Scilab Textbook Companion for
Fluid Mechanics For Chemical Engineers
by N. D. Nevers[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

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Chapter 1

Introduction

Scilab code Exa 1.1 Mass

```
1  clc
2  //let the total mass of mud be 100lbm
3  m_total =100; //lbm
4  //70% by wt of mud is sand(SiO2)and remaining is
       water
5  m_sand =0.7* m_total ; //lbm
6  m_water =0.3* m_total ; //lbm
7  rho_sand =165; //lbm/ft^3
8  rho_water =62.5; //lbm/ft^3
9  //rho=mass/volume
10 rho_mud=m_total/((m_sand/rho_sand)+(m_water/
       rho_water));
11 disp("The density of mud=")
12 disp(rho_mud)
13 disp("lbm/ft^3")
```

Scilab code Exa 1.2 Shear stress

```
1  clc
2  //Example 1.2
3  //Calculate the shear stress at the surface of the
       inner cylinder
4  D1=25.15//mm
5  D2=27.62//mm
6  dr=0.5*(D2-D1)//mm
7  f=10//rpm
8  Vo=(%pi)*D1*f/60//mm/s
9  //Let D denote d/dr
10 DV=Vo/dr//s^-1
11 tow=0.005//Nm
12 L=92.37//mm
13 s=2*tow/D1^2/(%pi)/L*10^6//N/m^2
14 printf("The stress at the surface of the inner
       cylinder is %f N/m^2",s);
```

Scilab code Exa 1.3 `Surface tension`

```
1  clc
2  //problem on surface tension
3  l=0.10;//m (length of sliding part)
4  f=0.00589;//N (pull due to 0.6 gm of mass)
5  f_onefilm=f/2;//N
6  //surface tension=(force for one film)/(length)
7  sigma=f_onefilm/l;
8  disp("The surface tension of fluid is")
9  disp(sigma)
10 disp("N/m")
```

Scilab code Exa 1.4 `speed conversion`

```
1  clc
```

10

```
2 //Example 1.4
3 //Convert 327 miles/hr into ft/s
4 V=327// miles/hr
5 //1 mile = 5280 ft
6 //1 hour = 3600 sec
7 V1=V*(5280/3600)// ft/s
8 printf("327 miles/hr = %f ft/s",V1);
```

Scilab code Exa 1.5 `Time conversion`

```
1 clc
2 //Example 1,5
3 //Convert 2.6 hours into seconds
4 t=2.6// hr
5 //1 hr = 3600 s
6 t1=2.6*3600// s
7 printf("2.6 hours = %f seconds",t1);
```

Scilab code Exa 1.6 `Acceleration`

```
1 clc
2 //Example 1.6
3 //Calculate the acceleration in ft/min^2
4 m=10// lbm
5 F=3.5// lbf
6 //1 lbf.s^2 = 32.2 lbm.ft
7 //1 min = 60 sec
8 a=(F/m)*32.2*60^2// ft/min^2
9 printf("The acceleration provided is %f ft/min^2",a)
    ;
```

Scilab code Exa 1.7 Electrolysis

```
1  clc
2  //Example 1.7
3  //Calculate the wt of metallic aluminium deposited
       in an electrolytic cell
4  I=50000//Ampere or Coulumbs/sec
5  //1 hr = 3600 sec
6  I1=50000*3600//C/hr
7  //96500 C = 1 gm.eq
8  //1 mole of aluminium = 3 gm.eq
9  //1 mole of aluminium = 27 gm
10 m=I1*(1/96500)*(27/3)/1000//Kg/hr
11 printf("the wt of metallic aluminium deposited in an
        electrolytic cell is %f Kg/hr",m);
```

Chapter 2

Fluid statics

Scilab code Exa 2.1 Specific weight

```
1  clc
2  g=32.2;//ft/s^2
3  rho_water=62.3;//lbm/ft^3
4  //specific weoight=(density)*(acceleration due to
       gravity)
5  specific_wt=rho_water*g;//lbm.ft/ft^3.s^2
6  //1 lbf=32.2 lbm.ft/s^2
7  specific_wt=specific_wt/32.2;//lbf/ft^3
8  disp("Specific weight of water is")
9  disp(specific_wt)
10 disp("lbf/ft^3")
```

Scilab code Exa 2.2 Pressure at depth

```
1  clc
2  //calc pressure at depth of 304.9m
3  d=304.9;//m
4  rho_water=1024;//Kg/m^3
```

```
5  g=9.81;//m/s^2
6  p_atm=101.3;//KPa
7  //gauge pressure=(desity)*(acc. due to gravity)*(
       depth)
8  p_depth=p_atm+rho_water*g*d/1000;//KPa
9  disp("pressure at the depth is")
10 disp(p_depth)
11 disp("KPa")
```

Scilab code Exa 2.3 Gauge pressure

```
1  clc
2  //gauge pressure=(density)*(acc. due to gravity)*(
       depth)
3  rho_oil=55;//lbm/ft^3
4  g=32.2;//ft/s^2
5  d=60;//ft (depth of oil cylinder)
6  gauge_pressure=rho_oil*g*d/32.2;//lbf/ft^2
7  disp("Gauge pressure is")
8  disp(gauge_pressure)
9  disp("lbf/ft^2")
10 //1 ft=12 in
11 gauge_pressure=gauge_pressure/144;//lbf/in^2
12 disp("Gauge pressure is")
13 disp(gauge_pressure)
14 disp("lbf/in^2")
```

Scilab code Exa 2.4 Density of air

```
1  clc
2  //calc of density of air at a certain height
3  p_atm=14.7;//psia
4  T=289;//K
```

```
5  //P2=P1*exp^(-(acc. due to gravity)*(mass of air)*(
       height)/(universal gas const.)/(temp.))
6  g=9.81;//m/s^2
7  R=8314;//N.m^2/Kmol/K
8  //for height of 1000 ft=304.8m
9  h=304.8;//m
10 p_1000=14.7*exp(-g*29*h/R/289);
11 disp("pressure at 1000ft is")
12 disp(p_1000)
13 disp("psia")
14 //for height of 10000 ft=3048m
15 h=3048;//m
16 p_10000=p_atm*exp(-g*29*h/R/289);
17 disp("pressure at 10000ft is")
18 disp(p_10000)
19 disp("psia")
20 //for height of 100000 ft=30480m
21 h=30480;//m
22 p_100000=14.7*exp(-g*29*h/R/289);
23 disp("pressure at 100000ft is")
24 disp(p_100000)
25 disp("psia")
```

Scilab code Exa 2.5 Pressure at height

```
1  clc
2  //calc pressuer at different heights considering on
       density change in air
3  p_atm=14.7;//psia
4  g=9.81;//m/s^2
5  //P2=P1*[1-(acc. due to gravity)*(mass of air)*(
       height)/(univ. gas const.)/(temp.)]
6  T=289;//K
7  R=8314//N.m^2/Kmol/K
8  //for height of 1000ft=304.8m
```

```
9  h=304.8//m
10 p_1000=p_atm*[1-g*29*h/R/T];
11 disp("pressure at 1000ft is")
12 disp(p_1000)
13 disp("psia")
14 //for height of 10000ft=3048m
15 h=3048//m
16 p_10000=p_atm*[1-g*29*h/R/T];
17 disp("pressure at 10000ft is")
18 disp(p_10000)
19 disp("psia")
20 //for height of 100000ft=30480m
21 h=30480//m
22 p_100000=p_atm*[1-g*29*h/R/T];
23 disp("pressure at 100000ft is")
24 disp(p_100000)
25 disp("psia")
26 //NOTE that the pressure comes out to be negative at
       100000ft justifying that density of air changes
       with altitude
```

Scilab code Exa 2.6 `Pressure`

```
1  clc
2  //calc atm pressure on a storage tank roof
3  p_atm=14.7;//psia
4  //diameter of roof is 120ft
5  d_roof=120;//ft
6  //force=(pressure)*(area)
7  f_roof=p_atm*(%pi)*d_roof^2/4*144;//lbf ;144 because
       1ft=12inch
8  disp("Force exerted by atmosphere on the roof is")
9  disp(f_roof)
10 disp("lbf")
```

Scilab code Exa 2.7 Pressure

```
1  clc
2  // calc atm pressure on a storage tank roof
3  p_atm=14.7;// psia
4  // diameter of roof is 120 ft
5  d_roof=120;// ft
6  // force=(atm. pressure + gauge pressure)*(area)
7  // gauge pressure=(desity)*(acc. due to gravity)*(
       depth)
8  rho_water=62.3//lbm/ft^3
9  g=32.2;// ft/s^2
10 // depth of water on roof=8 inch=o.667 ft
11 h=0.667;// ft
12 gauge_pressure=rho_water*g*h/32.2*(%pi)*d_roof^2/4;
       // lbf
13 disp(gauge_pressure)
```

Scilab code Exa 2.8 Force

```
1  clc
2  // calc the total force on a lock gate
3  // lock gate has water on one side and air on the
       other at atm. pressure
4  w=20;//m (width of the lock gate)
5  h=10;//m (height of the lock gate)
6  p_atm=1;//atm
7  rho_water=1000;//Kg/m^3
8  g=9.81//m/s^2
9  // for a small strip of dx height at the depth of x
       on the lock gate
```

```
10  //net pressure on strip = (p_atm+(rho_water)*g*x) −
        p_atm
11  //thus, net pressure on strip = (rho_water)*g*x
12  //force on strip = (rho_water*g*x)*w.dx = (rho_water
        )*g*w*(x.dx)
13  //force on lock gate = integration of force on strip
        fromm h=0 to h=10
14  //integration(x.dx) = x^2/2
15  //for h=0 to h=10; integration (x.dx) = h^2/2
16  force_lockgate=(rho_water)*g*w*h^2/2;
17  disp("The net force on the lock gate is")
18  disp(force_lockgate/10^6)
19  disp("MN")
```

Scilab code Exa 2.9 Thickness

```
1   clc
2   //calc thickness of an oil storage
3   sigma_tensile=20000;//lbf/in^2 (tensile stress is
        normally 1/4 rupture stress)
4   //max pressure is observed at the bottom of the
        storage
5   p_max=22.9;//lbf/in^2
6   //diameter of storaeg tank = 120ft =1440in
7   d=1440;//in
8   t=(p_max)*d/sigma_tensile/2;//in
9   disp("Thichness of the storage tank is")
10  disp(t)
11  disp("in")
```

Scilab code Exa 2.10 Thickness

```
1   clc
```

```
 2 //calc thickness of a storage tank
 3 p_working=250;//lbf/in^2
 4 //diameter of the cylinder = 10ft = 120in
 5 d=120;//in
 6 sigma_tensile=20000;//lbf/in^2
 7 t=p_working*d/sigma_tensile/2;//in
 8 disp("Thichness of the storage tank is")
 9 disp(t)
10 disp("in")
```

