Scilab Textbook Companion for Introduction To Fluid Mechanics by James A. Fay[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

INTRODUCTION

Scilab code Exa 1.1 The rise in sea level

```
// Example 1_1
clc;funcprot(0);
// Given data
h_avg=3800;// The ocean's average depth in m
deltaT=1;// The increase in ocean temperature in K
alpha=1.6*10^-4;// The average thermal expansion
    coefficient in K^-1

// Calculation
deltah=alpha*deltaT*h_avg;// The rise in sea level
    in m
printf('\nThe rise in sea level is %0.3f m',deltah);
```

Scilab code Exa 1.2 The partial density of oxygen

```
// Example 1_2
clc;funcprot(0);
// Given data
```

```
T=98.6;// Temperature in  F
p=1.0133*10^5;// Pressure in N/m^2
M=32;// The molecular weight of oxygen
R=8.3143*10^3;// Universal gas constant in J/kg.K
O=20/100;// The maximum oxygen concentration in oxygenated blood in %

// Calculation
rho=(p*M)/(R*(273.15+((5/9)*(T-32))));// Density in kg/m^3
rho_O2=O*rho;// The partial density of blood oxygen in kg/m^3
printf("\nThe partial density of oxygen in blood at this concentration is %0.4f kg/m^3",rho_O2);
```

Scilab code Exa 1.3 How many cubic meters of water are there in one acre foot

```
// Example 1_3
clc;funcprot(0);
// Given data
// From table 1.6
// Conversion between EES and SI units
ft=3.048*10^-1;// Conversion of EES uint of foot to SI unit value(m)
acre=4.048*10^3;// Conversion of EES uint of acre to SI unit value(m^2)

// Calculation
acreft=1*acre*ft;// m^3
printf("\n%0.0f cubic meters of water are there in one acre-foot",acreft);
```

Chapter 2

FLUID STATICS

Scilab code Exa 2.1 The pressure force per unit volume

```
// Example 2_1
clc;funcprot(0);
// Given data
p_0=1.0133*10^5;// The sea level pressure in Pa
alpha=1.2*10^-4;// m^-1

// Calculation
z=0;// km
minusdelp=alpha*p_0*exp(-alpha*z);// The pressure
    force per unit volume in N/m^3
printf("\nAt z=0,The pressure force per unit volume
    -delp=(%0.2f N/m^3)i_z",minusdelp);
z=5;// km
minusdelp=alpha*p_0*exp(-alpha*z*10^3);// The
    pressure force per unit volume in N/m^3
printf("\nAt z=5,The pressure force per unit volume
    -delp=(%0.3f N/m^3)i_z",minusdelp);
```

Scilab code Exa 2.3 The total force exerted on the plate

```
// Example 2_3
clc;funcprot(0);
// Given data
D=1;// The diameter of a circular flat plate in m
h=3;// Distance in m
theta=45;// Angle in degrees
rho=1*10^3;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
p_c=rho*g*h;// The gage pressure at the plate
    centroid in Pa
A=(%pi*D^2)/4;// Area in m^2
F=p_c*A;// The total force exerted on the plate by
    the water in N
printf("\nThe total force exerted on the plate by
    the water,F=%1.3e N",F);
y_cp=-(rho*g*D^2)/(16*sqrt(2)*p_c);// The distance
    between the center of pressure cp and the
    centroid of the circular plate in m
printf("\nThe distance between the center of
    pressure cp and the centroid of the circular
    plate,y_cp=%1.3e m",y_cp);
```

Scilab code Exa 2.7 The minimum ratio of width to height

```
// Example 2_7
clc;funcprot(0);
// Given data
//The block has a width W, a height H and a specific
     gravity SG.
// GM=0;

//Solution
SG=(3-sqrt(3))/6;
```

```
printf("\nSG<=%0.4f",SG)
SG=(3+sqrt(3))/6;
printf("\nSG>=%0.4f",SG)
printf("\nIce cubes and styrofoam cubes will float upright, but not soap cubes!");
```

Scilab code Exa 2.8 The gage pressure at the bottom of the tank

```
// Example 2_8
clc;funcprot(0);
// Given data
d=3;// The internal diameter of a horizontal cylindrical fuel oil storage tank in m
SG=0.87;// Specific gravity of water oil
t=0.2;// Thickness in m
z_0=0;// The initial height in m
z_1=-1.3;// The height of the water-oil interface in m
z_2=-1.5;// The height of the bottom of the tank in m
rho_w=1*10^3;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
p_bminusp_0=rho_w*-g*((SG*(z_1-z_0))+(z_2-z_1));// The gage pressure at the bottom of the tank in Pa
printf("The gage pressure at the bottom of the tank is %0.4e Pa",p_bminusp_0);
```

Scilab code Exa 2.9 The temperature pressure and density of the U S Standard Atmos

```
// Example 2_9
clc;funcprot(0);
```

```
// Given data
// From table 2.1
z=5;// Altitude in km
z_i=0;// The initial height in km
dTbydz=-6.5;// The temperature gradient from 0 to 5 km in K/km
T_i=288.15;// Temperature in K
p_i=1.0133*10^5;// Pressure in Pa
R=287;// Gas constant in J/kg.K

//Calculation
// Using equation 2.41,
T=T_i+((dTbydz)*(z-z_i));// Temperature in K
// Using equation 2.42,
p=p_i*(T/T_i)^(-1/((dTbydz*10^-3)*29.26));// The pressure in Pa
rho=p/(R*T);// The density in kg/m^3
printf("\nT=%0.1f K \np=%1.4e Pa \nrho=%0.4f kg/m^3",T,p,rho);
```

Scilab code Exa 2.10 The approximate maximum diameter d

```
// Example 2_10
clc;funcprot(0);
// Given data
rho_w=1*10^3;// The density of water in kg/m^3
r=7.3*10^-2;// The air/water interfacial tension in N/m
g=9.8066;// The acceleration due to gravity in m/s^2

// Calculation
d=sqrt((6*r)/(rho_w*g))*10^3;// The approximate maximum diameter d of a bubble of air in water in mm
printf("\nThe approximate maximum diameter d of a
```

```
bubble of air in water is %1.1f m",d);
```

Chapter 3

CONSERVATION OF MASS

Scilab code Exa 3.5 The volume flow rate Q of water through the pump

```
// Example 3_5
clc;funcprot(0);
// Given data
R=1;// The radius of a cylindrical tank in m
V_w=1;// The  velocity in mm/s

// Calculation
Q=%pi*R^2*V_w*10^-3;// The volume flow rate of water
    through the pump in m^3/s
printf("\nThe volume flow rate Q of water through
   the pump is %1.3e m^3/s",Q);
```

Scilab code Exa 3.6 The velocity V of the water leaving the nozzle

```
// Example 3_6
clc;funcprot(0);
// Given data
Q=1*10^3;// The water volume flow rate in m^3/s
```

```
D=2;// The diameter of the fire hose at exit nozzle
   in inch

// Calculation
V=(4*(Q/60)*3.785*10^-3)/(%pi*(D*2.54*10^-2)^2);//
   The velocity of the water leaving the nozzle in m
   /s
// We have used table 1.6 to convert gallons to
   cubic meters.
printf("\nThe velocity of the water leaving the
   nozzle,v=%2.2f m/s",V);
```

Scilab code Exa 3.9 The volume of fresh water

```
// Example 3_9
clc;funcprot(0);
// Given data
v=10;// The volume of the tank in m^3
rho_s0=3.0;// The initial salt density in kg/m^3
t=0;// Time in s
Q=0.01;// The volume flow rate in m^3/s

// Calculation
// (b)
// V=Q*t;
V=v*log(2);//
printf("\nThe volume of fresh water,V=%0.3f m^3",V);
```

Chapter 4

INVISCID FLOW

Scilab code Exa 4.4 The maximum value of h

```
// Example 4_4
clc;funcprot(0);
// Given data
V_1=50;// Velocity in m/s
alpha=45;// Angle in degree
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
w_1=V_1*sind(alpha);// m/s
h=(w_1)^2/(2*g);// Height in m
printf("\nThe maximum value of h is %2.2f m",h)
```

