Scilab Textbook Companion for Introductory Fluid Mechanics by J. Katz[1]

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Book Description

Title: Introductory Fluid Mechanics

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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

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Chapter 1

Basic Concepts and Fluid Properties

Scilab code Exa 1.1 Chapter1 Example1

```
clc
//initialization of new variables
clear
M=29 // Molecular weight of air
R=8314.3 // J/mol K  Gas constant
T=300 //K  Temperature
P=1 //kg/cm^2  Pressure
g=9.8 //m/s^2  Acceleration due to gravity
//calculations
R=R/M
P=P*g*10^4
rho=P/(R*T)
//result
printf(' Density = %.3f kg/m^3 ',rho)
```

Scilab code Exa 1.2 Chapter1 Example2

```
clc
//initialization of new variables
clear
t=2 //cm  thickness
U=3 //m/s   Velocity
mu=0.29 //kg/m s   Coefficient of Viscocity
//calculations
tau=mu*U/(t*10^-2)
//results
printf(' Shear = %d N/m^2',tau)
```

Scilab code Exa 1.4 Chapter1 Example4

```
clc
//initialization of new variables
clear
sigma=2.5*10^-2 //N/m
D=10 //cm
//calculations
R=D/2
dP=2*sigma/(R*10^-2)
//result
printf('The pressure difference is = %.1f N/m^2',dP)
```

Scilab code Exa 1.5 Chapter1 Example5

```
clc
//initialization of new variables
clear
R=1 //mm
sigma=0.073 //N/m
theta=0 //degrees
rho=1000 //kg/m^3
```

```
g=9.8 //m/s^2
//calculations
theta=theta*%pi/180 //radians
h=2*sigma*cos(theta)/(rho*g*R*10^-3)
//result
printf('The rise of water = %.3f m',h)
R=1 //mm
sigma=0.48 //N/m
theta=130 //degrees
rho=13600 //kg/m^3
g=9.8 //m/s^2
//calculations
theta=theta*%pi/180 //radians
h=2*sigma*cos(theta)/(rho*g*R*10^-3)
//result
printf('\n The rise of mercury = %.4f m',h)
```

Scilab code Exa 1.6 Chapter1 Example6

```
clc
//initialization of new variables
clear
E=2.34*10^9 //N/m^2  Modulus of Elasticity
d=1 //km    depth
rho=1000 //kg/m^3   density
g=9.8 //m/s^2    Acceleration due to gravity
//calculations
d=d*1000
dp=rho*g*d
dVV=dp/E
//result
printf('The change in pressure is %.2e N/m^2 ',dp)
printf('\n Change in volume is %.3e ',dVV)
```

Scilab code Exa 1.7 Chapter1 Example7

```
clc
//initialization of new variables
clear
T=300 //K
gama=1.4
R=286.6
//calculation
// for air
a=sqrt(gama*R*T)
//result
printf('The speed of sound in air is %.1f m/s ',a)
// for sea water
E=2.34*10^9 // N/m^2
rho=1000 //kg/cm^2
a=sqrt(E/rho)
//result
printf(' \n The speed of sound in sea waer is %d m/s
    ',a)
```

Chapter 2

The Fluid Dynamic Eqaution

Scilab code Exa 2.3 Chapter2 Example3

```
clc
//initialization of new variables
clear
A1=30 //cm^2  Area at station 1
u1=1 //m/s    Velocity at station 1
A3=20 //cm^2  Area at station 3
u3=1.2 //m/s   Velocity at Station 3
A2=20 //cm^2    Area at station 2
rho=1000 //kg/m^3  density
// Calculations
// m stands for mass flow rate which is conserved
m1=rho*u1*A1*10^-4
m3=rho*u3*A3*10^-4
m2=m1-m3
u2=m2/(rho*A2*10^-4)
//result
printf('Mass flow rate entering station 1 is %.1f kg
   /s',m1)
printf('\n Mass flow rate entering station 2 is %.1f
    kg/s',m2)
printf('\n The average velocity leaving at station 2
```

```
is %.1f m/s ',u2)
```

Scilab code Exa 2.4 Chapter2 Example4

```
clc
//initialization of new variables
clear
Ue=5 //m/s  Velocity
Ae=20 //cm^2  Area
dp=0   // Pressure difference
rho=1000 //kg/m^3    density
//calculations
Ae=Ae*10^-4
Fx=rho*Ue^2*Ae
//result
printf('The force on the water pipe is %d N',Fx)
```

Chapter 3

Fluid Statics

Scilab code Exa 3.1 Chapter3 Example1

```
clc
//initialization of new variables
clear
h=380 //m
T=300 //K
g=9.81 //m/s^2
R=286.6  //m2/(s^2 K)
//calculations
Pr=exp(-g*h/(R*T)) //P2/P1
P1=1  //atm
dP=(P1-Pr)*101325 //N/m^2
//result
printf('The difference in pressure is %d N/m^2',dP)
```

Scilab code Exa 3.2 Chapter3 Example2

```
clc
//initialization of new variables
```

```
clear
d=4 //m  Diameter
h=10 //m  depth
th=60 //degrees  Wall inclination
rho=1000 //kg/m^3  density
g=9.8 //m/s^2  Accelaration due to gravity
//calculations
p=rho*g*h
th=th*%pi/180
R=d/2
S=%pi*R^2
Fz=-p*S
Y=%pi*R^4/(4*h*%pi*R^2/sin(th))
M=Fz*Y
//result
printf('Hydrostatic force = %.2e N',Fz)
printf('\n Y coordinate of center of pressure with
    respect to centroid is %.4f m',Y)
printf('\n The moment required to open it is %.2e Nm
    ',-M)
```

Scilab code Exa 3.3 Chapter3 Example3

```
clc
//initialization of new variables
clear
d=5 //m  depth
h=11 //m     where traingle base is located
rho=1000 //kg/m^3  density
g=9.8 //m/s^2  Acceleration due to gravity
s=6 //m  from figure
theta=30 //degrees
k=8 //m from the figure
kk=4 //m  from the figure
b=6 //m from the figure
```

```
//calculations
theta=theta*%pi/180
h_bar=d+k*sin(theta)
p=rho*g*h_bar
S=0.5*b*(kk+k)
Fz=-p*S
Ixx=b*(kk+k)^3/36
Ixy=b*(b-2*s)*(kk+k)^2/72
y_bar=h_bar/sin(theta)
X=Ixy/(y_bar*S)
Y=Ixx/(y_bar*S)
//results
printf('Force = %.3e N',Fz)
printf('\n coordinates of center of pressure
   relative to centroid are \n (X, Y) = (%.3f, %.3f)
    m',X,Y)
```