Scilab code Exa 2.11 Payload

```
 1 clc
 2 //calc payload of a helium balloon
 3 p_atm=1;//atm
 4 T=293;//K
 5 d=3;//m (diameter of the balloon)
 6 //buoyant force=(density of air)*g*(volume of
      balloon)
 7 //weight of balloon = (density of helium)*g*(volume
      of balloon)
 8 //density for gases = PM/RT
 9 //payload of balloon = buoyant force - weight
10 V_balloon=(%pi)*d^3/6;//m^3
11 R=8.2*10^(-2);//m^3.atm/mol/K
12 M_air=29;//Kg/Kmol
13 M_he=4;//Kg/Kmol
14 g=9.81;//m/s^2
15 payload=(V_balloon)*g*p_atm*(M_air-M_he)/R/T;//N
16 disp("Payload of the balloon is")
17 disp(payload)
18 disp("N")
```

Scilab code Exa 2.12 Fraction of block inside water

```
1 clc
2 //wooden block floating in two phase mix of water
      and gasoline
3 //calc fraction of block in water
4 SG_wood=0.96;//Specific gravity
5 SG_gasoline=0.72;
6 //Let r be the ratio - V_water/V_wood
7 r=(SG_wood-SG_gasoline)/(1-SG_gasoline);
8 disp("Fraction of wood in water")
9 disp(r)
```

Scilab code Exa 2.13 Gauge pressure

```
1 clc
2 //calc gauge pressure of cylinder in a manometer
3 //height of water above pt.C = 2.5 ft
4 rho_water=62.3;//lbm/ft^3;
5 h1=2.5;//ft
6 rho_gas=0.1;//lbm/ft^3
7 h2=0.5;//ft (height of gas)
8 g=32.2;//ft/s^2
9 gauge_pressure=[(rho_water)*g*h1+(rho_gas)*g*h2
      ]/144/32.2;//lbf/in^2
10 disp("Gauge pressure is")
11 disp(gauge_pressure)
12 disp("lbf/in^2")
```

Scilab code Exa 2.14 Pressure difference

```
1 clc
```

```
2  //calc pressure diff between two tanks in a two
      liquid manometer
3  rho_water=62.3;//lbm/ft^3
4  SG_oil=1.1;
5  rho_oil=SG_oil*(rho_water);
6  g=32.2;//ft/s^2
7  h1_1=1;//ft
8  h1_2=2;//ft
9  h2_1=2;//ft
10 h2_2=1;//ft
11 p_diff=[(rho_water)*g*(h1_1-h1_2)+(rho_oil)*g*(h2_1-
      h2_2)]/32.2/144;//lbf/in^2
12 disp("The pressure difference is")
13 disp(p_diff)
14 disp("lbf/in^2")
```

Scilab code Exa 2.15 Gauge pressure

```
1  clc
2  //calc pressure of gauge through a spring piston
      system
3  k=10000;//N/m (spring constant)
4  x=0.025;//m (displacement in spring)
5  A=0.01;//m^2 (area of piston)
6  gauge_pressure=k*x/A/1000;//KPa
7  disp("The gauge pressure is")
8  disp(gauge_pressure)
9  disp("KPa")
```

Scilab code Exa 2.16 Pressure difference

```
1  clc
2  //calc pressure diff at the mouth of the fire place
```

```
3  g=32.2;//ft/s^2
4  h=20;//ft (height of fireplace)
5  rho_air=0.075;//lbm/ft^3
6  T_air=293;//K (surrounding temperature)
7  T_fluegas=422;//K
8  p_diff=g*h*(rho_air)*[1-(T_air/T_fluegas)]/32.2/144;
      //lbf/in^2
9  disp("The pressure difference is")
10 disp(p_diff)
11 disp("lbf/in^2")
```

Scilab code Exa 2.17 Gauge pressure

```
1  clc
2  rho_water=1000;//Kg/m^3
3  g=9.81;//m/s^2
4  h=5;//m (depth of water)
5  //for elevator not accelerated
6  p_gauge=(rho_water)*g*h/1000;//KPa
7  disp("THe gauge pressure is")
8  disp(p_gauge)
9  disp("KPa")
10 //for elevator accelerated at 5m/s^2 in upward
      direction
11 a=5;//m/s^2
12 p_gauge=(rho_water)*(g+a)*h/1000;//KPa
13 disp("THe gauge pressure is")
14 disp(p_gauge)
15 disp("KPa")
16 //for elevator accelerated at 5m/s^2 in downward
      direction
17 a=5;//m/s^2
18 p_gauge=(rho_water)*(g-a)*h/1000;//KPa
19 disp("THe gauge pressure is")
20 disp(p_gauge)
```

```
21  disp("KPa")
```

Scilab code Exa 2.18 `Angle`

```
1  clc
2  //angle free surface makes with the horizontal in an
        accelerated body
3  a=1;//ft/s^2
4  g=32.2;//ft/s^2
5  theta=atan(a/g);//radians
6  theta=theta*180/%pi;//degrees
7  disp("The angle made by free surface with the
      horizontal is")
8  disp(theta)
9  disp("degrees")
```

Scilab code Exa 2.19 `Height of liquid`

```
1  clc
2  //calc the height to which liq in a cylinder rises
      when rotated
3  f=78/60;//rps
4  r=0.15;//m
5  g=9.81;//m/s^2
6  //omega=2*(%pi)*f
7  z=[(2*(%pi)*f)^2]*r^2/2/g;//m
8  disp("The liquid in the cylinder rises to a height
      of")
9  disp(z)
10 disp("m")
```

Scilab code Exa 2.20 Thickness

```
1  clc
2  // calc thickness of liquid strip at the bottom of
      the industrial centrifuge
3  // Let difference between heights at bottom and top
      be d
4  d=20; // in
5  r_a=14; // in
6  f=1000/60; // rps
7  g=32.2; // ft/s^2
8  r_b=[(r_a)^2-2*(d)*g*12/(2*(%pi)*f)^2]^0.5; // in
9  disp("The thickness of water strip at bottom of
      industrial centrifuge")
10 disp(r_b)
11 disp("in")
```

Chapter 3

The balance equation and mass balance

Scilab code Exa 3.4 volumetric flow rate

```scilab
1  clc
2  //Calculate vol. flow rate, mass flow  rate and
       average vel of gasoline through pipe
3  V=15;//gal volume of gasoline
4  t=2;//min
5  rho_water=62.3;//lbm/ft^3
6  sg=0.72;//specific gravity
7  q=(15/2)*(0.1336/60)//ft^3/s vol. flow rate
8  printf("volumetric flow rate is %f ft^3/s\n",q);
9  m=q*sg*rho_water//lbm/s
10 printf("Mass flow rate is %f lbm/s\n",m);
11 d=1;//in diameter of pipe
12 a=((%pi)*d^2/4)/144;//ft^2 area of pipe
13 v_avg=q/a//ft/s
14 printf("The average velocity is %f ft/s",v_avg);
```

Scilab code Exa 3.5 `Velocity and Mass flow rate`

```
1  clc
2  //Example 3.5
3  //calculate velocity and mass flow rate of natural
       in a pipe
4  d1=2;//ft diameter of pipe at position 1
5  a1=(%pi)/4*d1^2;//ft^2
6  v1=50;//ft/s vel of gas at position 1
7  rho1=2.58;//lbm/ft^3 density of gas at position 1
8  d2=3;//ft diameter of pipe at position 2
9  a2=(%pi)/4*d2^2;
10 rho2=1.54;//lbm/ft^3 density at position 2
11 v2=(rho1/rho2)*(a1/a2)*v1//ft/s
12 printf("Velocity is %f ft/s\n",v2);
13 m=rho1*v1*a1//lbm/s mass flow rate
14 printf("The mass flow rate is %f lbm/s",m);
```

Scilab code Exa 3.6 `Velocity and Mass flow rate`

```
1  clc
2  //Example 3.6
3  //calculate the mass flow rate, volumetric flow rate
       and velocity of waterin a pipe
4  d1=0.25;//m diameter of pipe at position 1
5  v1=2;//m/s velocity
6  rho=998.2;//kg/m^3  density of water
7  a1=(%pi)/4*d1^2;//m^2
8  d2=0.125//m diameter of pipe at position 2
9  a2=(%pi)/4*d2^2;//m^2
10 m=rho*a1*v1//kg/s mass flow rate
11 printf("Mass flow rate is %f kg/s\n",m);
12 q=m/rho//m^3/s volumetric flow rate
13 printf("The volumetric flow rate is %f m^3/s\n",q);
14 v2=(a1/a2)*v1//m/s velocity
```

```
15 printf("Velocity of water is %f m/s",v2);
```

Scilab code Exa 3.7 `Time required`

```
1 clc
2 //Example 3.7
3 //calulate the time required
4 p_initial=1;//atm pressure initially
5 p_final=0.0001;//atm pressure finally
6 V=10;//ft^3 volume of system
7 q=1;//ft^3/min vol. flow rate
8 t=(V/q)*log(p_initial/p_final)//min
9 printf("The time required is %f min",t);
```

Scilab code Exa 3.8 `Steady state pressure`

```
1 clc
2 //Example 3.8
3 //calculate the final or steady state pressure in
     tank
4 m_in=0.0001;//lbm/min
5 q_out=1;//ft^3/min
6 rho_sys=m_in/q_out//lbm/ft^3
7 rho_air=0.075;//lbm/ft^3
8 p_initial=1;//atm
9 p_steady=p_initial*(rho_sys/rho_air)//atm
10 printf("The steady state pressure is %f atm",
     p_steady);
```

Scilab code Exa 3.9 `Velocity of rising water`

```
1  clc
2  //Example 3.9
3  //calculate how fast the level of water is rising or
        falling in a cylindrical tank
4  d=3;//m diameter of tank
5  a=(%pi)*d^2/4;//m^2
6  d_in=0.1;//m inner diameter of inflow pipe
7  d_out=0.2;//m
8  v_in=2;//m/s
9  v_out=1;//m/s
10 q_in=((%pi)*d_in^2/4)*v_in;//m^3/s
11 q_out=((%pi)*d_out^2/4)*v_out;//m^3/s
12 //let D represent d/dt
13 DV=q_in-q_out;//m^3/s
14 if DV>1 then
15   printf("The water level in tank is rising\n");
16 else if DV<1 then
17     printf("The water level in tank is falling\n");
18     else
19       printf("No accumulation\n");
20       end
21 //let h be the height of water in tank
22 Dh=DV/a//m/s
23 printf("The rate of level of water is rising or
      falling in a cylindrical tank is %f m/s",Dh);
```

Scilab code Exa 3.11 `volumetric flow rate`

```
1  clc
2  //Example 3.11
3  //calculate flow rate of ventilation air supply
4  q=5/8;//kg/hr mass evaporation rate of benzene
5  c=1.3*10^(-6);//kg/m^3 concentration of benzene
6  Q=q/c/3600//m^3/s
7  printf("The flow rate of ventilation air supply is
```

```
%f m^3/s",Q);
```

