

Scilab Textbook Companion for
Fundamentals of Fluid Mechanics
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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

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

Scilab code Exa 3 density and weight of air

```
1 V=0.84; //ft^3
2 p=50; //psi
3 T=70; //degree fahrenheit
4 atmp=14.7; //psi
```

Scilab code Exa 4 reynolds number calculation

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

Scilab code Exa 5 shearing stress calculation

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

Scilab code Exa 6 final pressure calculation

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

Scilab code Exa 7 ratio of speeds

```
1 s=550; //(mph)
2 h=35000; //ft
3 T=-66; //degrees fahrenheit
4 k=1.40;
```

Scilab code Exa 8 diameter of tube

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

Scilab code Exa 1.2 force by tank

```
1 clc;
2 clear;
3 m=36; //kg
4 acc=7; //ft/sq sec
5 W=m*9.81;
6 disp("W=")
7 disp(W)
8 //F=W+m*acc
9 //1 ft= 0.3048 m
10 F=W+(m*acc*0.3048);
11 disp("N" ,F,"F=")
```

Scilab code Exa 1.3 density and weight of air

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

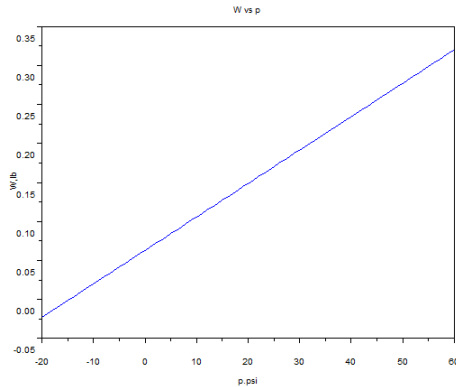


Figure 1.1: density and weight of air

```

7 //the air density d=P/(RT)
8 //1ft^2=144 inches^2
9 d=((p+atmp)*144)/((1716)*(T+460));
10 disp(d)
11 //slugs/ft^3
12 //weight of air
13 W=d*32.2*V;
14 //1lb=1 slug.ft/sq sec
15 disp(" lb ",W,"W=")
16 //taking various values of p a graph is plotted
    between W and p
17 x= -20:60;
18 for p= -20: 60
19     i=p+21;
20     y(1,i)=((p+atmp)*144/((1716)*(T+460)))*32.2*V;
21
22 end
23 plot(x,y)
24 xtitle('W vs p', 'p. psi ', 'W, lb ')

```

Scilab code Exa 1.4 reynolds number calculation

```
1  clc ;
2  clear ;
3  vis=0.38; //Ns/m^2
4  sg=0.91; //specific gravity of Newtonian fluid
5  dia=25; //mm
6  vel=2.6; //m/s
7
8  //calculating in SI units
9  //fluid density d=sg*(density of water @ 277K)
10 d=sg*1000; //kg/m^3
11 //Reynolds number Re=d*vel*dia/vis
12 Re=(d*vel*dia)/(vis*1000); //(kgm/sec^2)/N
13 disp(156,"Re in SI units=")
14 //calculating in BG units
15 d1=d*1.94/1000 //slugs/ft^3
16 vel1=vel*3.281 //ft/s
17 dia1=(dia/1000)*3.281 //ft
18 vis1=vis*(2.089/100) //lb*s/ft^2
19 Re1=(d1*vel1*dia1)/vis1; //(slugs.ft/sec^2)/lb
20 disp(Re1,"Re in Bg units=")
```

Scilab code Exa 1.5 shearing stress calculation

```
1  clc ;
2  clear ;
3  vis=0.04; //lb*sec/ft^2
4  vel=2; //ft/sec
5  h=0.2; //inches
6
7  //given  $u=(3*vel/2)(1-(y/h)^2)$ 
8  //shearing stress  $t=vis*(du/dy)$ 
9  // $(du/dy)=-3*vel*y/h$ 
10 //along the bottom of the wall  $y=-h$ 
```

```

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

```

Scilab code Exa 1.6 final pressure calculation

```

1  clc;
2  clear;
3  p1=14.7; //psi(abs)
4  V1=1; //ft^3
5  V2=0.5; //ft^3
6  //for isentropic compression, (p1(d1^k))=(p2/(d2^k))
7  //volume*density=constant(mass)
8  ratd=V1/V2;
9  p2=((ratd)^1.66)*p1; //psi(abs)
10 disp("psi(abs)",p2,"final pressure p2=")
11
12 i=1;
13 ratV=0.01:0.01:1.0;
14
15 for j=0.01:0.01:1.0
16     pres(i)=p1/((j)^1.66);
17     i=i+1;
18
19 end
20
21 plot2d(ratV,pres,rect=[0,0,1,1000])
22 xtitle('p2 vs V2/V1','V2/V1','p2 psi')

```

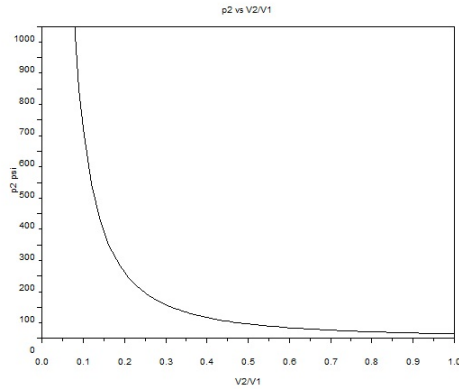


Figure 1.2: final pressure calculation

Scilab code Exa 1.7 ratio of speeds

```

1  clc;
2  clear;
3  s=550; //(mph)
4  h=35000; //ft
5  T=-66; //degrees fahrenheit
6  k=1.40;
7  //speed of sound c=(kRT) ^0.5
8  c=((k*1716*(T+460))) ^0.5; //ft/s
9  disp("ft/s",c,"speed of sound c=")
10 //speed of sound V=(s m/hour)*(5280 ft/m)/(3600 s/
    hour)
11 V=s*5280/3600; //ft/s
12 disp("ft/s",V,"air speed =")
13 ratio=V/c; //Mach number
14 disp(ratio,"ratio of V/c = Mach Number=")

```

Scilab code Exa 1.8 diameter of tube

```
1  clc;
2  clear;
3  T=20; //degree celcius
4  h=1; //mm
5  //h=(2*st*cos(x)/(sw*R))
6  //where st= nsurface tension , x= angle of contact ,
   sw= specific weight of liquid , R= tube radius
7  st= 0.0728; //N/m
8  sw=9.789; //kN/m^3
9  x=0;
10 R=(2*st*cos(x))/(sw*1000*h/1000); //m
11 D=2*R*1000; //mm
12 disp("mm",D,"minimum required tube diameter= ")
13 h=0.1:0.1:2;
14 for i=0.1:0.1:2
15     R=(2*st*cos(x))/(sw*1000*i/1000);
16     dia(i*10)=2*R*1000;
17 end
18
19 plot2d(h,dia,rect=[0,0,2,100])
20 xtitle("D vs h", "h, mm", "D, mm")
```

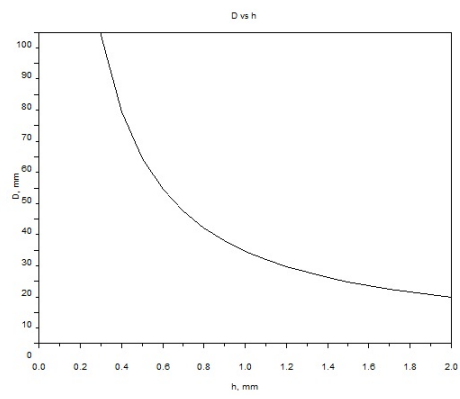


Figure 1.3: diameter of tube

Chapter 2

Fluids at rest pressure and its effects

Scilab code Exa 2.1 pressure at interface

```
1  clc;
2  clear;
3  sg=0.68; //specific gravity of gasoline
4  htg=17; //ft (height of gasoline)
5  htw=3; //ft (height of water)
6  //pressure p= (gamma*h)+atmp;
7  //pressure at water-gasoline interface p1 =sg*g*htg
   +atmp
8  p1=sg*62.4*htg; //atmp=0 , p1 is in lb/ft^2
9  pr1=p1/144; //lb/in^2
10 //pressure head as feet of water H
11 H= p1/62.4; //ft
12 //similarly pressure p2 at tank bottom
13 p2=62.4*htw+p1; //lb/ft^2
14 pr2 = p2/144; //lb/in^2
15 //pressure head as ft of water H1
16 H1=p2/62.4; //ft
17 disp(" lb/in^2",pr1," lb/ft^2 =", p1," pressure at
   interface=")
```

```

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

```

Scilab code Exa 2.2 pressure depth variation

```

1  clc;
2  clear;
3  h=1250; // ft
4  T=59; //degree fareheit
5  p=14.7; //psi (abs)
6  sw=0.0765; //lb/ft^3, (specific weight of air at p)
7
8  //considering air to be compressible
9  //p1/p2= exp(-(g*(z1-z2))/(R*T))
10 ratp=exp(-(32.2*h)/(1716*(59+460)));
11 disp(ratp,"ratio of pressure at the top to that at
    the base considering air to be compressible=")
12
13 //considering air to be incompressible
14 //p2=p1-(sw*(z2-z1));
15 ratp1=1-((sw*h)/(p*144));
16 disp(ratp1,"ratio of pressure at the top to that at
    the base considering air to be incompressible=")
17 count=1;
18 zdiff=0:5000;
19
20 for i= 0:5000
21     j(count)=1-((sw*i)/(p*144));
22     count=count+1;
23 end
24 num=1;

```

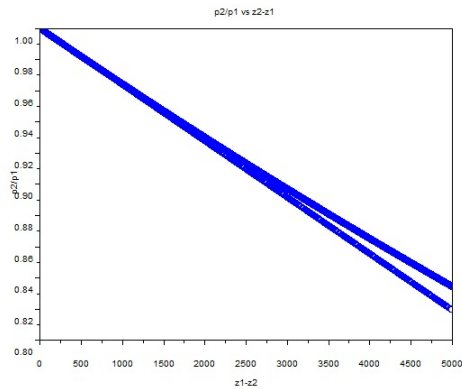


Figure 2.1: pressure depth variation

```

25
26 for k=0:5000
27     l(num)=exp(-(32.2*k)/(1716*(59+460)));
28     num=num+1;
29
30 end
31 plot(zdiff,j,"o")
32 plot(zdiff,l,"+")
33 xtitle("p2/p1 vs z2-z1","z1-z2","p2/p1")

```

Scilab code Exa 2.3 pressure at bottom

```

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

```

```

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

```

Scilab code Exa 2.4 reading of gage

```

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

```

Scilab code Exa 2.5 pressure drop calculation

```

1 clc;
2 clear;
3 gamma1=9.8;//kN/m^3
4 gamma2=15.6;//kN/m^3
5 h1=1;//m

```

```

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

```

Scilab code Exa 2.6 force on plane

```

1 clc;
2 clear;
3 dia=4; //m
4 sw=9.8; //kN/m^3; specific weight of water
5 hc=10; //m
6 ang=60; //degrees
7 A=%pi*(dia^2)/4;
8 fres=sw*hc*A;
9 //for the coordinate system shown xc=xres=0
10 Ixc=%pi*((dia/2)^4)/4;
11 yc=hc/(sin(ang*%pi/180));
12 yres= (Ixc/(yc*A))+yc;
13 ydist=yres-yc;
14 disp("kN",fres,"The resultant force acting on the
    gate of the reservoir =");
15 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 ")
16 M=fres*(ydist)*1000;
17 disp("N*m",M,"Moment required to open the gate=")
18 hc=1:30;
19 for i=1:30
20     ydist(i)=((Ixc/(i/(sin(ang*%pi/180))*A)));
21 end
22

