Scilab Textbook Companion for Fluid Mechanics - Worked Examples For Engineers by C. Schaschke[1]

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Book Description

Title: Fluid Mechanics - Worked Examples For Engineers

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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

Fluid Statics

Scilab code Exa 1.1 1

```
clc
rho=924; //kg/m^3
g=9.81; //m/s^2
H=2; //m
d=2; //depth in m

p=rho*g*H;
a=d*H;

F=p*a/2;
disp("Total force exerted over the wall =")
disp(F)
disp("N")
```

Scilab code Exa 1.2 2

```
clc
p_v=50*10^3; //N/m^2
```

```
r=1; //m
p_atm=101.3*10^3; //N/m^2
rho=1000; //kg/m^3
H=2.5; //m
g=9.81; //m/s^2

F=p_v*%pi*r^2;
disp("Total vertical force tending to lift the dome =")
disp(F)
disp("N")

p=p_atm+p_v+rho*g*H;
disp("Absolute pressure at the bottom of the vessel =")
disp(p)
disp("N/m^2")

Fd=(p_v+rho*g*H)*%pi*r^2+rho*g*2*%pi*r^2/3;
disp("Downward force imposed by the gas and liquid = ")
disp(Fd)
disp("N")
```

Scilab code Exa 1.3 3

```
clc
a1=0.3; //m^2
m=1000; //kg
a2=0.003; //m^2
rho_oil=750; //kg/m^3
H=2; //m
g=9.81; //m/s^2

F1=m*g;
```

```
F2=a2*(F1/a1-rho_oil*g*H);
disp("The force on the plunger =")
disp(F2)
disp("N")
```

Scilab code Exa 1.4 4

```
clc
rho_0=800; //kg/m^3
rho_aq=1100; //kg/m^3

// rho_0*g*H=rho_aq*g*(H-0.5);

H=0.5*rho_aq/(rho_aq-rho_0);
disp("H=")
disp(H)
disp("m")

// For a fixed length of chamber of 3 m, the
   interface between the two phases is determined
   from the pressure in the chamber and discharge
   point.
// rho_0*g*H1+rho_aq*g*H2=rho_aq*g*(H-0.5);
// H=H1+H2

rho_0=600; //kg/m^3

H1=0.5*rho_aq/(rho_aq-rho_0);
disp("The lowest possible position of the inteiface
   in the chamber below the overflow.")
disp(H1)
disp("m")
```

Scilab code Exa 1.5 5

```
clc
rho_o=900; //kg/m^3
rho_n=1070; //kg/m^3
H=1; //m
g=9.81; //m/s^2
dp=10*10^3; //N/m^2

// H=H1+H2

H1=(dp-rho_n*g*H)/(rho_o-rho_n)/g;
disp("The position of the interface between the legs
    =")
disp(H1)
disp("m")
```

Scilab code Exa 1.6 6

```
clc
dp=22*10^3; //N/m^2
g=9.81; //m/s^2
H=1.5; //m
rho=1495; //kg/m^3
rho_s=1270; //kg/m^3
rho_c=2698; //kg/m^3

p=dp/g/H;
disp("the density of the solution with crystal =")
disp(p)
disp("kg/m^3")

// rho=f1*rho_s+f2*rho_c
// f1+f2=1

```

```
f2=(rho-rho_s)/(rho_c-rho_s);
disp("The fraction of crystals =")
disp(f2)
```

Scilab code Exa 1.7 7

```
clc
p_atm=101.3*10^3; // N/m^2
rho=1000; // kg/m^3
g=9.81; // m/s^2
H1=3; //m
a=0.073; // N/m
r1=5*10^(-4); //m

p1=p_atm+rho*g*H1+2*a/r1;

// p2=p_atm+rho*g*H2+2*a/r2;

// p1*4/3*%pi*r1^3=p2*4/3*%pi*r2^3

// Solving above two equations we get
r2=0.053; //mm
disp("Radius of the bubble =")
disp(r2)
disp("mm")
```

Scilab code Exa 1.8 8

```
clc
H=0.2; //m
rho=1000; //kg/m^3
rho_Hg=13600; //kg/m^3
g=9.81; //m/s^2
```

```

dp=(rho_Hg-rho)*g*H;
disp("Differential pressure =")
disp(dp)
disp("N/m^2")
```

Scilab code Exa 1.9 9

```
clc

// p1-rho*g*(H+H1)=p2-rho*g*H1-rho_air*g*H

rho=1000;
g=9.81; // m/s^2
H=0.4; //m
dp=rho*g*H;
disp("Pressure drop in the pipe =")
disp(dp)
disp("N/m^2")
```

Scilab code Exa 1.10 10

```
clc
dp=20*10^3; //N/m^2
rho_Hg=13600; //kg/m^3
rho=700; //kg/m^3
g=9.81; //m/s^2
d=0.02; //m

H=dp/(rho_Hg-rho)/g;

V=%pi/4*d^2*H;
disp("Quantity of mercury to be removed =")
```

```
disp(V)
disp("m^3")
```

Scilab code Exa 1.11 11

```
clc
rho=800; //kg/m^3
g=9.81; //m/s^2
L=0.12;
theta=%pi/180*20; // radians

dp=rho*g*L*sin(theta);
disp("The gauge pressure across the filter =")
disp(dp)
disp("N/m^2")
```

Scilab code Exa 1.12 12

```
clc
mc=100; //kg
g=9.81; //m/s^2
rho=1000; //kg/m^3
rho_c=7930; //kg/m^3

m=mc*rho/rho_c;

F=mc*g-m*g;
disp("The tension in the cable =")
disp(F)
disp("N")
```

Scilab code Exa 1.13 13

```
clc
rho=1000;
x=0.06;
rho_0=800;
x_0=0.04;

L=(rho*x-rho_0*x_0)/(rho-rho_0);

rho_L=900;
x_L=L-rho/rho_L*(L-x);
disp("Length of the stem above the liquid of SG 0.9
    =")
disp(x_L)
disp("m")
```

