

Scilab Textbook Companion for
Machine Design
by T. H. Wentzell, P. E¹

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February 25, 2015

¹Funded by a grant from the National Mission on Education through ICT, <http://spoken-tutorial.org/NMEICT-Intro>. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website <http://scilab.in>

Book Description

Title: Machine Design

Author: T. H. Wentzell, P. E

Publisher: Cengage Learning, New Delhi

Edition: 1

Year: 2007

ISBN: 978-81-315-0878-7

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

What Is Mechanical Design

Scilab code Exa 1.2 Sample Engineering Calculation

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-1.2   Page 13  ') //Example 1.2
4
5  Sy=61000 // [psi] Tensile strength
           of AISI 1020 cold drawn steel from Appendix 4
           Page no 470
6  SF=2; // [] safety factor
7  F=300; // [lb] Weight of the ball
8  L=36; // [in] Length of round
           bar
9  Sy=61000; // [psi] Tensile strength
           from Appendix 4
10 M=F*L; // [in*lb] Bending moment
           Appendix 2
11
12 Sall=Sy/SF; // [psi] Allowable stress
13 Z=M/Sall; // [in^3] Section modulus
           for bending Sall=M/Z
14 D=(32*Z/%pi)^(1/3); // [in] Diameter of bar
```

```

15
16 //Use 13/8 in bar
17 D1=1.625;
18
19 mprintf('\n\n Diameter of Bar is %f in',D1);
20
21 //Checking Deflection
22 I=%pi*D1^4/64; // [in^4] Moment of
    inertia Appendix 3
23 E=30*10^6; // [lb/in^2] Modulus of
    elasticity
24 Delta=F*L^3/(3*E*I); // [in] Deflection
25
26 //Note- In the book I=0.342 in^4 is used instead of
    I=0.3422814 in^4
27
28 mprintf('\n The deflection of bar is %f in',Delta);
29
30
31 //Note: The deviation of answer from the answer
    given in the book is due to round off error.(In
    the book values are rounded while in scilab
    actual values are taken)

```

Chapter 2

Force Work and Power

Scilab code Exa 2.1 Torque

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-2.1   Page 26  ') //Example 2.1
4
5 T=1080*12; // [in*lb] Torque in axle
6 d=30; // [in] Diameter of tire
7 F=T/(d/2); // [lb] Force exerted on
           the road surface
8
9 mprintf('\n\n The tire exerts %f lb force on the
         road surface',F);
```

Scilab code Exa 2.2 Work and Power

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-2.2   Page 28  ') //Example 2.2
```

```

4
5 G=3.6; //Differential ratio
6 N=3500/G; // [rpm] Axle
    rotational speed
7 d=30; // [in] Diameter of
    tire
8 dist=N/(60)*(%pi*d) // [in] Distance
    traveled in 1 sec
9 dist=dist/12; // [ft] Distance
    traveled in 1 sec
10 t=1; // [sec] Time period
11 F=864; // [lb] Force
    exerted by tire on road surface
12
13 W=F*dist; // [ft*lb] Workdone
    in 1 sec
14 P=F*dist/t; // [ft*lb/sec] Power
15 hp=P/550; // [hp] Power in
    horse power 1hp=550 ft*lb/sec
16
17 mprintf('\n\n Power to do work %f hp',hp);
18
19 //Comparing it to motor output:
20
21 Tm=300*12; // [in*lb] Engine
    torque
22 Nm=3500; // [rpm] Engine
    speed
23 Pm=Tm*Nm/63000;
24
25 mprintf('\n Motor output %f hp',Pm);
26 mprintf('\n The power output equaled the power at
    tire/road surface. ');
27
28 //Note: The deviation of answer from the answer
    given in the book is due to round off error.(In
    the book values are rounded while in scilab
    actual values are taken)

```

Scilab code Exa 2.3 Force Pressure Relationship

```
1  clc ;
2  clear ;
3  mprintf( 'MACHINE DESIGN \n Timothy H. Wentzell , P.E.
           \n EXAMPLE-2.3   Page 29  ')    //Example 2.3
4
5  T=300*12;           //[in*lb] Engine torque
6  d=8;               //[in] Crankshaft effective
           diameter
7
8  F=T/(d/2);         //[lb] Force exerted by
           piston
9
10 A=%pi*(2^2)/4;     //[in^2] Area of cross
           section of piston
11 P=F/A;             //[lb/in^2] Pressure in
           cylinder
12
13 mprintf( '\n\n Pressure inside cylinder %f lb/in^2',P
           );
```

Chapter 3

Stress and Deformation

Scilab code Exa 3.1 Stress and Deflection under Compressive Axial Load

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-3.1    Page No-41 \n');
4
5  F=20000;           //[lb] Load applied to steel
   bar
6  L=6;              //[in] Length of steel bar
7  d=1;              //[in] Diameter of steel bar
8  A=%pi*(d^2)/4;   //[in^2] Area of cross
   section of steel bar
9  E=30*10^6;        //[lb/in^2] Modulus of
   elasticity for AISI 1020 hot-rolled steel
10 Sy=30000;         //[lb/in^2] Yield limit
11
12 S=F/A;            //[lb/in^2] Stress in bar
13 mprintf('\na. Stress in bar=%f lb/in^2.',S);
14
15 delta=F*L/(A*E);  //[in] Change in length of
   bar
16 mprintf('\nb. bar shorten by %f in.',delta);
```

```

17
18 if Sy>S then
19     mprintf(' \nc. The stress of %f psi is less than
                Sy of %f psi, so it will\n return to its
                original size because the yield limit was not
                exceeded. ',S,Sy);
20 else
21     mprintf('The bar will not return to its original
                length ')
22 end
23
24 //Note: The deviation of answer from the answer
        given in the book is due to round off error.(In
        the book values are rounded while in scilab
        actual values are taken)

```

Scilab code Exa 3.2 Stress and Deflection due to Bending

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
        \n EXAMPLE-3.2 Page No.43\n ');
4
5 b=2;           //[in] Width of beam
6 h=2;           //[in] Height of beam
7 I=(b*h^3)/12;  //[in^4] Moment of inertia
8 F=3000;        //[lb] Load applied to
        beam
9 L=36;          //[in] Length of beam
10 c=1;          //[in] Distance of outer
        most fiber from neutral axis
11 E=30*10^6;    //[lb/in^2] Modulus of
        elasticity
12 Sy=30000;     //[lb/in^2] Yield strength
13 Su=55000;     //[lb/in^2] Ultimate

```

```

    strength
14 SF=2;                                //[ ] Safety factor based
    on ultimate stress
15
16 M=F*L/4;                             //[lb*in] Bending moment
17 S=(M/I)*c;                            //[lb/in^2] Bending stress
18
19 //Note-In the book I=1.33 in^4 is used instead of I
    =1.3333333 in^2
20
21 mprintf('\na. The maximum stress in beam is %f lb/in
    ^2',S);
22
23 delta=-F*L^3/(48*E*I);                //[in] Maximum deflection
    in this beam
24
25 mprintf('\nb. The maximum deflection in this beam is
    %f in.',delta);
26
27 if Sy>S then
28     mprintf('\nc. Yes, the stress of %f lb/in^2 is
        less than the yield of Sy=%f lb/in^2.',S,Sy);
29 else
30     mprintf('\nc. No, the stress of %f lb/in^2 is
        greater than the yield of Sy=%f lb/in^2',S,Sy
    );
31 end
32
33 Sall=Su/SF;                            //[lb/in^2] Allowable
    stress
34
35 if Sall>S then
36     mprintf('\nd. It is acceptable because allowable
        stress is greater than the actual stress of
        %f lb/in^2.',S);
37 else
38     mprintf('\nd. Design is not acceptable because
        allowable stress is less than the actual

```



```

        stress of %f lb/in2.',S)
39 end
40
41 //Note: The deviation of answer from the answer
        given in the book is due to round off error.(In
        the book values are rounded while in scilab
        actual values are taken)

```

Scilab code Exa 3.3 Shear Stress

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
        \n EXAMPLE-3.3 Page No.45\n');
4
5  Su=80*103;           //[lb/in2] Ultimate strength
6  d=0.5;               //[in] Diameter of pin
7  As=%pi*d2/4;       //[in2] Area of cross section
        of pin
8  F=20*103;          //[lb] Load acting
9
10 Ss=F/(2*As);         //[lb/in2] Shear stress
11
12 if 0.5*Su>=Ss & 0.6*Su>=Ss then
13     mprintf('Pin would not fail');
14 else
15     mprintf('\n Actual stress is too high and the
        pin would fail.');
```

Scilab code Exa 3.4 Torsional Shear Stress

```

1  clc;
```

```

2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-3.4 Page No.46\n');
4
5 hp=10;           //[hp] Power transmitted
6 rpm=1750;       //[rpm] Turning speed
7 d=0.5;          //[in] Diameter of shaft
8 L=12;           //[in] Length of shaft
9 G=11.5*10^6     //[lb/in^2] shear modulus of
                 elasticity
10 Su=62000;      //[lb/in^2]
11
12 T=63000*hp/rpm;  //[in*lb] Torque transmitted
13 Z=%pi*d^3/16;   //[in^3] Polar section modulus
14 Ss=T/Z;         //[lb/in^2] Torsional shear
                 stress
15
16 //Note- In the book Z=0.025 in^3 is used instead of
           Z=0.0245437 in^3
17
18 mprintf('\na. Stress in the shaft is %f lb/in^2.',Ss
          )
19
20 J=%pi*d^4/32;   //[in^4] Polar moment of inertia
21 theta=T*L/(J*G);  //[radians]
22
23 //Note- In the book J=0.0061 in^4 is used instead of
           J=0.0061359 in^4
24
25 mprintf('\nb. The angular deflection of shaft would
           be %f radians',theta);
26
27 SF=3;           //[ ] Safety factor based on
                 ultimate strength
28
29 Zd=T/(0.5*Su/SF);  //[in^3] Polar section modulus
                 required for SF=3
30 Dd=(16*Zd/%pi)^(1/3);  //[in] Diameter of shaft

```

```

        required Z=%pi*d^3/16
31
32 mprintf('\nc. Diameter of shaft required is %f in.',
        Dd);

