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

Chapter 1

Introduction

Scilab code Exa 1.1 Mass

```
clc
//let the total mass of mud be 100lbm
m_total=100;//lbm
//70% by wt of mud is sand(SiO2)and remaining is
    water
m_sand=0.7*m_total;//lbm
m_water=0.3*m_total;//lbm
rho_sand=165;//lbm/ft^3
rho_water=62.5;//lbm/ft^3
//rho=mass/volume
rho_mud=m_total/((m_sand/rho_sand)+(m_water/
    rho_water));
disp("The density of mud=")
disp(rho_mud)
disp("lbm/ft^3")
```

Scilab code Exa 1.2 Shear stress

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

Scilab code Exa 1.3 Surface tension

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

Scilab code Exa 1.4 speed conversion

```
clc
```

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

Scilab code Exa 1.5 Time conversion

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

Scilab code Exa 1.6 Acceleration

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

Scilab code Exa 1.7 Electrolysis

```
clc
//Example 1.7
//Calculate the wt of metallic aluminium deposited
   in an electrolytic cell
I=50000//Ampere or Coulumbs/sec
//1 hr = 3600 sec
I1=50000*3600//C/hr
//96500 C = 1 gm.eq
//1 mole of aluminium = 3 gm.eq
//1 mole of aluminium = 27 gm
m=I1*(1/96500)*(27/3)/1000//Kg/hr
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

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

Scilab code Exa 2.2 Pressure at depth

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

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

Scilab code Exa 2.3 Gauge pressure

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

Scilab code Exa 2.4 Density of air

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

```
//P2=P1*exp^(-(acc. due to gravity)*(mass of air)*(
   height)/(universal gas const.)/(temp.))
g=9.81;//m/s^2
R=8314;//N.m^2/Kmol/K
//for height of 1000 ft=304.8m
h=304.8;//m
p_1000=14.7*exp(-g*29*h/R/289);
disp("pressure at 1000ft is")
disp(p_1000)
disp("psia")
//for height of 10000 ft=3048m
h=3048;//m
p_10000=p_atm*exp(-g*29*h/R/289);
disp("pressure at 10000ft is")
disp(p_10000)
disp("psia")
//for height of 100000 ft=30480m
h=30480;//m
p_100000=14.7*exp(-g*29*h/R/289);
disp("pressure at 100000ft is")
disp(p_100000)
disp("psia")
```

Scilab code Exa 2.5 Pressure at height

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

```
h=304.8//m
p_1000=p_atm*[1-g*29*h/R/T];
disp("pressure at 1000ft is")
disp(p_1000)
disp("psia")
//for height of 10000ft=3048m
h=3048//m
p_10000=p_atm*[1-g*29*h/R/T];
disp("pressure at 10000ft is")
disp(p_10000)
disp("psia")
//for height of 100000ft=30480m
h=30480//m
p_100000=p_atm*[1-g*29*h/R/T];
disp("pressure at 100000ft is")
disp(p_100000)
disp("psia")
//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

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

Scilab code Exa 2.7 Pressure

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

Scilab code Exa 2.8 Force

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

```
//net pressure on strip = (p_atm+(rho_water)*g*x) - p_atm
//thus, net pressure on strip = (rho_water)*g*x
//force on strip = (rho_water*g*x)*w.dx = (rho_water)*g*w*(x.dx)
//force on lock gate = integration of force on strip fromm h=0 to h=10
//integration(x.dx) = x^2/2
//for h=0 to h=10; integration (x.dx) = h^2/2
force_lockgate=(rho_water)*g*w*h^2/2;
disp("The net force on the lock gate is")
disp(force_lockgate/10^6)
disp("MN")
```