Scilab code Exa 1.14 14

```
clc
m_s=5*10^6; //kg
T2=4.5; //m
T1=3; //m
rho_hc=950; //kg/m^3
Q=125; //m^3/h

m_hc=m_s*(T2/T1-1);
disp("Quantity delivered =")
disp(m_hc)
disp("kg")

t=m_hc/rho_hc/Q;
disp("Time taken =")
disp(t)
disp("hours")
```

Chapter 2

Continuity Momentum and Energy

Scilab code Exa 2.1 1

```
clc
Q1=0.02; //m^3/s
d1=0.15; //m
d2=0.05; //m
d3=0.1; //m
v2=3; //m/s


v3=(4*Q1/%pi-d2^2*v2)/d3^2;
disp("velocity at pipe 3 =")
disp(v3)
disp("m/s")

Q3=%pi*d3^2/4*v3;
disp("Flowrate at pipe 3 =")
disp(Q3)
disp("m^3/s")

Q2=%pi*d2^2/4*v2;
```

```
disp("Flowrate at pipe 2")
disp(Q2)
disp("m^3/s")

disp("Velocity at pipe 2")
disp(v2)
disp("m/s")

v1=4*(Q2+Q3)/%pi/d1^2;
disp("Velocity at pipe 1 =")
disp(v1)
disp("m/s")

disp("Flowrate at pipe 1")
disp(Q1)
disp("m^3/s")
```

Scilab code Exa 2.2 2

```
clc
d1=0.2; //m
d2=d1;
p1=1*10^5; //N/m^2
p2=80*10^3; //N/m^2
Q=150; //m^3/h
rho=900; //kg/m^3
theta1=0; //radians
theta2=%pi; //radians

a1=%pi*d1^2/4;
a2=%pi*d2^2/4;

F1=p1*a1; // Upstream force
F2=p2*a2; // Downstream force

```

```
v1=4*Q/3600/%pi/d1^2;
v2=v1;

flux=rho*Q/3600*v2; //Momentum flux

Fx=F1*cos(theta1)-F2*cos(theta2)+flux*(cos(theta2) -
    cos(theta1));
Fy=F1*sin(theta1)-F2*sin(theta2)-flux*(sin(theta2)-
   sin(theta1));

F=sqrt(Fx^2+Fy^2);
disp("Force exerted by the liquid on the bend =")
disp(F)
disp("N")
```

Scilab code Exa 2.3 3

```
clc
rho=1000; //kg/m^3
d=0.05; //m
L=500; //m
v=1.7; //m/s

a=%pi*d^2/4;
F=rho*a*L*v;

P=F/a/10^3;
disp("Average pressure =")
disp(P)
disp("kN/m^2")
```

Scilab code Exa 2.4 4

```
clc
g=9.8; //m/s^2
dz=0.2; //m ; dz1=z1-z2=z1-z2
rho=1000; //kg/m^3
dz1=2; //m ; dz1=z1-z_A
dz2=0; //m ; dz2=z1-z_B
dz3=-1.5; //m ; dz3=z1-z_C

v2=sqrt(2*g*dz);

v_A=v2;
v_B=v2;
v_C=v2;

p_A=rho*g*(dz1-v_A^2/2/g);
p_B=rho*g*(dz2-v_B^2/2/g);
p_C=rho*g*(dz3-v_C^2/2/g);

disp("Velocity at pt. A =")
disp(v_A)
disp("m/s")

disp("Velocity at pt. B =")
disp(v_B)
disp("m/s")

disp("Velocity at pt. C =")
disp(v_C)
disp("m/s")

disp("Pressure at pt. A =")
disp(p_A)
disp("kN/m^2")

disp("Pressure at pt. B =")
disp(p_B)
disp("kN/m^2")

```

```
disp("Pressure at pt. C =")
disp(p_C)
disp("kN/m^2")
```

Scilab code Exa 2.5 5

```
clc
Q=10; // m^3/hr
d1=0.05; //m
d2=0.1; //m
rho=1000; //kg/m^3

a1=%pi*d1^2/4;
a2=%pi*d2^2/4;

v1=Q/3600/a1;
v2=(d1/d2)^2*v1;

PD=rho*Q/3600*(v1-v2)/a2;
disp("Pressure drop =")
disp(PD)
disp("N/m^2")
```

Scilab code Exa 2.7 7

```
clc
Q=100; //m^3/hr
d1=0.2; //m
d2=0.15; //m
p1=80*10^3; //N/m^2
rho=1000; //kg/m^3
g=9.8; //m/s^2

```

```
a1=%pi*d1^2/4;
a2=%pi*d2^2/4;
v1=Q/3600/a1;
v2=Q/3600/a2;
H_L=0.2*v2^2/2/g;
p2=p1+rho/2*(v1^2-v2^2)-rho*g*H_L;

F_u=p1*a1; // Upstream force
F_d=p2*a2; // Downstream force

F_x=rho*Q/3600*(v2-v1)-F_u+F_d;
disp("Force required =")
disp(F_x)
disp("N")
```

Scilab code Exa 2.9 9

```
clc
N=60; //rpm
r2=0.25; //m
g=9.8; //m/s^2

w=2*%pi*N/60;
dz_12=(w*r2)^2/2/g; // dz_12=z2-z1
c=w*r2^2;
dz_23=c^2/2/g/r2^2;// dz_23=z3-z2

dz_13=dz_23+dz_12;
disp("Total depression =")
disp(dz_13)
disp("m")
```

Chapter 3

Laminar Flow and Lubrication

Scilab code Exa 3.2 2

```
clc
Re=2000;
d=0.008; //m

L1=0.058*Re*d;
disp("The furthest distance the fluid can flow into
   the 8 mm inside diameter pipe before fully
   developed laminar flow can exist is ");
disp(L1);
disp("m");
```

