // allowance for depreciation
17 N = (C*(I+T+D+M)+(Co-Cs)*I)/(a*(1+b)) // pieces per
       year
18 printf("\n Number of pieces which must be produced
       to break even so that fixture may pay for itself
        = %d pieces per year" , N)
19 // Answers vary due to round off error
```

Scilab code Exa 5.26 To find cost for new fixture

```
1  clc
2  N = 9000 // number of pieces
3  Co = 700 // cost of old fixture
4  Cs = 250 // scrap value
5  a = 10 //saving per piece in paisa
6  a = a/100
7  b = 30 // overhead applied on direct labour saved
8  b = b/100
9  I = 8 // interest rate
10 I = I/100
11 M = 3 // allowance for maintenance
12 M = M/100
13 T = 12 // allowance for tax
14 T = T/100
15 H = 3/2 // amortization
16 D = 1/H // allowance for depreciation
17 C = (N*a*(1+b)-(Co-Cs)*I)/(I+T+D+M) // cost in Rs
18 printf("\n Cost for new fixture = Rs %d" , C)
19 // Answers vary due to round off error
```

Scilab code Exa 5.27 find time to amortize fixture

```
1  clc
2  n = 6500 // yearly production
3  c = 1350 // cost of fixture
4  a = 10 //saving per piece in paisa
5  a = a/100
6  b = 30 // overhead applied on direct labour saved
7  b = b/100
8  I = 8 // interest rate
9  I = I/100
10 M = 3 // allowance for maintenance
11 M = M/100
12 T = 12 // allowance for tax
13 T = T/100
```

```
14 co = 700 // cost of old fixture
15 cs = 250 // scrap value
16 H = (c)/((n*a*(1+b))-I*(co-cs)-c*(I+T+M)) //
      amotization in years
17 printf("\n Time taken to amortize the fixture = %0.1
      f years" , H)
```

Scilab code Exa 5.28 To find profit

```
1 clc
2 n = 9000 // production of pieces per year
3 c = 1000 // fixture costs
4 Co = 700 // cost of old fixture
5 Cs = 250 // scrap value
6 a = 10 //saving per piece in paisa
7 a = a/100
8 b = 30 // overhead applied on direct labour saved
9 b = b/100
10 I = 8 // interest rate
11 I = I/100
12 M = 3 // allowance for maintenance
13 M = M/100
14 T = 12 // allowance for tax
15 T = T/100
16 h = 1.5 // amortization
17 D = 1/h // allowance for depreciation
18 V = (n*a*(1+b))-(c*(I+T+D+M))-((Co-Cs)*I) // profit
19 printf("\n profit = Rs %d " , V)
20 // Answers vary due to round off error
```

Scilab code Exa 5.29 To find BEP Cost and Components

```
1 clc
```

```
2  fc1 = 100000 // fixed cost in Rs
3  vc1 = 100 // variable cost in Rs per unit
4  sp = 200 // selling price in Rs per unit
5  q1 = fc1/(sp-vc1) // quantity of production at break
       even point
6  fc2 = 125000 // fixed cost in Rs
7  vc2 = 90 // variable cost in Rs per unit
8  q2 = fc2/(sp-vc2) // quantity of production at break
       even point
9  p = 20000 // profit in Rs
10 q3 = (fc1 + p)/(sp-vc1) // quantity of production at
       profit of Rs 20000
11 printf("\n Break even point = %d pieces \n If fixed
       cost is 125000 and variable cost is Rs 90 per
       unit then break even point = %d pieces\n Number
       of components to get profit of Rs 20000 = %d
       pieces" , q1 , q2 ,q3)
```

Scilab code Exa 5.30 To find break even point

```
1  clc
2  fc1 = 12000 // fixed cost for machine A in Rs
3  fc2 = 48000 // fixed cost for machine B in Rs
4  n1 = 6 // unit production cost in Rs per piece for
       machine A
5  n2 = 1.2 // unit production cost in Rs per piece for
       machine B
6  q = (fc2-fc1)/(n1-n2) // break even point
7  printf("\n Break even point = %d pieces" , q)
```

Scilab code Exa 5.31 To find break even quantity

```
1  clc
```

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```
2  // capstan lathe
3  tc1 = 300 // total cost in Rs
4  mc1 = 2.5 // material cost per piece in Rs
5  olc1 = 5 // operation labour cost per hour in Rs
6  ct1 = 5 // cycle time per piece in min.
7  slc1 = 20 // setting up labour cost in Rs per hour
8  st1 = 1 // setting up time in hour
9  mo1 = 300/100 // machine over heads of operation
      labour cost
10 o1 = mo1*olc1 // overheads of capstan lathe in Rs
      per hour
11 fc1 = tc1 + slc1*st1 + o1*st1 // fixed cost of
      capstan lathe in Rs
12 vc1 = mc1 + (olc1*ct1)/60 + (o1*ct1)/60 // variable
      cost in Rs
13 // Automatic (single spindle)
14 tc2 = 300 // total cost in Rs
15 cc2 = 1500 // cost of cams in Rs
16 mc2 = 2.5 // material cost per piece in Rs
17 olc2 = 2 // operation labour cost per hour in Rs
18 ct2 = 1 // cycle time per piece in min.
19 slc2 = 20 // setting up labour cost in Rs per hour
20 st2 = 8 // setting up time in hour
21 mo2 = 1000/100 // machine over heads of operation
      labour cost
22 o2 = mo2*olc2 // overheads of single spindle in Rs
      per hour
23 fc2 = tc2 + cc2 + slc2*st2 + o2*st2 // fixed cost of
       single spindle in Rs
24 vc2 = mc2 + (olc2*ct2)/60 + (slc2)/60 // variable
      cost in Rs
25 q = (fc2-fc1)/(vc1-vc2) // break even quantity
26 printf("\n Break even quantity for a component which
       can be produced on either the capstan lathe or
      single spindle automatic = %d pieces" , q)
```

Scilab code Exa 5.32 To do break even analysis

```scilab
1  clc
2  // Engine lathe
3  t = 12 // time/piece in min.
4  l = 7 // overhead cost/hr
5  o = 4 // direct labour cost/hr
6  s = 2 // set up time in hour
7  sr = 8 // set up rate per
8  // turret lathe
9  T = 5 // time/piece in min.
10 L = 5 // overhead cost/hr
11 O = 8 // direct labour cost/hr
12 S = 8 // set up time in hour
13 SR = 8 // set up rate per
14 q = 60*(S*SR-s*sr)/(t*(l+o)-T*(L+O)) // break even
      point
15 q = round(q)
16 printf("\n Break even point = %d pieces" , q)
```

Scilab code Exa 5.33 To calculate minimum number of pieces

```scilab
1  clc
2  fc1 = 80000 // fixed cost for turret lathe in Rs
3  fc2 = 32000 // fixed cost for engine lathe in Rs
4  n1 = 16 // production of pieces per year in turret
      lathe
5  n2 = 10 // production of pieces per year in engine
      lathe
6  vc1 = 2 //operators cost in turret lathe
7  vc2 = 2.5 // operators cost in engine lathe
8  Q=poly(0,'Q')
```

```
 9 Q=roots((fc1+1/n1*vc1*Q)-(fc2+2.5*Q/10))
10 printf("\n Break even point = %d pieces" , Q)
```

Scilab code Exa 5.34 To determine the point

```
1 clc
2 st1 = 15 // set up time for engine lathe in min.
3 ut1 = 15 // unit time for engine lathe in min.
4 st2 = 90 // set up time for automatic lathe in min.
5 ut2 = 1.5 // unit time for engine lathe in min.
6 q = (st2-st1)/(ut1-ut2) // quantity of production
7 printf("\n The point at which the automatic lathe
      will be justified = %0.2 f " , q)
8 // Answers vary due to round off error
```

Scilab code Exa 5.35 To find quantity of pieces

```
1 clc
2 // Automatic lathe
3 p = 30 // number of pieces produced per hour
4 l = 4 // labour rate per hour in Rs
5 d = 4.50 // hourly depreciation rate per machine in
      hour
6 s = 4 // set up time in hour
7 // turret lathe
8 P = 10 // number of pieces produced per hour
9 L = 4 // labour rate per hour in Rs
10 D = 1.50 // hourly depreciation rate per machine in
      hour
11 S = 2 // set up time in hour
12 q = (P*p*(S*L+S*D-s*l-s*d))/(P*(l+d)-p*(L+D)) //
      quantity of pieces at break even point
```

```
13  printf("\n Quantity of pieces at Break even point =
       %d pieces" , q)
```

Scilab code Exa 5.36 To determine quantity of production

```
1  clc
2  Pa = 8.4 // unit tool process cost for method A in
       Rs
3  Pb = 14.8 // unit tool process cost for method B in
       Rs
4  Ta = 6480 //total tool cost for method A in Rs
5  Tb = 1616 //total tool  cost for method B in Rs
6  q = (Ta-Tb)/(Pb-Pa) // break even point
7  printf("\n Quantity of production at break even
       point = %d pieces" , q)
```

Scilab code Exa 5.37 find preference between machines and production

```
1  clc
2  // machine A
3  ic1 = 50000 // initial cost
4  hoc1 = 10 // hourly operating charges
5  pp1= 5 // pieces produced per hour
6  i = 15 // interest rate
7  i = i/100
8  oh = 2000 // operating hours
9  fc1 = ic1*i // fixed cost
10 vc1 = oh*hoc1 // variable cost
11 tc1 = fc1+vc1 // total charges
12 ao1 = oh*pp1 // annual output
13 c1 = tc1/ao1 // cost per unit
14 // machine B
15 ic2 = 80000 // initial cost
```

```
16  hoc2 = 8 // hourly operating charges
17  pp2= 8 // pieces produced per hour
18  fc2 = ic2*i // fixed cost
19  vc2 = oh*hoc2 // variable cost
20  tc2 = fc2+vc2 // total charges
21  ao2 = oh*pp2 // annual output
22  c2 = tc2/ao2 // cost per unit
23  printf("\n (i) Cost per unit for machine A = Rs %0.2
        f\n Cost per unit machine B = Rs %0.2 f",c1,c2)
24  disp("machine B will be preferred")
25  // machine A
26  ao3 = 4000 // annual output
27  oc3 = ao3*hoc1/pp1 // operating charges
28  tc3 = oc3+fc1 // total annual charge
29  c3 = tc3/ao3 // cost/piece
30  // machine B
31  ao4 = 4000 // annual output
32  oc4 = ao4*hoc2/pp2 // operating charges
33  tc4 = oc4+fc2 // total annual charge
34  c4 = tc4/ao4// cost/piece
35  printf("\n (ii) Cost per unit for machine A = Rs %0
        .2 f\n Cost per unit machine B = Rs %0.2 f",c3,c4)
36  disp("machine A will be preferred")
37  A = hoc1/pp1 // operating cost per piece on machine
        A
38  B = hoc2/pp2 // operating cost per piece on machine
        B
39  Q = fc2 - fc1 // annual production
40  printf("\n(iii) Annual production to make cost per
        piece equal for two machines = %d pieces" , Q )
```

Scilab code Exa 5.38 To find BEP and various sales

```
1  clc
2  as = 80000 // annual sales in Rs
```

```
3  vc = 64000 // variable expenses in Rs
4  c = 16000 // contribution in Rs
5  fc = 24000 // fixed expenses in Rs
6  l = 8000 // losses in Rs
7  p = 9000 // profit in Rs
8  s1 = fc + vc // sales at B.E.P in Rs
9  s2 = (fc + vc + p)/0.945 // sales at net income of
      Rs9000 and corporate tax rate being 5.5%
10 q = 10000 // quantity of units
11 sp = (fc+vc)/q // selling price per unit in Rs
12 printf("\n Sales at break even point = %d units" ,
      s1 )
13 printf("\n Sales at net income of Rs9000 and
      corporate tax rate being 5.5 = Rs %0.2f\n Sales
      per unit if B.E.P brought down to 10000 units =
      Rs %0.2f per unit" ,s2 , sp)
```

Scilab code Exa 5.39 To determine break even point

```
1  clc
2  fc = 55000 // fixed cost in Rs
3  vc = 45 // variable cost per piece in Rs
4  sp = 100 // selling price per piece in Rs
5  p = (vc/sp)*100 // percentage of variable cost to
6  pm = 100 - p // profit margin
7  bep = ((55000/55)*100)/100 // Break even point
8  printf("\n Break even point = %d pieces" , bep)
```

