Scilab Textbook Companion for Fundamentals of Fluid Mechanics by B. R. Munson, D. F. Young And T. H. Okiishi[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.

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Chapter 1

basic properties of fluids

Scilab code Exa 2 force by tank

```
m=36;//kg
acc=7;//ft/sq sec
```

Scilab code Exa 3 density and weight of air

```
V=0.84;//ft^3
p=50;//psi
T=70;//degree farenheit
atmp=14.7;//psi
```

Scilab code Exa 4 reynolds number calculation

```
vis=0.38; //Ns/m^2
sg=0.91; //specific gravity of Newtonian fluid
dia=25; //mm
vel=2.6; //m/s
```

Scilab code Exa 5 shearing stress calculation

```
vis=0.04; //lb*sec/ft^2
vel=2; //ft/sec
h=0.2; //inches
```

Scilab code Exa 6 final pressure calculation

```
p1=14.7; //psi(abs)
V1=1; //ft^3
V2=0.5; //ft^3
```

Scilab code Exa 7 ratio of speeds

```
s=550; //(mph)
h=35000; //ft
T=-66; //degrees farenheit
k=1.40;
```

Scilab code Exa 8 diameter of tube

```
T=20;//degree celcius
h=1;//mm
```

Scilab code Exa 1.2 force by tank

```
clc;
clear;
m=36;//kg
acc=7;//ft/sq sec
W=m*9.81;
disp("W=")
disp(W)
//F=W+m*acc
//1 ft= 0.3048 m
F=W+(m*acc*0.3048);
disp("N",F,"F=")
```

Scilab code Exa 1.3 density and weight of air

```
clc;
clear;
V=0.84;//ft^3
p=50;//psi
T=70;//degree farenheit
atmp=14.7;//psi
```

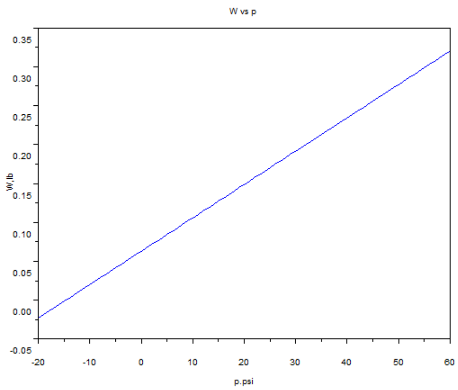

Figure 1.1: density and weight of air

```
//the air density d=P/(RT)
//1ft^2=144 inches^2
d=((p+atmp)*144)/((1716)*(T+460));
disp(d)
//slugs/ft^3
//weight of air
W=d*32.2*V;
//1lb=1 slug.ft/sq sec
disp("lb",W,"W=")
//taking various values of p a graph is plotted between W and p
x= -20:60;
for p= -20: 60
    i=p+21;
    y(1,i)=((p+atmp)*144/((1716)*(T+460)))*32.2*V;

end
plot(x,y)
xtitle('W vs p','p.psi','W,lb')
```

Scilab code Exa 1.4 reynolds number calculation

```
clc;
clear;
vis=0.38;//Ns/m^2
sg=0.91;//specific gravity of Newtonian fluid
dia=25;//mm
vel=2.6;//m/s

//calculating in SI units
//fluid density d=sg*(density of water @ 277K)
d=sg*1000;//kg/m^3
//Reynolds number Re=d*vel*dia/vis
Re=(d*vel*dia)/(vis*1000);//(kgm/sec^2)/N
disp(156,"Re in SI units=")
//calculating in BG units
d1=d*1.94/1000//slugs/ft^3
vel1=vel*3.281//ft/s
dia1=(dia/1000)*3.281//ft
vis1=vis*(2.089/100)//lb*s/ft^2
Re1=(d1*vel1*dia1)/vis1;//(slugs.ft/sec^2)/lb
disp(Re1,"Re in Bg units=")
```

Scilab code Exa 1.5 shearing stress calculation

```
clc;
clear;
vis=0.04;//lb*sec/ft^2
vel=2;//ft/sec
h=0.2;//inches

//given u=(3*vel/2)(1-(y/h)^2)
//shearing stress t=vis*(du/dy)
//(du/dy)=-(3*vel*y/h)
//along the bottom of the wall y=-h
```

```
//(du/dy)=(3*vel/h)
t=vis*(3*vel/(h/12));//lb/ft^2
disp("lb/ft^2",t,"shaering stress t on bottom wall=")
//along the midplane y=0
//(du/dy)=0
t1=0;//lb/ft^2
disp("lb/ft^2",t1,"shearing stress t on midplane=")
```

Scilab code Exa 1.6 final pressure calculation

```
clc;
clear;
p1=14.7;//psi(abs)
V1=1;//ft^3
V2=0.5;//ft^3
//for isentropic compression, (p1(d1^k))=(p2/(d2^k))
//volume*density=constant(mass)
ratd=V1/V2;
p2=((ratd)^1.66)*p1;//psi(abs)
disp("psi(abs)",p2,"final pressure p2=")

i=1;
ratV=0.01:0.01:1.0;

for j=0.01:0.01:1.0
    pres(i)=p1/((j)^1.66);
    i=i+1;

end

plot2d(ratV,pres,rect=[0,0,1,1000])
xtitle('p2 vs V2/V1','V2/V1','p2 psi')
```

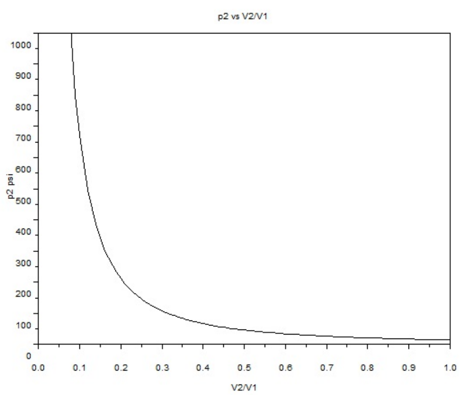

Figure 1.2: final pressure calculation

Scilab code Exa 1.7 ratio of speeds

```
clc;
clear;
s=550;//(mph)
h=35000;//ft
T=-66;//degrees farenheit
k=1.40;
//speed of sound c=(kRT)^0.5
c=((k*1716*(T+460)))^0.5;//ft/s
disp("ft/s",c,"speed of sound c=")
//speed of sound V=(s m/hour)*(5280 ft/m)/(3600 s/
   hour)
V=s*5280/3600;//ft/s
disp("ft/s",V,"air speed =")
ratio=V/c;//Mach number
disp(ratio,"ratio of V/c = Mach Number=")
```

Scilab code Exa 1.8 diameter of tube

```
clc;
clear;
T=20;//degree celcius
h=1;//mm
//h=(2*st*cos(x)/(sw*R))
//where st= nsurface tension, x= angle of contact,
   sw= specific weight of liquid, R= tube radius
st= 0.0728;//N/m
sw=9.789;//kN/m^3
x=0;
R=(2*st*cos(x))/(sw*1000*h/1000);//m
D=2*R*1000;//mm
disp("mm",D,"minimum required tube diameter= ")
h=0.1:0.1:2;
for i=0.1:0.1:2
    R=(2*st*cos(x))/(sw*1000*i/1000);
    dia(i*10)=2*R*1000;
end

plot2d(h,dia,rect=[0,0,2,100])
xtitle("D vs h","h, mm", "D, mm")
```

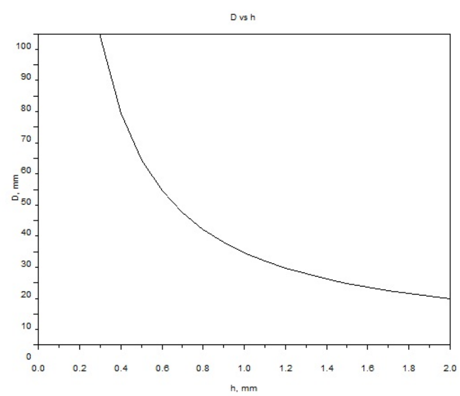

Figure 1.3: diameter of tube

Chapter 2

Fluids at rest pressure and its effects

Scilab code Exa 2.1 pressure at interface

```
clc;
clear;
sg=0.68;//specific gravity of gasoline
htg=17;//ft (height of gasoline)
htw=3;//ft (height of water)
//pressure p= (gamma*h)+atmp;
//pressure at water- gasoline interface p1 =sg*g*htg
   +atmp
p1=sg*62.4*htg; //atmp=0 , p1 is in lb/ft^2
pr1=p1/144;//lb/in^2
//pressure head as feet of water H
H= p1/62.4;//ft
//similarly pressure p2 at tank bottom
p2=62.4*htw+p1;//lb/ft^2
pr2 = p2/144;//lb/in^2
//pressure head as ft of water H1
H1=p2/62.4;//ft
disp("lb/in^2",pr1,"lb/ft^2 =", p1,"pressure at
   interface=")
```

```
disp(" ft",H," pressure head at interface in feet of
    water =")
disp(" lb/in^2",pr2," lb/ft^2 =", p2," pressure at
    bottom=")
disp(" ft",H1," pressure head at bottom in feet of
    water =")
```

Scilab code Exa 2.2 pressure depth variation

```
clc;
clear;
h=1250;//ft
T=59;//degree fareheit
p=14.7;//psi (abs)
sw=0.0765;//lb/ft^3, (specific weight of air at p)

//considering air to be compressible
//p1/p2= exp(-(g*(z1-z2))/(R*T))
ratp=exp(-(32.2*h)/(1716*(59+460)));
disp(ratp," ratio of pressure at the top to that at
    the base considering air to be compressible=")

//considering air to be incompressible
//p2=p1-(sw*(z2-z1));
ratp1=1-((sw*h)/(p*144));
disp(ratp1," ratio of pressure at the top to that at
    the base considering air to be incompressible=")
count=1;
zdiff=0:5000;

for i= 0:5000
    j(count)=1-((sw*i)/(p*144));
    count=count+1;
end
num=1;
```

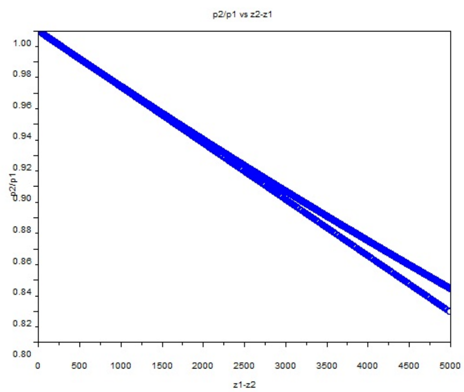

Figure 2.1: pressure depth variation

```

for k=0:5000
    l(num)=exp(-(32.2*k)/(1716*(59+460)));
    num=num+1;

end
plot(zdiff,j,"o")
plot(zdiff,l,"+")
xtitle("p2/p1 vs z2-z1","z1-z2","p2/p1")
```

Scilab code Exa 2.3 pressure at bottom

```
clc;
clear;
T=10;//degree C
dmax=40;//m
p=598;//mm Hg
//pressure in lake at any depth h is given by p=
    gamma*h + local barometric pressure 'pbar'
```

```
//pbar/(gamma Hg)=598 mm= .598 m ; (gamma Hg) = 133
   kN/m^3
pbar=0.598*133; //kN/m^2
//(gamma water)=9.804 kN/m^3 at 10 dergree C
p=(9.804*40)+pbar; //kN/m^2
disp("kPa",pbar,"The local barometric pressure=")
disp("kPa",p,"The absolute pressure at a depth of 40
    m in the lake=")
```

Scilab code Exa 2.4 reading of gage

```
clc;
clear;
sg1=0.90; //specific gravity of oil
sg2=13.6; //specific gravity of Hg
h1=36; //inches
h2=6; //inches
h3=9; //inches
//pressure equation: airp+h1*sg1*(gamma water)+h2*
   sg1*(gamma water)-h3*sg2*(gamma water)=0
airp=-(sg1*62.4*((h1/12)+(h2/12)))+(sg2*62.4*(h3/12)
   ); //lb/ft^2
//gage pressure = airp
pgage=airp/144;
disp(" psi",pgage,"Gage pressure=")
```

Scilab code Exa 2.5 pressure drop calculation

```
clc;
clear;
gamma1=9.8; //kN/m^3
gamma2=15.6; //kN/m^3
h1=1; //m
```

```
h2=0.5; //m
//pA-(gamma1)*h1-h2*(gamma2)+(gamma1)*(h1+h2)=pB
//pA-pB=diffp
diffp=((gamma1)*h1+h2*(gamma2)-(gamma1)*(h1+h2));
disp("kPa",diffp,"The difference in pressures at A
    and B =")
```

Scilab code Exa 2.6 force on plane

```
clc;
clear;
dia=4; //m
sw=9.8; //kN/m^3; specific weight of water
hc=10; //m
ang=60; //degrees
A=%pi*(dia^2)/4;
fres=sw*hc*A;
//for the coordinate system shown xc=xres=0
Ixc=%pi*((dia/2)^4)/4;
yc=hc/(sin (ang*%pi/180));
yres= (Ixc/(yc*A))+yc;
ydist=yres-yc;
disp("kN",fres,"The resultant force acting on the
    gate of the reservoir =");
disp("m below the shaft and is perpendicular to the
    gate surface.",ydist,"The resultant force acts
    through a point along the diameter of the gate at
     a distance of ")
M=fres*(ydist)*1000;
disp("N*m",M,"Moment required to open the gate=")
hc=1:30;
for i=1:30
    ydist(i)=((Ixc/(i/(sin (ang*%pi/180))*A)));
end

```

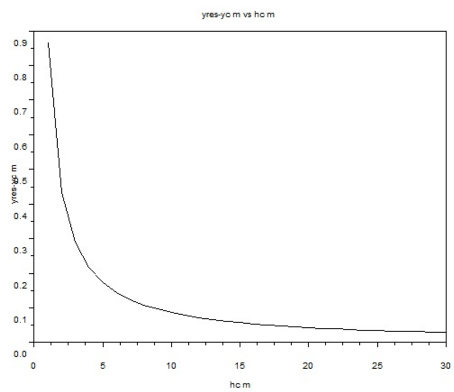

Figure 2.2: force on plane

```
plot2d(hc,ydist)
xtitle("yres-yc m vs hc m","hc m","yres-yc m")
```

Scilab code Exa 2.7 hydrostatic pressure force

```
clc;
clear;
sw=64;//lb/ft^3; specific weight of water
h=10;//ft
a=3;//ft
b=3;//ft

//shape is triangular, hence hc=h-(a/3)
hc=h-(a/3);
A=(0.5*a*b);//ft^3; area of the right angled
    triangle
fres=sw*hc*A;//lb
Ixc=b*(a^3)/36;
Ixyc=b*(a^2)*(b)/72;
```

```
//according to the coordinate system taken yc=hc and
    xc=0
yres=(Ixc/(hc*A))+hc;
xres=(Ixyc/(hc*A));
ydist=yres-hc;
disp("lb",fres,"The resultant force on the area
   shown is=")
disp("ft",yres,"yR=")
disp("ft",xres,"xR=")
disp("ft below the centroid of the area.",ydist,"ft
   to the right of and ",xres,"The centre of
   pressure is")
```

