Scilab Textbook Companion for Fluid Mechanics by R. H. F. Pao[1]

Created by
Rahul Paramata
Chemical Engineering
Chemical Engineering
IIT Bombay
College Teacher
Na
Cross-Checked by
Lavitha Pereira

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Book Description

Title: 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

Chapter 2

Fluid Statics

Scilab code Exa 2.1 Final pressure

```
clc
clear
//Initialization of variables
gam=0.0765 //lb/ft^3
p=14.7 //psia
dz=10560 //ft
//calculations
pg=p*144/gam
p2=p*exp(-dz/pg)
gam2=p2/p*gam
//results
printf("Final pressure = %.2f psia",p2)
printf("\n Final specific weight = %.4f lb/ft^3",
   gam2)
```

Scilab code Exa 2.2 Final specific weight

```
clc
```

```
clear
//Initialization of variables
gam=0.0765 //lb/ft^3
p=14.7 //psia
dz=10560 //ft
n=1.235
//calculations
pg=p*144/gam
p2=p*(1- dz/pg *(n-1)/n)^(n/(n-1))
gam2=(p2/p)^(1/n) *gam
//results
printf("Final pressure = %.2f psia",p2)
printf("\n Final specific weight = %.4f lb/ft^3",
    gam2)
```

Scilab code Exa 2.3 Absolute pressure in feet of water

```
clc
clear
//Initialization of variables
pb=28.5 //in mercury
d=13.6 //g/cc
gam=62.4
pobs=-4 //psi
//calculations
patm=pb/12 *gam*d/144
pabs=patm+pobs
P=pabs*144/gam
//results
printf("Absolute pressure = %.1f psia",pabs)
printf("\n Absolute pressure in feet of water = %.1f
    ft of water",P)
```

Scilab code Exa 2.4 Absolute pressure of Air

```
clc
clear
//Initialization of variables
pb=28 //in mercury
d=13.6 //g/cc
gam=62.4
xm=15 //in
xw=10 //in
patm=28 //in
//calculations
pB=-xm/12 *gam/144 *d + xw*gam/144
pair=patm/12 *gam/144 *d - xm/12 *gam/144 *d
//results
printf("The pressure gauge at B indicates a reading of %.2f psi vacuum",-pB)
printf("\n Absolute pressure of Air = %.2f psia",pair)
```

Scilab code Exa 2.5 Pressure difference

```
clc
clear
//Initialization of variables
pb=28.5 //in mercury
d=13.6 //g/cc
gam=62.4
xm=10 //in
xw=2 //ft
//calculations
dp= xw*gam/144 - xm/12 *gam/144 + xm/12 *gam/144 *d
//results
printf("Pressure difference = %.2f psi",dp)
if dp>0 then
```

```
    printf("\n Pressure at A is greater than that at
       B")
elseif dp=0
    printf("\n Pressure at both A and B are equal")
else
    printf("\n Pressure at A is less than that at B"
      )
end
```

Scilab code Exa 2.6 Magnitude of total force

```
clc
clear
//Initialization of variables
gam=62.4
x1=4 //ft
x2=6  //ft
y1=6 //ft
z=8 //ft
dy=1 //ft
angle=60 //degrees
//calculations
A1=x1*x2
A2=1/2 *y1^2
yc = (A1*(x1+x2+dy) + A2*(x1+x2))/(A1+A2)
hc=yc*sind(angle)
F=hc*gam*(A1+A2)
ic1=1/12 *x1*y1^3
ic2=1/36*y1*x2^3
ad1=A1*(x1+x2+dy-yc)^2
ad2=A2*(x1+x2-yc)^2
It=ic1+ic2+ad1+ad2
ydc=It/(yc*(A1+A2))
function m= momen(u)
    m= gam*sind(angle) *(2*x1+u)*0.5*(x2-u)*(y1-u)
```

```
endfunction
MED=intg(0, y1, momen)
FEDC=gam*sind(angle) *A2*(x1+x2)
xed=MED/FEDC
xp= (A1*2*(x1+x2+dy) + (x1+x2)*(A2)*(x1+xed))/(A1*(
    x1+x2+dy) + A2*(x1+x2))
//results
printf("Magnitude of total force = %d lb",F)
printf("\n Vertical location of force = %.3f ft",ydc
    )
printf("\n Horizontal location of force = %.2f ft
    from AB",xp)
printf("\n Direction of force is perpendicular to
    the plane surface")
```

Scilab code Exa 2.7 Magnitude of total force

```
clc
clear
//Initialization of variables
gam=62.4
z=10 //ft
z2=5 //ft
z3=4.25 //ft
p=2 //psig
//calculations
h=p*144/gam
Av=z^2
Fh=gam*(z+h)*Av
hpc=1/12 *z^4 /((h+z)*z^2)
Fv=gam*(z2+h) *z^2 + gam*%pi/4 *z^2 *z
xp= (gam*(z2+h) *z^2 *z2 + gam*%pi/4 *z^2 *z*z3)/(Fv
    )
F=sqrt(Fh^2 + Fv^2)
//results
```

```
printf("Magnitude of force = %d lb",F)
printf("\n horizontal distance from line of action
    of Fv = %.2f ft from AG",xp)
```

Scilab code Exa 2.8 Location of metacenter

```
clc
clear
//Initialization of variables
gam=0.0765 //lb/ft^3
l=40 //ft
w=16 //ft
d=8 //ft
z=6  //ft
BG=1 //ft
//calculations
I=1/12 *l*w^3
V=l*w*z
IVG=I/V - BG
MB=I/V
//results
printf("I/V -BG = %.2f ft ",IVG)
if IVG >0 then
    printf("\n Barge is stable")
else
    printf("\n The barge is unstable")
end
printf("\n Location of metacenter = %.2f ft above
    the center of buoyancy ",MB)
```

Chapter 3

Fluid Kinematics

Scilab code Exa 3.1 Mean velocity

```
clc
clear
//Initialization of variables
gam=0.0765 //lb/ft^3
Q=100 //ft^3/sec
d1=2.5 //ft
d2=9 //in
l=12 //ft
//calculations
A1=%pi/4 *d1^2
V1=Q/A1
A2=%pi*l*d2/12
V2=Q/A2
//results
printf("Mean velocity of flow at section 1 = %.1f ft
   /sec",V1)
printf("\n Mean velocity of flow at section 2 = %.2f
    ft/sec",V2)
```

Scilab code Exa 3.5 component of velocity

```
clc
clear
//Initialization of variables
x=3
y=1
//calculations
u=-3*y^2
v=-6*x
//results
printf("Horizontal component of velocity = %d ",u)
printf("\n vertical component of velocity = %d ",v)
```

Chapter 4

Fluid Dynamics

Scilab code Exa 4.1 dp/ds

```
clc
clear
//Initialization of variables
rho=1.5 //g/cc
g=32.2 //ft/s^2
dzds=-0.5
x1=0
x2=3
//calculations
function dpds = func(s)
    dpds=-rho*g*dzds - rho*(3+9*s)*9
endfunction
r1=func(x1)
r2=func(x2)
//results
printf("At the upper end, dp/ds = %.1f lb/ft^2 per
   foot",r1)
printf("\n At the lower end, dp/ds = %.1f lb/ft^2
   per foot",r2)
```

Scilab code Exa 4.2 pressure difference

```
clc
clear
//Initialization of variables
g=32.2 //ft/s^2
v1=3 //ft/s
z1=1.5 //ft
rho=1.5 //g/cc
z2=0
v2=30 //ft/s
//calculations
dp= rho*(v2^2 /2 - g*z1 +g*z2 - v1^2 /2)
//results
printf("pressure difference = %.1f lb/ft^2",dp)
```