Scilab code Exa 5.40 To calculate economic lot size

```
1  clc
2  f1 = 335 // fixed cost in Rs for capstan lathe
3  k = 0.25 // stock carrying factor in paise per piece
```

```
 4  k = k/100
 5  N1 = sqrt(f1/k) // pieces for capstan lathe
 6  a1 = 4.16 // variable cost per piece for capstan
        lathe
 7  tc1 = a1+f1/N1+k*N1 // total cost for capstan lathe
 8  f2 = 2120 // fixed cost in Rs for turret lathe
 9  N2 = sqrt(f2/k) // pieces for turret lathe
10  a2 = 2.863 // variable cost per piece for turret
        lathe
11  tc2 = a2+f2/N2+k*N2 // total cost for turret lathe
12  printf("\n Total cost per piece for capstan lathe =
        Rs %0.2f\n Total cost per piece for turret lathe
        = Rs %0.2f" , tc1 , tc2)
13  // Answers vary due to round off error
```

Scilab code Exa 5.41 To find EOQ and total cost

```
 1  clc
 2  R=500 // cost of ordering in Rs per order
 3  A=12000 //annual consumption units
 4  C=3.00 // unit cost of item
 5  K=3 // unit storage cost
 6  I1=0.2 // interest rate
 7  function y=f(N)
 8  function G=f2(N)
 9  G=C*A+I1*C*N/2+K*N/2+A*R/N // total cost per year
10  endfunction
11  y=derivative(f2,N)
12  endfunction
13  funcprot(0)
14  N=fsolve(2000,f)
15  O = A/N // number of orders
16  N1 = 2400 // units
17  tc = C*A + I1*C*N1/2 + K*N1/2 + A*R/N1 // total cost
        in Rs
```

```
18  I2 = (2*R*A)/(C*N1^2)
19  printf("\n Economic  order  quantity = %d units\n Totl
        cost = Rs %d per  year\n I = %0.4f",N1,tc,I2)
20  disp(" It is clear that inventory cost will get
        increased very greatly")
```

Scilab code Exa 5.42 Determine optimum lot size

```
1  clc
2  A = 40000 // number of units per year
3  I = 25 // carrying cost in percent
4  I = I/100
5  C1 = 8 // cost for 0 < N < 1000 per unit in Rs
6  C2 = 7.5 // cost for 1000 < N < 10000 per unit in Rs
7  C3 = 7.25 // cost for N >= 10000 per unit in Rs
8  R = 250 // ordering cost per order in Rs
9  N = 10000 // units
10 N1 = sqrt(2*R*A/(I*C3)) // optimal quantity for
        lowest curve
11 G1= C3*A+(A*R)/N+I*C3*N/2 // total cost in Rs
12 N2 = sqrt(2*R*A/(I*C2)) // optimal quantity for
        higher curve
13 G2= C2*A+(A*R)/N2+I*C2*N2/2 // total cost in Rs
14 N3 = sqrt(2*R*A/(I*C1)) // optimal quantity for
        highest curve
15 G3 = C1*A+(A*R)+1 // total cost in Rs
16 printf("\n Total cost for lowest cost curve = Rs %0
        .2f\n Total cost for next higher curve = Rs %0.2f
        \n Total cost for highest curve = Rs %0.2f " , G1
        ,G2,G3)
17 disp("Comparing all total cost lowest is Rs
        300,062.50 for an order quantity of 10,000.")
18 disp("N = 10,000 and No. of orders = 4")
```

Scilab code Exa 5.43 To find most economical lot size

```
1  clc
2  c = 50000 // components
3  R=500 // cost of ordering in Rs per order
4  A=12000 //annual consumption units
5  C=3.00 // unit cost of item
6  K=1.50 // unit storage cost
7  I=0.2 // interest rate
8  function y=f(N)
9      function G=f2(N)
10          G=0.02*N+1500000/N
11      endfunction
12  y=derivative(f2,N)
13  endfunction
14  funcprot(0)
15  N=fsolve(2000,f)
16  l = c/N // number of lots
17  l = ceil(l)
18  ls = c/l // lot size
19  printf("\n The lot size = %d components",ls)
```

Chapter 9

Limits Tolerences and Fits

Scilab code Exa 9.1 To find allowance and tolerence

```
1 clc
2 h1 = 37.52 // high limit of hole in mm
3 h2 = 37.50 // low limit of hole in mm
4 s1 = 37.47 // high limit of shaft in mm
5 s2 = 37.45 // low limit of shaft in mm
6 ht = h1-h2 // hole tolerence in mm
7 st = s1-s2 // shaft tolerence in mm
8 a = h2-s1 // allowance in mm
9 printf("\n Hole tolerence = %0.2f mm\n Shaft
     tolerence = %0.2f mm\n Allowance = %0.2f mm" ,ht
     ,st ,a)
```

Scilab code Exa 9.2 Determine dimensions of shaft and hole

```
1 clc
2 t = 0.075 // tolerence in mm
3 h2 = 75 // low limit of hole in mm
4 a = 0.10 // allowance in mm
```

```
5  h1 = h2+t  // high limit of hole in mm
6  s1 = h2-a // high limit of shaft in mm
7  s2 = s1-t // low limit of shaft in mm
8  printf(")\n High limit of hole = %0.3f mm\n High
       limit of shaft = %0.2f mm\n Low limit of shaft =
       %0.3f mm" ,h1 ,s1 , s2)
```

Scilab code Exa 9.3 Determine dimensions of hole and shaft

```
1  clc
2  t = 0.225 // tolerence in mm
3  h2 = 75 // low limit of hole in mm
4  a = 0.0375 // interference in mm
5  h1 = h2+t  // high limit of hole in mm
6  s2 = h1+a // low limit of shaft in mm
7  s1 = s2+t // high limit of shaft in mm
8  printf(")\n High limit of hole = %0.3f mm\n Low limit
       of shaft = %0.4f mm\n High limit of shaft = %0.4
       f mm" ,h1 ,s2 , s1)
```

Scilab code Exa 9.4 Calculate fundamental deviations and tolerences

```
1  clc
2  s1 = 50 // diameter of step1 in mm
3  s2 = 80 // diameter of step2 in mm
4  d = (s1*s2)^(1/2)  // mm
5  i = (0.45*(d)^(1/3)+0.001*d)/10^3 // mm
6  t1 = 25*i // tolerence for hole in mm
7  t2 = 16*i // tolerence for shaft in mm
8  a1 = 0 // fundamental deviation for hole in mm
9  a2 = 5.5*(d)^0.41 // fundamental deviation for shaft
       in microns
10 a2 = a2/10^4 // mm
```

```
11  h1 = 60 // low limit of hole in mm
12  h2 = h1+t1 // high limit of tolerence in mm
13  s1 = h1 - t2 // high limit of shaft in mm
14  s2 = s1-t2 // low limit of shaft in mm
15  printf("\n Tolerence for hole = %0.3f mm\n Tolerence
        for shaft = %0.3f mm" , t1 ,t2)
16  printf("\n Fundamental deviation for hole = %0.2f mm
        \n Fundamental deviation for shaft = %0.3f mm" ,
        a1 , a2 )
17  printf("\n Low limit of hole = %d mm\n High limit of
        hole = %0.3f mm\n High limit of shaft = %0.2f mm
        \n Low limit of hole = %0.2f mm" ,h1 ,h2 , s1 ,
        s2)
18  // Answers vary due to round off error
```

Scilab code Exa 9.5 Find tolerences limits and clearance

```
1  clc
2  b = 30 // basic size in mm
3  s1 = 0.005 // maximum limit of shaft in mm
4  s2 = 0.018 // minimum limit of shaft in mm
5  h1 = 0.020 // maximum limit of hole in mm
6  h2 = 0.0 // minimum limit of hole in mm
7  t1 = s2-s1 // shaft tolerence in mm
8  t2 = h1-h2 // hole tolerence in mm
9  Sh = b-s1 // high limit of shaft in mm
10 Sl = b-s2 // low limit of shaft in mm
11 Hh = b+h1 // high limit of hole in mm
12 Hl = b+h2 // low limit of hole in mm
13 c1 = Hh-Sl // maximum clearance in mm
14 c2 = Hl-Sh // minimum clearance in mm
15 printf("\n Basic size = %d mm\n Shaft tolerence = %0
        .3f mm\n Hole tolerence = %0.3f mm",b,t1,t2)
16 printf("\n High limit of shaft = %0.3f mm\n Low
        limit of shaft = %0.3f mm\n High limit of hole =
```

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```
          %0.3 f mm \n Low limit of hole = %0.3 f mm" , Sh , Sl ,
          Hh , Hl )
17 printf ( "\n Maximum clearance = %0.3 f mm\n Minimum
          clearance = %0.3 f mm" , c1 , c2 )
```

Scilab code Exa 9.6 Determine limits of shaft and hole

```
 1 clc
 2 minc = 0.01 // minimum clearance in mm
 3 bs = 25 // basic size in mm
 4 maxc = 0.02 // maximum clearance in mm
 5 x=poly (0 , ' x ')
 6 y =1.5* x
 7 x=roots ( y +0.01+ x -0.02)
 8 y=horner ( y , x )
 9 // hole basis system
10 low_h1 = bs // low limit of hole in mm
11 high_h1 = bs+y // high limit of hole in mm
12 u_s = low_h1 -minc // upper limit of shaft in mm
13 low_s1 = u_s-x // lower limit of shaft in mm
14 // shaft basis system
15 high_s = bs // high limit of shaft in mm
16 low_s2 = bs-x // low limit of shaft in mm
17 low_h2 = bs+minc // low limit of hole in mm
18 high_h2 = low_h2+y // high limit of hole in mm
19 printf ( " Hole basis system \n Lower limit of hole =
          %d mm\n Higher limit of hole = %0.3 f mm\n Higher
          limit of shaft = %0.3 f mm \n Lower limit of shaft
          = %0.3 f mm" , low_h1 , high_h1 , u_s , low_s1 )
20 printf ( "\n Shaft basis system \n high limit of shaft
          = %0.3 f mm\n lower limit of shaft = %0.3 f mm\n
          lower limit of hole = %0.3 f mm\n upper limit of
          hole = %0.3 f mm" , high_s , low_s2 , low_h2 , high_h2 )
```

Scilab code Exa 9.7 Determine dimensions of shaft and hole

```
1  clc
2  bs = 100 // basic size in mm
3  s1 = 120// diameter of step1 in mm
4  s2 = 80 // diameter of step2 in mm
5  d = (s1*s2)^(1/2) // mm
6  d = ceil(d)
7  i = (0.45*(d)^(1/3)+0.001*d)/10^3 // mm
8  t1 = 16*i // tolerence for hole in mm
9  t2 = 25*i // tolerence for shaft in mm
10 G = (2.5*(d)^0.34)/10^3 // fundamental deviation for
       hole in mm
11 e = (11*(d)^0.11)/10^3 // fundamental deviation for
      shaft in microns
12 // Hole
13 LLh = bs+G // lower limit of hole in mm
14 HLh = LLh+t1 // higher limit of hole in mm
15 // shaft
16 ULs = bs-e // upper limit of shaft in mm
17 LLs = ULs-t2 // lower limit of shaft in mm
18 printf("\n lower limit of hole = %0.3 f mm\n higher
      limit of hole = %0.3 f mm\n upper limit of shaft =
       %0.3 f mm\n lower limit of shaft = %0.3 f mm" ,
      LLh , HLh , ULs , LLs )
19 // Error in textbook
```

Scilab code Exa 9.8 Determine size of bearing and journal

```
1  clc
2  tb = 0.005 // tolerence on bearing in mm
3  tj = 0.004 // tolerence on journal in mm
```

```
4  a = 0.002 // allowance in mm
5  //hole−basis system
6  b = 100 // basic size in mm
7  Bl = b // lower limit of bearing in mm
8  Bh = Bl+tb // higher limit of bearing in mm
9  Jh = Bl-a // higher limit of journal in mm
10 Jl1 = Jh - tj // lower limit of journal in
11 // shaft−basis system
12 Ju = b // upper limit of journal in mm
13 Jl2 = Ju-tj // lower limit of journal in mm
14 Bl = Ju+a // lower limit of bearing in mm
15 Bu = Bl+tb // upper limit of bearing in mm
16 printf("\n Hole basis system \n Lower limit of
      journal = %d mm\n Higher limit of bearing = %0.3f
       mm\n Higher limit of journal = %0.3f mm \n Lower
       limit of journal = %0.3f mm", Bl,Bh,Jh,Jl1)
17 printf("\n shaft basis system \n upper limit of
      journal = %0.3f mm\n lower limit of journal = %0
      .3f mm\n lower limit of bearing = %0.3f mm\n
      upper limit of bearing = %0.3f mm" , Ju,Jl2,Bl,Bu
      )
```

Scilab code Exa 9.9 `Determine size of two mating parts`

```
1  clc
2  // Hole−basis system
3  b = 100 // basic size in mm
4  i1 = 0.12 // maximum interference in mm
5  i2 = 0.05 // minimum interfernce in mm
6  t = (i1-i2)/2 // tolerence in mm
7  Sh = b+i1 // upper limit of shaft in mm
8  Hl = b // lower limit of hole in mm
9  Hh = b+t // higher limit of hole in mm
10 Sl1 = Sh-t //lower limit of shaft in mm
11 // shaft−basis system
```