```

Scilab code Exa 3.5 Critical Load in Pinned End Column

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
        \n EXAMPLE-3.5 Page No.53\n');
4
5  L=30;                //[in] Length of link
6  d=5/8;              //[in] Diameter of link
7  I=%pi*d^4/64;      //[in^4] Moment of
        inertia
8  A=%pi*d^2/4;        //[in^2] Area of cross
        section
9  E=30*10^6;          //[lb/in^2] Modulus of
        elasticity
10
11 r=sqrt(I/A);         //[in] Radius of gyration
12
13 mprintf('\n The radius of gyration %f in.',r);
14
15 K=1;                //[ ] End support
        condition factor
16
17 Le=K*L;             //[in] Effective length
18
19 mprintf('\n Effective length is %f in',Le);
20
21 SR=Le/r;            //[ ] Slenderness ratio
22
23 mprintf('\n Slenderness ratio is %f.',SR)

```

```

24
25 Sy=42000;           //[lb/in^2] Yield strength
26
27 Cc=sqrt(2*pi^2*E/Sy);   //[ ] Column constant
28
29 mprintf('The column constant is %f.',Cc);
30
31 if SR>Cc then
32     mprintf('\n Slenderness ratio is greater than
              column constant, so use the euler formula')
33 end
34
35 I=%pi*d^4/64;       //[in^4] Moment of inertia
36
37 mprintf('\n The moment of inertia is %f in^4',I);
38
39 Pc=%pi^2*E*I/Le^2;   //[lb] Critical force
40
41 //Note- In the book I=0.0075 in^4 is used instead of
      I=0.0074901 in^4
42
43 mprintf('\n The critical force is %f lb.',Pc);

```

Scilab code Exa 3.6 Critical Load in Fixed End Column

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-3.6 Page No.55\n');
4
5  L=60;           //[in] Length of column
6  Sy=36000;      //[lb/in^2] Yield strength
7  SF=2;         //[ ] Safty factor
8  E=30*10^6;    //[lb/in^2] Modulus of
                elasticity

```

```

9
10 A=2.26; // [in^2] Area of cross
    section (Appendix 5.4)
11 I=0.764; // [in^4] Moment of inertia
    (Appendix 5.4)
12
13 r=sqrt(I/A); // [in] Radius of gyration
14
15 K=0.65; // [] End support condition
    factor from Figure 3.8
16 Le=K*L; // [in] Effective length
17
18 fprintf('\n The effective length is %f in.',Le);
19
20 SR=Le/r; // [] Slenderness ratio
21
22 fprintf('\n The slenderness ratio is %f.',SR);
23
24 Cc=sqrt(2*pi^2*E/Sy); // [] Column constant
25
26 fprintf('\n The column constant is %f.',Cc);
27
28 if Cc>SR then
29     fprintf('\n The column constant is greater than
        slenderness ratio, so use the Johnson formula
        .');
30 end
31
32 F=(A*Sy/SF)*(1-Sy*SR^2/(4*pi^2*E));
33
34 fprintf('\n The acceptable load for a safty factor
    of 2 is %f lb.',F);

```

Chapter 4

Combined Stress and Failure Theories

Scilab code Exa 4.1 Design of Short Column with Eccentric Load

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-4.1   Page 66  ')
4
5  D=2;           //[in] Dia. of short column
6  F=10000;      //[lb] Load applied
7  L=15;         //[in] Length of column
8  e=2;          //[in] Offset of load
9
10 A=(%pi*D^2)/4;  //[in^2] Area of cross section
    of column
11 SA=F/A;        //[lb/in^2] Axial Stress
12
13 Z=(%pi*D^3)/32;  //[in^4] Section modulus for
    bending
14 M=F*e;         //[lb*in] Bending moment
15 SB=M/Z;        //[lb/in^2] Bending stress
16
```

```

17 S=-SA-SB;           //S=(+-)SA+(+-)SB Max. stress
18
19 //The bending stress and axial stress are added on
    inner side of column
20
21 mprintf('\n\n Maximum stress in column is %f lb/in
    ^2.\n',S)

```

Scilab code Exa 4.2 Coplanar Shear

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-4.2   Page 67  ')
4
5  F1=800;           //[lb] Vertical force
6  F2=600;           //[lb] Horizontal force
7  D=0.5;            //[in] Pin diameter
8  A=(%pi*D^2)/4;    //[in^2] Area of cross section of
    pin
9
10 F=sqrt(F1^2+F2^2);  //[lb] Resultant force on pin
11 S=F/A;             //[lb/in^2] Shear stress in pin
12
13 //If forces were not perpendicular, they would be
    added vectorially.
14 mprintf('\n\n Shear stress in pin is %f lb/in^2.',S)
    ;

```

Scilab code Exa 4.3 Combined Torsion and Shear

```

1  clc;
2  clear;

```

```

3  mprintf('MACHINE DESIGN\n Timothy H. Wentzell, P.E.\
      n Example 4.3   Page no 68');
4
5  P=50;           //[hp] Power transmitted
6  N=300;         //[rpm] Speed
7  D=10;          //[in] Effective pitch diameter of
      sprocket
8  d=1;           //[in] Diameter of shaft from
      figure 4.3
9  Z=(%pi*d^3)/16;  //[in^3] Section modulus of shaft
10 A=(%pi*d^2)/4;  //[in^2] Area of cross section
11
12 T=(63000/N)*P;  //[lb*in] Torque required to
      transmit power
13 F=T/(D/2);     //[lb] Driving force in chain
14
15 Ss=F/A;        //[lb/in^2] Shear stress in shaft
16
17 St=T/Z;        //[lb/in^2] Torsional stress in
      shaft
18
19 S=Ss+St;       //[lb/in^2] Resultant stress
20
21 //Note—There is mistake in addition of Ss and St.
22
23 //This value would be compared to shear stress
      allowable for shaft material
24
25 mprintf('\n\n The combined stress in 1 inch diameter
      shaft is %f lb/in^2.',S);

```

Scilab code Exa 4.4 Combined Normal and Shear Stress

```

1  clc;
2  clear;

```



```

3  mprintf('MACHINE DESIGN\n Timothy H. Wentzell, P.E.\
      n Example 4.4  Page no 71 ')
4
5  P=20;                //[hp] Power transmitted by chain
      drive
6  n=500;               //[rpm] speed
7  d=8;                //[in] Pitch diameter of sprocket
8  fos=2;
9  D=1.25;             //[in] Diameter of shaft
10 L=12;               //[in] Distance between two
      supporting bearings
11 Z1=%pi*D^3/16;      //[in^3] Section modulus for
      torsion
12 Z2=%pi*D^3/32;      //[in^3] Section modulus for
      bending
13
14 T=63000*P/n;        //[in*lb] Torque on shaft
15
16 F=T/(d/2);          //[lb] Force in chain
17
18 M=F*L/4;            //[in*lb] Bending moment in shaft
19
20 Ss=T/Z1;            //[lb/in^2] Torsional shear stress
21
22 Sb=M/Z2;            //[lb/in^2] Bending normal stress
23
24 //Note- In the book Sb=9860 lb/in^2 is used instead
      of Sb=9856.7075 lb/in^2
25
26 S=(Sb/2)+sqrt(Ss^2+(Sb/2)^2);  //[lb/in^2] Combined
      max. stress
27
28 Sy=30000;           //[lb/in^2]From APPENDIX 4 Page no
      -470 for AISI 1020 and Hot-rolled steel
29 FOS=(Sy/2)/S;       //[ ] Actual factor of safty
30
31 if S < Sy/2 then    //Strength is greater than
      combined stress so design is safe

```

```
32     mprintf('\n\n Design is acceptable and Combined
           stress is %f lb/in^2',S);
33 else
34     mprintf('\n\n Design is not acceptable');
35 end
```

Chapter 5

Repeated Loading

Scilab code Exa 5.1 Design of a Shaft using the Soderberg Method

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-5.1 Page No.93\n');
4
5  SF=2;           // [] Safety factor
6  F=500;         //[lb] Load
7  L=40;          //[in] Length of shaft
8  Su=95000;      //[lb/in^2] Ultimate
                  strength (Appendix 4)
9  Sy=60000;      //[lb/in^2] Yield strength
                  (Appendix 4)
10
11 Mmax=F*L/4;    //[lb*in] Maximum bending
                  moment
12 Mmin=-F*L/4;  //[lb/in^2] Minimum
                  bending moment
13
14 Csurface=1;    // [] As surface is
                  polished
15 Csize=0.85;   // [] Assuming 0.5<D<2
```

```

16 Ctype=1; // [] Bending stress
17
18 Sn=Csize*Csurface*Ctype*(0.5*Su); // [lb/in ^2]
    Endurance limit
19
20 if Mmax==abs(Mmin) then
21     Sm=0; // [lb/in ^2] Mean stress
22 end
23
24 Sa=Sn/SF; // [lb/in ^2] As (1/SF)=(Sm/
    Sy)+(Sa/Sn) from soderberg equation
25
26 Sa_Z=(Mmax-Mmin)/2; // [lb*in ^2] Product of
    altenating stress and section modulus
27
28 Z=Sa_Z/Sa; // [in ^4] Section modulus
29
30 D=(32*Z/%pi)^(1/3); // [in] Diameter of shaft
31
32 D1=1.375; // [in] Next higher
    available is 1.375 in. so use D1
33
34 mprintf('\n The required diameter of rotating shaft
    is %f in.', D1);

```

Scilab code Exa 5.2 Design of a Cantilever Beam using the Soderberg Method

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-5.2 Page No.95\n');
4
5 Su=90000; // [lb/in ^2] Ultimate
    strength (Appendix 8)