Scilab code Exa 2.8 pressure prism concept

```
clc;
clear;
sg=0.9;// specific gravity of oil
a=0.6;//m
pgage=50;//kPa
h1=2;//m
h2=2.6;//m

//the force on the trapezoid is the sum of the force
    on the rectangle f1 and force on triangle f2
f1=((pgage*1000)+(sg*1000*9.81*h1))*(a^2);//N
f2=sg*1000*9.81*(h2-h1)*(a^2)/2;//N
fres=f1+f2;//N
//to find vertical location of fres; fres*yres=(f1*(
   a/2))+(f2*(h1-h2))
yres=((f1*(a/2))+(f2*(a/3)))/fres;//m
disp("kN",(fres/1000),"The resultant force on the
   plate is=")
disp("m above the bottom plate alond the vertical
   line of symmetry.",yres,"The force acts at a
```

```
distance of ")
```

Scilab code Exa 2.9 force on curve

```
clc;
clear;
dia=6;//ft
l=1;//ft

//horizontal force f1=sw*hc*A
hc=dia/4;//ft
sw=62.4;//lb/ft^3
A=dia/2*l;//ft^2
f1=sw*hc*A;//lb
//this force f1 acts at a height of radius/3 ft
   above the bottom
ht=(dia/2)/3;//ft
//weight w = sw*volume
w=sw*((dia/2)^2)*%pi/4*l;//lb
//this force acts through centre of gravity which is
    4*radius/(3*%pi) right of the centre of conduit
dist=(4*dia/2)/(3*%pi);//ft
//horizontal force that tank exerts on fluid = f1
//vertical force that tank exerts on fluid = w
//resultant force fres =((f1)^2+(w)^2)^0.5
fres =((f1)^2+(w)^2)^0.5;//lb
disp("lb",fres,"The resultant force exerted by the
   tank on the fluid=");
disp("ft",dist,"above the bottom of the conduit and
   to the right of the axis of the conduit at a
   distance of","ft",ht,"The force acts at a
   distance of")
```

Scilab code Exa 2.10 tension in cable

```
clc;
clear;
dia=1.5;//m
wt=8.5;//kN
//tension in cable T=bouyant force(Fb)-wt
//fluid is water
sw=10.1;//kN/m^3
vol=%pi*dia^3/6;//m^3
Fb=sw*vol;//kN
T=Fb-wt;//kN
disp("kN",T,"The tension in the cable =")
```

Scilab code Exa 2.11 maximum acceleration calculation

```
clc;
clear;
sg=0.65;
l1=0.75;//ft
l2=0.5;//ft
//0.5 ft =z1(max)
//0.5=0.75*(ay(max)/g)
aymax=(0.5*32.2)/0.75;//ft/s^2
disp("ft/s^2",aymax,"The max acceleration that can
   occur before the fuel level drops below the
   transducer=")
```

Chapter 3

Fluids in motion Bernoulli equation

Scilab code Exa 3.6 pitot static tube

```
clc;
clear;
v1=100;//mi/hr
ht=10000;//ft
//from standard table for static pressure at an
   altitude
p1=1456//lb/ft^2(abs)
P1=1456*0.006947;//psi
d=0.001756;//slugs/ft^3
//1 mi/hr = 1.467 ft/s
p2=p1+(d*(v1*1.467)^2/2);//lb/ft^3
//in terms of gage pressure p2g
p2g=p2-p1;//lb/ft^2
//1lb/ft^2 = 0.006947 psi
P2=p2*0.006947;//psi
P2g=p2g*0.006947;//psi
//pressure difference indicated by the pitot tube =
   pdiff
pdiff=P2-P1;//psi
```

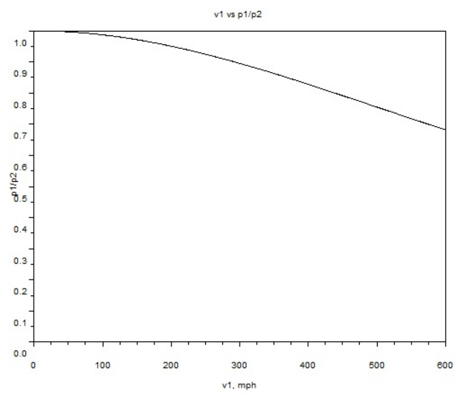

Figure 3.1: pitot static tube

```
disp("psi",P1,"Pressure at point 1 =")
disp("psi",P2g,"Pressure at point 2 in terms of gage
    pressure=")
disp("psi",pdiff,"pressure difference indicated by
    the pitot static tube=")
v1=0:1:600;
for i=0:600
    prat(i+1)=p1/(p1+(d*(i*1.467)^2/2));
end
plot2d(v1,prat,rect=[0,0,600,1]);
xtitle("v1 vs p1/p2","v1, mph","p1/p2")
```

Scilab code Exa 3.7 determination of flowrate

```
clc;
clear;
dia=0.1; //m
dia1=1.0; //m
h=2.0; //m
```

```
//bernoulli's equation: p1+(0.5*d*V1^2)+(sw*z1)= p2+(0.5*d*V2^2)+(sw*z2)
//assuming p1=p2=0, and z1=h and z2=0
//(0.5*d*V1^2)+(g*h)= (0.5*d*V2^2)
//assuming steady flow Q1=Q2, Q=A*V. hence, A1*V1=A2*V2
//V1=((dia/dia1)^2)*V2
//hence V2=((2*g*h)/(1-(dia/dia1)^4))^0.5
V2=((2*9.81*h)/(1-(dia/dia1)^4))^0.5;
Q=(%pi/4*(dia)^2)*V2;
disp("m^3/sec",Q,"The flow rate needed is=")
//let Q0 be the flow rate when v1=0, i.e. dia>>dia
//Q0=(2*g*h)^0.5 and Qrat=Q/Q0
count=1;
i=0:0.05:0.8;

for k=0.00:0.05:0.80
    Qrat(count)=1/((1-(k^4))^0.5);
    count=count+1;
end

plot2d(i,Qrat,rect=[0,1,0.8,1.1])
xtitle("d/D vs Q/Q0","d/D","Q/Q0")
```

Scilab code Exa 3.8 flowrate and pressure

```
clc;
clear;
dia=0.03;//m
dia1=0.01;//m
p=3;//kPa(gage)
//density of air d is found using standard temp and pressure conditions
```

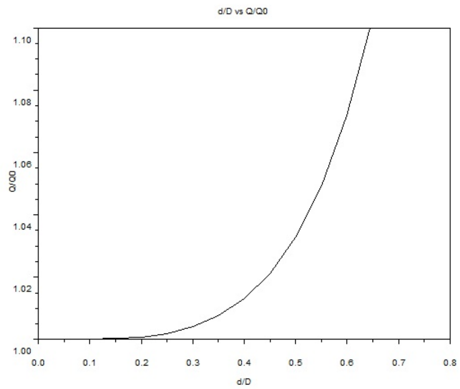

Figure 3.2: determination of flowrate

```
d=(p+101)*1000/((286.9)*(15+273));
//applying Bernoulli's equation at points 1,2 and 3; p=p1
v3=((2*p*1000)/d)^0.5;
Q=%pi/4*(dia1^2)*v3;
//by continuity equation, A2*v2=A3*v3
v2=((dia1/dia)^2)*v3;
p2=(p*1000)-(0.5*d*(v2^2));
disp("m^3/s",Q,"Flowrate =")
disp("N/m^2",p2,"Pressure in the hose=")
```

Scilab code Exa 3.10 maximum height determination

```
clc;
clear;
T=60;//degree farenheit
z1=5;//ft
atmp=14.7;//psia
//applying bernoulli equation at points 1,2 and 3
z3=-5;//ft
v1=0;//large tank
```

```
p1=0;//open tank
p3=0;//open jet
//applying continuity equation A2*v2=A3*v3; A2=A3;
   so v2=v3
v3=(2*32.2*(z1-z3))^0.5;
//vapor pressure of water at 60 degree farenheit =
   p2=0.256 psia
p2=0.256;
z2=z1-((((p2-atmp)*144)+(0.5*1.94*v3^2))/62.4);
disp("ft",z2,"The maximum height over which the
   water can be siphoned without cavitation occuring
   =")
```

Scilab code Exa 3.11 pressure difference range

```
clc;
clear;
sg=0.85;
Q1=0.005;//m^3/s
Q2=0.05;//m^3/s
dia1=0.1;//m
dia2=0.06;//m

//A2/A1=dia2/dia1
d=sg*1000;
Arat=(dia2/dia1)^2;
A2=%pi/4*(dia2^2);
pdiffs=(Q1^2)*d*(1-(Arat^2))/(2*1000*(A2^2));
pdiffl=(Q2^2)*d*(1-(Arat^2))/(2*1000*(A2^2));
disp("kPa",pdiffl,"to","kPa",pdiffs,"kPa","The
   pressure difference ranges from =")
```

Scilab code Exa 3.12 flow through channel

```
clc;
clear;
z1=5;//m
a=0.8;//m
b=6;//m
Cc=0.61;//since a/z1=ratio=0.16<0.2; Cc=
    contracction coefficient
z2=Cc*a;
//Q/b=flowrate
flowrate=z2*((2*9.81*(z1-z2))/(1-((z2/z1)^2)))^0.5;
//considering z1>>z2 and neglecting kinetic energy
    of the upstream fluid
flowrate1=z2*(2*9.81*z1)^0.5;
disp("m^2/s",flowrate,"The flowrate per unit width="
    )
disp("m^2/s",flowrate1,"The flowrate per unit width
    when we consider z1>>z2=")
count=1;
j=5:15;
for i=5:15
    fr(count)=z2*((2*9.81*(i-z2))/(1-((z2/i)^2)))
        ^0.5;
    count=count+1;
end
plot2d(j,fr,rect=[0,0,15,9])
xtitle("Q/b vs z1","z1,m","Q/b, m^2/s")
```

Scilab code Exa 3.13 increased flowrate determination

```
clc;
clear;
//Q=A*V=(H^2)*tan(theta/2)*(C2*(2*g*H)^0.5)
//Q3H0/QH0=(3H0)^2.5/(H0)^2.5=3^2.5
```

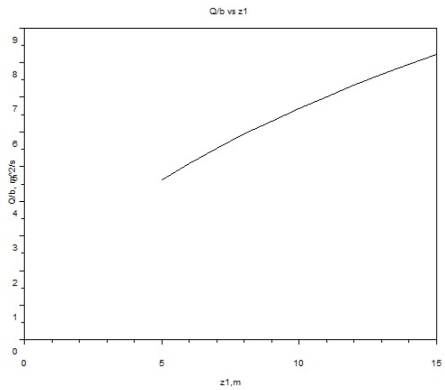

Figure 3.3: flow through channel

```
Qrat=3^2.5;
disp("The flowrate is proportional to H^2.5")
disp("times.",Qrat,"When depth is increased from H0
   to 3H0 Q increases ")
```

Scilab code Exa 3.15 stagnation pressure calculation

```
clc;
clear;
h=10;//Km
//air is in a standard atmosphere
p1=26.5;//kPa
T1=-49.9;//degree celcius
d=0.414;//Kg/m^3
k=1.4;
Ma1=0.82;//Mach
//for incompressible flow,
pdiff=(k*Ma1^2)/2*p1;
//for compressible isentropic flow,
pdiff1=((1+((k-1)/2)*(Ma1^2))^(k/(k-1))-1)*p1;
disp("Stagnation pressure on leading edge on the
```

```
   wing of the Boeing:")
disp("kPa",pdiff,"flow is imcompressible =")
disp("kPa",pdiff1,"flow is compressible and
   isentropic =")
```

Scilab code Exa 3.17 stagnation pressure determination

```
clc;
clear;
V=5;//m/s
sg=1.03;
h=50;//m
//since static pressure is greater than stagnation
   pressure, Bernoulli's equation is incorrect
//p2=(d*(V1^2)/2)+(d*g*h) ; V1=V
p2=(((sg*1000)*(V^2)/2) + (sg*1000*9.81*h))/1000;//
   kPa
disp("kPa",p2,"The pressure at stagnation point 2 ="
   )
```

Chapter 4

Kinematics of fluid motion

Scilab code Exa 4.6 delivery speed calculation

```
clc;
clear;
pratet=-8;//dollars/hr
pratex=0.2;//dollars/mi
exec("C:\Program Files\scilab-5.3.0\bin\TCP\4_6data.
    sci");
u=(-pratet)/pratex;
disp("mi/hr",u,"The delivery speed=")
```

Chapter 5

Flow analysis using control volumes

Scilab code Exa 5.1 Minimum Pumping capacity

```
clc;
clear;
v2=20;//m/s
dia2= 40;//mm

//m1=m2
//d1*Q1=D2*Q2; where d1=d2 is density of seawater
//hence Q1=Q2
Q=v2*(%pi*((dia2/1000)^2)/4);//m^3/sec
disp("m^3/sec",Q,"Flowrate=")
```

Scilab code Exa 5.2 average velocity calculation

```
clc;
clear;
v2=1000;//ft/sec
```

```
p1=100;//psia
p2=18.4;//psia
T1=540;//degree R
T2=453;//degree R
dia=4;//inches
//m1=m2
//d1*A1*v1=d2*A2*v2
//A1=A2 and d=p/(R*T); since air at pressures and
   temperatures involved behaves as an ideal gas
v1=p2*T1*v2/(p1*T2);
disp("ft/sec",v1,"Velocity at section 1 =")
```

Scilab code Exa 5.3 Mass Flowrate determination

```
clc;
clear;
m1=22;//slugs/hr
m3=0.5;//slugs/hr
//-m1+m2+m3=0
m2=m1-m3;
disp("slugs/hr",m2,"Mass flowrate of the dry air and
    water vapour leaving the dehumidifier=")
```

Scilab code Exa 5.5 change in depth

```
clc;
clear;
Q=9;//gal/min
l=5;//ft
b=2;//ft
H=1.5;//ft
```

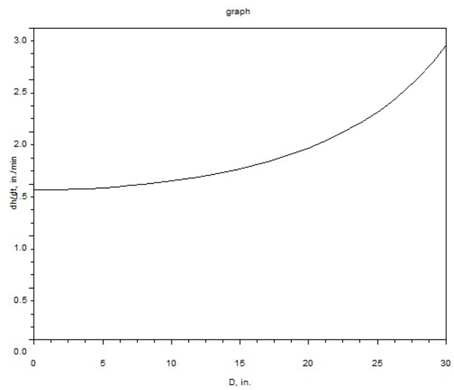

Figure 5.1: change in depth

```
//continuity equation to water: integral of m= d*((h
    *b*l)+(H-h)*A); where A is cross-sectional area
    of faucet
//m=d*(b*l-A)*dh/dt, where dh/dt= hrate
//m=d*Q
//since A<<l*b, it can be neglected
fn=poly([0 (1.94*l*b)],"h","c");
x=derivat(fn);//x=m/(dh/dt)
hrate=Q*12*1.94/(x*7.48);
disp("in./min",hrate,"Time rate of change of depth
    of water in tub =")
d=0:30;
for i=0:30
    hrate1(i+1)=(Q*12*12*12)/(((l*b*12*12)-(%pi*(i
        ^2)/4))*7.48);
end
plot2d(d,hrate1,rect=[0,0,30,3])
xtitle("graph","D, in.","dh/dt, in./min")
```