Scilab code Exa 2.9 Thickness

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

Scilab code Exa 2.10 Thickness

```
clc
```

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

Scilab code Exa 2.11 Payload

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

Scilab code Exa 2.12 Fraction of block inside water

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

Scilab code Exa 2.13 Gauge pressure

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

Scilab code Exa 2.14 Pressure difference

```
clc
```

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

Scilab code Exa 2.15 Gauge pressure

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

Scilab code Exa 2.16 Pressure difference

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

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

Scilab code Exa 2.17 Gauge pressure

```
clc
rho_water=1000;//Kg/m^3
g=9.81;//m/s^2
h=5;//m (depth of water)
//for elevator not accelerated
p_gauge=(rho_water)*g*h/1000;//KPa
disp("THe gauge pressure is")
disp(p_gauge)
disp("KPa")
//for elevator accelerated at 5m/s^2 in upward
    direction
a=5;//m/s^2
p_gauge=(rho_water)*(g+a)*h/1000;//KPa
disp("THe gauge pressure is")
disp(p_gauge)
disp("KPa")
//for elevator accelerated at 5m/s^2 in downward
    direction
a=5;//m/s^2
p_gauge=(rho_water)*(g-a)*h/1000;//KPa
disp("THe gauge pressure is")
disp(p_gauge)
```

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

Scilab code Exa 2.18 Angle

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

Scilab code Exa 2.19 Height of liquid

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

Scilab code Exa 2.20 Thickness

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

Chapter 3

The balance equation and mass balance

Scilab code Exa 3.4 volumetric flow rate

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

Scilab code Exa 3.5 Velocity and Mass flow rate

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

Scilab code Exa 3.6 Velocity and Mass flow rate

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

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

Scilab code Exa 3.7 Time required

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

Scilab code Exa 3.8 Steady state pressure

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

Scilab code Exa 3.9 Velocity of rising water

```
clc
//Example 3.9
//calculate how fast the level of water is rising or
    falling in a cylindrical tank
d=3;//m diameter of tank
a=(%pi)*d^2/4;//m^2
d_in=0.1;//m inner diameter of inflow pipe
d_out=0.2;//m
v_in=2;//m/s
v_out=1;//m/s
q_in=((%pi)*d_in^2/4)*v_in;//m^3/s
q_out=((%pi)*d_out^2/4)*v_out;//m^3/s
//let D represent d/dt
DV=q_in-q_out;//m^3/s
if DV>1 then
  printf("The water level in tank is rising\n");
else if DV<1 then
    printf("The water level in tank is falling\n");
    else
      printf("No accumulation\n");
      end
//let h be the height of water in tank
Dh=DV/a//m/s
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

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

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

Scilab code Exa 4.2 Kinetic energy

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

Scilab code Exa 4.3 Kinetic energy

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

Scilab code Exa 4.4 Change in internal energy

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

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

Scilab code Exa 4.5 Work

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

Scilab code Exa 4.6 Mass consumed in nuclear reactor

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

```
c=3*10^8;//m/s
c1=3;//velocity of light without power
pow=8//power of 10 in speed of light
Dm=(DW-DQ)/c/c1//kg/s
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

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

Scilab code Exa 5.2 Velocity

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

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

Scilab code Exa 5.3 Velocity

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

Scilab code Exa 5.4 Velocity

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

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

Scilab code Exa 5.5 Velocity

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

Scilab code Exa 5.6 Velocity

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

Scilab code Exa 5.7 Velocity

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

Scilab code Exa 5.8 volumetric flow rate

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

Scilab code Exa 5.9 volumetric flow rate

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

Scilab code Exa 5.10 Pressure difference

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

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

Scilab code Exa 5.11 volumetric flow rate

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

Scilab code Exa 5.12 Absolute pressure

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

```
//one end of the inverted manometer is immersed in a tank and the other end is open to atmosphere 10 ft below tank level
//pt 1 is at tank water level, pt 2 is at top of inverted manometer and pt3 is at the other end of manometer
dh=10//ft
v3=(2*g*dh)^0.5//ft/s
p1=p_atm//lbf/in^2
rho_water=62.3//lbm/ft^3
//Difference of height between pt 1 and pt 2 is 40 ft
dh1=40//dft
p2=p1-(rho_water*v3^2/2/32.2/144)-(rho_water*g*dh1)/32.2/144//lbf/in^2
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

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