Chapter 4

The first law of thermodynamics

Scilab code Exa 4.1 Change in potential energy

```
1  clc
2  //Example 4.1
3  //calculate change in pot. energy per unit mass and
       total change in pot. energy
4  g=9.81;//m/s^2 acc. due to gravity
5  dh=23;//m change in height
6  dpe=g*dh//m^2/s^2 change in pot energy per unit mass
7  printf("change in pot. energy per unit mass is %f m
       ^2/s^2\n",dpe);
8  m=10;//kg
9  dPE=m*dpe//kgm^2/s^2 or J change in pot. energy
10 printf("The total change in potential energy is %f J
       ",dPE);
```

Scilab code Exa 4.2 Kinetic energy

```
1  clc
2  //Example 4.2
3  //calculate the kinetic energy of bullet
4  m=0.01; //lbm mass of bullet
5  v=2000; //ft/s
6  KE=(m*v^2/2)*(1.356/32.2) //J
7  printf("the kinetic energy of bullet is %f J",KE);
```

Scilab code Exa 4.3 Kinetic energy

```
1  clc
2  //Example 4.3
3  //Calculate the kinetic energy of bullet fired from
       a airplane
4  v_bp=2000; //ft/s vel of bullet wrt plane
5  v_p=-1990; //ft/s
6  v_b=v_bp+v_p //ft/s vel of bullet wrt ground
7  m=0.01; //lbm
8  KE=(m*v_b^2/2)*(1.356/32.2) //J
9  printf("the kinetic energy of bullet fired from a
       airplane is %f J",KE);
```

Scilab code Exa 4.4 Change in internal energy

```
1  clc
2  //Example 4.4
3  //calculate the change in internal energy of the
       system
4  p=14.7; //lbf/in^2 atmospheric pressure
5  dV=1; //ft^3 change in volume
6  dW=p*dV*(144/778) //Btu work done
7  dQ=-42; //Btu heat removed from the system
```

```
8  dU=dQ-dW//Btu change in internal energy of the
       system
9  printf("the change in internal energy of the system
       is %f Btu",dU);
```

Scilab code Exa 4.5 `Work`

```
1  clc
2  //Example 4.5
3  //calculate the work done
4  //work done=change in pot. energy + change in
       kinetic energy considering steady flow and
       adiabatic conditions
5  v_in=3;//m/s
6  v_out=10;//m/s
7  dke=(v_in^2-v_out^2)/2;//m^2/s^2
8  g=9.81;//m/s^2
9  dh=15;//m change in height in inlet and outlet
10 dpe=g*dh;//m^2/s^2
11 W=dpe+dke//J/kg
12 printf("The work done is %f J/Kg",W);
```

Scilab code Exa 4.6 `Mass consumed in nuclear reactor`

```
1  clc
2  //Example 4.6
3  //calculate the mass consumed in a nuclear reactor
       per unit time
4  //let D=d/dt
5  DQ=-13*10^8;//J/s
6  DW=7*10^8;//J/s
7  //Dm=(DQ-DW)/c^2 where c is velocity of light sice E
       =mc^2
```

```
 8  c=3*10^8; //m/s
 9  c1=3;// velocity  of  light  without  power
10  pow=8//power  of  10  in  speed  of  light
11  Dm=(DW-DQ)/c/c1//kg/s
12  printf("the  mass  consumed  in  a  nuclear  reactor  per
        unit  time  is  %f * 10^(-%d)  kg/s",Dm,pow);
```

Chapter 5

Bernoulli Equation

Scilab code Exa 5.1 `Increase in temperature`

```
1 clc
2 //Example 5.1
3 //Calculate the increase in temperature due to
      falling water of waterfall
4 g=9.81;//m/s^2 acc. due to gravity
5 dz=100;//m Height of waterfall
6 du=g*dz;//J/kg Change in internal energy
7 Cv=4184;//J/kg/K;
8 dT=du/Cv//K Change in temperature
9 printf("Change in temperature is %f K or degree
      centigrade",dT);
```

Scilab code Exa 5.2 `Velocity`

```
1 clc
2 //Example 5.2
3 //calculate velocity of air coming out from the
      nozzle
```

```
 4  T=528;//R Rankine scale
 5  R=10.73;// psi.ft^3/R/lbmol universal gas constant
 6  p=14.71;// psi
 7  p_atm=14.7;// psi
 8  M=29;//lbm/lbmol
 9  //considering the velocity at the start of the
       nozzle is negligible
10  v=((2*R*T/p/M)*(p-p_atm)*(144*32.2))^0.5;//ft/s
11  printf("Velocity of the air flowing out of the pipe
       %f ft/s",v);
```

Scilab code Exa 5.3 `Velocity`

```
1  clc
2  //Example 5.3
3  //Calculate the velocity of water flowing out of a
       nozzle at the bottom of a tank
4  g=32.2;//ft/s^2
5  h=30;//ft height tank
6  //considering the velocityof water at the top of the
        tank is negligible
7  v=(2*g*h)^0.5;//ft/s
8  printf("The velocity of the water flowing out
       through the nozzle is %f ft/s",v);
```

Scilab code Exa 5.4 `Velocity`

```
1  clc
2  //Example 5.4
3  //calculate velocity of water flowing out of nozzle
4  A_nozzle=1//ft^2
5  A_tank=4//ft^2
6  g=32.2//ft/s^2
```

```
7  h=30//ft
8  v=(2*g*h/(1-(A_nozzle/A_tank)^2))^0.5//ft/s
9  printf("The velocity of water flowing out of nozzle
       is %f ft/s",v);
```

Scilab code Exa 5.5 `Velocity`

```
1  clc
2  //Example 5.5
3  //calculate the velocity of water flowing out of a
       nozzle
4  g=32.2//ft/s^2
5  h=30//ft
6  M_air=29//dimentionless (molecular weight)
7  M_CO2=44//dimentionless (molecular weight)
8  v=(2*g*h*(1-(M_air/M_CO2)))^0.5//ft/s
9  printf("The velocity of water flowing out of nozzle
       is %f ft/s",v);
```

Scilab code Exa 5.6 `Velocity`

```
1  clc
2  //Example 5.6
3  //calculate velocity of sailboat using pitot tube
4  h=1//m height of water above the water level
5  g=9.81//m/s^2
6  v=(2*g*h)^0.5//m/s
7  printf("The velocity of sailboat is %f m/s",v);
```

Scilab code Exa 5.7 `Velocity`

```
1  clc
2  //Example  5.7
3  //Calculate  velocity  of  air  flowing  through  an  air
       duct
4  dP=0.05//psi  or  lbf/in^2
5  rho_air=0.075//lbm/ft^3
6  //1ft  =  12in
7  //1  lbf.s^2  =  32.2  lbm.ft
8  v=(2*dP*144*32.2/rho_air)^0.5//ft/s
9  printf("The  velocity  of  air  in  the  air  duct  is  %f  ft
       /s",v);
```

Scilab code Exa 5.8 volumetric flow rate

```
1  clc
2  //Example  5.8
3  //calculate  volumetric  flow  rate  using  a  venturi−
       meter
4  dP=1//psi
5  rho_water=62.3//lbm/ft^3
6  d1=1//ft  area  at  pt  1  in  venturimeter
7  A1=(%pi)*d1^2/4//ft^2
8  d2=0.5//ft
9  A2=(%pi)*d2^2/4//ft^2
10 //1ft  =  12in
11 //1  lbf.s^2  =  32.2  lbm.ft
12 v=((2*dP*144*32.2/rho_water)/(1-(A2/A1)^2))^0.5//ft/
       s
13 printf("The  velocity  of  the  water  flowing  through
       venturimeter  is  %f  ft/s\n",v);
14 q=v*A2//ft^3/s
15 printf("The  volumetric  flow  rate  of  water  is  %f  ft
       ^3/s",q);
```

Scilab code Exa 5.9 `volumetric flow rate`

```
1  clc
2  //Example 5.9
3  //calculate actual volumetric flow rate using a
       venturi-meter
4  dP=1//psi
5  rho_water=62.3//lbm/ft^3
6  d1=1//ft area at pt 1 in venturimeter
7  A1=(%pi)*d1^2/4//ft^2
8  d2=0.5//ft
9  A2=(%pi)*d2^2/4//ft^2
10 //1ft = 12in
11 //1 lbf.s^2 = 32.2 lbm.ft
12 v_th=((2*dP*144*32.2/rho_water)/(1-(A2/A1)^2))^0.5//
       ft/s
13 Cv=0.984//dimentionless
14 v_act=Cv*v_th//ft/s actual velocity
15 printf("The velocity of the water flowing through
       venturimeter is %f ft/s\n",v_act);
16 q=v_act*A2//ft^3/s
17 printf("The volumetric flow rate of water is %f ft
       ^3/s",q);
```

Scilab code Exa 5.10 `Pressure difference`

```
1  clc
2  //Example 5.10
3  //Calculate the pressure difference in a pipe
4  v1=1//m/s
5  d1=0.4//m
6  A1=(%pi)*d1^2/4//m^2
```

```
7  d2=0.2//m
8  A2=(%pi)*d2^2/4//m^2
9  v2=A1*v1/A2//m/s
10 Cv=0.62//dimentionless
11 rho_water=998.2//kg/m^3
12 dP=(rho_water*v2^2/2/Cv^2)*(1-(A2/A1)^2)/1000//KPa
13 printf("The pressure difference in the pipe is %f
      KPa",dP);
```

Scilab code Exa 5.11 `volumetric flow rate`

```
1  clc
2  //Example 5.11
3  //Calculate the flow rate of helium with rotameter
      caliberated with nitogen
4  M_N2=28//dimentionless
5  M_He=4//dimentionless
6  //Density is proportional to molecular weight
7  q_N2=100//cm^3/min
8  q_He=q_N2*(M_N2/M_He)^0.5//cm^3/min
9  printf("The flow rate of Helium is %f cm^3/min",q_He
      );
```

Scilab code Exa 5.12 `Absolute pressure`

```
1  clc
2  //Example 5.12
3  //Calculate the absolute pressure at the top of a
      inverted manometer tube
4  p_atm=14.7//lbf/in^2
5  g=32.2//ft/s^2
```

39

```
6  //one end of the inverted manometer is immersed in a
       tank and the other end is open to atmosphere 10
      ft below tank level
7  //pt 1 is at tank water level, pt 2 is at top of
      inverted manometer and pt3 is at the other end of
       manometer
8  dh=10//ft
9  v3=(2*g*dh)^0.5//ft/s
10 p1=p_atm//lbf/in^2
11 rho_water=62.3//lbm/ft^3
12 //Difference of height between pt 1 and pt 2 is 40
      ft
13 dh1=40//dft
14 p2=p1-(rho_water*v3^2/2/32.2/144)-(rho_water*g*dh1)
      /32.2/144//lbf/in^2
15 printf("The absolute pressure at the top of the
      inverted manometer is %f lbf/in^2",p2);
```