Scilab code Exa 5.6 mass flowrate estimation

```
clc;
clear;
v=971; //km/hr
v2=1050; //km/hr
A1=0.80; //m^2
d1=0.736; //Kg/m^3
A2=0.558; //m^2
d2=0.515; //Kg/m^3

//w1=v=intake velocity
//mass flow rate of fuel intake = d2*A2*w2 - d1*A1*
    w1
w2=v2+v;
m=(d2*A2*w2 - d1*A1*v)*1000;
disp("kg/hr",m,"The mass flow rate of fuel intake =
    ")
```

Scilab code Exa 5.7 Speed of water

```
clc;
clear;
Q=1000; //ml/s
A2=30; //mm^2
rotv=600; //rpm

//mass in = mass out
w2=(Q*0.001*1000000)/(2*A2*1000);
disp("m/s",w2,"Average speed of water leaving each
    nozzle when sprinkle head is stationary and when
    it rotates with a constant speed of 600rpm =")
```

Scilab code Exa 5.8 Speed of plunger

```
clc;
clear;
Ap=500;//mm^2
Q2=300;//cm^3/min
Qleak=0.1*Q2;//cm^3/min
//A1=Ap
//mass conservation in control volume
//-d*A1*V + m2 + d*Qleak =0; m2=d*Q2
//V=(Q2+Qleak)/Ap
V=(Q2+Qleak)*1000/Ap;
disp("mm/min",V,"The speed at which the plunger
    should be advanced=")
```

Scilab code Exa 5.9 change in depth

```
clc;
clear;
Q=9;//gal/min
l=5;//ft
b=2;//ft
H=1.5;//ft
//deforming control volume
//hrate=Q/(l*b-A)
//A<<l*b
hrate=Q*12/(l*b*7.48);
disp("in./min",hrate,"Time rate of change of depth
    of water in tub =")
```

Scilab code Exa 5.11 Anchoring force determination

```
clc;
```

```
clear;
dia1=16;//mm
h=30;//mm
dia2=5;//mm
Q=0.6;//litre/sec
mass=0.1;//kg
p1=464;//kPa
d=999;//kg/m^3
m=d*Q/1000;//kg/s
A1=%pi*((dia1/1000)^2)/4;//m^2
w1=Q/(A1*1000);//m/s
A2=%pi*((dia2/1000)^2)/4;//m^2
w2=Q/(A2*1000);//m/s
Wnozzle=mass*9.81;//N
volwater=((1/12)*(%pi)*(h)*((dia1^2)+(dia2^2)+(dia1*
    dia2)))/(1000^3);//m^3
Wwater=d*volwater*9.81;//N
F=m*(w1-w2)+Wnozzle+(p1*1000*A1)+Wwater;//N
disp("N",F,"The anchoring force=")
```

Scilab code Exa 5.12 Anchoring force calculation

```
clc;
clear;
A=0.1;//ft^2
v=50;//ft/s
p1=30;//psia
p2=24;//psia

d=1.94;//slugs/ft^3
//v1=v2=v and A1=A2=A
m=d*v*A;
Fay=-m*(v+v)-((p1-14.7)*A*144)-((p2-14.7)*A*144);
disp("lb",0," and the x component of anchoring force
    is","lb",Fay,"The y component of anchoring force
```

```
    is ")
```

Scilab code Exa 5.13 Frictional force determination

```
clc;
clear;
p1=100;//psia
p2=18.4;//psia
T1=540;//degree R
T2=453;//degree R
V2=1000;//ft/s
V1=219;//ft/s
dia=4;//in

//m=m1=m2
A2=%pi*((4/12)^2)/4;//ft^2
//equation of state d*R*T=p
d2=p2*144/(1716*T2);
m=A2*d2*V2;//slugs/s
Rx=A2*144*(p1-p2)-(m*(V2-V1));//lb
disp("lb",Rx,"Frictional force exerted by pipe wall
    on air flow=")
```

Scilab code Exa 5.15 nominal thrust calculation

```
clc;
clear;
v1=200;//m/s
v2=500;//m/s
A1=1;//m^2
p1=78.5;//kPa(abs)
T1=268;//K
p2=101;//kPa(abs)
```

```

//F=-p1*A1 + p2*A2 + m*(v2-v1)
//m=d1*A1*v1
//d1=(p1)/(R*T1)
d1=(p1*1000)/(286.9*T1);
m=d1*v1*A1;
F=-((p1-p2)*A1*1000) + m*(v2-v1);
disp("N",F,"The thrust for which the stand is to be designed=")
```

Scilab code Exa 5.17 force determination

```
clc;
clear;
v1=100;//ft/sec
v0=20;//ft/sec
ang=45;//degrees
A1=0.006;//ft^2
l=1;//ft
//m1=m2=m; continuity equation
//d=density of water= constant
//w=speed of water relative to the moving control volume=constant=w1=w2
//w1=v1-v0
w=v1-v0;
d=1.94;//slugs/ft^3
//-Rx=(w1)(-m1)+(w2cos(ang))(m2)
Rx=d*(w^2)*A1*(1-cos(ang*%pi/180));
//wwater=(specific wt of water)*A1*l
wwater=62.4*A1*l;
Rz=(d*(w^2)*(sin(ang*%pi/180))*A1)+wwater;
R=((Rx^2)+(Rz^2))^0.5;
angle=(atan(Rz/Rx))*180/(%pi);
disp("lb",R,"The force exerted by stream of water on vane surface=")
```

```
disp("degrees",angle,"The force points right and
    down from the x direction at an angle of=")
```

Scilab code Exa 5.18 resisting torque calculation

```
clc;
clear;
Q=1000;//ml/sec
A=30;//mm^2
r=200;//mm
n=500;//rev/min
//v2 is tangential; v2=vang2
m=(Q/1000000)*999;//kg/sec
//m=2*d*(A)*v2=d*Q
v2=(Q)/(2*A);//m/sec
//Torque reuired to hold sprinkler stationary
Tshaft=(-(r/1000)*(v2)*m);//Nm
//u2=speed of nozzle=r*omega
//v21=v2-u2
omega=n*(2*%pi)/60;//rad/sec
v21=v2-(r*omega/1000);
//resisting torque when sprinker is rotating at a
    constant speed of n rev/min
Tshaft1=(-(r/1000)*(v21)*m);//Nm
//when no resistintg torque is applied
//Tshaft=0
omega1=v2/(r/1000);
n1=(omega1)*60/(2*%pi);//rpm
disp("Nm",Tshaft,"Resisting torque required to hold
    the sprinker stationary=")
disp("Nm",Tshaft1,"Resisting torque when sprinker is
     rotating at a constant speed of 500 rev/min=")
disp("rpm",n1,"Speed of sprikler when no resisting
    torque is applied=")
x=0:800;
```

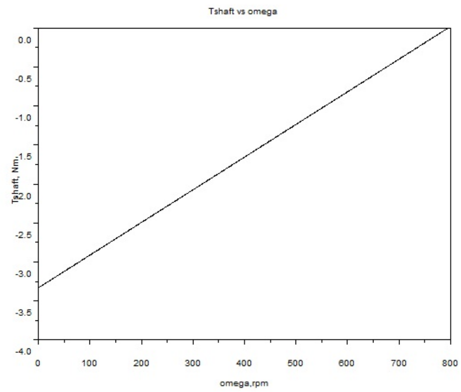

Figure 5.2: resisting torque calculation

```
for i=0:800
    y(i+1)=(-(r/1000)*(v2-((r/1000)*i*(2*%pi)/60))*m);
end
plot2d(x,y,rect=[0,-4,800,0])
xtitle("Tshaft vs omega","omega,rpm","Tshaft, Nm")
```

Scilab code Exa 5.19 estimation of power

```
clc;
clear;
h=1;//in
Q=230;//ft^3/min
ang=30;//degrees
dia1=10;//in
dia2=12;//in
n=1725;//rpm
//m=d*Q
```

```
m=(2.38/1000)*Q/60;
//u2=rotor blade speed
u2=(dia2/2)*(n*2*(%pi)/(12*60));
//m=d*A2*Vr2 and A2=2*%pi*r2*h and r2=dia2/2
//hence, m=d*2*%pi*r2*h*Vr2
//Vr2=w2*sin(ang)
w2=m*12*12/((2.38/1000)*2*(%pi)*(dia2/2)*(h)*sin(ang
    *(%pi)/180));//ft/sec
Vang2=u2-(w2*cos(ang*(%pi)/180));//ft/sec
Wshaft=m*u2*Vang2/(550);//hp
disp("hp",Wshaft,"The power required to run the fan=
    ")
```

Scilab code Exa 5.20 Determination of power

```
clc;
clear;
Q=300;//gal/min
d1=3.5;//in.
p1=18;//psi
d2=1;//in.
p2=60;//psi
diffu=3000;//ft*lb/slug

//energy equation
//m(u2-u1+(p1/d)-(p2/d)+((v2^2)-(v1^2))/2 + g*(z2-z1
    ))=q-Wshaft
m=Q*1.94/(7.48*60);//slugs/sec
v1=Q*12*12/(%pi*(d1^2)*60*7.48/4);
v2=Q*12*12/(%pi*(d2^2)*7.48*60/4);
Wshaft=m*(diffu + (p2*144/1.94) - (p1*144/1.94) +
    (((v2^2)-(v1^2))/2))/550;//hp
disp("hp",Wshaft,"The power required by the pump=")
disp("hp",m*(diffu/550),"The internal energy change
    accounts for =")
```

```
disp("hp",m*(((p2*144/1.94) - (p1*144/1.94))/550),"
   The pressure rise accounts for =")
disp("hp",m*(((v2^2)-(v1^2))/(550*2)),"The kinetic
   energy change accounts for =")
```

Scilab code Exa 5.21 work output calculation

```
clc;
clear;
v1=30;//m/s
h1=3348;//kJ/kg
v2=60;//m/s
h2=2550;//kJ/kg

//energy equation
//wshaftin=Wshaftin/m= (h2-h1 + ((v2^2)-(v1^2))/2)
//wshaftout=-wshaftin
wshaftout=h1-h2 + (((v1^2)-(v2^2))/2000);
disp("KJ/kg",wshaftout,"The work output involved per
    unit mass of steam through-flow=")
```

Scilab code Exa 5.22 temperature change determination

```
clc;
clear;
z=500;//ft
//energy equation
//T2-T1 = (u2 - u1)/c = g*(z2 - z1)/c; c=specific
   heat of water = 1 Btu/(lbm* degree R)
diffT = 32.2*z/(778*32.2);//degree R
disp("degree R",diffT,"The temperature change
   associated with this flow=")
```

Scilab code Exa 5.23 volume flowrates comparison

```
clc;
clear;
dia=120; //mm
p=1.0; //kPa

//using energy equation
//Q=A2*v2=A2*((p1-p2)/(d*(1+Kl)/2)); d =density , Kl=
    loss coefficient
Kl1=0.05;;
Kl2=0.5;
//for rounded entrance cyliindrical vent
Q1=(%pi*((dia/1000)^2)/4)*(p*1000*2/(1.23*(1+Kl1)))
    ^0.5;
//for cylindrical vent
Q2=(%pi*((dia/1000)^2)/4)*(p*1000*2/(1.23*(1+Kl2)))
    ^0.5;

disp("m^3/sec",Q1,"The volume fowrate associated
    with the rounded entrance cylindrical vent
    configuration =")
disp("m^3/sec",Q2,"The volume fowrate associated
    with the cylindrical vent configuration =")
KLoss=0:0.01:0.5;
count=1;
for i=0:0.01:0.5
    flow(count)=(%pi*((dia/1000)^2)/4)*(p
        *1000*2/(1.23*(1+i)))^0.5;
    count=count+1;
end
plot2d(KLoss,flow,rect=[0,0,0.5,0.5])
xtitle("Q vs KL","KL","Q, (m^3)/sec")
```

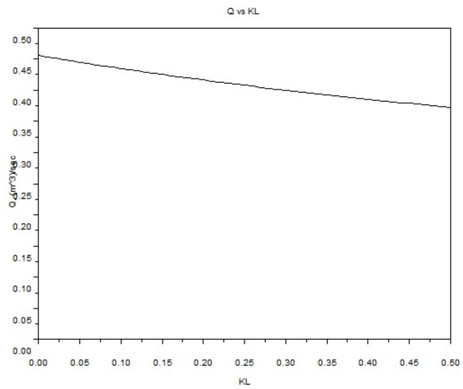

Figure 5.3: volume flowrates comparison

Scilab code Exa 5.24 useful work determination

```
clc;
clear;
p=0.4;//kW
dia=0.6;//m
v2=12;//m/s
v1=0;//m/s
//energy equation
Wuseful=(v2^2)/2;
//wshaftin= Wshaftin/m
wshaftin=(p*1000)/(1.23*%pi*(0.6^2)*12/4);
eff=Wuseful/wshaftin;
disp("N.m/kg",Wuseful,"The work to air which provides useful effect-=")
disp(eff,"Fluid mechanical efficiency of this fan=")
```

Scilab code Exa 5.25 flowrate and powerloss

```
clc;
clear;
p=10;//hp
z=30;//ft
hl=15;//ft
//energy equation
//hs=Wshaftin/(sw*Q) = hl+z
Q=(p*550)/((hl+z)*62.4);
wloss=62.4*Q*hl/550;
disp("ft^3/s",Q,"Flowrate =")
disp("hp",wloss,"Power loss=")
loss=0:25;
for i=0:25
    q(i+1)=(p*550)/((i+z)*62.4);
end
plot2d(loss,q,rect=[0,0,25,3.5])
xtitle("Flowrate vs headloss","hs,ft","Q, ft^3/sec")
```

Scilab code Exa 5.26 nonuniform velocity profile

```
clc;
clear;
m=0.1;//kg/min
dia1=60;//mm
alpha1=2.0;
dia2=30;//mm
alpha2=1.08;
p=0.1;//kPa
```

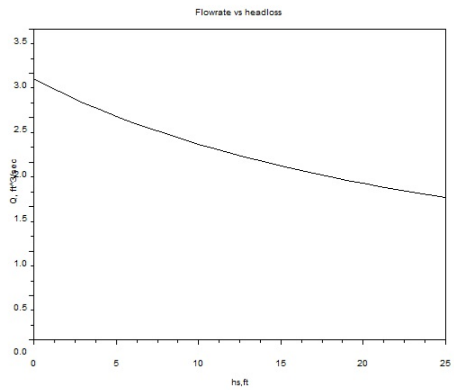

Figure 5.4: flowrate and powerloss

```
power=0.14;//W

wshaftin=power*60/m;//Nm/kg
vavg1=m*1000*1000/(60*1.23*%pi*dia1*dia1/4);
vavg2=m*1000*1000/(60*1.23*%pi*dia2*dia2/4);
loss1=wshaftin-(p*1000/1.23)+((vavg1^2)/2)-((vavg2
    ^2)/2);//Nm/kg
loss2=wshaftin-(p*1000/1.23)+(alpha1*(vavg1^2)/2)-(
    alpha2*(vavg2^2)/2);//Nm/kg
disp("Nm/kg",loss1,"Loss for uniform velocity
    profile=")
disp("Nm/kg",loss2,"Loss for actual velocity profile
    =")
```