```
P1=24.7//psia
rho_water=62.3//lbm/ft^3
P2=P1-(rho_water)*v2^2/32.2/144/2//psia
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

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

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

Scilab code Exa 6.2 Viscosity

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

Scilab code Exa 6.3 Fanning friction factor

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

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

Scilab code Exa 6.4 Gauge pressure

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

Scilab code Exa 6.5 volumetric flow rate

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

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

Scilab code Exa 6.6 Pressure difference

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

Scilab code Exa 6.8 Power

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

Scilab code Exa 6.9 Pressure drop

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

Scilab code Exa 6.10 Pressure difference

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

Scilab code Exa 6.11 Pressure drop

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

Scilab code Exa 6.12 Pressure drop

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

Scilab code Exa 6.13 Leakage rate

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

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

Chapter 7

The momentum balance

Scilab code Exa 7.2 Velocity

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

Scilab code Exa 7.3 Force

```
clc
//Example 7.3
```

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

Scilab code Exa 7.4 Force

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

Scilab code Exa 7.5 Force

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

```
//F_bolts = -F_liq-F_atm
//F_bolts = -(Pg + P_atm)A - (-P_atm.A)
//F_bolts = -Pg.A
F_bolts=-Pg*A
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

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

Scilab code Exa 7.7 Support forces

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

```
A=0.1//m^2
m=500//Kg/s
rho=998.2//Kg/m^3
q=m/rho//m^3/s
v=q/A//m/s
Vx_initial=v//m/s
Vx_final=0//m/s
Vy_initial=0//m/s
Vy_final=-v//m/s
Fx=m*(Vx_final-Vx_initial)-p1*1000*A//N
printf("The support force in the x direction is %f N \n",Fx);
Fy=m*(Vy_final-Vy_initial)-p1*1000*A//N
printf("The support force in the y direction is %f N ",Fy);
```

Scilab code Exa 7.8 Thrust

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

Scilab code Exa 7.9 Specific impulse

```
clc
```

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

Scilab code Exa 7.10 Mass flow rate

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

Scilab code Exa 7.12 Velocity

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

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

Scilab code Exa 7.15 Velocity

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

Scilab code Exa 7.16 Verticle downward velocity

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

```
Vx=50//m/s
m=rho_air*A*Vx//Kg/s
Fy=9810//N Weight of the aircraft
Vy=Fy/m//m/s
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

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

Scilab code Exa 7.18 Torque

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

```
rho=8.33//lbm/gal
m=rho*q//lbm/min
f=1800//rev/min frequency of impeller
omega=2*(%pi)*f//rad/min
r_in=1/12//ft
r_out=6/12//ft
//1 min = 60 sec
//1 lbf.s^2 = 32.2 lbm.ft
tou=m*omega*(r_out^2-r_in^2)/32.2/3600//lbf.ft
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

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

Scilab code Exa 8.2 Speed of sound

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

Scilab code Exa 8.3 Temperature of gas

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

Scilab code Exa 8.4 Speed of sound

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

Scilab code Exa 8.5 Pressure and density

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

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

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

Scilab code Exa 8.8 Cross sectional area

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

Scilab code Exa 8.9 Temperature of gas

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

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

Scilab code Exa 8.12 Temperature and pressure of gas

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

Scilab code Exa 8.13 Temperature and velocity of air

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

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

Scilab code Exa 8.14 Ratio of area of nozzle

```
clc
//Example 8.14
//Calculate the ratio of area of throat to area of a certain point
A_throat=1//in^2
A_exit=1.5//in^2
ratio_A=2.2385//dimentionless
ratio_A1=ratio_A*(A_throat/A_exit)//dimentionless
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