Scilab code Exa 4.3 Power transferred

```
clc
clear
//Initialization of variables
pd=15 //psia
rhod=0.005//slug/ft^3
pi=150 //psia
rhoi=0.03 //slug/ft^3
dz=-25 //ft
vd=1000 //ft/s
vi=100 //ft/s
ud=200 //Btu/slug
ui=250 //Btu/slug
g=32.2 //ft/s^2
J=778
```

```
uff=5 //ft/s
Q=50 //Btu/sec
//calculations
pr=pd/rhod*144 - pi/rhoi *144
zr=g*(dz)
vr=(vd^2 -vi^2)/2
ur=(ud-ui)*J
jeh=J*Q*g/uff
gem=pr+zr+vr+ur+jeh
power=gem*uff/g
//results
printf("Power transferred = %d ft-lb/sec",power)
```

Scilab code Exa 4.4 Kinetic energy correction factor

```
clc
clear
//Initialization of variables
r0=1
ri=0
//calculations
function v= func1(y)
    v= 2*y^(1/7) *(y-1)
endfunction
V=intg(ri,r0,func1)
function alpha= func2(y)
    alpha= 1/ (%pi*V^3) *2*%pi *(y)^(3/7) *(y-1)
endfunction
a2=intg(ri,r0,func2)
//results
printf("Kinetic energy correction factor = %.2f",a2)
```

Scilab code Exa 4.5.a Pressure at the lower end if friction is neglected

```
clc
clear
//Initialization of variables
gam=62.4
pu=40 //psia
zu=25 //ft
vu=8 //ft/s
g=32.2 //ft/s^2
vl=8 //ft/s
zl=0 //ft
//calculations
pl= gam*(pu*144/gam +zu-zl+ (vu^2 -vl^2)/(2*g))/144
//results
printf("Pressure at the lower end if friction is
    neglected = %.2f psig",pl)
```

Scilab code Exa 4.5.b Pressure at the lower end if friction is neglected

```
clc
clear
//Initialization of variables
hl=5
gam=62.4
pu=40 //psia
zu=25 //ft
vu=8 //ft/s
g=32.2 //ft/s^2
vl=8 //ft/s
zl=0 //ft
//calculations
pl= gam*(pu*144/gam +zu-zl-hl+ (vu^2 -vl^2)/(2*g))
    /144
//results
printf("Pressure at the lower end if friction is
    neglected = %.2f psig",pl)
```

Scilab code Exa 4.6.b Pressure

```
clc
clear
//Initialization of variables
gam=62.4
pa=0
za=15 //ft
va=0
pg=0
zg=0
g=32.2 //ft/s^2
d=4 //in
dg=2 //in
zd=25  //ft
//calculations
vg= sqrt(2*g*(pa/gam +za+va^2 /(2*g) -pg/gam - zg))
Ag=%pi/4 *(dg/12)^2
Q=Ag*vg
A=%pi/4 *(d/12)^2
v4=Q/A
pc=-v4^2 *gam/(2*g*144)
pgd= za-zd - v4^2 /(2*g)
pd=pgd*gam/144
pe=-v4^2 *gam/(2*g*144)
pfg= za- v4^2 /(2*g)
pf=pfg*gam/144
//results
printf("Pressure at C = %.2f psig",pc)
printf("\n Pressure at D = %.2f psig",pd)
printf("\n Pressure at E = %.2f psig",pe)
printf("\n Pressure at F = %.2f psig",pf)
```

Scilab code Exa 4.6 discharge

```
clc
clear
//Initialization of variables
gam=62.4
pa=0
za=15 //ft
va=0
pg=0
zg=0
g=32.2 //ft/s^2
dg=2 //in
//calculations
vg= sqrt(2*g*(pa/gam +za+va^2 /(2*g) -pg/gam - zg))
Ag=%pi/4 *(dg/12)^2
Q=Ag*vg
//results
printf("discharge = %.2f ft^3/sec",Q)
```

Scilab code Exa 4.7 Time required

```
clc
clear
//Initialization of variables
d1=6 //ft
d2=3 //in
pa=2 //ft
d=13.6
sg=0.75
h1=5 //sec
h2=3 //sec
```

```
g=32.2 //ft/s^2
//calculations
pag=pa/12 *d/sg
function time = func(h)
    time= -d1^2 /(d2/12)^2 /(sqrt(2*g)) *(pag+h)
       ^(-0.5)
endfunction
ti=intg(h1,h2,func)
//results
printf("Time required = %.1f sec",ti)
```

Scilab code Exa 4.8 Rate of flow

```
clc
clear
//Initialization of variables
x=12 //ft
angle=30 //degrees
g=32.2 //ft/s^2
z=-2 //ft
d=2 //in
//calculations
vj= x/cosd(angle) *sqrt(g/(2*(x*tand(angle) -z)))
Q=%pi/4 *(d/12)^2 *vj
//results
printf("Rate of flow = %.2f ft^3/s",Q)
```

Scilab code Exa 4.9 Discharge

```
clc
clear
//Initialization of variables
x=10 //in of mercury
```

```
sg=13.6 //g/cc
d1=8 //in
d2=4 //in
g=32.2 //ft/s^2
//calculations
vdiff=x/12 *sg- x/12
Vts=vdiff/(1-(d2/d1)^4)
Vt=sqrt(2*g*Vts)
Q=Vt*%pi/4 *(d2/12)^2
//results
printf("Discharge = %.2f ft^3/s",Q)
```

Scilab code Exa 4.11 Horsepower

```
clc
clear
//Initialization of variables
gam=62.4
ds=12 //in
dd=10 //in
Q=4 //ft^3/s
pd=40 //psia
ps=-6 //psia
zd=5 //ft
zs=0
g=32.2 //ft/s^2
//calculations
vs=Q/(%pi/4 *(ds/12)^2)
vd=Q/(%pi/4 *(dd/12)^2)
emp = (pd-ps)*144/gam + zd-zs + (vd^2 - vs^2)/(2*g)
hpp=emp*Q*gam/550
//results
printf("Horsepower input of the test pump = %.1f hp"
    ,hpp)
```

Scilab code Exa 4.12 component of force

```
clc
clear
//Initialization of variables
d1=12 //in
d2=8 //in
v1=15 //ft/s
p1=12 //psig
p2=5.85 //psig
rho=1.94 //ft^3/slug
angle=60 //degrees
//calculations
Q=%pi/4 *(d1/12)^2 *v1
v2=Q/(%pi/4 *(d2/12)^2)
pa1=p1*%pi/4 *(d1)^2
pa2=p2*%pi/4 *(d2)^2
qv1=rho*Q*v1
qv2=rho*Q*v2
Fx=pa1+qv1+ cosd(angle)*(pa2+qv2)
Fy=sind(angle)*(pa2+qv2)
//results
printf("Horizontal component of force = %d lb",Fx)
printf("\n Vertical component of force = %d lb",Fy)
```

Scilab code Exa 4.14.b Thrust

```
clc
clear
//Initialization of variables
de=4 //in
T=1000 //lb
```

```
g=32.2 //ft/s^2
vele=8.5 //lb/s
pe=16.5 //psia
pa=14.7 //psia
pa2=1 //psia
//calculations
Ae=%pi/4 *de^2
Ve= (T-(pe-pa)*Ae)*g/vele
T2=vele/g *Ve + (pe-pa2)*Ae
//results
printf("Thrust = %d lb",T2)
```

Scilab code Exa 4.14 Exit velocity

```
clc
clear
//Initialization of variables
de=4 //in
T=1000 //lb
g=32.2 //ft/s^2
vele=8.5 //lb/s
pe=16.5 //psia
pa=14.7 //psia
//calculations
Ae=%pi/4 *de^2
Ve= (T-(pe-pa)*Ae)*g/vele
//results
printf("Exit velocity = %d ft/s",Ve)
```