```

```

6 Sy=37000; // [lb/in ^2] Yield
   strength (Appendix 8)
7 Sni=34000; // [lb/in ^2] Endurance
   limit (Appendix 8)
8 SF=1.6; // [] Safety factor
9
10 F=1000; // [lb] Load
11 L=12; // [in] Length of
   cantilever beam
12
13 Mmax=F*L; // [lb*in] Maximum bending
   moment
14 Mmin=0; // [lb*in] Minimum bending
   moment
15
16 Csize=0.85 // [] Assuming 0.5<D<2 in
17 Ctype=1; // [] Bending stress
18 Csurface=1; // [] As surface is
   polished
19
20 Malt=(Mmax-Mmin)/2; // [lb*in] Alternating
   bending moment
21
22 Mmean=(Mmax+Mmin)/2; // [lb*in] Mean bending
   moment
23
24 Sn=Csize*Csurface*Ctype*Sni; // [lb/in ^2] Modified
   endurance limit
25
26 Z=((Mmean/Sy)+(Malt/Sn))*SF; // [in ^3] Section
   modulus
27
28 D=(32*(Z)/%pi)^(1/3); // [in] Diameter of bar
29
30 mprintf('\n The required diameter of bar using the
   soderberg method is %f in.',D);

```

Scilab code Exa 5.3 Design of a Cantilever Beam using the Modified Goodman Method

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-5.3 Page No.97\n');
4
5  Su=90000;           //[lb/in^2] Ultimate
   strength (Appendix 8)
6  Sy=37000;          //[lb/in^2] Yield
   strength (Appendix 8)
7  Sni=34000;         //[lb/in^2] Endurance
   limit (Appendix 8)
8  SF=1.6;            //[] Safety factor
9
10 F=1000;            //[lb] Load
11 L=12;              //[in] Length of
   cantilever beam
12
13 Mmax=F*L;          //[lb*in] Maximum bending
   moment
14 Mmin=0;            //[lb*in] Minimum bending
   moment
15
16 Csize=0.85         //[] Assuming 0.5<D<2 in
17 Ctype=1;           //[] Bending stress
18 Csurface=1;       //[] As surface is
   polished
19
20 Malt=(Mmax-Mmin)/2; //[lb*in] Alternating
   bending moment
21
22 Mmean=(Mmax+Mmin)/2; //[lb*in] Mean bending
```

```

    moment
23
24 Sn=Csize*Csurface*Ctype*Sni; //[lb/in^2] Modified
    endurance limit
25
26 Z=((Mmean/Su)+(Malt/Sn))*SF; //[in^3] Section
    modulus
27
28 D=(32*(Z)/%pi)^(1/3);        //[in] Diameter of bar
29
30 mprintf('\n The required diameter of bar using the
    soderberg method is %f in.',D);
31
32 //Note that the modified Goodman results in a less
    conservative size as would be expected from
    figure 5.10

```

Scilab code Exa 5.4 Design of Water Pump Connecting Rod

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-5.4 Page No.98\n');
4
5  Su=95000;           //[lb/in^2] Ultimate strength
6  Sy=60000;           //[lb/in^2] Yield strength
7  SF=1.5;             //[ ] Safety factor
8
9  Fmax=1000;          //[lb] Maximum load
10 Fmin=-6000;         //[lb] Minimum load
11
12 Fmean=(Fmax+Fmin)/2;  //[lb] Mean load
13 Fmean=abs(Fmean);     //[lb] Considering absolute
    value
14 Falt=(Fmax-Fmin)/2;  //[lb] Alternating load

```

```

15
16 Csize=1           // [] Assuming b<0.5 in
17 Ctype=0.8        // [] Axial stress
18 Csurface=0.86    // [] Machined surface Figure
    5.7b
19
20 Sn=Csize*Csurface*Ctype*(0.5*Su); // [lb/in^2]
    Modified endurance limit
21
22 A=((Fmean/Sy)+(Falt/Sn))*SF;      // [in^2] Area of
    cross section of rod
23
24 b=sqrt(A);                      // [in] Side of
    square cross section
25
26 mprintf('\n The required square size in the center
    section is %f in.',b);

```

Scilab code Exa 5.5 Factor of Safety for Design with Stress Concentration Factor

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-5.5 Page No.100\n');
4
5  Su=80000;           // [lb/in^2] Ultimate
    strength
6  Sy=71000;          // [lb/in^2] Yield strength
7
8  D=0.6;             // [in] Diameter of shaft
9  d=0.5;             // [in] Diameter of shaft
    at notch
10 r=0.05;            // [in] Radius of notch
11 Z=%pi*d^3/16;      // [in^3] Polar section

```



```

    modulus
12 Tmax=200;           //[lb*in] Maximum load
13 Tmin=0;            //[lb*in] Minimum load
14
15 Smax=Tmax/Z;       //[lb/in^2] Maximum stress
16 Smin=Tmin/Z;       //[lb/in^2] Minimum stress
17
18 Smean=(Smax+Smin)/2;  //[lb/in^2] Mean stress
19 Salt=(Smax-Smin)/2;  //[lb/in^2] Alternating
    stress
20
21 Csize=0.85;         //[ ] Assume 0.5<D<2 in
22 Csurface=0.88;     //[ ] Machined surface
    Figure 5.7b
23 Ctype=0.6;         //[ ] Torsional stress
24
25 Sn=Csize*Csurface*Ctype*(0.5*Su);  //[lb/in^2]
    Modified endurance limit
26
27 Kt=1.32;           //[ ] (D/d)=1.2, (r/d)=0.1
    from Appendix 6c
28
29 N=inv(Smean/(0.5*Sy)+Kt*Salt/Sn);  //[ ] Safety
    factor
30
31 mprintf('\n The factor of safety for this design is
    %f',N);

```

Scilab code Exa 5.6 Factor of Safety for Design when Desired Life is known

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-5.6 Page No.102\n');
4

```

```

5 //From Example Problem 5.5
6 Sy=71000; // [lb/in^2] Yield strength
7 Smax=8148.7331 ; // [lb/in^2] Maximum stress
8 Smin=0; // [lb/in^2] Minimum stress
9 Smean=(Smax+Smin)/2; // [lb/in^2] Mean stress
10 Salt=(Smax-Smin)/2; // [lb/in^2] Alternating
    stress
11 Sn=18000; // [lb/in^2] Modified
    endurance strength
12 Kt=1.32 // [] Stress concentration
    factor
13
14 Nd=100000; // [cycles] Desired life
15
16 Snn=Sn*(10^6/Nd)^0.09; // [lb/in^2]
17
18 N=inv(Smean/(0.5*Sy)+Kt*Salt/Snn); // [] Factor of
    safety
19
20 mprintf('\n The new factor of safety for this
    condition is %f.',N);

```

Chapter 6

Fasteners and Fastening Methods

Scilab code Exa 6.1 Torquing Method

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-6.1 Page No.120\n');
4
5  As=0.334;           //[in^2] Tensile stress area
                       (Table 6.1)
6  Sp=85000;          //[lb/in^2] Proof strength (
                       Table 6.3)
7  D=3/4;             //[in] Nominal diameter of
                       thread
8
9  Fi=0.85*As*Sp;     //[lb] Desired intial preload
10 C=0.2;             //[ ] Torque coefficient
11
12 T=C*D*Fi;          //[in*lb] Torque
13
14 mprintf('\n The required torque is %f lb*in.',T);
```

Scilab code Exa 6.2 Turn of Nut Method

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-6.2 Page No.121\n');
4
5  L=5;           //[in] Length of engagement
6  E=30*10^6;    //[lb/in^2] Modulus of
          elasticity
7  As=0.334;     //[in^2] Tensile stress area
          (Table 6.1)
8  Sp=85000;     //[lb/in^2] Proof strength (
          Table 6.3)
9  Fi=0.85*As*Sp; //[lb] Desired intial preload
10
11 Delta=Fi*L/(As*E) //[in] Elongation
12
13 pitch=0.1;    //[in] Pitch for 3/4 UNC
14 TA=Delta*360/pitch; //[Degree] Torque angle
15
16 mprintf('\n The angle of rotation needed is %f
          degree.',TA);
```

Scilab code Exa 6.3 Elastic Analysis of Bolted Connections

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-6.3 Page No.122\n');
4
```

```

5 Alpha=6.5*10^-6;           //[in/(in*F)] Thermal
    expansion coefficient (Appendix 8)
6 L=5;                       //[in] Length of engagement
7
8 Delta=0.01204;            //[Degree] Elongation
9
10 DT=Delta/(Alpha*L);      //[F] The temperature we
    would need to heat this bolt above the sevice
    temperature
11
12 mprintf('\n The temperature we would need to heat
    this bolt above the sevice temperature is %f F.',
    DT);

```

Scilab code Exa 6.4 Elastic Analysis of Bolted Connections

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-6.4 Page No.124\n');
4
5  Dp=20;                     //[in] Pressure vessel head
    diameter
6  Ds=1.25;                   //[in] Stud diameter
7  Ls=6;                       //[in] Stud length
8  Af=50;                      //[in^2] Clamped area of
    flanges
9
10 E=30*10^6;                 //[lb/in^2] Modulus of
    elasticity
11 C=0.15;                    //[ ] Torque coefficient
12 Si=120000;                 //[lb/in^2] Proof strength (
    Table 6.3)
13 A=1.073;                   //[in^2] Tensile stress area
    (Table 6.1)

```

```

14
15 Fi=0.9*Si*A;           //[lb] Desired intial load
16
17 T=C*Ds*Fi;           //[lb*in] Torque
18
19 mprintf('\n1. The required torque is %f lb*in.',T);
20
21 Pp=500;               //[lb/in^2] Pressure inside
    the pressure vessel
22 Ap=%pi*Dp^2/4;       //[in^2] Pressure vessel
    head cross section area
23
24 Kb=A*E/Ls;           //[lb/in] Stiffness per stud
25 Kf=Af*E/Ls;         //[lb/in] Stiffness per
    flange
26 Fe=Pp*Ap;           //[lb] Force on pressure
    vessel head
27
28 Ft=10*Fi+(10*Kb/(10*Kb+Kf))*Fe;  //[lb] Total load
    on the bolt
29
30 mprintf('\n2. The total load on the bolt is %f lb.',
    Ft);