```

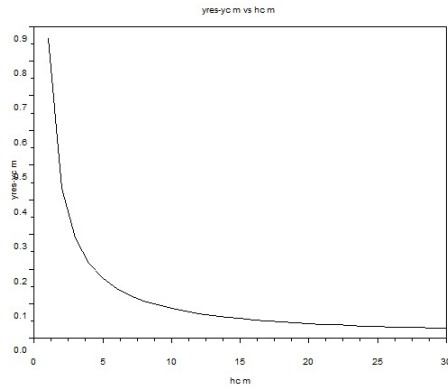



Figure 2.2: force on plane

```

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

```

Scilab code Exa 2.7 hydrostatic pressure force

```

1  clc;
2  clear;
3  sw=64; //lb/ft^3; specific weight of water
4  h=10; //ft
5  a=3; //ft
6  b=3; //ft
7
8  //shape is triangular, hence hc=h-(a/3)
9  hc=h-(a/3);
10 A=(0.5*a*b); //ft^3; area of the right angled
    triangle
11 fres=sw*hc*A; //lb
12 Ixc=b*(a^3)/36;
13 Ixyc=b*(a^2)*(b)/72;

```

```

14 //according to the coordinate system taken yc=hc and
    xc=0
15 yres=(Ixc/(hc*A))+hc;
16 xres=(Ixyc/(hc*A));
17 ydist=yres-hc;
18 disp("lb",fres,"The resultant force on the area
    shown is=")
19 disp("ft",yres,"yR=")
20 disp("ft",xres,"xR=")
21 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

```

1 clc;
2 clear;
3 sg=0.9; // specific gravity of oil
4 a=0.6; //m
5 pgage=50; //kPa
6 h1=2; //m
7 h2=2.6; //m
8
9 //the force on the trapezoid is the sum of the force
    on the rectangle f1 and force on triangle f2
10 f1=((pgage*1000)+(sg*1000*9.81*h1))*(a^2); //N
11 f2=sg*1000*9.81*(h2-h1)*(a^2)/2; //N
12 fres=f1+f2; //N
13 //to find vertical location of fres; fres*yres=(f1*(
    a/2))+f2*(h1-h2))
14 yres=((f1*(a/2))+f2*(a/3))/fres; //m
15 disp("kN", (fres/1000), "The resultant force on the
    plate is=")
16 disp("m above the bottom plate along the vertical
    line of symmetry.",yres,"The force acts at a

```

distance of ")

Scilab code Exa 2.9 force on curve

```
1  clc;
2  clear;
3  dia=6; // ft
4  l=1; // ft
5
6  //horizontal force f1=sw*hc*A
7  hc=dia/4; // ft
8  sw=62.4; //lb/ft^3
9  A=dia/2*l; //ft^2
10 f1=sw*hc*A; //lb
11 //this force f1 acts at a height of radius/3 ft
    above the bottom
12 ht=(dia/2)/3; //ft
13 //weight w = sw*volume
14 w=sw*((dia/2)^2)*%pi/4*l; //lb
15 //this force acts through centre of gravity which is
    4*radius/(3*%pi) right of the centre of conduit
16 dist=(4*dia/2)/(3*%pi); //ft
17 //horizontal force that tank exerts on fluid = f1
18 //vertical force that tank exerts on fluid = w
19 //resultant force fres =((f1)^2+(w)^2)^0.5
20 fres =((f1)^2+(w)^2)^0.5; //lb
21 disp("lb",fres,"The resultant force exerted by the
    tank on the fluid=");
22 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

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

Scilab code Exa 2.11 maximum acceleration calculation

```
1  clc;
2  clear;
3  sg=0.65;
4  l1=0.75; // ft
5  l2=0.5; // ft
6  // 0.5 ft =z1(max)
7  // 0.5=0.75*(ay(max)/g)
8  aymax=(0.5*32.2)/0.75; // ft/s^2
9  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

```
1  clc;
2  clear;
3  v1=100; //mi/hr
4  ht=10000; //ft
5  //from standard table for static pressure at an
   altitude
6  p1=1456 //lb/ft^2(abs)
7  P1=1456*0.006947; //psi
8  d=0.001756; //slugs/ft^3
9  //1 mi/hr = 1.467 ft/s
10 p2=p1+(d*(v1*1.467)^2/2); //lb/ft^3
11 //in terms of gage pressure p2g
12 p2g=p2-p1; //lb/ft^2
13 //1lb/ft^2 = 0.006947 psi
14 P2=p2*0.006947; //psi
15 P2g=p2g*0.006947; //psi
16 //pressure difference indicated by the pitot tube =
   pdiff
17 pdiff=P2-P1; //psi
```

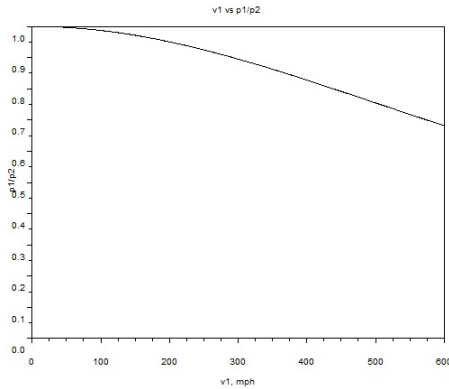


Figure 3.1: pitot static tube

```

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

```

Scilab code Exa 3.7 determination of flowrate

```

1 clc;
2 clear;
3 dia=0.1; //m
4 dia1=1.0; //m
5 h=2.0; //m

```

```

6 //bernoulli 's equation: p1+(0.5*d*V1^2)+(sw*z1)= p2
  +(0.5*d*V2^2)+(sw*z2)
7 //assuming p1=p2=0, and z1=h and z2=0
8 //(0.5*d*V1^2)+(g*h)= (0.5*d*V2^2)
9 //assuming steady flow Q1=Q2, Q=A*V. hence, A1*V1=A2
  *V2
10 //V1=((dia/dia1)^2)*V2
11 //hence V2=((2*g*h)/(1-(dia/dia1)^4))^0.5
12 V2=((2*9.81*h)/(1-(dia/dia1)^4))^0.5;
13 Q=(%pi/4*(dia)^2)*V2;
14 disp("m^3/sec",Q,"The flow rate needed is=")
15 //let Q0 be the flow rate when v1=0, i.e. dia>>dia
16 //Q0=(2*g*h)^0.5 and Qrat=Q/Q0
17 count=1;
18 i=0:0.05:0.8;
19
20 for k=0.00:0.05:0.80
21     Qrat(count)=1/((1-(k^4))^0.5);
22     count=count+1;
23 end
24
25 plot2d(i,Qrat,rect=[0,1,0.8,1.1])
26 xtitle("d/D vs Q/Q0","d/D","Q/Q0")

```

Scilab code Exa 3.8 flowrate and pressure

```

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

```

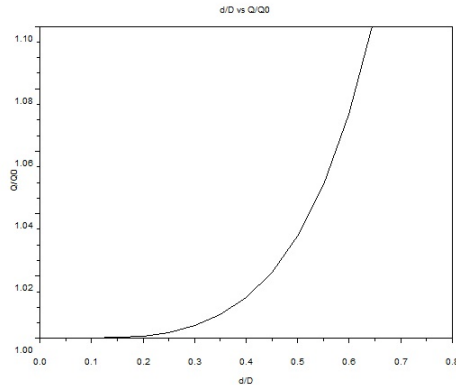


Figure 3.2: determination of flowrate

```

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

```

Scilab code Exa 3.10 maximum height determination

```

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

```



```

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

```

Scilab code Exa 3.11 pressure difference range

```

1 clc;
2 clear;
3 sg=0.85;
4 Q1=0.005; //m^3/s
5 Q2=0.05; //m^3/s
6 dia1=0.1; //m
7 dia2=0.06; //m
8
9 //A2/A1=dia2/dia1
10 d=sg*1000;
11 Arat=(dia2/dia1)^2;
12 A2=%pi/4*(dia2^2);
13 pdiffs=(Q1^2)*d*(1-(Arat^2))/(2*1000*(A2^2));
14 pdiff1=(Q2^2)*d*(1-(Arat^2))/(2*1000*(A2^2));
15 disp("kPa",pdiff1,"to", "kPa",pdiffs,"kPa", "The
    pressure difference ranges from =")

```

Scilab code Exa 3.12 flow through channel

```

1  clc;
2  clear;
3  z1=5; //m
4  a=0.8; //m
5  b=6; //m
6  Cc=0.61; //since a/z1=ratio=0.16<0.2; Cc=
    contraction coefficient
7  z2=Cc*a;
8  //Q/b=flowrate
9  flowrate=z2*((2*9.81*(z1-z2))/(1-((z2/z1)^2)))^0.5;
10 //considering z1>>z2 and neglecting kinetic energy
    of the upstream fluid
11 flowrate1=z2*(2*9.81*z1)^0.5;
12 disp("m^2/s",flowrate,"The flowrate per unit width="
    )
13 disp("m^2/s",flowrate1,"The flowrate per unit width
    when we consider z1>>z2=")
14 count=1;
15 j=5:15;
16 for i=5:15
17     fr(count)=z2*((2*9.81*(i-z2))/(1-((z2/i)^2)))
        ^0.5;
18     count=count+1;
19 end
20 plot2d(j,fr,rect=[0,0,15,9])
21 xtitle("Q/b vs z1", "z1,m", "Q/b, m^2/s")

```

Scilab code Exa 3.13 increased flowrate determination

```

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

```

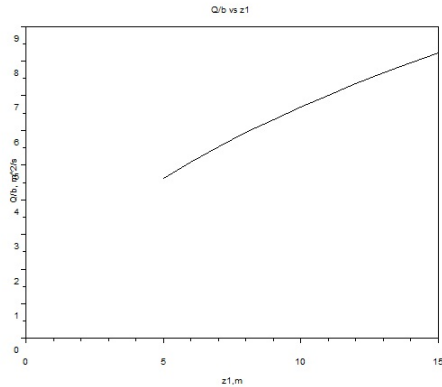


Figure 3.3: flow through channel

```

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

```

Scilab code Exa 3.15 stagnation pressure calculation

```

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

```

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

Scilab code Exa 3.17 stagnation pressure determination

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

Chapter 4

Kinematics of fluid motion

Scilab code Exa 4.6 delivery speed calculation

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

Chapter 5

Flow analysis using control volumes

Scilab code Exa 5.1 Minimum Pumping capacity

```
1 clc;
2 clear;
3 v2=20; //m/s
4 dia2= 40; //mm
5
6 //m1=m2
7 //d1*Q1=D2*Q2; where d1=d2 is density of seawater
8 //hence Q1=Q2
9 Q=v2*(%pi*((dia2/1000)^2)/4); //m^3/sec
10 disp("m^3/sec",Q,"Flowrate=")
```

Scilab code Exa 5.2 average velocity calculation

```
1 clc;
2 clear;
3 v2=1000; //ft/sec
```

```

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

```

Scilab code Exa 5.3 Mass Flowrate determination