```
12  Su = b // upper limit of shaft in mm
13  Sl2 = b-t // lower limit of shaft in mm
14  Hl1 = b-i1 // lower limit of hole in mm
15  Hu = Hl1+t // higher limit of hole in mm
16  printf("\n Hole basis system \n upper limit of shaft
         = %0.3f mm\n lower limit of hole = %0.3f mm\n
        higher limit of hole = %0.3f mm\n lower limit of
        shaft = %0.3f mm" , Sh,Hl,Hh,Sl1)
17  printf("\n Shaft basis system \n upper limit of
        shaft = %0.3f mm\n lower limit of shaft = %0.3f
        mm\n lower limit of hole = %0.3f mm\n upper limit
         of hole = %0.3f mm" , Su,Sl2,Hl1,Hu)
```

Scilab code Exa 9.10 Determine size of hole and shaft

```
1   clc
2   aa = 0.04 // average allowance in mm
3   a = 0.012 // allowance in mm
4   Max = aa+a // maximum allowance in mm
5   Min = aa-a // minimum allowance in mm
6   t = (Max-Min)/3 // tolerence in mm
7   ts = t // tolerence in shat in mm
8   th = 2*t // tolerence in hole in mm
9   b = 100 // basic size in mm
10  Hl = b // lower limit of hole in mm
11  Hu = b+th // upper limit of hole in mm
12  Su = b-0.028 // upper limit of shaft in mm
13  Sl = Su-ts // lower limit of shaft in mm
14  printf("\n lower limit of hole = %d mm\n upper limit
         of hole = %0.3f mm\n upper limit of shaft = %0.3
        f mm\n lower limit of shaft = %0.3f mm" ,Hl,Hu,Su
        ,Sl)
```

Chapter 11

Surface finish

Scilab code Exa 11.1 Calculate CLA value

```
1  clc
2  v = 15000 // vertical magnification
3  h = 100 // horizontal magnification
4  l = 0.8 // sampling length in mm
5  a1 = 160 // area above datum line in mm^2
6  a2 = 90 // area above datum line in mm^2
7  a3 = 180 // area above datum line in mm^2
8  a4 = 50 // area above datum line in mm^2
9  a5 = 95 // area below datum line in mm^2
10 a6 = 65 // area below datum line in mm^2
11 a7 = 170 // area below datum line in mm^2
12 a8 = 150 // area below datum line in mm^2
13 a = (a1+a2+a3+a4+a5+a6+a7+a8)/(v*h)
14 CLA= a/l
15 printf("\n C.L.A value = %0.2f*10^-6 m " , CLA*1000)
```

Scilab code Exa 11.2 Calculate average and rms value

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```
 1  clc
 2  // from figure 11.23
 3  y1 = 0.15 // mu_m
 4  y2 = 0.25 // mu_m
 5  y3 = 0.35 // mu_m
 6  y4 = 0.25 // mu_m
 7  y5 = 0.30 // mu_m
 8  y6 = 0.15 // mu_m
 9  y7 = 0.10 // mu_m
10  y8 = 0.30 // mu_m
11  y9 = 0.35 // mu_m
12  y10 = 0.10 // mu_m
13  y1sqr = y1^2 // mu_m
14  y2sqr = y2^2// mu_m
15  y3sqr = y3^2 // mu_m
16  y4sqr = y4^2 // mu_m
17  y5sqr = y5^2 // mu_m
18  y6sqr = y6^2 // mu_m
19  y7sqr = y7^2 // mu_m
20  y8sqr = y8^2 // mu_m
21  y9sqr = y9^2 // mu_m
22  y10sqr = y10^2 // mu_m
23  n = 10
24  yn = (y1+y2+y3+y4+y5+y6+y7+y8+y9+y10)/n //
        arithmetic average in mu_m
25  rms = sqrt((y1sqr+y2sqr+y3sqr+y4sqr+y5sqr+y6sqr+
        y7sqr+y8sqr+y9sqr+y10sqr)/n) // r.m.s value in
        mu_m
26  printf("\n The arithmetic average = %0.2f*10^-6 m \n
          The r.m.s. value = %0.3f*10^-6 m",yn,rms)
```

Chapter 13

Analysis of metal forming processes

Scilab code Exa 13.1 To find drawing load

```
1  clc
2  sigma_0 = 240 // N/mm^2
3  d1 = 5 // initial wire diameter in mm
4  d0 = 5.5 // final wire diameter in mm
5  x = d1/d0 // mm
6  alpha = 8 // angle of contact
7  alpha = alpha*%pi/180
8  mu = 0.1 // coefficient of friction
9  B = mu*cotg(alpha)
10 sigma_d = (sigma_0*(1+B)*(1-(x)^(2*B)))/B // N/mm^2
11 l = 3 // die land in mm
12 mu = 0.1 // coefficient of friction
13 r1 = d1/2 // mm
14 sigma_t = sigma_0 - (sigma_0 - sigma_d)/exp((2*mu*l)
       /r1) // N/mm^2
15 dl = sigma_t*%pi*(r1)^2 // drawing load in N
16 printf("\n Total drawing load = %0.1f N" , dl)
17 // Answers vary due to round off error
```

Scilab code Exa 13.2 Calculate drawing force

```
1  clc
2  alpha = 15 // angle of contact
3  alpha = alpha*%pi/180
4  bita = 0 // degree
5  mu = 0.1 // coefficient of friction
6  mu1 = mu
7  mu2 = mu
8  h1 = 1.75 // mm
9  h0 = 2.5 // mm
10 B = (mu1+mu2)/(tan(alpha)-tan(bita))
11 y1 = (1+B)*(1-(h1/h0)^B)/B  //sigma_d/sigma_0 for
       plug mandrels in N/mm^2
12 z = 1/((h0/h1)-1)
13 y2 = log10(z)// sigma_d/sigma_0 for movable mandrels
        in N/mm^2
14 printf("\n The pipe drawing force force on plug
       mandrels = %0.3f \n The pipe drawing forcw on
       mandrels = %0.3f",y1,y2)
15 disp("Use of movable mandrel substantially reduces
       drawing force")
```

Scilab code Exa 13.3 find neutral section slips and pressure

```
1  clc
2  h0 = 25 // thickness of plate in mm
3  h1 = 20 // mm
4  delta_h = h0-h1 // mm
5  sigma = 100 // maximum pressure in N/mm^2
6  D = 500 // rolled diameter in mm
7  r = D/2 // rolled radius in mm
```

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```
8  alpha = acos(1-(delta_h/D)) // angle of contact in
      radians
9  mu = tan(alpha) // coefficient of friction
10 Ho = 2*sqrt(r/h1)*atan(sqrt(r/h1)*mu)
11 Hn = (Ho - (log(h0/h1))/mu)/2
12 theta = sqrt(h1/r)*tan(sqrt(h1/r)*(Hn/2)) // radian
13 hn = h1 + r*theta^2 // neutral section in mm
14 x = hn/h0
15 bs = (1-x)*100 // backward slip
16 y = hn/h1
17 fs = (y-1)*100 // forward slip
18 sigma0 = 2*sigma/sqrt(3)
19 pn = sigma0*hn*exp(mu*Hn)/h1 //N/mm^2
20 printf("\n Neutral section = %0.1f mm" , hn)
21 printf("\n Backward slip = %0.1f percent\n Forward
      slip = %0.1f percent" , bs,fs)
22 printf("\n Maximum pressure = %0.1f N/mm^2" , pn)
23  // 'Answers vary due to round off error'
```

Scilab code Exa 13.4 To determine maximum force

```
1  clc
2  Do = 250 // diameter in mm
3  ho = 250 // hieght in mm
4  delta_h = 100 // mm
5  h = 150 // mm
6  sigma0 = 55 // N/mm^2
7  d = Do*sqrt(ho/(ho-delta_h)) // diameter in mm
8  mu = 0.42 // coefficient of friction
9  R = 162.5 // mm
10 pa = sigma0/2*(h/(mu*R))^2*(%e^(2*mu*R/h)-2*mu*R/h
      -1) // N/mm^2
11 p = pa*%pi*(R)^2 // force in kN
12 printf("\n Force = %d kN",p/1000)
```

Scilab code Exa 13.5 Determine sticking radius and total load

```
1  clc
2  d = 150 // diameter in mm
3  h = 10 // thickness in mm
4  R = d/2 // radius in mm
5  mu = 0.2 // coefficient of friction
6  sigma_0 = 200 // N/mm^2
7  Rs = R - (h/(2*mu))*log(1/(sqrt(3)*mu)) // sticking
       radius in mm
8  Ps = sigma_0*exp(2*mu*(R-Rs)/h) // pressure at
       sticking radius in N/mm^2
9  function y=f(r)
10     y=2*%pi*r*sigma_0*exp(2*mu/h*(R-r))
11 endfunction
12 L_sld = intg(48.5,75,f)
13 L_sld = L_sld/1000 // load on sliding portion in kN
14 Pc = Ps + (2*sigma_0*Rs)/(h*sqrt(3)) // pressure at
       centre in N/mm^2
15 L_sp = (Pc+Ps)*%pi*(Rs)^2/(2*1000) // load on
       sticking portion in kN
16 F_l = L_sld + L_sp // total forging load in kN
17 printf("\n Sticking radius = %0.1f mm \n Total
       forging load = %0.3f MN",Rs ,F_l/1000)
18 // 'Answers vary due to round off error'
```

Scilab code Exa 13.7 To find drawing load and power

```
1  clc
2  RA = 0.30
3  d = 12 // diameter in mm
4  alpha = 6  // angle of contact in degree
```

```
5  alpha = 6*%pi/180 // angle of contact in radian
6  mu = 0.10 // coefficient of friction
7  sigma_0 = 240  // N/mm^2
8  B = mu*cotg(alpha)
9  x = 1 - RA
10 sigma_d  = (sigma_0*(1+B)*(1-(x)^B))/B // N/mm^2
11 r1  = sqrt(x)*(d/2) // mm
12 l = sigma_d*%pi*(r1)^2 // load in kN
13 ita = 98 // efficiency
14 ita = ita/100
15 s = 2.3 // drawing speed in m/s
16 P = (l*s)/ita // kW
17 printf("\n Drawing load = %0.2f kN\n Power of motor
        = %0.2f kW" , l/1000 ,P/1000 )
18 // 'Answers vary due to round off error '
```

Scilab code Exa 13.8 calculate drawing load and power rating

```
1  clc
2  mu1 = 0.15 // coefficient of friction
3  mu2 = 0.18 // coefficient of fricton
4  alpha = 14 // angle of contact in degree
5  alpha = alpha*%pi/180
6  bita = 10 // semi-cone angle in degree
7  bita = bita*%pi/180
8  sigma_0 = 1.40 // kN/mm^2
9  h0 = 1.5 //mm
10 h1 = 1 // mm
11 B = (mu1+mu2)/(tan(alpha)+tan(bita))
12 sigmad = (sigma_0*(1+B)*(1-(h1/h0)^B))/B // drawing
        stress in kN/mm^2
13 d1 = 11 // outside diameter in mm
14 t = 1 // thickness in mm
15 d2 = d1-2*t // mm
16 a = (%pi*((d1)^2-(d2)^2))/4 // area in mm^2
```

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```
17  l = sigmad*a // load in kN
18  s = 0.65 // drawing speed in m/s
19  w = l*s // work in kJ/s
20  p = w // power in kW
21  printf("\n Drawing load = %0.3f kN\n Power rating of
        motor = %0.2f kW" , l , p)
22  // 'Answers vary due to round off error '
```

Scilab code Exa 13.9 To calculate forging loads

```
1  clc
2  sigma_0 = 50 // pressure at start in MPa
3  B = 0.9 // width in m
4  h1 = 0.2 // thickness in m
5  b = 0.3 // tool bite in m
6  // At commencement of forging
7  FL = sigma_0*B*b*(1+(b/(4*h1))) // forging load in
     MN
8  // At completion of forging
9  h2 = 0.1 // thickness in m
10 sigma_0c = 150 // pressure at completion in MPa
11 FL2 = sigma_0c*B*b*(1+(b/(4*h2))) // forging load in
     MN
12 printf("\n Forging load at start of forging = %0.4f
     MN\n Forging load at completion of forging = %0.3
     f MN" , FL , FL2)
```

Scilab code Exa 13.10 Determine extrusion load

```
1  clc
2  sigma_0 = 250 // N/mm^2
3  d1 = 5 // initial wire diameter in mm
4  d0 = 15 // final wire diameter in mm
```

```
5  r0 = d0/2
6  r1 = d1/2
7  x = (r0/r1)^2 // mm
8  alpha = 45 // angle of contact
9  alpha = alpha*%pi/180
10 mu = 0.1 // coefficient of friction
11 B = mu*cotg(alpha)
12 sigma_x0  = (sigma_0*(1+B)*(1-(x)^B))/B // N/mm^2
13 sigma_x0 = -sigma_x0
14 l = 37.5 // length 0f billet in mm
15 tau1 = sigma_0/2 // Mpa
16 Pe = sigma_x0 + (4*tau1*l)/d0 // extrusion pressure
       in Mpa
17 el = Pe*%pi*(r0)^2 // extrusion load in MN
18 printf("\n Extrusion load = %d MN" , el/10000)
```