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

Scilab code Exa 10.2 Elevation

```
clc
//Example 10.2
//Calculate the maximum elevation above the lowest water level in sump at which pump inlet can be placed
P1=3.72//psia Or lbf/in^2
P2=14.5//psia Or lbf/in^2
dP=P2-P1//psia Or lbf/in^2
rho=61.3//lbm/ft^3
g=32.2//ft/s^2
//1 ft = 12 in
//1 lbf.s^2 = 32.2 lbm.ft
h_loss=4//ft
v=10//ft/s
h_max=(dP/rho/g)*144*32.2-(v^2/2/g)-h_loss//ft
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

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

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

Scilab code Exa 10.4 Work

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

Scilab code Exa 10.5 Pump head

```
clc
//Example 10.5
//Calculate the pump head
N=1750//rev/min
```

```
//1 min 60 sec
omega=2*(%pi)*N/60//radians/sec
Q=100//gal/min
//1 gallon = 231 in^3
//1 ft =12 in
//1 min = 60 sec
d_inlet = 2.067//ft
A_inlet=(%pi)/4*(d_inlet^2)//ft^2
V1=(Q/A_inlet)*231/60/12//ft/s
d_outlet = 1.61//ft
A_outlet=(%pi)/4*(d_outlet^2)//ft^2
V2=(Q/A_outlet)*231/60/12//ft/s
g=32.2//ft/s^2
d_inner=0.086//ft
d_outer=0.336//ft
h=(omega)^2/g*((d_outer^2)-(d_inner)^2)+(V2^2-V1^2)
   /2/g//ft
printf("The pump head is %f ft",h);
```

Scilab code Exa 10.6 Pump head

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

Scilab code Exa 10.7 Pressure rise

```
clc
//Example 10.7
//Calculate the estimated pressure rise in the first stage of mutisatge centrifugal compressor
rho=0.075//lbm/ft^3
omega=1047//rad/sec
d=2//ft
dP=(1/2)*(rho)*(omega*d/2)^2/32.2/144//psia
//1 lbf.s^2 = 32.2 lbm into feed
//1 ft = 144 in^2
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

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

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

Chapter 11

Flow through porous media

Scilab code Exa 11.1 volumetric flow rate

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

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

Scilab code Exa 11.2 Pressure gradient

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

Scilab code Exa 11.3 Permeability

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

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

Chapter 12

Gas liquid flow

Scilab code Exa 12.1 Eta and slip velocity

```
clc
//Example 12.1
//Calculate the eta and slip velocity
ratio_Q=10//dimentionless (ratio of Qg to Ql)
x=3.5/ratio_Q//dimentionless
eta=1/(1+x)//dimentionless
printf("Eta = %f\n",eta);
Vl=2.06//ft/s
Vl_avg=Vl/(1-eta)//ft/s
Vg_avg=ratio_Q*Vl/eta//ft/s
V_slip=Vg_avg-Vl_avg//ft/s
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

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

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

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

Scilab code Exa 13.4 Pressure gradient

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

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

Scilab code Exa 13.5 Headstrom Reynold number and fanning friction factor

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

Chapter 15

Two and three dimentional fluid mechanics

Scilab code Exa 15.4 Time required

```
clc
//Example 15.4
//Calculate the time taken by water in a long pipe
   to reach its steady state velocity
//let (new)*t/r0^2 be denoted by y
y=0.05//dimentionless
r0=0.077//m
mew=1//Pa.s
rho=1000//Kg/m^3
new=mew/rho//m^2/s
t=y*r0^2/new//s
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

```
clc
//Example 17.1
//Calculate the boundary layer thickness
//for the aeroplane
v=1.61*10^(-4)//ft^2/s
x=2//ft
V=200//miles/hr
//1 mile = 5280 ft
//1 hr = 3600 sec
delta_aeroplane=5*(v*x/(V*5280/3600))^0.5
printf("The boundary layer thickness for the
   aeroplane is %f ft\n",delta_aeroplane);
//for the boat
v1=1.08*10^(-5)//ft^2/s
x1=2//ft
V1=10//miles/hr
//1 mile = 5280 ft
//1 hr = 3600 sec
delta_boat=5*(v1*x1/(V1*5280/3600))^0.5
printf("The boundary layer thickness for the boat is
    %f ft\n",delta_boat);
```