```

1 clc;
2 clear;
3 m1=22; // slugs/hr
4 m3=0.5; // slugs/hr
5 // -m1+m2+m3=0
6 m2=m1-m3;
7 disp("slugs/hr",m2,"Mass flowrate of the dry air and
    water vapour leaving the dehumidifier=")

```

Scilab code Exa 5.5 change in depth

```

1 clc;
2 clear;
3 Q=9; // gal/min
4 l=5; // ft
5 b=2; // ft
6 H=1.5; // ft

```

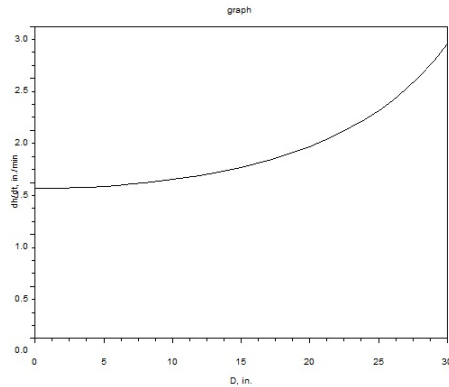


Figure 5.1: change in depth

```

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

```

Scilab code Exa 5.6 mass flowrate estimation

```
1  clc ;
2  clear ;
3  v=971; //km/hr
4  v2=1050; //km/hr
5  A1=0.80; //m^2
6  d1=0.736; //Kg/m^3
7  A2=0.558; //m^2
8  d2=0.515; //Kg/m^3
9
10 //w1=v=intake velocity
11 //mass flow rate of fuel intake = d2*A2*w2 - d1*A1*
    w1
12 w2=v2+v;
13 m=(d2*A2*w2 - d1*A1*v)*1000;
14 disp("kg/hr",m,"The mass flow rate of fuel intake =
    ")
```

Scilab code Exa 5.7 Speed of water

```
1  clc ;
2  clear ;
3  Q=1000; //ml/s
4  A2=30; //mm^2
5  rotv=600; //rpm
6
7  //mass in = mass out
8  w2=(Q*0.001*1000000)/(2*A2*1000);
9  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

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

Scilab code Exa 5.9 change in depth

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

Scilab code Exa 5.11 Anchoring force determination

```
1  clc;
```

```

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

```

Scilab code Exa 5.12 Anchoring force calculation

```

1 clc;
2 clear;
3 A=0.1; //ft^2
4 v=50; //ft/s
5 p1=30; //psia
6 p2=24; //psia
7
8 d=1.94; //slugs/ft^3
9 //v1=v2=v and A1=A2=A
10 m=d*v*A;
11 Fay=-m*(v+v)-((p1-14.7)*A*144)-((p2-14.7)*A*144);
12 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

```
1  clc ;
2  clear ;
3  p1=100; // psia
4  p2=18.4; // psia
5  T1=540; // degree R
6  T2=453; // degree R
7  V2=1000; // ft/s
8  V1=219; // ft/s
9  dia=4; // in
10
11 //m=m1=m2
12 A2=%pi*((4/12)^2)/4; //ft^2
13 //equation of state d*R*T=p
14 d2=p2*144/(1716*T2);
15 m=A2*d2*V2; //slugs/s
16 Rx=A2*144*(p1-p2)-(m*(V2-V1)); //lb
17 disp("lb",Rx,"Frictional force exerted by pipe wall
      on air flow=")
```

Scilab code Exa 5.15 nominal thrust calculation

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

```

9
10 //F=-p1*A1 + p2*A2 + m*(v2-v1)
11 //m=d1*A1*v1
12 //d1=(p1)/(R*T1)
13 d1=(p1*1000)/(286.9*T1);
14 m=d1*v1*A1;
15 F=-((p1-p2)*A1*1000) + m*(v2-v1);
16 disp("N",F,"The thrust for which the stand is to be
    designed=")

```

Scilab code Exa 5.17 force determination

```

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

```

```
22 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

```
1  clc;  
2  clear;  
3  Q=1000; //ml/sec  
4  A=30; //mm^2  
5  r=200; //mm  
6  n=500; //rev/min  
7  //v2 is tangential; v2=vang2  
8  m=(Q/1000000)*999; //kg/sec  
9  //m=2*d*(A)*v2=d*Q  
10 v2=(Q)/(2*A); //m/sec  
11 //Torque reuired to hold sprinkler stationary  
12 Tshaft=(-(r/1000)*(v2)*m); //Nm  
13 //u2=speed of nozzle=r*omega  
14 //v21=v2-u2  
15 omega=n*(2*%pi)/60; //rad/sec  
16 v21=v2-(r*omega/1000);  
17 //resisting torque when sprinkler is rotating at a  
    constant speed of n rev/min  
18 Tshaft1=(-(r/1000)*(v21)*m); //Nm  
19 //when no resistintg torque is applied  
20 //Tshaft=0  
21 omega1=v2/(r/1000);  
22 n1=(omega1)*60/(2*%pi); //rpm  
23 disp("Nm",Tshaft,"Resisting torque required to hold  
    the sprinkler stationary=")  
24 disp("Nm",Tshaft1,"Resisting torque when sprinkler is  
    rotating at a constant speed of 500 rev/min=")  
25 disp("rpm",n1,"Speed of sprikler when no resisting  
    torque is applied=")  
26 x=0:800;
```

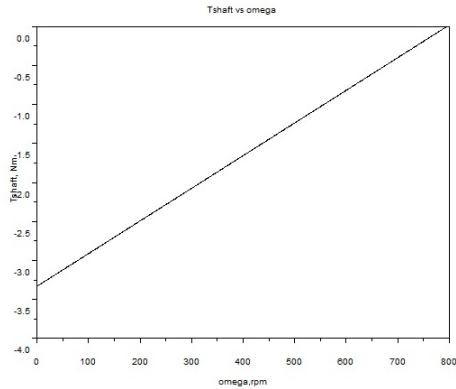


Figure 5.2: resisting torque calculation

```

27
28 for i=0:800
29     y(i+1)=(-(r/1000)*(v2-((r/1000)*i*(2*%pi)/60))*m
        );
30 end
31 plot2d(x,y,rect=[0,-4,800,0])
32 xtitle("Tshaft vs omega","omega,rpm","Tshaft , Nm")

```

Scilab code Exa 5.19 estimation of power

```

1 clc;
2 clear;
3 h=1; //in
4 Q=230; //ft^3/min
5 ang=30; //degrees
6 dia1=10; //in
7 dia2=12; //in
8 n=1725; //rpm
9 //m=d*Q

```

```

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

```

Scilab code Exa 5.20 Determination of power

```

1  clc;
2  clear;
3  Q=300; // gal/min
4  d1=3.5; // in.
5  p1=18; // psi
6  d2=1; // in.
7  p2=60; // psi
8  diffu=3000; // ft*lb/slug
9
10 //energy equation
11 //m(u2-u1+(p1/d)-(p2/d)+((v2^2)-(v1^2))/2 + g*(z2-z1
    ))=q-Wshaft
12 m=Q*1.94/(7.48*60); // slugs/sec
13 v1=Q*12*12/(%pi*(d1^2)*60*7.48/4);
14 v2=Q*12*12/(%pi*(d2^2)*7.48*60/4);
15 Wshaft=m*(diffu + (p2*144/1.94) - (p1*144/1.94) +
    (((v2^2)-(v1^2))/2))/550; //hp
16 disp("hp",Wshaft,"The power required by the pump=")
17 disp("hp",m*(diffu/550),"The internal energy change
    accounts for =")

```



```

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

```

Scilab code Exa 5.21 work output calculation

```

1 clc;
2 clear;
3 v1=30; //m/s
4 h1=3348; //kJ/kg
5 v2=60; //m/s
6 h2=2550; //kJ/kg
7
8 //energy equation
9 //wshaftin=Wshaftin/m= (h2-h1 + ((v2^2)-(v1^2))/2)
10 //wshaftout=-wshaftin
11 wshaftout=h1-h2 + (((v1^2)-(v2^2))/2000);
12 disp("KJ/kg",wshaftout,"The work output involved per
    unit mass of steam through-flow=")

```

Scilab code Exa 5.22 temperature change determination

```

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

```

Scilab code Exa 5.23 volume flowrates comparison

```
1  clc;
2  clear;
3  dia=120; //mm
4  p=1.0; //kPa
5
6  //using energy equation
7  //Q=A2*v2=A2*((p1-p2)/(d*(1+Kl)/2)); d =density , Kl=
    loss coefficient
8  Kl1=0.05;;
9  Kl2=0.5;
10 //for rounded entrance cyliindrical vent
11 Q1=(%pi*((dia/1000)^2)/4)*(p*1000*2/(1.23*(1+Kl1)))
    ^0.5;
12 //for cylindrical vent
13 Q2=(%pi*((dia/1000)^2)/4)*(p*1000*2/(1.23*(1+Kl2)))
    ^0.5;
14
15 disp("m^3/sec",Q1,"The volume fowrate associated
    with the rounded entrance cylindrical vent
    configuration =")
16 disp("m^3/sec",Q2,"The volume fowrate associated
    with the cylindrical vent configuration =")
17 KLoss=0:0.01:0.5;
18 count=1;
19 for i=0:0.01:0.5
20     flow(count)=(%pi*((dia/1000)^2)/4)*(p
        *1000*2/(1.23*(1+i)))^0.5;
21     count=count+1;
22 end
23 plot2d(KLoss,flow,rect=[0,0,0.5,0.5])
24 xtitle("Q vs KL","KL","Q, (m^3)/sec")
```

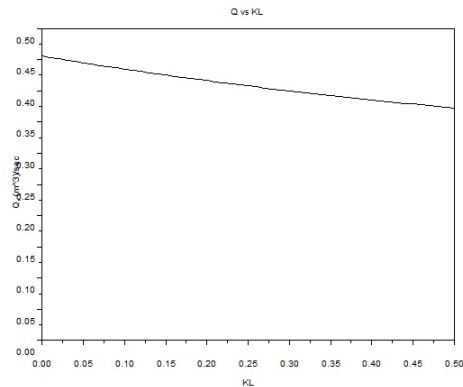


Figure 5.3: volume flowrates comparison

Scilab code Exa 5.24 useful work determination

```

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

```

Scilab code Exa 5.25 flowrate and powerloss

```
1  clc;
2  clear;
3  p=10; //hp
4  z=30; //ft
5  h1=15; //ft
6  //energy equation
7  //hs=Wshaftin/(sw*Q) = h1+z
8  Q=(p*550)/((h1+z)*62.4);
9  wloss=62.4*Q*h1/550;
10 disp("ft ^3/s",Q,"Flowrate =")
11 disp("hp",wloss,"Power loss=")
12 loss=0:25;
13 for i=0:25
14     q(i+1)=(p*550)/((i+z)*62.4);
15 end
16 plot2d(loss,q,rect=[0,0,25,3.5])
17 xtitle("Flowrate vs headloss","hs,ft","Q, ft ^3/sec")
```

Scilab code Exa 5.26 nonuniform velocity profile

```
1  clc;
2  clear;
3  m=0.1; //kg/min
4  dia1=60; //mm
5  alpha1=2.0;
6  dia2=30; //mm
7  alpha2=1.08;
8  p=0.1; //kPa
```