Scilab code Exa 4.5 The power required

```
// Example 4_5
clc;funcprot(0);
// Given data
rho=1.225;// The density of air in kg/m^3
```

```
A_0=1.0;// Area of orifice in cm^2
A_pV=2.5*10^-4;// The volumetric flow rate in m^3/s

// Calculation
P=(rho*(A_pV)^3)/(2*(A_0*10^-4)^2);// The power expended in inhaling in W
printf("\nThe power P expended in inhaling (or exhaling) is %1.2e W",P)
```

Scilab code Exa 4.6 how long it will take for the oil to drain completely from the

```
// Example 4_6
clc;funcprot(0);
// Given data
D_t=30;// The diameter of an oil storage tank in m
H=5;// The depth of the oil in m
D_p=5;// The inside diameter of pipe in cm
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
t=(D_t/(D_p/100))^2*sqrt((2*H)/g);// Time in s
t=t/3600;// Time in hours
printf("\nIt will take %3.0f hr for the oil to drain completely from the tank.",t)
```

Scilab code Exa 4.8 The location and value of the maximum pressure in the tank

```
// Example 4_8
clc;funcprot(0);
// Given data
rho=8.6*10^2;// The density of gasoline in kg/m^3
L=1.0;// The tank length in m
H=0.6;// The tank height in m
```

```
g=9.807; // The acceleration due to gravity in m/s^2

// Calculation
p=rho*g*(H+(2*L)); // Pa
printf("\nThe maximum pressure in the tank,p=p_a+%1
    .3e Pa",p)
```

Scilab code Exa 4.9 The height h

```
// Example 4_9
clc;funcprot(0);
// Given data
R=5; // The radius of a jar in cm
n=33; // tThe turntable has been revolving at a
    steady speed in rpm
g=9.807; // The acceleration due to gravity in m/s^2

// Calculation
omega=(2*%pi*n)/60; // Acceleration
h=(omega*R*10^-2)^2/(2*g); // The height h in m
printf("\nThe height,h=%1.3e m",h);
```

Chapter 5

CONSERVATION OF MOMENTUM

Scilab code Exa 5.4 The force that the fire man exerts on the hose nozzle to hold

```
// Example 5_4
clc;funcprot(0);
// Given data
Q=150;// The water stream volume flow rate in gal/
   min
D=1;// The nozzle exit diameter in inch
rho=1*10^3;// The density of water in kg/m^3

// Calculation
Q=(Q*3.785*10^-3)/60;// The water stream volume flow
    rate in m^3/s
V_out=(4*Q)/(%pi*(D*2.54*10^-2)^2);// The velocity
   in m/s
F_e=rho*Q*V_out;// The force in N
F_e=F_e/4.448;// The force in lbf
printf("\nThe force,F_e=%2.2f lbf",F_e);
```

Scilab code Exa 5.5 The force F exerted on the nozzle by the coupling

```
// Example 5_5
clc;funcprot(0);
// Given data
D=1;// Diameter of hose at inlet in inch
d=2;// Diameter of hose at outlet in inch
// From example 5.4,F_e=rho*Q*V_out
F_e=176.8;// The force in N

// Calculation
// F_c=rho*Q*V_out*[1/2*((A_in/A_out)+(A_out/A_in)
    -1];
// A_in=4*A_out
F_c=F_e*((1/2)*(4+(1/4))-1);// The force exerted on
    the nozzle by the coupling in N
printf("\n The force exerted on the nozzle by the
    coupling,F_c=%3.1f N",F_c);
```

Scilab code Exa 5.6 The restraining force F required to hold the rocket in place

```
// Example 5_6
clc;funcprot(0);
// Given data
m=2;// The mass flow rate in kg/s
V_e=200;// The rocket exhaust velocity in m/s

// Calculation
F=m*V_e;// The restraining force required to hold
    the rocket in place in N
printf("\nThe restraining force required to hold the
     rocket in place,F_c=%0.0f N",F);
```

Scilab code Exa 5.7 The value of the force F exerted on the engine by the airframe

```
// Example 5_7
clc;funcprot(0);
// Given data
V_f=250;// The speed of flight in m/s
rho_a=0.4;// The density of air in kg/m^3
A_in=1;// The inlet area in m^2
m_f=2;// The mass flow rate of fuel in kg/s
V_e=500;// The speed of exhaust jet in m/s

// Calculation
m_in=rho_a*V_f*A_in;// The mass flow rate of air at
    inlet in kg/s
m_out=m_in+m_f;// The mass flow rate of air at
    outlet in kg/s
F=(m_out*V_e)-(m_in*V_f);// The force exerted on the
     engine by the airframe in N
printf("\nThe value of the force F exerted on the
    engine by the airframe is %1.1e N",F);
```

Scilab code Exa 5.8 The wake speed The propulsive efficiency and the engine power

```
// Example 5_8
clc;funcprot(0);
// Given data
V_f=200;// The speed of flying air plane in km/h
rho=1.2;// The density of air in kg/m^3
F=3*10^3;// The propulsive force in N
D_p=2;// The diameter of the propeller in m

// Calculation
// (a)
V_f=(V_f*10^3)/3600;// The speed of flying air plane
     in m/s
```

```
A_p=(%pi*D_p^2)/4;// Area of propeller in m^2
V_w=sqrt((V_f^2)+((2*F)/(rho*A_p)));// The wake speed in m/s
printf("\nThe wake speed,V_w=%2.2f m/s",V_w);

// (b)
n_prop=(2*V_f)/(V_w+V_f)*100;// The propulsive efficiency in %
printf("\nThe propulsive efficiency is %2.2f percentage",n_prop);
// (c)

P_p=(F*(V_w+V_f))/(2*10^3);// The engine powerin kW
printf("\nThe engine power for this air craft is %3.1f kW",P_p);
```

Scilab code Exa 5.9 The maximum power that can be generated by a wind turbine

```
// Example 5_9
clc;funcprot(0);
// Given data
D=6;// The diameter of wind turbine in m
V_w=20;// The wind speed in m/s
rho=1.2;// The density of air in kg/m^3

// Calculation
A_p=((%pi/4)*(6)^2);// m^2
maxP_wt=((8/27)*(rho)*A_p*(V_w*0.447)^3)/1000;// The maximum power that can be generated by a wind turbine in kW
printf("\nThe maximum power that can be generated by a wind turbine is %1.3f kW",maxP_wt);
```

Scilab code Exa 5.10 The wake speed

```
// Example 5_10
clc;funcprot(0);
// Given data
A_w=100;// The wake area in m^2
x=100;// m
// From example 5.7,
rho_w=0.4;// The density of air in kg/m^3
V_f=250;// The speed of flight in m/s
F=2.6*10^4;// The restraining force in N

// Calculation
V_w=V_f+(F/(rho_w*A_w*V_f));// m/s
printf("\nThe wake speed,V_w=%3.1f m/s",V_w);
```

Scilab code Exa 5.11 what is the value of the jet speed at that point

```
// Example 5_11
clc;funcprot(0);
// Given data
V_s=1;// The speed of water jet in m/s
D_s=3;// The diameter of a hole in cm
D_j=10;// The jet diameter in cm
x=1;// Distance from the source in m

// Calculation
V_j=V_s*(D_s/D_j);// m/s
printf("\nThe value of the jet speed V_j at that point is %0.1f m/s.",V_j);
```

Scilab code Exa 5.12 The pressure rise in the jet pump

```
// Example 5_12
clc;funcprot(0);
// Given data
D_s=1;// The diameter of jet in  inch
D=3;// The inside diameter of a pipe in inch
Q_s=100;// The jet volumetric flow rate in GPM (
   gallons per minute)
Q_1=500;// The volumetric flow rate in GPM
rho=1*10^3;// The density of water in kg/m^3

// Calculation
A_s=(%pi/4)*(D_s*2.54*10^-2)^2;// m^2
A=9*A_s;// m^2
Q_s=(Q_s*3.785*10^-3)/60;// m^3/s
Q_1=5*Q_s;// m^3/s
V_1=Q_1/(A-A_s);// m/s
V_s=Q_s/A_s;// m/s
// Assume dp=p_2-p_1;
dp=(A_s/A)*(1-(A_s/A))*rho*(V_s-V_1)^2;// The
   pressure rise in the jet pump in Pa
printf("\nThe pressure rise in the jet pump,p_2-p_1=
   %1.3e Pa",dp);
```