Scilab code Exa 3.4 Chapter3 Example4

```
clc
//initialization of new variables
clear
F=20.9 //N
Vc=310 //cm^3
rho_w=1000 //kg/m^3
g=9.8 //m/s^2
//calculations
Wc=F+rho_w*g*Vc*10^-6
rho_c=Wc/(Vc*10^-6*g)
//result
printf('The crown density is %d kg/m^3',rho_c)
```

Scilab code Exa 3.5 Chapter3 Example5

```
clc
//initialization of new variables
clear
W=275 //kg
rho_c=1.22 //kg/m^3
D=15 //m
g=9.8 //m/s^2
Tc=290 //K
//calculations
L=W*g
Tr=1-(6*L/(rho_c*g*%pi*D^3))  // Tc/Th
Th=Tc/Tr
//result
printf('The temperature required is %.1f K',Th)
```

Chapter 4

Introduction to Fluid in Motion

Scilab code Exa 4.1 Chapter4 Example1

```
clc
//initialization of new variables
clear
An=1 //cm^2
Un=15 //m/s
Ub=10 //m/s
U1=5 //m/s
U2=5 //m/s
th=120 //degrees
rho=1000 //kg/m^3
//calculations
th=th*%pi/180
Fx=rho*U1^2*An*10^-4*(cos(th)-1)
Fz=rho*U1^2*An*10^-4*sin(th)
W=Fx*Ub
//results
printf('The forces acting are Fx = %.2f N \n Fz = %
    .2f N ',Fx,Fz)
printf('\n The power generated is %.1f W',-W)
```

Scilab code Exa 4.2 Chapter4 Example2

```
clc
//initialization of new variables
clear
u=15 //m/s
D=0.1 //m
u1=10 //m/s
u2=10 //m/s
rho=1000 //kg/m^3
th=60 //degrees
//calculations
th=th*%pi/180
A=%pi*D^2/4
Fx=rho*u^2*A*(cos(th)-1)
//result
printf('Force on the wedge is  Fx = %.1f N',Fx)
printf('\n Fz = 0 N')
```

Scilab code Exa 4.7 Chapter4 Example7

```
clc
//initialization of new variables
clear
m=1 //kg
p=10^5 //N/m^2
A=1 //cm^2
w=0.5 //kg
rho=1000 //kg/m^2
//calculations
Ue=sqrt(2*p/rho)
m_0=w+m
```

```
m_s=w
Uf=Ue*log(m_0/m_s)
//results
printf('The exit velocity is %.2f m/s',Ue)
printf('\n The final velocity of the system is %.2f
   m/s ',Uf)
```

Scilab code Exa 4.8 Chapter4 Example8

```
clc
//initialization of new variables
clear
h=20 //cm
g=9.8 //m/s^2
rho_w=1000 //kg/m^3
rho_a=1.2 //kg/m^3
//calculations
dP=rho_w*g*h*10^-2
U=sqrt(2*dP/rho_a)
//results
printf('Air speed is %.2f m/s ',U)
```

Chapter 5

Viscous Incompressible Flow Exact Solutions

Scilab code Exa 5.2 Chapter5 Example2

```
clc
//initialization of new variables
clear
U=5 //m/s
h=1 //cm
mu=0.001
//calculations
Uav=U/2
Q=U*h*10^-2/2
tau_xz=mu*U/(h*10^-2)
S=1 //m^2
F=tau_xz*S
//results
printf('Shear stress per unit width at wall is %.1f
   N/m^2',tau_xz)
printf('\n The force required is %.1f N',F)
```

Scilab code Exa 5.3 Chapter5 Example3

```
clc
//initialization of new variables
clear
Uav=1 //m/s
h=1 //cm
mu=0.001
rho=1000 //kg/m^3
//calculations
h=h*10^-2
Umax=1.5*Uav
Dp=-12*mu*Uav/h^2
tau=-h/2*Dp
Re=rho*Uav*h/mu
Cf=12/Re
//results
printf('Max velocity = %.2f m/s ',Umax)
printf('\n Pressure gradient = %.2f N/m^3',Dp)
printf('\n shear = %.1f N',tau)
printf('\n friction coefficient = %.2e ',Cf)
```

Scilab code Exa 5.4 Chapter5 Example4

```
clc
//initialization of new variables
clear
h1=0.2 //mm gap
hr=2.2  //gap ratio
u=50 //m/s  linear velocity
mu=1.8*10^-5  // Coefficient of Viscocity
l=1 //cm  Length of the magnetic pickup
//calculations
l=l*10^-2
h1=h1*10^-3
```

```
L=0.16*mu*u*(l/h1)^2
R=4.7*h1/l
//results
printf('Lift = %.2f N/m',L)
printf('\n Drag to Lift ratio = %.3f ',R)
```

Scilab code Exa 5.5 Chapter5 Example5

```
clc
//initialization of new variables
clear
L=3 //m
D=1.2 //cm
Q=0.5 //L/min
mu=1.9*10^-2
rho=814 //kg/m^3
//calculations
R=D/2*10^-2
Q=Q/60*10^-3
Dp=-Q*8*mu/(%pi*R^4)
S=%pi*R^2
Uav=Q/S
Re=rho*Uav*D/mu
//results
printf('The pressure drop is %.1f N/m^2',Dp)
// Answer given in the ext is wrong by a scale of 10
```

Scilab code Exa 5.6 Chapter5 Example6

```
clc
//initialization of new variables
clear
L=10 //m
```

```
D=0.02 //m
Uav=0.15 //m/s
rho=1000 //kg/m^3
mu=10^-3
g=9.8 //m/s^2
//calculations
Re=rho*Uav*D/mu
f=64/Re
Hf=f*L*Uav^2/(D*2*g)
//results
printf('Head loss is = %.4f m',Hf)
```

