# Scilab Textbook Companion for A Textbook Of Fluid Mechanics And Hydraulic Machines (in S.i. Units)- partially solved by R. K. Bansal[1]

Created by
Vikas Pratap Singh
Ra
Chemical Engineering
$\text{Iit}_g$
College Teacher
None
Cross-Checked by
None

July 31, 2019

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

# Book Description

**Title:** A Textbook Of Fluid Mechanics And Hydraulic Machines (in S.i. Units)- partially solved

**Author:** R. K. Bansal

**Publisher:** Laxmi Publications

**Edition:** 9

**Year:** 2005

**ISBN:** 9788131808153

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

# Properties of Fluid

**Scilab code Exa 1.1** Specific Gravity

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.1
clc
clear
W=7
V=1/1000
g=9.81
d_water=1000
w=W/V
mprintf("The Specific weight of the liquid is %d \n",w)
d=w/g
mprintf("The density of the liquid is %.2f \n",d)
SG=d/d_water
mprintf("The Specific Gravity o fthe liquid is %d \n",SG)
```

**Scilab code Exa 1.2** Specific Gravity

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.2
clc
clear
//Given Data Set in the Problem
V=1/1000
SG=0.7
d_water=1000
g=9.81

//Calculations
// Density of Petrol
d=SG*d_water
mprintf("The Density of Petrol is %f \n",d)
//Specific Weight of Petrol
w=d*g
mprintf("The Specific weight of Petrol is %f \n",w)
// Weight of 1 litre of Petrol
W=w*V
mprintf("The Weight of 1 litre of Petrol is %f \n",W
    )
```

---

**Scilab code Exa 1.3** Shear stress

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.3

y=poly(0,"y")
u=2/3*y-y^2                  // Defining the Velocity
```

```
Function
a=derivat(u)                    //Taking Derivative of the Velocity
visc=8.63/10                    //Converting Dynamic Viscosity from poise to N s/m^2
ss1=visc*horner(a,0)            //Shear stress=(Dynamic viscosity *Velocity Gradient) at y=0
mprintf("The shear stress at y=0 is %f N/m^2 \n",ss1)
ss2=visc*horner(a,0.15)         //Shear stress=(Dynamic viscosity *Velocity Gradient) at y=0.15
mprintf("The shear stress at y=0.15 is %f ",ss2)
```

**Scilab code Exa 1.4** `Fluid viscosity`

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.4

//Given Data Set in the Problem
dy=0.025/1000
v=60/100
ss=2

//Calculations
//To find the Viscosity
//Shear Stress=Viscosity * Velocity gradient
du=(60-0)/100
vel_grad=du/dy                  //Defining velocity gradient across the plate
visc=ss/vel_grad
visc_poise=visc*10              //Converting viscosity to poise from Ns/m^2
mprintf("The Viscosity between the plates is %f
```

```
poise",visc_poise)
```

**Scilab code Exa 1.5** Force and Power calculation for plates constant speed

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.5

//Given Data Set in the Problem
Area=1500000/(1000)^2          //Area in m^2
du=0.4
dy=0.15/1000          //Distance between the plates
   In metres
visc=1/10          //In SI Units of Ns/m^2

//Calulations
//Force required to maintain that speed
ss=visc*(du/dy)                  //ss is the shear
   stress
Force=ss*Area                              //Force
   required= Shear stress * Area
mprintf("The Force required to maintain the speed is
   %f N\n",Force)

//Power required
Power=Force*du          //Power =(Force)*(Speed at
   which the plate has to be kept moving)
mprintf("The Power required to maintain the speed is
   %f W\n ",Power)
```

**Scilab code Exa 1.6** Shear intensity

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.6

//Given Data Set in the Problem
visc=1/10                //In SI Units
D=10/100                 //In SI Units
dy=1.5/1000              //Distance between shaft and
     journal bearing
N=150                    //In RPM

//Calculations
//Intensity of the shear due to the Oil
du= (%pi*D*N)/60                    //du=( DN )
    /60....The tangential velocity which causes shaer
ss=visc*(du/dy)
mprintf("The Shear stress due to the oil is %f N/m^2
     \n",ss)
```

---

**Scilab code Exa 1.7** `dynamic viscosity`

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.7

//Given Data Set in the Problem
Area=0.8*0.8
theta=%pi/6
W=300
du=0.3
dy=1.5/1000