```

Chapter 7

Impact and Energy Analysis

Scilab code Exa 7.1 Impact Energy

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-7.1 Page No.137\n');
4
5  D=2;           //[in] Diameter of bar
6  W=500;        //[lb] Weight
7  h=1;          //[in] Height from which the
                weight falls
8  A=%pi*D^2/4;  //[in^2] Area of cross section
                of bar
9  L=10;         //[in] Length of bar
10 E=30*10^6;    //[lb/in^2] Modulus of
                elasticity
11
12 S=(W/A)+(W/A)*(1+(2*h*E*A/(L*W)))^(0.5);  //[lb/in
                ^2] Stress in the bar
13
14 mprintf('\n Stress in the bar is %f lb/in^2.',S);
15
16 Delta=S*L/E;  //[in] Deflection
```

```
17
18 mprintf(' \n Deflection in the bar is %f in.',Delta);
```

Scilab code Exa 7.2 Velocity and Impact

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
  \n EXAMPLE-7.2 Page No.139\n');
4
5 W=2000;           //[lb] Weight of automobile
6 L=36;            //[in] Length of stop
7 D=2;            //[in] Diameter of steel bar
8 V=5*5280*12/3600;  //[in/s] Velocity of automobile
9
10 A=%pi*D^2/4;    //[in^2] Area of cross section
  of bar
11 E=30*10^6;      //[lb/in^2] Modulus of
  elasticity
12
13 k=A*E/L;        //[lb/in] Stiffness of the bar
14 g=386;          //[in/s^2] Acceleration due to
  gravity
15
16 Delta=sqrt(2/k*W*(V^2/(2*g)+0));  //[in] Deflection
17
18 mprintf(' \n The deflection in the bar is %f in.',
  Delta);
19
20 S=Delta*E/L;    //[in] Stress in the bar
21
22 //Note-In the book Delta=0.124 is used instead of
  Delta=0.123800
23
24 mprintf(' \n The stress in the bar is %f lb/in^2.',S)
```


;

Scilab code Exa 7.3 Impact on Beam

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-7.3 Page No.141\n');
4
5  W=3000;           //[lb] Weight of automobile
6  L=40*12;         //[in] Length of the beam
7  I=64.2;          //[in^4] Moment of inertia of
                    the beam
8  Sy=48000;        //[lb/in^2] Yield strength of
                    the beam
9  c=8/2;           //[in] Distance from the
                    outermost fiber to neutral axis
10 E=30*10^6;       //[lb/in^2] Modulus of
                    elasticity
11 g=32.2;          //[ft/s^2] Acceleration due
                    to gravity
12
13 M=I*Sy/c;        //[lb*in] Moment at which
                    beam will yield
14 F=4*M/L;         //[lb] Force at which beam
                    will yield
15
16 Delta=F*L^3/(48*E*I); //[in] Deflection
17 KE=F*Delta/2;    //[lb*in] Kinetic energy
18
19 V=sqrt(2*g*KE/W); //[in/s] Velocity
20 V=V/5280*3600;  //[miles/hr] Velocity
21
22 mprintf(' \n At %f miles/hr velocity the beam will
          yield.',V);
```

Scilab code Exa 7.4 Designing for Impact

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-7.4 Page No.143\n');
4
5  D=3/4;           //[in] Diameter of the bolt
6  At=0.334;       //[in^2] Area of thread
7  As=%pi*D^2/4;   //[in^2] Area of shank
8
9  //Note-In the book As=0.442 in^2 is used instead of
   As=0.4417865 in.
10
11 E=30*10^6;      //[lb/in^2] Modulus of
   elasticity
12 Lt=2;           //[in] Length of the thread
13 Ls=6;           //[in] Length of the shank
14 h=0.03;         //[in] Height from which the
   weight falls
15 W=500;          //[lb] Falling load
16
17 Kt=At*E/Lt;     //[lb/in] Stiffness of
   threaded portion
18 Ks=As*E/Ls;     //[lb/in] Stiffness of shank
19
20 K=Kt*Ks/(Kt+Ks); //[lb/in] Overall stiffness
21
22 Delta=(W/K)+(W/K)*sqrt(1+2*h*K/W); //[in] Deflection
23
24 A=[Ls/E, Lt/E; 0.442, -0.334];
25 b=[Delta; 0];
26 S=A\b;
27
```

```

28 S=max(S);           //[lb/in^2] Maximum stress in
    the bolt
29
30 //Note-In the book Delta=0.0048 in is used instead
    of Delta=0.0047619 in.
31
32 mprintf('\n The maximum stress in this bolt is %f lb
    /in^2.',S);
33
34 Ln=8;               //[in] Length when shank has
    same area as threads
35 Kn=At*E/Ln;        //[lb/in] Stiffness
36 Deltan=(W/Kn)+(W/Kn)*sqrt(1+2*h*Kn/W);  //[in]
    Deflection
37 S=Deltan*E/Ln;     //[ln/in^2] Stress
38
39 mprintf('\n If shank has the same area as threads
    then stress is %f lb/in^2 and deflection is %f in
    .',S,Deltan);

```

Chapter 8

Spring Design

Scilab code Exa 8.1 Design of Helical Compression Spring

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-8.1 Page No.160\n');
4
5  Dm=0.625;           //[in] Mean diameter of spring
6  F=35;              //[lb] Load
7
8
9  K=1.25;             //[ ] Wahl factor for Dm/Dw=6.25 (
    figure 8.8)
10 Q=190000;          //[lb/in^2] Expected ultimate
    strength
11
12 LF=0.263;          //[ ] Loading factor
13
14 Dw=(K*8*F*Dm/(LF*pi*Q))^(1/2.846); //[in] Wire
    diameter
15
16 mprintf('\n The wire diameter of spring is %f in.',
    Dw);
```

```
17
18 //Use U.S Steel 12-gage wire: Dw=0.105 in.
```

Scilab code Exa 8.2 Determination of number of coils

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-8.2 Page No.163\n');
4
5  Dw=0.105;           //[in] Wire diameter
6  Dm=0.620;          //[in] Mean diameter of spring
7  F=35;              //[lb] Load
8  G=11.85*10^6;      //[lb/in^2] Shear modulus of
          elasticity
9  Delta=0.5;         //[in] Deflection
10
11 Na=Delta*G*Dw^4/(8*F*Dm^3); //[] Number of active
          coils
12
13 Nat=Na+2;           //[] Total number of coils
14
15 Lf=2;               //[in] Free length of spring
16
17 P=(Lf-2*Dw)/Nat;   //[in] Pitch (Table 8.1)
18
19 mprintf('\n Pitch is %f in.',P);
20
21 k=G*Dw^4/(8*Dm^3*Na); //[lb/in] Spring rate
22
23 mprintf('\n Spring rate is %f lb/in.',k);
24
25 mprintf('\n The total number of coils necessary to
          meet design criteria are %f.',Nat);
26
```

```
27 //Note: The deviation of answer from the answer
    given in the book is due to round off error.(In
    the book values are rounded while in scilab
    actual values are taken)
28
29 //Note: The deviation of answer from the answer
    given in the book is due to round off error.(In
    the book values are rounded while in scilab
    actual values are taken)
```

Scilab code Exa 8.3 Stability of Spring

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-8.3 Page No.165\n');
4  Lf=2;           //[in] Free length of spring
5  Dm=0.620;      //[in] Mean diameter of spring
6
7  R=Lf/Dm;       //[ ] Free length to mean diameter
    ratio
8
9  mprintf('\n The ratio of the free length of spring
    to mean diameter of spring is %f.',R);
10 mprintf(' From Figure 8.9 for squared and ground
    ends, this is a stable spring.');
```

Scilab code Exa 8.4 Deflection of Spring

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-8.4 Page No.165\n');
```

```

4
5 F=35;           //[lb] Load
6 k=73.3;        //[lb/in] Spring rate
7
8 x=F/k;         //[in] Deflection
9
10 mprintf('\n The deflection in the spring would be %f
    in. ',x);

```

Scilab code Exa 8.5 Flat Springs

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-8.5 Page No.166\n');
4
5  b=12;           //[in] Width of plate
6  h=1;           //[in] Thickness of plate
7  L=72;          //[in] Length of plate
8  I=b*h^3/12;    //[in^4] Moment of inertia
9
10 Delta=4;       //[in] Deflection
11 E=10*10^6;     //[lb/in^2] Modulus of
    elasticity
12
13 F=3*Delta*E*I/L^3;  //[lb] Force
14
15 mprintf('\n The force at this point is %f lb.',F);
16
17 k=F/Delta;      //[lb/in] Stiffness
18
19 mprintf('\n stiffness is %f lb/in.',k);
20
21 //Note: The deviation of answer from the answer
    given in the book is due to round off error.(In

```

```
the book values are rounded while in scilab
actual values are taken)
22
23 //Note: The deviation of answer from the answer
given in the book is due to round off error.(In
the book values are rounded while in scilab
actual values are taken)
```

Scilab code Exa 8.6 Energy from Deflection

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
\n EXAMPLE-8.6 Page No.167\n');
4
5 F=322;           //[lb] Force
6 Delta=4;        //[in] Deflection
7
8 U=F*Delta/2;    //[in*lb] Energy
9
10 mprintf('\n The energy from the 4-inch deflection
was %f lb*in. ',U);
```

Chapter 10

Pneumatic and Hydraulic Drives

Scilab code Exa 10.1 Calculation of Hydraulic Cylinder Diameter and Standard Rod Size

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-10.1 Page No.195\n');
4
5  P=100;           //[lb/in^2] Hydraulic pressure
6  F=450;           //[lb] Extension force
7  Fr=400;         //[lb] Retraction force
8
9  A=F/P;           //[in^2] Cross section area
10 D=sqrt(4*A/%pi); //[in] Bore of cylinder
11
12 mprintf('\n The bore of cylinder is %f in.',D);
13
14 //Use 2.5in bore cylinder
15
16 Dm=2.5;          //[in] Bore of cylinder
17 Dr=1;            //[in] Diameter of rod
```