Scilab code Exa 5.7 Chapter5 Example7

```
clc
//initialization of new variables
clear
Q=6 //L/min
D=3 //cm
K=0.32
g=9.8 //m/s^2
rho=1000 //kg/m^3
//calculations
R=D/2*10^-2
S=%pi*R^2
Q=Q/60*10^-3
Uav=Q/S
Hf=K*Uav^2/(2*g)
dP=Hf*rho*g
//results
printf('The pressure drop is %.2f N/m^2',dP)
printf('\n Head loss is %.2e m',Hf)
```

Scilab code Exa 5.8 Chapter5 Example8

```
clc
//initialization of new variables
clear
h=20 //m
a=2 //m
f=0.015
D=0.3 //m
K=0.3
g=9.8 //m/s^2
rho=804 //kg/m^3
mu=1.9*10^-3 //N s/m^2
//calculations
u2=sqrt((h+a)*2*g/(1+f*202/D+2*K))
S=%pi*D^2/4
Q=u2*S
Re=rho*u2*D/mu
//results
printf('Average discarge velocity = %.2f m/s',u2)
printf('\n Re = %.3e ',Re)
```

Scilab code Exa 5.9 Chapter5 Example9

```
clc
//initialization of new variables
clear
h2=0.2 //m
D=0.01 //m
h1=0.1 //m
rho=1254 //kg/m^3
mu=0.62 //N s/m^2
g=9.8 //m/s^2
//calculations
// Quadratic equation: a*u^2+b*u+c=0
```

```
a=1/(2*g)
b=32*mu*h2/(rho*g*D^2)
c=-(h1+h2)
u2a=(-b+sqrt(b^2-4*a*c))/(2*a)
u2b=(-b-sqrt(b^2-4*a*c))/(2*a)
u2=max(u2a,u2b)
//results
printf('Exit velocity is %.3f m/s',u2)
// Answer in the text differs by a scale of 10
```

Scilab code Exa 5.10 Chapter5 Example10

```
clc
//initialization of new variables
clear
h=20 //m
D1=0.3 //m upto 50 m distance
D2=0.2 //m
K=0.1
L1=50 //m
L2=100 //m
f=0.015
g=9.8 //m/s^2
//calculations
u3=sqrt(h*2*g/(1+f*L1/D1*(D2/D1)^4+K*(D2/D1)^4+f*L2/
    D2))
S3=%pi*D2^2/4
Q=u3*S3
//results
printf('Average discharge velocity is %.2f m/s',u3)
printf('\n The corresponding flow rate is %.2f m/s',
    Q)
```

Scilab code Exa 5.11 Chapter5 Example11

```
clc
//initialization of new variables
clear
L=20 //m
D=6 //cm
th=40 //degrees
Q=7.63 //L/s
rho=900 //kg/m^3
mu=0.18 //N s/m^2
g=9.8 //m/s^2
//calculations
th=th*%pi/180
R=D/2*10^-2
S=%pi*R^2
U=Q*10^-3/S
Re=rho*U*D*10^-2/mu
f=64/Re
Hf=f*L/D*U^2/(2*g)*10^2
Dp=rho*g*(L*sin(th)+Hf)
P=Dp*Q*10^-3
//result
printf('Power = %.1f W',P)
```

Scilab code Exa 5.12 Chapter5 Example12

```
clc
//initialization of new variables
clear
Q=5 //L/min
L=10 //m
D=5 //cm
UD=3 //cm
L1=12 //m
```

```
K1=0.9
K2=0.2
f=0.025
//calculations
Q=Q*10^-3
D=D*10^-2
R=D/2
UD=UD*10^-2
UR=UD/2
Ur=f*L/D/(f*L1/UD+2*K1+2*K2)
Ur=sqrt(Ur)
Ul=Q/%pi*1/(R^2+Ur*UR^2)
Ql=%pi*R^2*Ul*10^3
//results
printf('Velocity and flow rate in the lower pipe are
    respectively %.2f m/s %.2f L/s',Ul,Ql)
```

Scilab code Exa 5.13 Chapter5 Example13

```
clc
//initialization of new variables
clear
z=0.8 //m
b=1 //m
th=60 //degrees
n=0.012
phi=0.3 //degrees
//calculations
th=th*%pi/180
phi=phi*%pi/180
S=(1+z/tan(th))*z
Ph=1+2*z/sin(th)
Rh=S/Ph
Uav=1/n*Rh^(2/3)*sqrt(tan(phi))
Q=Uav*S
```

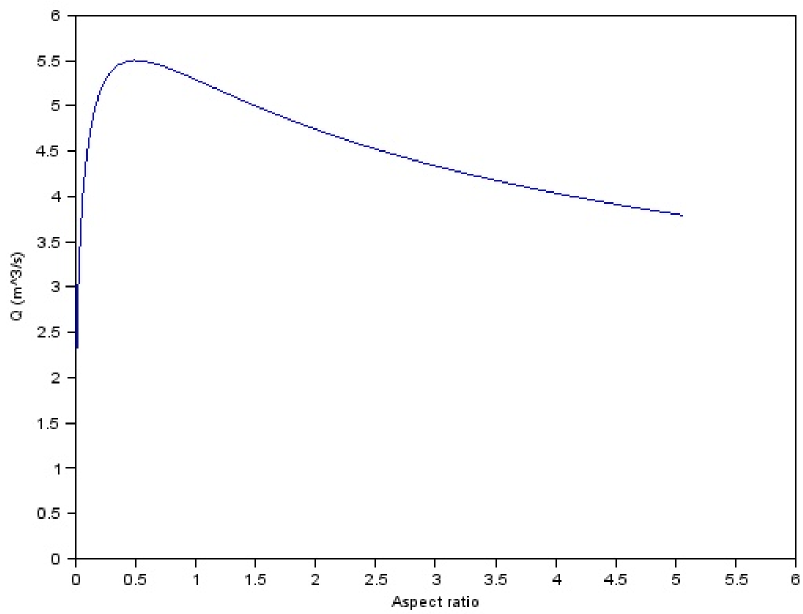

Figure 5.1: Chapter5 Example14

```
//results
printf('Average velocity is %.2f m/s',Uav)
printf('\n Flow rate = %.2f m^3/s',Q)
```