Scilab code Exa 13.11 To find roll pressures

```
1  clc
2  h0 = 4.05 // thickness of plate in mm
3  h1 = 3.55 // mm
4  D = 500 // rolled diameter in mm
5  r = D/2 // rolled radius in mm
6  mu = 0.04 // coefficient of friction
7  sigma = 210 // N/mm^2
8  delta_h = h0-h1 // mm
9  p = 2*sigma/sqrt(3) // N/mm^2
10 alpha = acos(1-(delta_h/D)) // angle of contact
11 Ho = 2*sqrt(r/h1)*atan(sqrt(r/h1)*alpha)
12 Hn1 = (Ho - (log(h0/h1))/mu)/2
13 theta = sqrt(h1/r)*tan(sqrt(h1/r)*(Hn1/2)) //
       radians
14 hn = h1 + 2*r*(1-cos(theta)) // mm
15 pn1 = p*hn*exp(mu*Hn1)/h1 // roll pressure in N/mm^2
16 // b) roll pressure when coefficient of friction is
```

```
       0.4
17  mu2 = 0.4 // coefficient of friction
18  Hn2 = (Ho - (log(h0/h1))/mu2)/2
19  theta = sqrt(h1/r)*tan(sqrt(h1/r)*(Hn2/2)) //
        radians
20  hn2 = h1 + r*theta^2 // mm
21  pn2 = (p*hn2*exp(mu2*Hn2))/h1 // roll pressure in N/
        mm^2
22  // c) if tension is applied of 35 N/mm^2
23  sigma_f = 35 // front tension in N/mm^2
24  pn3 = (p-sigma_f)*hn*exp(mu*Hn1)/h1 // roll ressure
        in N/mm^2
25  printf("\n (a) Roll pressure at enter and exit = %0
        .1f N/mm^2\n    Roll pressure at neutral plane =
        %0.2f N/mm^2" ,p , pn1)
26  printf("\n (b) Roll pressure at neutral point when
        co-efficient of friction is 0.40 = %0.2f N/mm^2"
        , pn2)
27  printf("\n (c) Roll pressure when 35 N/mm^2 tension
        is applied at neutral point = %0.2f N/mm^2" , pn3
        )
28  // 'Answers vary due to round off error'
```

Scilab code Exa 13.12 Determine neutral plane

```
1  clc
2  h1 = 6.35 // thickness in  mm
3  mu = 0.2 // coefficient of friction
4  r = 50 // rolled radius in cm
5  r = r*10 // mm
6  R = 30 // reduction in percent
7  h0 = h1*100/(100-R) // mm
8  delta_h = h0-h1 // mm
9  alpha = acos(1-(delta_h/(2*r))) // angle of contact
10 Ho = 2*sqrt(r/h1)*atan(sqrt(r/h1)*alpha)
```

```
11  Hn = (Ho - (log(h0/h1))/mu)/2
12  theta = sqrt(h1/r)*tan(sqrt(h1/r)*(Hn/2)) // neutral
        plane in radians
13  theta = theta*180/%pi // neutral plane in degrees
14  printf("\n Neutral plane = %0.2f degree" , theta)
15  // 'Answers vary due to round off error '
```

Chapter 14

Theory of metal cutting

Scilab code Exa 14.1 `calculate the tool life`

```
1 clc
2 v1 = 18 // cutting speed in m/min
3 t1 = 3 // tool life in hours
4 n = 0.125 // exponent
5 c = v1*(t1*60)^n // constant
6 v2 = 24 // cutting speed in m/min
7 t = (c/v2)^(1/0.125) // tool life in min.
8 printf("Tool life = %d min." , t)
```

Scilab code Exa 14.2 `Calculate the optimum cutting speed`

```
1 clc
2 c_t = 8 // tool change time in min.
3 r_t = 5 // tool re-grind time in min.
4 mr_c = 5 // machine running cost per hour
5 d = 30 // total depreciation per re-grind in paisa
6 n = 0.25 // exponent
7 c = 150 // constant
```

```
 8  c_c = mr_c*c_t/60 // total change cost in Rs
 9  r_c = mr_c*r_t/60 // regrind cost in Rs
10  ct = c_c+r_c+d/100 // tooling cost in Rs
11  cm = mr_c/60 // machining cost in Rs
12  v = c*((cm*n)/(ct*(1-n)))^n // cutting speed in m/
       min.
13  printf("\n Cutting speed = %0.1f m/min." , v)
```

Scilab code Exa 14.3 To find different orthogonal cutting picture

```
 1  clc
 2  mu1 = 0.15 // coefficient of friction
 3  mu2 = 0.18 // coefficient of fricton
 4  alpha = 14 // angle of contact in degree
 5  alpha = alpha*%pi/180
 6  bita = 10 // semi−cone angle in degree
 7  bita = bita*%pi/180
 8  sigma_0 = 1.40 // kN/mm^2
 9  h0 = 1.5 //mm
10  h1 = 1 // mm
11  B = (mu1+mu2)/(tan(alpha)+tan(bita))
12  sigmad = (sigma_0*(1+B)*(1-(h1/h0)^B))/B // drawing
       stress in kN/mm^2
13  d1 = 11 // outside diameter in mm
14  t = 1 // thickness in mm
15  d2 = d1-t // mm
16  a = (%pi*((d1)^2-(d2)^2))/4 // area in mm^2
17  l = sigmad*a // load in kN
18  s = 0.65 // drawing speed in m/s
19  w = l*s // work in kJ/s
20  p = w // power in kW
21  printf("\n Drawing load = %0.3f kN\n Power rating of
       motor = %0.2f kW" , l , p)
22  clc
23  t = 0.127 // uncut chip thickness in mm
```

```
24  b = 6.35 // width of cut in mm
25  v = 2 // cutting speed in m/s
26  alpha = 10 // rake angle in degrees
27  fc = 567 // cutting force in N
28  ft = 227 // thrust force in N
29  tc = 0.228 // chip thickness in mm
30  r = t/tc // chip thickness ratio
31  alpha = alpha*%pi/180 // rake angle in radians
32  phi = atan(r*cos(alpha)/(1-(r*sin(alpha)))) // shear
        angle
33  phi1 = phi*180/%pi // shear angle
34  printf("\n Shear angle = %0.2f degree" , phi1)
35  mu =((fc*sin(alpha)+ft*cos(alpha))/(fc*cos(alpha)-ft
      *sin(alpha))) //coefficient of friction
36  bita = atan(mu) // friction angle
37  bita = bita*180/(%pi)
38  printf("\n Friction angle = %0.2f degree", bita )
39  fs = fc*cos(phi)-ft*sin(phi) //shear force in N
40  taus = (fs*sin(phi))/(b*t) // shear stress
41  printf("\n Shear stress = %0.1f N/mm^2" , taus)
42  cp = fc*v/1000 // cutting power in kw
43  printf("\n Cutting power = %0.3f kw " , cp)
44  vc = v*r // chip velocity in m/s
45  printf("\n Chip velocity = %0.3f m/s",vc)
46  ss = cotg(phi) + tan(phi-alpha) // shear strain
47  printf("\n shear strain = %0.3f" , ss)
48  spl = t/sin(phi) // shear plane length
49  vs = v*cos(alpha)/cos(phi-alpha) // shear velocity
50  S = vs*10/spl // shear strain rate
51  S = S*10^3 // shear strain rate
52  printf("\n Shear strain rate = %.3f s^-1" , S)
53  // 'Answers vary due to round off error '
```

Scilab code Exa 14.4 `To find tool life`

```
1  clc
2  v = 30 // cutting speed in m/min
3  feed = 0.3 // feed rate in mm/rev.
4  d = 2.5 // depth of cut in mm
5  t = 60 // tool life in min.
6  c = v*t^0.13*feed^0.77*d^0.37 // constant
7  printf("\n constant = %0.2f " , c)
8  v2 = v*1.2 // cutting speed in m/min
9  t2 = (c/(v2*feed^0.77*d^0.37)) // tool life when
       cutting speed increased by 20% in min.
10 t2 = t2^(1/0.13)
11 f2 = feed*1.2 // feed rate in mm/rev.
12 t3 = (c/(v*d^0.37*f2^0.77)) // tool life when feed
       rate increased by 20% in min.
13 t3 = t3^(1/0.13)
14 d2 = d*1.2 // depth of cut in mm
15 t4 = (c/(v*feed^0.77*d2^0.37)) // tool life when
       depth of cut increased by 20% in min.
16 t4 = t4^(1/0.13)
17 t5 = (c/(v2*d2^0.37*f2^0.77)) // tool lfe in min.
18 t5 = t5^(1/0.13)
19 printf("\n Tool life when cutting speed increased by
        20 = %0.2f min." , t2)
20 printf("\n Tool life when feed rate increased by 20
       = %0.2f min." , t3)
21 printf("\n Tool life when depth of cut increased by
       20 = %0.2f min." , t4)
22 printf("\n Tool life when all taken together after
       increasing by 20 = %0.2f min." , t5)
23 // 'Answers vary due to round off error'
```

Scilab code Exa 14.5 find force and coefficient of friction

```
1  clc
2  t = 0.25 // uncut chip thickness in mm
```

```
3  b = 2.5 // width of cut in mm
4  v = 2.5 // cutting speed in m/s
5  alpha = 10 // rake angle in degrees
6  fc = 1130 // cutting force in N
7  ft = 295 // thrust force in N
8  tc = 0.45 // chip thickness in mm
9  r = t/tc // chip thickness ratio
10 alpha = alpha*%pi/180 // rake angle in radians
11 phi = atan((r*cos(alpha))/(1-r*sin(alpha))) // shear
        angle
12 phi2 = phi*180/%pi // shear angle
13 fs = fc*cos(phi) - ft*sin(phi) //shear force in N
14 printf("\n Force of shear at shear plane = %0.2f N"
      , fs)
15 mu = atan((fc*sin(alpha)+ft*cos(alpha))/(fc*cos(
      alpha)-ft*sin(alpha))) //friction anglele
16 printf("\n Friction angle = %0.3f degree", mu )
17 // 'Answers vary due to round off error'
```

Scilab code Exa 14.6 To find terms of orthogonal cutting

```
1  clc
2  t = 0.2 // uncut chip thickness in mm
3  alpha = 15 // rake angle in degrees
4  tc = 0.62 // chip thickness in mm
5  r = t/tc // chip thickness ratio
6  crc = 1/r // chip reduction coefficient
7  printf("\n Cutting ratio = %0.3f\n Chip reduction co
      -efficient = %0.1f" , r , crc)
8  alpha = alpha*%pi/180 // rake angle in radians
9  phi = atan(r*cos(alpha)/(1-r*sin(alpha))) // shear
      angle
10 phi = phi*180/%pi // shear angle
11 printf("\n Shear angle = %0.2f degree" , phi)
12 ss = cotg(phi*%pi/180) + tan((phi*%pi)/180-(alpha*
```

```
    %pi)/180) // shear strain
13 printf(" \n shear strain = %0.3 f" , ss)
14 // 'Answers vary due to round off error'
```

Scilab code Exa 14.7 To solve tool life equation

```
1 clc
2 v1 = 25 // cutting speed in m/min
3 t1 = 90 // tool life in min.
4 v2 = 35 // cutting speed in m/min
5 t2 = 20 // tool life in min
6 n = log(v2/v1)/log(t1/t2) // exponent
7 C = v1*(t1)^n // constant
8 t = 60 // tool life in min.
9 v = C/(t)^n // cutting speed in m/min.
10 printf(" \n n = %0.3 f \n C = %0.1 f \n Cutting speed =
       %0.2 f m/min." , n , C,v)
11 // 'Answers vary due to round off error'
```

Scilab code Exa 14.8 Determine normal and tangential force

```
1 clc
2 t = 0.5 // uncut chip thickness in mm
3 b = 3 // width of cut in mm
4 alpha = 15 // rake angle in degrees
5 alpha = alpha*%pi/180 // rake angle in radians
6 r = 0.383 // chip thickness ratio
7 mu = 0.7 // average coefficient of friction on tool
       face
8 bita = atan(mu) // friction angle
9 tau = 280 // yield stress in N/mm^2
10 phi = atan((r*cos(alpha))/(1-r*sin(alpha))) // shear
       angle
```

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```
11  fc = (tau*b*t)/(sec(bita-alpha)*cos(phi+bita-alpha)*
        sin(phi)) // cutting force in N
12  ft = (fc*(mu-tan(alpha)))/(1+mu*tan(alpha)) //
        thrust force in N
13  F = fc*sin(alpha)+ft*cos(alpha) // tangential force
        on tool face in N
14  F = ceil(F)
15  N = fc*cos(alpha)-ft*sin(alpha) // normal force on
        tool face in N
16  printf("Tangential force on tool face = %d N\n
        normal force on tool face = %0.1f N" , F,N)
17  // 'Answers vary due to round off error'
```

Scilab code Exa 14.9 To find cutting and thrust force