Scilab code Exa 5.29 expanded air velocity

```
clc;
clear;
p1=100;//psia
T1=520;//degree R
p2=14.7;//psia
```

```
//for incompressible flow

d=p1*144/(1716*T1);//where d=density , calculated by
   assuminng air to behave like an ideal gas
//Bernoulli equation
v2=(2*(p1-p2)*144/d)^0.5;//ft/sec
disp("ft/sec",v2,"The velocity of expanded air
   considering incompressible flow =")

//for compressible flow

k=1.4;//for air
d1=d;
d2=d1*((p2/p1)^(1/k));//where d2=density of expanded
    air
//bernoulli equation
V2=((2*k/(k-1))*((p1*144/d1)-(p2*144/d2)))^0.5;//ft/
   s
disp("ft/s",V2,"The velocity of expanded air
   considering compressible flow =")
```

Chapter 6

Flow Analysis of Using Differential Methods

Scilab code Exa 6.4 inviscid flow pressure

```
clc;
clear;
p1=30;//kPa
d=1000;//kg/(m^3)
r1=1;//m
r2=0.5;//m
//applying energy equation between points (1) and
    (2) and using the equation V^2=16*(r^2)
V1=(16*(r1^2))^0.5;//m/sec
V2=(16*(r2^2))^0.5;//m/sec
p2=((p1*1000)+(d*((V1^2)-(V2^2))/2)/1000;//kPa
disp("kPa",p2,"The pressure at point (2) =")
```

Scilab code Exa 6.5 Volume rate calculation

```
clc;
```

```
clear;ang1=0;//radians
ang2=%pi/6;//radians
vp='-2*log(r)';
//vr=d(vp)/d'r
//vr=(-2)/r;
//vang=(1/r)*(d(vp)/d(ang))
vang=0;
q=(integrate('-2','ang',ang1,ang2));
disp("ft^2/sec",q,"Volume rate of flow (per unit length) into the opening = ")
```

Scilab code Exa 6.7 pressure at elevation

```
clc;
clear;
h=200;//ft
U=40;//mi/hr
d=0.00238;//slugs/ft^3
//V^2= (U^2)*(1 + (2*b*cos(ang)/r) + ((b^2)/(r^2)))
//at point 2, ang=%pi/2
//r=b*(%pi-ang)/sin(ang)=(%pi*b/2)
V=U*(1+(4/(%pi^2)))^0.5;//mi/hr
y2=h/2;//ft
//bernoulli equation
//p1-p2= d*((V2^2)-(V1^2)) + (sw*(y2-y1))
V1=U*(5280/3600);
V2=V*(5280/3600);
pdiff=((d*((V2^2)-(V1^2))/2) + (d*32.2*(y2)))/144;//psi
disp("mi/hr",V,"The magnitude of velocity at (2) for a 40 mi/hr approaching wind =")
disp("psi",pdiff,"The pressure difference between points (1) and (2)=")
u=0:100;

```

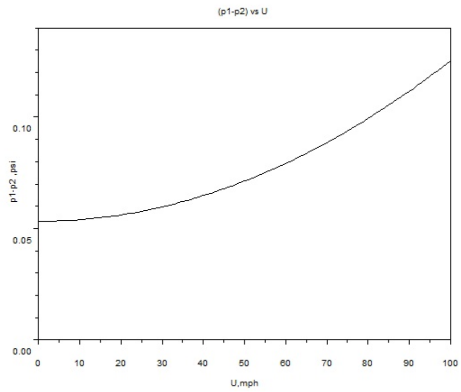

Figure 6.1: pressure at elevation

```
for i=0:100
    pd(i+1)= ((d*((((i*(1+(4/(%pi^2)))^0.5)
        *(5280/3600))^2)-((i*(5280/3600))^2))/2) + (d
        *32.2*(y2)))/144;
end
plot2d(u,pd,rect=[0,0,100,0.14])
xtitle("(p1-p2) vs U","U,mph","p1-p2 ,psi")
```

Scilab code Exa 6.10 flow in annulus

```
clc;
clear;
d=1.18*1000;//kg/m^3
vis=0.0045;//Ns/m^2, viscosity
Q=12;//ml/sec
dia1=4;//mm
l=1;//m
dia2=2;//mm
V=Q/(1000000*%pi*((dia1/1000)^2)/4);//mean velocity ,
```

```
m/sec
Re=(d*V*dia1/1000)/vis;
disp(" is well below critical value of 2100 so flow is laminar.",Re,"a) The Reynolds number ")
pdiff=(8*vis*(l)*(12/1000000)/(%pi*(dia1/2000)^4))/1000; //kPa
disp("kPa",pdiff,"The pressure drop along a 1 m length of the tube which is far from the tube entrance so that the only component of velocity is parallel to the the tube axis=")
//for flow in the annulus
V1=Q/(1000000*%pi*(((dia1/1000)^2)-((dia2/1000)^2))/4); //mean velocity, m/sec
Re1=d*((dia1-dia2)/1000)*V1/vis;
disp(" is well below critical value of 2100 so flow is laminar.",Re1,"b) The Reynolds number ")
r1=dia1/2000;
r2=dia2/2000;
pdiff1=((8*vis*(l)*(12/1000000)/(%pi))*((r1^4)-(r2^4)-((((r1^2)-(r2^2))^2)/(log(r1/r2))))^(-1))/1000; //kPa
disp("kPa",pdiff1,"The pressure drop along a 1 m length of the symmetric annulus =")

rratio=0.001:0.001:0.5;
count=1;
for i=0.001:0.001:0.5
    pratio(count)=1/((i^4)*((1/(i^4))-1-((((1/(i^2))-1)^2)/log(1/i))));
    count=count+1;
end
plot2d(rratio,pratio,rect=[0,0,0.5,8])
xtitle("ri/ro vs pdiff(annulus)/pdiff(tube)","ri/ro","pdiff(annulus)/pdiff(tube)")
```

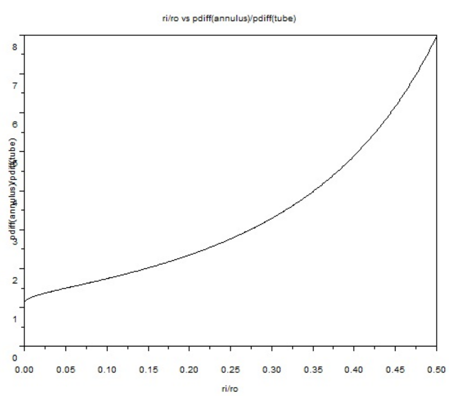

Figure 6.2: flow in annulus

Chapter 7

Dimensional Analysis Modelling and Similitude

Scilab code Exa 7.5 prototype performance prediction

```
clc;
clear;
D=0.1;//m
H=0.3;//m
v=50;//km/hr
Dm=20;//mm
T=20;//degree C
fm=49.9;//Hz ; frequency for the model
//f=func(D,H,V,d,vis)
//f=T^(-1); D=l; H=L; V=L*(T^(-1)); d=M*(L^(-3));
    vis=M*(L^(-1))*(T^(-1))
//by applying pi theorem,
//(f*D/V)=funct((D/H),(d*V*D/vis))
//hence; Dm/Hm = D/H, dm*Vm*Dm/vism = d*V*D/vis, and
    (f*D/V)=(fm*Dm/Vm)
Hm=(Dm*H*1000/(D*1000));//mm
V=v*1000/3600;//m/s
vism=1/1000;//kg/(m*s)
vis=1.79/100000;//kg/(m*s)
```

```
d=1.23;//kg/(m^3)
dm=998;//kg/(m^3)
Vm=(vism*d*D*V*1000)/(vis*dm*Dm);//m/s
f=(V/Vm)*(Dm/(D*1000))*fm;//Hz
disp("mm",Hm,"The model dimension =")
disp("m/s",Vm,"The velocity at which the test should
    be performed=")
disp("Hz",f,"The predicted prototype vortex
   shredding frequency =")
```

Scilab code Exa 7.6 reynolds number similarity

```
clc;
clear;
D=2;//ft
Q=30;//cfs
Dm=3;//in
//Rem=Re; hence (Vm*Dm/kvism)=(V*D/kvis); where kvis
    is kinematic viscosity
//kvis=kvism; same fluid is used for model and
   prototype
//(Vm/V)=(D/Dm)
//Q=VA; hence Qm/Q = (Vm*Am)/(V*A)=(Dm/D)
Qm=(Dm/12)*Q/D;//cfs
disp("cfs",Qm,"The required flowrate in the model=")
Drat=0.04:0.01:1;
count=1;
for i=0.04:0.01:1
    Vrat(count)=1/i;
    count=count+1;
end
plot2d(Drat,Vrat,rect=[0,0,1,25])
xtitle("Vm/V vs Dm/D","Dm/D","Vm/V")
```

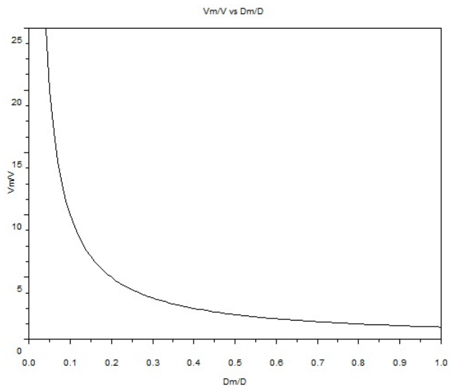

Figure 7.1: reynolds number similarity

Scilab code Exa 7.7 predicting prototype performance

```
clc;
clear;
V=240;//mph
ratio=1/10;
Vair=240;//mph
Fm=1;//lb; Fm =drag force on model
p=14.7;//psia; standard atmospheric pressure
//Re=Rem
//(d*V*l/vis)=(dm*Vm*lm/vism)
//here Vm=V and lm/l=ratio
//assumption made is that an increase in pressure
   does not significantly change viscosity
drat=V/(ratio*Vair);//where drat=dm/d
//for an ideal gas p=d*R*T
//T=Tm
//hence, pm/p=dm/d; pm/p=prat
```

```
pm=p*drat;
//F/(0.5*d*(V^2)*(l^2))=Fm/(0.5*dm*(Vm^2)*(lm^2))
F=(1/drat)*((V/Vair)^2)*((1/ratio)^2)*Fm;
disp("psia",pm,"The required air pressure in the
    tunnel=")
disp("lb",F,"The corrosponding drag on the prtotype
    for a 1 lb drag on the model=")
```

Scilab code Exa 7.8 froude number similarity

```
clc;
clear;
w=20;//m
Q=125;//(m^3)/s
ratio=1/15;
t=24;//hours
wm=ratio*w;//m
//Vm/(gm*lm)^0.5 = V/(g*l)^0.5
//gm=g
//Q=VA and lm/l=1/15
//hence Qm/Q = ((lm/l)^0.5)*((lm/l)^2) = ratio^2.5
Qm=(ratio^2.5)*Q;
//V=l/t
//tm/t=(V/Vm)*(lm/l)=ratio^0.5
tm=(ratio^0.5)*t;//hours
disp("m",wm,"The required model width=")
disp("(m^3)/s",Qm,"The required model flowrate=")
disp("hrs",tm,"The operating time for the model=")
lrat=0.01:0.01:0.5;
count=1;
for i=0.01:0.01:0.5
    tmodel(count)=(i^0.5)*t;
    count=count+1;
end
plot2d(lrat,tmodel,rect=[0,0,0.5,20])
```

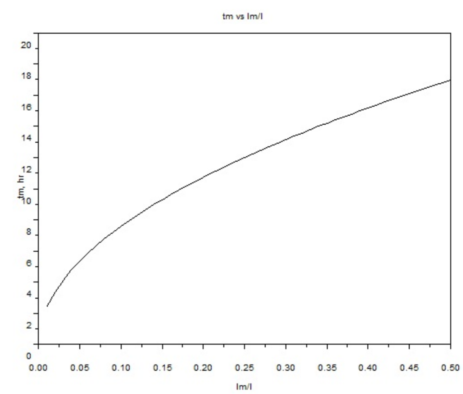

Figure 7.2: froude number similarity

```
xtitle("tm vs lm/l","lm/l","tm, hr")
```

Chapter 8

Pipe flow

Scilab code Exa 8.1 calculating time required

```
clc;
clear;
T1=50;//degree farenheit
D=0.73;//in
vol=0.0125;//ft^3
T2=140;//degree farenheit

vis1=2.73/100000;//lb*s/ft^2 at 50 degree farenheit
vis2=0.974/100000;//lb*s/ft^2 at 140 degree farenheit

//for 50 degree farenheit
//if flow is laminar, maximum Re=2100; Re=d*V*D/vis
V1=2100*vis1/(1.94*D/12);
t1=vol/(%pi*((D/12)^2)/4*V1);
//if flow is turbulent, minimum Re=4000
V2=4000*vis1/(1.94*D/12);
t2=vol/(%pi*((D/12)^2)/4*V2);

//for 140 degree farenheit
//if flow is laminar, maximum Re=2100; Re=d*V*D/vis
```

```
V3=2100*vis2/(1.94*D/12);
t3=vol/(%pi*((D/12)^2)/4*V3);
//if flow is turbulent , minimum Re=4000
V4=4000*vis2/(1.94*D/12);
t4=vol/(%pi*((D/12)^2)/4*V4);

disp("For laminar flow")
disp("seconds",t1,"The time taken to fill the glass at 50 degree F=")
disp("seconds",t3,"The time taken to fill the glass 100 degree F=")
disp("For turbulent flow:")
disp("seconds",t2,"The time taken to fill the glass at 50 degree F=")
disp("seconds",t4,"The time taken to fill the glass at 140 degree F=")
```

Scilab code Exa 8.2 laminar pipe flow

```
clc;
clear;
vis=0.4;//Ns/(m^2)
d=900;//kg/(m^3)
D=0.02;//m
Q=2.0*(10^-5);//(m^3)/s
x1=0;
x2=10;//m
p1=200;//kPa
x3=5;//m
V=Q/(%pi*(D^2)/4);//m/s
Re=d*V*D/vis;
disp("Hence the flow is laminar.",Re,"a) Reynolds number =")
pdiff=128*vis*(x2-x1)*Q/(%pi*(D^4)*1000);
//for part b0 p1=p2; Q=%pi*(pdiff-(sw*l*sin(ang)))*(
```

```
    D^4)/(128*vis*l)
ang=(asin(-128*vis*Q/(%pi*d*9.81*(D^4))))*180/%pi;
//since sin(ang) doesn= not depend on pdiff , the the
     pressure is constant all along the pipe
//hence for c)
p3=p1;//kPa
disp("kPa.",pdiff,"The pressure drop required if the
     pipe is horizontal=")
disp("degrees.",ang,"b) The angle of the hill the
    pipe must be on if the oil is to flow at the same
     rate as a) but with (p1=p2) =")
disp("kPa",p3,"c) For conditions of part b), the
    pressure at x3=5 m = ")
```