Scilab code Exa 5.14 Chapter5 Example14

```
clc
//initialization of new variables
clear
n = 0.012;
S = 1;
```

```
alpha = 1;//degrees
Z = 0.00005:0.05:5;
k = (5-0.00005)/0.05 +1;
for i = 1:k
    R_h(i) = S/((1/Z(i))+2*Z(i));
    U_av(i) = (1/n)*(R_h(i)^(2/3))*sqrt(tan(alpha*
       %pi/180));
    Q(i) = U_av(i)*S;
    b(i) = S/Z(i);
    AR(i) = Z(i)/b(i);
end

plot(AR(1:46),U_av(1:46));
xlabel('Aspect ratio');
ylabel('Q (m^3/s)');
```

Scilab code Exa 5.15 Chapter5 Example15

```
clc
//initialization of new variables
clear
D=1 //m
alpha=0.5 //degrees
n=0.012
//calculations
R=D/2


theta = 1:1:180;
R_h = 0.5*R - (45*R/%pi)*(sin(2*theta*%pi/180))./(
   theta*180/%pi);
Z = R*(1-cos(theta*%pi/180));
U_av = (1/n)*(R_h^(2/3))*sqrt(tan(alpha));
```

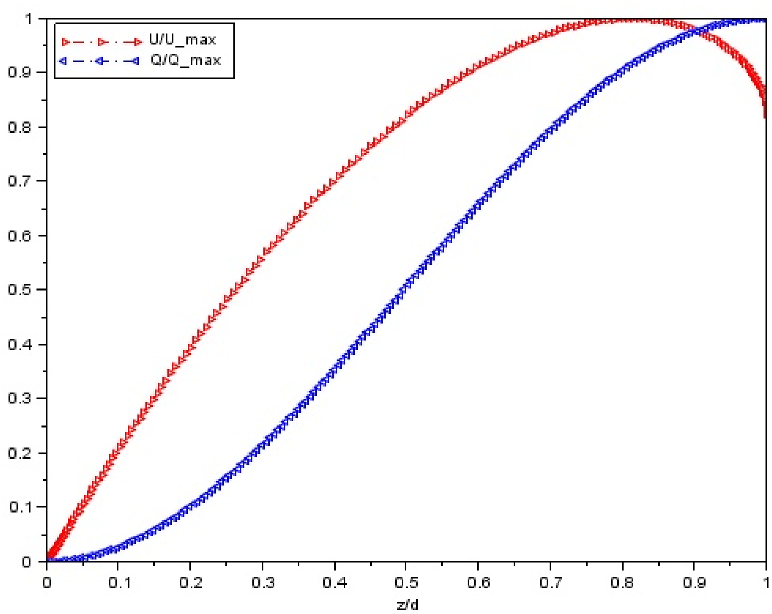

Figure 5.2: Chapter5 Example15

```
Q = U_av*%pi*R^2 .*(theta*180/%pi) - (0.5*R^2)*sin
    (2*theta*%pi/180);

plot(Z/D,(U_av-U_av(1))/max(U_av-U_av(1)),'r>-.');
//ylabel('U/U_max');
plot((Q-Q(1))/max(Q-Q(1)),Z/D,'b<-.');
//ylabel('Q/Q_max');
xlabel('z/d');
legend(['U/U_max”;'Q/Q_max';],opt=2);
```

Scilab code Exa 5.16 Chapter5 Example16

```
clc
//initialization of new variables
clear
u1=8 //m/s
z1=1 //m
g=9.8 //m/s^2
//calculations
Fr1=u1/sqrt(g*z1)
zr=(-1+sqrt(1+8*Fr1^2))/2
z2=z1*zr
u2=u1*z1/z2
Fr2=u2/sqrt(g*z2)
hr=1-zr+u1^2/(2*g*z1)-u2^2/(2*g*z1)
loss=hr*z1/(z1+u1^2/(2*g))
//results
printf('Fr1 = %.3f',Fr1)
printf('\n Fr2 = %.3f',Fr2)
printf('\n percent of loss = %.1f percent',loss*100)
```

Scilab code Exa 5.17 Chapter5 Example17

```
clc
//initialization of new variables
clear
D=0.5 //m
H=0.5 //m
d=1 //m
g=9.8 //m/s^2
//calculations
Cd=0.399+0.0598*H/D
Q=Cd*d/2*sqrt(2*g)*H^(3/2)
//results
printf('Flow rate is Q = %.3f m^3/s',Q)
```

Chapter 7

The Laminar Boundary Layer

Scilab code Exa 7.1 Chapter7 Example1

```
clc
//initialization of new variables
clear
w=1 //m
L=0.5 //m
u=2 //m/s
rho=1000 //kg/m^3
mu=10^-3
//calculations
ReL=rho*u*L/mu
Cd=2*0.664/sqrt(ReL)
D=2*Cd*1/2*rho*u^2*(w*L)
del=1.721*L/sqrt(ReL)
th=0.664*L/sqrt(ReL)
//results
printf('The drag on teh plate is %.3f N',D)
```

Scilab code Exa 7.2 Chapter7 Example2

```
clc
//initialization of new variables
clear
u=12 //m/s
w=10 //m
L=4 //m
rho=1.22 //kg/m^3
mu=1.8*10^-5
//calculations
ReL=rho*u*L/mu
Cd=0.0032 //from figure
D=2*Cd*1/2*rho*u^2*(w*L)
//results
printf('Total drag on plates is %.2f N',D)
```

Chapter 8

High Reynolds Number Flow Over Bodies

Scilab code Exa 8.1 Chapter8 Example1

```
clc
//initialization of new variables
clear
sigma=5 //m^2/s
x0=1
y0=1 //(x0,y0) location of source
x=0
y=-1
//calculations
u=sigma/(2*%pi)*(x-x0)/((x-x0)^2+(y-y0)^2)
w=sigma/(2*%pi)*(y-y0)/((x-x0)^2+(y-y0)^2)
//results
printf('u = %.3f m/s',u)
printf('\n w = %.3f m/s',w)
```

Scilab code Exa 8.2 Chapter8 Example2

```
clc
//initialization of new variables
clear
mu=1 //m^3/s
x0=0
z0=0
x=1
z=0
//calculations
u=mu/(2*%pi)*((x-x0)^2-(z-z0)^2)/((x-x0)^2+(z-z0)^2)
    ^2
w=mu/(2*%pi)*2*(x-x0)*(z-z0)/((x-x0)^2+(z-z0)^2)^2
//results
printf('u = %.2f m/s',u)
printf('\n w = %.2f m/s',w)
```