Scilab code Exa 4.16 Horsepower dissipation

```
clc
clear
```

```
//Initialization of variables
q=240 //ft^3/sec/ft
v1=60 //ft/s
gam=62.4
rho=1.94 //slug/ft^3
g=32.2 //ft/s^2
//calculations
y1=q/v1
v2=8.6 //ft/s
y2=28 //ft
hl= (y1+ v1^2 /(2*g)) - (y2+ v2^2 /(2*g))
hpp=hl*q*gam/550
//results
printf("Downstream depth = %.1f ft",y2)
printf("\n Horsepower dissipation = %d hp per foot
    width",hpp)
```

Scilab code Exa 4.17 Acceleration

```
clc
clear
//Initialization of variables
dh=3 //in
L=12 //in
g=32.2 //ft/s^2
//calculations
a=dh/L *g
//results
printf("Acceleration = %.2f ft/s^2",a)
```

Chapter 5

Fluid Viscosity and Flow of real fluids

Scilab code Exa 5.3 Viscosity of oil

```
clc
clear
//Initialization of variables
m=1155 //lb
gam=62.4
spg=0.93
t=3*60 //sec
d=1/6 //in
L=20 //ft
dp=2.5 //psi
//calculations
Q=m/(t*spg*gam)
A=%pi/4 *d^2
V=Q/A
mu=dp*d^2 *144/(32*V*L)
//results
printf("Viscosity of oil = %.4f lb-sec/ft^2",mu)
```

Scilab code Exa 5.4 Alpha/ beta

```
clc
clear
//Initialization of variables
g=32.2
gam=62.4
r0=1
//calculations
function al= func1(r)
    al=8/r0^8 *(r0^2-r^2)^3 *(2*r)
endfunction
alpha=intg(0,r0,func1)
function a2= func2(r)
    a2=4/r0^6 *(r0^2 -r^2) ^2 *(2*r)
endfunction
bet=intg(0,r0,func2)
//results
printf("Alpha = %d ",alpha)
printf("\n beta = %.2f",bet)
```

Scilab code Exa 5.5.a Energy loss

```
clc
clear
//Initialization of variables
spg=0.93
mu=3.1e-3 //lb-sec/ft^2
gam=62.4
z=50 //m
p1=60 //psia
p2=25 //psia
```

```
//calculations
p1g=144*p1
p2g=144*p2 + spg*gam*z
dp=p1g-p2g
//results
if p1g>p2g then
    printf("The flow is in upward direction")
else
    printf("The flow is in downward direction")
end
printf("\n Energy loss= %d ft-lb/ft^3",dp)
```

Scilab code Exa 5.5.b Flow rate

```
clc
clear
//Initialization of variables
hl=2140 //ft-lb/ft^3
spg=0.93
mu=3.1e-3 //lb-sec/ft^2
gam=62.4
z=50 //m
p1=60 //psia
p2=25 //psia
d=1 //in
//calculations
V= hl*(d/12)^2 /(32*mu*z)
Q=V*%pi/4 *(d/12)^2
Q2=Q*7.48*60
//results
printf("Flow rate = %.2f gal/min",Q2)
```

Scilab code Exa 5.7 Flow in model

```
clc
clear
//Initialization of variables
muw=2.04e-5 //lb-sec/ft^2
rhow=1.94 //slugs/ft^3
mua=3.74e-7 //lb-sec/ft^2
rhoa=0.00237 //slug/ft^3
Qw=200 //gal/min
Lr=5
//calculations
Qa=Qw*Lr *(rhow/rhoa)*(mua/muw)
//results
printf("Flow in model = %d gal/min",Qa)
```

Chapter 6

Dimensional Analysis and Model similitude

Scilab code Exa 6.3 Pressure drop

```
clc
clear
//Initialization of variables
dg=0.5 //in
dw=12 //in
rhog=0.022 //slug/ft^3
rhow=1.94 //slug/ft^3
muw=2.34e-5 //lb-sec/ft^2
mug=3.50e-7 //lb-sec/ft^2
Qg=0.15 //ft^3/s
dpg=100 //lb/ft^2
//calculations
Vr=dg/dw *rhog/rhow *muw/mug
Qr=Vr*dw^2 /dg^2
Qw=Qr*Qg
dpr=rhow/rhog *(Vr)^2
dpw=dpr*dpg
//results
printf("Flow rate of water = %.2f ft^3/s",Qw)
```

```
printf("\n Pressure drop = %.1f lb/ft^2",dpw)
```

Scilab code Exa 6.4 Time, Accelaration and Force ratio

```
clc
clear
//Initialization of variables
Lr=1/10
rhom=2
rhop=1.94
//calculations
Vr=sqrt(Lr)
Tr=Lr/Vr
ar=Vr/Tr
Fr=rhom/rhop *ar*Lr^3
//results
printf("Velocity ratio = %.4f",Vr)
printf("\n Time ratio = %.4f",Tr)
printf("\n Acceleration ratio = %d ",ar)
printf("\n Force ratio = %.6f",Fr)
```

Chapter 7

Flow of In compressible fluids in closed conduits

Scilab code Exa 7.1.b Kinematic viscosity

```
clc
clear
//Initialization of variables
z1=2 //ft
Q=0.1 //gal/min
alpha=2
g=32.2 //ft/s^2
L=4 //ft
D=1/96 //ft
//calculations
v2=Q/(7.48*60* %pi/4 *D^2)
hl=z1-alpha*v2^2 /(2*g)
Nr=64/hl *L/D *v2^2 /(2*g)
mu=v2*D/Nr
//results
printf("Kinematic viscosity = %.2e ft^2/s",mu)
```

Scilab code Exa 7.1.c Theoretical entrance transistion length

```
clc
clear
//Initialization of variables
z1=2 //ft
Q=0.1 //gal/min
alpha=2
g=32.2 //ft/s^2
L=4 //ft
D=1/96 //ft
//calculations
v2=Q/(7.48*60* %pi/4 *D^2)
hl=z1-alpha*v2^2 /(2*g)
Nr=64/hl *L/D *v2^2 /(2*g)
Ld=0.058*Nr*D
//results
printf("Theoretical entrance transistion length = %
    .3f ft",Ld)
```

Scilab code Exa 7.1 Reynolds number

```
clc
clear
//Initialization of variables
z1=2 //ft
Q=0.1 //gal/min
alpha=2
g=32.2 //ft/s^2
L=4 //ft
D=1/96 //ft
//calculations
v2=Q/(7.48*60* %pi/4 *D^2)
hl=z1-alpha*v2^2 /(2*g)
Nr=64/hl *L/D *v2^2 /(2*g)
```

```
//results
printf("Reynolds number is %d.  Hence the flow is
    laminar",Nr)
//The answer is a bit different due to rounding off
    error in textbook
```

Scilab code Exa 7.2 Horsepower required

```
clc
clear
//Initialization of variables
Q=350 //gal/min
D=6 //in
rho=0.84
gam=62.4
g=32.2 //ft/s^2
mu=9.2e-5 //lb-sec/ft^2
L=5280 //ft
//calculations
V=Q/(7.48*60*%pi/4 *(D/12)^2)
Nr=V*D/12 *rho*gam/g /mu
f=0.3164/(Nr)^0.25
hl=f*L*12/D *V^2 /(2*g)
hp=hl*gam*Q*rho/(550*7.48*60)
//resu;ts
printf("Horsepower required = %.2f hp/mile",hp)
```