Scilab code Exa 5.13 The maximum power of the turbine

```
// Example 5_13
clc;funcprot(0);
// Given data
h=100;// Height in m
A_n=1.0;// The area of the turbine jet stream in in
   ^2
alpha=20;// The blade angle in degree
g=9.807;// The acceleration due to gravity in m/s^2
rho=1*10^3;// The density of water in kg/m^3

```

```
// Calculation
// (a)
V_n=sqrt(2*g*h);// The nozzle velocity V_n in m/s
printf("\n(a)The nozzle velocity V_n=%2.2f m/s",V_n)
    ;
// (b)
maxP_b=((1+cosd(alpha))/2)*(rho*(A_n*2.54*10^-2)^2*(
    V_n^3/2))/1000;// The maximum power P, of the
    turbine in kW
printf("\n(b)The maximum power P_t of the turbine is
     %2.2f kW.",maxP_b);
// (c)
V_b=V_n/2;// The blade speed in m/s
F_b=rho*(A_n*2.54*10^-2)^2*(V_n-V_b)^2*(1+cosd(alpha
    ));// The force in N
printf("\n(c)The blade speed,V_b=%2.2f m/s \n    The
    force when maximum power is being produced,F_b=%3
    .1f N",V_b,F_b);
```

Scilab code Exa 5.16 The velocity V of the fluid stream relative to the ground

```
// Example 5_16
clc;funcprot(0);
// Given data
A=10;// The internal area of the rotating tube  in
    mm^2
V=5;// The speed of water flow in m/s
alpha=30;// Angle in degree
R=10;// The tip radial dimension in mm
T=2*10^-2;// Torque in Nm
rho=1*10^3;// The density of water in kg/m^3

// Calculation
omega=(V/(R*10^-2)*cosd(alpha))-((T)/(2*rho*(A
    *10^-6)*(R/100)^2*V));// The angular speed of the
```

```
    sprinkler rotor in s^-1
V=[(V*sind(alpha)),((V*cosd(alpha))-(omega*R*10^-2))
   ];// The velocity V of the fluid stream relative
   to the ground in m/s
printf("\n(a)The angular speed of the sprinkler
   rotor,omega=%2.2f s^-1 \n(b)The velocity V in the
    ground reference frame is:V=(%1.1f m/s)i_r+(%1.1
   f m/s)i_theta",omega,V(1),V(2));
```

Chapter 6

LAMINAR VISCOUS FLOW

Scilab code Exa 6.1 The numerical values of all the viscous stress components

```
// Example 6_1
clc;funcprot(0);
// Given data
a=1.0;// s^-1
b=0.1;// s^-1
c=2.0;// s^-1,where a,b,c are constants
z=1;// m
mu=1.82*10^-5;// Pa s

// Calculation
tau_xz=mu*(a-(2*b*z));// The non-zero viscous stress
    component in Pa
tau_zx=tau_xz;// The non-zero viscous stress
   component in Pa
tau_yz=mu*c;// The non-zero viscous stress component
    in Pa
tau_zy=tau_yz;// The non-zero viscous stress
   component in Pa
printf("The numerical values of all the viscous
   stress components,tau_xz=tau_zx=%1.3e Pa & tau_yz
   =tau_zy=%1.2e Pa",tau_xz,tau_yz);
```

Scilab code Exa 6.2 The value of DELTA p

```
// Example 6_2
clc;funcprot(0);
// Given data
a=1.0;// s^-1
b=0.1;// s^-1
c=2.0;// s^-1  where a,b,c are constants
z=1;// m
mu=1.82*10^-5;// Pa s

// Calculation
delp=mu*(2*b);// Pa/m
printf("[delp=%1.2e Pa/m] i_x",delp)
```

Scilab code Exa 6.4 The torque T applied to the shaft to overcome the friction

```
// Example 6_4
clc;funcprot(0);
// Given data
D=10;// The diameter of circular shaft in cm
L=10;// The bearing length in cm
h=0.1;// The gap betwen the shaft and the bearing in
   mm
mu=6.7*10^-5;// Viscosity in Pa/s
n=3600;// rpm

// Calculation
omega=(2*%pi*n)/60;// s^-1
T=(%pi*mu*omega*(L/100)*(D/100)^3)/(4*(h/1000));//
   The torque applied to the shaft in Nm
```

```
P=T*omega;// The power consumed in the bearing by
    friction in W
printf("\nThe torque applied to the shaft,T=%1.3e Nm
    \nThe power consumed in the bearing by friction,
    P=%1.3f W",T,P);
```

Scilab code Exa 6.5 The volume flow rate of rainwater through the crack

```
// Example 6_5
clc;funcprot(0);
// Given data
W=1.0;// Width of concrete slabs in m
L=0.1;// Depth in m
h=1.0;// Width of a crack in mm
mu=1.13*10^-3;// Pa s
rho=1*10^3;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
Q=(rho*g*(h*10^-3)^3*W)/(12*mu);// m^3/s (or) l/s
printf("\nThe volume flow rate of rainwater through
    the crack,Q=%1.3e m^3/s (or) %0.4f l/s",Q,Q*1000)
    ;
```

Scilab code Exa 6.6 The film thickness h

```
// Example 6_6
clc;funcprot(0);
// Given data
V=0.1;// The speed of coating liquid in m/s
nu=1.0*10^-6;// The liquid kinematic viscosity in m
    ^2/s
g=9.807;// The acceleration due to gravity in m/s^2
```

```

// Calculation
h=sqrt((2*nu*V)/g);// m
printf("\nThe film thickness h=%1.3e m",h);
```

Scilab code Exa 6.7 The numerical value of the pump efficiency

```
// Example 6_7
clc;funcprot(0);
// Solution
// P_out=(3*%pi*mu*W*omega^2*D^3)/(16*h);
// P_in=(5*%pi*mu*W*omega^2*D^3)/(8*h);
// n_p=P_out/P_in;
n_p=(((3*%pi)/16)/((5*%pi)/8))*100;//The pump
    efficiency in %
printf("\nThe pump efficiency,n_p=%0.0f percentage",
    n_p);
```

Scilab code Exa 6.8 the kinematic viscosity of the oil mixture

```
// Example 6_8
clc;funcprot(0);
// Given data
H=3;// Distance in m
L=30;// Length in cm
D=3;// Diameter in mm
V=100;// cm^3
t=152;// s
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
Q=(V*10^-6)/t;// The flow rate in m^3/s
```

```
nu=((%pi*((D*10^-3)^4)*g)/(128*Q))*(1+(H/L));// The
    kinematic viscosity of the oil mixture in m/s^2
printf("\nThe kinematic viscosity of the oil mixture
     is %1.3e m^2/s",nu);
// The answer provided in the text book is wrong
```

Scilab code Exa 6.9 The Reynolds number

```
// Example 6_9
clc;funcprot(0);
// Given data
a=1.5;// Radius in cm
W=3;// Length in cm
hbar=5*10^-5;// Clearance in m
mu=2*10^-2;// Viscosity of lubricating oil in Pa s
rho=9*10^2;// Density of lubricating oil in kg/m^3
N=3600;// rpm
n=0.5;// The eccentricity

// Calculation
// (a)
omega=(2*%pi*N)/60;// s^-1
L=(12*%pi*mu*omega*W*10^-2)*((a*10^-2)^3/(hbar)^2)*(
    n/((sqrt(1-n^2))*(2+n^2)));// The load force in N
// (b)
T=(4*%pi*mu*omega*W*10^-2)*((a*10^-2)^3/(hbar))
    *((1+(2*n^2))/((sqrt(1-n^2))*(2+n^2)));// The
    torque in Nm
P=omega*T;// Power in W
// (c)
Re_h=(rho*omega*a*10^-2*hbar*(1-n^2))/(mu*(2+n^2));
    // Reynolds number
printf("\n(a)The maximum load F=%1.3e N \n(b)The
    torque,T=%0.4f Nm \n    The frictional power of
    the bearing,P=%2.2f W \n(c)The reynolds number,
```

```
Re_h=%2.2f",L,T,P,Re_h);
Re_h=((a*10^-2)/hbar)
// The answer provided in the text book is wrong
```