Scilab code Exa 8.3 Chapter8 Example3

```
clc
//initialization of new variables
clear
gama=5 //m^2/s
x0=1
y0=1 //(x0,y0) location of source
x=0
y=-1
//calculations
w=-gama/(2*%pi)*(x-x0)/((x-x0)^2+(y-y0)^2)
u=gama/(2*%pi)*(y-y0)/((x-x0)^2+(y-y0)^2)
//results
printf('u = %.3f m/s',u)
printf('\n w = %.3f m/s',w)
x=3
y=0
//calculations
```

```
w=-gama/(2*%pi)*(x-x0)/((x-x0)^2+(y-y0)^2)
u=gama/(2*%pi)*(y-y0)/((x-x0)^2+(y-y0)^2)
//results
printf('\n for the second point')
printf('\n u = %.3f m/s',u)
printf('\n w = %.3f m/s',w)
```

Scilab code Exa 8.6 Chapter8 Example6

```
clc
//initialization of new variables
clear
Re=3*10^6
CdT=0.004
x=0.4 //40%
//calculations
Cd=2*0.664/sqrt(Re)
Cd=x*Cd+(1-x)*CdT
Cd=2*Cd
//results
printf('For two sides the drag coefficient is
    estimated as %.4f',Cd)
```

Scilab code Exa 8.7 Chapter8 Example7

```
clc
//initialization of new variables
clear
h=15 //m
D=0.25 //m
u=30 //m/s
rho=1.2 //kg/m^3
mu=1.81*10^-5
```

```
Cd=0.7
Re=rho*u*D/mu
D=Cd*1/2*rho*u^2*(h*D)
M=h/2*D
//results
printf('D = %.1f N',D)
printf('\n M = %d N m',M)
```

Scilab code Exa 8.8 Chapter8 Example8

```
clc
//initialization of new variables
clear
D=0.5 //cm
rAl=2700 //kg/m^3
mu=0.29
rOil=919 //kg/m^3
g=9.8 //m/s^2
//calculations
D=D*10^-2
R=D/2
U=2/(9*mu)*(rAl-rOil)*g*R^2
//result
printf('The ball will sink with %.3f m/s',U)
```

Scilab code Exa 8.9 Chapter8 Example9

```
clc
//initialization of new variables
clear
Cd=1.2
r=1.2 //kg/m^3
u=15 //km/h
```

```
l=1 //m
b=1 //m
//calculations
D=Cd*1/2*r*(u/3.6)^2*(l*b)
//result
printf('The force on the plate is %.1f N',D)
```

Scilab code Exa 8.10 Chapter8 Example10

```
clc
//initialization of new variables
clear
u=25 //km/h
t=1 //h
S=0.36 //m^2
Cd=0.88
r=1.2 //kg/m^3
//calculations
D=Cd*1/2*r*(u/3.6)^2*(S)
P=D*u/3.6
E=P*t*3600
//results
printf('Drag force = %.2f N',D)
printf('\n Power = %.2f W',P)
printf('\n Energy spent is %.1f KJ',E/1000)
```

Scilab code Exa 8.11 Chapter8 Example11

```
clc
//initialization of new variables
clear
u=20 //km/h
Cd=0.15
```

```
S=4 //m^2
r=1025 //kg/m^3
//calculations
D=Cd*1/2*r*(u/3.6)^2*(S)
P=D*u/3.6
//results
printf('Drag force = %d N',D)
printf('\n Power = %.2f KW',P/1000)
```

Scilab code Exa 8.12 Chapter8 Example12

```
clc
//initialization of new variables
clear
m=90 //kg
D=6 //m
g=9.8 //m/s^2
r=1.2 //kg/m^3
Cd=1.2
//calculations
R=D/2
S=%pi*R^2
U=sqrt(2*m*g/(Cd*r*S))
//results
printf('U = %.2f m/s',U)
```

Scilab code Exa 8.13 Chapter8 Example13

```
clc
//initialization of new variables
clear
Cd=0.32
S=1.8 //m^2
```

```
Pe=300 //hp
u=100 //km/h
r=1.2 //kg/m^3
//calculations
D=Cd*1/2*r*(u/3.6)^2*(S)
P=D*u/3.6
//result
printf('Power required = %.1f kW = %.1f hp',P/1000,P*1.341/1000)
```

Scilab code Exa 8.14 Chapter8 Example14

```
clc
//initialization of new variables
clear
D=0.3 //m
u=35 //m/s
r=1.2 //kg/m^3
mu=1.81*10^-5
St=0.23
//calculations
Re=r*u*D/mu
f=St*u/D
//results
printf('So there are %d full cycles per second',f)
```

Scilab code Exa 8.15 Chapter8 Example15

```
clc
//initialization of new variables
clear
w=2 //m
u=100 //km/h
```

```
r=1.2 //kg/m^3
mu=1.81*10^-5
//calculations
D=w
Re=r*u*D/(3.6*mu)
St=0.23 //based on Re
f=St*u/(3.6*D)
l=u/(3.6*f)
//results
printf('Oscillation frequency is %.2f Hz',f)
printf('\n The distance between two cycles is %.2f m
    ',l)
```

Scilab code Exa 8.16 Chapter8 Example16

```
clc
//initialization of new variables
clear
D=0.65 //cm
u=50 //km/h
r=1.2 //kg/m^3
mu=1.81*10^-5
//calculations
D=D*10^-2
Re=r*u*D/(3.6*mu)
St=0.21 //based on Re
f=St*u/(3.6*D)
//results
printf('So there are %d full cycles per second',f)
```

Scilab code Exa 8.17 Chapter8 Example17

```
clc
```

```
//initialization of new variables
clear
D=3 //cm
u=11 //m/s
w=7000 //RPM
r=1.2 //kg/m^3
//calculations
D=D*10^-2
R=D/2
S=%pi*R^2
Rw=R*2*%pi*w/60*1/u
Cl=0.27 //based on Rw
Cd=0.63 //based on Rw
L=Cl*0.5*r*u^2*S
D=Cd*0.5*r*u^2*S
//results
printf('Lift = %.3f N',L)
printf('\n Drag = %.3f N',D)
```