```
1  clc
2  t = 0.25 // uncut chip thickness in mm
3  b = 0.5 // width of cut in cm
4  v = 8.2 // cutting speed in m/min.
5  alpha = 20 // rake angle in degrees
6  alpha2 = alpha*%pi/180 // rake angle in radians
7  r = 0.351 // cutting ratio
8  phi = atan(r*cos(alpha2)/(1-r*sin(alpha2))) // shear
        angle in radians
9  phi2 = phi*180/%pi // shear angle in degrees
10 alpha2 = alpha*%pi/180 // rake angle in radians
11 bita = 35+alpha-phi2 // degrees
12 s = cotg(phi) + tan(phi-alpha2) // shear strain
13 e = s/sqrt(3) // natural strain
14 sigma = 784*(e)^0.15 // tensile property in N/mm^2
15 tau = sigma/sqrt(3) // yield shear stress in N/mm^2
16 As = (b*10*t)/sin(phi) // shear plane area in mm^2
17 Fs = tau*As // shear gorce in N
18 R = Fs/cos(phi+(bita*%pi/180)-alpha2)
19 Fc = R*cos((bita*%pi/180)-alpha2) // cutting force
```

```
      in N
20 Ft = R*sin((bita*%pi/180)-alpha2) // thrust force in
      N
21 printf("\n Cutting force= %0.1f N\n Thrust force =
      %0.1f N" , Fc , Ft)
22 // 'Answers vary due to round off error '
```

Scilab code Exa 14.10 find terms of orthogonal rake system

```
 1 clc
 2 f = 0.2 // feed in mm/rev.
 3 t = 0.2 // uncut chip thickness in mm
 4 alpha = 10 // rake angle in degrees
 5 fc = 1600 // cutting force in N
 6 ft = 850 // thrust force in N
 7 tc = 0.39 // chip thickness in mm
 8 r = t/tc // chip thickness ratio
 9 d = 2 // depth of cut in mm
10 b = 2 // mm
11 alpha2 = alpha*%pi/180 // rake angle in radians
12 phi = atan(r*cos(alpha2)/(1-r*sin(alpha2))) // shear
      angle in radians
13 phi2 = phi*180/%pi // shear angle in degree
14 fs = fc*cos(phi)-ft*sin(phi) //shear force in N
15 fn = fc*sin(phi)+ft*cos(phi) // normal force in N
16 f = fc*sin(alpha2)+ft*cos(alpha2) // friction force
      in N
17 mu =((fc*tan(alpha2)+ft)/(fc-ft*tan(alpha2))) //
      kinetic coefficient of friction
18 s = fc/(b*t) // specific cutting energy in N/mm^2
19 printf("\n Shear force = %d N\n Normal force = %0.1f
      N\n Friction force = %0.1f N\n Kinetic
      coefficient of friction = %0.3f" , fs , fn ,f ,
      mu)
20 printf("\n Specific cutting energy = %d N/mm^2" , s)
```

```
21 // 'Answers vary due to round off error '
```

Scilab code Exa 14.11 Calculate CLA

```
1  clc
2  cs = 20 // side cutting edge angle in degree
3  ce = 30 // end cutting edge angle in degree
4  f = 0.1 // feed in mm/rev.
5  r = 3 // nose radius in mm
6  cs2 = cs*%pi/180 // side cutting edge angle in
        radians
7  ce2 = ce*%pi/180 // end cutting edge angle in
        radians
8  h = (1-cos(ce2))*r + f*sin(ce2)*cos(ce2) - sqrt((2*f
        *r*(sin(ce2))^3)-((f^2)*(sin(ce2))^4))
9  Ra = h/4 // Centre line average roughness in mm
10 printf("\n Centre line average roughness = %0.2 f
        *10^-6m" , Ra*10^3)
11 // 'Answers vary due to round off error '
```

Scilab code Exa 14.12 Calculate back and side rake angle

```
1  clc
2  i = 0 // inclination angle in degree
3  alpha = 10 // orthogonal rake angle in degree
4  lemda = 75 // principal cutting edge angle in degree
5  alpha = alpha*%pi/180 // orthogonal rake angle in
        radian
6  lemda = lemda*%pi/180 // principal cutting edge
        angle in radian
7  alpha_b = atan(cos(lemda)*tan(alpha)+sin(lemda)*tan(
        i)) //back rake angle in radians
```

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```
8 alpha_b = alpha_b*180/%pi // back rake angle in
      degree
9 alpha_s = atan(sin(lemda)*tan(alpha)-cos(lemda)*tan(
      i)) // side rake angle in radians
10 alpha_s = alpha_s*180/%pi // side rake angle in
      degree
11 printf("\n Back rake angle = %0.2f degree\n Side
      rake angle = %0.2f degree" , alpha_b,alpha_s)
```

Scilab code Exa 14.13 Calculate inclination and rake angle

```
1 clc
2 alphab = 8 // back rake in degree
3 alphas = 4 // side rake in degree
4 cs = 15 // side cutting edge angle in degree
5 lemda = 90 - cs // approach angle in degree
6 alphab = alphab*%pi/180 // back rake in radian
7 alphas = alphas*%pi/180 // side rake in radian
8 cs = cs*%pi/180 // side cutting edge angle in radian
9 lemda = lemda*%pi/180 // approach angle in radian
10 alpha = atan(tan(alphas)*sin(lemda)+tan(alphab)*cos(
      lemda)) // orthogonal rake angle in radian
11 alpha = alpha*180/%pi // orthogonal rake angle in
      degree
12 i = atan(sin(lemda)*tan(alphab)-cos(lemda)*tan(
      alphas)) // inclnation angle in radian
13 i = i*180/%pi // inclnation angle in degree
14 printf("\n Othogonal rake angle = %0.2f degree\n
      Inclination angle = %0.1f degree" , alpha , i)
```

Scilab code Exa 14.14 find different powers and resistance

```
1 clc
```

```
2  cs = 15  // side cutting edge angle in degree
3  v = 0.2  // cutting speed in m/s
4  f = 0.5  // feed rate in mm/rev.
5  d = 3.2  // depth of cut in mm
6  fc = 1593*(f)^0.85*(d)^0.98  // cutting force in N
7  pc = fc*v/1000  // cutting power in kw
8  ita_mt = 0.85  // efficiency of lathe
9  pm = pc/ita_mt  // motor power in kw
10 a = f*d  // area of uncut chio in mm^2
11 r = fc/a  // specific cutting resistance in N/mm^2
12 p = pc/(a*v)// unit power in W/(mm^3)*s
13 printf("\n Cutting power = %0.3f kw\n Motor power =
       %0.2f kw\n Specific cutting resistance = %0.2f N/
       mm^2\n Unit power = %0.3f W/(mm^3)*s" , pc,pm,r,p
       )
14 // 'Answers vary due to round off error '
```

Scilab code Exa 14.15 Calculate percentage increase in tool life

```
1  clc
2  C = 400
3  n=0.5
4  a=2  // (T1/T2)^n
5  b=2^(1/n)  // T2
6  i = (b-1)*100  // percentage increase
7  printf("\n Percentage increase = %d percent" , i)
```

Scilab code Exa 14.16 To find percentage of total energy

```
1  clc
2  t = 0.127  // uncut chip thickness in mm
3  b = 6.35  // width of cut in mm
4  v = 1.20  // cutting speed in m/min.
```

```
5  alpha = 10 // rake angle in degrees
6  fc = 556.25 // cutting force in N
7  ft = 222.50 // thrust force in N
8  tc = 0.229 // chip thickness in mm
9  r = t/tc // chip thickness ratio
10 R = sqrt((fc^2)+(ft^2))
11 bita = (acos(fc/R)) + alpha*%pi/180 //
12 f = R*sin(bita) //
13 fe = f*r // friction energy
14 p = (f*r*100)/fc // percentage of fricton enrgy and
      total energy
15 printf("\n The percentage of total energy that goes
      into overcoming friction at tool chip interface =
      %0.2f percent" , p)
16 // 'Answers vary due to round off error '
```

Scilab code Exa 14.17 To find power and different energies

```
1  clc
2  D = 300 // diameter in mm
3  r = 45 // rev/min.
4  d = 2 // depth of cut in mm
5  f = 0.3 // feed in mm/rev
6  fc = 1850 // cutting force in N
7  ff = 450 // feed force in N
8  V = 2.5*10^6 // metal removed in mm
9  v = (%pi*D*r)/(60*1000) // cutting velocity in m/s
10 pc = fc*v/1000 // cutting power in kW
11 fv = f*r/60*1000 // feed velocity in m/s
12 fp = fv*ff // feed power in W
13 mrr = d*f*v*60*1000 // mm^3/min.
14 ce = pc*1000*60/mrr // specific cutting energy in W*
      s/mm^2
15 E = ce*V/(3600*1000) // energy consumed
16 printf("\n Power consumption = %0.2f W\n Specific
```

```
      cutting  energy  =  %0.2 f  W∗s /mm^3\n  Energy  consumed
         =  %0.3 f  kWh"  , pc , ce , E )
17  //  'Answers  vary  due  to  round  off  error '
```

Scilab code Exa 14.18 Determine components of force and power

```
 1  clc
 2  D = 100 // diameter  in  mm
 3  cs = 30 // side  cutting  edge  angle  in  degree
 4  lemda = 90 - cs // approach  angle  in  degree
 5  d = 2.5 // depth  of  cut  in  mm
 6  f = 0.125 // feed  in  mm/rev .
 7  N = 300 // turning  speed  of  job  in  rev ./ min .
 8  mu = 0.6 // coefficient  of  friction
 9  tau = 400 // ultimate  shear  stress  in  Mpa
10  bita = atand ( mu ) // friction  angle  in  radian
11  alphas = 10 // side  rake  angle
12  alphab = 6 // back  rake  angle
13  alpha = atand ( tand ( alphas ) * sind ( lemda ) + tand ( alphab ) *
        cosd ( lemda )) // orthogonal  rake  angle  in  degree
14  phi = 45 - ( bita - alpha ) // shear  angle
15  Fc = tau * d * f /( secd ( bita - alpha ) * cosd ( phi + bita - alpha ) *
        sind ( phi )) // cutting  force  in  N
16  Ft = Fc * tand ( bita - alpha ) // thrust  component  in  N
17  Ff = Ft * sind ( lemda ) // feed  force  along  axis  of  job
        in  N
18  Rf = Ft * cosd ( lemda ) // radial  force  normal  to  axis
        of  job  in  N
19  v = %pi * D * N /(1000*60) // velocity  in  m/s
20  p = Fc * v // power  in  watts
21  printf (" \n  Cutting  force  = %d  N\n  Thrust  force  = %0
        .3 f  N\n  Feed  force  = %0.1 f  N\n  Radial  force  = %0
        .3 f  N\n  Cutting  power  = %d  watts"  , Fc , Ft , Ff , Rf , p
        )
22  //  'Answers  vary  due  to  round  off  error '
```

Chapter 15

Design and manufacture of cutting tools

Scilab code Exa 15.1 `calculate horsepower at cutter and motor`

```
1  clc
2  w = 10 // width of cut in cm
3  h = 0.32 // depth of cut in cm
4  n = 8 // number of teeth in cutter
5  ft = 0.033 // feed rate per tooth
6  N = 200 // cutter speed in rpm
7  ita = 60/100 // efficiency
8  f = n*ft*N // feed rate in cm/min.
9  mrr = w*h*f // metal removal rate in cm^3/min.
10 k = 8.2 // machinibility factor from table 15.3
11 hpc = mrr/k // horsepower at cutter
12 hpm = hpc/ita // horsepower at motor
13 printf("\n Horsepower at cutter = %0.2f\n Horsepower
        at motor = %0.2f" , hpc , hpm)
14 // 'Answers vary due to round off error'
```