Scilab code Exa 6.10 The Reynolds number

```
// Example 6_10
clc;funcprot(0);
// Given data
D=1.0*10^-6;// Diameter of solid particle in m
rho_p=2*10^3;// The density of particle in kg/m^3
rho_f=1.206;// The density of air in kg/m^3
mu=1.80*10^-5;// Viscosity in Pa s
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
// (a)
V_f=(2*(rho_p-rho_f)*g*D^2)/(9*mu);// The free fall
    velocity in m/s
// (b)
Re_D=(rho_f*V_f*D)/mu;// The Reynolds number
printf("\n(a)The free fall velocity,V_f=%1.3e m/s \n
    (b)The Reynolds number,Re_D=%1.3e",V_f,Re_D);
```

Scilab code Exa 6.11 The pressure drop required to force the fuel through the filt

```
// Example 6_11
clc;funcprot(0);
// Given data
D_i=3;// The inner diameter of hollow cylinder in cm
D_o=10;// The outer diameter of hollow cylinder in
    cm
L=20;// Length in cm
```

```
Q=1;// The fuel flow rate in l/min
mu=2*10^-6;// The fuel viscosity in Pa s
k=1*10^-6;// The fuel filter permeability in m^2

// Calculation
// Assume dp=p_in-p_out
dp=((mu*Q/60)/(2*%pi*k*L/100))*log(D_o/D_i);// The
   pressure drop in Pa
printf("\n The pressure drop,p_in-p_out=%1.3e Pa",dp
   );
```

Scilab code Exa 6.12 The numerical value of t

```
// Example 6_12
clc;funcprot(0);
// Given data
// From Example 6_4
h=0.1;// The gap betwen the shaft and the bearing in
   mm
mu=6.7*10^-5;// Viscosity in Pa/s
rho=8.0*10^2;// kg/m^3

//Calculation
// (b)
t=(rho*(h*10^-3)^2)/mu;// s
printf("\nThe numerical value of t is %0.4f s",t);
```

Scilab code Exa 6.13 The power P absorbed by the vibration damper

```
// Example 6_13
clc;funcprot(0);
// Given data
D=0.5;// The diameter of cirrcular disk in m
```

```
mu=1.0;// The viscosity of oil in Pa s
rho=9.0*10^2;// Density in kg/m^3
omega=1*10^3;// The angular frequency in s^-1
phi=1*10^-3;// The angular amplitude

// Calculation
P=(%pi/32)*mu*(omega*phi)^2*((omega*rho)/(2*mu))^(1/2)*D^4;// W
printf("\nThe power absorbed by the vibration damper,P=%1.3f W",P);
```

Scilab code Exa 6.14 The Reynolds number

```
// Example 6_14
clc;funcprot(0);
// Given data
// L=10h;
Lbyh=10;

// Calculation
// Re=(V*h)/nu;
Re=Lbyh*(12/1.328)^2;// Reynolds number
printf("For flow velocities having Vh/v  %3.1f. the pressure drop would be given by (a),while for Vh/v  %3.1f it would be given by (b).",Re,Re);
// The answer provided in the text book is wrong
```

Chapter 7

TURBULENT VISCOUS FLOW

Scilab code Exa 7.1 The pressure drop and the power

```
// Example 7_1
clc;funcprot(0);
// Given data
D=6;// The diameter of a steel pipe in inch
Q=2000;// Volume flow rate in gpm
L=1.0;// Length in km
nu=1.0*10^-6;// Kinematic viscosity in m^2/s
rho=1*10^3;// The density of water in kg/m^3

// Calculation
// (a)
D=D*2.54*10^-2;// m
Q=(Q*3.782*10^-3)/60;// m^3/s
Vbar=(4*Q)/(%pi*D^2);// m/s
Re_D=(Vbar*D)/nu;// Reynolds number
// (b)
epsilon=5*10^-5;// physical height in m
function[X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*
```

```
        sqrt(y(1)))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);
dp=f*((1/2)*rho*Vbar^2)*((L*10^3)/D);// The pressure
    drop in  Pa
P=dp*Q;// The power required to maintain the flow in
    W
printf("\n(a)Re_D=%1.3e.The How is turbulent since
    the Reynolds number exceeds the transition value
    of 2300. \n(b)The pressure drop,deltap=%1.3e Pa \
    n(c)The power required to maintain the flow,P=%1
    .3e W",Re_D,dp,P);
// The answer is varied due to round off error
```

Scilab code Exa 7.3 The ships frictional drag force and the power

```
// Example 7_3
clc;funcprot(0);
// Given data
L=100;// The length of the ship in m
A=3*10^3;// Surface area in m^2
rho=1.03*10^3;// The density of sea water in kg/m^3
V=8;// Speed in m/s
epsilon=1*10^-4;// The surface roughness in m
nu=1*10^-6;// The kinematic viscosity in m^2/s

// Calculation
Re_L=(V*L)/nu;// The length Reynolds number Re_L
// If the ship surface were smooth,
C_D_fp=0.455/(log10(Re_L))^2.58;// The drag
    coefficient
// For a rough surface,
C_D_fp=0.30/(log10(14.7*(L/epsilon))^2.5);// The
```

```
    drag coefficient for a rough surface
D=((1/2)*rho*V^2)*A*C_D_fp;// The ship's frictional
    drag force in N
P=D*V;// The power in MW
printf("\nThe ships frictional drag force,D=%1.4e N
    \nThe power required to overcome drag force,DV=%1
    .3f MW",D,P/10^6);
```

Scilab code Exa 7.4 The friction coefficient

```
// Example 7_4
clc;funcprot(0);
// Given data
z_1=1;// m
z_2=10;// m
k=0.4;// The von Karman constant
ubar_1=6;// m/s
ubar_2=9;// m/s

// Calculation
ustar=(ubar_2-ubar_1)/(2.5*log(10));// m/s
y_0=10/exp(ubar_2/(2.5*ustar));// m
C_f=(2*ustar^2)/ubar_2^2;// The friction coefficient
printf("\nu_*=%0.3f m/s \ny_0=%1.2e m \nThe friction
     coefficient,C_f=%1.2e",ustar,y_0,C_f);
```

Scilab code Exa 7.6 The relative air speed

```
// Example 7_6
clc;funcprot(0);
// Given data
x=40;// Fixed distance in m
V_v=100;// Vehicular speed in m/s
```

```
C_D=1.0;// The truck drag coefficient
A=9;// The trucks frontal area in m^2
alpha_w=0.05;

// Calculation
V_w=V_v*((C_D*A)/(%pi*(2*alpha_w*x)^2));// km/h
dV=V_v-V_w;// The relative air speed in km/h
printf("\nThe relative air speed,V_v-V_w=%2.1f km/h"
   ,dV)
```

Chapter 8

CONSERVATION OF ENERGY

Scilab code Exa 8.2 The reduction in head

```
// Example 8_2
clc;funcprot(0);
// Given data
D=2;// The diameter of the pipe in inch
h_in=10;// Elevation in m
Q=425;// The volumetric flow rate in gal/min
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
D=D*2.54*10^-2;// m
Q=(Q*3.785*10^-3)/60;// The volumetric flow rate in
    m^3/s
V=(4*Q)/(%pi*D^2);// m/s
deltah=h_in-(V^2/(2*g));// m
printf("The reduction in head,h_in-h_out=%1.3f m",
    deltah);
```

Scilab code Exa 8.3 The turbine efficiency

```
// Example 8_3
clc;funcprot(0);
// Given data
P=8*10^6;// The mechanical power delivered to an
    electric generator in MW
deltah=10;// The change in head between the turbine
    inlet and outlet in m
Q=100;// The volumetric flow rate in m^3/s
rho=1*10^3;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
n_t=(P/(rho*g*Q*deltah))*100;// The turbine
    efficiency in %
printf(" The turbine efficiency n_t=%2.2f percentage
    ",n_t);
```