Scilab code Exa 8.18 Chapter8 Example18

```
clc
//initialization of new variables
clear
c=3.5 //m
u=20 //km/h
alpha=5 //degrees
r=1.2 //kg/m^3
//calculations
alpha=alpha*%pi/180
Cl=2*%pi*alpha
L=0.5*Cl*r*(u/3.6)^2*c*1
//results
printf('Lift per unit span is %.2f N',L)
```

Scilab code Exa 8.19 Chapter8 Example19

```
clc
//initialization of new variables
clear
m=50 //kg
r=1.2 //kg/m^3
u=150 //km/h
Cl=0.5
g=9.8 //m/s^2
//calculations
c=m*g/(0.5*r*(u/3.6)^2*Cl)
Cd=0.005 //from figure
r=Cl/Cd
//results
printf('The chord length required is %.2f m',c)
printf('\n Lift to Drag ratio is %d',r)
```

Scilab code Exa 8.20 Chapter8 Example20

```
clc
//initialization of new variables
clear
c=3.5 //m
b=10 //m
u=20 //km/h
r=1.2 //kg/m^3
a=5 //degrees
//calculations
a=a*%pi/180
Cl=2*%pi*a/(1+2*c/b)
L=Cl*0.5*r*(u/3.6)^2*(c*b)
```

```
AR=b/c
Cdi=Cl^2/(%pi*AR)
Di=Cdi*0.5*r*(u/3.6)^2*(c*b)
//results
printf('Lift = %.2f N',L)
```

Scilab code Exa 8.21 Chapter8 Example21

```
clc
//initialization of new variables
clear
m=100 //tonne
u=200 //km/h
b=47 //m
r=1.22 //kg/m^3
g=9.8 //m/s^2
//calculations
gama=m*1000*g/(r*u/3.6*b)
w=2*gama/(%pi*b/2)
//results
printf('Downwash = %.2f m/s',w)
```

Scilab code Exa 8.22 Chapter8 Example22

```
clc
//initialization of new variables
clear
a=8 //degrees  In text calculated for 8 degrees even
    thoygh they mentioned it as 5 degrees
c=0.5 //m
b1=2 //m
b2=4 //m
//calculations
```

```
a=a*%pi/180
AR1=b1/c
AR2=b2/c
Cla1=2*%pi/(1+b1/AR1)
Cla2=2*%pi/(1+b2/AR2)
Cl1=Cla1*a
Cl2=Cla2*a
Cd1=Cl1^2/(%pi*AR1)
Cd2=Cl2^2/(%pi*AR2)
r1=Cl1/Cd1
r2=Cl2/Cd2
//results
printf('Lift to induced drag ratios are respectively
    %.2f and %.2f ',r1,r2)
```

Scilab code Exa 8.23 Chapter8 Example23

```
clc
//initialization of new variables
clear
m=250 //tonne  Weight
b=64.4 //m     wing span
S=541 //m^2    Wing area
c=8.4 //m      Wing chord
r=1.1 //kg/m^3    Air density
u=600 //km/h      air speed
g=9.8 //m/s^2   Acceleration due to gravity
//calculations
u=u/3.6
Cl=m*g*1000/(0.5*r*u^2*S)
AR=b^2/S
Cla=2*%pi/(1+2/AR)
aa=Cl/Cla
aa=aa*180/%pi
//results
```

```
printf('Airplane angle of attack is %.1f degrees',aa
   )
printf('\n Lift slope is %.2f ',Cla)
```

Scilab code Exa 8.24 Chapter8 Example24

```
clc
//initialization of new variables
clear
b=4 //m   wide
c=0.5 //m   chord
a=5 //degrees   angle of inclination
u=12 //m/s  speed
r=1030 //kg/m^3  density
//calculations
a=a*%pi/180
AR=b/c
Cla=2*%pi/(1+2/AR)
Cl=Cla*a
W=Cl*0.5*r*u^2*b
Cdi=Cl^2/(%pi*AR)
Di=0.5*Cdi*r*u^2*b
P=Di*u
printf('The power required is %.2f kW',P/1000)
printf('\n The weight of the boat is %.d N',W)
```

Scilab code Exa 8.25 Chapter8 Example25

```
clc
//initialization of new variables
clear
u=70 //m/s
a=20 //degrees
```

```
b=15 //m
c=25 //m
r=1.2 //kg/m^3
//calculations
AR=b^2/(0.5*b*c)
a=a*%pi/180
Cl=(0.963+1.512*AR)*sin(a)
W=Cl*0.5*r*u^2*(b*c/2)
D=W*tan(a)
//results
printf('Airplane weight is %.1f N',W)
printf('\n Drag is %.1f N',D)
```

Chapter 10

Elements of Inviscid Compressible flow

Scilab code Exa 10.1 Chapter10 Example1

```
clc
//initialization of new variables
clear
T=300 //k
gama=1.4
R=286.6
//calculations
a=sqrt(gama*R*T)
//results
printf('The speed of sound in air is %.2f m/s',a)
```

Scilab code Exa 10.2 Chapter10 Example2

```
clc
//initialization of new variables
clear
```

```
T0=850 //k
T=270 //k
gama=1.4
//calculations
M=sqrt(2/(gama-1)*(T0/T-1))
//results
printf('M = %.2f',M)
```

Scilab code Exa 10.3 Chapter10 Example3

```
clc
//initialization of new variables
clear
M=1
T0=300 //k
P0=4 //atm
gama=1.4
//calculations
Tr=1+(gama-1)*M^2/2
Pr=Tr^(gama/(gama-1))
P=P0/Pr
T=T0/Tr
//results
printf('At the section:')
printf('\n Pressure is %.2f atm',P)
printf('\n Temperature is %.2f K',T)
```

Scilab code Exa 10.5 Chapter10 Example5

```
clc
//initialization of new variables
clear
P0=4 //atm
```

```
T0=300 //K
At=5 //cm^2
Ae=10 //cm^2
//calculations
//case (1)
P1=3.8 //atm
Pr=P0/P1
M1=0.26  //from the figure
Ar=2.32
Aa=Ae/Ar  //A*
Art=At/Aa //At/A*
Mt=0.64 //from the figure
printf('case (1)')
printf('\n Exit Mach = %.2f ',Mt)
//case (2)
Aer=2.00 //from figure
M2=0.3 //based on the area ratio
Pr=0.939
P2=Pr*P0
printf('\n case (2)')
printf('\n back Pressure is %.2f atm',P2)
printf('\n Exit Mach = %.2f ',M2)
printf('\n So when the pressure at the exit is lowered a bit, the velocity at the throat becomes sonic.')
//case (3)
Ar=2.00 //from figure
M2=2.2 //based on area ratio
Pr=0.094
P2=Pr*P0
printf('\n case (3)')
printf('\n back pressure is %.2f atm',P2)
printf('\n Exit Mach = %.2f ',M2)
printf('\n The pressure ratio has to be very smaller to create a supersonic nozzle')
```