Scilab code Exa 8.3 net force calculation

```
clc;
clear;
T=[60 80 100 120 140 160];//degree F
d=[2.07 2.06 2.05 2.04 2.03 2.02];//(slugs/(ft^3))
vis=[0.04 0.019 0.0038 0.00044 0.000092 0.000023];//
    lb*sec/(ft^2)
Q=0.5;//(ft^3)/sec
T1=100;//degree F
l=6;//ft
D=3;//in
//Q=K*pdiff; where pdiff=p1-p2
//hence K=%pi*(D^4)/(128*vis*l)
count=1;
for i=1:6
    K(i)=(%pi*((D/12)^4))/(128*vis(i)*l);
end
plot2d(T,K,logflag='nl')
xtitle("K vs T","T, degree F","K, (ft^5)/(lb.sec)")
pdiff=(128*Q*vis(3)*l)/(%pi*((D/12)^4));//when
```

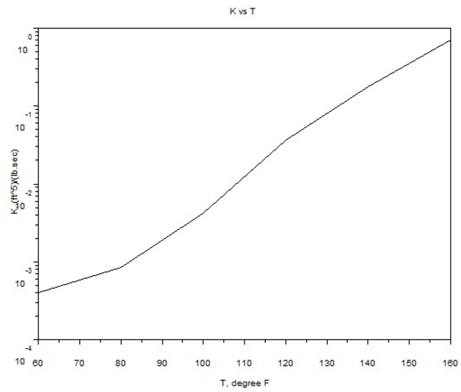

Figure 8.1: net force calculation

```
   temperature is 100 degree F
disp("lb/(ft^2)",pdiff,"The pressure drop for the
   given Q and T =")
V=Q/(%pi*((D/12)^2)/4);//ft/sec
Re=d(3)*V*(D/12)/vis(3);
disp("hence the flow is laminar",Re,"The reynolds
   number=")
stress=pdiff*(D/12)/(4*l);//lb/(ft^2)
disp("lb/(ft^2)",stress,"The wall stress for the
   given Q and T =")
Fp=(%pi/4)*((D/12)^2)*pdiff;//lb
Fv=(2*%pi)*((D/12)/2)*l*stress;//lb
disp("lb",Fp,"The net pressure force =")
disp("lb",Fv,"The net viscous/shear force =")
```

Scilab code Exa 8.4 turbulent pipe flow

```
clc;
clear;
```

```
T=20;//degree C
d=998;//kg/(m^3)
kvis=1.004*(10^-6);//(m^2)/s; where kvis=kinematic
    viscosity
D=0.1;//m
Q=0.04;//(m^3)/sec
pgrad=2.59;//kPa/m; where pgrad is pressure gradient
r=0.025;//m
stress=D*(pgrad*1000)/(4*1);//N/(m^2)
uf=(stress/d)^0.5;//m/sec; where uf is frictional
    velocity
ts=5*kvis*1000/(uf);//mm; where ts is the thickness
    of the viscous sublayer
disp("mm",ts,"The thickness of the viscous sublayer=
    ")
V=Q/(%pi*(D^2)/4);//m/s
Re=V*D/kvis;
disp("hence the flow is turbulent.",Re,"The reynolds
     number=")
n=8.4;//from turbulent flow velocity profile diagram

//Q=(%pi)*(R^2)*V
R=1;//assumption
//let Q/Vc=x
x=integrate('((1-(r/R))^(1/n))*(2*%pi*r)','r',0,R);
q=%pi*(R^2)*V;
Vc=q/x;//m/s
disp("m/s",Vc,"The approximate centerline velocity="
    )
stress1=(2*stress*r)/D;//N/(m^2)
//d(uavg)/dr=urate=-(Vc/(n*R))*((1-(r/R))^((1-n)/n))
    ; where uavg=average velocity
urate=-(Vc/(n*(D/2)))*((1-(r/(D/2)))^((1-n)/n));//s
    ^(-1)
stresslam=-(kvis*d*urate);//N/(m^2)
stressratio=(stress1-stresslam)/stresslam;
disp(stressratio,"The ratio of teh turbulent to
    laminar stress at a point midway between the
```

```
centreline and the pipe wall =")
```

Scilab code Exa 8.5 pressure drop calculation

```
clc;
clear;
D=4;//mm
V=50;//m/sec
l=0.1;//m
d=1.23;//kg/(m^3)
vis=1.79/100000;//N*sec/(m^2)
Re=d*V*(D/1000)/vis;
//if flow is laminar
f=64/Re;
pdiff=f*l*0.5*d*(V^2)/((D/1000)*1000);//kPa
disp("kPa",pdiff,"The pressure drop if the flow is
   laminar=")
//if flow is turbulent
//roughness=0.0015; hence f=0.028
f1=0.028;
pdiff1=f1*l*0.5*d*(V^2)/((D/1000)*1000);//kPa
disp("kPa",pdiff1,"The pressure drop if flow is
   turbulent=")
```

Scilab code Exa 8.6 minor losses calculation

```
clc;
clear;
A=[22 28 35 35 4 4 10 18 22];
V=[36.4 28.6 22.9 22.9 200 200 80 44.4 36.4];
//minimum area is at location 5, hence max velocity
   is at 5
c5=(1.4**1716*(460+59))^0.5;//ft/sec
```

```
Ma5=V(5)/c5;
//applying energy equation between locations  1 and
   9
//hL=hp=(p1-p9)/sw=pdiff/sw
//Pa=sw*Q*hp=sw*A(5)*V(5)*hL
KLcorner=0.2;
KLdif=0.6;
KLscr=4;
hL=((KLcorner*(((V(7))^2)+((V(8))^2)+((V(2))^2)+((V
   (3))^2))) + (KLdif*(((V(6))^2))) + (KLcorner*((V
   (5))^2)) + (KLscr*((V(4))^2)))/(2*32.2);//ft
Pa=0.0765*A(5)*V(5)*hL/550;//hp
pdiff=0.0765*hL/144;//psi
disp("psi",pdiff,"The value of (p1-p9)=")
disp("hp",Pa,"The horsepower supplied to the fluid
   by the fan=")
v=50:300;
count=1;
for i=50:300
   power(count)=0.0765*((((KLcorner*((A(5)*i/A(7))
      ^2)+((A(5)*i/(A(8)))^2)+((A(5)*i/A(2))^2)+((A
      (5)*i/A(3))^2))) + (KLdif*(((A(5)*i/A(6))^2)))
       + (KLcorner*((i)^2)) + (KLscr*((A(5)*i/A(4))
      ^2)))/(2*32.2))*(A(5))*i/550;
   count=count+1;
end
plot2d(v,power,rect=[0,0,300,250])
xtitle("Pa vs V5","V5, ft/sec","Pa, hp")
```

Scilab code Exa 8.7 duct size determination

```
clc;
clear;
```

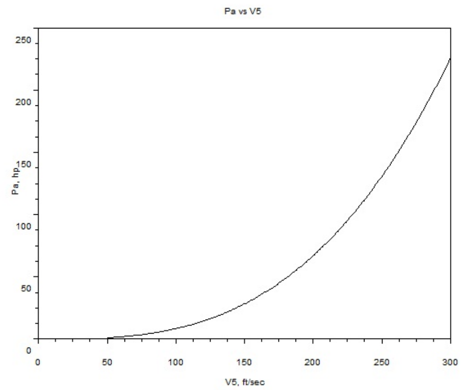

Figure 8.2: minor losses calculation

```
T=120;//degree F
D=8;//in
vavg=10;//ft/s
roughness=0;
kvis=1.89/10000;//(ft^2)/s
Re=vavg*(D/12)/kvis;
//from this value of Re and roughness/D=0, and using
    Moody's chart
f=0.022;
hLperl=f*(vavg^2)/(D*2*32.2/12);
//Dh=4*A/P=4*(a^2)/(4*a)=a

//Vs=(%pi*((D/12)^2)*vavg)/(4*a^2)
//a=f*((%pi*((D/12)^2)*vavg)/(4*a^2))/(2*32.2) and
   Reh=((%pi*((D/12)^2)*vavg)/(4*a^2))*a/kvis
//by trial and error
f=0.023;
x=(%pi*((D/12)^2)*vavg/4)^2;
y=x*f/(2*32.2);
a=((y/0.0512)^(1/5))*12;//in
disp("inches",a,"The duct size(a) for the square
   duct if the head loss per foot remains the same
   for the pipe and the duct=")
```

Scilab code Exa 8.8 determining pressure drop

```
clc;
clear;
T=60;//degree F
D=0.0625;//ft
Q=0.0267;//(ft^3)/sec
Df=0.5;//in
l1=15;//ft
l2=10;//ft
l3=5;//ft
l4=10;//ft
l5=10;//ft
l6=10;//ft
V1=Q/(%pi*(D^2)/4);//ft/sec
V2=Q/(%pi*((Df/12)^2)/4);//ft/sec
d=1.94;//slugs/ft
vis=2.34/100000;//lb*sec/(ft^2)
Re=d*V1*D/vis;
disp("hence the flow is turbulent",Re,"The reynolds
    number =")
//applying energy equation between points 1 and 2
//when all head losses are excluded
p1=(d*32.2*(l2+l4))+(0.5*d*((V2^2)-(V1^2)));//lb/(ft
    ^2)
disp("psi",p1/144,"a)The pressure at point 1 when
    all head losses are neglected=")
//if major losses are included
f=0.0215;
hLmajor=f*(l1+l2+l3+l4+l5+l6)*(V1^2)/(D*2*32.2);
p11=p1+(d*32.2*hLmajor);//lb/(ft^2)
disp("psi",p11/144,"b)The pressure at point 1 when
    only major head losses are included=")
//if major and minor losses are included
```

```
KLelbow=1.5;
KLvalve=10;
KLfaucet=2;
hLminor=(KLvalve+(4*KLelbow)+KLfaucet)*(V1^2)/(2*32.2);
p12=p11+(d*32.2*hLminor);//lb/(ft^2)
disp("psi",p12/144,"c)The pressure at point 1 when both major and minor head losses are included=")
H=(p1/(32.2*1.94))+(V1*V1/(2*32.2));//ft
dist=0:60;
for i=0:15
    press(i+1)=p1/144;
    press1(i+1)=((d*32.2*(l2+l4))+(0.5*d*((V2^2)-(V1^2)))+(d*32.2*(f*(l1+l2+l3+l4+l5+l6-i)*(V1^2)/(D*2*32.2)))+(d*32.2*(KLvalve+(4*KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))/144;
    head(i+1)=H;
    head1(i+1)=((press1(i+1))*144/(32.2*1.94))+((V1^2)/(2*32.2));
end
for i=16:25
    press(i+1)=((d*32.2*((l2+l4)-(i-15)))+(0.5*d*((V2^2)-(V1^2))))/144;
    press1(i+1)=((d*32.2*((l2+l4)-(i-15)))+(0.5*d*((V2^2)-(V1^2)))+(d*32.2*f*(l1+l2+l3+l4+l5+l6-i)*(V1^2)/(D*2*32.2))+(d*32.2*(KLvalve+(3*KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))/144;
    head(i+1)=H;
    head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)/(2*32.2))+(i-l1);
end
for i=26:30
    press(i+1)=((d*32.2*((l2+l4)-(25-15)))+(0.5*d*((V2^2)-(V1^2))))/144;
     press1(i+1)=((d*32.2*((l2+l4)-(25-15)))+(0.5*d*((V2^2)-(V1^2)))+(d*32.2*(f*(l1+l2+l3+l4+l5+l6-i)*(V1^2)/(D*2*32.2)))+(d*32.2*(KLvalve+(2*KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))
```

```
           /144;
      head(i+1)=H;
     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+l2;
end
for i=31:40
     press(i+1)=((d*32.2*((l2+l4)-(i-l1-l3)))+(0.5*d
        *((V2^2)-(V1^2))))/144;
     press1(i+1)=((d*32.2*((l2+l4)-(i-l1-l3)))+(0.5*d
        *((V2^2)-(V1^2)))+(d*32.2*(f*(l1+l2+l3+l4+l5+
        l6-i)*(V1^2)/(D*2*32.2)))+(32.2*d*(KLvalve+(
        KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))/144;
     head(i+1)=H;
     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(i-(l1+l3));
end
for i=41:50
     press(i+1)=((d*32.2*((l2+l4)-(40-l1-l3)))+(0.5*d
        *((V2^2)-(V1^2))))/144;
     press1(i+1)=((d*32.2*((l2+l4)-(40-l1-l3)))+(0.5*
        d*((V2^2)-(V1^2)))+(d*32.2*(f*(l1+l2+l3+l4+l5
        +l6-i)*(V1^2)/(D*2*32.2)))+(d*32.2*(KLvalve+
        KLfaucet)*(V1^2)/(2*32.2)))/144;
      head(i+1)=H;
     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(l2+l4);
end
for i=51:60
     press(i+1)=((d*32.2*((l2+l4)-(40-l1-l3)))+(0.5*d
        *((V2^2)-(V1^2))))/144;
      press1(i+1)=((d*32.2*((l2+l4)-(40-l1-l3)))
         +(0.5*d*((V2^2)-(V1^2)))+(d*32.2*(f*(l1+l2+
         l3+l4+l5+l6-i)*(V1^2)/(D*2*32.2)))+d*32.2*((
         KLfaucet)*(V1^2)/(2*32.2)))/144;
      head(i+1)=H;
     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(l2+l4);
end
```

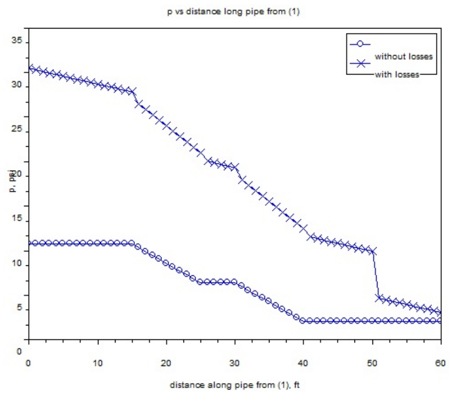

Figure 8.3: determining pressure drop

```
plot(dist,press,"o-")
plot(dist,press1,"x-")
h1=legend(['without losses';'with losses'])
xtitle("p vs distance long pipe from (1)","distance
   along pipe from (1), ft","p, psi")
xclick(1);
clf();
plot(dist,head,"o-")
plot(dist,head1,"x-")
h2=legend(['energy line with no losses';'energy line
    including losses'])
xtitle("H vs distance long pipe from (1)","distance
   along pipe from (1), ft","H,elevation to energy
   line, ft")

end
```