Scilab code Exa 5.13 Pressure at throat

```
1  clc
2  //Example 5.13
3  //Calculate pressure at the throat in a venturimeter
4  dP=10//psi or lbf/in^2
5  rho_water=62.3//lbm/ft^3
6  //1ft = 12in
7  //1 lbf.s^2 = 32.2 lbm.ft
8  v3=(2*dP*144*32.2/rho_water)^0.5//ft/s
9  printf("The velocity of water after the throat is %f
       ft/s\n",v3);
10 ratio_A=0.5//dimentionless (ratio of throat area to
      pipe area)
11 v2=v3/ratio_A//ft/s
12 printf("The velocity of water at the throat is %f ft
      /s\n",v2);
```

```
13  P1 =24.7 // psia
14  rho_water =62.3 //lbm/ ft ^3
15  P2=P1 -( rho_water )* v2 ^2/32.2/144/2 // psia
16  printf (" The  pressure  of  water  at  the  throat  is  %f
         psia ",P2 );
```

Chapter 6

Fluid friction in steady on dimentional flow

Scilab code Exa 6.1 `Pressure drop`

```
1  clc
2  //Example 6.1
3  //calculate the drop in pressure per unit length in
      a pipe
4  q=50//gal/min flow rate
5  d=3.068//in inner diameter
6  a=(%pi)*(3.068/12)^2/4//ft^2
7  //1 ft^3 = 7.48 gal
8  //1 min = 60 sec
9  v_avg=q/a/60/7.48//ft/s
10 mew=50//cP
11 //1 cP = 0.000672 lbm/ft/s
12 rho=62.3//lbm/ft^3
13 R=(d/12)*v_avg*rho/(mew*0.000672)//dimentionless
      reynold's no.
14 if (R<2000)
15   printf("Laminar flow\n");
16 else
17   printf("Turbulent flow\n");
```

```
18  end
19  dx=3000// ft  length  of  pipe
20  //1  gal  =  231  in^3
21  //1  cP. ft^3  =  0.0000209  lbf.s
22  dp=(q/60)*(128/%pi)*(mew/d^4)*dx*231*0.0000209/12//
        lbf/in^2  or  psi
23  //let  D  represent  d/dx
24  Dp=(dp/dx)*100// psi/ft
25  printf("The  pressure  gradient  in  the  pipe  is  %f  psi
        /100 ft ",Dp);
```

Scilab code Exa 6.2 `Viscosity`

```
1  clc
2  //Example  6.2
3  //calculate  viscosity  of  fluid  using  a  viscometer
4  rho=1050//Kg/m^3
5  g=9.81//m/s^2
6  dz=0.12//m  change  in  height
7  d=0.001//m  inner  diameter  of  capillary  of  viscometer
8  q=10^(-8)//m^3/s
9  dx=0.1//m  length  of  capillary
10  mew=(rho*g*dz*(%pi)*d^4)*1000/128/(q*dx)//cP
11  printf("The  viscosity  of  the  fluid  is  %f  cP",mew);
```

Scilab code Exa 6.3 `Fanning friction factor`

```
1  clc
2  //Example  6.3
3  //Calculate  the  fanning  friction  factor
4  R=10^5//dimentionless  reynold 's  no.
5  ratio_ED=0.0002//dimentionless
```

```
6 f=0.001375*(1+(20000*ratio_ED+10^6/R)^(1/3))//
     dimentionless
7 printf("The fanning friction factor is %f",f);
```

Scilab code Exa 6.4 `Gauge pressure`

```
1 clc
2 //Example 6.4
3 //Calculate the gauge pressure in the tank
4 q=300//gal/min flow rate
5 d=3.068//in inner diameter
6 a=(%pi)*(3.068/12)^2/4//ft^2
7 //1 ft^3 = 7.48 gal
8 //1 min = 60 sec
9 v_avg=q/a/60/7.48//ft/s
10 f=0.0091//dimentionless fanning friction factor
11 dx=3000//ft
12 rho=62.3//lbm/ft^3
13 dp=4*f*(dx/(d/12))*rho*(v_avg^2/2)/32.2/144//lbf/in
     ^2 or psi
14 printf("The gauge pressure in the tank is %f psi",dp
     );
```

Scilab code Exa 6.5 `volumetric flow rate`

```
1 clc
2 //Example 6.5
3 //Calculate volumetric flow rate of gasoline through
     a pipe
4 d=0.1//m internal diameter of pipe
5 A=%pi*d^2/4//m^2
6 dx=100//m length of pipe
7 f=0.005//dimentionless fanning friction factor
```

```
 8  dz=10//m difference in water level
 9  g=9.81//m/s^2
10  v=((2*g*dz/4/f)*d/dx)^0.5//m/s
11  printf("The velocity of gasoline through pipe is %f
        m/s\n",v);
12  q=A*v//m^3/s
13  printf("The volumteric flow arte od gasoline through
          the pipe is %f m^3/s",q);
```

Scilab code Exa 6.6 `Pressure difference`

```
 1  clc
 2  //Example 6.6
 3  //Calculate pressure difference across the duct
 4  p=14.75//lbf/in^2
 5  M=29//lbm/lbmol
 6  R=10.73//lbf.ft^3/(in^2.lbmol.R)
 7  T=500//R Rankine temperature scale
 8  rho=p*M/(R*T)//lbm/ft^3
 9  q=500//ft^3/min
10  d=1//ft
11  A=(%pi)*d^2/4//ft^2
12  v=(q/60)/A//ft/s
13  mew=0.017//cP
14  //1cP = 0.000672 lbm/ft/s
15  R=d*v*rho/(mew*0.000672)//dimentionless reynold's no
        .
16  f=0.00465//fanning friction factor
17  dx=800//ft lenght of duct
18  //1 ft = 12 in
19  //1 lbf.s^2 = 32.2 lbm.ft
20  dP=rho*(4*f*(dx/d)*(v^2/2))/32.2/144//lbf/in^2
21  printf("The pressure drop across the duct is %f lbf/
        in^2",dP);
```

Scilab code Exa 6.8 Power

```
1  clc
2  //Example 6.8
3  //Calculate the pump power required
4  q=200//gal/min
5  rho=62.3//lbm/ft^3
6  //1 ft^3 = 7.48 gal
7  m=(q/60)*rho/7.48//lbm/s
8  dx=2000//ft
9  dp=3.87//psi/100ft
10 F=(dp/100)*dx/rho*32.2*144//ft
11 //1 hp = 550 lbf.ft/s
12 Po=F*m/550//hp
13 printf("The pump power required is %f hp",Po);
```

Scilab code Exa 6.9 Pressure drop

```
1  clc
2  //Example 6.9
3  //Calculate the drop in pressure per unit length in
       a pipe
4  dp=0.1//psi
5  dx=800//ft
6  //let D represent d/dx
7  //1 psi = 6895 Pa
8  //1 m = 3.28 ft
9  Dp=(dp/dx)*6895*3.28//Pa/m
10 printf("The drop in pressure per unit length in the
       pipe is %f Pa/m",Dp);
```

Scilab code Exa 6.10 `Pressure difference`

```scilab
1  clc
2  //Example 6.10
3  //Calculate the pressure difference created due to
        expansion and contraction
4  rho=62.3//lbm/ft^3
5  K=1.5//dimentionless
6  v=13//ft/s
7  //1 ft = 12 in
8  //1 lbf.s^2 = 32.2 lbm.ft
9  dp=rho*K*(v^2/2)/32.2/144//lbf/in^2
10 printf("The pressure drop due to expansion and
        contraction is %f lbf/in^2",dp);
```

Scilab code Exa 6.11 `Pressure drop`

```scilab
1  clc
2  //Example 6.11
3  //Calculate the pressure drop in the pipe due to
        fittings
4  dx=3000//ft actual length of pipe
5  dx1=281//ft equivalent length of fittings
6  p=484//psi
7  dx_total=dx+dx1//ft
8  dp_total=p*(dx_total/dx)//psi
9  dp_vnf=dp_total-p//psi pressure drop fue to valves
        and fittings
10 printf("The pressure drop due to valves and fittings
         is %f psi",dp_vnf);
```

Scilab code Exa 6.12 `Pressure drop`

```
1  clc
2  //Example 6.12
3  //Calculate pressure drop due to valves and fittings
4  K=27.56//deimentionless
5  rho=62.3//lbm/ft^3
6  v=13//ft/s
7  //1 ft = 12 in
8  //1 lbf.s^2 = 32.2 lbm.ft
9  dp=rho*K*(v^2/2)/32.2/144//psi
10 printf("THe pressure drop due to valves and fittings
       is %d psi",dp);
```

Scilab code Exa 6.13 `Leakage rate`

```
1  clc
2  //Example 6.13
3  //Calculate the gasoline leakage rate through a seal
4  p=100//lbf/in^2
5  l=1//in length od seal in direction of leak
6  mew=0.6//cP
7  d=0.25//in diameter of valve stem
8  t=0.0001//in thickness of valva stem
9  //1 cP = 0.0000209 lbf.s/ft^2
10 //1 ft = 12 in
11 q=(p/l)*(1/12/mew)*(%pi)*d*t^3/0.0000209*144*3600//
       in^3/hr
12 printf("The volumetric leakage rate of gasoline is
       %f in^3/hr\n",q);
13 rho=0.026//lbm/in^3
14 m=q*rho//lbm/hr
```

```
15  printf("The mass leakage rate of gasoline is %f lbm/
        hr",m);
```

Chapter 7

The momentum balance

Scilab code Exa 7.2 `Velocity`

```
1  clc
2  //Example 7.2
3  //Calulate the final velocity of duck after being
      hit by a bullet
4  m_duck=3//lbm
5  v_duck=-15//ft/s due west
6  m_bullet=0.05//lbm
7  v_bullet=1000//ft/s due east
8  //total initial momentum = final momentum
9  v_sys=((m_duck*v_duck)+(m_bullet*v_bullet))/(m_duck+
      m_bullet)//ft/s
10 printf("The final velocity of the duck is %f ft/s",
      v_sys);
```

Scilab code Exa 7.3 `Force`

```
1  clc
2  //Example 7.3
```

```
3  // calculate  the  force  required  to  hold  of  water  from
       a  hoze
4  rho =998.2// Kg/m^3
5  q=0.01//m^3/ s
6  v_initial =30//m/ s
7  v_final =0//m/ s
8  F=q*rho *( v_final - v_initial )//N
9  printf ("The  force  required  to  hold  of  water  from  a
      hoze  %f  N",F);
```

Scilab code Exa 7.4 Force

```
1  clc
2  // Example  7.4
3  // calculate  the  force  required  to  hold  of  water  from
       a  hoze
4  rho =998.2// Kg/m^3
5  q=0.01//m^3/ s
6  v_initial =30//m/ s
7  v_final = -15//m/ s
8  F=q*rho *( v_final - v_initial )//N
9  printf ("The  force  required  to  hold  of  water  from  a
      hoze  %f  N",F);
```