```

18 A2=%pi*Dm^2/4-%pi*Dr^2/4; //[in^2]
19 F2=P*A2;                //[lb] Force
20
21 if F2>=Fr then
22     mprintf('\n The diameter of rod is %f in.',Dr);
23 else
24     mprintf('\n This would not meet requirement');
25 end
26
27 //This would meet requirement
28
29 Ab=%pi*Dm^2/4;          //[in^2] Cross section area
30 //Note-In the book V=180.7 is used instead of V
   =180.64158
31 d=20;                  //[in] stroke
32 V=Ab*d+A2*d;           //[in^3] Volume per cycle
33 t=2;                   //[s] Cycle time
34 FR=V/t;                //[in^3/s] Flowrate
35
36 FR=FR*7.48*60/1728;    //[gal/min] Flowrate
37
38 mprintf('\n Flow rate required is %f gal/min.',FR);

```

Scilab code Exa 10.2 Pneumatic Pop Rivet Gun

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
   \n EXAMPLE-10.2 Page No.198\n');
4
5  Pa=100;                //[lb/in^2] Air pressure
6  Da=4;                  //[in] Diameter
7  Aa=%pi*Da^2/4;        //[in^2] Cross section area
8
9  F1=Pa*Aa;              //[lb]

```

```

10 Do=1; // [in]
11 Ao=%pi*Do^2/4; // [in]
12 Po=F1/Ao; // [lb/in^2]
13
14 mprintf('\n The oil pressure is %f lb/in^2.',Po);
15
16 D2o=3; // [in]
17 A2o=%pi*D2o^2/4; // [in^2]
18 F2=Po*A2o;
19
20 mprintf('\n Force F on piston rod is %f lb.',F2);
21
22 D=1; // [in]
23 d=4; // [in]
24 A=%pi*D^2/4; // [in^2]
25
26 V=A*d; // [in^3]
27
28 mprintf('\n The volume in 1-inch cylinder for the 4-
inch travel is %f in^3.',V);
29
30 A3=%pi*3^2/4; // [in^2]
31 l3=V/A3; // [in]
32
33 mprintf('\n Travel for 3-inch cylinder is %f in.',l3
);

```

Chapter 11

Gear Design

Scilab code Exa 11.1 Double Reduction Spur Gear Set

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
           \n EXAMPLE-11.1 Page No.217\n');
4
5  N2=60;
6  N1=20;
7  N3=20;
8  N4=60;
9
10 Vr=(N2/N1)*(N4/N3);
11
12 //Output speed
13 n1=3600;
14 n4=n1/Vr;
15
16 mprintf('\n The output speed is %f rpm.',n4);
17
18 //Output torque
19 T1=200;
20 T4=T1*Vr;
```

```

21
22 mprintf(' \n The output torque is %f lb*in.',T4);
23
24 //Input horsepower
25 hpi=T1*n1/63000;
26
27 mprintf(' \n The input horsepower is %f hp.',hpi);
28
29 //Output horsepower
30 hpo=T4*n4/63000;
31
32 mprintf(' \n The output horsepower is %f hp.',hpo);

```

Scilab code Exa 11.2 Double Reduction Spur Gear Set with Idler

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-11.2 Page No.219\n');
4
5 Na=20;
6 Nb=65;
7 Nc=20;
8 Nd=22;
9 Ne=60;
10
11 //train value
12 Vr=(Nb/Na)*(Nd/Nc)*(Ne/Nd);
13
14 mprintf(' \n Train value = %f ',Vr);
15
16 //Output speed
17 na=3000;
18 ne=na/Vr;
19

```

```

20 mprintf('\n \Output speed = %f rpm.',ne);
21
22 //Output torque
23 Ta=10;
24 Te=Ta*Vr;
25
26 mprintf('\n Output torque = %f lb*in.',Te);
27
28 //Direction
29
30 mprintf('\n Direction\n    If Gear A is clockwise,\n
        Gear B is counterclockwise.\n    Gear C is
        counterclockwise.\n    Gear D is clockwise. \n
        Gear E is counterclockwise.');
```

Scilab code Exa 11.3 Calculation of Pitch Diameter Circular Pitch and Shaft Centre to Centre Distance

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
        \n EXAMPLE-11.3 Page No.231\n');
```

```

4
5  Np=16;
6  Ng=32;
7  Pd=8;
8
9  //Pitch diameter
10 Dp=Np/Pd;
11
```

```

12 mprintf('\n Pinion pitch diameter is %f in.',Dp);
13
14 Dg=Ng/Pd;
15
16 mprintf('\n Gear pitch diameter is %f in.',Dg);
17
18 //Circular pitch
19 Pc=%pi*Dp/Np;
20
21 mprintf('\n Circular pitch is %f in.',Pc);
22
23 //Centerline distance
24 CC=(Dp+Dg)/2;
25
26 mprintf('\n Centerline distance is %f in.',CC);

```

Scilab code Exa 11.4 Bevel Gear

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-11.4 Page No.236\n');
4
5 //Torque in input shaft
6 hp=1.5;
7 n=3450;
8 T=63000*hp/n;
9
10 mprintf('\n Torque in input shaft is %f lb*in.',T);
11
12 //Note-In the book T=27.4 in-lb is used instead of T
    =27.391304
13
14 //Output torque
15 Ng=24;

```

```

16 Np=10;
17 Tout=(Ng/Np)*T;
18
19 mprintf('\n Output torque is %f lb*in.',Tout);
20
21 //Output speed
22 nout=(Np/Ng)*n;
23
24 mprintf('\n Output speed is %f rpm.',nout);

```

Scilab code Exa 11.5 Calculation of Gear Train Value Input and Output Torque and Speed

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-11.5 Page No.241\n');
4
5  //Gear train value
6  Na=12;
7  Nb=36;
8  Nc=16;
9  Nd=64;
10 Vr=(Nb/Na)*(Nd/Nc);
11
12 mprintf('\n Gear train value is %f ',Vr);
13
14 //Motor torque
15 hp=1.5;
16 n=1750;
17 T=63000*hp/n;
18
19 mprintf('\n Motor torque is %f in-lb.',T);
20
21 //Output torque

```



```

22 Tout=T*Vr;
23
24 fprintf('\n Output torque is %f in-lb.',Tout);
25
26 //Output speed
27 nout=n/Vr;
28
29 fprintf('\n Output speed is %f rpm.',nout);
30
31 //Directions
32 fprintf('\n Directions\n Gear A is clockwise.\n
Gear B is counterclockwise.\n Gear C is
counterclockwise.\n Gear D is clockwise.');
```

Scilab code Exa 11.6 Precision Spur Gears

```

1 clc;
2 clear;
3 fprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
\n EXAMPLE-11.6 Page No.243\n');
```

```

4
5 //Velocity ratio
6 N2=2400;
7 N1=20;
8 Vr=N2/N1;
9
10 fprintf('\n Velocity ratio = %f ',Vr);
11
12 fprintf('\n Possible Solution: \n Three sets of
gears \n -20 tooth and 80 tooth\n -20 tooth
```

and 100 tooth\n -20 tooth and 120 tooth. ');

Chapter 12

Spur Gear Design and Selection

Scilab code Exa 12.1 Forces on Spur Gear Teeth

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
           \n EXAMPLE-12.1 Page No.254\n');
4
5  P=5;
6  n=1725;
7  T=63000*P/n;
8
9  //Pitch circle diameter
10 Np=20;
11 Pd=8;
12 Dp=Np/Pd;
13
14 mprintf('\n Pitch circle diameter = %f in.',Dp);
15
16 //Transmitted force
17 Ft=2*T/Dp;
18
19 mprintf('\n Transmitted force = %f lb.',Ft);
20
```

```

21 //Separating force
22 theta=20*%pi/180;
23 Fn=Ft*tan(theta);
24
25 mprintf('\n Separating force = %f lb.',Fn);
26
27 //Maximum force
28 Fr=Ft/cos(theta);
29
30 mprintf('\n Maximum force = %f lb.',Fr);

```

Scilab code Exa 12.2 Surface Speed

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-12.2 Page No.256\n');
4
5 //Surface speed
6 Dp=2.5;
7 n=1725;
8 Vm=%pi*Dp*n/12;
9
10 mprintf('\n Surface speed = %f ft/min.',Vm);

```

Scilab code Exa 12.3 Strength of Gear Teeth

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-12.3 Page No.258\n');
4 //Pinion
5 Su=95*10^3;

```

```

6 Sn=0.5*Su;
7 Y=0.320;
8 b=1;
9 Pd=8;
10
11 Fsp=Sn*b*Y/Pd;
12
13 mprintf('\n Force allowable for pinion = %f lb.',Fsp
    );
14
15 //Gear
16 Sn=0.5*88*10^3;
17 Y=0.421;
18 Fsg=Sn*b*Y/Pd;
19
20 mprintf('\n Force allowable for gear = %f lb.',Fsg);

```

Scilab code Exa 12.4 Dynamic Load

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-12.4 Page No.262\n');
4
5 //Dynamic load
6 Vm=1129;
7 Ft=146;
8 Fd=(600+Vm)*Ft/600;
9
10 mprintf('\n Dynamic load = %f lb.',Fd);
11
12 Fs=1900;
13 Nsf=2;
14
15 //Comparing to the allowable stress

```

```

16
17 if (Fs/Nsf)>Fd then
18     mprintf('\n This is an acceptable design. ');
19 end

```

Scilab code Exa 12.5 Calculation of Factor of Safety Used in Catalog

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-12.5 Page No.263\n');
4
5  Su=55*10^3;
6  Sn=0.5*Su;
7
8  Np=24;
9  Pd=12;
10 Dp=Np/Pd;
11
12 mprintf('\n Pitch circle diameter = %f in.',Dp);
13
14 n=1800;
15 Vm=%pi*Dp*n/12;
16
17 mprintf('\n Surface speed = %f ft/min.',Vm);
18
19 b=3/4;
20 Y=0.302;
21 Fs=Sn*b*Y/Pd;
22
23 mprintf('\n Allowable stress = %f lb.',Fs);
24
25 Fd=Fs;
26 Ft=600*Fd/(600+Vm);
27

```

```

28 mprintf('\n Force transmitted = %f lb.',Ft);
29
30 T=Ft*Dp/2;
31
32 P=T*n/63000;
33
34 mprintf('\n Power transmitted = %f hp.',P);
35
36 //Compared to catalog
37 hp_catalog=4.14;
38
39 Nsf=P/hp_catalog;
40
41 mprintf('\n Safety factor = %f .',Nsf);