//Calculations
```

```
W_alongPlane=W*cos(%pi/2-theta)
Shear_Force=W_alongPlane
ss=Shear_Force/Area
visc=ss/(du/dy)                          //Shear Stress+
   Viscosity * Velocity Gradient
mprintf("The Dynamic Viscosity of the Oil is %f
   poise",visc*10)
```

**Scilab code Exa 1.8** Shear stress

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.8

//Given data set in the problem
dy=1.25/100
visc=14/10
u=2.5

//Calculations
ss=visc*((u-0)/dy)                    //shear stress=
   viscosity*(velocity gradient across the oil)
mprintf("The shear stress between the plates is %f N
   /m^2",ss)
```

**Scilab code Exa 1.9** Dynamic and kinematic viscosity

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.9

```

```

//Given Data Set in the Problem
Area=(60*60)/(100*100)
dy=12.5/1000
u=2.5
du=u-0
Force=98.1
ss=Force/Area

//Calculations
//1)Dynamic viscosity of Oil in poise
                                                    //Shear Stress=(Force/Area)=viscosity*Velocity gradient
Dyn_visc=ss/(du/dy)
mprintf("The Dynamic Viscosity o fthe oil is %f poise \n",Dyn_visc*10)

//2) Kinematic viscosity of th eoil in stokes in SG of Oil is 0.95
SG=0.95
density_oil=SG*1000
Kin_visc=Dyn_visc/density_oil
mprintf("The Kinematic viscosity of the oil is %f stokes",Kin_visc*10^4)
```

**Scilab code Exa 1.10** `kinematic viscosty`

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
```

```
// Problem 1.10


//Given Data Set in the Problem
density=981
ss=0.2452
vel_grad=0.2

//Calculations
visc=ss/(vel_grad)
kin_visc=visc/density
mprintf("The Kinematic viscosity of the oil is %f
   stokes\n",kin_visc*10^4)
```

**Scilab code Exa 1.11** Specific Gravity

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.11


//Given Data Set in the Problem
visc=0.05/10
kin_visc=0.035/(10^4)
dens_water=1000

//Calculations
dens_oil=visc/kin_visc
SG=dens_oil/dens_water
mprintf("The Specifc Gravity of Oil is %f \n",SG)
```

**Scilab code Exa 1.12** Viscosity

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.12


//Given Data Set in the Problem
kin_visc=6*10^-4
SG=1.9
dens_water=1000

//Calculations
dens_liquid=SG*dens_water
visc=dens_liquid*kin_visc                    //Kinematic viscosity=Dynamic Viscosity/density of liquid
mprintf("The Dynamic viscosity of th liquid is %f poise \n",visc*10)
```

---

**Scilab code Exa 1.13** Shear stress

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.13


//Given Data Set in the Problem
y=poly(0,"y")
u=3*y/4-y^2
visc=8.5/10

//Calculations
du_dy=(horner(derivat(u),0.15))

```

```
ss=visc*du_dy
mprintf("The shear stress at y=0.15 m is %f N/m^2 \n
   ",ss)
```

**Scilab code Exa 1.14** Power Calculation

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.15


//Given Data Set in the Problem(SI Units)
visc=6/10
D=0.4
N=190
L=90/1000
t=1.5/1000


//Calculations
u_tangent=%pi*D*N/60
du=u_tangent-0
dy=t
ss=visc*du/dy
Area=%pi*D*L
Force=ss*Area                              //Force
   =shear stress *Area
T=Force*D/2                               //Torque =
   Force*(D/2)
Power_lost=(2*%pi/60)*N*T                  //Power
   lost =(2*pi/60)*Torgue*Speed of the shaft
mprintf("The Power lost in the bearing of the sleeve
    is %f W",Power_lost)
```