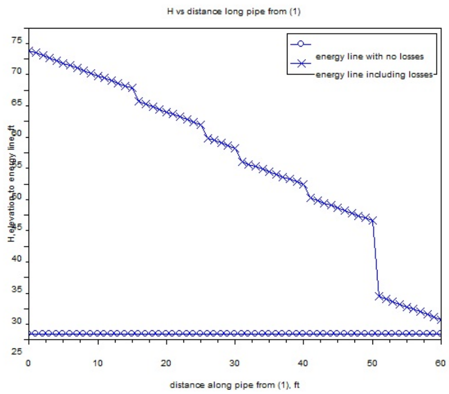

Figure 8.4: determining pressure drop

Scilab code Exa 8.9 determining head loss

```
clc;
clear;
T=140;//degree F
sw=53.7;//lb/(ft^3)
vis=8/100000;//lb*sec/(ft^2)
l=799;//miles
D=4;//ft
Q=117;//(ft^3)/sec
V=9.31;//ft/sec
//energy equation=> hp=hL=f*(l/D)*((V^2)/(2*g))
f=0.0125;
hp=f*(l*5280/D)*((V^2)/(2*32.2));//ft
Pa=sw*Q*hp/550;//hp
disp("hp",Pa,"The horsepower required to drive the
    system=")
dia=2:0.01:6;
count=1;
for i=2:0.01:6
    power(count)=sw*Q*(f*(l*5280/i)*(((Q/(%pi*(i^2)
        /4))^2)/(2*32.2)))/550;
    count=count+1;
end
```

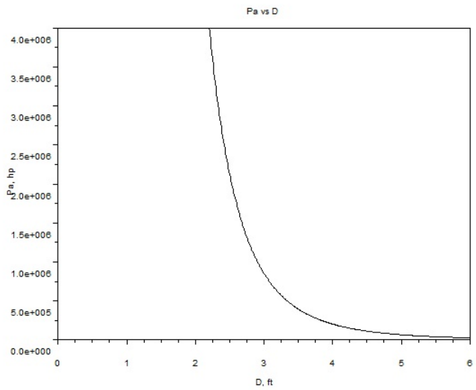

Figure 8.5: determining head loss

```
plot2d(dia,power,rect=[0,0,6,4000000])
xtitle("Pa vs D","D, ft","Pa, hp")
```

Scilab code Exa 8.10 air flowrate determination

```
clc;
clear;
D=4;//in
l=20;//ft
n=4;//number of 90 degree elbows
h=0.2;//in
T=100;//degree F
//energy equation between the inside of the dryer
   and the exit of the vent pipe
p1=(h/12)*62.4;//lb/(ft^2)
KLentrance=0.5;
KLelbow=1.5;
sw=0.0709;//lb/(ft^3)
f=0.022;//assumption
```

```
//hence,
V=((p1/sw)*2*32.2/(1+(f*l/(D/12))+KLentrance+(n*
    KLelbow)))^0.5;//ft/sec
Q=V*(%pi*((D/12)^2)/4);//(ft^3)/sec
disp("(ft^3)/sec",Q,"The flowrate=")
```

Scilab code Exa 8.11 flowrate through turbine

```
clc;
clear;
Pa=50;//hp
D=1;//ft
l=300;//ft
f=0.02;
z1=90;//ft
//energy equation between the surface of the lake
    and the outlet of the pipe
//p1=V1=p2=z2=0; V2=V
//hL=f*l*(V^2)/(D *2*g)
//hT=Pa/(sw*%pi*(D^2)*V/4)
c1=(Pa*550)/(62.4*%pi*(D^2)/4)//561
c2=f*l/(D*2*32.2)//0.0932
fn=poly([c1 (-z1) 0 ((1/(2*32.2))+(c2))],"V","c");
r=roots(fn);
V1=r(1);//ft/sec
V2=r(2);//ft/sec
Q1=(%pi*(D^2)/4)*V1;//(ft^3)/sec
Q2=(%pi*(D^2)/4)*V2;//(ft^3)/sec
disp("(ft^3)/sec",Q2,"and","(ft^3)/sec",Q1,"The
    possible flowrates are=")
```

Scilab code Exa 8.12 minimum pipe diameter

```
clc;
clear;
roughness=0.0005;//ft
Q=2;//(ft^3)/sec
pd=0.5;//psi; where pd=pressure drop
l=100;//ft
d=0.00238;//slugs/(ft^3)
vis=3.74*(10^(-7));//lb*sec/(ft^2)
x=Q/(%pi/4);//where x =V*(D^2)
//energy equation with z1=z2 and V1=V2
y=l*d*(x^2)*0.5/(pd*144);//where y=(D^5)/f
f=0.027;//using reynolds number, roughness and moody
    's chart
D=(y*f)^(1/5);//ft
disp("ft",D,"The diameter of the pipe should be =")
q=0.01:0.01:3;
count=1;
for i=0.01:0.01:3
    dia(count)=((l*d*((i/(%pi/4))^2)*0.5/(pd*144))*f
       )^(1/5);
    count=count+1;
end
plot2d(q,dia,rect=[0,0,3,0.25])
xtitle("D vs Q","Q, (ft^3)/sec","D, ft")
```

Scilab code Exa 8.13 pipe diameter calculation

```
clc;
clear;
T=60;//degree F
kvis=1.28*(10^(-5));//(ft^2)/sec
l=1700;//ft
roughness=0.0005;//ft
```

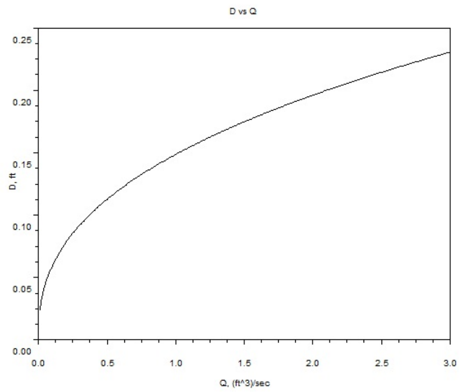

Figure 8.6: minimum pipe diameter

```
Q=26;//(ft^3)/sec
n=4;//number of flanged 45 degree elbows
z1=44;//ft
x=Q/(%pi/4);//where x=V*(D^2)
KLentrance=0.5;
KLelbow=0.2;
KLexit=1;
//Finding f from Re, roughness and moody's chart
f=0.01528;
sumKL=(n*KLelbow)+KLentrance+KLexit;
y=f*l;
//V^2 = (x^2)/(D^4)
//energy equation with p1=p2pV1=V2=z2=0
z=(2*32.2*z1)/((x^2)*l);
k=sumKL/l;
fn=poly([(-f) (-k) 0 0 0 z],'D','c');
r=roots(fn);
disp("ft",r(1),"The diameter=")
count=1;
len=400:2000;
for i=400:2000
    root=roots(poly([(-f) (-(sumKL/i)) 0 0 0
       ((2*32.2*z1)/((x^2)*i))],'a','c'));
    dia(count)=root(1);
```

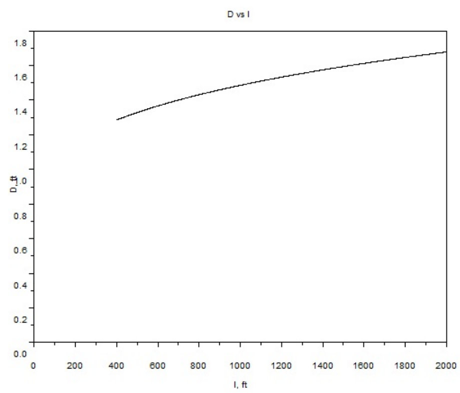

Figure 8.7: pipe diameter calculation

```
    count=count+1;
end
plot2d(len,dia,rect=[0,0,2000,1.8])
xtitle("D vs l","l, ft","D, ft")
```

Scilab code Exa 8.14 flowrate in reservoir

```
clc;
clear;
D=1;//ft
f=0.02;
z1=100;//ft
z2=20;//ft
z3=0;//ft
l1=1000;//ft
l2=500;//ft
l3=400;//ft
//assuming fluid flows into B
//applying energy equation bwtween (1 and 3) and (1
```

```
    and 2) and using the relation V1=V2+V3
c1=z1*32.2*2/(f*l1);
c2=(z1-z2)*32.2*2/(f*l1);
x=(c1-c2)/(l3/l1);//160
y=(l2/l1)/(l3/l1);//1.25
a=c2-x;//98
b=(a*2*(y+(l2/l1)));//539
c=4*x+b;//1179
d=-((y+(l2/l1))^2)+(4*y);//-2.5625
e=-(a^2);//-9604
fn=poly([e 0 c 0 d],'V2','c');
r=roots(fn);
V2=r(1);
V1=(c2-(l2/l1)*V2)^0.5;
A=(%pi/4*(D^2));
Q1=V1*A;
Q2=V2*A;
Q3=Q1-Q2;
disp("(ft^3)/sec",Q1,"Q1 (out of A)=")
disp("(ft^3)/sec",Q2,"Q2 (into B)=")
disp("(ft^3)/sec",Q3,"Q3 (into C)=")
```

Scilab code Exa 8.15 diameter of nozzle

```
clc;
clear;
D=60;//mm
pdiff=4;//kPa
Q=0.003;//(m^3)/sec
d=789;//kg/(m^3)
vis=1.19*(10^(-3));//N*sec/(m^2)
Re=d*4*Q/(%pi*D*vis);
//assuming B=dia/D=0.577, where dia=diameter of
    nozzle, and obtaining Cn from Re as 0.972
Cn=0.972;
```

```
B=0.577;
dia=((4*Q/(Cn*%pi))/((2*pdiff*1000/(d*(1-(B^4))))
    ^0.5))^0.5;
disp("mm",dia*1000,"Diameter of the nozzle=")
```

Chapter 9

External Flow Past Bodies

Scilab code Exa 9.1 lift and drag

```
clc;
clear;
U=25;//ft/sec
p=0;//gage
b=10;//ft
t=1.24*(10^-3);//where t=stress*(x^0.5)
a=0.744;//where a=p/(1-((y^2)/4))
p1=-0.893;//lb/(ft^2)
drag1=2*integrate('t*b/(x^0.5)','x',0,4);
drag2=integrate('(((a*(1-((y^2)/4))))-p1)*b','y'
    ,-2,2);
disp("lb",drag1,"The drag when plate is parallel to
    the upstream flow=")
disp("lb",drag2,"The drag when plate is
    perpendicular to the upstream flow=")
```

Scilab code Exa 9.5 boundary layer transition

```
clc;
clear;
U=10;//ft/sec
Twater=60;//degree F
Tglycerin=68;//degree F
kviswater=1.21*(10^-5);//(ft^2)/sec
kvisair=1.57*(10^-4);//(ft^2)/sec
kvisglycerin=1.28*(10^-2);//(ft^2)/sec
Re=5*(10^5);//assumption
xcrwater=kviswater*Re/U;//ft
xcrair=kvisair*Re/U;//ft
xcrglycerin=kvisglycerin*Re/U;//ft
btwater=5*(kviswater*xcrwater/U)^0.5;//ft; where bt=
    thickness of boundary layer
btair=5*(kvisair*xcrair/U)^0.5;//ft
btglycerin=5*(kvisglycerin*xcrglycerin/U)^0.5;//ft
disp("a)WATER")
disp(,"ft",xcrwater,"location at which boundary
    layer becomes turbulent=")
disp("ft",btwater,"Thickness of the boundary layer="
    )
disp("b)AIR")
disp(,"ft",xcrair,"location at which boundary layer
    becomes turbulent=")
disp("ft",btair,"Thickness of the boundary layer=")
disp("c)GLYCERIN")
disp(,"ft",xcrglycerin,"location at which boundary
    layer becomes turbulent=")
disp("ft",btglycerin,"Thickness of the boundary
    layer=")
```

Scilab code Exa 9.7 drag estimation

```
clc;
clear;
```

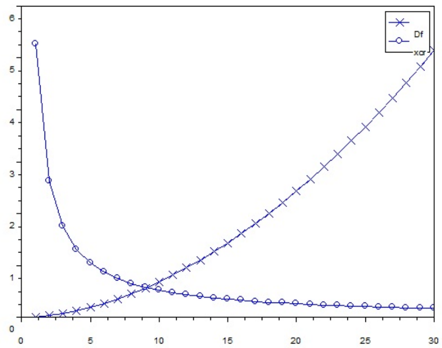

Figure 9.1: drag estimation

```
T=70;//degree F
U1=0;//ft/sec
U2=30;//ft/sec
l=4;//ft
b=0.5;//ft
d=1.94;
vis=2.04*(10^(-5));
x=d*l/vis;
U=1:U2;
for i=1:U2
    Re(i)=x*i;
    CDf(i)=0.455/((log10(Re(i)))^2.58);
    Df(i)=0.5*d*i*i*l*b*CDf(i);
    xcr(i)=vis*(5*(10^5))/(d*i);
end
plot(U,Df,"x-")
plot(U,xcr,"o-")
h1=legend(['Df';'xcr'])
```

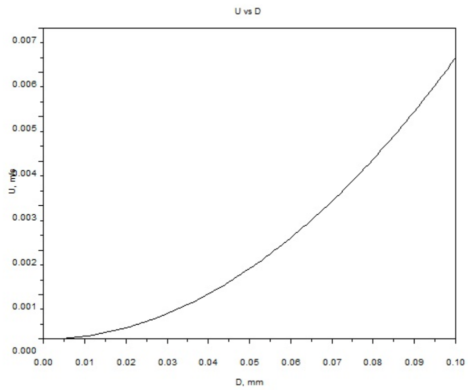

Figure 9.2: speed of grain

Scilab code Exa 9.10 speed of grain

```
clc;
clear;
D=0.1; //mm
sg=2.3;
vis=1.12*(10^(-3)); //N*s/(m^2)
//by free body diagram and assuming CD=24/Re
U=(sg-1)*999*9.81*((D/1000)^2)/(18*vis);
disp("m/sec",U,"The velocity of the particle through still water =")
dia=0:0.001:0.1;
count=1;
for i=0:0.001:0.1
    u(count)=(sg-1)*999*9.81*((i/1000)^2)/(18*vis);
    count=count+1;
end
plot2d(dia,u,rect=[0,0,0.1,0.007])
xtitle("U vs D","D, mm","U, m/s")
```

Scilab code Exa 9.11 velocity of updraft

```
clc;
clear;
D=1.5;//in
//assuming CD=0.5 and verifying this value using
   value of Re
CD=0.5;
dice=1.84;//slugs/(ft^3); density of ice
dair=2.38*(10^(-3));//slugs/(ft^3)
U=(4*dice*32.2*(D/12)/(3*dair*CD))^0.5;//ft/sec
disp("mph",U*3600/5275,"The velocity of the updraft
   needed=")
```

Scilab code Exa 9.12 drag and deceleration

```
clc;
clear;
Dg=1.69;//in.
Wg=0.0992;//lb
Ug=200;//ft/sec
Dt=1.5;//in.
Wt=0.00551;//lb
Ut=60;//ft/sec
kvis=(1.57*(10^(-4)));//(ft^2)/sec
Reg=Ug*Dg/kvis;
Ret=Ut*Dt/kvis;
//the corresponding drag coefficients are calculated
    as
CDgs=0.25;//standard golf ball
CDgsm=0.51;//smooth golf ball
CDt=0.5;//table tennis ball
Dgs=0.5*0.00238*(Ug^2)*%pi*((Dg/12)^2)*CDgs/4;//lb
Dgsm=0.5*0.00238*(Ug^2)*%pi*((Dg/12)^2)*CDgsm/4;//lb
Dt=0.5*0.00238*(Ut^2)*%pi*((Dt/12)^2)*CDt/4;//lb
```

```
//the  corresponding decelerations are a=D/s=g*D/W
//deceleration relative to g=D/W
decgs=Dgs/Wg;
decgsm=Dgsm/Wg;
dect=Dt/Wt;
disp("STANDARD GOLF BALL:")
disp("lb",Dgs,"The drag coefficient=")
disp(decgs,"The deceleration relative to g=")
disp("SMOOTH GOLF BALL:")
disp("lb",Dgsm,"The drag coefficient=")
disp(decgsm,"The deceleration relative to g=")
disp("TABLE TENNIS BALL:")
disp("lb",Dt,"The drag coefficient=")
disp(dect,"The deceleration relative to g=")
```