Scilab code Exa 8.4 The temperature difference between the bearing surfaces

```
// Example 8_4
clc;funcprot(0);
// Given data
lambda=4;// W/mK
// From example 6.4
mu=6.7*10^-5;// Pa s
V=18.85;// m/s
h=1*10^-4;// m

// Calculation
// (a)
q_w=-(mu)*((V^2)/h);// The heat flux to the wall (y
    =0) for the bearing in W/m^2
// (b)
```

```
deltaT=(mu/lambda)*((V^2)/(2*h));// The temperature difference T_h-T_o across the oil gap in K
printf("\n(a)The heat flux to the wall (y =0) for the bearing,q_w=%1.3e W/m^2 \n(b)The temperature difference T_h-T_o across the oil gap is %2.2f K",q_w,deltaT);
```

Scilab code Exa 8.5 `The temperature rise in the water`

```
// Example 8_5
clc;funcprot(0);
// Given data
Q=5;// The flow rate of water through a pipe in gal/min
q=10*10^3;// kW
c_p=4.18;// The specific heat in J/kg.K
rho=1*10^3;// The density of water in kg/m^3

// Calculation
Q=(Q*3.785*10^-3)/60;// The flow rate of water through a pipe in m^3/s
deltaT=q/(rho*Q*c_p*10^3);// The temperature rise in the water in K
printf("The temperature rise in the water,T_out-T_in=%1.3f K",deltaT);
```

Chapter 9

FLOW IN FLUID SYSTEMS

Scilab code Exa 9.1 The static pressure change between the pipe inlet and outlet

```
// Example 9_1
clc;funcprot(0);
// Given data
D=8;// The diameter of the steel pipe in inch
z_in=100;// Elevation in m
z_out=22;// Elevation in m
L=2.2;// The distance in km
Q=1000;// The flow rate in m^3/s
g=9.807;// The acceleration due to gravity in m/s^2
nu=1.0*10^-6;// The kinematic viscosity in m/s^2
rho=1*10^3;// The density of water in kg/m^3

// Calculation
// (a)
D=D*2.54*10^-2;// m
Q=Q*(3.782*10^-3)/60;// m^3/s
V=(4*Q)/(%pi*D^2);// m/s
Re_D=(V*D)/nu;// Reynolds number
epsilon=5*10^-5;// physical height
function [X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*
```

```
    sqrt(y(1))))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);

K_f=f*((L*10^3)/D);// The head loss coefficient
// (b)
deltah_f=K_f*((V^2)/(2*g));// The head loss in m
// (c)
dp=(deltah_f-(z_in-z_out))*rho*g;// The static
    pressure change between the pipe inlet and outlet
printf("\n(a)The head loss coefficient,K_f=%1.3e \n(
    b)The head loss,deltah_f=%2.2f \n(c)The static
    pressure change between the pipe inlet and outlet
    ,p_in-p_out=%1.3e Pa",K_f,deltah_f,dp);
```

Scilab code Exa 9.2 The volume flow rate Q

```
// Example 9_2
clc;funcprot(0);
// Given data
// From Example 9_1
D=8;// The diameter of the steel pipe in inch
z_in=100;// Elevation in m
z_out=22;// Elevation in m
L=2.2;// The distance in km
g=9.807;// The acceleration due to gravity in m/s^2
nu=1.0*10^-6;// The kinematic viscosity in m/s^2
rho=1*10^3;// The density of water in kg/m^3
dp=0;// The static pressure in Pa

// Calculation
D=D*2.54*10^-2;// m
deltah_f=(dp/(rho*g))+(z_in-z_out);// m
```

```
// From equation 9.9
sqrtoffintoRe_D=((2*g*deltah_f*D^3)/(((nu)^2)*L*10^3))^(1/2);
epsilon=5*10^-5;// physical height in m
Re_D=-2*sqrtoffintoRe_D*log10(((epsilon/D)/3.7)+(2.51/(sqrtoffintoRe_D)));// Reynolds number
Q=(%pi*D*nu*Re_D)/4;// The volume flow rate in m^3/s
Q=(Q*60)/(3.782*10^-3)// The volume flow rate in gal/min
printf("The volume flow rate ,Q=%4.0f gal/min",Q);
```

Scilab code Exa 9.3 The minimum diameter pipe

```
// Example 9_3
clc;funcprot(0);
// Given data
dp=100;// The pressure drop in psi
rho=1*10^3;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2
Q=2000;// The flow rate of water in gal/min
D=4;// The next pipe size in inch
L=100;// Length in m
nu=1*10^-6;// m^2/s

// Calculation
deltah=(dp*6.895*10^3)/(rho*g);// m
printf("\nh_in-h_out=%2.2f m",deltah);
D=D*2.54*10^-2;// m
Q=Q*(3.782*10^-3)/60;// m^3/s
V=(4*Q)/(%pi*D^2);// m/s
Re_D=(V*D)/nu;// Reynolds number
epsilon=5*10^-5;// physical height
function [X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*sqrt(y(1))))))-(1/sqrt(y(1)));
```

```
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);
K_f=f*((L)/D);// The head loss coefficient
deltah_f=K_f*((V^2)/(2*g));// The head loss in m
printf("\nD=%0.4f m \nQ=%1.3e m^3/s \nV=%2.2f m/s \nRe_D=%1.3e \nf=%1.3e \nK_f=%2.2f \nh_in-h_out=%3.1f m",D,Q,V,Re_D,f,K_f,deltah_f)
printf("\nThe head loss of 205.9 m is greater than the allowable los s of 70.31 m.");

// If we try the next size pipe, D = 6 in,
D=6;// inch
D=D*2.54*10^-2;// m
Q=2000;// The flow rate of water in gal/min
Q=Q*(3.782*10^-3)/60;// m^3/s
V=(4*Q)/(%pi*D^2);// m/s
Re_D=(V*D)/nu;// Reynolds number
epsilon=5*10^-5;// physical height
function[X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*sqrt(y(1))))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);
K_f=f*((L)/D);// The head loss coefficient
deltah_f=K_f*((V^2)/(2*g));// The head loss in m
printf("\nD=%0.4f m \nQ=%1.3e m^3/s \nV=%1.3f m/s \nRe_D=%1.3e \nf=%1.3e \nK_f=%2.2f \nh_in-h_out=%2.2f m",D,Q,V,Re_D,f,K_f,deltah_f)
printf("\nThis is smaller than the allowable head loss so that a 6 in diameter pipe is acceptable.")
```

Scilab code Exa 9.4 The head loss and pressure drop

```
// Example 9_4
clc;funcprot(0);
// Given data
l=6;// in
b=12;// in
A=6*12;// in^2
L=20;// Length in ft
Q=1000;// ft^3/min
epsilon=1*10^-5;// The duct roughness in m
nu=1.51*10^-5;// m/s
rho=1.204;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2

// Calculation
D=(4*(l*b))/(2*(l+b));// m
D=D*2.54*10^-2;// m
Q=Q*(2.832*10^-2)/60;// m^3/s
A=A*(2.54*10^-2)^2;// m^2
V=Q/A;// m/s
L=L*0.3048;// m
Re_D=(V*D)/nu;// Reynolds number
function[X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*
        sqrt(y(1))))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);
K_f=f*((L)/D);// The head loss coefficient
deltah=K_f*((V^2)/(2*g));// The head loss in m
dp=rho*g*deltah;// The pressure drop in Pa
printf("\nThe head loss,h_in-h_out=%1.3f m \nThe
```

```
pressure drop,p*_in-p*_out=%2.2f Pa",deltah,dp);
```

Scilab code Exa 9.5 The head loss between the supply and collector headers

```
// Example 9_5
clc;funcprot(0);
// Given data
D=1;// Diameter in cm
L=22;// The lngth of a copper tube in m
Q=4;// The water flow rate in the circuit in l/min
g=9.807;// The acceleration due to gravity in m/s^2
nu=1.0*10^-6;// The kinematic viscosity in m/s^2

// Calculation
D=1*10^-2;// m
Q=(Q*1*10^-3)/60;// m^3/s
A=(%pi*(D)^2)/4;// m^2
V=Q/A;// m/s
Re_D=(V*D)/nu;// Reynolds number
epsilon=1*10^-6;// Roughness in m
function[X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*
        sqrt(y(1))))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);
K_f=f*((L)/D);// The head loss coefficient
SigmaK=11.4;
deltah=(K_f+SigmaK)*((V^2)/(2*g));// The total head
    loss in m
printf("The total head loss,deltah=%1.2f m",deltah);
```