```

Scilab code Exa 12.6 Spur Gear Design

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-12.6 Page No.266\n');
4
5  //Miscellaneous properties
6  Np=48;
7  Pd=12;
8  Dp=Np/Pd;
9  Vr=3;
10 Ng=Np*Vr;
11
12 //Surface speed
13 n=900;
14 Vm=%pi*Dp*n/12;
15
16 mprintf('\n Surface speed = %f ft/min.',Vm);
17

```

```

18 //Force on teeth
19 hp=2;
20 Ft=33000*hp/Vm;
21
22 mprintf('\n Force on teeth = %f lb.',Ft);
23
24 //Dynamic force
25 Fd=(600+Vm)*Ft/600;
26
27 mprintf('\n Dynamic force = %f lb.',Fd);
28
29 //Width
30 Su=30*10^3;
31 Sn=0.4*Su;
32 Y=0.344;
33 Nsf=2;
34 b=Fd*Nsf*Pd/(Sn*Y);
35 b=round(b);
36
37 mprintf('\n Width = %f in.',b);
38
39 if (8/Pd)<b&b<(12.5/Pd) then
40     mprintf('\n This is an acceptable design. ');
41 end

```

Scilab code Exa 12.7 Buckingham Method of Gear Design

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-12.7 Page No.270\n');
4
5 Su=95*10^3;
6 Sn=0.5*Su;
7 Np=24;

```



```

8 Pd=16;
9 Dp=Np/Pd;
10
11 //Torque
12 n=3450;
13 P=3;
14 T=P*63000/n;
15
16 mprintf('\n Torque = %f in-lb.',T);
17
18 //Force transmitted
19 Ft=2*T/Dp;
20
21 mprintf('\n Force transmitted = %f lb.',Ft);
22
23 //Surface speed
24 Vm=%pi*Dp*n/12;
25
26 mprintf('\n Surface speed = %f ft/min.',Vm);
27
28 //Force allowable
29 Y=0.337;
30 b=1;
31 Fs=Sn*b*Y/Pd;
32
33 mprintf('\n Force allowable = %f lb.',Fs);
34
35 //Dynamic load using Buckingham's equation
36 C=830;
37 Fd=Ft+0.05*Vm*(b*C+Ft)/(0.05*Vm+(b*C+Ft)^0.5);
38
39 Nsf=1.4;
40 if (Fs/Nsf)>Fd then
41     mprintf('\n This is a suitable design');
42 end

```

Scilab code Exa 12.8 Wear of Gears

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
           \n EXAMPLE-12.8 Page No.272\n');
4
5  Ng=42;
6  Np=24;
7  Q=2*Ng/(Ng+Np);
8
9  Kg=270;
10 Dp=1.5;
11 b=1;
12
13 Fw=Dp*b*Q*Kg;
14 Fd=699;
15 Nsf=1.2;
16
17 if (Fw/Nsf)<Fd then
18     mprintf('\n (Fw/Nsf)<Fd So this would not be
              suitable design');
19 end
20
21 //If the surfaces each had a BHN = 450
22
23 Kg=470;
24 Fw=Dp*b*Q*Kg;
25
26 if(Fw/Nsf)>Fd then
27     mprintf('\n\n If the surfaces each had a BHN =
              450 ');
28     mprintf('\n (Fw/Nsf)>Fd So this would be
              suitable design.');
```

29 end

Chapter 13

Helical Bevel and Worm Gears

Scilab code Exa 13.1 Helical Gears

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-13.1 Page No.280\n');
4
5  //Pitch-line velocity
6  Nt=24;
7  Pd=12;
8  Dp=Nt/Pd;
9  n=1750;
10 Vm=%pi*Dp*n/12;
11
12 mprintf('\n Pitch-line velocity = %f ft/min.',Vm);
13
14 //Transmitted force
15 hp=5;
16 Ft=33000*hp/Vm;
17
18 mprintf('\n Transmitted force = %f lb.',Ft);
19
20 //Axial force
```

```

21 psi=15*%pi/180;
22 Fa=Ft*tan(psi);
23
24 mprintf('\n Axial force = %f lb.',Fa);
25
26 //Separating force
27 theta=20*%pi/180;
28 psit=atan(tan(theta)/cos(psi));
29 Fn=Ft*tan(psit);
30
31 mprintf('\n Separating force = %f lb.',Fn);

```

Scilab code Exa 13.2 Helical Gear Stresses

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-13.2 Page No.282\n');
4
5  //Normal plane pitch
6  Pd=16;
7  psi=45*%pi/180;
8  Pdn=Pd/cos(psi);
9
10 mprintf('\n Normal plane pitch = %f in.',Pdn);
11
12 N=24;
13 S=30000;
14 b=0.5;
15 Ne=N/cos(psi)^3;
16 Y=0.427;
17 Fs=S*b*Y/Pdn;
18
19 mprintf('\n Allowable force = %f lb.',Fs);
20

```

```

21 Dp=24/16;
22 n=600;
23 Vm=%pi*Dp*n/12;
24
25 mprintf('\n Surface speed = %f ft/min.',Vm);
26
27 Ft=Fs/((600+Vm)/600);
28
29 mprintf('\n Force transmitted = %f lb.',Ft);
30
31 P=Ft*Vm/33000;
32
33 mprintf('\n Power rating = %f hp.',P);
34
35 //Note—There is an error in the answer given in
    textbook

```

Scilab code Exa 13.3 Bevel Gear Forces

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
    \n EXAMPLE-13.3 Page No.286\n');
4
5  Np=24;
6  Ng=36;
7  Pd=8;
8  Yp=33.7*%pi/180;
9  Yg=56.3*%pi/180;
10 theta=14.5*%pi/180;
11
12 //Pitch diameter
13 Dp=Np/Pd;
14
15 mprintf('\n Pitch diameter = %f in.',Dp);

```

```

16
17 //Transmitted force
18 n=2200;
19 P=8;
20 T=63000*P/n;
21
22 Ft=2*T/Dp;
23
24 mprintf('\n Transmitted force = %f lb.',Ft);
25
26 //Separating force – Pinion
27 Fnp=Ft*tan(theta)*cos(Yp);
28
29 mprintf('\n Separating force–Pinion = %f lb.',Fnp);
30
31 //Separating force–Gear
32 Fng=Ft*tan(theta)*cos(Yg);
33
34 mprintf('\n Separating force = %f lb.',Fng);
35
36 //Axial force–Pinion
37 Fap=Ft*tan(theta)*sin(Yp);
38
39 mprintf('\n Axial force–Pinion= %f lb.',Fap);
40
41 //Axial force–Gear
42 Fag=Ft*tan(theta)*sin(Yg);
43
44 mprintf('\n Axial force–Gear = %f lb.',Fag);

```

Scilab code Exa 13.4 Worm Gear Forces

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.

```

```

        \n EXAMPLE-13.4 Page No.288\n');
4
5 //Pitch diameter
6 Ng=60;
7 Pd=6;
8 Dp=Ng/Pd;
9
10 mprintf('\n Pitch diameter = %f in.',Dp);
11
12 //Circular pitch
13 Pc=%pi*Dp/Ng;
14
15 mprintf('\n Circular pitch = %f in.',Pc);
16
17 L=Pc;
18
19 //Lead angle
20 D=2;
21 LA=atan(L/(%pi*D));
22 LA=LA*180/%pi;
23
24 mprintf('\n Lead angle = %f deg.',LA);
25
26 //Centerline distance
27 CC=(D+Dp)/2;
28
29 mprintf('\n Centerline distance = %f in.',CC);
30
31 //Velocity ratio
32 Ntgear=60;
33 Nstarts_worm=1;
34 Vr=Ntgear/Nstarts_worm;
35
36 mprintf('\n Velocity ratio = %f',Vr);
37
38 //Output speed
39 nin=1750;
40 nout=nin/Vr;

```



```
41
42 mprintf(' \n Output speed = %f rpm. ',nout);
```

Scilab code Exa 13.5 Calculation of Normal Circular Pitch Dynamic Load Force Allowable

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-13.5 Page No.292\n');
4
5 //Normal circular pitch
6 Pc=0.524;
7 LA=4.77*%pi/180;
8 Pcn=Pc*cos(LA);
9
10 mprintf(' \n Normal circular pitch = %f in.',Pcn);
11
12 //Force transmitted
13 hp=5;
14 n=29.2;
15 T=63000*hp/n;
16 Dp=10;
17 Ft=2*T/Dp;
18
19 mprintf(' \n Force transmitted = %f lb.',Ft);
20
21 Vm=%pi*Dp*n/12;
22
23 //Dynamic load
24 Fd=(1200+Vm)*Ft/1200;
25
26 mprintf(' \n Dynamic load = %f lb.',Fd);
27
28 //Force allowable
```

```

29 Su=95*10^3;
30 Y=0.392;
31 b=1;
32 Sn=0.5*Su;
33 Fs=Sn*Y*b*Pcn/%pi;
34
35 mprintf('\n Force allowable = %f lb.',Fs);
36
37 //Safty factor
38 Nsf=Fs/Fd;
39
40 mprintf('\n Safty factor = %f .',Nsf);
41
42 //Note—There is an error in the answer given in
    textbook

```

Scilab code Exa 13.6 Efficiency of Worm Gear Drive

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-13.6 Page No.294\n');
4
5  //Efficiency
6  LA=4.77*%pi/180;
7  f=0.03;
8  e=tan(LA)*(1-f*tan(LA))/(f+tan(LA));
9
10 mprintf('\n Efficiency = %f .',e);
11
12 //Torque input
13 hp=5;
14 n=1750;
15 T=63000*hp/n;
16

```

```
17 mprintf('\n Torque input = %f in-lb.',T);
18
19 Vr=60;
20 Tout=0.73*Vr*T;
21
22 mprintf('\n Output torque = %f in-lb.',Tout);
```

Scilab code Exa 13.7 Heat Generated

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-13.7 Page No.296\n');
4
5 hpin=5
6 e=0.73;
7 Q=(1-e)*hpin*2544;
8
9 mprintf('\n Heat generated by system = %f Btu/hr.',Q
        );
10
11 //Note-There is an error in the answer given in
    textbook
```

Chapter 14

Belt and Chain Drives

Scilab code Exa 14.1 Calculation of Front Force Net Driving Force Force on Shaft etc