Scilab code Exa 3.4 4

```
clc
del_p=90*10^3; // N/m^2
d=0.126; // m
R=0.126/2; // m
u=1.2;
```

```
L=60; // m
Rho=1260;

Q=%pi * del_p * R^4 / (8*u*L);
disp("The glycerol delivery rate is ");
disp(Q);
disp("m^3/s");

Re=4*Rho*Q/(u*%pi*d);
disp("The Reynolds number is ");
disp(Re);
disp("As Re is below 2000, therefore confirming
   laminar flow.");
```

Scilab code Exa 3.5 5

```
clc
u=0.015; //Ns/m^2
Q=0.004/60; //m^3/s
dp=100;
rho=1100; //kg/m^3

R=(8*u*Q/(%pi*dp))^(1/4);
Re=(4*rho*Q/(%pi*u*(2*R)));

disp("Diameter of the pipe =")
disp(R)
disp("m")

disp("Reynolds number =")
disp(Re)
```

Scilab code Exa 3.6 6

```
clc
u=0.03; //Ns/m^2
Q=10^(-7); //m^3/s
dp=integrate('8*u*Q/%pi/0.005^4/(1-L)^4', 'L', 0,
   0.5)
disp("Pressure difference =")
disp(dp)
disp("N/m^2")
```

Scilab code Exa 3.8 8

```
clc
u=0.1; // Ns/m^2
d=0.1; //m
R=0.05; // m
Rho=900; //kg/m^3

v_max=2; // m/s
v=v_max/2; // m/s

disp("At the pipe wall (r =R), therefore, the shear
   stress is");
Tw=-2*u*v_max/R;
disp(Tw);
disp("N/m^2");
disp("The negative sign indicates that the shear
   stress is in the opposite direction to flow.");

disp("pressure drop per metre length of pipe is");

del_p=4*u*v_max/R^2;
disp(del_p);
disp("N/m");
```

Scilab code Exa 3.9 9

```
clc
u=0.032; // Ns/m^2
Re=2000; // maximum value
Rho=854;
del_p=150; // N/m^2

d=(32*u^2*Re/(Rho*del_p))^(1/3);
disp("The maximum inside diameter is found to be ")
disp(d)
disp("m")
```

Scilab code Exa 3.10 10

```
clc
rho=1000; //kg/m^3
u=0.1; //Ns/m^2
g=9.81; //m/s^2
L=10; //m
H=2; //m
Q=14/3600; //m^3/s
d=0.05; //m

dp=rho*g*(L+H) - (128*Q*u*L/%pi/0.05^4);
disp("Pressure drop across the valve =")
disp(dp)
disp("N/m^2")
```

Scilab code Exa 3.12 12

```
clc
Q=3*10^(-6); // m^3/s
u=0.001; // Ns/m^2
W=1;
rho=1000; // kg/m^3
g=9.81; // m/s^2
d=1.016*10^(-4); // m

theta=asind(3*Q*u/W/rho/g/d^3);
disp("Exact angle of inclination =")
disp(theta)

d1=1.25*10^(-4); // m

u1=W*rho*g*sind(theta)*(d1^3)/(3*Q);
disp("Viscosity of the second liquid =")
disp(u1)
disp("Ns/m^2")
```

Scilab code Exa 3.17 17

```
clc
u=1.5; // Ns/m^2
v=0.5; // m/s
H=0.02/2; // m

t=-u*3*v/H;
disp("The shear stress =")
disp(t)
disp("N/m^2")
disp("It acts in the opposite direction to the flow.
    ")
```

Scilab code Exa 3.18 18

```
clc
N=600/60; // revolutions per sec
r=0.025; // m
t=400; // N/m^2
l=0.002; // m

w=2*%pi*N;

u=t*l/w/r;
disp("Viscosity =")
disp(u)
disp("Ns/m^2")

T=integrate('2*%pi*u*w/l*r^3', 'r', 0, r);
disp("Torque =")
disp(T)
disp("Nm")
```

Scilab code Exa 3.19 19

```
clc;
u=0.153; //Ns/m^2
r=0.05; // m
N=30; // rps
t=2/10^5; //s
L=0.2; // m

tau=u*(2*%pi*N*r/t);

F=tau*2*%pi*r*L;
```

```

T=F*r;

w=2*%pi*N;
P=T*w;

disp("The torque on the bearing is found to be ");
disp(T);
disp("Nm");
disp("and the power required to overcome the
    frictional resistance is ");
disp(P);
disp("W");
```

Scilab code Exa 3.20 20

```
clc;
t=0.0005; // s
P=22; //
r=300/60; //
R_1=0.1; //
R_2=0.0625; //

w=2*%pi*r;

u=2*t*P/(%pi*w^2*((R_1)^4-(R_2)^4));
disp("The viscosity of the oil is found to be ");
disp(u);
disp("Nsm-2.");
```

Chapter 4

Dimensional Analysis

Scilab code Exa 4.5 5

```
clc
Rho_full=800; // kg/m^3
v_full=1.8; // m/s
u_full=9*10^(-4);// Nm/s^2
Rho_model=1000; // kg/m^3
u_model=10^(-3); // Ns/m^2
d_full= 2;
d_model=1;
del_p_fmodel=4000; // N/m^2

v_model = (((Rho_full * v_full)/u_full)/(Rho_model/
    u_model))*(d_full/d_model);

del_p_f=del_p_fmodel*Rho_full*(v_full)^2/Rho_model/(
    v_model)^2;
disp("The pressure drop per unit length in the full-
    scale pipe is expected to be ")
disp(del_p_f)
disp("kN/m^2");
```

Chapter 5

Flow measurement by differential head

Scilab code Exa 5.1 1

```
clc
rho_m=840; //kg/m^3
g=9.8; //m/s^2
H=0.03; //m
rho=1.2; //kg//m^3

dp=rho_m*g*H;

v1=sqrt(2*dp/rho);
disp("Velocity =")
disp(v1)
disp("m/s")
```