Scilab code Exa 9.6 The flow rate Q through the system

```
// Example 9_6
clc;funcprot(0);
// Given data
L=1.5;// The length in km
D=6;// Diameter in inch
h=80;// m
// Assume
deltah_l=20;// m
g=9.807;// The acceleration due to gravity in m/s^2
nu=1*10^-6;// m/s^2
epsilon=5*10^-5;// roughness in m

// Calculation
D=D*2.54*10^-2;// m
sqrtoffintoRe_D=((2*g*deltah_l*D^3)/(((nu)^2)*L
    *10^3))^(1/2);
Re_D=-2*sqrtoffintoRe_D*log10(((epsilon/D)/3.7)
    +(2.51/(sqrtoffintoRe_D)));// Reynolds number
Q=(%pi*D*nu*Re_D)/4;// The volume flow rate in m^3/s
Q_20=(Q*60)/(3.782*10^-3)// The volume flow rate in
    gal/min
deltah=150*(1-(Q_20/1000)^2);// m
dh_20=deltah-(h+deltah_l);// m
deltah_l=40;// m
sqrtoffintoRe_D=((2*g*deltah_l*D^3)/(((nu)^2)*L
    *10^3))^(1/2);
Re_D=-2*sqrtoffintoRe_D*log10(((epsilon/D)/3.7)
    +(2.51/(sqrtoffintoRe_D)));// Reynolds number
Q=(%pi*D*nu*Re_D)/4;// The volume flow rate in m^3/s
Q_40=(Q*60)/(3.782*10^-3)// The volume flow rate in
    gal/min
deltah=150*(1-(Q_40/1000)^2);// m
dh_40=deltah-(h+deltah_l);// m
Q=((((dh_20)/(dh_20-dh_40))*(Q_40-Q_20))+Q_20);//
    GPM
deltah=150*(1-(Q/1000)^2);// m
```

```
deltah_l=deltah-h;// m
printf("\nThe flow rate through the system,Q=%3.1f GPM \ndeltah=%3.1f m \ndeltah_l=%2.2f m",Q,deltah,deltah_l);
printf("\nContinuing this process to improve our estimate of Q and Ah we finally arrive at:Q=527.7(GPM);deltah=108.3 m")
```

Scilab code Exa 9.7 The head loss in the piping and the power produced by the turb

```
// Example 9_7
clc;funcprot(0);
// Given data
h=100;
Q=10;
n_t=.85;
D=1.5;
L=300;
delta_t=93.99;
epsilon=1*10^-4;
nu=1.0*10^-6;// The kinematic viscosity in m/s^2
rho=1*10^3;// The density of water in kg/m^3
g=9.81;// The acceleration due to gravity in m/s^2

// Calculation
V=(4*Q)/(%pi*D^2);// m/s
Re_D=(V*D)/nu;// Reynolds number
function [X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*sqrt(y(1))))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);
K_f=f*((L)/D);// The head loss coefficient
```

```
SigmaK=3.681;
deltah_1=SigmaK*((V^2)/(2*g));// The head loss in m
P=n_t*(rho*Q)*g*deltah_1;
P=P/10^3;
printf("\nThe head loss in the piping, deltah_1=%1.3f
    m \nThe power produced by the turbine,P=%3.0f kW
   ",deltah_1,P);
```

Scilab code Exa 9.8 The flow rate through the hoses

```
// Example 9_8
clc;funcprot(0);
// Given data
L=50;// Lengths of garden hose in ft
D_A=3/4;// Diameter of hose A in inch
D_B=1/2;// Diameter of hose B in inch
p=40;// Pressure in the tank in psig
nu=1.0*10^-6;// The kinematic viscosity in m/s^2
rho=1*10^3;// The density of water in kg/m^3
g=9.807;// The acceleration due to gravity in m/s^2
epsilon=0;

// Calculation
D_A=D_A*2.54*10^-2;// m
D_B=D_B*2.54*10^-2;// m
L=L*0.3048;// m
deltah_l1=(p*6.895*10^3)/(rho*g);// m
deltah_A1=10;// m
deltah_B1=18.12;// m
sqrtoffintoRe_D_A=((2*g*deltah_A1*D_A^3)/(((nu)^2)*L
   ))^(1/2);
Re_D_A=-2*sqrtoffintoRe_D_A*log10(2.51/(
   sqrtoffintoRe_D_A));// Reynolds number
Q_A1=(%pi*D_A*nu*Re_D_A)/4;// The volume flow rate
   in m^3/s
```

```
sqrtoffintoRe_D_B=((2*g*deltah_B1*D_B^3)/(((nu)^2)*L))^(1/2);
Re_D_B=-2*sqrtoffintoRe_D_B*log10((2.51/(sqrtoffintoRe_D_B)));// Reynolds number
Q_B1=(%pi*D_B*nu*Re_D_B)/4;// The volume flow rate in m^3/s
V_A=(4*Q_A1)/(%pi*D_A^2);// m/s
V_B=(4*Q_B1)/(%pi*D_B^2);// m/s
// Assume deltah=SigmaK*((V^2)/(2*g))
deltah=((0.4*V_A^2)+(0.4*V_B^2))/(2*g);// m
deltah_f=deltah_l1-deltah;// m
// We decide to allocate this total to
deltah_A2=2;// m
deltah_B2=25.43;// m
sqrtoffintoRe_D_A=((2*g*deltah_A2*D_A^3)/(((nu)^2)*L))^(1/2);
Re_D_A=-2*sqrtoffintoRe_D_A*log10((2.51/(sqrtoffintoRe_D_A)));// Reynolds number
Q_A2=(%pi*D_A*nu*Re_D_A)/4;// The volume flow rate in m^3/s
sqrtoffintoRe_D_B=((2*g*deltah_B2*D_B^3)/(((nu)^2)*L))^(1/2);
Re_D_B=-2*sqrtoffintoRe_D_B*log10((2.51/(sqrtoffintoRe_D_B)));// Reynolds number
Q_B2=(%pi*D_B*nu*Re_D_B)/4;// The volume flow rate in m^3/s
V_A=(4*Q_A2)/(%pi*D_A^2);// m/s
V_B=(4*Q_B2)/(%pi*D_B^2);// m/s
deltah_l2=((0.4*V_A^2)+(0.4*V_B^2))/(2*g);// m
//Indicating the first and second guesses by '1' and '2' we find a third guess to be:
deltah=deltah_A2-((Q_A2-Q_B2)*((deltah_A1-deltah_A2)/((Q_A1-Q_B1)-(Q_A2-Q_B2))));// m
printf('\nThe flow rate through the hoses Q_A=%1.3e m^3/s;Q_B=%1.3e m^3/s;SigmaK(V^2/2g)=%0.4f m',Q_A2,Q_B2,deltah_l2);
// The answer is vary due to roundoff error
```