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-14.1 Page No.306\n');
4
5  //Torque on small pulley
6  hp=2;
7  n=2450;
8  T=63000*hp/n;
9
10 mprintf('\n Torque on small pulley = %f in-lb.',T);
11 r=6/2;
12 Fd=T/r;
13
14 //Front force
15 Fb=10;
16 Ff=Fd+Fb;
17
18 mprintf('\n Front force = %f lb.',Ff);
19
```

```

20 //Force pulling the shafts
21 Ft=Ff+Fb
22
23 mprintf('\n Force pulling the shafts = %f lb.',Ft);
24
25 //Surface speed
26 D=2*r;
27 Vm=%pi*D*n/12;
28
29 mprintf('\n Surface speed = %f ft/min.',Vm);
30
31 //Ratio
32 D2=10;
33 Mw=D2/D;
34
35 mprintf('\n Ratio = %f .',Mw);
36
37 //Output speed
38 no=n/Mw;
39
40 mprintf('\n Output speed = %f rpm.',no);
41
42 //Note—There is an error in the answer given in
    textbook

```

Scilab code Exa 14.2 Calculation of Angle of Contact Length of Belt Ratio and Surface Speed etc

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
    \n EXAMPLE-14.2 Page No.310\n');
4
5 //Length of belt
6 C=19;

```

```

7 D1=4;
8 D2=6;
9
10 L1=2*C+1.57*(D1+D2)+(D2-D1)^2/(4*C);
11
12 //Assuming a 54-inch belt is available
13 L=54;
14
15 mprintf('\n Length of belt = %f in.',L);
16
17 //Centerline distance
18 B=4*L-6.28*(D2+D1);
19
20 C=(B+sqrt(B^2-32*(D2-D1)^2))/16;
21
22 mprintf('\n Centerline distance = %f in.',C);
23
24 //Ratio
25 Mw=D2/D1;
26
27 mprintf('\n Ratio = %f.',Mw);
28
29 //Surface speed
30 n=1800;
31 Vm=%pi*D1*n/12;
32
33 mprintf('\n Surface speed = %f ft/min.',Vm);
34
35 //Angle of contact
36
37 theta=180-2*(180/%pi)*asin((D2-D1)/(2*C));
38
39 mprintf('\n Angle of contact = %f deg.',theta);

```

Scilab code Exa 14.3 V Belts

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-14.3 Page No.315\n');
4
5  //Power rating of belt
6  P1=27+2.98;
7  SF=1.5;
8  P=P1/SF;
9  P=round(P);
10
11 mprintf(' \n Power rating = %f hp.',P);
12
13 //Length of belt
14 C=20;
15 D1=8;
16 D2=16;
17 L1=2*C+1.57*(D1+D2)+(D2-D1)^2/(4*C);
18
19 //Use an 80-inch belt
20 L=80;
21
22 mprintf(' \n Length of belt = %f in.',L);

```

Scilab code Exa 14.4 Chain Drive

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-14.4 Page No.321\n');
4
5  P=5.31;
6
7  mprintf(' \n Horsepower rating = %f hp.',P);
8

```

```

 9 Nti=12;
10 N1=1800;
11 N2=900;
12
13 //Output sprocket
14 Nto=(N1/N2)*Nti;
15
16 mprintf('\n Number of tooth on output sprocket = %f.
           ',Nto);
17
18 //Surface speed
19 Pc=0.5;
20 D1=Pc*Nti/%pi;
21 n=1800;
22 Vm=%pi*D1*n/12;
23
24 mprintf('\n Surface speed = %f ft/min.',Vm);
25
26 mprintf('\n Type of lubrication – Bath or disc
           lubrication ');
27
28 //Length of chain
29 C=10;
30 D2=Pc*Nto/%pi;
31
32 L1=2*C+1.57*(D1+D2)+(D2-D1)^2/(4*C);
33
34 //Use 29 or 30 inch chain
35
36 L=30;
37
38 mprintf('\n Length of chain = %f in.', L);
39
40 hp=5.31;
41
42 T=63000*hp/n;
43
44 F=2*T/D1;

```



```
45
46 mprintf('\\n Force in chain = %f lb.',F);
47
48 //Comparism with ultimate strength 3700 lb – not a
    valid comparison because of speed etc.
```

Chapter 15

Keys and Couplings

Scilab code Exa 15.1 Design of Keys

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-15.1 Page No.332\n');
4
5  //Torque
6  P=5;
7  n=1750;
8  T=63000*P/n;
9
10 mprintf('\n Torque = %f in-lb.',T);
11
12 //Length of key for shear
13 Su=61000;
14 Ss=0.5*Su;
15 b=0.125;
16 D=0.5;
17 Ls1=2*T/(Ss*b*D);
18 SF=2.5;
19
20 Ls=SF*Ls1;
```

```

21
22 mprintf('\n Length of key for shear = %f in.',Ls);
23
24 //Length of key for compression
25 Sc=51000;
26 t=0.125;
27 Lc1=4*T/(Sc*t*D);
28
29 Lc=SF*Lc1;
30
31 mprintf('\n Length of key for compression = %f in.',
    Lc);

```

Scilab code Exa 15.2 Splines

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
    \n EXAMPLE-15.2 Page No.335\n');
4
5  //Torque capacity
6  Ss=30500;
7  D=1;
8  L=2;
9  T1=Ss*%pi*D^2*L/16;
10
11 SF=2;
12
13 T=T1/SF;
14
15 mprintf('\n Torque capacity 1 = %f in-lb.',T);
16 n=6;
17 d=0.81;
18 A=(D-d)*L*n/2;
19

```

```
20 S=1000;  
21 rm=(1+0.810)/4;  
22  
23 T2=S*A*rm;  
24  
25 mprintf('\\n Torque capacity 2 = %f in-lb.',T2);
```

Chapter 16

Clutches and Brakes

Scilab code Exa 16.1 Calculation of Torque and Power

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
           \n EXAMPLE-16.1 Page No.358\n');
4
5  //Torque capacity
6  f=0.3;
7  N=120;
8  ro=12;
9  ri=9;
10 Tf=f*N*(ro+ri)/2;
11
12 mprintf('\n Torque capacity = %f in-lb. ',Tf);
13 n=2000;
14 //Power
15
16 Pf=Tf*n/63000;
17
18 mprintf('\n Power = %f hp. ',Pf);
```

Scilab code Exa 16.2 Determination of Breaking Torque

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
           \n EXAMPLE-16.2 Page No.359\n');
4
5  //Normal force
6  W=100;
7  L=20;
8  a=4;
9  N=(W*L)/a;
10
11 mprintf('\n Normal force = %f lb.',N);
12
13 //Torque friction
14 f=0.4;
15 D=12;
16 Tf=f*N*D/2;
17
18 mprintf('\n Torque friction = %f in-lb.',Tf);
```

Scilab code Exa 16.3 Torque Transmitting Capacity

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
           \n EXAMPLE-16.3 Page No.360\n');
4
5  //For alpha=20 deg.
6  alpha=20*(%pi/180);
7  f=0.35;
```

```

8  rm=12/2;
9  Fa=75;
10 Tf=(f*rm*Fa)/(sin(alpha)+f*cos(alpha));
11
12 mprintf('\n Torque capacity (alpha=20 deg.) = %f in-
    lb. ',Tf);
13
14 //For alpha=10 deg.
15 alpha=10*(%pi/180);
16 Tf=(f*rm*Fa)/(sin(alpha)+f*cos(alpha));
17
18 mprintf('\n Torque capacity (alpha=10 deg.) = %f in-
    lb. ',Tf);

```

Scilab code Exa 16.4 Calculation of Stopping Force Torque per Brake
Normal Brake Force etc

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
    \n EXAMPLE-16.4 Page No.361\n');
4
5  //Stopping rate
6  V=60*5280/3600;
7  Va=0.5*V;
8  D=400;
9  t=D/Va;
10 a=V/t;
11
12 mprintf('\n Stopping rate = %f ft/sec^2.',a);
13
14 //Stopping force
15 W=40000;
16 g=32.2;
17 F=W*a/g;

```

```

18
19 //Torque
20 r=36/2;
21 T=F*r;
22
23 mprintf('\n Torque = %f in-lb.',T);
24
25 //For each wheel
26 T=T/10;
27
28 //Braking normal force
29 rm=10;
30 f=0.4;
31 N=T/(f*rm);
32
33 mprintf('\n Braking normal force = %f lb.',N);
34
35 //Note—There is an error in the answer given in
    textbook

```

Scilab code Exa 16.5 Rotational Inertia and Brake Power

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
    \n EXAMPLE-16.5 Page No.365\n');
4 W=3500;
5 V=73;
6 g=32.2;
7 V=50*5280/3600;
8 V=round(V);
9
10 //Kinetic energy to be absorbed
11 KE=W*V^2/(2*g);
12

```



```
13 mprintf('\\n Kinetic energy to be absorbed = %f ft-lb
    . ',KE);
14
15 //Temperature rise
16 Uf=KE;
17 Wb=40;
18 c=93;
19 deltaT=Uf/(Wb*c);
20
21 mprintf('\\n Temperature rise = %f deg.',deltaT);
22
23 //Stopping time
24 a=20;
25 t=V/a;
26
27 mprintf('\\n Stopping time = %f sec.',t);
28
29 //Frictional power
30 t=round(t*10)/10;
31 fhp=Uf/(550*t);
32
33 mprintf('\\n Frictional power = %f hp.',fhp)
```

Chapter 17

Shaft Design

Scilab code Exa 17.1 Design Stresses in Shaft

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-17.1 Page No.379\n');
4
5  hp=5;
6  n=1750;
7  T=63000*hp/n;
8
9  //Torsional stress in the shaft
10 D=0.75;
11 Z1=%pi*D^3/16;
12
13 Ss=T/Z1;
14
15 mprintf('\n Torsional stress in the shaft = %f lb/in
          ^2.', Ss);
16
17 //Load at the gear pitch circle
18 Nt=40;
19 Pd=10;
```

```

20 Dp=Nt/Pd;
21
22 Ft=2*T/Dp;
23
24 mprintf('\n Load at gear pitch circle = %f lb.',Ft);
25
26 //Resultant force on the shaft
27 theta=20*%pi/180;
28 Fr=Ft/cos(theta);
29
30 mprintf('\n Resultant force = %f lb.',Fr);
31
32 //Maximum moment
33 L=15;
34 Mm=Fr*L/4;
35
36 mprintf('\n Maximum moment = %f in-lb.',Mm);
37
38 //Stress
39 D2=0.75;
40 Z2=%pi*D2^3/32;
41 Z2=round(Z2*1000)*10^-3;
42
43 S=Mm/Z2;
44
45 mprintf('\n Stress = %f lb/in^2.',S);
46
47 //Note—There is an error in the answer given in
   textbook