Scilab code Exa 7.3 Alpha/ beta

```
clc
clear
//Initialization of variables
n=7
```

```
//calculations
alpha= (n+1)^3 *(2*n+1)^3 /(4*n^4 *(n+3)*(2*n+3))
bet=(n+1)^2 *(2*n+1)^2 /(2*n^2 *(n+2)*(2*n+2))
//results
printf("alpha = %.2f",alpha)
printf("\n beta = %.2f",bet)
```

Scilab code Exa 7.5 Horsepower input of the fan

```
clc
clear
//Initialization of variables
spg=0.84
z=1 //in
gam=62.4
patm=14.7 //psia
T=459.6+85 //R
R=53.3
g=32.2 //ft/s^2
D=3 //ft
mu=3.88e-7 //lb-sec/ft^2
//calculations
dp=spg*z/12 *gam
rho=patm*144/(R*T*g)
umax=sqrt(2*dp/rho)
V=0.8*umax
Nr=V*D*rho/mu
V2=0.875*umax
mass=rho*%pi/4 *D^2 *V2
emf=V2^2 /(2*g)
hp=emf*mass*g/550
//results
printf("Mass flow rate = %.2f slug/sec",mass)
printf("\n Horsepower input of the fan = %.2f hp",hp
    )
```

Scilab code Exa 7.7.a velocity

```
clc
clear
//Initialization of variables
D=36 //in
rho=0.00226  //slug/ft^3
mu=3.88e-7 //lb-sec/ft^2
umax=62.2 //ft/s
V=54.5 //ft/s
Nr=9.5e5
r0=18 //in
r=12 //in
n=8.8
k=0.4
//calculations
f=0.0032 + 0.221/(Nr^0.237)
Vs=sqrt(f/8) *V
y=r0-r
u1=umax*(y/r0)^(1/n)
u2=umax+ 2.5*Vs*log(y/r0)
u3=umax+ Vs/k *(sqrt(1-y/r0) + log(1-sqrt(1-y/r0)))
u4=Vs*(5.5+ 5.75*log10(Vs*y/12 *rho/mu))
//results
printf("Using equation 7-13, velocity = %.1f ft/s",
    u1)
printf("\n Using equation 7-18, velocity = %.1f ft/s
    ",u2)
printf("\n Using equation 7-25, velocity = %.1f ft/s
    ",u3)
printf("\n Using equation 7-34a, velocity = %.1f ft/
    s",u4)
```

Scilab code Exa 7.7.b buffer zone

```
clc
clear
//Initialization of variables
D=36 //in
rho=0.00226  //slug/ft^3
mu=3.88e-7 //lb-sec/ft^2
umax=62.2 //ft/s
V=54.5 //ft/s
Nr=9.5e5
r0=18 //in
r=12 //in
n=8.8
k=0.4
//calculations
f=0.0032 + 0.221/(Nr^0.237)
Vs=sqrt(f/8) *V
y=r0-r
delta1=D*5*sqrt(8) /(Nr*sqrt(f))
vss=70
thick=13*delta1
//results
printf("Outer edge of buffer zone is at %d",vss)
printf("\n Thickness of buffer zone = %.4f in",thick
    )
```

Scilab code Exa 7.7.c velocity

```
clc
clear
//Initialization of variables
```

```
D=36 //in
rho=0.00226  //slug/ft^3
mu=3.88e-7 //lb-sec/ft^2
umax=62.2 //ft/s
V=54.5 //ft/s
Nr=9.5e5
r0=18 //in
r=12 //in
n=8.8
k=0.4
//calculations
f=0.0032 + 0.221/(Nr^0.237)
Vs=sqrt(f/8) *V
delta1=D*5*sqrt(8) /(Nr*sqrt(f))
y=delta1
u2=Vs^2 *delta1/12 *rho/mu
u1=62.2 *(delta1/18)^(1/n)
//results
printf("using equation 7-13, velocity = %.1f ft/s",
   u1)
printf("\n using equation 7-30, velocity = %.1f ft/s
   ",u2)
```

Scilab code Exa 7.7.d velocity

```
clc
clear
//Initialization of variables
D=36 //in
rho=0.00226  //slug/ft^3
mu=3.88e-7 //lb-sec/ft^2
umax=62.2 //ft/s
V=54.5 //ft/s
Nr=9.5e5
r0=18 //in
```

```
r=12 //in
n=8.8
k=0.4
//calculations
f=0.0032 + 0.221/(Nr^0.237)
Vs=sqrt(f/8) *V
delta1=D*5*sqrt(8) /(Nr*sqrt(f))
y=14*delta1
u2=62.2*(y/18)^(1/n)
u3=Vs*(5.50 + 5.75*log10(Vs*y/12 *rho/mu))
//results
printf("Using equation 7-13, velocity = %.1f ft/s",
   u2)
printf("\n using equation 7-34a, velocity = %.1f ft/
   s",u3)
```

Scilab code Exa 7.7.e shearing stress

```
clc
clear
//Initialization of variables
D=36 //in
rho=0.00226  //slug/ft^3
mu=3.88e-7 //lb-sec/ft^2
umax=62.2 //ft/s
V=54.5 //ft/s
Nr=9.5e5
r0=18 //in
r=12 //in
n=8.8
k=0.4
//calculations
f=0.0032 + 0.221/(Nr^0.237)
Vs=sqrt(f/8) *V
delta1=D*5*sqrt(8) /(Nr*sqrt(f))
```

```
u2=Vs^2 *delta1/12 *rho/mu
T0=rho*Vs^2
T02=mu*u2/delta1 *12
//results
printf("Using equation 7-9a, shearing stress = %.5f
   lb/ft^2",T0)
printf("\n Using equation 7-28, shearing stress = %
   .5f lb/ft^2",T02)
disp("The answers are a bit different due to
   rounding off error in textbook")
```

Scilab code Exa 7.8 velocity

```
clc
clear
//Initialization of variables
umax=62.2 //ft/s
r0=18 //in
e=0.0696 //in
r=6 //in
//calculations
Vs=umax/(8.5 + 5.75*log10(r0/e))
u=Vs*(8.5 + 5.75*log10(r/e))
//results
printf("Velocity = %.1f ft/s",u)
```

Scilab code Exa 7.9 roughness factor

```
clc
clear
//Initialization of variables
d=8 //in
V=3.65 //ft/s
```

```
u1=4.75 //ft/s
r0=4 //in
//calculations
f=0.0449
Q=V*%pi/4 *(d/12)^2
Vs=(u1-V)/3.75
r0e=10^((u1/Vs - 8.5)/5.75)
e=r0/r0e
//results
printf("Flow rate = %.2f ft^3/s",Q)
printf("\n roughness factor = %.3f in",e)
```

Scilab code Exa 7.10 Pressure difference

```
clc
clear
//Initialization of variables
e0=0.00085 //ft
alpha=0.25 ///year
t=15 //years
r0=3 //in
Q=500 //gal/min
d=6 //in
mu=2.04e-5 //lb-sec/ft^2
rho=1.94 //slugs/ft^3
g=32.2 //ft/s^2
L=1 //ft
gam=62.4
//calculations
e15=e0*(1+ alpha*t)
ratio=r0/(12*e15)
V=Q/(7.48*60*%pi/4 *(d/12)^2)
Nr=V*d*rho/(mu*12)
f=0.036
hl=f*L/(d/12) *V^2 /(2*g)
```

```
dp=gam*hl
//results
printf("Pressure difference = %.2f lb/ft^2 per foot
    of horizontal pipe",dp)
```