Scilab code Exa 15.2 Determine broaching power and Design broach

```scilab
1  clc
2  l = 35 // length of bore in mm
3  v = 0.15 // cutting speed in m/s
4  t1 = 0.01 // upper limit in mm
5  t2 = 0.05 // upper limit in mm
6  D = 32.25 // finished broach in mm
7  D1 = 32.25+t2 // mm
8  d = 32.75 // finish diameter in mm
9  d1 = 32.75 + t1 //finish diameter of hole in mm
10 s = 0.05 // mm
11 B = 1.30 // blunt broach factor
12 c = 45 // specific cutting force in N/mm^2
13 n = 3 // number of teeth cutting at a time
14 F = n*%pi*d1*s*c*B // force needed for broaching in
      N
15 bp = F*v/1000 // Broaching power in kw
16 // broach design
17 p = 1.75*sqrt(l) // pitch in mm
18 theta = 10 // face angle in degree
19 alha1 = 1.5 // relief angle for roughing in degree
20 alha2 = 1.0 // relief angle for finishing in degree
21 w = 0.3*p // width of land in mm
22 h = 0.4*p // depth of cutting teeth in mm
23 r = 0.3*p // tooth fillet radius in mm
24 T = (d1-D1)/2 // mm
25 n = T/s // number of cutting teeth
26 n = round(n)
27 l = (n+7)*p //length of toothed portion of broach in
      mm
28 printf("\n (i)Broaching power = %0.4f kW",bp)
29 disp("(ii) Broach Design")
30 printf(" (a) Pitch diameter = %0.2fmm\n (b) width of
      land = %0.2f mm \n    depth of cutting teeth =
    %0.2f mm\n    Tooth fillet radius= %0.2f mm", p,w
    ,h,r)
31 printf("\n (c) Length of toothed portion of broach =
```

```
        %d mm" , l )
32  // 'Answers vary due to round off error '
```

Scilab code Exa 15.3 `Estimate moment thrust force and power`

```
1  clc
2  Hb = 200 // brinell hardness
3  d = 12.7 // diameter in mm
4  f = 0.254 // feed in mm/rev.
5  N = 100 // rpm
6  M = (Hb*(d)^2*f)/8 //moment in kgf-mm
7  k = 1.1 //material factor
8  p = (1.25*(d)^2*k*N*(0.056+1.5*f))/(10)^5 // power
      in kW
9  T1a = (1.7*M)/d // thrust force kgf
10 T1b = (3.5*M)/d // kgf
11 T1 = (T1a+T1b)/2 // average
12 w = 0.14*d // thickness in mm
13 T2a = (0.1*%pi*(w)^2*Hb)/4 // thrust force kgf
14 T2b = (0.2*%pi*(w)^2*Hb)/4 // thrust force kgf
15 T2 = (T2a+T2b)/2 // average
16 avg = T1+T2 // kgf
17 thrust = 1.16*k*d*(100*f)^0.85 // kgf
18 printf(" \n Moment = %0.1f kgf-mm\n Power = %0.3f hp\
      n Average force = %d kgf\n Thrust force = %0.1f
      kgf" ,M, p ,avg , thrust)
19 // Error in textbook
```

Scilab code Exa 15.4 `Design shell inserted blade reamer`

```
1  clc
2  d = 55 // diameter in mm
3  ul = 0.035 // upper limit in mm
```

```
4  ll = 0.000 // lower limit in mm
5  Dmax = d+ul // maximum diameter of hole in mm
6  Dmin = d+ll // minimum diameter of hole in mm
7  IT = 0.035 // hole tolerence in mm
8  dmax = Dmax-0.15*IT // maximum diameter of reamer in
       mm
9  dmin = dmax-0.35*IT // minimum diameter of reamer in
       mm
10 l = ((d/4)+(d/3))/2 // length of guiding section in
       mm
11 Z = 1.5*sqrt(d)+2 // number of teeth
12 Z = ceil(Z)
13 printf("\n 1 Diameter of reamer \n Maximum diameter
       of reamer = %0.3f mm \n Minimum diameter of
       reamer = %0.3f mm \n 2 Back taper = 0.05 mm \n 3
       Values of various angles \n Rake angle = 5 degree
        \n Plan approach angle = 45 degree \n Circular
       land = 0.25 to 0.50 mm \n Secondary clearance
       angle = 10 degree \n 4 Length of reamer \n Length
        of fluted portion = 82.5 mm \n Length of reaming
        allowance = 0.18 mm \n Length of cutting section
        = 2.25 mm \n Length of guiding section = %d mm \
       n 5 Number of teeth = %d" , dmax,dmin,l,Z)
14 // Answer vary due to round off error
```

Scilab code Exa 15.5 To design single point cutting tool

```
1  clc
2  Pm = 10 // power of motor in kw
3  v = 40 // cutting speed in m/min.
4  ita = 70 // efficiency
5  ita = ita/100
6  Pc = Pm*ita
7  Fc = (Pc*1000*60)/v // cutting force
8  sigmab = 250 // stress in Mpa
```

```
9  B = sqrt((Fc*1.25*6)/(sigmab*1.6)) // width of shank
       in mm
10 h = 1.6*B // hieght of shank in mm
11 l = 1.25*h // shank overang in mm
12 printf("\n The width of shank = %0.1f mm\n Height of
       shank = %0.2f mm\n Shank overhang = %0.1f mm" ,
     B,h,l)
13 // 'Answers vary due to round off error '
```

Scilab code Exa 15.8 find various terms for stainless steel

```
1  clc
2  l = 150 // length in mm
3  D = 12.70 // diameter in mm
4  dia = 12.19 // diameter on centre lathe in mm
5  N = 400 // spindle speed in rev./min
6  s = 203.20 // axial speed in mm/min.*####
7  v = (%pi*D*N)/(1000*60) // cutting velocity in m/s
8  d = (D-dia)/2 // depth of cut in mm
9  f = s/N // feed in mm/rev.
10 Dave = (D+dia)/2 // average diameter in mm
11 V = %pi*Dave*N
12 a = d*f // area of cut in mm^2
13 mrr = a*V // metal removal rate in mm^3/min.
14 T = l/(f*N) // machine timing in min.
15 c = 56 // constant from table
16 p = d*f*v*60*c // power in watts
17 omega = (2*%pi*N)/60 // rpm
18 t = p/omega // torque in Nm
19 Fc = (2*t*1000)/Dave // cutting force in N
20 printf("\n Cutting speed = %0.2f m/s\n MRR = %d mm
       ^3/min.\n Time to cut = %0.2f min.\n Power = %0.1
       f watts\nCutting force = %d N" , v , mrr , T ,p ,
     Fc)
21 // Answers are given wrong in book
```

Scilab code Exa 15.9 To find MRR power and torque

```
1  clc
2  f = 0.2 // feed in mm/rev.
3  N = 800 // spindle speed in rev./min.
4  d = 10 // doameter of hole in mm
5  mrr = %pi*(d^2)*f*N/4 // metal removal rate in mm^3/
      min.
6  mrr = mrr/60 // mm^3/s
7  p = 0.5*mrr // cutting power from table 14.2 in
      watts
8  omega = 2*%pi*N/60 // rpm
9  T = p/omega // torque in N.m
10 printf("\n MRR = %0.2f mm^3/s\n Cutting power = %0.3
      f watts\n Torque = %0.2f N.m" , mrr,p,T)
```

Scilab code Exa 15.10 find MRR power torque and time

```
1  clc
2  l = 300 // length in mm
3  w = 100 // width in mm
4  f = 0.25 // feed in mm/tooth
5  d = 3.2 // depth of cut in mm
6  D = 50 // cutter diameter in mm
7  n = 20 // number of cutter teeth
8  N = 100 // cutter speed in rev./min.
9  tf = f*n*N // table feed in mm/min.
10 mrr = w*d*tf // metal removal rate in mm^3/min.
11 mrr = mrr/60 // mm^3/s
12 p = 6*mrr // cutting power from table 14.2 in watts
13 omega = 2*%pi*N/60 // rpm
```

```
14  T = p/omega // torque in N.m
15  att = sqrt((D*d)-(d^2)) // added table travel in mm
16  t = (l+att)/tf // cutting time in min.
17  t = t*60 // s
18  printf("\n MRR = %0.2f mm^3/s\n Cutting power = %d
       watts\n Torque = %0.2f N.m\n Cutting time = %0.1
       fs" , mrr ,p,T,t)
```

Chapter 16

Gear manufacture

Scilab code Exa 16.1 Calculate settings of gear tooth

```
1 clc
2 n = 34 // number of teeths
3 m = 5 // module in mm
4 w = m*n*sin (%pi/(n*2)) //tooth thickness in mm
5 h = m*(1+(n*(1 - cos(%pi/(n*2)))/2)) // chordal
    addendum in mm
6 printf(")\n Tooth thickness = %0.3f mm\n Chordal
    addendum = %0.3f mm" ,w ,h)
7 // 'Answers vary due to round off error'
```

Chapter 17

Thread manufacturing

Scilab code Exa 17.1 Calculate best wire size

```
1 clc
2 d = 80 // outside diameter in mm
3 p = 6  // pitch diameter in mm
4 d = 0.5774*p // best wire size in mm
5 printf("\n Best wire size = %0.3f mm" , d)
```

Scilab code Exa 17.2 Calculate size and distances over wire

```
1 clc
2 D = 20 // diameter in mm
3 p = 2.5 // pitch diameter in mm
4 d = 0.5774*p // mm
5 W = D+3*d-1.5156*p// best wire size in mm
6 printf("\n Best wire size = %0.3f mm\n Distance over
       wires = %0.3f mm" ,d, W)
7 // Answer vary due to round off error
```

Chapter 21

Statical quality control

Scilab code Exa 21.1 Construct R and X chart

```
1  clc
2  clf()
3  n = 10 // number of samples
4  A2 = 0.577
5  D3 = 0
6  D4 = 2.115
7  // number of defectives
8  x1 = 11.274
9  x2 = 11.246
10 x3 = 11.204
11 x4 = 11.294
12 x5 = 11.252
13 x6 = 11.238
14 x7 = 11.230
15 x8 = 11.276
16 x9 = 11.208
17 x10 = 11.266
18 r1 = 0.15
19 r2 = 0.20
20 r3 = 0.33
21 r4 = 0.46
```

```
22  r5 = 0.10
23  r6 = 0.15
24  r7 = 0.20
25  r8 = 0.23
26  r9 = 0.50
27  r10 = 0.30
28  x = x1+x2+x3+x4+x5+x6+x7+x8+x9+x10
29  r = r1+r2+r3+r4+r5+r6+r7+r8+r9+r10
30  Xavg = x/n
31  Ravg = r/n
32  // for X chart
33  ucl1 = Xavg + A2*Ravg
34  lcl1 = Xavg - A2*Ravg
35  // for R chart
36  ucl2 = D4*Ravg
37  lcl2 = D3*Ravg
38  printf("\n control limits \n  For X charts \n UCL =
        %0.2f cm \n LCL = %0.2f cm\n For R charts \n UCl
        = %0.3f \n LCL = %0.3f" , ucl1,lcl1,ucl2,lcl2)
39  // X chart
40  x=[1,2,3,4,5,6,7,8,9,10];
41  y
        =[11.274,11.246,11.204,11.294,11.252,11.238,11.230,11.276,11.208,

42  plot(x,y)
43  xtitle("X chart","Sample No.","X")
44  // R chart
45  xset("window",1)
46  z =
        [0.15,0.20,0.33,0.46,0.10,0.15,0.20,0.23,0.50,0.30]

47  plot(x,z)
48  xtitle("R chart" ,"Sample no.", "R")
```

Scilab code Exa 21.2 Construct the control charts

```
1  clc
2  clf()
3  n = 100 // total number of sub groups
4  s = 10 // number of samples
5  // number of defectives
6  d1 = 3
7  d2 = 2
8  d3 = 3
9  d4 = 5
10 d5 = 3
11 d6 = 3
12 d7 = 2
13 d8 = 4
14 d9 = 3
15 d10 = 2
16 d = d1+d2+d3+d4+d5+d6+d7+d8+d9+d10 // total number
      of defectives
17 p1 = d/(n*s) // average fraction of defectives
18 sigmap1 = sqrt(p1*(1-p1)/n)
19 ucl1 = p1 + 3*sigmap1
20 lcl1 = p1 - 3*sigmap1
21 // control chart for fraction defectives
22 x = linspace(0,10,10)
23 y = linspace(0,0.081,10)
24 plot(x,y)
25 xtitle("Control chart for fraction defectives" , "
      Samples" ,"Fraction defectives")
26 // percent defective (mean)
27 p1 = p1*100
28 sigmap2 = sqrt(p1*(100-p1)/n)
29 ucl2 = p1 + 3*sigmap2
30 lcl2 = p1 - 3*sigmap2
31 printf("\n Control limits \n Fraction defectives \n
      UCL = %0.3f\n LCL = %0.4f\n Percent defectives \n
      UCL = %0.1f \n LCL = %0.1f", ucl1,lcl1,ucl2,lcl2
      )
32 // control chart for percent defect
33 xset("window" ,1)
```

```
34 z = linspace (0 ,8.1 ,10)
35 plot (x,z)
36 xtitle (" Control chart for percent defects " , " Sample
       no." , " percent defects ")
37 //  'Answers vary due to round off error '
```