Scilab code Exa 5.2 2

```
clc
```

```
r=[0 0.05 0.10 0.15 0.20 0.225 0.25];
v=[19 18.6 17.7 16.3 14.2 12.9 0];

// We define a new variable dQ=v*2*%pi*r. According
   to the given values of r, v, we get dQ as follows
dQ=[0 5.8 11.1 15.4 17.8 18.2 0];
plot(r,dQ)
xtitle("", "Radius", "v*2*%pi*r")
// From the graph area under the curve comes out to
   be 2.74
Q=2.74; // m^3/s
disp(" Rate of flow =")
disp(Q)
disp("m^3/s")

d=0.5; // m

v=4*Q/%pi/d^2;
disp("Average velocity =")
disp(v)
disp("m/s")
```

Scilab code Exa 5.3 3

```
clc
d1=0.1; //m
rho_Hg=13600; //kg/m^3
rho=1000; //kg/m^3
g=9.81; //m/s^2
H=0.8; //m
Cd=0.96;
Q=0.025; //m^3/s

a=%pi*d1^2/4;
dp=(rho_Hg-rho)*g*H;
```

```

B=((2*dp/(rho*((Q/Cd/a)^2)))+1)^(1/4);

d2=d1/B;
disp("Throat diameter =")
disp(d2)
disp("m")

// The shortest possible overall length of venturi is therefore an entrance cone of 7.1 cm length (20 degrees), a throat of 2.5 cm(0.25 pipe-diameters) and an exit cone of 19.7 cm (7.5 degrees) giving an overall length of 29.3 cm.

L=29.3; //cm
disp("Overall Length =")
disp(L)
disp("m")
```

Scilab code Exa 5.4 4

```
clc
Cd_o=0.65;
d=0.05;
d_o=0.025;
Cd_v=0.95;
d_v=0.038;

// (Q_o/Cd_o)^2*((d/d_o)^4 - 1)=(Q_v/Cd_v)^2*((d/d_v)^4 - 1)

// Q_v=4*Q_o
// Q = Q_v + Q_o
// Q = 5*Qv
Q1=20;
```

```
Q2=100-Q1;

disp("Flow through orifice =")
disp(Q1)
disp("%")

disp("Flow through venturi =")
disp(Q2)
disp("%")
disp("Thus 20 % of the flow passes through the
    orifice meter while 80 % of the flow passes
    through the venturi.")
```

Scilab code Exa 5.5 5

```
clc
Qa=0.003/60; // m^3/s
Ca=20; // g/l
Co=0.126; // g/l
dp=3700; // N/m^2
p=1000; // N/m^2
d=0.1; // m

a=%pi*d^2/4;
Qi=Qa*((Ca-Co)/Co);
Q=Qi+Qa;
B=10/6;

Cd=Q/a/sqrt(2*dp/p/(B^4-1));
disp("Coefficient of discharge =")
disp(Cd)
```

Scilab code Exa 5.6 6

```
clc
rho=850; // kg/m^3
Q=0.056; // m^3/s
Cd=0.98;
d1=0.2; // m
d2=0.1; // m
g=9.81; // m/s^2
dz=0.3; // m

a=%pi*(d1)^2/4;

dp=rho/2*((Q/Cd/a)^2*((d1/d2)^4 - 1) + 2*g*(dz));
disp("The differential pressure =")
disp(dp)
disp("N/m^2")
```

Scilab code Exa 5.7 7

```
clc
g=9.81; // m/s^2
H=0.5; // m
rho_m=1075; // kg/m^3
rho=860; // kg/m^3
B=0.225/0.075;
a1=%pi/4*(0.225)^2;
Cd=0.659;

v_t=sqrt(2*g*H*(rho_m-rho)/rho/(B^4-1));

Q=Cd*a1*v_t;
disp("Rate of flow =")
disp(Q)
disp("m^3/s")
```

Scilab code Exa 5.8 8

```
clc
m_f=0.03; // kg
rho_f=5100; // kg/m^3
d_l=0.3; // m
d_b=0.22; // m
H_tube=0.2; // m
Cd=0.6;
H=0.1; // m
g=9.81; // m/s^2
rho=1000; // kg/m^3

V_f=m_f/rho_f;

theta=2*atan((d_l-d_b)/2/H_tube);

m=Cd*H*tan(theta/2)*sqrt(8*V_f*g*rho*(rho_f-rho)*%pi
    );
disp("Mass flowrate =")
disp(m)
disp("kg/s")
```

Scilab code Exa 5.9 9

```
clc
d1=0.05; // m
d2=0.025; // m
Cd=0.97;
dp=1200; // N/m^2
rho=1000; // kg/m^3
H=0.15; // m
```

```
theta=2; // degrees
V_f=10^(-4); // m^3
g=9.81; // m/s^2
rho_f=8000; // kg/m^3

B=d1/d2;
a=%pi/4*d1^2;

Q=Cd*a*sqrt(2*dp/rho/(B^4-1));
disp("Flow rate of water =")
disp(Q)
disp("m^3/s")

Cd=Q/(H/rho*tand(theta/2)*sqrt(8*V_f*g*rho*(rho_f-rho)*%pi));
disp("Coefficient of discharge of the rotameter =")
disp(Cd)
```

Chapter 6

Tank drainage and variable head flow

Scilab code Exa 6.1 1

```
clc;
Q=5000/3600/24; // m^3 per second
C_d=0.6;
r=0.01/2; // m
g=9.8; // m/s^2
H=0.2; // m
a_o=%pi*r^2;

n=Q/C_d/a_o/sqrt(2*g*H);
disp("The number of orifices required are")
disp(n);
```