Scilab code Exa 7.5 Force

```
1  clc
2  // Example  7.5
3  // Calculate  the  force  exerted  on  the  flange  when  the
       valve  of  the  nozzle  is  closed
4  // Let  the  gauge  pressure  be  denoted  by  Pg
5  Pg=100// lbf/in^2
6  A=10//in^2
```

```
 7  // F_bolts = −F_liq−F_atm
 8  // F_bolts = −(Pg + P_atm)A − (−P_atm.A)
 9  // F_bolts = −Pg.A
10  F_bolts=-Pg*A
11  printf("The force exerted on the flange when the
        valve of the nozzle is closed is %f lbf",F_bolts)
        ;
```

Scilab code Exa 7.6 Force

```
 1  clc
 2  // Example 7.6
 3  // Calculate the force exerted on the flange
 4  dP=100// lbf/in^2
 5  A_out=1// in^2
 6  rho=62.3// lbm/ft^3
 7  ratio_A=0.1// dimentionless
 8  //1 ft = 12 in
 9  //1 lbf.s^2 = 32.2 lbm.ft
10  v_out=(2*dP/rho/(1-ratio_A^2)*32.2*144)^0.5// ft/s
11  v_in=12.3// ft/s
12  m=rho*A_out*v_out/144// lbm/s
13  F=m*(v_out-v_in)/32.2// lbf
14  printf("The force exerted on the flange is %f lbf",F
        );
```

Scilab code Exa 7.7 Support forces

```
 1  clc
 2  // Example 7.7
 3  // Calculate the support forces in x and y direction
        in a 90 degree bend tube
 4  p1=200//KPa
```

```
5  A =0.1//m^2
6  m=500//Kg/s
7  rho=998.2//Kg/m^3
8  q=m/rho//m^3/s
9  v=q/A//m/s
10 Vx_initial=v//m/s
11 Vx_final=0//m/s
12 Vy_initial=0//m/s
13 Vy_final=-v//m/s
14 Fx=m*(Vx_final-Vx_initial)-p1*1000*A//N
15 printf("The support force in the x direction is %f N
       \n",Fx);
16 Fy=m*(Vy_final-Vy_initial)-p1*1000*A//N
17 printf("The support force in the y direction is %f N
       ",Fy);
```

Scilab code Exa 7.8 Thrust

```
1  clc
2  //Example 7.8
3  //Calculate the thrust on a rocket
4  m=1000//Kg/s
5  v_out=-3000//m/s its in the negative y direction
6  v_in=0//m/s
7  A=7//m^2
8  P=35000//Pa
9  F_thrust=(-m*(v_out-v_in)+P*A)/1000000//MN
10 printf("The thrust on the rocket is %f MN",F_thrust)
       ;
```

Scilab code Exa 7.9 Specific impulse

```
1  clc
```

```
2  //Example 7.9
3  //Calculate the specific impulse for a rocket
4  Vy_exh=-3000//m/s in negative y direction
5  Isp=-Vy_exh/1000//KN.s/Kg
6  printf("The specific impulse on the rocket is %f KN.
        s/Kg",Isp);
```

Scilab code Exa 7.10 `Mass flow rate`

```
1  clc
2  //Example 7.10
3  //Calculate the Mass air flow rate required by a jet
        engine
4  F_thrust=20000//lbf
5  Vx_out=1350//ft/s
6  Vx_in=0//ft/s
7  //1 lbf.s^2 = 32.2 lbm.ft
8  m=F_thrust/(Vx_out-Vx_in)*32.2//lbm/s
9  printf("The mass air flow rate required by a jet
        engine is %f lbm/s",m);
```

Scilab code Exa 7.12 `Velocity`

```
1  clc
2  //Example 7.12
3  //Calculate the final velocity of a rocket after
        launch
4  Isp=430//lbf.s/lbm specific impulse
5  v_initial=0//m/s
6  //1 lbf.s^2 = 32.2 lbm.ft
7  Vrel_out=-Isp*32.2//ft/s
8  ratio_m=0.1//dimentionless (ratio of final mass to
        initial mass)
```

```
9  v_final=Vrel_out*log(ratio_m)//ft/s
10 printf("The velocity of the rocket after launch is
      %f ft/s",v_final);
```

Scilab code Exa 7.15 `Velocity`

```
1  clc
2  //Example 7.15
3  //Calculate the velocity and height of flow in an
      open channel
4  v1=4//ft/s
5  g=32.2//ft/s^2
6  z1=0.0005//ft
7  Fr=v1^2/(g*z1)//dimentionless (Fraude number)
8  ratio_z=-0.5+(0.25+2*Fr)^0.5//dimentionless
9  //ratio_z = z2/z1
10 z2=ratio_z*z1//ft
11 printf("The height of flow in open channel is %f ft\
      n",z2);
12 v2=v1/(ratio_z)//ft/s
13 printf("The velocity of flow in open channel is %f
      ft/s",v2);
```

Scilab code Exa 7.16 `Verticle downward velocity`

```
1  clc
2  //Example 7.16
3  //calculate the verticle downward velocity of air
      hitting an aircraft wing
4  l=15//m length of wing
5  b=3//m thickness of wing
6  A=l*b//m^2 area of the colliding surface of the wing
7  rho_air=1.21//Kg/m^3
```

```
8  Vx=50//m/s
9  m=rho_air*A*Vx//Kg/s
10 Fy=9810//N Weight of the aircraft
11 Vy=Fy/m//m/s
12 printf("The verticle downward velocity of air
       hitting the aircraft wing is %f m/s",Vy);
```

Scilab code Exa 7.17 ratio of weight of aircraft to engine

```
1  clc
2  //Example 7.17
3  //Calculate the ratio of the total weight of the
       aircraft to the weight of engine
4  //Let ratio of weight to thrust be denoted by r1
5  //Let ratio of thrust to the engine weight be
       denoted by r2
6  r1=10//dimentionless
7  r2=2//dimentionless
8  //weight/engine wt = (weight/thrust)*(thrust/engine
       wt)
9  //let ratio of total wt to engine wt be denoted by
       r3
10 r3=r1*r2//dimentionless
11 printf("The ratio of the total weight of the
       aircraft to the weight of engine is %f",r3);
```

Scilab code Exa 7.18 Torque

```
1  clc
2  //Example 7.18
3  //Calculate the torque exerted on the rotor in a
       centrifugal pump
4  q=100//gal/min
```

```
 5  rho =8.33// lbm / gal
 6  m=rho*q// lbm / min
 7  f =1800// rev / min  frequency  of  impeller
 8  omega =2*(%pi)*f// rad / min
 9  r_in =1/12// ft
10  r_out =6/12// ft
11  //1  min  =  60  sec
12  //1  lbf.s^2  =  32.2  lbm.ft
13  tou=m*omega*(r_out^2-r_in^2)/32.2/3600// lbf.ft
14  printf(" The  torque  exerted  on  the  rotor  is  %f  lbf.ft
         ",tou);
```

Chapter 8

One dimentional high velocity gas flow

Scilab code Exa 8.1 Speed of sound

```
1  clc
2  //Example 8.1
3  //Calculate the speed of sound in water amd steel at
        20 C
4  //for steel
5  K_steel=1.94*10^11//Pa
6  rho_steel=7800//Kg.m^3
7  c_steel=(K_steel/rho_steel)^0.5/1000//Km/s
8  printf("the speed of sound in steel at 20 C is %f km
        /s\n",c_steel);
9  //for water
10 K_water=3.14*10^5//lbf/in^2
11 rho_water=62.3//lbm/ft^3
12 //1 ft =12 in
13 //1 lbf.s^2 = 32.2 lbm.ft
14 c_water=(K_water/rho_water*144*32.2)^0.5//ft/s
15 printf("the speed of sound in water at 20 C is %f ft
        /s",c_water);
```

Scilab code Exa 8.2 Speed of sound

```
1  clc
2  //Example 8.2
3  //Calculate the speed of sound in air at 20 C
4  R=10.73//lbf.ft^3/in^2/lbmol/R
5  //1 ft = 12 in
6  //1 lbf.s^2 = 32.2 lbm.ft
7  R1=(R*144*32.2)^0.5//ft/s*(lbm/lbmol/R)^0.5
8  k=1.4//dimentionless
9  T=528//R (Rankine temperature scale)
10 M=29//lbm/lbmol
11 c=R1*(k*T/M)^0.5//ft/s
12 printf("the speed of sound in air at 20 C is %f ft/s
       ",c);
```

Scilab code Exa 8.3 Temperature of gas

```
1  clc
2  //Example 8.3
3  //Calculate the temperature of the gas where is mach
       number is 2
4  Ma=2//dimentionless (Mach number)
5  k=1.4//dimentionless
6  T1=528//R (Rankine temperature scale)
7  T2=T1/((Ma^2*(k-1)/2)+1)//R (Rankine temperature
       scale)
8  printf("The temperature of the gas when mach number
       is 2 is %f R",T2);
```

Scilab code Exa 8.4 `Speed of sound`

```
1  clc
2  //Example 8.4
3  //Calculate the speed of sound in air at 20 C
4  R=10.73//lbf.ft^3/(in^2.lbmol.R)
5  //1 ft = 12 in
6  ////1 lbf.s^2 = 32.2 lbm.ft
7  R_root=(R*144*32.2)^0.5//ft/s*(lbm/lbmol.R)^0.5
8  Ma=2//dimentionless (Mach number)
9  k=1.4//dimentionless
10 T=298//R (Rankine temperature scale)
11 M=29//lbm/lbmol
12 c=R_root*(k*T/M)^0.5//ft/s
13 printf("%f",c);
14 v=c*Ma//ft/s
15 printf("The speed of sound in air at 20 C is %f ft/s
        ",v);
```

Scilab code Exa 8.5 `Pressure and density`

```
1  clc
2  //Example 8.5
3  //Calculate the pressure and density at a pt where
        temperature ratio is 1.8 and initial pressure and
         density are given
4  ratio_T=1.8//dimentionless
5  P1=2//bar
6  k=1.4//dimentionless
7  P2=P1/ratio_T^(k/(k-1))//bar
8  printf("The pressure where temperature ratio is 1.8
        and initial pressure is 2 bar is %f bar\n",P2);
9  rho1=2.39//Kg/m^3
10 rho2=rho1/ratio_T^(1/(k-1))//Kg/m^3
11 printf("The density where temperature ratio is 1.8
```

and initial density is 2.39 Kg/m^3 is %f Kg/m^3",
rho2);

