Scilab Textbook Companion for Advanced Engineering Fluid Mechanics by K. Muralidhar and G. Biswas[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 2

Derivation of Equations Governing Fluid Motion

Scilab code Exa 2.5 Pressure Drop

```scilab
1 //Example 2.5
2 //Pressure Drop
3 //Page No. 56
4 clc;clear;close;
5
6 D=50;      //in mm
7 D=D/1000; //converted mm to m
8 u=5;         //in m/s^-1
9 L=6;      //in m
10 rho=995.6;      //in kg/m^-3
11 mu=79.77*10^-5;      //Pa-s
12 Re=(rho*u*D)/mu;
13 f=0.316/Re^(1/4);
14 dp=(f*L*u^2*rho)/(2*D);
15 m=rho*u*%pi*(D/2)^2;
16 P=m*dp/rho;
17 printf('\nPressure Drop = %f N/m^2\nPower Required =
       %f\n\n\n\nNote : Calculation mistakes in book.\
     nDifference in answer due to approximation in
```

```
      book ' , dp , P ) ;
```

Scilab code Exa 2.6 Pressure Drop

```scilab
 1  //Example  2.6
 2  // Pressure  Drop
 3  // Page  No.  56
 4  clc ; clear ; close ;
 5
 6  D =50;           // in  mm
 7  D = D /1000;  // converted  mm to  m
 8  L =6;    // in  m
 9  rho =995.6;         // in  kg/mˆ3
10  g =9.81;           // in  m/ sˆ−2
11  mu =79.77*10ˆ -5;      // in  Pa−s
12
13  // case  1
14  u =10;           // in  m/ sˆ−1
15  Re =( rho * u * D ) / mu ;
16  f =0.316/ Re ˆ(1/4) ;
17  dp (1) =( f * L * u ˆ2* rho ) /(2* D ) ;
18
19
20  // case  2
21  u =20;                // in  m/ sˆ−1
22  Re =( rho * u * D ) / mu ;
23  f =0.316/ Re ˆ(1/4) ;
24  dp (2) =( f * L * u ˆ2* rho ) /(2* D ) ;
25
26  u1 =[10  20];      // in  m
27  h_l =[ dp (1) /( rho * g )  dp (2) /( rho * g ) ];
28  f = interpln ([ h_l ; u1 ] ,20) *% pi * D ˆ2/4;
29  f = f *1000;             // conversion  to  lit / s
30  printf ( ' \ nFlow  Rate  =  %g  lit / s \ n \ nNote :  Slight
         calculation  errors  in  the  book ' , f ) ;
```

6

Chapter 5

Laminar Boundary Layers

Scilab code Exa 5.1 Skin Friction Drag

```
1  //Example 5.1
2  //Skin Friction Drag
3  //Page No. 288
4  clc;clear;close;
5
6  u=3;                //in m/s
7  L=1;                //in m
8  b=2;                //in m
9  rho=1.23;            //in kg/m^3
10 mu=1.46*10^-5;        //in m^2/s
11 Re=(u*L)/mu;
12 Cf=1.328/Re^(1/2);
13 F=Cf*rho*u*u*L*b/2;
14 d1=L*5/(Re)^(1/2);
15 d2=L*1.7208/(Re)^(1/2);
16 d3=L*0.664/(Re)^(1/2);
17 d1=d1*1000;        //conversion to mm
18 d2=d2*1000;        //conversion to mm
19 d3=d3*1000;        //conversion to mm
20 printf('\nDrag on the plate = %f N\nBoundary Layer
        Thickness = %f mm\nDisplacement Thickness = %f mm
```

```
\nMomentum  Thickness = %f mm\n\n\n\n',F,d1,d2,d3)
  ;
```