Scilab code Exa 6.2 2

```
clc;
x=0.86; // m
```

```
g=9.8; // m/s
y=0.96; // m
H=0.2; // m


v_act=x*sqrt(g/2/y);

v=sqrt(2*g*H);

Cv=v_act/v;
disp("The coefficient of velocity for the orifice is
    found to be")
disp(Cv);
```

Scilab code Exa 6.3 3

```
clc;
Vt=1; // m^3
d_t=1; // m
C_d=0.6;
d_o=0.02; // m
g=9.8; // m/s^2
a_o=%pi*(d_o)^2/4;

A=%pi*(d_t)^2/4;

H1=4*Vt/%pi/(d_t)^2;

t=A/C_d/a_o*sqrt(2*H1/g);
disp("Total drainage is found to take ")
disp(t)
disp(" seconds");
```

Scilab code Exa 6.4 4

```
clc;
C_d=0.6;
d_o=0.05; // m
g=9.8; // m/s^2;
R=2; //
H1=1.5; //

a_o=%pi*d_o^2/4;

t=%pi/C_d/a_o/sqrt(2*g)*(4/3*R*H1^(3/2)-2/5*H1^(5/2)
    );
disp("The time to drain the tank is found to be ")
disp(t);
disp("seconds");
```

Scilab code Exa 6.6 6

```
clc
Cd=0.62;
a=0.01; // m^2
g=9.81; // m/s^2
H=0.3; // m
A1=4*2; // m^2
H1=0.3; // m
H2=0.1; // m
A2=2*2; // m^2

Q=Cd*a*sqrt(2*g*H);
disp("The rate of flow =")
disp(Q)
disp("m^3/s")

t=2*A1*(H1^(1/2)-H2^(1/2))/(Cd*a*sqrt(2*g)*(1+A1/A2)
```

```
    );
disp("The time taken to reduce the difference in
    levels to 10 cm is ")
disp(t)
disp("s")
```

Scilab code Exa 6.8 8

```
clc;
Qs=0.4; // m^3/s
H1=1.5; // m
Q=0.2; // m^3/s
H2=0.5; // m
l=15; // m
b=10; // m
A=l*b;

k=Qs*H1^(-1/2);


t=-2*A/k^2 *(Q*log((Q-k*(H2)^0.5)/(Q-k*(H1)^0.5))+k
    *((H2)^0.5-(H1)^0.5));
disp("The time required for the level in the tank to
     fall to 1 m is ")
disp(t)
disp("second")
```

Scilab code Exa 6.9 9

```
clc
Cd=0.62;
d=0.05;
a_o=%pi*d^2/4;
```

```
g=9.81; // m/s^2

k=Cd*a_o*sqrt(2*g);

// We have got two simultaneous equations

// Q-k*0.65^(1/2)=0.1/90*A
// Q-k*1.225^(1/2)=0.05/120*A

M=[1 -0.1/90;1 -0.05/120];
N=[k*0.65^(1/2);k*1.225^(1/2)];

X=inv(M)*N;

Q=X(1,1);
A=X(2,1);

disp("The Area of the tank =")
disp(A)
disp("m^2")

disp("Flowrate =")
disp(Q)
disp("m^3/s")
```

Scilab code Exa 6.10 10

```
clc
H1=1.5; // m
V=0.75; // m^3
d1=1.2; // m
u=0.08; // Ns/m^2
L=3; // m
rho=1100; // kg/m^3
g=9.81; // m/s^2
```

```
d=0.025; // m

a=%pi*d^2/4;
A=%pi*d1^2/4;
H2=H1-(V/A);

t=-32*u*L*A/(a*rho*g*d^2)*log(H2/H1);

disp("Time taken =")
disp(t)
disp("s")
```

Chapter 7

Open channels notches and weirs

Scilab code Exa 7.2 2

```
clc;
l=1; // m
b=0.3; // m
n=0.014; // s/m^(1/3)
i=1/1000;

A=l*b;
P=2*b+l;
m=A/P;

Q=A/n*m^(2/3)*sqrt(i);
disp("The delivery of water through the channel is
   found to be ")
disp(Q)
disp("m^3/s")
```

Scilab code Exa 7.3 3

```
clc
n=0.015; // m^(-1/3)s
i=1;
H=[4.0 4.1 4.2 4.13];

A=12*H;
P=12+2*H;
m=A/P;
C=m^(1/6)/n;

Q=C*A*sqrt(m*i);

// An analytical solution for depth H is not
   possible. It is therefore necessary to use a
   graphical or trial and error approach.

// The corresponding values of A, P, MHD (m), Q are
   given below as per the taken values of H.
A=[48 49.2 50.4 49.56];
P=[20 20.2 20.4 20.26];
m=[2.4 2.44 2.47 2.45];
Q=[57.36 59.38 61.39 59.98];

plot(H,Q)

r=[4.13 4.13];
s=[57 60];
plot(r,s,'r')

t=[4 4.13];
u=[60 60];
plot(t,u,'r')

xtitle("", "Depth H", "Flowrate Q")

// Therefore the depth is found to be approximately
```

```
    4.13

depth=4.13; //m
disp("Depth = ")
disp(depth)
disp("m")

C1=(2.45)^(1/6)/n;
disp("Chezy Coefficient =")
disp(C1)
```

Scilab code Exa 7.4 4

```
clc;
Q=300/60; // m^3/s
i=1/1600;

H=(Q/140*sqrt(2/i))^(2/3);

A=2*H^2;
disp("The minimum flow area is found to be ")
disp(A)
disp("m^2")
```

Scilab code Exa 7.5 5

```
clc
d=0.9144; // m
C=100; // m^(1/2)s^(-1)
R=d/2;

H=[0.1 0.15 0.2 0.25 0.201];