**Scilab code Exa 1.15** Velocity gradients and shear stress

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.15


//Given Data Set in the Problem(SI Units)
dist=20/100
u_vertex=120/100
visc=8.5/10
//Assuming u=a*y^2+b*y+c applying all three boundary conditions , we get the y vector and velocity vector as below;
y_vector=[0 0 1;400 20 1;40 1 0]
vel_vector=[0;-120;0]
[constants]=linsolve(y_vector,vel_vector)
//1) Velocity grdient =2ay+b
//For y=0, 10, 20 cm
y=[0,10,20]
du_dy=2*constants(1)*y+constants(2);
ss=visc*du_dy;
printf("The shear stress at y=%d,%d,%d cm are %f,%f, and %fN/m^2",y(1),y(2),y(3),ss(1),ss(2),ss(3));
```

**Scilab code Exa 1.16** Speed calculation for given force on a sleeve

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.16
```

```
//Given Data Set in the Problem(SI Units)
F1=40
F2=200
u1=50/100

//Calculations
//We know, Shear stress=Force/Area=viscosity*(
    Velocity Gradient)
//ie,  F/A=viscosity*(u/y)
//F/u=Viscosity*(A/y)
//F1/u1=F2/u2=constant
u2=F2*u1/F1
mprintf("The Speed of the sleeve when a force of 200
   N is applied is %f cm/s",u2*100)
```

**Scilab code Exa 1.17** `Viscosity`

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.17


//Given Data Set in the Problem(SI Units)
d=15/100
d_outer=15.10/100
l=25/100
T=12
N=100


//Calculations
u_tang=%pi*d*N/60
```

```
Area_surface=%pi*d*l
du=u_tang-0
dy=(d_outer-d)/2
        //We know, Shear stress=Force/Area=viscosity
           *(Velocity Gradient)
        //also, Torque=Force*Diameter/2.......or..
           Force=(Torque*2)/Diameter
         //hence,  2*Torque/(diameter*area)=
            Viscosity*(Vel. gradient)
visc=2*T/(d*Area_surface*du/dy)
mprintf("The Viscosity of the  liquid is %f poise",
   visc*10)
```

**Scilab code Exa 1.18** Force required to drag a thin plate

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.18


//Given Data Set in the Problem(SI Units)
Area=0.5
du=0.6
visc=0.81
y=2.4/100
dy=2.4/2/100

//Calculations
//Case 1:When the thin plate is in the middle
ss=visc*(du/dy)
F_upper=ss*Area
F_lower=ss*Area
F=F_upper+F_lower
mprintf("The Total shear force on the thin plate in
```

```
    the middle of the two plates is %f N \n",F)

//Case 2: When the palte is at a distanvce of 0.8 cm
    from one plate
dy_upper=y-0.8/100
dy_lower=0.8/100
F_upper2=visc*du/dy_upper*Area
F_lower2=visc*du/dy_lower*Area
F2=F_upper2+F_lower2
mprintf("The Total shear force on the thin plate at
    a distance 0.8 cm from one plate is %f N \n",F2)
```

**Scilab code Exa 1.19** Force to lift a plate in fluid

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.19


//Given Data Set in the Problem(SI Units)
gap=2.2/100
visc=2
SG=0.9
g=9.81
W_dens=SG*1000*g
Vol=1.2*1.2*0.2/100
Area=1.2*1.2
t=0.2/100
vel=0.15
W=40

//Calculations
dis_from_plate=(gap-t)/2          //Distance of the
    plate from each of the two plates
```

```
ss=visc*(vel/dis_from_plate)
Force_left=ss*1.2*1.2
Force_right=ss*1.2*1.2
F=Force_left+Force_right          //Sum of Force on the right + left side of the plate
Upthrust=W_dens*Vol               //Calculates Buoyant force on the plate
F_down=W-Upthrust                 //net downward force on the plate except shear forces
F_ToLift=F+F_down                 //som total of all forces on the plate
mprintf("The Force required to lift the plate is %f N \n",F_ToLift)
```

**Scilab code Exa 1.20** gas constant and density

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.20


//Given Data Set in the Problem(SI Units)
w=16
t=25
T=273+t
p=0.25*10^6
g=9.81

//Calculations
//1)Density
density=w/g
mprintf("The Density of the gas is %f kg/m^3 \n",density)

```

```
//2)Gas consatnt
R=p/(density*T)
mprintf("The gas constant is %f Nm/kg-K \n",R)
```

**Scilab code Exa 1.21** Pressure and temperature

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.21


//Given Data Set in the Problem(SI Units)
V1=0.6
t=50
T1=273+t
P1=0.3*10^6
V2=0.3
k=1.4

//Calculations
//1) Isothermal
//Using pv=constant
P2=P1*V1/V2
mprintf("The Final Pressure for isothermal
   conditions is %f N/mm^2 \n",P2*10^-6)