Scilab code Exa 8.6 Cross sectional area

```
1  clc
2  //Example 8.6
3  //Calculate the cross sectional area, pressure,
      temperature and mach number at a pt in duct where
       air velocity is 1400 ft/s
4  P1=30//psia
5  T1=660//R (Rankine temperature scale)
6  m=10//lbm/s mass flow rate
7  v1=1400//ft/s
8  R=4.98*10^4//(ft^2/s^2)*(lbm/lbmol.R)^0.5
9  k=1.4//dimentionless
10 M=29//lbm/lbmol
11 T2=T1-v1^2*((k-1)/k)*M/2/R//R (Rankine temperature
      scale)
12 printf("The temperature at the pt in the duct where
      air velocity is 1400 ft/s is %f R\n",T2);
13 c=223*(k*T2/M)^0.5//ft/s
14 Ma=v1/c//dimentionless (Mach number)
15 printf("The mach number at the pt in the duct where
      air velocity is 1400 ft/s is %f\n",Ma);
16 P2=P1/(T1/T2)^(k/(k-1))//psia
17 printf("The pressure at the pt in the duct where air
       velocity is 1400 ft/s is %f psia\n",P2);
18 //1 lbf.s^2 = 32.2 lbm.ft
19 A0=m/(P1*(M*k)^0.5*32.2/223/(T1)^0.5/((k-1)/2+1)^((k
      +1)/2/(k-1)))//in^2
20 ratio_A=((Ma^2*(k-1)/2+1)/((k-1)/2+1))^((k+1)/2/(k
      -1))/Ma//dimentionless
21 A=ratio_A*A0//in^2
22 printf("The cross sectional at the pt in the duct
```

where air velocity is 1400 ft/s is %f in^2",A);

Scilab code Exa 8.7 Cross sectional area

```
1  clc
2  //Example 8.7
3  //Calculate the cross sectional area, pressure,
       temperature and mach number at a pt in duct where
        air velocity is 1400 ft/s
4  P1=30//psia
5  T1=660//R (Rankine temperature scale)
6  ratio_T=0.83333//dimentionless
7  m=10//lbm/s mass flow rate
8  v1=1400//ft/s
9  R=4.98*10^4//(ft^2/s^2)*(lbm/lbmol.R)^0.5
10 k=1.4//dimentionless
11 M=29//lbm/lbmol
12 T2=T1*ratio_T//R (Rankine temperature scale)
13 printf("The temperature at the pt in the duct where
        air velocity is 1400 ft/s is %f R\n",T2);
14 c=223*(k*T2/M)^0.5//ft/s
15 Ma=v1/c//dimentionless (Mach number)
16 printf("The mach number at the pt in the duct where
        air velocity is 1400 ft/s is %f\n",Ma);
17 ratio_t=0.7528//dimentionless
18 ratio_P=0.3701//dimentionless
19 ratio_A=1.0587//dimentionless
20 T=T1*ratio_t//R (Rankine temperature scale)
21 printf("T=%f\n",T);
22 P=P1*ratio_P//psia
23 printf("P=%f",P);
```

Scilab code Exa 8.8 Cross sectional area

```
1  clc
2  //Example 8.8
3  //Calculate the cross sectional area, pressure,
       temperature and mach number at a pt in duct where
        air velocity is 1400ft/s
4  P1=30//psia
5  T1=660//R (Rankine temperature scale)
6  m=10//lbm/s mass flow rate
7  v1=4000//ft/s
8  R=4.98*10^4//(ft^2/s^2)*(lbm/lbmol.R)^0.5
9  k=1.4//dimentionless
10 M=29//lbm/lbmol
11 T2=T1-v1^2*((k-1)/k)*M/2/R//R (Rankine temperature
       scale)
12 printf("The temperature at the pt in the duct where
       air velocity is 1400 ft/s is %f R\n",T2);
13 c=223*(k*T2/M)^0.5//ft/s
14 Ma=v1/c//dimentionless (Mach number)
15 P2=P1/(T1/T2)^(k/(k-1))//psia
16 //1 lbf.s^2 = 32.2 lbm.ft
17 A0=m/(P1*(M*k)^0.5*32.2/223/(T1)^0.5/((k-1)/2+1)^((k
       +1)/2/(k-1)))//in^2
18 ratio_A=((Ma^2*(k-1)/2+1)/((k-1)/2+1))^((k+1)/2/(k
       -1))/Ma//dimentionless
19 A=ratio_A*A0//in^2
```

Scilab code Exa 8.9 Temperature of gas

```
1  clc
2  //Example 8.9
3  //Calculate the temperatures at different pts in a
       duct with different mach numbers
4  //for mach number=0.5
5  ratio_T=0.9524//dimentionless
6  T1=293.15//K
```

```
7  T2=T1/ratio_T//K
8  printf("The temperature at the pt in the duct where
      mach number is 0.5 is %f K\n",T2);
9  //for mach number 2
10 ratio_t=0.5556//dimentionless
11 t2=293.15//K
12 t1=t2*ratio_t//K
13 printf("The temperature initially at the start of
      the nozzle is %f K",t1);
```

Scilab code Exa 8.12 Temperature and pressure of gas

```
1  clc
2  //Example 8.12
3  //Calculate the reservoir temperature and the
      pressure of air around the aircraft
4  gama=1.4//dimentionless
5  Ma=2//dimentionless (Mach number)
6  To=273.15//K
7  Tr=To*(Ma^2*(gama-1)/2+1)//K
8  printf("the reservoir temperature of air around the
      aircraft is %f K\n",Tr);
9  P1=50//KPa
10 Pr=P1*(Tr/To)^(gama*5/2)//KPa
11 printf("The pressure of air around the aircraft is
      %f KPa",Pr);
```

Scilab code Exa 8.13 Temperature and velocity of air

```
1  clc
2  //Example 8.13
3  //Calculate temperature and the velocity of air
      inside the shock wave
```

```
4  //Let subscript y denote air inside the shock wave
        and x denote the air outside the shock wave
5  ratio_T=1.2309//dimentionless
6  Tx=528//R (Rankine temperature scale)
7  Ty=ratio_T*Tx//R (Rankine temperature scale)
8  printf("temperature of air inside the shock wave is
        %f R\n",Ty);
9  My=0.7558//dimentionless
10 cy=1249//ft/s
11 Vy=My*cy//ft/s
12 printf("the velocity of air inside the shock wave is
         %f ft/s",Vy);
```

Scilab code Exa 8.14 Ratio of area of nozzle

```
1  clc
2  //Example 8.14
3  //Calculate the ratio of area of throat to area of a
         certain point
4  A_throat=1//in^2
5  A_exit=1.5//in^2
6  ratio_A=2.2385//dimentionless
7  ratio_A1=ratio_A*(A_throat/A_exit)//dimentionless
8  printf("the ratio of area of throat to area of a
        certain point is %f",ratio_A1);
```

Chapter 10

Pumps compressors and turbines

Scilab code Exa 10.1 `Efficiency of pump`

```
1  clc
2  //Example  10.1
3  //Calculate  the  efficiency  of  a  pump
4  Q=50// gal/min
5  P1=30// psia  0r  lbf/in^2
6  P2=100// psia  0r  lbf/in^2
7  dP=P2-P1// psia  0r  lbf/in^2
8  power=2.8// hp
9  //1  ft  =  12  in
10 //1  hp.min  =  33000  lbf.ft
11 //1  gal  =  231  in^3
12 eta=(Q*dP/power)*(1/33000)*231*(1/12)// dimentionless
13 printf(" The  efficiency  of  the  pump  is  %f", eta);
```

Scilab code Exa 10.2 `Elevation`

```
1  clc
2  //Example 10.2
3  //Calculate the maximum elevation above the lowest
      water level in sump at which pump inlet can be
      placed
4  P1=3.72//psia 0r lbf/in^2
5  P2=14.5//psia 0r lbf/in^2
6  dP=P2-P1//psia 0r lbf/in^2
7  rho=61.3//lbm/ft^3
8  g=32.2//ft/s^2
9  //1 ft = 12 in
10 //1 lbf.s^2 = 32.2 lbm.ft
11 h_loss=4//ft
12 v=10//ft/s
13 h_max=(dP/rho/g)*144*32.2-(v^2/2/g)-h_loss//ft
14 printf("the maximum elevation above the lowest water
        level in sump at which pump inlet can be placed
      is %f ft",h_max);
```

Scilab code Exa 10.3 Work

```
1  clc
2  //Example 10.3
3  //Calculate the work requird per pound mole for a
      100% efficient isothermal and adiabatic
      compressor
4  R=1.987//Btu/lbmol/R (universal gas constant)
5  T=528//R (Rankine temperature scale)
6  ratio_P=10//dimentionless
7  //for isothermal compressor
8  W1=R*T*log(ratio_P)//Btu/lbmol
9  printf("The work required per pound mole for a 100
      percent efficient isothermal compressor is %f ",
      W1);
10 printf("Btu/lbmol\n");
```

```
11  //for adiabatic compressor
12  gama=1.4//dimentionless
13  W2=(gama/(gama-1))*R*T*(ratio_P^((gama-1)/gama)-1)//
       Btu/lbmol
14  printf("The work required per pound mole for a 100
       percent efficient adiabatic compressor is %f ",W2
       );
15  printf("Btu/lbmol");
```

Scilab code Exa 10.4 Work

```
1  clc
2  //Example 10.4
3  //Calculate the work requird per pound mole for a
       100% efficient 2 stage adiabatic compressor
4  R=1.987//Btu/lbmol/R (universal gas constant)
5  T=528//R (Rankine temperature scale)
6  ratio_P1=3//dimentionless
7  ratio_P2=10/3//dimentionless
8  gama=1.4//dimentionless
9  W=(gama/(gama-1))*R*T*((ratio_P1^((gama-1)/gama)-1)
       +(ratio_P2^((gama-1)/gama)-1))//Btu/lbmol
10  printf("The work required per pound mole for a 100
       percent efficient adiabatic compressor is %f ",W)
       ;
11  printf("Btu/lbmol");
```

Scilab code Exa 10.5 Pump head

```
1  clc
2  //Example 10.5
3  //Calculate the pump head
4  N=1750//rev/min
```

```
5  //1 min 60 sec
6  omega=2*(%pi)*N/60//radians/sec
7  Q=100//gal/min
8  //1 gallon = 231 in^3
9  //1 ft =12 in
10 //1 min = 60 sec
11 d_inlet = 2.067//ft
12 A_inlet=(%pi)/4*(d_inlet^2)//ft^2
13 V1=(Q/A_inlet)*231/60/12//ft/s
14 d_outlet = 1.61//ft
15 A_outlet=(%pi)/4*(d_outlet^2)//ft^2
16 V2=(Q/A_outlet)*231/60/12//ft/s
17 g=32.2//ft/s^2
18 d_inner=0.086//ft
19 d_outer=0.336//ft
20 h=(omega)^2/g*((d_outer^2)-(d_inner)^2)+(V2^2-V1^2)
      /2/g//ft
21 printf("The pump head is %f ft",h);
```