```

```
theta=acos((R-H)/R);
A=R^2*(theta-sin(2*theta)/2);
P=2*R*theta;
m=A/P;

// An analytical solution for depth H is not
   possible. It is therefore necessary to use a
   graphical or trial and error approach.

// The corresponding values of theta, A, P, MHD (m),
   Q are given below as per the taken values of H.

theta=[0.674 0.834 0.973 1.101 0.975];
A=[0.039 0.070 0.106 0.146 0.107];
P=[0.616 0.763 0.890 1.006 0.891];
m=[0.063 0.092 0.119 0.145 0.120];
Q=[248.7 543.2 932.2  1412.9 940.0];

plot(H,Q)

i=[0.201 0.201];
j=[0 940];
plot(i,j,'r')

k=[0 0.201];
l=[940 940];
plot(k,l,'r')

xtitle("", "Depth H", "Flowrate Q")

Depth=0.201; // m
disp("The depth in the channel =")
disp(Depth)
disp("m")
```

Scilab code Exa 7.7 7

```
clc;
Cd=0.56;
B=1.2; // m
g=9.8; // m/s^2
H=0.018; // m

Q=2/3*Cd*B*sqrt(2*g)*H^(3/2);
disp("The rate of flow of liquid over the weir is ")
disp(Q)
disp("m^3/h")
```

Scilab code Exa 7.8 8

```
clc;
H2=5.5;
Q1=217;
Q2=34;
H1=8.5;

H0=(H2*(Q1/Q2)^(2/3)-H1)/((Q1/Q2)^(2/3)-1);
disp("The height of the weir crest above the surface
    of the river is found to be ")
disp(H0)
disp("m")
```

Scilab code Exa 7.9 9

```
clc
H=0.07; // average head
rate=-0.02/600; // (dH/dt)
H1=0.08; // m
```

```
H2=0.01; // m

k=-rate/H^(3/2);

t=integrate('-1/k*H^(-3/2)', 'H', H1, H2);
disp("Time taken =")
disp(t)
disp("s")
```

Scilab code Exa 7.10 10

```
clc
Cd=0.62;
g=9.81; // m/s^2
H=0.03; // m

Q=8/15*Cd*sqrt(2*g)*H^(5/2);
disp("Rate of flow =")
disp(Q)
disp("m^3/s")
```

Scilab code Exa 7.11 11

```
clc
l=4; // m
b=2; // m
H1=0.15; // m
H2=0.05; // m

t=integrate('-l*b/1.5*H^(-5/2)', 'H', H1, H2);
disp("Time taken to reduce the head in the the tank
  =")
disp(t)
```

```
disp("s")
```

Chapter 8

Pipe friction and turbulent flow

Scilab code Exa 8.4 4

```
clc
rho=867; // kg/m^3
Q=12/3600; // m^3/s
u=7.5*10^(-4); // Ns/m^2
L=200; // m
H=10; // m
g=9.81; // m/s^2

d=(H*2*g/(4*0.079*(4*rho*Q/%pi/u)^(-1/4)*L*(4*Q/%pi)
    ^2))^(-4/19);
disp("Internal diameter of the pipeline =")
disp(d)
disp("m")

Re=4*rho*Q/%pi/d/u;
disp("Re =")
disp(Re)
disp("The value of Reynolds number lies between 4000
     and 10^5, confirming the validity of using the
    Blasius equation for smooth-walled pipes")
```

Scilab code Exa 8.5 5

```
clc
m=40/60; // kg/s
rho=873; // kg/m^3
d=0.025; // m
u=8.8*10^-4; // Ns/m^2
dp=55*10^3; //N/m^2
L=18; // m
g=9.81; // m/s^2

v2=4*m/rho/%pi/d^2;
Re=rho*v2*d/u;

// According to this value of Re, Prandtl's equation is satisfied.
// 1/sqrt(f)=4*log(Re*sqrt(f))-0.4
// By trial and error method we get friction factor equal to
f=0.0055;

H=dp/rho/g + v2^2/2/g + v2^2/2/g*(4*f*L/d+1.5);
disp("The minimum allowable height =")
disp(H)
disp("m")
```

Scilab code Exa 8.6 6

```
clc;
Q=15/3600; // m^3/s
d=0.05; // m
Rho=780;
```

```
u=1.7*10^(-3); // Ns/m^2
f=0.0065;
L=100; // m
g=9.8; // m^2/s

v=4*Q/%pi/d^2;

del_pf=2*f*Rho*v^2*L/d;
disp("The pressure drop due to friction is ")
disp(del_pf);
disp("kNm-2")

H_f=4*f*L*v^2/(d*2*g);
H_exit=v^2/2/g;
H_entrance=v^2/4/g;

H=H_f+H_exit+H_entrance;
disp("and the difference in levels is")
disp(H);
disp("m");
```

Scilab code Exa 8.7 7

```
clc
f=0.005;
L=10; // m
d=0.025; // m
g=9.81; // m/s^2

// H_L=4*f*L/d*v^2/2/g+0.5*v^2/2/g
// H_L=8.5*v^2/2/g

// By Bernoulli equation we get
// H=2.62+9.5*v2^2/2/g

```

```
// Applying the Bernoulli equation between the
   liquid surface and discharge point
// H_L=33.5*v2^2/2/g

// Solving above two we get
v2=1.9; // m/s

Q=%pi*d^2/4*v2;
disp("Rate of flow =")
disp(Q)
disp("m^3/s")

H=2.62+9.5*v2^2/2/g;
disp("The minimum allowable height =")
disp(H)
disp("m")
```

Scilab code Exa 8.8 8

```
clc;
d_A=0.025; // m
v_A=1.21; // m/s
d_B=0.05; // m
v_B=1.71; // m/s

Q_A=%pi*d_A^2*v_A/4;
disp("The rate of flow through parallel pipes A is "
   )
disp(Q_A);
disp("m^3/s")

Q_B=%pi*d_B^2*v_B/4;
disp("The rate of flow through parallel pipes B is "
   )
disp(Q_B);
```

```
disp("m^3/s")
```