//2) Adiabatic
//Using PV^k=constant  or P1V1^k=P2 V2^k
P2=P1*(V1/V2)^k
mprintf("The Final Pressure for Adiabatic conditions
    is %f N/mm^2 \n",P2*10^-6)
//Using T V^(k-1) = constant
T2=T1*(V1/V2)^(k-1)
mprintf("The Final Temperature for Adiabatic
```

```
conditions is %f C",T2-273)
```

**Scilab code Exa 1.22** Pressure by gas

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.22

//Given Data Set in the Problem(SI Units)

m=5
t=10
T=273+10
V=0.4
M=28
R=8314                //Universal Gas constant in N-m/(kg-mole K)

//Calculations
p=((m/M)*R*T)/V
mprintf("The pressure exerted by the 5kg Nitrogen gas is %f N/mm^2 \n",p*10^-6);
```

**Scilab code Exa 1.23** Bulk modulus of elasticity of a liquid

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.23

//Given Data Set in the Problem(SI Units)

```

```
p_i=70
p_f=130
dp=p_f-p_i
dV_V=0.15/100                    //Using dV/V=-dP/P

//Calculations
//Using K=dP/(-dV/V)
K=dp/(dV_V)
mprintf("The Bulk modulus of elasticity of the liquid is %f N.cm^2",K);
```

**Scilab code Exa 1.24** Bulk modulus of elasticity of a liquid

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.24

//Given Data Set in the Problem(SI Units)
V_i=0.0125
V_f=0.0124
p_i=80
p_f=150

//Caclulations
dV=V_i-V_f
dV_V=-dV/V_i
dp=p_f-p_i
K=dp/(-dV_V)                     //Using K=dP/(-dV/V)=Bulk modulus of elasticity
mprintf("The bulk modulus of elasticity of the liquid is %f N/cm^2",K);
```

**Scilab code Exa 1.25** `Droplet diameter`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.25

//Given Data Set in the Problem(SI Units)
st=0.0725            //Surface tension
p=0.02*10^4

//Calculations
//Using pressure =(4*Surface tension)/(diameter of
   the droplet)
d=4*st/p
mprintf("The diameter of the droplet is %f mm",d
   *10^3);
```

---

**Scilab code Exa 1.26** `surface tension`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.26

//Given Data Set in the Problem(SI Units)
d=40*10^-3
p=2.5


//Calculations
//Using Pressure =8*Surface tension/diameter of the
   soap bubble
st=p*d/8
mprintf("The Surface tension inside the soap bubble
```

```
is %f N/m",st)
```

**Scilab code Exa 1.27** pressure inside a droplet

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.27

//Given Data Set in the Problem(SI Units)
d=0.04*10^-3
p_outside=10.32*10^4
st=0.0725

//Calculations
//Using pressure =(4*Surface tension)/(diameter of the droplet)
p=4*st/d
//But this pressure obtained is p_inside-p_outside       thus ,
p_inside=p_outside+p
mprintf("The pressure inside the droplet is %f n/cm^2",p_inside*10^-4);
```

**Scilab code Exa 1.28** Capillary rise in a tube

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.28

//Given Data Set in the Problem
d=2.5*10^-3
```

```
st_w=0.0725
st_m=0.52
SG_m=13.6
dens_w=1000
dens_m=13.6*1000
g=9.81

//Calculations
//Using rise=4*surface tension/(density *g *diameter
    of capillary)
//CAPILLARY RISE FOR WATER (theta =0,cos 0=1)
h=4*st_w/(dens_w*g*d)
mprintf("The rise for water is %f cm \n",h*100)

//CAPILLARY RISE FOR MERCURY
//Using rise=4*surface tension/(density *g *diameter
    of capillary)
h=4*st_m*cos(%pi*130/180)/(dens_m*g*d)
mprintf("The rise  for mercury is  %f cm",h*100)
```

**Scilab code Exa 1.29** Capillary rise in a tube

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.29

//Given Data Set in the Problem
d=4*10^-3
st_w=0.073575
st_m=0.51
SG_m=13.6
dens_w=998
dens_m=13.6*1000
g=9.81
```