Scilab code Exa 7.11 horsepower required

```
clc
clear
//Initialization of variables
d2=4 //in
d1=3 //in
e=0.0005 //ft
mu=3.75e-5 //lb-sec/ft^2
rho=1.94 //slugs/ft^3
Q=100 //gal/min
L=100 //ft
g=32.2 //ft/s^2
gam=62.4
//calculations
A=%pi/4 *((d2/12)^2 -(d1/12)^2)
WP=%pi*(d1+d2)/12
R=A/WP
RR= 2*R/e
V= Q/(7.48*60*A)
Nr=V*4*R*rho/mu
f=0.035
hl=f*L/(4*R) *V^2 /(2*g)
hp=hl*Q/(7.48*60) *gam/550
//results
printf("horsepower required = %.2f hp/100 ft",hp)
```

Scilab code Exa 7.12 Discharge

```
clc
clear
//Initialization of variables
p1=25 //psig
p2=20 //psig
d1=18 //in
d2=12 //in
Cl=0.25
gam=62.4
g=32.2 //ft/s^2
//calculations
Vr=(d2/d1)^2
xv=(p2-p1)*144/gam
V22=xv/(-1-Cl+Vr^2) *2*g
V2=sqrt(V22)
Q=V2*%pi/4 *(d2/12)^2
//results
printf("Discharge = %.1f ft^3/s",Q)
```

Scilab code Exa 7.13 Discharge

```
clc
clear
//Initialization of variables
V61=10.8 //ft/s
V81=6.05 //ft/s
r0=3 //in
e=0.00015
d1=6 //in
rho=1.94 //slugs/ft^3
mu=2.34e-5 //ft-lb/s^2
//calculations
roe=r0/(12*e)
Nr1=V61*(d1/12)*rho/mu
f6=0.0165
```

```
V6=11.6 //ft/s
V8=6.52 //ft/s
Q=V6*%pi/4 *(d1/12)^2
//results
printf("Discharge = %.2f ft^3/s",Q)
```

Scilab code Exa 7.14 Diameter of steel pipe

```
clc
clear
//Initialization of variables
L=1000 //ft
Q=2000/(7.48*60) //ft63/s
g=32.2 //ft/s^2
p=5 //psi/1000 ft
gam=62.4
sp=0.7
f=0.02
r0=0.904/2
e=0.00015
mu=7e-6 //lb-ft/s^2
L=1000 //ft
//calculations
hl=p*144/(sp*gam)
D5=f*8*L*Q^2 /(%pi^2 *g*hl)
D=D5^(1/5)
Nr=4*Q*sp*gam/(g*(%pi*D*mu))
f2=0.0145
D5=f2*8*L*Q^2 /(%pi^2 *g*hl)
D1=D5^(1/5)
//results
printf("Diameter of steel pipe = %.3f ft",D1)
```

Chapter 8

Fluid Compressibility and Compressible Flow

Scilab code Exa 8.1 Final temperature

```
clc
clear
//Initialization of variables
pi=14.7 //psia
pf=50 //psia
cp=0.240 //Btu/lb R
cv=0.170 //Btu/lb R
J=778
T=60+459.6 //R
//calculations
R=J*(cp-cv)
k=cp/cv
gam=pi*144/(R*T)
V=1/gam
Vf=V*(pi/pf)^(1/k)
Tf=T*(pf*Vf/(pi*V))
//results
printf("Initial volume = %.2f ft^3",V)
printf("\n Final volume = %.2f cu ft",Vf)
```

```
printf("\n Final temperature = %.1f R",Tf)
```

Scilab code Exa 8.2 Pressure difference

```
clc
clear
//Initialization of variables
ratio=0.99
E=3.19e5 //lb/in^2
//calculations
pd=-E*log(ratio)
//ersults
printf("Pressure difference = %d psi",pd)
```

Scilab code Exa 8.3 Speed of test plane

```
clc
clear
//Initialization of variables
k=1.4
g=32.2 //ft/s^2
R=53.3 //ft-lb/lb R
T=389.9 //R
Nm=2
//calculations
c=sqrt(k*g*R*T)
V=Nm*c*3600/5280
//results
printf("Speed of test plane = %d mph",V)
```

Scilab code Exa 8.4.a Velocity at section

```
clc
clear
//Initialization of variables
T1=584.6 //R
g=32.2 //ft/s^2
k=1.4
R=53.3 //ft-lb/lb R
V1=600 //ft/s
T2=519.6 //R
//calculations
Nm1=V1/(sqrt(k*g*R*T1))
Nm22= ((1+ (k-1)/2 *Nm1^2)/(T2/T1) -1)*(2/(k-1))
Nm2=sqrt(Nm22)
V2=Nm2*sqrt(k*g*R*T2)
//results
printf("Velocity at section 2 = %d ft/s",V2)
```

Scilab code Exa 8.4.b Pressure difference between two stations

```
clc
clear
//Initialization of variables
T1=584.6 //R
g=32.2 //ft/s^2
k=1.4
R=53.3 //ft-lb/lb R
V1=600 //ft/s
T2=519.6 //R
pa=14.7 //psi
p1=50 //psia
//calculations
Nm1=V1/(sqrt(k*g*R*T1))
Nm22= ((1+ (k-1)/2 *Nm1^2)/(T2/T1) -1)*(2/(k-1))
```

```
Nm2=sqrt(Nm22)
pr=((1+ (k-1)/2 *Nm1^2)/(1+ (k-1)/2 *Nm2^2))^(k/(k
    -1))
p2=pr*(p1+pa)
dp=p1+pa-p2
//results
printf("Pressure difference between two stations = %
    .1f psi",dp)
```

Scilab code Exa 8.4.c Area ratio

```
clc
clear
//Initialization of variables
T1=584.6 //R
g=32.2 //ft/s^2
k=1.4
R=53.3 //ft-lb/lb R
V1=600 //ft/s
T2=519.6 //R
//calculations
Nm1=V1/(sqrt(k*g*R*T1))
Nm22= ((1+ (k-1)/2 *Nm1^2)/(T2/T1) -1)*(2/(k-1))
Nm2=sqrt(Nm22)
Ar= Nm1/Nm2 *((1+ (k-1)/2 *Nm2^2)/(1+ (k-1)/2 *Nm1
    ^2))^((k+1)/(2*(k-1)))
//results
printf("Area ratio = %.3f",Ar)
```

Scilab code Exa 8.4.d Density of air at station

```
clc
clear
```

```
//Initialization of variables
T1=584.6 //R
g=32.2 //ft/s^2
k=1.4
R=53.3 //ft-lb/lb R
V1=600 //ft/s
T2=519.6 //R
pa=14.7 //psi
p1=50 //psia
//calculations
Nm1=V1/(sqrt(k*g*R*T1))
Nm22= ((1+ (k-1)/2 *Nm1^2)/(T2/T1) -1)*(2/(k-1))
Nm2=sqrt(Nm22)
pr=((1+ (k-1)/2 *Nm1^2)/(1+ (k-1)/2 *Nm2^2))^(k/(k
    -1))
p2=pr*(p1+pa)
rho1=(p1+pa)*144/(g*R*T1)
rho2=p2*144/(g*R*T2)
//results
printf("Density of air at station 1 = %.5f slug/ft^3
    ",rho1)
printf("\n Density of air at station 2 = %.5f slug/
    ft^3",rho2)
```

Scilab code Exa 8.5 Mass rate of air flow

```
clc
clear
//Initialization of variables
p0=19.7 //psia
R=53.3 //lb-ft/lb-R
T0=539.6 //R
g=32.2 //ft/s^2
pa=14.7 //psia
d=1 //in
```

```
k=1.4
//calculations
rho0=p0*144/(g*R*T0)
pr=pa/p0
G=%pi/4 *(d/12)^2 *(2*k/(k-1) *p0*144*rho0)^(0.5) *(
    pr)^(1/k) *(1-pr^((k-1)/k))^0.5
//results
printf("Mass rate of air flow = %.5f slug/sec",G)
```