Scilab code Exa 9.9 The flow rate Q

```
// Example 9_9
clc;funcprot(0);
// Given data
D=1*10^-2;// m
h_1=10;// m
h_4=0;// m
L_12=3;// m
L_13=4;// m
L_14=5;// m
g=9.807;// The acceleration due to gravity in m/s^2
nu=1.0*10^-6;// The kinematic viscosity in m/s^2

// Calculation
// Because of the symmetry of the network. h1- h2 = h3-h4,Q12 = Q34 and Q13 = Q24.
// Assume
h_2a=5;// m
h_3a=5;// m
deltah_12=h_1-h_2a;// m
deltah_13=h_1-h_3a;// m
sqrtoffintoRe_D_12=((2*g*deltah_12*D^3)/(((nu)^2)*L_12))^(1/2);
Re_D_12=-2*sqrtoffintoRe_D_12*log10((2.51/(sqrtoffintoRe_D_12)));// Reynolds number
Q_12=(%pi*D*nu*Re_D_12)/4;// The volume flow rate in m^3/s
sqrtoffintoRe_D_13=((2*g*deltah_13*D^3)/(((nu)^2)*L_13))^(1/2);
Re_D_13=-2*sqrtoffintoRe_D_13*log10((2.51/(sqrtoffintoRe_D_13)));// Reynolds number
Q_13=(%pi*D*nu*Re_D_13)/4;// The volume flow rate in m^3/s
```

```
Q_23=0;// The volume flow rate in m^3/s
Q_24=Q_13;// The volume flow rate in m^3/s
deltaQ_2a=Q_12-Q_23-Q_24;// m^3/s
// Assume
h_2b=6;// m
h_3b=4;// m
deltah_12=4;// m
deltah_13=6;// m
deltah_23=2;// m
sqrtoffintoRe_D_12=((2*g*deltah_12*D^3)/(((nu)^2)*L_12))^(1/2);
Re_D_12=-2*sqrtoffintoRe_D_12*log10((2.51/(sqrtoffintoRe_D_12)));// Reynolds number
Q_12=(%pi*D*nu*Re_D_12)/4;// The volume flow rate in m^3/s
sqrtoffintoRe_D_13=((2*g*deltah_13*D^3)/(((nu)^2)*L_13))^(1/2);
Re_D_13=-2*sqrtoffintoRe_D_13*log10((2.51/(sqrtoffintoRe_D_13)));// Reynolds number
Q_13=(%pi*D*nu*Re_D_13)/4;// The volume flow rate in m^3/s
sqrtoffintoRe_D_23=((2*g*deltah_23*D^3)/(((nu)^2)*1))^(1/2);
Re_D_23=-2*sqrtoffintoRe_D_23*log10((2.51/(sqrtoffintoRe_D_23)));// Reynolds number
Q_23=(%pi*D*nu*Re_D_23)/4;// The volume flow rate in m^3/s
deltaQ_2b=Q_12-Q_23-Q_24;// m
h_2=h_2a-(((h_2b-h_2a)/(deltaQ_2b-deltaQ_2a))*deltaQ_2b);// m
// Proceeding in this manner for two more iterations, we converge to the solution:
h_2=5.11;// m
h_3=4.89;// m
deltah_12=h_1-h_2;// m
deltah_13=h_1-h_3;// m
deltah_23=h_2-h_3;// m
sqrtoffintoRe_D_12=((2*g*deltah_12*D^3)/(((nu)^2)*
```

```
    L_12))^(1/2);
Re_D_12=-2*sqrtoffintoRe_D_12*log10((2.51/(
    sqrtoffintoRe_D_12)));// Reynolds number
Q_12=(%pi*D*nu*Re_D_12)/4;// The volume flow rate in
     m^3/s
sqrtoffintoRe_D_13=((2*g*deltah_13*D^3)/(((nu)^2)*
    L_13))^(1/2);
Re_D_13=-2*sqrtoffintoRe_D_13*log10((2.51/(
    sqrtoffintoRe_D_13)));// Reynolds number
Q_13=(%pi*D*nu*Re_D_13)/4;// The volume flow rate in
     m^3/s
sqrtoffintoRe_D_23=((2*g*deltah_23*D^3)/(((nu)^2)*1)
    )^(1/2);
Re_D_23=-2*sqrtoffintoRe_D_23*log10((2.51/(
    sqrtoffintoRe_D_23)));// Reynolds number
Q_23=(%pi*D*nu*Re_D_23)/4;// The volume flow rate in
     m^3/s
Q_2=Q_13+Q_12;// m^3/s
printf("\nThe flow rate,Q=%1.3e m^3/s",Q_2);
```

Chapter 10

DIMENSIONAL ANALYSIS AND MODELING

Scilab code Exa 10.3 The propulsive power

```
// Example 10_3
clc;funcprot(0);
// Given data
L_p=100;// Length in m
L_m=2;// The model length in m
v_m=5*10^-2;// Displaced volume in m^3
A_wm=0.9*1;// Wetted area in m^2
rho_m=1*10^3;// kg/m^3
V_m=1.1;// m/s
D_m=2.66;// The drag force in N
rho_p=1.03*10^3;// kg/m^3
SR=1/50;
nu=1*10^-6;// m^2/s

// Calculation
// (a)
V_p=V_m/(sqrt(SR));
V_pn=V_p*(3600/(1.852*10^3));// naut.mi/h
// (b)
```

```
Re_Lm=(V_m*L_m)/nu;// Reynolds number
C_Dm=0.455/(log10(Re_Lm))^2.58;// The drag
    coefficient
D_fm=((1/2)*rho_m*V_m^2*A_wm)*C_Dm;// Drag force in
    N
D_wm=D_m-D_fm;// N
D_wp=D_wm*(rho_p/rho_m)*(1/SR)^3;// N
A_wp=A_wm*(1/SR)^2;// m^2
Re_Lp=(V_p*L_p)/nu;// Reynolds number
C_Dp=0.455/(log10(Re_Lp))^2.58;// The drag
    coefficient
D_fp=((1/2)*rho_p*V_p^2*A_wp)*C_Dp;// Drag force in
    N
D_p=D_wp+D_fp;// Drag force in N
// (c)
P_p=(D_p*V_p)/10^6;// The power in kW
printf("\n(a)The corresponding speed V_p=%2.2f naut.
    mi/h \n(b)The drag force V_p in ocean water,D_p=
    %1.3e N \n(c)The propulsive power,P=%1.3f MW",
    V_pn,D_p,P_p);
```

Scilab code Exa 10.4 The turbine diameter and shaft speed

```
// Example 10_4
clc;funcprot(0);
// Given data
V_wbyomegaD_m=0.1;
C_pm=0.50;// The power coefficient
V_w=10;// The wind speed in m/s
P_wtp=100;// kW
rho=1.2;// The density of air in kg/m^3

// Calculation
omega_p=sqrt((%pi*C_pm*rho*V_w^5)/(8*P_wtp*10^3*
    V_wbyomegaD_m^2));// s^-2
```

```
omega=omega_p*(60/(2*%pi));// RPM
D_p=(1/V_wbyomegaD_m)*(V_w/omega_p);// m
printf("\nThe turbine diameter,D_p=%2.1f m",D_p);
```

Scilab code Exa 10.5 The pump speed diameter and power

```
// Example 10_5
clc;funcprot(0);
// Given data
Q=1000;// GPM
h=100;// Head in m
g=9.807;// The acceleration due to gravity in m/s^2
// Reading values from figure 10.5
C_Q=7*10^-3;
C_h=0.116;
C_p=1.16*10^-3;
rho=1*10^3;// The density of water in kg/m^3

// Calculation
Q=Q*((3.785*10^-3)/60);// m^3/s
omega=((g*h)^(3/4)*(C_Q)^(1/2))/(Q^(1/2)*(C_h)^(3/4)
    );// s^-1
omega_rpm=omega*(60/(2*%pi));// rpm
D=(Q/(omega*C_Q));// The diameter D in m
P=(rho*omega^3*D^5*C_p);// The power in kW
printf("\nThe pump speed=%4.0f \nDiameter,D=%0.4f m
    \nThe power=%2.2f kW",omega_rpm,D,P);
```

Scilab code Exa 10.6 The dimensionless angular speed

```
// Example 10_6
clc;funcprot(0);
// Given data
```

```
C_Du=1.4;// Drag coefficient of the upwind facing
    cup
C_Dd=0.4;// Drag coefficient of the downwind facing
    cup

// Calculation
omegaRbyV=sqrt((C_Du-C_Dd)/(C_Du+(4*C_Dd)));// The
    dimensionless angular speed
printf("\nThe dimensionless angular speed at which
    the anemometer rotates is %0.4f.",omegaRbyV)
```

Chapter 12

COMPRESSIBLE FLOW

Scilab code Exa 12.1 The speed of sound

```
// Example 12_1
clc;funcprot(0);
// Given data
T=300;// Temperature in K
R_a=287.0;// Gas constant for air in J/kg.K
C_pbyR_a=3.5;
R_h=2077;// Gas constant for helium in J/kg.K
C_pbyR_h=2.5;

// Calculation
// (a)
a=sqrt((C_pbyR_a/(C_pbyR_a-1))*R_a*T);// m/s
printf("\n(a)The speed of sound in air,a=%3.1f m/s",
    a);
// (b)
a=sqrt((C_pbyR_h/(C_pbyR_h-1))*R_h*T);// m/s
printf("\n(b)The speed of sound in helium,a=%4.0f m/
    s",a);
```