Scilab code Exa 9.13 torque estimation

```
clc;
clear;
U=88;//fps
Ds=40;//ft
Dc=15;//ft
b=50;//ft
Res=U*Ds/(1.57*(10^(-4)));
Rec=U*Dc/(1.57*(10^(-4)));
//from these values of Re drag coefficients are
   found as
CDs=0.3;
CDc=0.7;
//by summing moments about the base of the tower
Drs=0.5*0.00238*(U^2)*%pi*(Ds^2)*CDs/4;//lb
Drc=0.5*0.00238*(U^2)*b*Dc*CDc;//lb
M=(Drs*(b+(Ds/2)))+(Drc*(b/2));//ft*lb
disp("ft*lb",M,"The moment needed to prevent the
   tower from tripping=")
```

Scilab code Exa 9.15 lift and power

```
clc;
clear;
U=15;//ft/sec
b=96;//ft
c=7.5;//ft
W=210;//lb
CD=0.046;
eff=0.8;//power train efficiency
d=2.38*(10^(-3));//slugs/(ft^3)
//W=L
CL=2*W/(d*(U^2)*b*c);
D=0.5*d*(U^2)*b*c*CD;
P=D*U/(eff*550);//hp
disp(CL,"The lift coefficient=")
disp("hp",P,"The power required by the pilot=")
```

Scilab code Exa 9.16 angular velocity determination

```
clc;
clear;
W=2.45*(10^(-2));//N
D=3.8*(10^(-2));//m
U=12;//m/s

//W=L
d=1.23;//kg/(m^3)
W=0.5*d*(U^2)*(D^2)*%pi*CL/4;
CL=2*W/(d*(U^2)*%pi*(D^2)/4);
//using this value of CL, omega*D/(2*U)=x is found
    as
```

```
x=0.9;
omega=2*U*x/D;//rad/sec
angvel=omega*60/(2*%pi);//rpm; where angvel is
    angular velocity
disp("rpm",angvel,"The angular velocity=")
```

Chapter 10

Flow in Open Channels

Scilab code Exa 10.2 elevation of surface

```
clc;
clear;
z2=0.5;//ft
q=5.75;//(ft^2)/sec
y1=2.3;//ft
z1=0;//ft
V1=2.5;//ft/sec
//bernoulli equation
a=y1+((V1^2)/(2*32.2))+z1-z2;//ft; where a=y2+((V^2)/(2*g))
//countinuity equation
b=(y1*V1);//(ft^2/sec); where b=(y2*V2)
c1=2*32.2;
c2=(-c1)*a;
c3=b^2;
fn=poly([c3 0 c2 c1],"y2","c");
y2=roots(fn);
sum1=y2(3)+z2;//ft
sum2=y2(1)+z2;//ft
E1=y1+(c3/(y1^2));//ft
Emin=3*((q^2)/(32.2^(1/3)))/2;//ft
```

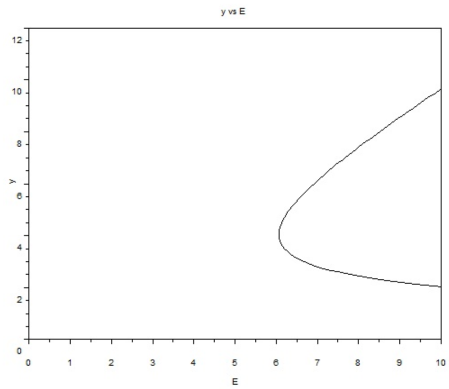

Figure 10.1: elevation of surface

```
z=E1-Emin;//ft
//using this value of z, the surface elevation is
   found to be sum1
disp("ft",sum1,"The elevation of the water surface
   downstream of the ramp=")
count=1;
y=1:0.1:10;
for i=1:0.1:10
    E(count)=i+(c3/(i^2));
    count=count+1;
end
plot2d(E,y,rect=[0,0,10,12])
xtitle("y vs E","E","y")
```

Scilab code Exa 10.3 froude number determination

```
clc;
clear;
y=5;//ft
```

```
angle=40;//degree
l=12;//ft
rate=1.4;//ft per 1000 ft of length
K=1.49;
A=(l*y)+(y*y/tan(angle*%pi/180));//ft
P=(l+(2*y/sin(angle*%pi/180)));//ft
Rh=A/P;
S0=rate/1000;
x=K*(A)*(Rh^(2/3))*(S0^0.5);//where Rh=Q*n
n=0.012;
Q=x/n;//cfs
disp("cfs",Q,"The flowrate=")
V=Q/A;//ft/sec
Fr=V/(32.2*y)^0.5;
disp(Fr,"Froude number=")
```

Scilab code Exa 10.4 determining flow depth

```
clc;
clear;
y=5;//ft
angle=40;//degree
l=12;//ft
rate=1.4;//ft per 1000 ft of length
Q=10;//m^3/sec
//A=(l*y)+(y*y/tan(angle*%pi/180)) ft^2
bw=l*1/3.281;//m; where bw=bottom width 3.66
//P=bw(2*y/sin(angle*%pi/180)) m
//Rh=A/P
n=0.03;
c1=1/tan(angle*%pi/180);//1.19
c2=(Q*n/((rate/1000)^0.5))^3;//515
c3=2/sin(angle*%pi/180);//3.11
fn=poly([(-c2*bw*bw) (-c2*2*c3*bw) (-c2*c3*c3) 0 0 (
   bw^5) (5*c1*bw^4) (10*(c1^2)*(bw^3)) (10*(c1^3)*(
```

```
    bw^2)) (5*(c1^4)*(bw)) (c1^5)],"y","c");
r=roots(fn);
disp("m",r(1),"The depth of the flow=")
```

Scilab code Exa 10.7 flowrate estimation

```
clc;
clear;
S0=1/500;
n1=0.02;
z1=0.6;//ft
n2=0.015;
n3=0.03;
z2=0.8;//ft
l1=3;//ft
l2=2;//ft
l3=3;//ft
y=z1+z2;//ft
K=1.49;
A1=l1*(z1);//ft^2
A2=l2*(y);//ft^2
A3=l3*(z1);//ft^2
P1=l1+z1;//ft
P2=l2+(2*z2);//ft
P3=l3+z1;//ft
Rh1=A1/P1;//ft
Rh2=A2/P2;//ft
Rh3=A3/P3;//ft
Q=K*(S0^0.5)*((A1*(Rh1^(2/3))/n1)+(A3*(Rh3^(2/3))/n3
    )+(A2*(Rh2^(2/3))/n2));//(ft^3)/sec
disp("(ft^3)/sec",Q,"The flowrate=")
```

Scilab code Exa 10.8 aspect ratio determination

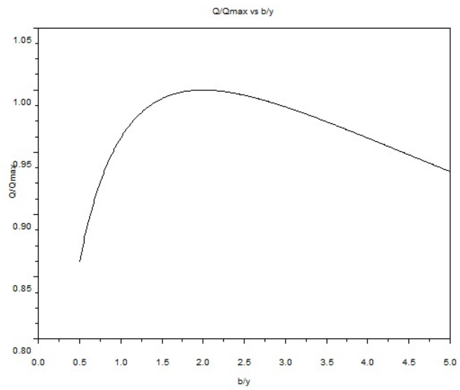

Figure 10.2: aspect ratio determination

```
clc;
clear;
//A=b*y
//p=b+2*y
//Q=K*A*(Rh^(2/3))*(S0^0.5)/n
//dA/dy=0
//from the above, we get
aspratio=2;//asp ratio=aspect ratio=b/y
disp(aspratio,"The aspect ratio=")
asprat=0.5:0.01:5;
count=1;
for  i=0.5:0.01:5
    Qrat(count)=(((2*sqrt(1/2))+(sqrt(2)))/((2*sqrt
       (1/i))+(sqrt(i))))^(2/3);
    count=count+1;
end
plot2d(asprat,Qrat,rect=[0,0.8,5,1.05])
xtitle("Q/Qmax vs b/y","b/y","Q/Qmax")
```

Scilab code Exa 10.9 hydraulic jump

```
clc;
clear;
w=100;//ft
y1=0.6;//ft
V1=18;//ft/sec
Fr1=V1/(32.2*y1)^0.5;
disp(Fr1,"The Froude number before the jump=")
yratio=0.5*(-1+(1+(8*(Fr1^2)))^0.5);//where yratio=
    y2/y1
y2=y1*yratio;//ft
disp("ft",y2,"The depth after the jump=")
//Q1=Q2, hence
V2=(y1*V1)/y2;//ft/sec
Fr2=V2/(32.2*y2)^0.5;
disp(Fr2,"The froude number after the jump=")
Q=w*y1*V1;//(ft^3)/sec
hL=(y1+(V1*V1/(32.2*2)))-(y2+(V2*V2/(2*32.2)));//ft
Pd=62.4*hL*Q/550;//hp
disp("hp",Pd,"Power dissipated within the jump=")
depth1=0.4:0.01:1.53;
count=1;
for i=0.4:0.01:1.53
    power(count)=62.4*(((i+((Q/(i*w))^2)/(32.2*2)))
       -((i*(0.5*(-1+(1+(8*(((Q/(i*w))/(32.2*i)^0.5)
       ^2)))^0.5)))+((((i*(Q/(i*w)))/(i
       *(0.5*(-1+(1+(8*(((Q/(i*w))/(32.2*i)^0.5)^2))
       )^0.5))))^2)/(2*32.2))))*Q/550;
    count=count+1;
end
plot2d(depth1,power,rect=[0,0,1.6,1000])
xtitle("Pa vs y1","y1, ft","Pa, hp")
xclick(1);
clf();
y=0.5:0.01:4;
n=1;
for i=0.5:0.01:4
```

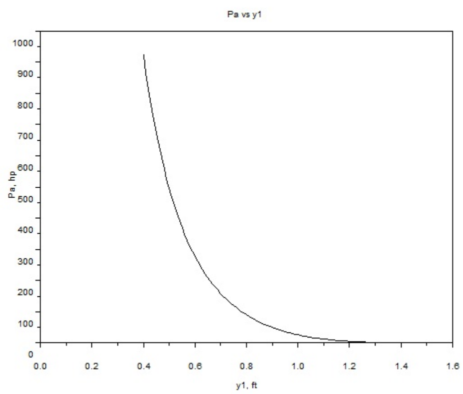

Figure 10.3: hydraulic jump

```
    E(n)=(i+(((Q/w)^2)/(2*32.2*i*i)));
    n=n+1;
end
plot2d(E,y,rect=[0,0,6,4])
xtitle("y vs E","E, ft","y, ft")
```

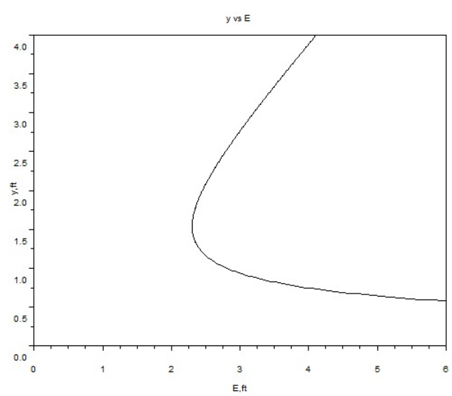

Figure 10.4: hydraulic jump

Chapter 11

Analysis of Compressible Flow

Scilab code Exa 11.1 Internal Energy enthalphy

```
clc;
clear;
D=4;//in
T1=540;//degree R
p1=100;//psia
T2=453;//degree R
p2=18.4;//psia
k=1.4;
R=1716/32.174;//ft*lb/(lbm*(degree R))
cv=R/(k-1);//ft*lb/(lbm*(degree R))
udiff=cv*(T2-T1);//ft*lb/lbm; change in internal
    energy
disp("ft*lb/lbm",udiff,"a)The change in internal
    energy between (1) and (2)=")
cp=k*cv;//ft*lb/(lbm*(degree R))
hdiff=cp*(T2-T1);//ft*lb/lbm; change in enthalpy
disp("ft*lb/lbm",hdiff,"b)The  change in enthalpl
    energy between (1) and (2)=")
ddiff=(1/R)*((p2*144/T2)-(p1*144/T1));//lbm/(ft^3);
    change in density
disp("lbm/(ft^3)",ddiff,"The change in density
```

```
betwenn (1) and (2)=")
```

Scilab code Exa 11.2 change in entropy

```
clc;
clear;
D=4;//in
T1=540;//degree R
p1=100;//psia
T2=453;//degree R
p2=18.4;//psia

dratio=(p1/T1)*(T2/p2);
sdif=(cv*(log(T2/T1)))+(R*(log(dratio)));//ft*lb/lbm*(degree R); change in entropy
disp("ft*lb/lbm*(degree R)",sdif,"The change in entropy between (1) and (2)=")
```

Scilab code Exa 11.3 speed of sound

```
clc;
clear;
T=0;//degree C
R=286.9;//J/(kg*K)
k=1.401;
c=(R*(T+273.15)*k)^0.5;//m/s
disp("m/sec",c,"The speed of sound for air at 0 degree C =")
```

Scilab code Exa 11.4 Mach cone

```
clc;
clear;
z=1000;//m
Ma=1.5;
T=20;//degree C
//alpha=atan(z/x), x=V*t,and Ma=(1/sin(alpha));
    where alpha is the angle of the Mach cone
//V=Ma*c
c=343.3;//m/s found from the value of temperature
V=Ma*c;//m/sec
t=z/(Ma*c*tan(asin(1/Ma)));//sec
disp("sec",t,"The number of seconds to wait after
    the plane passes over-head before it is heard=")
Mach=0.01:0.01:4;
count=1;
for i=0.01:0.01:4
    time(count)=z/(i*c*tan(asin(1/i)));
    count=count+1;
end
plot2d(Mach,time,rect=[0,0,4,3])
xtitle("t vs Ma","Ma","t, sec")
```

Scilab code Exa 11.5 mass flowrate determination

```
clc;
clear;
A=1*(10^(-4));//m^2
p1=80;//kPa(abs)
p2=40;//kPa(abs)
p0=101;//kPa(abs)
pcritical=0.528*p0;//kPa(abs)
k=1.4;
//for (a) pth=p1>pcritical
```