Scilab code Exa 8.6 Mass rate of air flow

```
clc
clear
//Initialization of variables
p0=64.7 //psia
R=53.3 //lb-ft/lb-R
T0=539.6 //R
g=32.2 //ft/s^2
pa=14.7 //psia
d=1 //in
k=1.4
//calculations
rho0=p0*144/(g*R*T0)
pr=pa/p0
G=%pi/4 *(d/12)^2 *(k*p0*144*rho0)^(0.5) *(2/(k+1))
    ^((k+1)/(2*(k-1)))
//results
printf("Mass rate of air flow = %.5f slug/sec",G)
```

Scilab code Exa 8.7.a weight of air flow through the nozzle

```
clc
clear
```

```
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
pe=14.7 //psia
p0=114.7 //psia
T0=524.6 //R
g=32.2 //ft/s^2
d=0.5 //in
//calculations
pr=pe/p0
prcr=0.528
pr=prcr*p0
rho0= p0*144/(g*R*T0)
G=%pi/4 *(d/12)^2 *(k*p0*144*rho0)^(0.5) *(2/(k+1))^((k+1)/(2*(k-1)))
Wt=G*g
//results
printf("weight of air flow through the nozzle = %.4f lb/s",Wt)
```

Scilab code Exa 8.7.b Mach number exit

```
clc
clear
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
pe=14.7 //psia
p0=114.7 //psia
T0=524.6 //R
g=32.2 //ft/s^2
d=0.5 //in
Nm1=1
//calculations
pr=pe/p0
```

```
Nme=sqrt(2/(k-1) *((1/pr)^((k-1)/k) -1))
Te=T0/(1+ (k-1)/2 *Nme^2)
Ve=Nme*sqrt(k*g*R*Te)
At=%pi/4 *(d)^2
Ae=Nm1/Nme *((1+ (k-1)/2 *Nme^2)/(1+ (k-1)/2 *Nm1^2)
    )^((k+1)/(2*(k-1))) *At
//results
printf("Mach number exit = %.2f",Nme)
printf("\n Exit velocity = %d ft/s",Ve)
printf("\n Exit area = %.3f in^2",Ae)
```

Scilab code Exa 8.8.a Exit mach number

```
clc
clear
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
p0=100 //psia
T0=534.6 //R
g=32.2 //ft/s^2
d=0.5 //in
Nm1=1
A=2/144 //ft^2
//calculations
disp("Exit mach number is found using trial and
    error")
Nme=2.44
rho0=p0*144/(g*R*T0)
G= A*sqrt(k*p0*144*rho0) *(2/(k+1))^((k+1)/(2*(k-1))
    )
pe=p0*(1/(1+(k-1)/2 *Nme^2))^(k/(k-1))
Te=T0/(1+ (k-1)/2 *Nme^2)
Ve=Nme*(sqrt(k*g*R*Te))
//results
```

```
printf("\n Exit mass flow rate = %.3f slug/s",G)
printf("\n Exit pressure = %.2f psia",pe)
printf("\n Exit temperature = %.1f R",Te)
printf("\n Exit velocity = %d ft/s",Ve)
printf("\n Exit mach number = %.2f",Nme)
```

Scilab code Exa 8.8.b Exit mach number

```
clc
clear
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
p0=100 //psia
T0=534.6 //R
g=32.2 //ft/s^2
d=0.5 //in
Nm1=1
A=2/144 //ft^2
//calculations
disp("Exit mach number is found using trial and
   error")
Nme=0.24
rho0=p0*144/(g*R*T0)
G= A*sqrt(k*p0*144*rho0) *(2/(k+1))^((k+1)/(2*(k-1))
   )
pe=p0*(1/(1+(k-1)/2 *Nme^2))^(k/(k-1))
Te=T0/(1+ (k-1)/2 *Nme^2)
Ve=Nme*(sqrt(k*g*R*Te))
//results
printf("\n Exit mass flow rate = %.3f slug/s",G)
printf("\n Exit pressure = %.2f psia",pe)
printf("\n Exit temperature = %.1f R",Te)
printf("\n Exit velocity = %d ft/s",Ve)
printf("\n Exit mach number = %.2f",Nme)
```

Scilab code Exa 8.9 Mach number upstream

```
clc
clear
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
pu=6.43 //psia
Tu=244 //R
Nmu=2.44
//calculations
Nmd = sqrt(((k-1)*Nmu^2 +2)/(2*k*Nmu^2 - (k-1)))
pd=pu*(2*k*Nmu^2 - (k-1))/(k+1)
Td=Tu*(2*k*Nmu^2 - (k-1))/(k+1) *((k-1)*Nmu^2 +2)/((
    k+1)*Nmu^2)
//results
printf("Mach number upstream = %.3f ",Nmd)
printf("\n Pressure upstream = %.1f psia",pd)
printf("\n Temperature upstream = %.1f R",Td)
```

Scilab code Exa 8.10 Pressure at section

```
clc
clear
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
e=0.0005 //ft
mu=3.77e-7 //lb-sec/ft^2
pe=14.7 //psia
Te=524.6 //R
```

```
g=32.2 //ft/s^2
Vi=12.5 //ft/s
l=6 //in
b=8 //in
L=100 //ft
//calculations
rhoe=pe*144/(R*g*Te)
Ve=Vi/(g*rhoe*(l*b/144))
Nme=Ve/(sqrt(k*g*R*Te))
Rd=l*b/(2*(l+b)) /12
rr=2*R/e
Nr=Ve*4*Rd*rhoe/mu
f=0.019
f2=1/(2*k) *(1/Nme^2 -1) - (k+1)/(4*k) *log((1+ (k
   -1)/2 *Nme^2)/(Nme^2 *(1+(k-1)/2)))
ff=f*L/(8*Rd) +f2
Nm1=0.305
Tr2=(1+ (k-1)/2 *Nm1^2)/(1+ (k-1/2))
Tre=(1+ (k-1)/2 *Nme^2)/(1+ (k-1/2))
pr2=Nm1*(1+ (k-1)/2 *Nm1^2)^(0.5) /(1+(k-1)/2)^0.5
pre=Nme*(1+ (k-1)/2 *Nme^2)^(0.5) /(1+(k-1)/2)^0.5
p1=pe/pr2 *pre
T1=Te/Tr2 *Tre
//results
printf("Pressure at section 1 = %.1f psia",p1)
printf("\n Tempreature at section 1 = %.1f R",T1)
```

Scilab code Exa 8.11 Limiting pressure in adiabatic case

```
clc
clear
//Initialization of variables
k=1.4
R=53.3 //lb-ft/lb R
g=32.2 //ft/s^2
```

```
T1=534.6 //R
V1=400 //ft/s
p1=350 //psia
f=0.02
D=6/12 //ft
//calculations
Nm1=V1/sqrt(k*g*R*T1)
Nm2=1/sqrt(k)
p2=p1*(Nm1)/Nm2
fl= log(Nm1/Nm2) + 1/(2*k*Nm1^2) *(1- Nm1^2 /Nm2^2)
L12=fl*2*D/f
ps=p1*Nm1*(1+ (k-1)/2 *Nm1^2)^0.5 /(1+(k-1)/2)^0.5
Nm2=1
fl2= -(k+1)/(4*k) *log((1+ (k-1)/2 *Nm1^2)/(Nm1^2
    *(1+ (k-1)/2))) + 1/(2*k*Nm1^2) *(1- Nm1^2 /Nm2
    ^2)
L2=fl2*2*D/f
//results
printf("Limiting pressure = %.1f psia",p2)
printf("\n Distance = %.1f ft",L12)
printf("\n Limiting pressure in adiabatic case = %.1
    f psia",ps)
printf("\n Distance required = %.1f ft",L2)
```