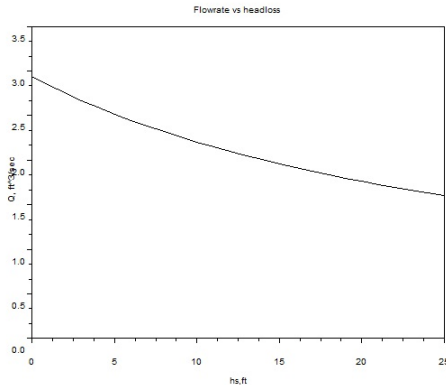


Figure 5.4: flowrate and powerloss

```

9  power=0.14; //W
10
11  wshaftin=power*60/m; //Nm/kg
12  vavg1=m*1000*1000/(60*1.23*%pi*dia1*dia1/4);
13  vavg2=m*1000*1000/(60*1.23*%pi*dia2*dia2/4);
14  loss1=wshaftin-(p*1000/1.23)+((vavg1^2)/2)-((vavg2
      ^2)/2); //Nm/kg
15  loss2=wshaftin-(p*1000/1.23)+(alpha1*(vavg1^2)/2)-(
      alpha2*(vavg2^2)/2); //Nm/kg
16  disp("Nm/kg",loss1," Loss for uniform velocity
      profile=")
17  disp("Nm/kg",loss2," Loss for actual velocity profile
      =")

```

Scilab code Exa 5.29 expanded air velocity

```

1  clc;
2  clear;
3  p1=100; //psia
4  T1=520; //degree R
5  p2=14.7; //psia

```

```

6
7 //for incompressible flow
8
9 d=p1*144/(1716*T1); //where d=density , calculated by
    assuminng air to behave like an ideal gas
10 //Bernoulli equation
11 v2=(2*(p1-p2)*144/d)^0.5; //ft/sec
12 disp("ft/sec",v2,"The velocity of expanded air
    considering incompressible flow =")
13
14 //for compressible flow
15
16 k=1.4; //for air
17 d1=d;
18 d2=d1*((p2/p1)^(1/k)); //where d2=density of expanded
    air
19 //bernoulli equation
20 V2=((2*k/(k-1))*((p1*144/d1)-(p2*144/d2)))^0.5; //ft/
    s
21 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

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

Scilab code Exa 6.5 Volume rate calculation

```
1  clc;
```

```

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

```

Scilab code Exa 6.7 pressure at elevation

```

1 clc;
2 clear;
3 h=200; // ft
4 U=40; //mi/hr
5 d=0.00238; // slugs/ft^3
6 //V^2= (U^2)*(1 + (2*b*cos(ang)/r) + ((b^2)/(r^2)))
7 //at point 2, ang=%pi/2
8 //r=b*(%pi-ang)/sin(ang)=(%pi*b/2)
9 V=U*(1+(4/(%pi^2)))^0.5; //mi/hr
10 y2=h/2; //ft
11 //bernoulli equation
12 //p1-p2= d*((V2^2)-(V1^2)) + (sw*(y2-y1))
13 V1=U*(5280/3600);
14 V2=V*(5280/3600);
15 pdiff=((d*((V2^2)-(V1^2)))/2) + (d*32.2*(y2))/144; //
psi
16 disp("mi/hr",V,"The magnitude of velocity at (2) for
a 40 mi/hr approaching wind =")
17 disp("psi",pdiff,"The pressure difference between
points (1) and (2)=")
18 u=0:100;
19

```

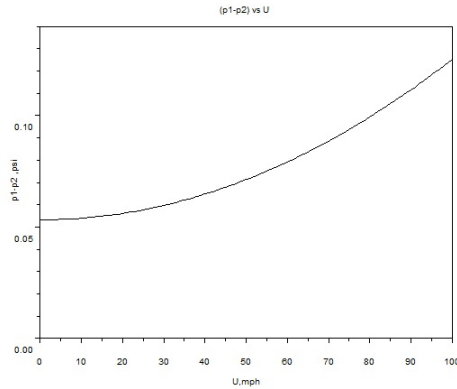



Figure 6.1: pressure at elevation

```

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

```

Scilab code Exa 6.10 flow in annulus

```

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

```

```

    m/sec
10 Re=(d*V*dia1/1000)/vis;
11 disp(" is well below critical value of 2100 so flow
    is laminar.",Re,"a) The Reynolds number ")
12 pdiff=(8*vis*(1)*(12/1000000)/(%pi*(dia1/2000)^4))
    /1000; //kPa
13 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=")
14 //for flow in the annulus
15 V1=Q/(1000000*%pi*(((dia1/1000)^2)-((dia2/1000)^2))
    /4); //mean velocity , m/sec
16 Re1=d*((dia1-dia2)/1000)*V1/vis;
17 disp(" is well below critical value of 2100 so flow
    is laminar.",Re1,"b) The Reynolds number ")
18 r1=dia1/2000;
19 r2=dia2/2000;
20 pdiff1=((8*vis*(1)*(12/1000000)/(%pi))*((r1^4)-(r2
    ^4)-((((r1^2)-(r2^2))^2)/(log(r1/r2))))^(-1))
    /1000; //kPa
21 disp("kPa",pdiff1,"The pressure drop along a 1 m
    length of the symmetric annulus =")
22
23 rratio=0.001:0.001:0.5;
24 count=1;
25 for i=0.001:0.001:0.5
26     pratio(count)=1/(((i^4)*((1/(i^4))-1-(((1/(i^2))
        -1)^2)/log(1/i)))));
27     count=count+1;
28 end
29 plot2d(rratio,pratio,rect=[0,0,0.5,8])
30 xtitle("ri/ro vs pdiff(annulus)/pdiff(tube)", "ri/ro"
    ," pdiff(annulus)/pdiff(tube)")

```

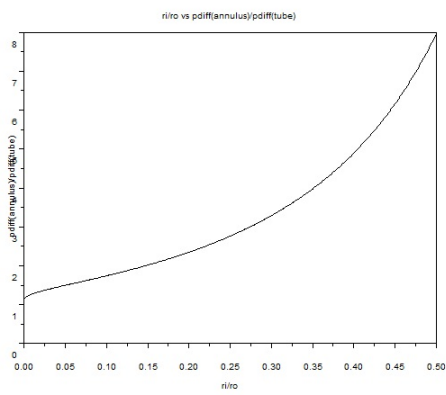


Figure 6.2: flow in annulus

Chapter 7

Dimensional Analysis Modelling and Similitude

Scilab code Exa 7.5 prototype performance prediction

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

```

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

```

Scilab code Exa 7.6 reynolds number similarity

```

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

```

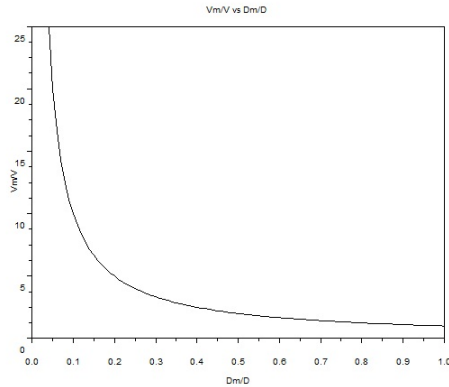


Figure 7.1: reynolds number similarity

Scilab code Exa 7.7 predicting prototype performance

```

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

```

```

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

```

Scilab code Exa 7.8 froude number similarity

```

1  clc;
2  clear;
3  w=20; //m
4  Q=125; //(m^3)/s
5  ratio=1/15;
6  t=24; //hours
7  wm=ratio*w; //m
8  //Vm/(gm*lm)^0.5 = V/(g*l)^0.5
9  //gm=g
10 //Q=VA and lm/l=1/15
11 //hence Qm/Q = ((lm/l)^0.5)*((lm/l)^2) = ratio^2.5
12 Qm=(ratio^2.5)*Q;
13 //V=l/t
14 //tm/t=(V/Vm)*(lm/l)=ratio^0.5
15 tm=(ratio^0.5)*t; //hours
16 disp("m",wm,"The required model width=")
17 disp("(m^3)/s",Qm,"The required model flowrate=")
18 disp("hrs",tm,"The operating time for the model=")
19 lrat=0.01:0.01:0.5;
20 count=1;
21 for i=0.01:0.01:0.5
22     tmodel(count)=(i^0.5)*t;
23     count=count+1;
24 end
25 plot2d(lrat,tmodel,rect=[0,0,0.5,20])

```

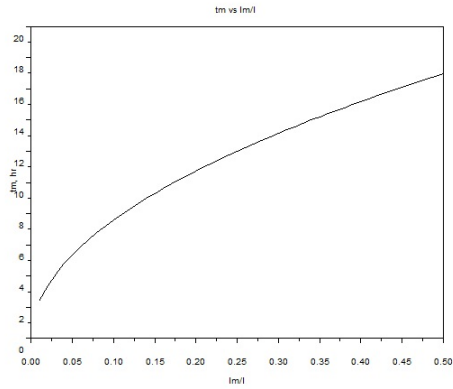


Figure 7.2: froude number similarity

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

Chapter 8

Pipe flow

Scilab code Exa 8.1 calculating time required

```
1  clc;
2  clear;
3  T1=50; //degree farenheit
4  D=0.73; //in
5  vol=0.0125; //ft^3
6  T2=140; //degree farenheit
7
8  vis1=2.73/100000; //lb*s/ft^2 at 50 degree farenheit
9  vis2=0.974/100000; //lb*s/ft^2 at 140 degree
   farenheit
10
11 //for 50 degree farenheit
12 //if flow is laminar , maximum Re=2100; Re=d*V*D/vis
13 V1=2100*vis1/(1.94*D/12);
14 t1=vol/(%pi*((D/12)^2)/4*V1);
15 //if flow is turbulent , minimum Re=4000
16 V2=4000*vis1/(1.94*D/12);
17 t2=vol/(%pi*((D/12)^2)/4*V2);
18
19 //for 140 degree farenheit
20 //if flow is laminar , maximum Re=2100; Re=d*V*D/vis
```

```

21 V3=2100*vis2/(1.94*D/12);
22 t3=vol/(%pi*((D/12)^2)/4*V3);
23 //if flow is turbulent, minimum Re=4000
24 V4=4000*vis2/(1.94*D/12);
25 t4=vol/(%pi*((D/12)^2)/4*V4);
26
27 disp("For laminar flow")
28 disp("seconds",t1,"The time taken to fill the glass
    at 50 degree F=")
29 disp("seconds",t3,"The time taken to fill the glass
    100 degree F=")
30 disp("For turbulent flow:")
31 disp("seconds",t2,"The time taken to fill the glass
    at 50 degree F=")
32 disp("seconds",t4,"The time taken to fill the glass
    at 140 degree F=")

```

Scilab code Exa 8.2 laminar pipe flow

```

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

```

```

    D^4)/(128*vis*1)
16 ang=(asin(-128*vis*Q/(%pi*d*9.81*(D^4)))*180/%pi;
17 //since sin(ang) doesn= not depend on pdiff, the the
    pressure is constant all along the pipe
18 //hence for c)
19 p3=p1;//kPa
20 disp("kPa.",pdiff,"The pressure drop required if the
    pipe is horizontal=")
21 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) =")
22 disp("kPa",p3,"c) For conditions of part b), the
    pressure at x3=5 m = ")

```

Scilab code Exa 8.3 net force calculation

```

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

```

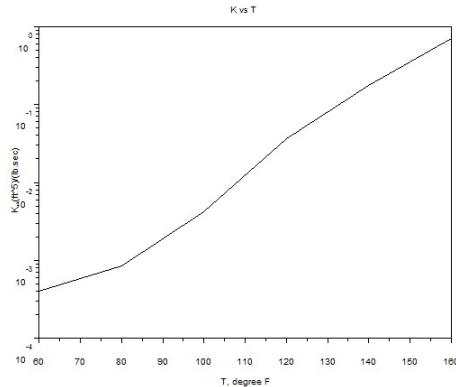


Figure 8.1: net force calculation