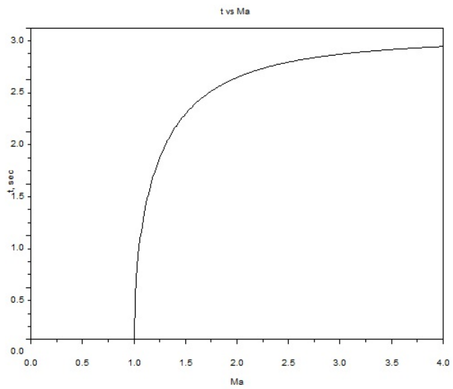

Figure 11.1: Mach cone

```
Math1=((((p0/p1)^((k-1)/k))-1)/((k-1)/2))^0.5; //Math=Mach number at throat
//dth/d0=p1/p0; dth=density at throat
dth1=(1.23)*(1/(1+(((k-1)/2)*(Math1^2))))^(1/(k-1)); //kg/(m^3); density at throat
Tth1=(288)*(1/(1+(((k-1)/2)*(Math1^2)))); //K; temperature at throat
Vth1=Math1*(286.9*Tth1*k)^0.5; //m/sec
m1=dth1*A*Vth1; //kg/sec
disp("kg/sec",m1,"a) The mass flowrate through the duct=")
//for (b) pth=p2<pcritical , hence
Math2=1;
dth2=1.23*(1/(1+(((k-1)/2)*(Math2^2))))^(1/(k-1)); //kg/(m^3); density at throat
Tth2=(288)*(1/(1+(((k-1)/2)*(Math2^2)))); //K; temperature at throat
Vth2=Math2*(286.9*Tth2*k)^0.5; //m/sec
m2=dth2*A*Vth2; //kg/sec
disp("kg/sec",m2,"b) The mass flowrate through the duct=")
```

Scilab code Exa 11.6 mass flowrate calculation

```
clc;
clear;
A=1*(10^(-4));//m^2
p1=80;//kPa(abs)
p2=40;//kPa(abs)

p0=101;//kPa(abs)
k=1.4;
//for (a)
pratio1=p1/p0;
//for this value of p1/p0,
Math1=0.59;
Tratio1=0.94;//=Tth/T0
dratio1=0.85;//=dth/d0
Tth1=Tratio1*(288);//K
dth1=dratio1*(1.23);//kg/(m^3)
Vth1=Math1*(286.9*Tth1*k)^0.5;//m/sec
m1=(dth1*A*Vth1);//kg/sec
disp("kg/sec",m1,"a)The mass flowrate=")
//for (b)
Math2=1;
Tratio2=0.83;//=Tth/T0
dratio2=0.64;//=dth/d0
Tth2=Tratio2*(288);//K
dth2=dratio2*(1.23);//kg/(m^3)
Vth2=Math2*(286.9*Tth2*k)^0.5;//m/sec
m2=(dth2*A*Vth2);//kg/sec
disp("kg/sec",m2,"b)The mass flowrate=")
```

Scilab code Exa 11.7 flow velocity determination

```
clc;
clear;
pratio=0.82;//ratio of static to stagnation pressure
T=68;//degree F
//for (a)
//for the value of pratio given Ma is calculated as
Ma1=0.54;
k1=1.4;
Tratio1=0.94;//T/T0
T1=Tratio1*(T+460);// degree R
V1=(Ma1*(53.3*T1*k1)^0.5)*(32.2^0.5);//ft/sec
//for (b)
k2=1.66;
Ma2=((((1/pratio)^((k2-1)/k2))-1)/((k2-1)/2))^0.5;
Tratio2=1/(1+(((k2-1)/2)*(Ma2^2)));//T/T0
T2=Tratio2*(T+460);//degree R
V2=(Ma2*(386*T2*k2)^0.5)*(32.2^0.5);//ft/sec
disp("ft/sec",V1,"The flow velocity if fluid is air=
   ")
disp("ft/sec",V2,"The flow velocity if fluid is
   helium=")
```

Scilab code Exa 11.11 fanno flow

```
clc;
clear;
k=1.4;
T0=518.67;//degree R
T1=514.55;//degree R
p1=14.3;//psia
R=53.3;//(ft*lb)/(lbm* degree R)
cp=R*k/(k-1);//(ft*lb/(lbm* degree R))
Tratio=T1/T0;
Ma=(((1/Tratio)-1)/((k-1)/2))^0.5;
x=(R*T1*k*32.2)^0.5;//ft/sec; where x=(R*T1*k)^0.5
```

```
y=p1*144/(R*T1)*(Ma*x);//lbm/((ft^2)*sec); where y=d*V
//for p=7 psia
p=7;//psia
fn=poly([(-T0) 1 ((y*y/(2*cp*p*p*144*144/(R^2)))/32.2)],"T","c");
r=roots(fn);
T=r(1);//K
sdif=(cp*log(T/T1))-(R*log(p/p1));//(ft*lb)/(lbm*degree R)
disp("K",T,"The corrosponding value of temperature for Fanno for downstream pressure of 7psia=")
disp("(ft*lb)/(lbm* degree R)",sdif,"The corrosponding value of entropy change for Fanno for downstream pressure of 7psia=")
count=1;
for i=1.4:0.1:7
    root=roots(poly([(-T0) 1 ((y*y/(2*cp*i*i*144*144/(R^2)))/32.2)],"T","c"));
    temp(count)=root(1);
    s(count)=(cp*log(temp(count)/T1))-(R*log(i/p1));
    count=count+1;
end
plot2d(s,temp)
xtitle("T vs s-s1","s-s1, ((ft*lb)/(lbm* degree R))","T, Degree R")
```

Scilab code Exa 11.12 choked fanno flow

```
clc;
clear;
T0=288;//K
p0=101;//kPa(abs)
```

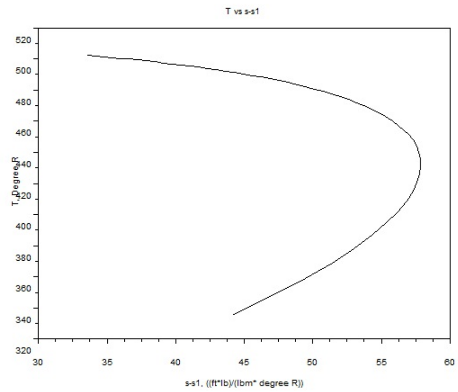

Figure 11.2: fanno flow

```
l=2; //m
D=0.1; //m
f=0.02;
k=1.4;
x=f*l/D;
Tratio=2/(k+1); //where Tratio is Tcritical/T0
Tcritical=Tratio*T0; //K = T2
Vcritical=(286.9*Tcritical*k)^0.5; //m/sec = V2
//from value of x, the following are found
Ma=0.63;
Trat=1.1; //where Trat=T1/Tcritical
Vrat=0.66; //where Vrat=V1/Vcritical
prat=1.7; //where prat=p1/pcritical
pratio=1.16; //where pratio=p0,1/p0critical
//from value of Ma, the following are found
Tfraction=0.93; //whereTfraction=T1/T0
pfraction=0.76; //where pfraction=p1/p0,1
dfraction=0.83; //where dfraction=d1/d0,1
//hence,
V1=Vrat*Vcritical; //m/sec
d1=dfraction*(1.23); //kg/(m^3)
m=d1*%pi*(D^2)*V1/4; //kg/sec
T1=Tfraction*T0; //K
p1=pfraction*p0; //kPa(abs)
```

```
T01=T0;//K and T01=T02
p01=p0;//kPa(abs)
p2=(1/prat)*(pfraction)*p01;//kpa(abs)
p02=(1/pratio)*p01;//kPa(abs)
disp("K",Tcritical,"Critical temperature=")
disp("m/sec",Vcritical,"Critical velocity=")
disp("m/sec",V1,"Velocity at inlet=")
disp("kg/sec",m,"Maximum mass flowrate=")
disp("K",T1,"Temperature at inlet=")
disp("kPa(abs)",p1,"Pressure at inlet=")
disp("K",T01,"stagnation temperature at inlet and
   exit=")
disp("kPa(abs)",p01,"The stagnation pressure at
   inlet=")
disp("kPa(abs)",p2,"Pressure at exit=")
disp("kPa(abs)",p02,"The stagnation pressure at exit
   =")
```

Scilab code Exa 11.13 effect of duct length on choked fanno flow

```
clc;
clear;
T0=288;//K
p0=101;//kPa(abs)
l=2;//m
D=0.1;//m
f=0.02;
pd=45;//kPa(abs)
f=0.02;
k=1.4;
lnew=(50/100)*l;
x=lnew*f/D;
//from this value of x, following are found
Ma=0.7;
prat=1.5;//where prat=p1/pcritical
```

```
//from this value of Ma, following are found
pratio=0.72;//where pratio=p1/p0
dratio=0.79;//where dratio=d1/d0,1
Vratio=0.73;//where Vratio=V1/Vcritical
//hence,
p2=(1/prat)*pratio*p0;//kPa(abs)
pcritical=p2;
//we find that pd<pcritical
d1=dratio*(1.23);//kg/(m^3)
Vcritical=(286.9*Tcritical*k)^0.5;//m/sec = V2
V1=Vratio*Vcritical;//m/sec
m=d1*%pi*(D^2)*V1/4;//kg/sec
disp("kg/sec",1.65,"is less than the flowrate for
   the longer tube =","kg/sec,",m,"The flowrate for
   the smaller tube=")
```

Scilab code Exa 11.14 unchoked fanno flow

```
clc;
clear;
T0=288;//K
p0=101;//kPa(abs)
l=2;//m
D=0.1;//m
f=0.02;
pd=45;//kPa(abs)
f=0.02;
m=1.65;//kg/sec
lnew=l/2;//m

x=f*l/D;
//from this value of x, Ma at exit is found as
Ma=0.7;
//and p2/pcritical is found as
pratio=1.5;
```

```
//and, from example 11.12,
prat=1.7;//where prat=p1/pcritical
pfraction=0.76;//where pfraction=p1/p0,1
//Hence,
p2=pratio*(1/prat)*pfraction*p0;//kPa(abs)
disp(Ma,"The Mach number at the exit=")
disp("kPa(abs)",p2,"The back pressure required=")
```

Scilab code Exa 11.15 rayleigh flow

```
clc;
clear;
k=1.4;
T0=518.67;//degree R
T1=514.55;//degree R
p1=14.3;//psia

R=53.3;//(ft*lb)/(lbm*degree R)
cp=R*k/(k-1);//(ft*lb/(lbm* degree R))
Tratio=T1/T0;
Ma=(((1/Tratio)-1)/((k-1)/2))^0.5;
x=(R*T1*k*32.2)^0.5;//ft/sec; where x=(R*T1*k)^0.5
y=p1*144/(R*T1)*(Ma*x);//lbm/((ft^2)*sec); where y=d
    *V
z=R*T1/(p1*144);//(ft^3)/lbm
c=(p1)+(y*y*z/(32.2*144));//psia; =constant
//when downstream pressure p=13.5 psia
p=13.5;//psia
a=(y^2)*R/(p*144*32.2*144);//(lb/(in^2))/degree R
fn=poly([(p-c) a],"T","c");
T=roots(fn);//degree R
sdif=(cp*log(T/T1))-(R*log(p/p1));//ft*lb/(lbm*
    degree R)
disp("degree R",T,"The corrosponding value of
    temperature for the downstream pressure of 13.5
```

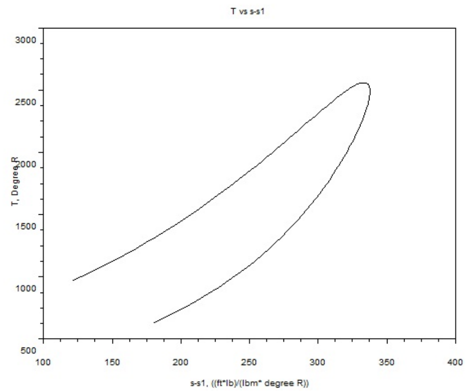

Figure 11.3: rayleigh flow

```
    psia=")
disp("ft*lb/(lbm*degree R)",sdif,"The corrosponding
    value of change in entropy for the downstream
    pressure of 13.5 psia=")
count=1;
for i=1:0.1:13.5
    temp(count)=roots(poly([(i-c) ((y^2)*R/(i
        *144*32.2*144))],"T","c"));
    s(count)=(cp*log(temp(count)/T1))-(R*log(i/p1));
    count=count+1;
end
plot2d(s,temp,rect=[100,500,400,3000])
xtitle("T vs s-s1","s-s1, ((ft*lb)/(lbm* degree R))"
    ,"T, Degree R")
```

Scilab code Exa 11.18 supersonic flow

```
clc;
clear;
```

```
p=60;//psia
T=1000;//degree R
px=12;//psia
k=1.4;
R=53.3;//ft*lb/(lbm*degree R)
pratio=p/px;
//for this value of pratio, Max is calculated as
Max=1.9;
//using this value of Max,  Tx/T0,x is found as
Tratio=0.59;
//T=T0,x=T0,y
Tx=Tratio*T;//degree R
cx=(R*Tx*k)^0.5;//ft/sec
Vx=1.87*cx*(32.2^0.5);//ft/sec
disp(Max,"The Mach number for the flow=")
disp("ft/sec",Vx,"The velocity of the flow=")
```

Scilab code Exa 11.19 converging diverging duct

```
clc;
clear;
x1=0.5;//m
x2=0.3;//m
Acritical=0.1;//m^2
//at x1, Max1 is found as
Max1=2.8;
//and px/p0,x is found as
pratio1=0.04;
//For this value of Max, py/px is found as
prat1=9;
pfraction1=prat1*pratio1;//where pfraction=py/p0,x =
    pIII/p0,x
//at x2, Max2 is found as
Max2=2.14;
//for this value of Max2, the following are found
```

```
prat2=5.2;
prat22=0.66;//where prat22=p0,y/p0,x
May=0.56;
//for this valur of May, Ay/Acritical is found as
Aratio=1.24;
Arat=(Acritical+(x1^2))/(Acritical+(x2^2));//where
    Aratio=A2/Ay
Afraction=Aratio*Arat;//where Afraction=A2/Acritical
A2=Acritical+(x1^2);//m^2
Acritical1=A2/Afraction;//where Acritical1 critical
    area for the isentropic flow downstream of the
    shock
//with the value of Afraction , the following are
    found
Ma2=0.26;
pfraction=0.95;//where pfraction=p2/p0,y
//hence,
pfrac=pfraction*prat22;//where pfrac=p2/p0,x
disp(pfraction1,"The ratio of back pressure to inlet
     stagnation pressure that will result in a normal
     shock at the exit of the duct=")
disp(pfrac,"The value of back pressure to inlet
    stagnation pressure required to position the
    shock at (x=0.3 m)=")
```

Chapter 12

Pumps and Turbines

Scilab code Exa 12.2 shaft power calculation

```
Q=1400;//gpm
N=1750;//rpm
b=2;//in
r1=1.9;//in
r2=7.0;//in
beta2=23;//degrees
alpha1=90;//degrees
```

Scilab code Exa 12.3 NPSH calculation

```
Q=0.5;//(ft^3)/sec
NPSHr=15;//ft
T=80;//degree F
patm=14.7;//psi
KL=20;
```

```
D=4;//in
```

Scilab code Exa 12.5 pump scaling laws

```
D1=8;//in
N1=1200;//rpm
D2=12;//in
N2=1000;//rpm
T=60;//degree F
```

Scilab code Exa 12.6 pelton wheel turbine

```
z0=200;//ft
l=1000;//ft
f=0.02;
D=8;//in.
B=150;//degree
R=1.5;//ft
z1=0;//ft
```

Scilab code Exa 12.8 dental drill characteristics

```
ri=0.133;//in.
ro=0.168;//in.
N=300000;//rpm
```