Scilab code Exa 8.9 9

```
clc
d2=0.06; // m
d1=0.12; // m
k=0.44;
f=0.05;
L1=500; // m
g=9.81; // m/s^2

// v1=d2^2/d1^2*v2

// H_f=4*f*L1/16/d*v2^2/2/g
// H_c=k*v2^2/2/g
// H_f=4*f*L2/d*v2^2/2/g
// H_exit=v2^2/2/g

v2=sqrt(30*2*g/173.4);

Q=%pi*d2^2/4*v2;
disp("The rate of flow =")
disp(Q)
disp("m^3/s")
```

Scilab code Exa 8.10 10

```
clc
m=12*10^3/3600; // kg/s
Rho=815; // kg/m^3
d=0.05; // m
e=0.02;
```

```
d1=50; // m
d2=0.038; // m
g=9.8; // m

v=4*m/Rho/%pi/d^2;

f1=1/(2*log10(d1/e)+2.28)^2;

L_eq=d1+2*d1*d;

H_50mm=4*f1*L_eq*v^2/(d*2*g);

v=4*m/(Rho*%pi*d2^2);

f2=1/(2*log10(38/e)+2.28)^2;

L_eq=d1+2*d1*d2;
H_38mm=4*f2*L_eq*v^2/(d2*2*g);

Hr=0.2*v^2/(2*g);

H_L=H_50mm+H_38mm+Hr;

del_p_f=Rho*g*H_L;
disp("The total pressure drop due to friction
    through the pipe system is ")
disp(del_p_f);
disp("N/m^2")
```

Scilab code Exa 8.11 11

```
clc
// H_L=1.2*v^2/2/g

// H_L=4*f*L_eq/d*V^2/2/g
```

```
// L_eq=60*d

// H_L=240*f*v^2/2/g
// Combining the two equations for head loss
// 1.2*v^2/2/g=240*f*v^2/2/g

f=1.2/240;
disp("Friction factor =")
disp(f)
```

Scilab code Exa 8.12 12

```
clc
// dp_AB+dp_BC=dp_AD+dp_DC

// dp_AD=2*f*rho*v^2*L/d

// dp_AD=16600*(3-Q)^2
// Likewise
// dp_AB=16600*Q^2
// dp_BC=16600*(Q+0.5)^2
// dp_DC=16600*(2.1-Q)^2
// By solving above 5 equations, we get

Q=1.175; //litres per second

disp("The rate of flow from B to C =")
disp(Q+0.5)
disp("litres per second")

dp_AD=16600*(3-Q)^2;
dp_AB=16600*Q^2;
dp_BC=16600*(Q+0.5)^2;
dp_DC=16600*(2.1-Q)^2;
```

```
disp("dp_AD =")
disp(dp_AD/1000)
disp("kN/m^2")

disp("dp_AB =")
disp(dp_AB/1000)
disp("kN/m^2")

disp("dp_BC =")
disp(dp_BC/1000)
disp("kN/m^2")

disp("dp_DC =")
disp(dp_DC/1000)
disp("kN/m^2")


disp("The lowest pressure drop is in the pipe
    connecting C and D")
```

Scilab code Exa 8.13 13

```
clc
H2=0.5; //m
H1=2; //m
A=4; //m^2
f=0.005;
L=20; //m
d=0.025; //m
g=9.81; // m/s^2

a=%pi*d^2/4;

t=integrate('-A*sqrt((4*f*L/d)+2.5)/a/(sqrt(2*g))*(H
```

```
    )^(-1/2)', 'H', H1, H2);
disp("Time taken =")
disp(t)
disp("s")
```

Scilab code Exa 8.14 14

```
clc

d0=0.15; // m
d1=0.1; // m
Q=50/3600; // m^3/s
f=0.0052;
Rho=972;

a=%pi/4*((d0)^2-(d1)^2);

P=%pi*((d0)+(d1));

d_eq=4*a/P;

v=Q/a;

del_p_f=2*f*Rho*v^2/d_eq;
disp("the pressure drop due to friction per metre
    length of tube is found to be ")
disp(del_p_f)
disp("Nm^2/m")
```

Scilab code Exa 8.15 15

```
clc
f=0.005;
```

```
Q=0.07; // m^3/s
g=9.81; // m/s^2

H_f=integrate('32*f*(Q)^(2)/(%pi)^(2)/g/(0.3-0.0666*
    L)^(5)', 'L', 0, 3);
disp("Fractional head loss =")
disp(H_f)
disp("m")
```

Scilab code Exa 8.16 16

```
clc
g=9.81; // m/s^2
H=4; // m
f=0.006;
L=50; // m
d=0.1; // m

v1=sqrt(2*g*H/(4*f*L/d + 1.3));

t=integrate('4/(v1^2-v^2)', 'v', 0, 0.99*v1);
disp("Time taken =")
disp(t)
disp("s")
```

Chapter 9

Pumps

Scilab code Exa 9.2 2

```
clc
d=0.1; // m
v_r=2; // m/s
f=0.005;
g=9.81; // m/s^2
L_s=2; // m
L_r=10; // m
Q1=1.1*10^(-2); // m^3/s
z_t=12; // m
z_s=5; // m
L1=20; // m

Q=%pi*d^2/4*v_r;
H=12-70*Q-4300*Q^2;
k=2*g*H/v_r^2 - (4*f*(L_s+L_r)/d) - 1;
disp("The head loss across the restriction orifice =
    ")
disp(k)
disp("velocity heads")

// For the case of the valve being fully open
```

```
v_t=4*Q1/%pi/d^2;
v_r=((2*g*(z_t-z_s) + (4*f*L1/d + 1)*v_t^2)/(4*f*L_r
   /d + k + 1))^(1/2);

H1=4*f*L_r/d*v_r^2/2/g + 4*f*L_s/d*(v_r^2+v_t^2)/2/g
    + k*v_r^2/2/g + v_r^2/2/g;

Q=%pi*d^2/4*(v_t+v_r);

H2=12-70*Q-4300*Q^2;

disp("System head =")
disp(H1)
disp("m")

disp("Delivered head =")
disp(H2)
disp("m")

disp("The delivered head therefore closely matches
   the system head at the flow rate of 1.1*10^(-2) m
   ^3/s, corresponding to the duty point")
```