```

    temperature is 100 degree F
19 disp(" lb/(ft ^2)",pdiff,"The pressure drop for the
    given Q and T =")
20 V=Q/(%pi*((D/12)^2)/4); //ft/sec
21 Re=d(3)*V*(D/12)/vis(3);
22 disp("hence the flow is laminar",Re,"The reynolds
    number=")
23 stress=pdiff*(D/12)/(4*1); //lb/(ft ^2)
24 disp(" lb/(ft ^2)",stress,"The wall stress for the
    given Q and T =")
25 Fp=(%pi/4)*((D/12)^2)*pdiff; //lb
26 Fv=(2*%pi)*((D/12)/2)*l*stress; //lb
27 disp(" lb",Fp,"The net pressure force =")
28 disp(" lb",Fv,"The net viscous/shear force =")

```

Scilab code Exa 8.4 turbulent pipe flow

```

1 clc;
2 clear;

```

```

3 T=20; //degree C
4 d=998; //kg/(m^3)
5 kvis=1.004*(10^-6); //(m^2)/s; where kvis=kinematic
    viscosity
6 D=0.1; //m
7 Q=0.04; //(m^3)/sec
8 pgrad=2.59; //kPa/m; where pgrad is pressure gradient
9 r=0.025; //m
10 stress=D*(pgrad*1000)/(4*1); //N/(m^2)
11 uf=(stress/d)^0.5; //m/sec; where uf is frictional
    velocity
12 ts=5*kvis*1000/(uf); //mm; where ts is the thickness
    of the viscous sublayer
13 disp("mm",ts,"The thickness of the viscous sublayer="
    ")
14 V=Q/(%pi*(D^2)/4); //m/s
15 Re=V*D/kvis;
16 disp("hence the flow is turbulent.",Re,"The reynolds
    number=")
17 n=8.4; //from turbulent flow velocity profile diagram
18
19 //Q=(%pi)*(R^2)*V
20 R=1; //assumption
21 //let Q/Vc=x
22 x=integrate('((1-(r/R))^(1/n))*(2*%pi*r)', 'r',0,R);
23 q=%pi*(R^2)*V;
24 Vc=q/x; //m/s
25 disp("m/s",Vc,"The approximate centerline velocity="
    )
26 stress1=(2*stress*r)/D; //N/(m^2)
27 //d(uavg)/dr=urate=-(Vc/(n*R))*((1-(r/R))^((1-n)/n))
    ; where uavg=average velocity
28 urate=-(Vc/(n*(D/2)))*((1-(r/(D/2)))^((1-n)/n)); //s
    ^(-1)
29 stresslam=-(kvis*d*urate); //N/(m^2)
30 stressratio=(stress1-stresslam)/stresslam;
31 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

```
1  clc;
2  clear;
3  D=4; //mm
4  V=50; //m/sec
5  l=0.1; //m
6  d=1.23; //kg/(m^3)
7  vis=1.79/100000; //N*sec/(m^2)
8  Re=d*V*(D/1000)/vis;
9  //if flow is laminar
10 f=64/Re;
11 pdiff=f*l*0.5*d*(V^2)/((D/1000)*1000); //kPa
12 disp("kPa",pdiff,"The pressure drop if the flow is
    laminar=")
13 //if flow is turbulent
14 //roughness=0.0015; hence f=0.028
15 f1=0.028;
16 pdiff1=f1*l*0.5*d*(V^2)/((D/1000)*1000); //kPa
17 disp("kPa",pdiff1,"The pressure drop if flow is
    turbulent=")
```

Scilab code Exa 8.6 minor losses calculation

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

```

7 Ma5=V(5)/c5;
8 //applying energy equation between locations 1 and
9
9 //hL=hp=(p1-p9)/sw=pdiff/sw
10 //Pa=sw*Q*hp=sw*A(5)*V(5)*hL
11 KLcorner=0.2;
12 KLdif=0.6;
13 KLscr=4;
14 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
15 Pa=0.0765*A(5)*V(5)*hL/550; //hp
16 pdiff=0.0765*hL/144; //psi
17 disp("psi",pdiff,"The value of (p1-p9)=")
18 disp("hp",Pa,"The horsepower supplied to the fluid
by the fan=")
19 v=50:300;
20 count=1;
21 for i=50:300
22     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;
23     count=count+1;
24 end
25 plot2d(v,power,rect=[0,0,300,250])
26 xtitle("Pa vs V5","V5, ft/sec","Pa, hp")

```

Scilab code Exa 8.7 duct size determination

```

1 clc;
2 clear;

```

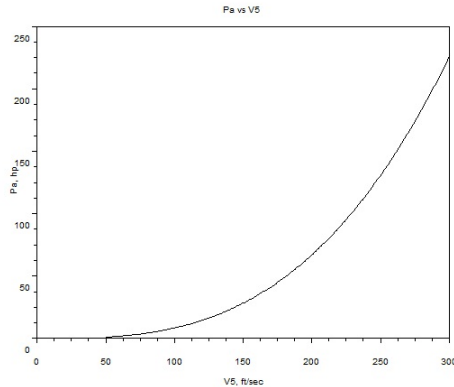


Figure 8.2: minor losses calculation

```

3 T=120; // degree F
4 D=8; // in
5 vavg=10; // ft / s
6 roughness=0;
7 kvis=1.89/10000; // (ft ^ 2) / s
8 Re=vavg*(D/12)/kvis;
9 //from this value of Re and roughness/D=0, and using
  Moody's chart
10 f=0.022;
11 hLperl=f*(vavg^2)/(D*2*32.2/12);
12 //Dh=4*A/P=4*(a^2)/(4*a)=a
13
14 //Vs=(%pi*((D/12)^2)*vavg)/(4*a^2)
15 //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
16 //by trial and error
17 f=0.023;
18 x=(%pi*((D/12)^2)*vavg/4)^2;
19 y=x*f/(2*32.2);
20 a=((y/0.0512)^(1/5))*12; // in
21 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

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

```

29 KLelbow=1.5;
30 KLvalve=10;
31 KLfaucet=2;
32 hLminor=(KLvalve+(4*KLelbow)+KLfaucet)*(V1^2)
    /(2*32.2);
33 p12=p11+(d*32.2*hLminor); //lb/(ft ^2)
34 disp(" psi",p12/144,"c)The pressure at point 1 when
    both major and minor head losses are included=")
35 H=(p1/(32.2*1.94))+(V1*V1/(2*32.2)); //ft
36 dist=0:60;
37 for i=0:15
38     press(i+1)=p1/144;
39     press1(i+1)=((d*32.2*(12+14))+(0.5*d*((V2^2)-(V1
        ^2)))+(d*32.2*(f*(11+12+13+14+15+16-i)*(V1^2)
        /(D*2*32.2)))+(d*32.2*(KLvalve+(4*KLelbow)+
        KLfaucet)*(V1^2)/(2*32.2)))/144;
40     head(i+1)=H;
41     head1(i+1)=((press1(i+1))*144/(32.2*1.94))+((V1
        ^2)/(2*32.2));
42 end
43 for i=16:25
44     press(i+1)=((d*32.2*((12+14)-(i-15)))+(0.5*d*((
        V2^2)-(V1^2))))/144;
45     press1(i+1)=((d*32.2*((12+14)-(i-15)))+(0.5*d*((
        V2^2)-(V1^2)))+(d*32.2*f*(11+12+13+14+15+16-i
        )*(V1^2)/(D*2*32.2)))+(d*32.2*(KLvalve+(3*
        KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))/144;
46     head(i+1)=H;
47     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(i-11);
48 end
49 for i=26:30
50     press(i+1)=((d*32.2*((12+14)-(25-15)))+(0.5*d*((
        V2^2)-(V1^2))))/144;
51     press1(i+1)=((d*32.2*((12+14)-(25-15)))+(0.5*d
        *((V2^2)-(V1^2)))+(d*32.2*(f*(11+12+13+14+15
        +16-i)*(V1^2)/(D*2*32.2)))+(d*32.2*(KLvalve
        +(2*KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))

```

```

        /144;
52     head(i+1)=H;
53     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+12;
54 end
55 for i=31:40
56     press(i+1)=((d*32.2*((12+14)-(i-11-13)))+(0.5*d
        *((V2^2)-(V1^2))))/144;
57     press1(i+1)=((d*32.2*((12+14)-(i-11-13)))+(0.5*d
        *((V2^2)-(V1^2)))+(d*32.2*(f*(11+12+13+14+15+
        16-i)*(V1^2)/(D*2*32.2)))+(32.2*d*(KLvalve+(
        KLelbow)+KLfaucet)*(V1^2)/(2*32.2)))/144;
58     head(i+1)=H;
59     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(i-(11+13));
60 end
61 for i=41:50
62     press(i+1)=((d*32.2*((12+14)-(40-11-13)))+(0.5*d
        *((V2^2)-(V1^2))))/144;
63     press1(i+1)=((d*32.2*((12+14)-(40-11-13)))+(0.5*
        d*((V2^2)-(V1^2)))+(d*32.2*(f*(11+12+13+14+15
        +16-i)*(V1^2)/(D*2*32.2)))+(d*32.2*(KLvalve+
        KLfaucet)*(V1^2)/(2*32.2)))/144;
64     head(i+1)=H;
65     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(12+14);
66 end
67 for i=51:60
68     press(i+1)=((d*32.2*((12+14)-(40-11-13)))+(0.5*d
        *((V2^2)-(V1^2))))/144;
69     press1(i+1)=((d*32.2*((12+14)-(40-11-13)))
        +(0.5*d*((V2^2)-(V1^2)))+(d*32.2*(f*(11+12+
        13+14+15+16-i)*(V1^2)/(D*2*32.2)))+d*32.2*((
        KLfaucet)*(V1^2)/(2*32.2)))/144;
70     head(i+1)=H;
71     head1(i+1)=(press1(i+1)*144/(32.2*1.94))+((V1^2)
        /(2*32.2))+(12+14);
72 end

```

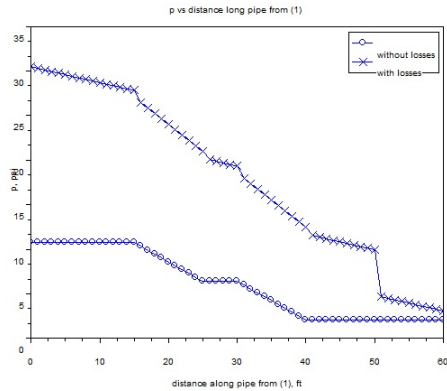


Figure 8.3: determining pressure drop

```

73 plot(dist,press,"o-")
74 plot(dist,press1,"x-")
75 h1=legend(['without losses';'with losses'])
76 xtitle("p vs distance long pipe from (1)","distance
       along pipe from (1), ft","p, psi")
77 xclick(1);
78 clf();
79 plot(dist,head,"o-")
80 plot(dist,head1,"x-")
81 h2=legend(['energy line with no losses';'energy line
       including losses'])
82 xtitle("H vs distance long pipe from (1)","distance
       along pipe from (1), ft","H,elevation to energy
       line , ft")
83
84 end

```

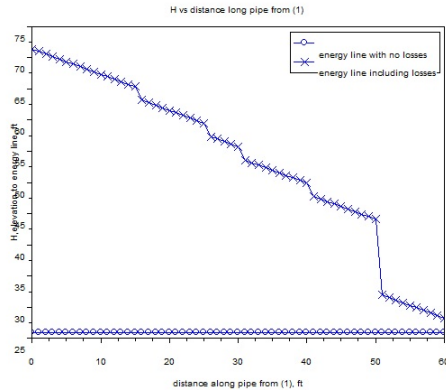


Figure 8.4: determining pressure drop

Scilab code Exa 8.9 determining head loss