Scilab code Exa 17.2 Force

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

Scilab code Exa 17.3 Laminar sublayer and buffer layer

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

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

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

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

Scilab code Exa 18.3 Turbulence

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

Scilab code Exa 18.4 Kolmogorov scale

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

Scilab code Exa 18.7 turbulent kinematic viscosity

```
clc
//Example 18.7
//Calculate the value of turbulent kinematic
   viscosity
K=0.00576//m^2/s^2
eta=0.0196//m^2/s^3
C_mew=0.09//dimentionless
v_t=C_mew*(0.00576)^2/(0.0196)//m^2/s
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

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

Scilab code Exa 19.2 Power required

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

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

Scilab code Exa 19.3 Impeller speed

```
clc
//Example 19.3
//Calculate the impeller speed in a model of a large
     mixer if the power per unit volume remains the
    same
//let D1/D2 be denoted by ratio_D
ratio_D=5//dimentionless
N2=240//rpm
N1=N2/ratio_D^(2/3)//rpm
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

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

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

Scilab code Exa 19.5 Concentration

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

Scilab code Exa 19.6 Concentration

```
clc
//Example 19.6
```

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

Scilab code Exa 19.7 Extent of mixing

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

Scilab code Exa 19.8 width of jet and entrainment ratio

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

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

Scilab code Exa 19.9 Concentration

```
clc
//Example 19.9
//Calculate the SO2 concentration at the centerline
Q=20//gm/s
u=3//m/s
sigma_y=30//m
sigma_z=20//m
y=60//m
z=20//m
H=0//m
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
printf("the SO2 concentration at the centerline is
    %f gm/m^3",c);
```

Chapter 20

Computational fluid dynamics

Scilab code Exa 20.1 fist and second derivative of fluid flow

```
clc
//Example 20.1
//Calculate first derivative and second derivative of the fluid flow
y_fd2=0.4336//m
y_fd1=0.4375//m
delta_yfd=y_fd2-y_fd1//m
x_fd2=0.75//m
x=0.5//m
delta_xfd=x_fd2-x//m
y_bd2=0.4375//m
y_bd1=0.2461//m
delta_ybd=y_bd2-y_bd1//m
x_bd1=0.25//m
delta_xbd=x-x_bd1//m
//Let D denote d/dx and D2 denote d^2/dx^2
Dy_fd=delta_yfd/delta_xfd//dimentionless
Dy_bd=delta_ybd/delta_xbd//dimentionless
Dy=(Dy_fd+Dy_bd)/2//dimentionless
printf("The first derivative of fluid flow is %f\n",Dy);
```

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

Scilab code Exa 20.3 Grid velocities

```
clc
//Example 20.3
//Calculate the grid velocities
v=1.077*10^(-5)//ft^2/s
t=2//sec
dy=0.01//ft
w=v*t/dy^2//dimentionless
//Let Vij represent velocity through the i,j grid
V00=5//ft/s
V10=5//ft/s
V01=0//ft/s
V02=0//ft/s
V12=0//ft/s
V11=V01+w*(V00-2*V01+V02)//ft/s
V21=V11+w*(V10-2*V11+V12)//ft/s
printf("The grid velocity for 2,1 is %f ft/s\n",V21);
V13=0//ft/s
V22=V12+w*(V11-2*V12+V13)//ft/s
printf("The grid velocity for 2,2 is %f ft/s\n",V22);
```