Scilab code Exa 10.6 Chapter10 Example6

```
clc
//initialization of new variables
clear
T0=2100 //k
P0=3.5 //atm
At=4 //cm^2
Ar=4.0 // Ae/At
Pa=1 //atm
gama=1.4
R=286.6
//calculations
Me=2.94
Pr=0.030
Tr=0.366
// from Isentropic table for Area ratio = 4
Pe=Pr*P0
Te=T0*Tr
ue=Me*sqrt(gama*R*Te)
re=Pe*10^5/(R*Te)
Ae=At*Ar
Ae=Ae*10^-4
Fx=re*ue^2*Ae+(Pe*10^5-0)*Ae
printf('The thrust in space is %.2f N',Fx)
// at sea level
M1=2.9
M2=sqrt((2+(gama-1)*M1^2)/(gama*(2*M1^2-1)+1))
P0r=0.358
Ar=3.85 //Isentropic table
Aer=1.433
Me=0.45
Per=0.870
Tr=0.961
```

```
// All the values from isentropic table
Pe=P0*P0r*Per
Te=T0*Tr
ue=Me*sqrt(gama*R*Te)
re=Pe*10^5/(R*Te)
Fx=re*ue^2*Ae+(Pe*10^5-Pa*10^5)*Ae
printf('\n The thrust at sea level is %.2f N',Fx)
```

Chapter 11

Fluid Machinary

Scilab code Exa 11.1 Chapter11 Example1

```
clc
//initialization of new variables
clear
r=0.3 //m
w=3000 //RPM
Cz=61 //m/s
th=45 //degrees
//calculations
U=%pi*2*r*w/60
beta1=atan(U/Cz)
beta1=beta1*180/%pi
beta2=th
DCth=U-Cz
//results
printf('Beta_1 = %d degrees',beta1)
```

Scilab code Exa 11.2 Chapter11 Example2

```
clc
//initialization of new variables
clear
Cz=120 //m/s
R_av=0.5 //m
T01=300 //k
w=4000 //RPM
alpha1=22 //degrees
beta2=27 //degrees
eta=0.98
Cp=0.24 // kcal/kg C
gama=1.4
//calculations
Cp=Cp*4200 //1 kcal= 4200 J
alpha1=alpha1*%pi/180
beta2=beta2*%pi/180
U=2*%pi*R_av*w/60
DCth=U-Cz*(tan(alpha1)+tan(beta2))
Pr=(1+eta*U*DCth/(Cp*T01))^(gama/(gama-1))
//results
printf('The pressure rise (compression ratio) is %.2
    f',Pr)
```

Scilab code Exa 11.3 Chapter11 Example3

```
clc
//initialization of new variables
clear
beta_d=15 //degrees  flow turn angle
r2=0.5 //m  tip radius
r1=0.2 //m   hub radius
w=5500 //RPM   rotaion speed
Cz=120 //m/s  Axial velocity
T=350 //k   Temperature
eta=0.98  //Efficiency
```

```
// air properties
gama=1.4
R=286.6
cp=0.24
//calculatons
cp=cp*4200
T01=T
Uhub=2*%pi*r1*w/60
Utip=2*%pi*r2*w/60
w1=sqrt(Utip^2+Cz^2)
a1=sqrt(gama*R*T)
M1=w1/a1
//Hub
beta1=atan(Uhub/Cz)
beta2=beta1*180/%pi-beta_d
beta2=beta2*%pi/180
Cp=1-cos(beta1)^2/cos(beta2)^2
DCth=Uhub-Cz*tan(beta2)
Pr=(1+eta*Uhub*DCth/(cp*T01))^(gama/(gama-1))
printf('Hub:')
printf('\n The pressure rise coefficient is %.2f',Cp)
printf('\n Compression ratio = %.3f',Pr)
//tip
beta1=atan(Utip/Cz)
beta2=beta1*180/%pi-beta_d
beta2=beta2*%pi/180
Cp=1-cos(beta1)^2/cos(beta2)^2
DCth=Utip-Cz*tan(beta2)
Pr=(1+eta*Utip*DCth/(cp*T01))^(gama/(gama-1))
printf('\n tip:')
printf('\n The pressure rise coefficient is %.2f',Cp)
printf('\n Compression ratio = %.3f',Pr)
```

Scilab code Exa 11.4 Chapter11 Example4

```
clc
//initialization of new variables
clear
r=0.5 //m   average radius
Cz=140 //m/s  Axial velocity
w=4000 //RPM  turn rate
T01=300 //K   Stagnation temperature ahead of rotor
alpha1=20 //degrees  Incoming velocity angle
Cp=0.45    //Pressure rise coefficient
eta=0.98  //efficiency
cp=0.24 //specific heat
gama=1.4
//calculations
temp=alpha1 //just to store it
cp=cp*4200
U=r*w*2*%pi/60
alpha1=alpha1*%pi/180
beta1=atan(U/Cz-tan(alpha1))
beta2=acos(sqrt(cos(beta1)^2/(1-Cp)))
DCth=U-Cz*(tan(alpha1)+tan(beta2))
Pr=(1+eta*U*DCth/(cp*T01))^(gama/(gama-1))
printf('part (1)')
printf('\n stagnation pressure rise (ratio)is %.2f',
   Pr)
// part (2)
Cz=100 //m/s
alpha1=atan(U/Cz-tan(beta1))
Dalpha=alpha1*180/%pi-temp
printf('\n Stator ahead of this stage must be
   rotated by %.1f degrees',Dalpha)
DCth=U-Cz*(tan(alpha1)+tan(beta2))
Pr=(1+eta*U*DCth/(cp*T01))^(gama/(gama-1))
printf('\n part (2)')
printf('\n stagnation pressure rise (ratio)is %.2f',
   Pr)
```