Chapter 9

Fluid flow about Immersed Bodies

Scilab code Exa 9.1.b Boundary layer thickness

```
clc
clear
//Initialization of variables
x=36/12
rho=2.45 //slugs/ft^3
mu=9.2e-3 //lb-sec/ft^2
v=3 //ft/s
//calculatons
Nr=v*x*rho/mu
z=[4.91 5.48 4.65]
x=36/12
delta=z*x/sqrt(Nr)
f=[0.332 0.365 0.322]
T=f*mu*v/x *sqrt(Nr)
//results
disp("Boundary layer thickness = ")
disp("In order of Blasius, parabola and pohlhauser")
format('v',6);delta
disp(delta)
```

```
disp("Shearing stress = ")
disp("In order of Blasius, parabola and pohlhauser")
format('v',6);T
disp(T)
```

Scilab code Exa 9.1 Drag on the plates

```
clc
clear
//Initialization of variables
rho=2.45 //slugs/ft^3
mu=9.2e-3 //lb-sec/ft^2
x=3
v=3 //ft/s
B=6/12 //ft
L=36/12 //ft
//calculatons
Nr=v*x*rho/mu
y=[1.32 1.46 1.328]
Cd=y*Nr^(-0.5)
Fd=2*Cd*B*L*(0.5*rho*v^2)
//results
disp("Drag on the plates using different formulae
    blasius, parabola and pohlhauser in order")
format('v',6);Fd
disp(Fd)
```

Scilab code Exa 9.2.b Horsepower required

```
clc
clear
//Initialization of variables
e=0.01 //ft
```

```
rho=2 //slugs/ft^3
mu=2.6e-5 //lb sec/ft^2
speed=10 //knots
L=250 //ft
A=30000 //ft^2
//calculations
V=speed*1.69
Nrl=V*L*rho/mu
Cdf=0.074/Nrl^0.2 -1700/Nrl
Fd=Cdf*A*0.5*rho*V^2
hp=Fd*V/550
//results
printf("Total frictional drag = %d lb",Fd)
printf("\n Horsepower required = %.1f hp",hp)
disp("The answer given in textbook is wrong. please
    use a calculator")
```

Scilab code Exa 9.2.c Total frictional drag

```
clc
clear
//Initialization of variables
e=0.01 //ft
rho=2 //slugs/ft^3
mu=2.6e-5 //lb sec/ft^2
speed=10 //knots
L=250 //ft
A=30000 //ft^2
//calculations
V=speed*1.69
Nrl=V*L*rho/mu
Cdf=1/(1.89 + 1.62*log10(L/e))^(2.5)
Fd=Cdf*A*0.5*rho*V^2
hp=Fd*V/550
//results
```

```
printf("Total frictional drag = %d lb",Fd)
printf("\n Horsepower required = %.1f hp",hp)
```

Scilab code Exa 9.2 Total frictional drag

```
clc
clear
//Initialization of variables
e=0.01 //ft
rho=2 //slugs/ft^3
mu=2.6e-5 //lb sec/ft^2
speed=10 //knots
L=250 //ft
A=30000 //ft^2
//calculations
V=speed*1.69
Nrl=V*L*rho/mu
Cdf=1.32 /sqrt(Nrl)
Fd=Cdf*A*0.5*rho*V^2
hp=Fd*V/550
//results
printf("Total frictional drag = %d lb",Fd)
printf("\n Horsepower required = %.1f hp",hp)
```

Scilab code Exa 9.3 Drag on the model

```
clc
clear
//Initialization of variables
V=200 //ft/s
L=5 //ft
B=2 //ft
rho=0.00232 //slug/ft^3
```

```
mu=3.82e-7 //lb-sec/ft^2
p2=14.815 //psia
pa=14.7 //psia
//calculations
Nr=V*L*rho/mu
Cdf=0.0032
Fdf=Cdf*%pi*L*B*0.5*rho*V^2
Fd=(p2-pa)*%pi/4 *(B*12)^2 -Fdf
//results
printf("Drag on the model = %.2f lb",Fd)
```

Scilab code Exa 9.4 Velocity of flow

```
clc
clear
//Initialization of variables
p1=14.7 //psia
z1=3 //ft
gam=62.4
rho=1.94 //slug/ft^3
pa=0.4 //psia
za=1 //ft
//calculations
v3=(pa-p1)*144 + (za-z1)*gam
V=sqrt(-v3*2/(3*rho))
//results
printf("Velocity of flow = %.1f ft/s",V)
disp("The answer is a bit different due to rounding
   off error in textbook")
```

Scilab code Exa 9.5 Horsepower required

```
clc
```

```
clear
//Initialization of variables
rpm=60
rho=2 //slugs/ft^3
mu=3.5e-5 //lb-sec/ft^2
D=4/12 //ft
r=2 //ft
//calcualtions
V=rpm*2*%pi/60 *2
Nr=V*D*rho/mu
Cd=1.1
Fd=Cd*%pi/4 *(D)^2 *0.5*rho*V^2
T=2*Fd*r
w=rpm*2*%pi/60
hp=T*w/550
//results
printf("Horsepower required = %.2f hp",hp)
```

Scilab code Exa 9.6 terminal velocity

```
clc
clear
//Initialization of variables
g=32.2 //ft/s^2
h=60000 //ft
F=2000 //;b
d=3 //ft
rho=0.00231
//calculations
V=sqrt(2*g*h)
disp("By trail and error")
Cd=0.25
Nm=0.87
A=%pi/4 *d^2
Vt=sqrt(2*F/(Cd*A*rho))
```

```
//results
printf("terminal velocity = %.1f ft/s",Vt)
```

Chapter 10

Dynamic Lift

Scilab code Exa 10.2.a Max. theoretical porpulsive force

```
clc
clear
//Initialization of variables
vel=50 //mph
w=240 //rpm
r0=3 //ft
L=30 //ft
rho=0.00230 //slug/ft^2
theta=30 //degrees
//calculations
V=vel*5280/3600
T=2*%pi*r0^2 *w*2*%pi/60
Fl=rho*V*T*L
F=r0*Fl*cosd(theta)
//results
printf("Max. theoretical porpulsive force = %d lb",F
  )
```

Scilab code Exa 10.2.b Force required

```
clc
clear
//Initialization of variables
vel=50 //mph
w=240 //rpm
r0=3 //ft
L=30 //ft
rho=0.00230 //slug/ft^2
theta=30 //degrees
Cl=2
Cd=1
//calculations
vc=r0*w
V=vel*5280/3600
vr=vc/V
A=2*r0*L
Fl=Cl*A*0.5*rho*V^2
Fd=Cd*A*0.5*rho*V^2
F=r0*(Fl*cosd(theta) + Fd*sind(theta))
//results
printf("Force required = %d lb",F)
```

Scilab code Exa 10.3.a Boundary circulation

```
clc
clear
//Initialization of variables
W=7500 //pounds
rho=0.00230
V=175*5280/3600 //ft/s
B=50
//calculations
T=W/(rho*V*B)
//results
printf("Boundary circulation = %d ft^2/s",T)
```

Scilab code Exa 10.3.b Horsepower required

```
clc
clear
//Initialization of variables
W=7500 //pounds
rho=0.00230
V=175*5280/3600 //ft/s
B=50
A=350 //ft^2
//calculations
Cl=W/(A*0.5*rho*V^2)
Cd=0.03
Fd=Cd*A*0.5*rho*V^2
hp=Fd*V/550
//results
printf("Horsepower required = %d hp",hp)
```