```

Scilab code Exa 17.2 Combined Stresses in Shaft

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.

```

```

    \n EXAMPLE-17.2 Page No.383\n');
4
5 //Combined stress using the maximum shear stress
  theorem
6
7 Ss=2170;
8 S=8780;
9 Sr=sqrt(Ss^2+(S/2)^2);
10
11 mprintf('\n Combined stress = %f lb/in^2.',Sr);

```

Scilab code Exa 17.3 Combined Stress Using Maximum Normal Stress Theory

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
  \n EXAMPLE-17.3 Page No.383\n');
4
5 //Combined stress using the maximum normal stress
  theory
6 Ss=2170;
7 S=8780;
8 Sr=S/2+sqrt(Ss^2+(S/2)^2);
9
10 mprintf('\n Combined stress = %f lb/in^2.',Sr);
11
12 //Note-There is an error in the answer given in
  textbook

```

Scilab code Exa 17.4 Comparison of Stresses to Allowable Values and Endurance Limit

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-17.4 Page No.385\n');
4
5  //Modifying factors for Sn
6  Su=88000;
7  Csize=0.85;
8  Csurface=0.88;
9  Ctype=1;
10
11  Sn=Csize*Csurface*Ctype*(0.5*Su);
12  Kt=2.3;
13  S=9300;
14
15  N=Sn/(Kt*S);
16
17  if N>2 then
18      mprintf('\n It would be an acceptable design. ');
19  else
20      mprintf('\n N<2,So this is not a suitable design
              for long term use. ');
21  end

```

Scilab code Exa 17.5 Critical Speed

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
          \n EXAMPLE-17.5 Page No.388\n');
4
5  //Deflection
6  D=0.75;
7  E=30*10^6;
8  L=15;

```

```
9 F=96;
10 I=%pi*D^4/64;
11
12 delta=F*L^4/(48*E*I);
13 delta=floor(100*delta)*10^-2;
14 Nc=188/sqrt(delta);
15
16 mprintf('\n Critical speed = %f rpm. ',Nc);
```

Chapter 18

Power Screws and Ball Screws

Scilab code Exa 18.1 Torque and Power in Power Screw

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-18.1 Page No.399\n');
4
5  //Torque
6  Dp=(1.5+1.208)/2;
7  F=5800;
8  L=1/3;
9  f=0.15;
10
11  Tup=(F*Dp/4)*(L+%pi*f*Dp)/(%pi*Dp-f*L);
12
13  mprintf('\n Torque up = %f in-lb.',Tup);
```

Scilab code Exa 18.2 Efficiency of a Power Screw

```
1  clc;
```

```

2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-18.2 Page No.400\n');
4
5 //Lead angle
6 L=1/3;
7 Dp=1.354;
8 LA=atan(L/(%pi*Dp));
9
10 mprintf('\n Lead angle = %f deg.',LA*180/%pi);
11
12 //Efficiency
13 f=0.15;
14 e=tan(LA)*(1-f*tan(LA))/(tan(LA)+f);
15
16 mprintf('\n Efficiency = %f',e*100);
17
18 //Power
19 n=175;
20 T=454;
21 P=T*n/63000;
22 Pt=P*2;
23
24 mprintf('\n Power = %f hp per lead screw.',P);
25
26 if f>tan(LA) then
27     mprintf('\n It is self-locking');
28 end

```

Scilab code Exa 18.3 Acme Threads

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
         \n EXAMPLE-18.3 Page No.402\n');

```



```

4 L=1/4;
5
6 Dp=1.375;
7 LA=atan(L/(%pi*Dp));
8
9 mprintf('\n Lead angle = %f deg.',LA*180/%pi);
10
11 //Torque
12 phi=14.5*%pi/180;
13 f=0.15;
14 F=5800;
15 Tup=(F*Dp/4)*(cos(phi)*tan(LA)+f)/(cos(phi)-f*tan(LA
    ));
16
17 mprintf('\n Torque = %f in-lb.',Tup);
18
19 //Power
20 n=175*4/3;
21 P=Tup*n/63000;
22
23 mprintf('\n Power = %f hp per lead screw.',P)

```

Scilab code Exa 18.4 Torque and Ball Screws

```

1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
    \n EXAMPLE-18.4 Page No.405\n');
4
5 //Torque
6 L=0.5;
7 F=5800/2;
8 T=0.177*F*L;
9
10 mprintf('\n Torque = %f in-lb.',T);

```

```
11
12 //Power
13 n=175*2/3;
14 P=T*n/63000;
15
16 mprintf( '\n Power = %f hp. ',P);
```

Chapter 19

Plain Surface Bearings

Scilab code Exa 19.1 Shaft Considerations

```
1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
           \n EXAMPLE-19.1 Page No.417\n');
4
5  //Length
6  F=20;
7  n=500;
8  PV=3000;
9  L1=%pi*F*n/(12*PV);
10
11 //Use 7/8-inch or longer bearing
12
13 L=7/8;
14
15 mprintf('\n Length of bearing = %f in.',L);
16
17 //Maximum pressure
18 A=(3/4)*(7/8);
19 P=F/A;
20
```

```
21 mprintf( '\n Maximum pressure = %f lb/in ^2.',P);
22
23 //Maximum velocity
24 D=3/4;
25 V=%pi*D*n/12;
26
27 mprintf( '\n Maximum velocity = %f ft/min.',V);
```

Scilab code Exa 19.2 Wear

```
1 clc;
2 clear;
3 mprintf( 'MACHINE DESIGN \n Timothy H. Wentzell , P.E.
          \n EXAMPLE-19.2 Page No.421\n');
4
5 //Life in hours of operation
6 t=0.01;
7 K=12*10^-10;
8 P=30.5;
9 V=98;
10 T=t/(K*P*V);
11
12 mprintf( '\n Life = %f hours.',T);
13
14 //Note-There is an error in the answer given in
    textbook
```

Chapter 20

Ball and Roller Bearings

Scilab code Exa 20.1 Life Expectancy of Ball Bearing

```
1 clc;
2 clear;
3 mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
         \n EXAMPLE-20.1 Page No.431\n');
4
5 //L10 design life
6 Cd=5050;
7 Pd=2400;
8 k=3;
9 Ld1=(Cd/Pd)^k*10^6;
10 Ld=Ld1/(1750*60);
11
12 mprintf('\n L10 design life = %f hr. ',Ld);
```

Scilab code Exa 20.2 Selection of Bearing to Meet Given Criteria

```
1 clc;
2 clear;
```

```

3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
      \n EXAMPLE-20.2 Page No.432\n');
4
5  //Dynamic load capacity
6  T=200;
7  n=1750;
8  L=T*n*60/10^6;
9  Pd=2400;
10 Ld=21;
11 Lc=1;
12 k=1/3;
13
14 Cd=Pd*(Ld/Lc)^k
15
16 mprintf('\n Dynamic load capacity required = %f lb.'
      ,Cd);
17
18 mprintf('\n Bearing 6211 meets this criterion.');
```

Scilab code Exa 20.3 Selection of Bearing to Meet Given Criteria

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell, P.E.
      \n EXAMPLE-20.3 Page No.434\n');
4
5  R=1200;
6  Ft=500;
7  n=1500;
8  L10=5000;
9
10 //Assume thrust factor=1.6
11
12 Y=1.6;
13
```

```

14 Pd=0.56*R+Y*Ft;
15
16 Ld=n*L10*60/10^6;
17 Lc=1;
18 k=3;
19 Cd=Pd*(Ld/Lc)^(1/k);
20
21 //For bearing number 6215
22
23 Cd1=11400;
24 Cs1=9700;
25
26 //Verify the assumption for Y
27 Ft_Cs1=Ft/Cs1;
28
29 Y=(0.056-Ft_Cs1)*(1.99-1.71)/(0.056-0.028)+1.71;
30
31 Pd=0.56*R+Y*Ft;
32
33 Cd=Pd*(Ld/Lc)^(1/k);
34
35 if Cd>Cd1 then
36     mprintf('\n Since Cd of bearing < Cd required ,
37         So bearing number 6215 is not acceptable. ');
38
39 //For bearing number 6216
40 Cd2=12600;
41 Cs2=10500;
42
43 Ft_Cs2=Ft/Cs2;
44 Y=(0.056-Ft_Cs2)*(1.99-1.71)/(0.056-0.028)+1.71;
45
46 Pd=0.56*R+Y*Ft;
47
48 Cd=Pd*(Ld/Lc)^(1/k);
49
50 if Cd<Cd2 then

```

```

51     mprintf('\n Since Cd of bearing > Cd required ,
        So bearing number 6215 meets the design
        criteria. ');
52 end

```

Scilab code Exa 20.4 Life of 6200 Series Bearing

```

1  clc;
2  clear;
3  mprintf('MACHINE DESIGN \n Timothy H. Wentzell , P.E.
        \n EXAMPLE-20.4 Page No.436\n');
4
5  //Thrust factor
6  Ft=300;
7  Cs=2320;
8  Ft_Cs=Ft/Cs;
9
10 Y=(0.17-Ft_Cs)*(1.45-1.31)/(0.17-0.11)+1.31;
11
12 mprintf('\n Thrust factor = %f ',Y);
13
14 V=1.2;
15 X=0.56;
16 R=1000;
17
18 P=V*X*R+Y*Ft;
19
20 Cd=3350;
21 Pd=1095;
22 k=3;
23
24 Ld=(Cd/Pd)^k*10^6;
25
26 mprintf('\n Life = %f revolutions. ',Ld);

```