Scilab code Exa 9.6 6

```
clc
NPSH=5; // m
p_v=18*10^3; // N/m^2
p_l=0.94*101.3*10^3; // N/m^2
rho=970; // kg/m^3
g=9.81; // m/s^2
z_s=3; // m
H_L=0.5; // m
d=3; // m
h=2.5; // m
```

```
Q=5; // m^3/h

z1=NPSH+(p_v-p_l)/rho/g + z_s + H_L;
V=%pi/4*d^2*(h-z1);
t=V/Q;

disp("Quantity of liquid delivered =")
disp(V)
disp("m^3")

disp("Time taken =")
disp(t)
disp("h")
```

Scilab code Exa 9.8 8

```
clc
N_s=0.14; // m^(3/4)s^(-3/2)
H=30; // m
p_v=7.38*10^3; // N/m^2
p_l=50*10^3; // N/m^2
rho=992; // kg/m^3
g=9.81; // m/s^2
H_L=0.2; // m

NPSH=2.8*N_s^(4/3)*H;
z1=NPSH+(p_v-p_l)/rho/g+H_L;
disp("The minimum level of the alarm =")
disp(z1)
disp("m")
```

Scilab code Exa 9.10 10

```
clc
dz=10; // z2-z1
g=9.81; // m/s^2
d=0.05; // m
f=0.005;
L=100; // m
N1=1200; // rpm

// H=z2-z1+16*Q^2/2/g/%pi^2/d^4*(4*f*L/d+1)
// H=10+5.42*10^5*Q^2

Q=[0.000 0.002 0.004 0.006 0.008 0.010];
H_p=[40.0 39.5 38.0 35.0 30.0 20.0];
H_s=[10.0 12.2 18.7 29.5 44.7 64.2];

plot(Q,H_p, 'b')
plot(Q,H_s, 'r')
xtitle("", "Flow", "Head")
legend("pump", "system")

a=[0.0066 0.0066];
b=[0 33.8];
plot(a,b, '--')
e=[0 0.0066];
f=[33.8 33.8];
plot(e,f, '--')

i=[0.0049 0.0049];
h=[0 23];
plot(i,h, '--')
l=[0 0.00495];
m=[23 23];
plot(l,m, '--')

// From graph
H1=34; // m
H2=23; // m
Q1=0.0066; // m^3/s
```

```
Q2=0.00495; // m^3/s

disp("Duty point =")
disp(Q1)
disp("m^3/s")

N2=N1*(H2/H1)^(1/2);
disp("The speed of the pump to reduce the flow by 25
    % =")
disp(N2)
disp("rpm")
```

Scilab code Exa 9.11 11

```
clc
Q=0.05; // m^3/s
v=2; // m/s
f=0.005;
L_s=5; // m
d=0.178; // m
g=9.81; // m/s^2
L_d=20; // m
p2=1.5*10^5; // N/m^2
p1=0.5*10^5; // N/m^2
rho=1000; //kg/m^3
z2=15; // m
z1=5; // m
N1=1500/60; // rps




d=(4*Q/%pi/v)^(1/2);
H_f_s=4*f*L_s/d*v^2/2/g;
H_f_d=4*f*L_d/d*v^2/2/g;
```

```
H=1/(1-0.25)*((p2-p1)/rho/g + v^2/2/g + z2 - z1 + H_f_s + H_f_d);

// n=rho*g*Q*H/P

Q=[0 5 10 15 20 25];
H=[9.25 8.81 7.85 6.48 4.81 2.96];
P=[- 0.96 1.03 1.19 1.26 1.45];
n=[0 45 75 800 75 50];

H=27.96; // m
H1=6.48; // m
Q1=0.015; // m^3/s
Q=0.05; // m^3/s
D1=0.15; // m
n=0.80;

disp("Differential Head =")
disp(H)
disp("m")

N=N1*(H/H1)^(3/4)*(Q1/Q)^(1/2);

D=D1*(Q*N1/Q1/N)^(1/5);
disp("The impeller diameter =")
disp(D)
disp("m")

disp("The rotational speed at maximum efficiency =")
disp(N)
disp("rps")

P=rho*g*Q*H/n;
disp("Power input to the pump =")
disp(P)
disp("W")
```

```
N_s=N1*Q1^(1/2)/H1^(3/4);
```

Scilab code Exa 9.12 12

```
clc
N=2000/60; // rps
Q=50/3600; // m^3/s
g=9.81; // m/s^2
H=5; // m

S_n=N*Q^(1/2)/(g*H)^(3/4);
disp("Suction specific speed =")
disp(S_n)
```

Scilab code Exa 9.14 14

```
clc
A=0.01; // m^2
L=0.3; // m
N=60/60; // rps
V_act=10.6/3600; // m^3/s
rho=1000; // kg/m^3
g=9.81; // m/s^2
Q=10.6/3600; // m^3/s
H=15; // m

V=A*L*N;

Cd=V_act/V;
disp("Coefficient of discharge =")
disp(Cd)

P=rho*g*Q*H;
```

```
disp("The power required =")
disp(P)
disp("W")
```

Scilab code Exa 9.15 15

```
clc
// x=r*(1-cos(wt))
// v=r*wsin(wt)
// V=2*A*w*r
// Q=V/2/%pi
// Q=A*w*r/%pi

// Q_peak=A*w*r

// Q_peak/Q=%pi

disp("The ratio of peak to average flow =")
disp(%pi)
```