Scilab code Exa 21.4 Calculate poisson probabilities

```
1 clc
2 n = 1000 // number of units
3 s = 4 // random sample
4 d = 50 // defectives
5 z = d*s/n
6 pp0 = exp (-0.2) *1 // poisson probabilities for 0
     defectives
7 pp1 = exp (-0.2) *(z) // poisson probabilities for 1
     defectives
8 pp2 = exp (-0.2) *(z^2/factorial(2)) // poisson
     probabilities for 2 defectives
9 pp3 = exp (-0.2) *(z^3/factorial(3))// poisson
     probabilities for 3 defectives
10 printf ("\n Proabilities for 0 ,1 ,2 and 3 defectives
     are : %0.3 f ,%0.4 f , %0.4 f , %0.5 f " , pp0 ,pp1 ,pp2 ,
     pp3 )
```

Scilab code Exa 21.5 Calculate probabilities of defective items

```
1 clc
2 d = 50 // defectives
3 l = 1000 // lot of pieces
4 p = d/l // proability of an event happening
5 q = 1-p // proability of an event not happening
6 n = 4 // sample size
```

```
 7  p0 = q^n // probabilities for 0 defectives
 8  p1 = 4*(q)^3*p // probabilities for 1 defectives
 9  p2 = 6*(q)^2*p^2 // probabilities for 2 defectives
10  p3 = 4*q*(p)^3 // probabilities for 3 defectives
11  printf("\n   Proabilities for 0,1,2 and 3 defectives
        are : %0.4f %0.4f %0.4f %0.6f" , p0,p1,p2,p3)
```

Scilab code Exa 21.6 Determine producers and consumers risk

```
 1  clc
 2  // producer's risk
 3  n = 71 // sample size
 4  AQL = 0.005
 5  LTPD = 0.05
 6  l_s = 500 // lot size
 7  z1 = n*AQL // mean number of defects
 8  pp1 = exp(-z1)+z1*exp(-z1) // poisson proability for
        1 or less defective
 9  alpha = (1-pp1)*100 // producer's risk
10  alpha = ceil(alpha)
11  // consumer's risk
12  z2 = n*LTPD // mean number of defects
13  pp2 = exp(-z2)+z2*exp(-z2) // poisson proability for
        1 or less defective
14  bita = pp2*100 // consumer's risk
15  printf("\n Producers risk = %d percent\n Consumers
        risk = %0.2f percent", alpha,bita)
```

Scilab code Exa 21.7 Evaluate preliminary and revised control limits

```
 1  clc
 2  td1= 20 // total number of days
 3  n1 = 200 // sample size
```

```scilab
4  // number of defectives
5  d1 = 10
6  d2 = 15
7  d3 = 10
8  d4 = 12
9  d5 = 11
10 d6 = 9
11 d7 = 22
12 d8 = 4
13 d9 = 12
14 d10 = 24
15 d11 = 21
16 d12 = 15
17 d13 = 8
18 d14 = 14
19 d15 = 4
20 d16 = 10
21 d17 = 11
22 d18 = 11
23 d19 = 26
24 d20 = 13
25 d = d1+d2+d3+d4+d5+d6+d7+d8+d9+d10+d11+d12+d13+d14+
      d15+d16+d17+d18+d19+d20 // total number of
      defectives
26 p1 = d/(n1*td1) // average fraction of defectives
27 sigmap1 = sqrt(p1*(1-p1)/n1)
28 ucl1 = p1 + 3*sigmap1
29 lcl1 = p1 - 3*sigmap1
30 // revised control limits
31 td2 = 18 // total number of days
32 D = d - (d10+d19) // number of defects
33 p2 = D/(n1*td2)
34 sigmap2 = sqrt(p2*(1-p2)/n1)
35 ucl2 = p2 + 3*sigmap2
36 lcl2 = p2 - 3*sigmap2
37 printf("\n Preliminary control limits \n UCL = %0.3f
       \n LCL = %0.3f \n Revised control limits \n UCL
      = %0.3f \n LCL = %0.3f" , ucl1,lcl1,ucl2,lcl2)
```

Scilab code Exa 21.8 Find control limits for c chart

```
1  clc
2  n1 = 15 // total number of sub groups
3  // number of defectives
4  d1 = 77
5  d2 = 64
6  d3 = 75
7  d4 = 93
8  d5 = 45
9  d6 = 61
10 d7 = 49
11 d8 = 65
12 d9 = 45
13 d10 = 77
14 d11 = 59
15 d12 = 54
16 d13 = 84
17 d14 = 40
18 d15 = 92
19 d = d1+d2+d3+d4+d5+d6+d7+d8+d9+d10+d11+d12+d13+d14+
      d15 // total number of defectives
20 c1 = d/n1
21 ucl1 = c1 + 3*sqrt(c1)
22 lcl1 = c1 - 3*sqrt(c1)
23 // revised control limits
24 n2 = 12 // total number of sub groups
25 D = d - (d4+d14+d15) // number of defects
26 c2 = D/n2
27 ucl2 = c2 + 3*sqrt(c2)
28 lcl2 = c2 - 3*sqrt(c2)
29 printf("\n Preliminary control limits \n UCL = %0.2f
      \n LCL = %0.2f \n Revised control limits \n UCL
      = %0.3f \n LCL = %0.3f" , ucl1,lcl1,ucl2,lcl2)
```

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Scilab code Exa 21.9 find control limits for charts

```
 1  clc
 2  n = 20 // number of samples
 3  A = 1.342
 4  A1 = 1.596
 5  A2 = 0.577
 6  d2 = 2.326
 7  d3 = 0.864
 8  D1 = 0
 9  D2 = 4.918
10  D3 = 0
11  D4 = 2.115
12  // number of defectives
13  x1 = 3290
14  x2 = 3180
15  x3 = 3350
16  x4 = 3470
17  x5 = 3080
18  x6 = 3240
19  x7 = 3260
20  x8 = 3310
21  x9 = 3640
22  x10 = 4110
23  x11 = 3220
24  x12 = 3590
25  x13 = 4270
26  x14 = 4040
27  x15 = 3580
28  x16 = 3500
29  x17 = 3570
30  x18 = 3560
31  x19 = 2740
32  x20 = 3200
```

```
33  r1  =  560
34  r2  =  410
35  r3  =  200
36  r4  =  300
37  r5  =  90
38  r6  =  650
39  r7  =  890
40  r8  =  410
41  r9  =  1120
42  r10  =  520
43  r11  =  580
44  r12  =  670
45  r13  =  480
46  r14  =  250
47  r15  =  170
48  r16  =  670
49  r17  =  440
50  r18  =  660
51  r19  =  560
52  r20  =  590
53  x  =  x1+x2+x3+x4+x5+x6+x7+x8+x9+x10+x11+x12+x13+x14+
        x15+x16+x17+x18+x19+x20
54  r  =  r1+r2+r3+r4+r5+r6+r7+r8+r9+r10+r11+r12+r13+r14+
        r15+r16+r17+r18+r19+r20
55  Xavg  =  x/n
56  Ravg  =  r/n
57  // for X chart
58  ucl1  =  Xavg  +  A2*Ravg
59  lcl1  =  Xavg  -  A2*Ravg
60  // for R chart
61  ucl2  =  D4*Ravg
62  lcl2  =  D3*Ravg
63  // Revised control limits
64  n1  =  15
65  n2  =  19
66  X  =  (x  -  (x5+x10+x13+x14+x19))/n1
67  R  =  (r  -  (r9))/n2
68  // for X chart
```

```
69  ucl3 = X + A2*R
70  lcl3 = X - A2*R
71  // for R chart
72  ucl4 = D4*R
73  lcl4 = D3*R
74  printf("\n Preliminary control limits \n  For X
        charts \n UCL = %0.2 f \n LCL = %0.2 f\n For R
        charts \n UCl = %0.3 f \n LCL = %0.3 f \n Revised
        control limits \n For X chart \n UCL = %0.3 f \n
        LCL = %0.3 f\n For R charts \n UCl = %0.3 f \n LCL
        = %0.3 f" , ucl1 , lcl1 , ucl2 , lcl2 , ucl3 , ucl3 , ucl4 ,
        lcl4)
75  //  'Answers vary due to round off error '
```

Scilab code Exa 21.10 Determine producers and consumers risk

```
1  clc
2  clf()
3  n = 50 // sample size
4  rn = 2 // rejection number
5  AQL = 0.02
6  LTPD = 0.08
7  // Producer 's risk
8  z1 = n*AQL // mean number of defectives
9  pp1 = exp(-z1)+z1*exp(-z1) // poisson proability for
       1 or less defective
10 alpha = (1-pp1)*100 // producer 's risk
11 // consumer 's risk
12 z2 = n*LTPD // mean number of defectives
13 bita = (exp(-z2)+z2*exp(-z2))*100 // consumer 's risk
14 d1 = 1 // incoming defective in percent
15 z3 = n*d1/100 // average number of defective
16 ppa1 = exp(-z3)+z3*exp(-z3) // proability of
       acceptance
17 ppa1 = ppa1*100
```

```
18  ppr1 = 100-ppa1 // proability of rejection
19  AOQ1 = ppr1*0 + ppa1*d1/100
20  d2 = 2 // incoming defective in percent
21  z4 = n*d2/100 // average number of defective
22  ppa2 = exp(-z4)+z4*exp(-z4) // proability of
        acceptance
23  ppa2 = ppa2*100
24  ppr2 = 100-ppa2 // proability of rejection
25  AOQ2 = ppr2*0 + ppa2*d2/100
26  d3 = 4 // incoming defective in percent
27  z5 = n*d3/100 // average number of defective
28  ppa3 = exp(-z5)+z5*exp(-z5) // proability of
        acceptance
29  ppa3 = ppa3*100
30  ppr3 = 100-ppa3 // proability of rejection
31  AOQ3 = ppr3*0 + ppa3*d3/100
32  d4 = 6 // incoming defective in percent
33  z6 = n*d4/100 // average number of defective
34  ppa4 = exp(-z6)+z6*exp(-z6) // proability of
        acceptance
35  ppa4 = ppa4*100
36  ppr4 = 100-ppa4 // proability of rejection
37  AOQ4 = ppr4*0 + ppa4*d4/100
38  d5 = 8 // incoming defective in percent
39  z7 = n*d5/100 // average number of defective
40  ppa5 = exp(-z7)+z7*exp(-z7) // proability of
        acceptance
41  ppa5 = ppa5*100
42  ppr5 = 100-ppa5 // proability of rejection
43  AOQ5 = ppr5*0 + ppa5*d5/100
44  printf("\n Producers risk = %0.2f percent\n
        Consumers risk = %0.3f percent", alpha,bita)
45  x = [1,2,4,6,8]
46  y = [0.91,1.4716,1.624,1.194,0.733]
47  plot(x,y)
48  xtitle("AOQ curve","Percent dectives" , "AOQ of lot"
        )
```

Chapter 22

Kinematics of machine tools

Scilab code Exa 22.1 Find range of cutting velocity

```
1  clc
2  d1 = 10 // min. dia of cutter in mm
3  d2 = 60 // max. dia of cutter in mm
4  v = 30e3 // operating speed in m/min
5  n1 = v / (%pi * d2) // n_min in rpm
6  n2 = v / (%pi * d1) // n_max in rpm
7  phi = (n2 / n1)^(1/5)
8  spindle_speeds = zeros()
9  for i=0:5
10     spindle_speeds(i+1) = phi^i * n1
11 end
12 cutter_dia = v ./ (%pi * spindle_speeds)
13 clf()
14 y = [0; v]
15 plot([0; cutter_dia(1)], y, [0; cutter_dia(2)], y,
       [0; cutter_dia(3)], y, [0; cutter_dia(4)], y, [0;
        cutter_dia(5)], y, [0; cutter_dia(6)], y)
16 xtitle("","cutter diameter mm","cutting velocity, m/
       min")
17 // from graph
18 vmax1 = 36 // m/min
```

```
19  vmin1 = 24.5 // m/min
20  r1 = vmax1 - vmin1 // Range of cutting speed for 12
        mm diameter in m/min
21  vmax2 = 36.5 // m/min.
22  vmin2 = 26 // m/min.
23  r2 = vmax2 - vmin2 // Range of cutting speed for 36
        mm diameter in m/min
24  printf("\n Range of cutting speed for 12 mm diameter
        = %0.1f m/min.\n Range of cutting speed for 36
        mm diameter = %0.1f m/min." , r1 , r2)
```