Scilab code Exa 12.2 The pressure amplitude and the velocity amplitude

```
// Example 12_2
clc;funcprot(0);
// Given data
T=20;//  C
SPL=20;// Sound Pressure level in dB
// From table 1.1,
rho_0=1.204;// kg/m^3
gamma=3.5/2.5;// Specific heat ratio

// Calculation
// (a) Inverting equation 12.18,
Pa=2*10^-5*(1*10^(20/10));// Pa
// (b) From equation 12.17,
a=(gamma*1.013*10^5*rho_0)^(1/2);// m/s
va=Pa/(rho_0*a);
//(c) From equation 12.17,
P_sw=(Pa)^2/(rho_0*a);
printf('\n(a)The pressure amplitude is %1.0e Pa \n(b
    )The velocity amplitude is %1.2e m/s \n   The
    power per unit area,P_sw=%1.2e W/m^2',Pa,va,P_sw)
    ;
// The answer provided in the book is wrong
```

Scilab code Exa 12.3 The Mach number in the test section

```
// Example 12_3
clc;funcprot(0);
// Given data
r=1.4;// The specific heat ratio
p_s=6*10^5;// The pressure in the large tank in Pa
p_t=5*10^4;// The pressure in the test section in Pa

// Calculation
```

```
M_t=sqrt((2/(r-1))*((p_t/p_s)^(-(r-1)/r)-1));// Mach
    number
printf("\nThe Mach number M_t in the test section is
    %1.3f",M_t);
```

Scilab code Exa 12.4 The mass flow rate of air from the tank and the external forc

```
// Example 12_4
clc;funcprot(0);
// Given data
p_s=4*10^5;// Pressure in Pa
a_s=347.2;// Sound speed in m/s
A_c=1*10^-4;// The flow area in m^2
p_a=1*10^5;// The atmospheric pressure in Pa
r=1.4;// The specific heat ratio
V_c=0.5787;

// Calculation
rho_c=(r*p_s)/a_s;// kg/m^3
m_c=rho_c*V_c*A_c;// kg/s
V_c=a_s/(sqrt(1+(r-1)/2));// m/s
p_c=((2/(r+1))^(r/(r-1)))*p_s;// N
F=(m_c*V_c)+((p_c-p_a)*A_c);// N
printf('\nThe mass flow rate of air from the tank=%1
    .2e kg/s \nThe external force F required to
    restrain the tank from moving is %2.2f N',m_c,F);
```

Scilab code Exa 12.5 The Mach number of the exit flow

```
// Example 12_5
clc;funcprot(0);
// Given data
r=1.3;// The specific heat ratio
```

```
V_e=0.90;// Exit velocity in % of maximum possible
    velocity

// Calculation
V_mebya_s=sqrt(2/(r-1));// The maximum possible exit
     velocity
function[X]=machnumber(y)
    X(1)=(V_e*V_mebya_s)-(y(1)*(1+((0.3*y(1)^2)/2))
        ^(-1/2));
endfunction
y=[1];
M_e=fsolve(y,machnumber);// The Mach number of the
    exit flow
A_ebyA_c=M_e*((2/(r+1))*((1+(((r-1)/2)*(M_e)^2)))
    ^((r+1)/(2*(r-1)));// The area ratio
D_r=sqrt(A_ebyA_c);// Corresponding diameter ratio
printf("\nThe exit Mach number,M_e=%1.3f \nThe area
    ratio=%1.3e \nThe diameter ratio=%2.2f",M_e,
    A_ebyA_c,D_r)
```

Scilab code Exa 12.6 The shock Mach number The shock speed and the pressure on the

```
// Example 12_6
clc;funcprot(0);
// Given data
a_1=347.2;// m/s
p_1=1*10^5;// Pa
r=1.4;// The specific heat ratio
V_p=100;// The velocity of piston in m/s

// Calculation
C=((r+1)*V_p)/(2*a_1);
function[X]=machnumber(y)
    X(1)=y(1)^2-(C*y(1))-1;
endfunction
```

```
y=[1];
M_1=fsolve(y,machnumber);// The shock Mach number
V_s=M_1*a_1;// The shock speed in m/s
p_2=(((2*r*M_1^2)-(r-1))/(r+1))*p_1;// The pressure
    on the piston face in Pa
printf("\nThe shock Mach number,M_1=%1.3f \nThe
    shock speed,V_s=%3.1f m/s \nThe pressure on the
    piston face,p_2=%1.2e Pa",M_1,V_s,p_2);
```

Scilab code Exa 12.7 The pressure at the point of choked flow

```
// Example 12_7
clc;funcprot(0);
// Given data
D=1;// The diameter of gas pipeline in m
epsilon=5*10^-5;// Surface roughness in m
p_1=2*10^6;// Pressure in Pa
T_1=20;// Temperature in C
a_1=446.1;// The natural gas sound speed in m/s
mu_1=9*10^-6;// Viscosity in Pa s
r=1.31;// The specific heat ratio
R=518.3;// The gas constant in J/kg.K
V_1=10;// The pipe flow speed in m/s

// Calculation
rho_1=(p_1)/(R*(T_1+273.15));// The density in kg/m
    ^3
Re_D=(rho_1*V_1*D)/mu_1;// Reynolds number
function[X]=frictionfactor(y)
    X(1)=-(2.0*log10(((epsilon/D)/3.7)+(2.51/(Re_D*
        sqrt(y(1))))))-(1/sqrt(y(1)));
endfunction
// Guessing a value of f=1*10^-2;
y=[1*10^-2];
f=fsolve(y,frictionfactor);// Friction factor
```

```
M_1=V_1/a_1;// Mach number
L_max=((D/f)*(((1-M_1^2)/(r*M_1^2))+(((r+1)/(2*r))*
    log(((r+1)*M_1^2)/(2*(1+((r-1)*M_1^2/2)))))))
    /1000;// The pipe length at which the flow would
    be choked in m
V_c=((V_1/M_1)*(sqrt((2+((r-1)*M_1^2))/(r+1))));//
    The flow speed in m/s
p_c=(p_1*V_c*M_1^2)/V_1;// The pressure at the point
     of choked flow in Pa
printf("\nThe pipe length at which the flow would be
     choked,L_max=%3.1f km \nThe flow speed at the
    point of choked flow,V_c=%3.0f m/s \nThe pressure
     at the point of choked flow,p_c=%1.3e Pa",L_max,
    V_c,p_c);
```

Scilab code Exa 12.8 The Mach number of the flow in the wind tunnel

```
// Example 12_8
clc;funcprot(0);
// Given data
theta=10;// The half angle of two dimensional wedge
    in degree
beta=20;// The attached shock wave angle in degree
r=1.4;// The specific heat ratio

// Calculation
M=sqrt(((2*tand(theta))+(2*cotd(beta)))/((2*cosd(
    beta)*sind(beta))-((r+(cosd(beta)*cosd(beta)))*
    tand(theta))));// The Mach number M of the flow
    in the wind tunnel
printf("The Mach number M of the flow in the wind
    tunnel,M=%1.3f",M);
```

Scilab code Exa 12.10 The outflow speeds from the two sections

```
// Example 12_10
clc;funcprot(0);
// Given data
u_0=100;// The average speed in m/s
r=1.31;// The specific heat ratio
a_0=446.1;// m/s

// Calculation
// (a)
u_out_1=((2/(r+1))*a_0)+(((r-1)/(r+1))*u_0);// The
    outflow speed of section 1 in m/s
mfr_ratio_1=(u_out_1/a_0)^(2/(r-1))*(u_out_1/u_0);//
     The mass flow rate ratio of section 1
u_out_2=-(((2/(r+1))*a_0)-(((r-1)/(r+1))*u_0));//
    The outflow speed of section 2 in m/s
mfr_ratio_2=(-u_out_2/a_0)^(2/(r-1))*(-u_out_2/u_0);
    // The mass flow rate ratio of section 2
printf("\n(a)The outflow speed of section 1,u_out=%3
    .1f m/s \n    The outflow speed of section 1,u_out
    =%3.1f m/s \n(b)The mass flow rate ratio of
    section 1 is %1.3f \n    The mass flow rate ratio
    of section 2 is %1.3f",u_out_1,u_out_2,
    mfr_ratio_1,mfr_ratio_2);
```