Scilab code Exa 10.6 `Pump head`

```
1  clc
2  //Example 10.6
3  //Calculate the pump head
4  rho=62.3//lbm/ft^3
5  g=32.2//ft/s^2
6  v=18.46//ft/s
7  //1 lbf/s^2 = 32.2 lbm.ft
8  h=(v^2/2)*32.2/rho/g//ft
9  printf("The pump head is %f ft",h);
```

Scilab code Exa 10.7 `Pressure rise`

```
1  clc
2  //Example 10.7
3  //Calculate the estimated pressure rise in the first
       stage of mutisatge centrifugal compressor
4  rho=0.075//lbm/ft^3
5  omega=1047//rad/sec
6  d=2//ft
7  dP=(1/2)*(rho)*(omega*d/2)^2/32.2/144//psia
8  //1 lbf.s^2 = 32.2 lbm into feed
9  //1 ft = 144 in^2
10 printf("the estimated pressure rise in the first
       stage of mutisatge centrifugal compressor is %f
       psia",dP);
```

Scilab code Exa 10.8 Efficiency of compressor

```
1  clc
2  //Example 10.8
3  //Calculate the efficiency of a compressor and the
       change respective change in temperature
4  m=100//Kg/hr
5  M=29//gm/mol
6  gama=1.4//dimentionless
7  R=8.314//J/mol/K
8  T=293.15//K
9  ratio_P=4//dimentionless
10 Po=(m/M)*R*T*(gama/(gama-1))*((ratio_P)^((gama-1)/
       gama)-1)/3600//kW
11 P_real=5.3//kW
12 eta=Po/P_real//dimentionless
13 printf("The efficiency of the compressor is %f\n",
       eta);
14 Cp=29.1//J/mol/K
15 dT_real=P_real*(M/m)*3600/Cp//K
16 printf("dT_real = %f K\n",dT_real);
```

```
17 dT_isentropic=Po*(M/m)*3600/Cp//K
18 printf("dT_isentropic = %f K",dT_isentropic);
```

Chapter 11

Flow through porous media

Scilab code Exa 11.1 `volumetric flow rate`

```
1  clc
2  //Example 11.1
3  //Calculate the volumetric flow rate
4  g=32.2//ft/s^2
5  dz=1.25//ft
6  Dp=0.03//in (Diameter of particle)
7  eta=0.33//dimentionless
8  rho=62.3//lbm/ft^3
9  mew=1.002//cP
10 dx=1//ft
11 //1 cP.ft.s = 6.72*10^(-4)//lbm
12 //1 ft = 12 in
13 Vs=g*dz*(Dp/12)^2*eta^3*rho/(150*mew*(1-eta)^2*dx
       *6.72*10^(-4))//ft/s
14 printf("The velocity of water is %f ft/s\n",Vs);
15 d=2//in (diameter of pipe)
16 A=(%pi)/4*(d/12)^2//ft^2
17 Q=Vs*A//ft^3/s
18 printf("The volumetric flow rate is %f ft^3/s\n",Q);
19 R=(Dp/12)*Vs*rho/(mew*6.72*10^(-4)*(1-eta))//
       dimentionless (Reynold's number)
```

```
20 printf(" Reynolds number is %f",R);
```

Scilab code Exa 11.2 Pressure gradient

```
1  clc
2  //Example 11.2
3  //Calculate the pressure gradient
4  Vs=2//ft/s
5  dp=0.03//in (diameter of particle)
6  rho=62.3//lbm/ft^3
7  eta=0.33//dimentionless
8  //let DP denote pressure gradient
9  //1 ft = 12 in
10 //1 lbf.s^2 = 32.2lbm.ft
11 DP=1.75*rho*Vs^2*(1-eta)/((dp/12)*eta^3*32.2*144)//
      psi/ft
12 printf("The pressure gradient is %f psi/ft",DP);
```

Scilab code Exa 11.3 Permeability

```
1  clc
2  //Example 11.3
3  //Calculate the permeability
4  Q=1//ft^3/min
5  mew=0.018//cP
6  dx=0.5//in
7  A=1//ft^2
8  dP=2//lbf/in^2
9  //1 ft = 12 in
10 //1 min = 60 sec
11 //1 ft^2.cP = 2.09*10^(-5) lbf.s
12 //1 darcy = 1.06*10^(-11) ft^2
```

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```
13  k=(Q*mew*(dx/12)/A/dP)*(1/144)*2.09*10^(-5)*(1/60)
        *(1/(1.06*10^(-11)))) //darcy
14  printf("The permeability is %f darcy",k);
```

Chapter 12

Gas liquid flow

Scilab code Exa 12.1 Eta and slip velocity

```
1  clc
2  //Example 12.1
3  //Calculate the eta and slip velocity
4  ratio_Q=10//dimentionless (ratio of Qg to Ql)
5  x=3.5/ratio_Q//dimentionless
6  eta=1/(1+x)//dimentionless
7  printf("Eta = %f\n",eta);
8  Vl=2.06//ft/s
9  Vl_avg=Vl/(1-eta)//ft/s
10 Vg_avg=ratio_Q*Vl/eta//ft/s
11 V_slip=Vg_avg-Vl_avg//ft/s
12 printf("The slip velocity is %f ft/s",V_slip);
```

Chapter 13

Non newtonian fluid flow in circular pipes

Scilab code Exa 13.1 Pressure gradient

```
1  clc
2  //Example 13.1
3  //Calculate the pressure gradient
4  v=1//ft/s
5  d=0.5//ft
6  A=(%pi)/4*d^2//ft^2
7  Q=v*A//ft^3/s
8  //Let DP denote the pressure gradient
9  n=0.41//dimentionless
10 K=0.66//kg/m/s
11 //1 m = 3.281 ft
12 Q1=Q/3.281^3//m^3/s
13 d1=d/3.281//m
14 DP=(Q1*8*(3*n+1)/(n*(%pi)*d1^3))^n*(4*K/d1)//Pa/m
15 printf("The pressure gradient is %f Pa/m",DP);
```

Scilab code Exa 13.3 Fanning friction factor and reynolds number by power law

```
1  clc
2  //Example 13.3
3  //Calculate the fanning friction factor and reynolds
        number by power law
4  DP=61.3//Pa/m (pressure gradient)
5  D=0.152//m
6  V_avg=0.305//m/s
7  rho=1000//kg/m^3
8  f=DP*D/(4*rho*V_avg^2/2)//dimentionless
9  printf("The fanning friction factor is %f\n",f);
10 n=0.41//dimentionless
11 K=0.66//dimentionless
12 R_pl=8*rho*V_avg^(2-n)*D^n/(K*(2*(3*n+1)/n)^n)//
        dimentionless
13 printf("The reynolds number is %f\n",R_pl);
14 if (R_pl<2000)
15     printf("The flow is Laminar");
16 else
17     printf("The flow is turbulent");
18 end
```

Scilab code Exa 13.4 Pressure gradient

```
1  clc
2  //Example 13.4
3  //Calculate the pressure gradient
4  D=0.152//m
5  V_avg=3.04//m/s
6  rho=1000//kg/m^3
7  n=0.41//dimentionless
8  K=0.66//dimentionless
9  R_pl=8*rho*V_avg^(2-n)*D^n/(K*(2*(3*n+1)/n)^n)//
        dimentionless
```

```
10  printf("The reynolds number is %f\n",R_pl);
11  f=0.004//dimentionless (fanning friction factor)
12  //Let DP denote the pressure gradient
13  DP=4*f*(rho/D)*(V_avg^2/2)/1000//KPa/m
14  printf("The pressure gradient is %f KPa/m",DP);
```

Scilab code Exa 13.5 Headstrom Reynold number and fanning friction factor

```
1   clc
2   //Example 13.5
3   //Calculate the headstrom ,reynold numbers and the
        fanning friction factor
4   tow_yield=3.8//Pa
5   mew=0.00686//Pa.s
6   D=0.0206//m
7   rho=1530//kg/m^3
8   V=3.47//m/s
9   He=tow_yield*D^2*rho/mew^2//dimentionless (headstrom
        number)
10  printf("The headstrom number is %f\n",He);
11  R=D*V*rho/mew//dimentionless (reynolds number)
12  printf("The reynolds number is %f\n",R);
13  dP=11069//Pa/m
14  f=dP*D/(4*rho*V^2/2)//dimentionless (fanning
        friction factor)
15  printf("The fanning friction factor is %f",f);
```

Chapter 15

Two and three dimentional fluid mechanics

Scilab code Exa 15.4 `Time required`

```
1  clc
2  //Example 15.4
3  //Calculate the time taken by water in a long pipe
       to reach its steady state velocity
4  //let (new)*t/r0^2 be denoted by y
5  y=0.05//dimentionless
6  r0=0.077//m
7  mew=1//Pa.s
8  rho=1000//Kg/m^3
9  new=mew/rho//m^2/s
10 t=y*r0^2/new//s
11 printf("the time taken by water in a long pipe to
       reach its steady state velocity is % f seconds",t
       );
```

Chapter 17

The boundary layer

Scilab code Exa 17.1 Boundary layer thickness

```
1  clc
2  //Example 17.1
3  //Calculate the boundary layer thickness
4  //for the aeroplane
5  v=1.61*10^(-4)//ft^2/s
6  x=2//ft
7  V=200//miles/hr
8  //1 mile = 5280 ft
9  //1 hr = 3600 sec
10 delta_aeroplane=5*(v*x/(V*5280/3600))^0.5
11 printf("The boundary layer thickness for the
        aeroplane is %f ft\n",delta_aeroplane);
12 //for the boat
13 v1=1.08*10^(-5)//ft^2/s
14 x1=2//ft
15 V1=10//miles/hr
16 //1 mile = 5280 ft
17 //1 hr = 3600 sec
18 delta_boat=5*(v1*x1/(V1*5280/3600))^0.5
19 printf("The boundary layer thickness for the boat is
        %f ft\n",delta_boat);
```

Scilab code Exa 17.2 `Force`

```
1  clc
2  //Example 17.2
3  //Calculate the force required to tow a square metal
        plate by a boat
4  rho_water=998.2//Kg/m^3
5  V=15//km/hr
6  v=1.004*10^(-6)//m^2/s
7  l=1//m length of plate
8  //1 km = 1000 m
9  //1 hr = 3600 s
10 Rx=(V*1000/3600)*l/v//dimentionless (reynold's
       number)
11 Cf=1.328/Rx^0.5//dimentionless
12 F=Cf*rho_water*(V*1000/3600)^2//N
13 printf("The force required to tow the square plate
       is %f N",F);
```

Scilab code Exa 17.3 `Laminar sublayer and buffer layer`

```
1  clc
2  //Example 17.3
3  //Calculate the distance between the wall and edge
       of the laminar sublayer and buffer layer
4  V=10//ft/s
5  l=0.25//ft
6  v=1.08*10^(-5)//ft^2/s
7  R=V*l/v//dimentionless (reynold's number)
8  f=0.0037//dimentionless (fanning friction factor)
9  u1=V*(f/2)^0.5//ft/s
```