Scilab code Exa 22.2 Determine speed ratios and teeth

```
1  clc
2  m = 2.5 // module in mm
3  phi = 1.2 // common ratio
4  n = 150 // speed in rev/min. of driving shaft
5  n1 = 70 // speed in rev/min. of driven shaft
6  n2 = (phi)^1*n1 // speed in rev/min. of driven shaft
7  n3 = (phi)^2*n1 // speed in rev/min. of driven shaft
8  n4 = (phi)^3*n1 // speed in rev/min. of driven shaft
9  T1=poly(0,'T1')
10 t1=n1/n*T1
11 T1=roots(t1+T1-80)
12 t1=horner(t1,T1)
13 T2=poly(0,'T2')
14 t2=n2/n*T2
15 T2=roots(t2+T2-80)
16 t2=horner(t2,T2)
17 T3=poly(0,'T3')
18 t3=n3/n*T3
19 T3=roots(t3+T3-80)
20 t3=horner(t3,T3)
21 T4=poly(0,'T4')
22 t4=n4/n*T4
```

```
23  T4=roots(t4+T4-80)
24  t4=horner(t4,T4)
25  t1 = floor(t1) // number of teeth on driving shaft
26  T1 = ceil(T1) // number of teeth on driven shaft
27  t2 = ceil(t2) // number of teeth on driving shaft
28  T2 = floor(T2) // number of teeth on driven shaft
29  t3 = floor(t3) // number of teeth on driving shaft
30  T3 = ceil(T3) // number of teeth on driven shaft
31  t4 = ceil(t4) // number of teeth on driving shaft
32  T4 = floor(T4) // number of teeth on driven shaft
33   // running speeds
34  n1 = n*t1/T1
35  n2 = n*t2/T2
36  n3 = n*t3/T3
37  n4 = n*t4/T4
38  printf("\n Number of teeth on driver and driven are
         :- \n t1 = %d ,T1 = %d\n t2 = %d ,T2 = %d \n t3 =
         %d ,T3 = %d \n t4 = %d ,T4 = %d ",t1,T1,t2,T2,t3
         ,T3,t4,T4)
39  printf("\n The actual running speed of driven shaft
         will be : \n n1 = %0.2f rev/min\n n2 = %0.2f rev/
         min \n n3 = %0.2f rev/min \n n4 = %0.2f rev/min",
         n1,n2,n3,n4)
40  // Answer of n3 is given wrong in book
41  // Answer vary due to round off error
```

Scilab code Exa 22.3 Calculate speed and number of teeths

```
1  clc
2  z = 6 // number of steps
3  n1 = 180 // rev/min
4  n2 = 100 // rev/min
5  Rn = n1/n2
6  phi = (Rn)^(1/(z-1)) // common ratio
7  n3 = phi*n2 // rev/min
```

```
 8  n4 = (phi)^2*n2 // rev/min
 9  n5 = (phi)^3*n2 // rev/min
10  n6 = (phi)^4*n2 // rev/min
11  n7 = 225 // speed of input shaft in rev/min
12  Ta=poly(0,'Ta')
13  tb=n7/n5*Ta
14  Ta=roots(tb+Ta-52)
15  tb=horner(tb,Ta)
16  tb = ceil(tb)
17  Tc=poly(0,'Tc')
18  td=n7/n6*Tc
19  Tc=roots(td+Tc-52)
20  td=horner(td,Tc)
21  Tc = ceil(Tc)
22  Te=poly(0,'Te')
23  tf=n7/n1*Te
24  Te=roots(tf+Te-52)
25  tf=horner(tf,Te)
26  tf = ceil(tf)
27  Th=poly(0,'Th')
28  tj=n2/n5*Th
29  Th=roots(tj+Th-46)
30  Th = ceil(Th)
31  tj=horner(tj,Th)
32  tj = floor(tj)
33  Ti=poly(0,'Ti')
34  tg=n5/n5*Ti
35  Ti=roots(tg+Ti-46)
36  tg=horner(tg,Ti)
37  printf("\n Ta = %d Tb = %d \n Tc = %d Td = %d \n Te
       = %d tf = %d \n Th = %d Tj = %d \n Ti = %d Tg =
       %d" , Ta,tb,Tc,td,Te,tf,tj,Th,Ti,tg)
38  // 'Answers vary due to round off error'
```

Scilab code Exa 22.4 `Calculate common ratio`

```
1  clc
2  v = 21 // cutting speed in rev/min.
3  z = 6
4  dmin = 5 // daimeter in mm
5  dmax = 20 // daimeter in mm
6  nmax = 1000*v/(%pi*dmin) // spindle speed in rev/min
     .
7  nmin = 1000*v/(%pi*dmax) // spindle speed in rev/min
     .
8  phi = (nmax/nmin)^(1/(z-1)) // common ratio
9  n1 = nmin // rev/min.
10 n2 = phi*n1 // rev/min.
11 n3 = (phi)^2*n1 // rev/min.
12 n4 = (phi)^3*n1 // rev/min.
13 n5 = (phi)^4*n1 // rev/min.
14 n6 = (phi)^5*n1 // rev/min.
15 printf("\n Common ratio = %0.2f \n Spindle speeds
     are : %0.2f , %0.1f , %0.2f , %0.2f ,%0.2f and %0
     .1f rev/min.",phi,n1,n2,n3,n4,n5,n6)
16 // 'Answers vary due to round off error'
```

Scilab code Exa 22.5 Calculate gear ratio teeth and speed

```
1  // from fig. 22.18A
2  clc
3  // Three gear ratios between input and intermediate
     shaft
4  nmax = 1400 // maximum speed in rev/min.
5  i1 = 1/1
6  i2 = 1/1.26
7  i3 = 1/(1.26)^2
8  // The two ratios between intermediate and output
     shaft
9  i4 = 1/1
10 i5 = 1/(1.26)^3
```

```
11  // number of teeth for input and intermediate shaft
12  t1 = 27/27
13  t2 = 24/30
14  t3 = 21/33
15  //  number of teeth for output and intermediate
        shaft
16  t4 = 34/34
17  t5 = 20/48
18  // output speeds in rev./min
19  n1 = t3*t5*nmax
20  n2 = t2*t5*nmax
21  n3 = t1*t5*nmax
22  n4 = t3*t4*nmax
23  n5 = t2*t4*nmax
24  n6 = t1*t4*nmax
25  printf("\n Three gear ratios between input and
        intermediate shaft i1 = %d i2 = %0.2f i3 = %0.3f
        \n  The two ratios between intermediate and
        output shaft i4 = %d i5 = %0.3f \n number of
        teeth for each pair between input and
        intermediate shaft t1 = 27/27 ,t2 = 24/30 , t3 =
        21/33 \n number of teeth for each pair between
        output and intermediate shaft = t4 = 34/34 ,t5 =
        20/48 \n Output speeds \n n1 = %d  rev/min , n2 =
        %d rev/min , n3 = %d rev/min \n n4 = %d rev/min ,
        n5 = %d rev/min , n6 = %d rev/min" ,i1 , i2 , i3
        , i4 , i5 , n1 , n2, n3,n4,n5,n6)
26  // Answer vary due to round off error
```

Chapter 23

Production planning and control

Scilab code Exa 23.1 Calculate forecast

```
1 clc
2 d1 = 90 // demand for first quarter
3 d2 = 100 // demand for second quarter
4 d3 = 80 // demand for third quarter
5 sa = (d1+d2+d3)/3 // simple average
6 printf("\n Forecast = %d" , sa)
```

Scilab code Exa 23.2 Calculate forecat by SMA method

```
1 clc
2 d1 = 300 // demand for july
3 d2 = 350 // demand for august
4 d3 = 400 // demand for september
5 d4 = 500 // demand for october
6 d5 = 600 // demand for november
7 d6 = 700 // demand for december
```

```
8  // assuming n = 3 , where n is number of time period
9  forecast = (d6+d5+d4)/3 // forecast
10 printf("\n Forecast = %d" , forecast)
```

Scilab code Exa 23.3 Calculate forecat by WMA method

```
1  clc
2  d1 = 500 // demand for october
3  d2 = 600 // demand for november
4  d3 = 700 // demand for december
5  w1 = 0.25 // relative weight with december
6  w2 = 0.25 // relative weight with november
7  w3 = 0.5 // relative weight with october
8  f = w1*d1 + w2*d2 + w3*d3 // forecast
9  printf("\n Forecast by weighted moving average = %d"
       , f)
```

Scilab code Exa 23.4 Calculate forecast for january

```
1  clc
2  alpha = 0.7 // smoothing coefficient
3  d1 = 250 // demand for november
4  d2 = 300 // demand for december
5  f1 = 200 // forecast for november
6  f2 = alpha*d1 + (1-alpha)*f1 // forecast for
       december
7  f3 = alpha*d2 + (1-alpha)*f2 // forecast for january
8  f3 = ceil(f3)
9  printf("\n Forecast for january = %d units" , f3)
```

Scilab code Exa 23.5 `Calculate total cost`

```
1  clc
2  s = 600 // set up cost per lot in Rs
3  c = 6 // unit cost of item in Rs
4  a = 100000 // annual demand for item
5  i = 25 // annual carrying charges of average
       inventory
6  i = 25/100
7  k = c*i // carrying cost factor in unit/year
8  n = sqrt(2*s*a/k) // most economic lot size
9  tc = a*c + s*a/n + k*n/2 // total cost in Rs
10 printf("\n Total cost = Rs %0.2f" , tc)
11 // 'Answers vary due to round off error'
```

Scilab code Exa 23.6 `Calculate economical order quantity`

```
1  clc
2  a = 8000 // annual requirement of parts
3  c = 60 // unit cost of part in Rs
4  r = 150 // ordering cost per lot in Rs
5  i = 30 // annual carrying charges of average
       inventory
6  i = 30/100
7  k = i*c // carrying cost per unit per year
8  n = sqrt(2*r*a/k) // most economical order quantity
9  printf("\n Most economical ordering quantity = %d
       units" , n)
```

Scilab code Exa 23.7 `Calculate economic lot size`

```
1  clc
2  a = 12000 // annual requirement
```

```
3  c = 5 // unit cost of part
4  s = 60 // set up cost per lot
5  p = 18750 // production rate per year
6  i = 20 // inventory carrying cost
7  i = 20/100
8  k = i*c // carrying cost per unit per year
9  n = sqrt(2*s/(1/a-1/p)*k) // Most economic lot size
10 printf("\n Most economic lot size = %d parts" , n)
```

Scilab code Exa 23.8 Calculate inventory control terms

```
1  clc
2  a = 15625 // annual requirement of parts
3  c = 12 // unit cost of part in Rs
4  r = 60 // ordering cost per lot in Rs
5  k = 1.2 // inventory carrying cost per unit
6  n = sqrt(2*r*a/k) // economical order quantity
7  oc = r*a/n // ordering cost in Rs
8  cc = k*n/2 // carrying cost in Rs
9  tc = oc + cc // total inventory cost in Rs
10 printf("\n Economical order quantity = %d units\n
       order cost = Rs %d\n carrying cost = Rs %d\n
       Total inventory cost = Rs %d" , n , oc , cc , tc)
```

Scilab code Exa 23.9 Calculate discount offered

```
1  clc
2  // case a
3  a = 50 // annual requirement of parts in tonnes
4  c = 500 // unit cost of part in Rs
5  r = 100 // ordering cost per order in Rs
6  i = 20 // inventory carrying cost
7  i = i/100
```

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```
 8  d = 2 // discount of purchase cost in percent
 9  k = i*c // inventory carrying cost per unit
10  n1 = sqrt(2*r*a/k) // economical order quantity
11  oc1 = r*a/n1 // ordering cost in Rs
12  cc1 = k*n1/2 // carrying cost in Rs
13  tc1 = oc1 + cc1 // total inventory cost in Rs
14  // case b
15  n2 = 25 // order per lot
16  oc2 = r*a/n2 // ordering cost in Rs
17  cc2 = k*n2/2 // carrying cost in Rs
18  tc2 = oc2 + cc2 // total inventory cost in Rs
19  i = tc2-tc1 // increase in cost in Rs
20  d_o = d*c*a/100 // discount offered
21  printf(" \n Increase in inventory cost = Rs %d\n
        Discount offered = Rs%d",i,d_o)
22  disp(" offer is worth accepting")
```

Scilab code Exa 23.10 Calculate EOQ and reorder point

```
 1  clc
 2  a = 1000000 // annual requirement of parts
 3  r = 32 // ordering cost per lot in Rs
 4  k = 4 // inventory carrying cost per unit
 5  d1 = 250 // number of working days
 6  d2 = 2 // days for safety stock
 7  d3 = 4 // lead time in days
 8  eoq = sqrt(2*r*a/k) // economical order quantity
 9  oc = r*a/eoq // ordering cost in Rs
10  cc = k*eoq/2 // carrying cost in Rs
11  tc = oc + cc // total inventory cost in Rs
12  ss = a*d2/d1 // safety stock
13  ro_p = ss+eoq*d3 // reorder point
14  printf(" \n Economic order qunantity = %d components\
        n Re-order point = %d components" , eoq ,ro_p)
```

Chapter 26

Plant layout

Calculate number of machine required

```
1  clc
2  N = 100000 // annual output of parts
3  s = 2 // expected scrap
4  t = 105 // estimated time per part in s
5  ita = 80 // production efficiency of machine
6  a = 2300 // number of working hours
7  output = (3600*ita)/(t*100) // parts required per
       hour
8  pr = N*(100+s)/(a*100) // output from one machine
       per hour
9  mr = pr/output // machines required
10 printf("\n Number of machines required = %0.2 f" , mr
       )
11 disp("If machine is to be used exclusively for part
       considered two machines required")
```

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