Scilab code Exa 5.2 Maximum Bending Moment

```scilab
1  //Example  5.2
2  //Maximum  Bending  Moment
3  //Page  No.  290
4  clc ; clear ; close ;
5
6  u =1.5;              // in  m/s
7  L =6;                // in  m
8  A =.15;              // in  m
9  rho =1000;           // in  kg/m^3
10 mu =1.02*10^-6;        // in  m^2/s
11 Cd =2.1;
12 Re =( u*A )/ mu ;
13 F = Cd* rho* u* u* L* A /2;
14 Mo = F* L /2;
15 I =( A ^4) /12;
16 sigma = Mo *( A /2)/ I ;
17 sigma = sigma /1000;      // conversion  to  kN/m^2  from  N
       /m^2
18 printf ( '\nDrag = %f  N\nBending  Moment  at  the  Base =
        %f  Nm\nBending  Stress  at  the  Bottom = %f  kN/m^2\n
       \n',F ,Mo ,sigma );
```

Scilab code Exa 5.5 Velocity Boundary Layer

```scilab
1  //Example  5.5
2  //Velocity  Boundary  Layer
3  //Page  No.  294
4  clc ; clear ; close ;
```

9

```
 5
 6  U=2;                //in m/s
 7  L=0.1;                //in m
 8  x=0.05;            //in m
 9  y=0.000225;                //in m
10  rho=983.1;            //in kg/m^3
11  f=0.629;         //refer book table 5.1;
12  mu=0.4748*10^-6;      //m^2/s
13  Re=(U*x)/mu;
14  d1=x*5/(Re)^(1/2);
15  n=y*(U/(mu*x))^(1/2);
16  u=U*f;
17  Re_L=U*L/mu;
18  Cf=1.328/Re_L^(1/2);
19  F=Cf*rho*U*U*L/2;
20  printf('\nThickness of velocity boundary layer at x
        = 5cm = %f m\nFluid Velocity at y = 0.0225cm = %f
         m/s\nDrag = %f N\n\n',d1,u,F);
```

Scilab code Exa 5.6 Velocity Boundary Layer

```
 1  //Example 5.6
 2  //Velocity Boundary Layer
 3  //Page No. 295
 4  clc;clear;close;
 5
 6  U=2;                    //in m/s
 7  L=0.1;                   //in m
 8  x=0.05;                  //in m
 9  y=0.000225;                //in m
10  rho=983.1;                //kg/m^3
11  mu=0.4748*10^-6;           //m^2/s
12  Re=(U*x)/mu;
13  d1=x*4.64/(Re)^(1/2);
14  n=y/d1;
```

```
15  u=U*(3*n-n^3)/2;
16  Tw=(0.323275*rho*U^2)/sqrt(Re);
17  Re_L=U*L/mu;
18  Cf=1.292/Re_L^(1/2);
19  F=Cf*rho*U*U*L/2;
20  printf('\nThickness of velocity boundary layer at x
        = 5cm = %f m\nFluid Velocity at y = 0.0225cm = %f
        m/s\nDrag = %f N\n\n',d1,u,F);
```

Scilab code Exa 5.7 Pressure Change

```
1  //Example 5.7
2  //Pressure Change
3  //Page No. 296
4  clc;clear;close;
5
6  U0=30;              //in m/s
7  h=80;               //in mm
8  d1=1;               //in mm
9  rho=1.23;           //in kg/m^3
10 dp=(rho*U0*U0/2)*(((h^2)/(h-2*d1)^2)^2-1);
11 printf('\nPressure Change = %f N/m^2\n\n',dp);
```

Scilab code Exa 5.9 Mass Flow Rate

```
1  //Example 5.9
2  //Mass Flow Rate
3  //Page No. 298
4  clc;clear;close;
5
6  L=1;                //in m
7  b=0.3;              //in m
8  U=30;               //in m/s
```

```
 9  d1 =0.0024;            // in  m
10  rho =1.23;             // in  kg/m^3
11  m_ab=rho*U*b*d1/2;
12  Rx =-1*rho*U*U*b*d1/6;
13  Rx =-1*Rx;
14  printf('\nMass flow rate across surface ab = %f kg/s
        \nThe force required to hold the plate in
        position is = %f N\n\n',m_ab,Rx);
15  printf('\n\n\nNote: Computational errors in book');
```