```
10  u01=5//dimentionless
11  y01=5//dimentionless
12  r1=y01*v/u1//ft
13  printf("the distance between the wall and edge of
        the laminar sublayer is %f ft\n",r1);
14  //for buffer layer
15  u02=12//dimentionless
16  y02=26//dimentionless
17  r2=y02*v/u1//ft
18  printf("the distance between the wall and edge of
        the buffer layer is %f ft",r2);
```

Scilab code Exa 17.4 Boundary layer thickness and drag

```
1  clc
2  //Example 17.4
3  //Calculate the boundary layer thickness and the
        drag on the plate
4  V=50//ft/s
5  l=20//ft
6  b=1//ft
7  v=1.08*10^(-5)//ft^2/s
8  R=V*l/v//dimentionless (reynold's number)
9  delta=0.37*l/R^0.2//ft
10 printf("The boundary layer thichness at the end of
        the plate is %f ft\n",delta);
11 Cf=0.072/R^0.2//dimentionless
12 rho_water=62.3//lbm/ft^3
13 V=50//ft/s
14 //let A be the area of contact
15 A=2*l*b//ft^2
16 //1 lbf.s^2 = 32.2 lbm.ft
17 F=(1/2)*Cf*rho_water*V^2*A/32.2//lbf
18 printf("The drag on the plate is %f lbf",F);
```

Chapter 18

Turbulence

Scilab code Exa 18.2 Energy per unit mass and dissipation rate

```
1  clc
2  //Example 18.2
3  //Calculate the energy per unit mass and heat
       dissipation rate
4  v=0.82//m/s
5  energy_per_unit_mass=v^2/2//J/Kg
6  printf("The energy per unit mass is %f J/Kg\n",
       energy_per_unit_mass);
7  //Let dissipation rate be denoted by eta
8  //Let D denote d/dL
9  DP=0.0286//Pa/m
10 rho=1.2//Kg/m^3
11 eta=DP*v/rho//m^2/s^3 or J/Kg/s
12 printf("The heat dissipation rate is %f J/Kg/s",eta)
       ;
```

Scilab code Exa 18.3 Turbulence

```
1  clc
2  //Example  18.3
3  //Calculate  the  value  of  k
4  Vx_rms=9.5//cm/s
5  Vy_rms=5//cm/s
6  k=(1/2)*((Vx_rms/100)^2+(Vy_rms/100)^2)//J/Kg
7  printf("k = %f J/Kg",k);
```

Scilab code Exa 18.4 `Kolmogorov scale`

```
1  clc
2  //Example  18.4
3  //Calculate  the  Kolmogorov  scale
4  v=1.613*10^(-4)//ft^2/s
5  eta=0.21//ft^2/s^3
6  kolmogorov_scale=(v^3/eta)^0.25//ft
7  printf("The Kolmogorov scale is %f ft",
       kolmogorov_scale);
```

Scilab code Exa 18.7 `turbulent kinematic viscosity`

```
1  clc
2  //Example  18.7
3  //Calculate  the  value  of  turbulent  kinematic
       viscosity
4  K=0.00576//m^2/s^2
5  eta=0.0196//m^2/s^3
6  C_mew=0.09//dimentionless
7  v_t=C_mew*(0.00576)^2/(0.0196)//m^2/s
8  printf("the value of turbulent kinematic viscosity
       is %f m^2/s",v_t);
```

Chapter 19

Mixing

Scilab code Exa 19.1 Time required for mixing

```
1  clc
2  //Example 19.1
3  //Calculate the time required for mixing
4  L=10^(-6)//m
5  D=1.2*10^(-9)//m^2/s
6  t=2*L^2/D//s
7  printf("The time required for mixing is %f seconds",
      t);
```

Scilab code Exa 19.2 Power required

```
1  clc
2  //Example 19.2
3  //Calculate the power required to run an impeller
4  D_tank=3//ft
5  D_impeller=D_tank/3//ft
6  N=4//rps
7  v=1.077*10^(-5)//ft^2/s
```

```
8  R_impeller=N*D_impeller^2//dimentionless (reynold's
       number)
9  //1 lbf.s^2 = 32.2 lbm.ft
10 //1 hp.s = 550 lbf.ft
11 rho_water=62.3//lbm/ft^3
12 P=5*rho_water*N^3*D_impeller^5/32.2/550//hp
13 printf("The power required to run an impeller is %f
       hp",P);
```

Scilab code Exa 19.3 `Impeller speed`

```
1  clc
2  //Example 19.3
3  //Calculate the impeller speed in a model of a large
       mixer if the power per unit volume remains the
       same
4  //let D1/D2 be denoted by ratio_D
5  ratio_D=5//dimentionless
6  N2=240//rpm
7  N1=N2/ratio_D^(2/3)//rpm
8  printf("the impeller speed in a model of a large
       mixer if the power per unit volume remains the
       same is %f rpm",N1);
```

Scilab code Exa 19.4 `Time required for blending`

```
1  clc
2  //Example 19.4
3  //Calculate the time required to blend two miscible,
       low viscosity liquids
4  D_tank=3//ft
5  D_impeller=D_tank/3//ft
6  H_tank=D_tank//ft
```

```
7  N=4//rps
8  t_blend=4.3*(D_tank/H_tank)*(D_tank/D_impeller)^2/N
       //s
9  printf("the time required to blend two miscible, low
        viscosity liquids is %f s",t_blend);
```

Scilab code Exa 19.5 Concentration

```
1  clc
2  //Example 19.5
3  //Calculate how far is the concentration of 0.1%
       from initial interface and the volume mixed
4  c=0.1//percent
5  c_interface=50//percent
6  c_original=0//percent
7  ratio_c=(c-c_interface)/(c_original-c_interface)//
       dimentionless
8  //erf(0.998)=2.15
9  //time required forfluid to travel 700 miles at 8ft/
       s is 4.57*10^5 sec
10 t=4.57*10^5//s
11 D=2*10^(-9)//m^2/s
12 x=2*2.15*(D*t)^0.5//m
13 printf("x=%f m\n",x);
14 v0=0.355//ft^3 of liquid/ft of pipe
15 //1 m = 3.281 ft
16 V_mixed=2*(3.281*x)*v0//ft^3
17 printf("the mixed volume is %f ft^3",V_mixed);
```

Scilab code Exa 19.6 Concentration

```
1  clc
2  //Example 19.6
```

```
3  //Calculate how far is the concentration of 0.1%
       from initial interface and the volume mixed
4  v=8//ft/s
5  f=0.0039//dimentionless (fanning friction factor)
6  D_turbulent=0.665*v*3.57*(f)^0.5//ft^2/s
7  //time required forfluid to travel 700 miles at 8ft/
       s is 4.57*10^5 sec
8  t=4.57*10^5//s
9  x=2*2.15*(D_turbulent*t)^0.5//ft
10 printf("x=%f m\n",x);
11 v0=0.355//ft^3 of liquid/ft of pipe
12 V_mixed=2*x*v0//ft^3
13 printf("the mixed volume is %f ft^3",V_mixed);
```

Scilab code Exa 19.7 Extent of mixing

```
1  clc
2  //Example 19.7
3  //Calculate how far downstream does the dye become
       uniformly distributed throughout the fluid
4  f=0.0039//dimentionless (fanning friction factor)
5  D=0.665//ft
6  L=D*0.56/(f)^0.5//ft
7  printf("L = %f ft",L);
```

Scilab code Exa 19.8 width of jet and entrainment ratio

```
1  clc
2  //Example 19.8
3  //Calculate the width of jet and entrainment ratio
4  Vo=40//ft/s
5  Do=1//ft
6  x=10//ft
```

```
 7  K=6.2//dimentionless
 8  V_centerline=Vo*K*(Do/x)//ft/s
 9  alpha=20//degrees
10  Dx=Do*(1+(x/Do)*sin(alpha*%pi/180))//ft
11  printf("The jet diameter is %f ft\n",Dx);
12  //Let entrainment ratio be r
13  r=0.62*(x/Do)^0.5//dimentionless
14  printf("The entrainment ratio is %f",r);
```

Scilab code Exa 19.9 Concentration

```
 1  clc
 2  //Example 19.9
 3  //Calculate the SO2 concentration at the centerline
 4  Q=20//gm/s
 5  u=3//m/s
 6  sigma_y=30//m
 7  sigma_z=20//m
 8  y=60//m
 9  z=20//m
10  H=0//m
11  c=Q/(2*%pi*u*sigma_y*sigma_z)*exp(-((y^2/2/sigma_y
       ^2)+((z-H)^2/2/sigma_z^2)))//gm/m^3
12  printf("the SO2 concentration at the centerline is
        %f gm/m^3",c);
```

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Chapter 20

Computational fluid dynamics

Scilab code Exa 20.1 fist and second derivative of fluid flow

```
1  clc
2  //Example 20.1
3  //Calculate first derivative and second derivative
      of the fluid flow
4  y_fd2=0.4336//m
5  y_fd1=0.4375//m
6  delta_yfd=y_fd2-y_fd1//m
7  x_fd2=0.75//m
8  x=0.5//m
9  delta_xfd=x_fd2-x//m
10 y_bd2=0.4375//m
11 y_bd1=0.2461//m
12 delta_ybd=y_bd2-y_bd1//m
13 x_bd1=0.25//m
14 delta_xbd=x-x_bd1//m
15 //Let D denote d/dx and D2 denote d^2/dx^2
16 Dy_fd=delta_yfd/delta_xfd//dimentionless
17 Dy_bd=delta_ybd/delta_xbd//dimentionless
18 Dy=(Dy_fd+Dy_bd)/2//dimentionless
19 printf("The first derivative of fluid flow is %f\n",
      Dy);
```

```
20  D2y=(Dy_fd-Dy_bd)/delta_xfd//dimentionless
21  printf("The second derivative of fluid flow is %f",
        D2y);
```

Scilab code Exa 20.3 Grid velocities

```
1   clc
2   //Example 20.3
3   //Calculate the grid velocities
4   v=1.077*10^(-5)//ft^2/s
5   t=2//sec
6   dy=0.01//ft
7   w=v*t/dy^2//dimentionless
8   //Let Vij represent velocity through the i,j grid
9   V00=5//ft/s
10  V10=5//ft/s
11  V01=0//ft/s
12  V02=0//ft/s
13  V12=0//ft/s
14  V11=V01+w*(V00-2*V01+V02)//ft/s
15  V21=V11+w*(V10-2*V11+V12)//ft/s
16  printf("The grid velocity for 2,1 is %f ft/s\n",V21)
        ;
17  V13=0//ft/s
18  V22=V12+w*(V11-2*V12+V13)//ft/s
19  printf("The grid velocity for 2,2 is %f ft/s\n",V22)
        ;
```