Scilab code Exa 11.5 Chapter11 Example5

```
clc
//initialization of new variables
clear
R=0.5
U=290 //m/s
c1=150 //m/s
alpha1=37 //degrees
beta2=alpha1
cp=0.24
eta=0.85
gama=1.4
T01=280 //k
//calculations
cp=cp*4200
alpha1=alpha1*%pi/180
Cth1=c1*sin(alpha1)
DCth=U-2*c1*sin(alpha1)
beta1=atan((U-Cth1)/c1*cos(alpha1))
Cp=1-cos(beta1)^2/cos(beta2)^2
Pr=(1+eta*U*DCth/(cp*T01))^(gama/(gama-1))
//results
printf('The compression ratio is %.2f',Pr)
```

Scilab code Exa 11.6 Chapter11 Example6

```
clc
//initialization of new variables
clear
r1=0.1 //m
r2=0.4 //m
```

```
bet=15 //degrees
eta=0.9
cp=0.24
w=5000 //RPM
Cth1=0
gama=1.4
T01=300 //K
//calculations
bet=bet*%pi/180
U2=r2*w*2*%pi/60
U1=r1*w*2*%pi/60
wr2=U2/2
cp=cp*4200
Cth2=wr2*tan(bet)+U2
Tr=(U2*Cth2-U1*Cth1)/(cp*T01)
Pr=(1+eta*Tr)^(gama/(gama-1))
//results
printf('The pressure rise is %.2f',Pr)
```

Scilab code Exa 11.7 Chapter11 Example7

```
clc
//initialization of new variables
clear
w=1000 //RPM
r1=0.05 //m
r2=0.10 //m
bet=0 //degrees
eta=0.9
r=1000 //kg/m^3
//calculations
bet=bet*%pi/180
U2=r2*w*2*%pi/60
Cth2=U2
dp=r*eta*U2*Cth2
```

```
U1=r1*w*2*%pi/60
beta1=50 //degrees
beta1=90-beta1
beta1=beta1*%pi/180
c1=U1*tan(beta1)
m=r*c1*%pi*r1^2
P=m*U2*Cth2
//results
printf('Pressure rise is %.1f N/m^2',dp)
printf('\n mass flow rate is %.2f kg/s',m)
printf('\n Power = %.2f W',P)

//wrong answer for pressure rise part in text
```

Scilab code Exa 11.8 Chapter11 Example8

```
clc
//initialization of new variables
clear
S=3 //cm^2
m=15 //kg/s
alpha2=68.5 //degrees
r=0.3 //m
w=1000 //RPM
ma=100 //kg
rho=1000 //kg/m^3
g=9.8 //m/s^2
//calculations
S=S*10^-4
alpha2=alpha2*%pi/180
U=r*w*2*%pi/60
c2=m/(rho*S)
cz=c2*cos(alpha2)
beta2=atan((c2*sin(alpha2)-U)/cz)
P=m*U*2*cz*tan(beta2)
```

```
v=P/(ma*g)
//results
printf('beta_2 = %.1f degrees',beta2*180/%pi)
printf('\n v = %.2f m/s',v)
```

Scilab code Exa 11.9 Chapter11 Example9

```
clc
//initialization of new variables
clear
r=0.3 //m
w=7000 //RPM
T01=1200 //K
rho2=0.5 //kg/m^3
R=0.5
beta2=30 //degrees
eta=0.9
gama=1.4
cp=0.24
//calculations
cp=cp*4200
U=r*w*2*%pi/60
beta2=beta2*%pi/180
// to solve for c2 and w2
//Ax=b
A=[-sin(%pi/2-beta2) -sin(beta2)
   cos(%pi/2-beta2) -cos(beta2)]
b=[-U;0]
x=inv(A)*b
w2=x(2)
c2=x(1)
wt=U*(U-2*w2*sin(beta2))
Tr=wt/(cp*T01)
Pr=(1-Tr/eta)^(gama/(gama-1))
//results
```

```
printf('The power of the turbine (per unit mass) is
   %.2f m^2/s^2',wt)
printf('\n The pressure ratio is %.3f',Pr)
printf('\n Because R = %.2f, half of pressure drop
   takes place in turbine',R)
```

Scilab code Exa 11.10 Chapter11 Example10

```
clc
//initialization of new variables
clear
r2=0.1 //m
m=1 //kg/s
T01=1200 //K
alpha2=65 //degrees
c2=330 //m/s
rho2=0.5 //kg/m^3
eta=0.9
gama=1.4
cp=0.24
//calculations
alpha2=alpha2*%pi/180
cp=cp*4200
Cthd=c2*sin(alpha2)
U=Cthd/2
P=m*U*Cthd
Tr=U*Cthd/(cp*T01)
Pr=(1-Tr/eta)^(gama/(gama-1))
RPM=U/(2*%pi*r2)
//results
printf('part (a)')
printf('\n Power generated is %.1f W',P)
printf('part (b)')
printf('\n Stagnation pressure drop is %.3f ',Pr)
printf('\n In rotor, zero static pressure drop takes
```

```
place')
printf('\n part (c)')
printf('\n RPM = %d RPM',RPM*60)
```

Scilab code Exa 11.11 Chapter11 Example11

```
clc
//initialization of new variables
clear
r=0.1 //m
RPM=1000 //RPM
c2=30 //m/s
S=2 //cm^2
beta3=60 //degrees
alpha2=90 //degrees
rho=1000 //kg/m^3
//calculations
beta3=beta3*%pi/180
alpha2=alpha2*%pi/180
S=S*10^-4
U=RPM*r*2*%pi/60
w2=c2-U
w3=w2
CthD=w2*sin(alpha2)+w2*sin(beta3)
m=rho*c2*S
T=m*r*CthD
P=m*U*CthD
//results
printf('mass flow rate is %.2f kg/s',m)
printf('\n Torque T = %.2f N m',T)
printf('\n Power P = %.2f W',P)
```

Scilab code Exa 11.12 Chapter11 Example12

```
clc
//initialization of new variables
clear
P=5 //kW
U=30 //km/h
eta=70 //percent
rho=1.22 //kg/m^3
//calculations
eta=eta/100
P=P*1000
R=sqrt(P*27/(8*eta*rho*(U/3.6)^3*%pi))
//results
printf('R = %.2f m',R)
```