Scilab code Exa 5.10 Mass flow within boundary layer

```
 1  //Example 5.10
 2  //Mass flow within boundary layer
 3  //Page No. 300
 4  clc;clear;close;
 5
 6  U=2;               // in m/s
 7  x1 =0.1;           // in m
 8  x2 =0.3;           // in m
 9  rho =1.17;         // in kg/m^3
10  nu =1.85*10^-5;          // in kg/ms
11  Re_x1=(rho*U*x1)/nu;
12  Re_x2=(rho*U*x2)/nu;
13  d1 =4.64*x1/sqrt(Re_x1);
14  d2 =4.64*x2/sqrt(Re_x2);
15  m=5*rho*U*(d2-d1)/8;
16  printf('\nMass flow rate = %f kg/s\n\n\n',m);
```

Chapter 7

Turbulent Flow

Scilab code Exa 7.2 Power required

```
1  //Example 7.2
2  //Power required
3  //Page No. 429
4  clc;clear;close;
5
6  Q=1;                //in m^3/s
7  D_i=0.5;            //in m
8  rho=1000;           //kg/m^3
9  nu=1.02*10^-6;          //in m^2/s
10 g=9.81;             //in m/s^2
11 U_av=Q/(%pi*D_i^2/4);
12 Re=U_av*D_i/nu;
13 f=0.01;
14 Fric_loss=f*U_av^2/(D_i*2*g);
15 P=Fric_loss*rho*g*Q;
16 printf('Power required = %f kW/km',P)
```

Scilab code Exa 7.3 Friction Factor

13

```
1  //Example 7.3
2  // Friction  Factor
3  //Page No.  430
4  clc ; clear ; close ;
5
6  D =60;        //  in  mm
7  Ep =1.2;          //in  mm
8  Re =10^8;
9  Factor=Ep/(D/2);
10
11 f =1/(1.74 -2* log10 ( Factor ))^2;
12 Er=1/ sqrt (f) -(1.74 -2* log10 ( Factor +18.7/( Re* sqrt (f )))
       );
13 printf ('f = %f \nEr = %f ',f , Er );
14 f1 =[0.0485 ,0.049 ,0.0475];
15 for  i =1:3
16     Er=1/ sqrt ( f1(i)) -(1.74 -2* log10 ( Factor +18.7/( Re*
           sqrt ( f1(i)))));
17     printf ('\n\nf = %f \nEr = %f ', f1 (i) , Er );
18 end
19 printf ('\n\nSince  minimum  error  value  is  shown  by  f
       =0.048605 ,  that  is  taken  to  be  final  answer \nNote
        :  Computational  error  in  book ')
```

Scilab code Exa 7.4 Developed flow of water

```
1  //Example  7.4
2  // Developed  flow  of  water
3  //Page No.  431
4  clc ; clear ; close ;
5
6  D =6;            //in  mm
7  D=D/100;         // conversion  to  m
8  R=D/2;
9  Q =5*10^ -3;     // conversion  to  m^3/s
```

```
10  L=10;                    //in m
11  n=7;                     //no unit
12  rho=1000;                //in kg/m^3
13  nu=1.02*10^-6;     //in m^2/s
14  U_av=Q/(%pi*D^2/4);
15  Re=U_av*D/nu;
16  f=0.3164/Re^(1/4);
17  Pg=(f*rho*U_av^2)/(2*D);              //Pressure
        Gradient
18  Pd=Pg*L;                              //Pressure Drop
        over 10m
19  Tw=Pg*R/2;
20  u_s=U_av*(n+1)*(2*n+1)/(2*n^2);
21  ds=(Tw*R^(1/7)/(nu*u_s*1000))^(-7/6);        //
        Thickness of laminar sublayer
22  printf('\nFriction Factor = %f \nPressure Drop over
        10m = %f N/m^2\nThickness of laminar sublayer =
        %f m',f,Pd,ds);
23  printf('\n\n\nNote: Slight computational errors in
        book')
```