Scilab code Exa 10.4 Horsepower required

```
clc
clear
//Initialization of variables
Fl=7500 //pounds
rho=0.00230
V=175*5280/3600 //ft/s
B=50
A=350 //ft^2
//calculations
Vi=2*Fl/(%pi*rho*V*B^2)
Cl=Fl/(A*0.5*rho*V^2)
```

```
Cdi=Cl*Vi/(V)
Fdi=Cdi*A*0.5*rho*V^2
hp=Fdi*V/550
//results
printf("Horsepower required = %.1f hp",hp)
```

Chapter 11

Flow of Liquids in Open Channels

Scilab code Exa 11.1.a Discharge using Darcy equation

```
clc
clear
//Initialization of variables
rho=1.94 //slugs/ft^3
mu=2.34e-5 //lb-sec/ft^2
y=5 //ft
T=25 //ft
d=10 //ft
slope=3/2
g=32.2 //ft/s^2
S=0.001
//calculations
A=y*d+ 2*0.5*y*(slope*y)
WP=d+ 2*sqrt(3^2 +2^2) /2 *y
R=A/WP
e=0.01 //ft
rr=2*R/e
f=0.019
C=sqrt(8*g/f)
```

```
V=C*sqrt(R*S)
Q=V*A
//results
printf("Discharge using Darcy equation = %.1f ft^3/s
    ",Q)
disp("The answer is a bit different due to rounding
    off error in textbook")
```

Scilab code Exa 11.1.b Discharge using kutter ganguillet formula

```
clc
clear
//Initialization of variables
rho=1.94 //slugs/ft^3
mu=2.34e-5 //lb-sec/ft^2
y=5 //ft
T=25 //ft
d=10 //ft
slope=3/2
g=32.2 //ft/s^2
S=0.001
n=0.017
//calculations
A=y*d+ 2*0.5*y*(slope*y)
WP=d+ 2*sqrt(3^2 +2^2) /2 *y
R=A/WP
e=0.01 //ft
rr=2*R/e
f=0.019
C=(41.65 + 0.00281/S + 1.811/n)/(1+( 41.65 +
    0.00281/S)*n/sqrt(R))
V=C*sqrt(R*S)
Q=V*A
//results
printf("Discharge using kutter ganguillet formula =
```

```
%.1f ft^3/s",Q)
disp("The answer is a bit different due to rounding
   off error in textbook")
```

Scilab code Exa 11.1.c Discharge using bazin formula

```
clc
clear
//Initialization of variables
rho=1.94 //slugs/ft^3
mu=2.34e-5 //lb-sec/ft^2
y=5 //ft
T=25 //ft
d=10 //ft
slope=3/2
g=32.2 //ft/s^2
S=0.001
m=0.21
//calculations
A=y*d+ 2*0.5*y*(slope*y)
WP=d+ 2*sqrt(3^2 +2^2) /2 *y
R=A/WP
e=0.01 //ft
rr=2*R/e
f=0.019
C=157.6 /(1+ m/sqrt(R))
V=C*sqrt(R*S)
Q=V*A
//results
printf("Discharge using bazin formula = %.1f ft^3/s"
   ,Q)
disp("The answer is a bit different due to rounding
   off error in textbook")
```

Scilab code Exa 11.1.d Discharge using Darcy equation

```
clc
clear
//Initialization of variables
rho=1.94 //slugs/ft^3
mu=2.34e-5 //lb-sec/ft^2
y=5 //ft
T=25 //ft
d=10 //ft
slope=3/2
g=32.2 //ft/s^2
S=0.001
n=0.017
//calculations
A=y*d+ 2*0.5*y*(slope*y)
WP=d+ 2*sqrt(3^2 +2^2) /2 *y
R=A/WP
e=0.01 //ft
rr=2*R/e
f=0.019
C=1.486*R^(1/6) /n
V=C*sqrt(R*S)
Q=V*A
//results
printf("Discharge using Darcy equation = %.1f ft^3/s
   ",Q)
disp("The answer is a bit different due to rounding
   off error in textbook")
```

Scilab code Exa 11.1.e froude number

```
clc
clear
//Initialization of variables
rho=1.94 //slugs/ft^3
mu=2.34e-5 //lb-sec/ft^2
y=5 //ft
T=25 //ft
d=10 //ft
slope=3/2
g=32.2 //ft/s^2
S=0.001
n=0.017
//calculations
A=y*d+ 2*0.5*y*(slope*y)
WP=d+ 2*sqrt(3^2 +2^2) /2 *y
R=A/WP
e=0.01 //ft
rr=2*R/e
f=0.019
C=(41.65 + 0.00281/S + 1.811/n)/(1+( 41.65 +
   0.00281/S)*n/sqrt(R))
V=C*sqrt(R*S)
T=d+ 2*(slope*y)
yh=A/T
Nf=V/(sqrt(g*yh))
//results
printf("froude number = %.2f",Nf)
```

Scilab code Exa 11.1.f Critical depth

```
clc
clear
//Initialization of variables
rho=1.94 //slugs/ft^3
mu=2.34e-5 //lb-sec/ft^2
```

```
y=5 //ft
T=25 //ft
d=10 //ft
slope=3/2
g=32.2 //ft/s^2
S=0.001
n=0.017
//calculations
A=y*d+ 2*0.5*y*(slope*y)
WP=d+ 2*sqrt(3^2 +2^2) /2 *y
R=A/WP
e=0.01 //ft
rr=2*R/e
f=0.019
C=(41.65 + 0.00281/S + 1.811/n)/(1+( 41.65 +
   0.00281/S)*n/sqrt(R))
V=C*sqrt(R*S)
Q=V*A
T=d+ 2*(slope*y)
yh=A/T
yc=2.88  //ft
//results
disp("yc is obtained using trial and error method")
printf("Critical depth = %.2f ft",yc)
```

Scilab code Exa 11.2 Minimum scale ratio

```
clc
clear
//Initialization of variables
Re=4000
rho=1.94 //slugs/ft^3
vm=5.91 //ft/s
mu=3.24e-5 //ft-lb/s^2
Rm=3.12 //ft
```

```
//calculations
lam3=Re*mu/(vm*4*Rm*rho)
lam=lam3^(2/3)
//results
printf("Minimum scale ratio = %.2e",lam)
```

Scilab code Exa 11.3 Discharge in the channel

```
clc
clear
//Initialization of variables
yc=2 //ft
g=32.2 //ft/s^2
d=10 //ft
gam=62.4
rho=1.94
B=10 //ft
//calculations
Vc=sqrt(g*yc)
Ac=yc*d
Q=Vc*Ac
y1=5.88 //ft
y2=0.88 //ft
V1=2.73 //ft/s
V2=18.25 //ft/s
Nf1=0.198
Nf2=3.43
F= 0.5*gam*y1^2 *B - 0.5*gam*y2^2 *B - Q*rho*V2 +Q*
    rho*V1
//results
printf("Discharge in the channel = %.1f ft^3/s",Q)
printf("\n Depth of the channel at upstream and
    downstream = %.2f ft and %.2f ft",y1,y2)
printf("\n froude numbers at upstream and downstream
     = %.3f and %.3f",Nf1,Nf2)
```

```
printf("\n Force applied = %d lb",F)
```

Scilab code Exa 11.4 distance from vena contracta

```
clc
clear
//Initialization of variables
S0=0.0009
n=0.018
w=20 //ft
d=0.5 //ft
Q=400 //ft^3/s
g=32.2 //ft/s^2
//calculations
y2=4 //ft
V2=Q/(w*y2)
Nf2=V2/sqrt(g*y2)
yr=0.5*(sqrt(1+ 8*Nf2^2) -1)
y1=yr*y2
L1=32.5
L2=37.1
L3=51.4
L=L1+L2+L3
//results
printf("distance from vena contracta = %.1f ft and
   %.2f ft",y2,y1)
printf("\n Total distance = %.1f ft",L)
```