```

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

```

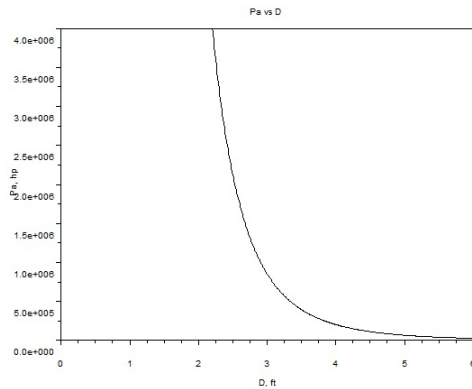


Figure 8.5: determining head loss

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

Scilab code Exa 8.10 air flowrate determination

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

```

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

```

Scilab code Exa 8.11 flowrate through turbine

```

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

```

Scilab code Exa 8.12 minimum pipe diameter

```

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

```

Scilab code Exa 8.13 pipe diameter calculation

```

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

```

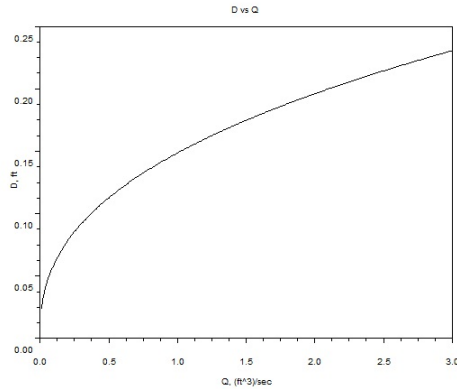



Figure 8.6: minimum pipe diameter

```

7 Q=26; //(ft^3)/sec
8 n=4; //number of flanged 45 degree elbows
9 z1=44; // ft
10 x=Q/(%pi/4); //where x=V*(D^2)
11 KLentrance=0.5;
12 KLelbow=0.2;
13 KLexit=1;
14 //Finding f from Re, roughness and moody's chart
15 f=0.01528;
16 sumKL=(n*KLelbow)+KLentrance+KLexit;
17 y=f*l;
18 //V^2 = (x^2)/(D^4)
19 //energy equation with p1=p2pV1=V2=z2=0
20 z=(2*32.2*z1)/((x^2)*1);
21 k=sumKL/l;
22 fn=poly([(-f) (-k) 0 0 0 z], 'D', 'c');
23 r=roots(fn);
24 disp("ft",r(1),"The diameter=")
25 count=1;
26 len=400:2000;
27 for i=400:2000
28     root=roots(poly([(-f) -(sumKL/i)) 0 0 0
29                     ((2*32.2*z1)/((x^2)*i))], 'a', 'c'));

```

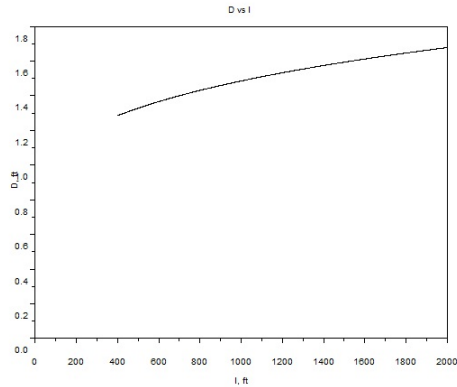


Figure 8.7: pipe diameter calculation

```

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

```

Scilab code Exa 8.14 flowrate in reservoir

```

1  clc;
2  clear;
3  D=1; // ft
4  f=0.02;
5  z1=100; // ft
6  z2=20; // ft
7  z3=0; // ft
8  l1=1000; // ft
9  l2=500; // ft
10 l3=400; // ft
11 //assuming fluid flows into B
12 //applying energy equation bwtween (1 and 3) and (1

```

```

    and 2) and using the relation  $V1=V2+V3$ 
13 c1=z1*32.2*2/(f*11);
14 c2=(z1-z2)*32.2*2/(f*11);
15 x=(c1-c2)/(13/11); // 160
16 y=(12/11)/(13/11); // 1.25
17 a=c2-x; // 98
18 b=(a*2*(y+(12/11))); // 539
19 c=4*x+b; // 1179
20 d=-((y+(12/11))^2)+(4*y); // -2.5625
21 e=-(a^2); // -9604
22 fn=poly([e 0 c 0 d], 'V2', 'c');
23 r=roots(fn);
24 V2=r(1);
25 V1=(c2-(12/11)*V2)^0.5;
26 A=(%pi/4*(D^2));
27 Q1=V1*A;
28 Q2=V2*A;
29 Q3=Q1-Q2;
30 disp("(ft^3)/sec",Q1,"Q1 (out of A)=")
31 disp("(ft^3)/sec",Q2,"Q2 (into B)=")
32 disp("(ft^3)/sec",Q3,"Q3 (into C)=")

```

Scilab code Exa 8.15 diameter of nozzle

```

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

```

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

Chapter 9

External Flow Past Bodies

Scilab code Exa 9.1 lift and drag

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

Scilab code Exa 9.5 boundary layer transition

```

1  clc;
2  clear;
3  U=10; //ft/sec
4  Twater=60; //degree F
5  Tglycerin=68; //degree F
6  kviswater=1.21*(10^-5); //(ft^2)/sec
7  kvisair=1.57*(10^-4); //(ft^2)/sec
8  kvisglycerin=1.28*(10^-2); //(ft^2)/sec
9  Re=5*(10^5); //assumption
10 xcrwater=kviswater*Re/U; //ft
11 xcrair=kvisair*Re/U; //ft
12 xcrglycerin=kvisglycerin*Re/U; //ft
13 btwater=5*(kviswater*xcrwater/U)^0.5; //ft; where bt=
    thickness of boundary layer
14 btair=5*(kvisair*xcrair/U)^0.5; //ft
15 btglycerin=5*(kvisglycerin*xcrglycerin/U)^0.5; //ft
16 disp("a)WATER")
17 disp(",ft",xcrwater,"location at which boundary
    layer becomes turbulent=")
18 disp("ft",btwater,"Thickness of the boundary layer=")
    )
19 disp("b)AIR")
20 disp(",ft",xcrair,"location at which boundary layer
    becomes turbulent=")
21 disp("ft",btair,"Thickness of the boundary layer=")
22 disp("c)GLYCERIN")
23 disp(",ft",xcrglycerin,"location at which boundary
    layer becomes turbulent=")
24 disp("ft",btglycerin,"Thickness of the boundary
    layer=")

```

Scilab code Exa 9.7 drag estimation

```

1  clc;
2  clear;

```

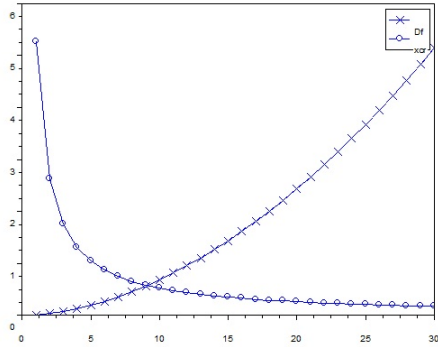


Figure 9.1: drag estimation

```

3 T=70; //degree F
4 U1=0; //ft/sec
5 U2=30; //ft/sec
6 l=4; //ft
7 b=0.5; //ft
8 d=1.94;
9 vis=2.04*(10^(-5));
10 x=d*l/vis;
11 U=1:U2;
12 for i=1:U2
13     Re(i)=x*i;
14     CDf(i)=0.455/((log10(Re(i)))^2.58);
15     Df(i)=0.5*d*i*i*l*b*CDf(i);
16     xcr(i)=vis*(5*(10^5))/(d*i);
17 end
18 plot(U,Df,"x-")
19 plot(U,xcr,"o-")
20 h1=legend(['Df';'xcr'])

```

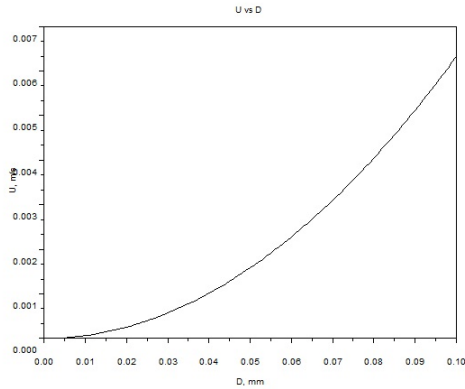


Figure 9.2: speed of grain

Scilab code Exa 9.10 speed of grain

```

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

```

Scilab code Exa 9.11 velocity of updraft

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

Scilab code Exa 9.12 drag and deceleration

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

```

19 //the corresponding decelerations are a=D/s=g*D/W
20 //deceleration relative to g=D/W
21 decgs=Dgs/Wg;
22 decgsm=Dgsm/Wg;
23 dect=Dt/Wt;
24 disp("STANDARD GOLF BALL:")
25 disp("lb",Dgs,"The drag coefficient=")
26 disp(decgs,"The deceleration relative to g=")
27 disp("SMOOTH GOLF BALL:")
28 disp("lb",Dgsm,"The drag coefficient=")
29 disp(decgsm,"The deceleration relative to g=")
30 disp("TABLE TENNIS BALL:")
31 disp("lb",Dt,"The drag coefficient=")
32 disp(dect,"The deceleration relative to g=")

```

Scilab code Exa 9.13 torque estimation

```

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

```

Scilab code Exa 9.15 lift and power

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

Scilab code Exa 9.16 angular velocity determination

```
1  clc;
2  clear;
3  W=2.45*(10^(-2)); //N
4  D=3.8*(10^(-2)); //m
5  U=12; //m/s
6
7  //W=L
8  d=1.23; //kg/(m^3)
9  W=0.5*d*(U^2)*(D^2)*%pi*CL/4;
10 CL=2*W/(d*(U^2)*%pi*(D^2)/4);
11 //using this value of CL, omega*D/(2*U)=x is found
    as
```

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

Chapter 10

Flow in Open Channels

Scilab code Exa 10.2 elevation of surface

```
1  clc;
2  clear;
3  z2=0.5; // ft
4  q=5.75; // (ft ^2)/sec
5  y1=2.3; // ft
6  z1=0; // ft
7  V1=2.5; // ft/sec
8  //bernoulli equation
9  a=y1+((V1^2)/(2*32.2))+z1-z2; // ft; where a=y2+((V^2)
    /(2*g))
10 //countinuity equation
11 b=(y1*V1); // (ft ^2/sec); where b=(y2*V2)
12 c1=2*32.2;
13 c2=(-c1)*a;
14 c3=b^2;
15 fn=poly([c3 0 c2 c1], "y2", "c");
16 y2=roots(fn);
17 sum1=y2(3)+z2; // ft
18 sum2=y2(1)+z2; // ft
19 E1=y1+(c3/(y1^2)); // ft
20 Emin=3*((q^2)/(32.2^(1/3)))/2; // ft
```

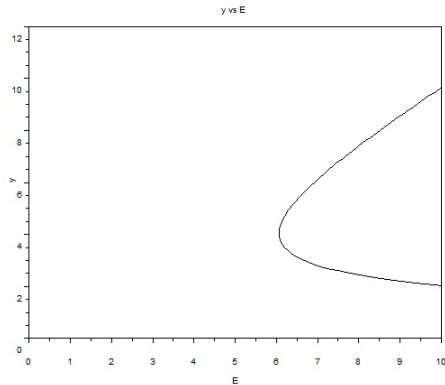


Figure 10.1: elevation of surface