Scilab code Exa 7.5 Drag force

```
1  //Example 7.5
2  //Drag force
3  //Page No. 433
4  clc;clear;close;
5
6  U=3;              //in m/s
7  b=1;              //in m
8  L=1;              //in m
9  Re_x=5*10^5;        //no unit
10  rho=1025;          //in kg/m^3
11  nu=1.044*10^-6;          //in m^2/s
12  Re_l=U*L/nu;          //reynolds number on the basis
```

```
      of keel length
13
14  //assuming turbulent boundary-layer
15  Cf =0.074/ Re_l ^(1/5) ;
16  Tw = rho * U ^2* Cf /2;
17  D1 = Tw * b * L ;
18  Df =2* D1 ;
19  printf ('\ nTotal Drag Force on the keel (assuming
        turbulent boundary-layer )= %f N ',Df );
20
21  //taking into account the growth of laminar growtn
        boundary
22  x_tr = Re_x * nu / U ;
23  d_tr = x_tr *5/ sqrt ( Re_x );
24  Cf_lam =1.328/ sqrt ( Re_x );
25  D1 = rho * U ^2* b *( Cf * L - Cf * x_tr + Cf_lam * x_tr )/2;
26  Df =2* D1 ;
27  printf ('\ nTotal Drag Force on the keel (taking into
        account the growth of laminar growtn boundary )=
        %f N \n \n \ nNote : Computational Error in the book ',
        Df );
```

Scilab code Exa 7.6 Moody design

```
 1  //Example 7.6
 2  //Moody design
 3  //Page No. 435
 4  clc ; clear ; close ;
 5
 6  U =3;              //in m/s
 7  b =1;                //in m
 8  L =800;          //in m
 9  Re_x =10^6;          //no unit
10  rho =1000;              //in kg/m^3
11  nu =1.02*10^ -6;          //in m^2/s
```

```
12  ut_ep_v=100;                  //no unit
13
14  //calculation via trial and error cannot be shown
        here
15  x=268;          // = R/e_p
16  u_t=U/(2.5*log(x)+8.5);
17  e_p=ut_ep_v*nu/u_t;
18  R=x*e_p;
19  D=2*R;
20  f=0.023;            //no unit
21  yl=5*nu/u_t;
22  yb=13*yl;
23  yl=yl*10^3;      //conversion to mm
24  yb=yb*10^3;      //conversion to mm
25  P=%pi*rho*nu*L*u_t^2*Re_x;
26  printf('\nDiameter = %g m\nLaminar Sub-Layer
        Thickness = %g mm\nBuffer Layer Thickness = %g mm
        \nPower required = %g W',D,yl,yb,P);
```

Chapter 9

Experimental Techniques

Scilab code Exa 9.8 Students t distribution

```
1  //Example  9.8
2  //Student's t-distribution
3  //Page No.  553
4  clc;clear;close;
5
6  n=9;
7  x_avg=17;
8  sigma=4;
9  t=2.31;           //from  table  A2  in  book
10 printf('\nx = %i +- %.2f\nx_avg = %i +- %.2f',x_avg,
       t*sigma,x_avg,t*sigma/sqrt(n));
```

Scilab code Exa 9.9 Students t distribution

```
1  //Example  9.9
2  //Student's t-distribution
3  //Page No.  553
4  clc;clear;close;
```

```
 5
 6  n=4;
 7  t=3.18;              //from  table  A2  in  book
 8  x=[65.3,68.2,67.7,66.4];
 9  x_avg=(x(1)+x(2)+x(3)+x(4))/4;
10  sigma=1.308;
11  printf('\nx = %.1f +- %.2f\nx_avg = %.1f +- %.3f',
        x_avg,t*sigma,x_avg,t*sigma/sqrt(n));
```