```

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

```

Scilab code Exa 10.3 froude number determination

```

1 clc;
2 clear;
3 y=5;//ft

```

```

4 angle=40; // degree
5 l=12; // ft
6 rate=1.4; //ft per 1000 ft of length
7 K=1.49;
8 A=(l*y)+(y*y/tan(angle*pi/180)); // ft
9 P=(1+(2*y/sin(angle*pi/180))); // ft
10 Rh=A/P;
11 S0=rate/1000;
12 x=K*(A)*(Rh^(2/3))*(S0^0.5); //where Rh=Q*n
13 n=0.012;
14 Q=x/n; // cfs
15 disp(" cfs",Q,"The flowrate=")
16 V=Q/A; // ft/sec
17 Fr=V/(32.2*y)^0.5;
18 disp(Fr,"Froude number=")

```

Scilab code Exa 10.4 determining flow depth

```

1 clc;
2 clear;
3 y=5; // ft
4 angle=40; // degree
5 l=12; // ft
6 rate=1.4; //ft per 1000 ft of length
7 Q=10; //m^3/sec
8 //A=(l*y)+(y*y/tan(angle*pi/180)) ft^2
9 bw=1*1/3.281; //m; where bw=bottom width 3.66
10 //P=bw(2*y/sin(angle*pi/180)) m
11 //Rh=A/P
12 n=0.03;
13 c1=1/tan(angle*pi/180); // 1.19
14 c2=(Q*n/((rate/1000)^0.5))^3; // 515
15 c3=2/sin(angle*pi/180); // 3.11
16 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");
17 r=roots(fn);
18 disp("m",r(1),"The depth of the flow=")

```

Scilab code Exa 10.7 flowrate estimation

```

1  clc;
2  clear;
3  S0=1/500;
4  n1=0.02;
5  z1=0.6; // ft
6  n2=0.015;
7  n3=0.03;
8  z2=0.8; // ft
9  l1=3; // ft
10 l2=2; // ft
11 l3=3; // ft
12 y=z1+z2; // ft
13 K=1.49;
14 A1=l1*(z1); // ft^2
15 A2=l2*(y); // ft^2
16 A3=l3*(z1); // ft^2
17 P1=l1+z1; // ft
18 P2=l2+(2*z2); // ft
19 P3=l3+z1; // ft
20 Rh1=A1/P1; // ft
21 Rh2=A2/P2; // ft
22 Rh3=A3/P3; // ft
23 Q=K*(S0^0.5)*((A1*(Rh1^(2/3))/n1)+(A3*(Rh3^(2/3))/n3
    )+(A2*(Rh2^(2/3))/n2)); // (ft^3)/sec
24 disp("(ft^3)/sec",Q,"The flowrate=")

```

Scilab code Exa 10.8 aspect ratio determination

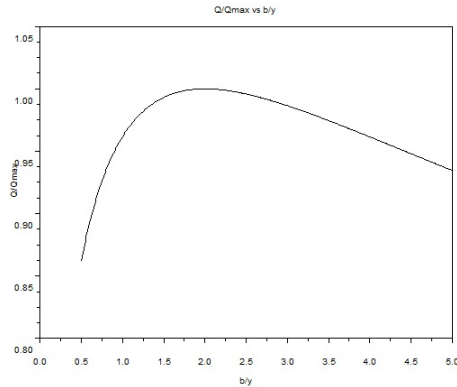


Figure 10.2: aspect ratio determination

```

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

```

Scilab code Exa 10.9 hydraulic jump

```

1  clc;
2  clear;
3  w=100; // ft
4  y1=0.6; // ft
5  V1=18; // ft/sec
6  Fr1=V1/(32.2*y1)^0.5;
7  disp(Fr1,"The Froude number before the jump=")
8  yratio=0.5*(-1+(1+(8*(Fr1^2)))^0.5); //where yratio=
    y2/y1
9  y2=y1*yratio; // ft
10 disp("ft",y2,"The depth after the jump=")
11 //Q1=Q2, hence
12 V2=(y1*V1)/y2; // ft/sec
13 Fr2=V2/(32.2*y2)^0.5;
14 disp(Fr2,"The froude number after the jump=")
15 Q=w*y1*V1; // (ft^3)/sec
16 hL=(y1+(V1*V1/(32.2*2)))-(y2+(V2*V2/(2*32.2))); // ft
17 Pd=62.4*hL*Q/550; //hp
18 disp("hp",Pd,"Power dissipated within the jump=")
19 depth1=0.4:0.01:1.53;
20 count=1;
21 for i=0.4:0.01:1.53
22     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;
23     count=count+1;
24 end
25 plot2d(depth1,power,rect=[0,0,1.6,1000])
26 xtitle("Pa vs y1","y1, ft","Pa, hp")
27 xclick(1);
28 clf();
29 y=0.5:0.01:4;
30 n=1;
31 for i=0.5:0.01:4

```

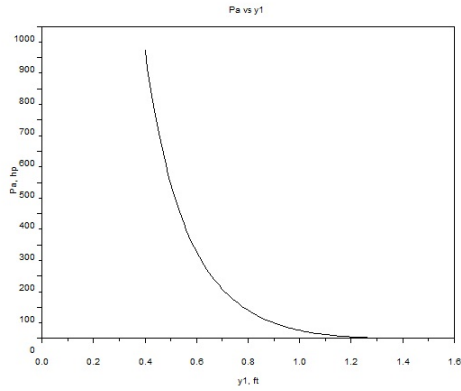


Figure 10.3: hydraulic jump

```

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

```

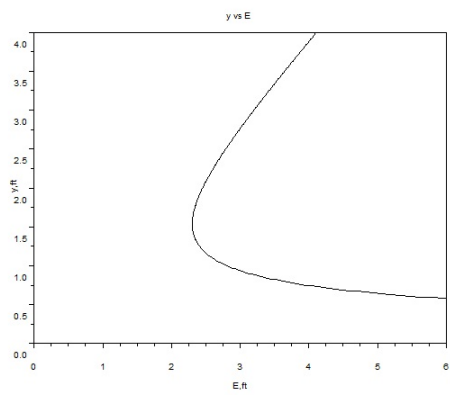


Figure 10.4: hydraulic jump

Chapter 11

Analysis of Compressible Flow

Scilab code Exa 11.1 Internal Energy enthalphy

```
1  clc;
2  clear;
3  D=4; //in
4  T1=540; //degree R
5  p1=100; //psia
6  T2=453; //degree R
7  p2=18.4; //psia
8  k=1.4;
9  R=1716/32.174; //ft*lb/(lbm*(degree R))
10 cv=R/(k-1); //ft*lb/(lbm*(degree R))
11 udiff=cv*(T2-T1); //ft*lb/lbm; change in internal
    energy
12 disp("ft*lb/lbm",udiff,"a)The change in internal
    energy between (1) and (2)=")
13 cp=k*cv; //ft*lb/(lbm*(degree R))
14 hdiff=cp*(T2-T1); //ft*lb/lbm; change in enthalpy
15 disp("ft*lb/lbm",hdiff,"b)The change in enthalpy
    energy between (1) and (2)=")
16 ddiff=(1/R)*((p2*144/T2)-(p1*144/T1)); //lbm/(ft^3);
    change in density
17 disp("lbm/(ft^3)",ddiff,"The change in density
```

between (1) and (2)=")

Scilab code Exa 11.2 change in entropy

```
1  clc;
2  clear;
3  D=4; //in
4  T1=540; //degree R
5  p1=100; //psia
6  T2=453; //degree R
7  p2=18.4; //psia
8
9  dratio=(p1/T1)*(T2/p2);
10 sdif=(cv*(log(T2/T1)))+(R*(log(dratio))); //ft*lb/lbm
    *(degree R); change in entropy
11 disp("ft*lb/lbm*(degree R)",sdif,"The change in
    entropy between (1) and (2)=")
```

Scilab code Exa 11.3 speed of sound

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

Scilab code Exa 11.4 Mach cone

```

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

```

Scilab code Exa 11.5 mass flowrate determination

```

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

```

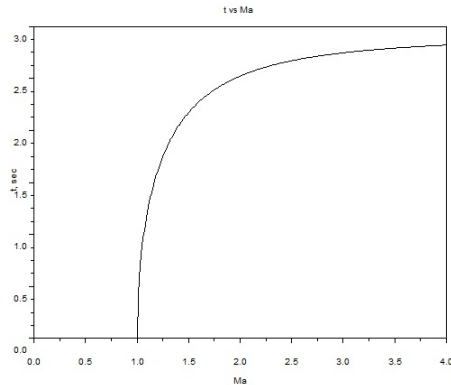


Figure 11.1: Mach cone

```

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

```

Scilab code Exa 11.6 mass flowrate calculation

```
1  clc ;
2  clear ;
3  A=1*(10^(-4)); //m^2
4  p1=80; //kPa(abs)
5  p2=40; //kPa(abs)
6
7  p0=101; //kPa(abs)
8  k=1.4;
9  //for (a)
10 pratio1=p1/p0;
11 //for this value of p1/p0,
12 Math1=0.59;
13 Tratio1=0.94; //Tth/T0
14 dratio1=0.85; //dth/d0
15 Tth1=Tratio1*(288); //K
16 dth1=dratio1*(1.23); //kg/(m^3)
17 Vth1=Math1*(286.9*Tth1*k)^0.5; //m/sec
18 m1=(dth1*A*Vth1); //kg/sec
19 disp("kg/sec",m1,"a)The mass flowrate=")
20 //for (b)
21 Math2=1;
22 Tratio2=0.83; //Tth/T0
23 dratio2=0.64; //dth/d0
24 Tth2=Tratio2*(288); //K
25 dth2=dratio2*(1.23); //kg/(m^3)
26 Vth2=Math2*(286.9*Tth2*k)^0.5; //m/sec
27 m2=(dth2*A*Vth2); //kg/sec
28 disp("kg/sec",m2,"b)The mass flowrate=")
```

Scilab code Exa 11.7 flow velocity determination

```

1  clc;
2  clear;
3  pratio=0.82; //ratio of static to stagnation pressure
4  T=68; //degree F
5  //for (a)
6  //for the value of pratio given Ma is calculated as
7  Ma1=0.54;
8  k1=1.4;
9  Tratio1=0.94; //T/T0
10 T1=Tratio1*(T+460); // degree R
11 V1=(Ma1*(53.3*T1*k1)^0.5)*(32.2^0.5); //ft/sec
12 //for (b)
13 k2=1.66;
14 Ma2=((((1/pratio)^((k2-1)/k2))-1)/((k2-1)/2))^0.5;
15 Tratio2=1/(1+(((k2-1)/2)*(Ma2^2))); //T/T0
16 T2=Tratio2*(T+460); //degree R
17 V2=(Ma2*(386*T2*k2)^0.5)*(32.2^0.5); //ft/sec
18 disp("ft/sec",V1,"The flow velocity if fluid is air="
      ")
19 disp("ft/sec",V2,"The flow velocity if fluid is
      helium=")

```

Scilab code Exa 11.11 fanno flow

```

1  clc;
2  clear;
3  k=1.4;
4  T0=518.67; //degree R
5  T1=514.55; //degree R
6  p1=14.3; //psia
7  R=53.3; //(ft*lb)/(lbm* degree R)
8  cp=R*k/(k-1); //(ft*lb)/(lbm* degree R)
9  Tratio=T1/T0;
10 Ma=((1/Tratio)-1)/((k-1)/2))^0.5;
11 x=(R*T1*k*32.2)^0.5; //ft/sec; where x=(R*T1*k)^0.5

```

```

12 y=p1*144/(R*T1)*(Ma*x); //lbm/((ft ^2)*sec); where y=d
    *V
13 //for p=7 psia
14 p=7; //psia
15 fn=poly([(-T0) 1 ((y*y/(2*cp*p*p*144*144/(R^2)))/32.2)],"T","c");
16 r=roots(fn);
17 T=r(1); //K
18 sdif=(cp*log(T/T1))-(R*log(p/p1)); //((ft*lb)/(lbm*
    degree R)
19 disp("K",T,"The corosponding value of temperature
    for Fanno for downstream pressure of 7psia=")
20 disp("(ft*lb)/(lbm* degree R)",sdif,"The
    corosponding value of entropy change for Fanno
    for downstream pressure of 7psia=")
21 count=1;
22 for i=1.4:0.1:7
23     root=roots(poly([(-T0) 1 ((y*y/(2*cp*i*i
        *144*144/(R^2)))/32.2)],"T","c"));
24     temp(count)=root(1);
25     s(count)=(cp*log(temp(count)/T1))-(R*log(i/p1));
26     count=count+1;
27 end
28 plot2d(s,temp)
29 xtitle("T vs s-s1","s-s1, ((ft*lb)/(lbm* degree R))",
    ,"T, Degree R")

```

Scilab code Exa 11.12 choked fanno flow

```

1 clc;
2 clear;
3 T0=288; //K
4 p0=101; //kPa(abs)

```

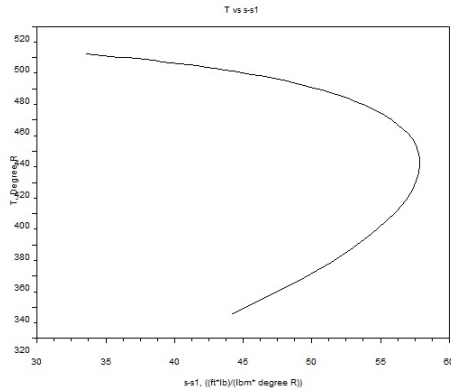


Figure 11.2: fanno flow

```

5 l=2; //m
6 D=0.1; //m
7 f=0.02;
8 k=1.4;
9 x=f*l/D;
10 Tratio=2/(k+1); //where Tratio is Tcritical/T0
11 Tcritical=Tratio*T0; //K = T2
12 Vcritical=(286.9*Tcritical*k)^0.5; //m/sec = V2
13 //from value of x, the following are found
14 Ma=0.63;
15 Trat=1.1; //where Trat=T1/Tcritical
16 Vrat=0.66; //where Vrat=V1/Vcritical
17 prat=1.7; //where prat=p1/pcritical
18 pratio=1.16; //where pratio=p0,1/p0critical
19 //from value of Ma, the following are found
20 Tfraction=0.93; //where Tfraction=T1/T0
21 pfraction=0.76; //where pfraction=p1/p0,1
22 dfraction=0.83; //where dfraction=d1/d0,1
23 //hence ,
24 V1=Vrat*Vcritical; //m/sec
25 d1=dfraction*(1.23); //kg/(m^3)
26 m=d1*%pi*(D^2)*V1/4; //kg/sec
27 T1=Tfraction*T0; //K
28 p1=pfraction*p0; //kPa( abs)

```

```

29 T01=T0; //K and T01=T02
30 p01=p0; //kPa(abs)
31 p2=(1/prat)*(pfraction)*p01; //kpa(abs)
32 p02=(1/pratio)*p01; //kPa(abs)
33 disp("K",Tcritical," Critical temperature=")
34 disp("m/sec",Vcritical," Critical velocity=")
35 disp("m/sec",V1," Velocity at inlet=")
36 disp("kg/sec",m,"Maximum mass flowrate=")
37 disp("K",T1," Temperature at inlet=")
38 disp("kPa(abs)",p1," Pressure at inlet=")
39 disp("K",T01," stagnation temperature at inlet and
    exit=")
40 disp("kPa(abs)",p01,"The stagnation pressure at
    inlet=")
41 disp("kPa(abs)",p2," Pressure at exit=")
42 disp("kPa(abs)",p02,"The stagnation pressure at exit
    =")

```

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

```

1  clc;
2  clear;
3  T0=288; //K
4  p0=101; //kPa(abs)
5  l=2; //m
6  D=0.1; //m
7  f=0.02;
8  pd=45; //kPa(abs)
9  f=0.02;
10 k=1.4;
11 lnew=(50/100)*l;
12 x=lnew*f/D;
13 //from this value of x, following are found
14 Ma=0.7;
15 prat=1.5; //where prat=p1/pcritical

```

```

16 //from this value of Ma, following are found
17 pratio=0.72; //where pratio=p1/p0
18 dratio=0.79; //where dratio=d1/d0,1
19 Vratio=0.73; //where Vratio=V1/Vcritical
20 //hence ,
21 p2=(1/prat)*pratio*p0; //kPa(abs)
22 pcritical=p2;
23 //we find that pd<pcritical
24 d1=dratio*(1.23); //kg/(m^3)
25 Vcritical=(286.9*Tcritical*k)^0.5; //m/sec = V2
26 V1=Vratio*Vcritical; //m/sec
27 m=d1*%pi*(D^2)*V1/4; //kg/sec
28 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

```

1  clc;
2  clear;
3  T0=288; //K
4  p0=101; //kPa(abs)
5  l=2; //m
6  D=0.1; //m
7  f=0.02;
8  pd=45; //kPa(abs)
9  f=0.02;
10 m=1.65; //kg/sec
11 lnew=l/2; //m
12
13 x=f*l/D;
14 //from this value of x, Ma at exit is found as
15 Ma=0.7;
16 //and p2/pcritical is found as
17 pratio=1.5;

```

```

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

```

Scilab code Exa 11.15 rayleigh flow

```

1  clc;
2  clear;
3  k=1.4;
4  T0=518.67; //degree R
5  T1=514.55; //degree R
6  p1=14.3; //psia
7
8  R=53.3; //(ft*lb)/(lbm*degree R)
9  cp=R*k/(k-1); //(ft*lb)/(lbm* degree R)
10 Tratio=T1/T0;
11 Ma=((1/Tratio)-1)/((k-1)/2))^0.5;
12 x=(R*T1*k*32.2)^0.5; //ft/sec; where x=(R*T1*k)^0.5
13 y=p1*144/(R*T1)*(Ma*x); //lbm/((ft^2)*sec); where y=d
    *V
14 z=R*T1/(p1*144); //(ft^3)/lbm
15 c=(p1)+(y*y*z/(32.2*144)); //psia; =constant
16 //when downstream pressure p=13.5 psia
17 p=13.5; //psia
18 a=(y^2)*R/(p*144*32.2*144); //(lb/(in^2))/degree R
19 fn=poly([(p-c) a],"T","c");
20 T=roots(fn); //degree R
21 sdif=(cp*log(T/T1))-(R*log(p/p1)); //ft*lb/(lbm*
    degree R)
22 disp("degree R",T,"The corresponding value of
    temperature for the downstream pressure of 13.5

```

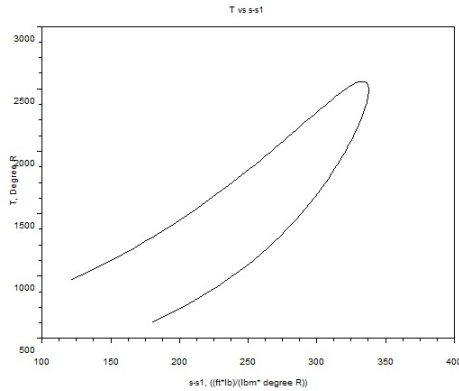


Figure 11.3: rayleigh flow

```

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

```

Scilab code Exa 11.18 supersonic flow

```

1 clc;
2 clear;

```



```

3 p=60; //psia
4 T=1000; //degree R
5 px=12; //psia
6 k=1.4;
7 R=53.3; //ft*lb/(lbm*degree R)
8 pratio=p/px;
9 //for this value of pratio, Max is calculated as
10 Max=1.9;
11 //using this value of Max, Tx/T0,x is found as
12 Tratio=0.59;
13 //T=T0,x=T0,y
14 Tx=Tratio*T; //degree R
15 cx=(R*Tx*k)^0.5; //ft/sec
16 Vx=1.87*cx*(32.2^0.5); //ft/sec
17 disp(Max,"The Mach number for the flow=")
18 disp("ft/sec",Vx,"The velocity of the flow=")

```

Scilab code Exa 11.19 converging diverging duct

```

1 clc;
2 clear;
3 x1=0.5; //m
4 x2=0.3; //m
5 Acritical=0.1; //m^2
6 //at x1, Max1 is found as
7 Max1=2.8;
8 //and px/p0,x is found as
9 pratio1=0.04;
10 //For this value of Max, py/px is found as
11 prat1=9;
12 pfraction1=prat1*pratio1; //where pfraction=py/p0,x =
    pIII/p0,x
13 //at x2, Max2 is found as
14 Max2=2.14;
15 //for this value of Max2, the following are found

```

```

16 pr2=5.2;
17 pr22=0.66; //where pr22=p0,y/p0,x
18 Ma=0.56;
19 //for this value of Ma, A/Acritical is found as
20 Aratio=1.24;
21 Arat=(Acritical+(x1^2))/(Acritical+(x2^2)); //where
    Aratio=A2/Ay
22 Afraction=Aratio*Arat; //where Afraction=A2/Acritical
23 A2=Acritical+(x1^2); //m^2
24 Acritical1=A2/Afraction; //where Acritical1 critical
    area for the isentropic flow downstream of the
    shock
25 //with the value of Afraction, the following are
    found
26 Ma2=0.26;
27 pfraction=0.95; //where pfraction=p2/p0,y
28 //hence,
29 pfrac=pfraction*pr22; //where pfrac=p2/p0,x
30 disp(pfraction1,"The ratio of back pressure to inlet
    stagnation pressure that will result in a normal
    shock at the exit of the duct=")
31 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

```
1 Q=1400; //gpm
2 N=1750; //rpm
3 b=2; //in
4 r1=1.9; //in
5 r2=7.0; //in
6 beta2=23; //degrees
7 alpha1=90; //degrees
```

Scilab code Exa 12.3 NPSH calculation

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

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

Scilab code Exa 12.5 pump scaling laws

```
1 D1=8; //in
2 N1=1200; //rpm
3 D2=12; //in
4 N2=1000; //rpm
5 T=60; //degree F
```

Scilab code Exa 12.6 pelton wheel turbine

```
1 z0=200; //ft
2 l=1000; //ft
3 f=0.02;
4 D=8; //in .
5 B=150; //degree
6 R=1.5; //ft
7 z1=0; //ft
```

Scilab code Exa 12.8 dental drill characteristics

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