```
//Calculations
//CAPILLARY RISE FOR WATER (theta =0,cos 0=1)
//Using rise=4*surface tension/(density *g *diameter
    of capillary)
h=4*st_w/(dens_w*g*d)
mprintf("The rise for water is %.3f mm \n",h*1000)

//CAPILLARY RISE FOR MERCURY
//Using rise=4*surface tension/(density *g *diameter
    of capillary)
h=4*st_m*cos(%pi*130/180)/(dens_m*g*d)
mprintf("The rise  for mercury is  %.3f mm",h*100)
```

**Scilab code Exa 1.30** size of glass capillary tube

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.30

//Given Data Set in the Problem
h=0.2*10^-3
st=0.0725
dens=1000
g=9.81

//Calculations
//Using rise=4*surface tension/(density *g *diameter
    of capillary)
d=4*st/(dens*g*h)
mprintf("The diameter oif the capillary for the rise
    of 0.2 mm is %f cm",d*100)
```

**Scilab code Exa 1.31** minimum size of glass capillary tube

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.31

//Given Data Set in the Problem
h=2*10^-3
st=0.073575
theta=0
dens=1000
g=9.81

//Calculations
//Using rise=4*surface tension/(density *g *diameter
     of capillary)
d=4*st/(dens*g*h)
mprintf("The diameter of the capillary is %f cm",d
    *100)
```

**Scilab code Exa 1.32** power lost in sleeve for a given oil film thickness

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 1-Properties of Fluid
// Problem 1.32

//Given Data Set in the Problem
visc=5/10
D=0.5
N=200
```

```
L=100/10^3
t=1*10^-3

//Calculations
//Using , tangential velocity=(pi*D*N)/60
u_tang=%pi*D*N/60
du=u_tang-0
dy=t
du_dy=du/dy
ss=visc*(du_dy)                    //Shear stress =
    viscosity*Velocity gradient
Area=%pi*D*L
F_shear=ss*Area
T=F_shear*D/2                      //Torque=Shear
    force*D/2
Power_lost=T*(2*%pi*N/60)          //Power lost =
    Torque*(2*pi*N/60)
mprintf("ThePower lost by the sleeve of 100m in oil
    is %f kW",Power_lost*10^-3)
```

# Chapter 2

# Pressure and it measurements

**Scilab code Exa 2.1** `weight lifted`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.1

//Given Data Set in the Problem
D=30/100
d=4.5/100
F=500

//Calculations
A_ram=%pi/4*D^2          //Area of ram
A_plunger=%pi/4*d^2          //Area pof plunger
P_plunger=F/A_plunger
 //Pressure is transmitted equally in all directions
    ,thus ,
W_ram=P_plunger*A_ram
mprintf("The Weight of the ram is %f kN",W_ram/1000)
   ;
```

**Scilab code Exa 2.2** Force required at the plunger

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.2

//Given Data Set in the Problem
d_ram=20/100
d_plunger=3/100
F_ram=30*10^3

//Calculations
A_plunger=%pi/4*d_plunger^2
A_ram=%pi/4*d_ram^2
//We know that, Pressure on plunger =Pressure on ram
//Thus, (F/A)_ram=(F/A)_plunger
//F_plunger=(F/A)_ram * A_plunger
F_plunger=F_ram/A_ram*A_plunger
mprintf("The Force required at the plunger is %f N",
    F_plunger)
```

**Scilab code Exa 2.3** pressure due to a column

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.3


//Given Data Set in the Problem
z=0.3
```

```
SG_oil=0.8
SG_mercury=13.6
dens_water=1000
g=9.81

//Calculations
//Pressure of water column
p_w=dens_water*g*z
mprintf("The Pressure due to the water column is %f
    N/cm^2 \n",p_w*10^-4)

//Pressure of oil column
p_o=dens_water*g*z*SG_oil
mprintf("The Pressure due to the oil column is %f N/
    cm^2\n ",p_o*10^-4)

//Pressure of water column
p_m=dens_water*g*z*SG_mercury
mprintf("The Pressure due to the mercury column is
    %f N/cm^2",p_m*10^-4)
```

**Scilab code Exa 2.4** fluid height

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.4

//Given Data Set in the Problem
P=3.924
dens_water=1000
g=9.81
SG_oil=0.9

//Calculations
```

```
//If the fluid is water
z_water=P/(dens_water*g)
mprintf("The height in water column is %f m of water \n",z_water*10^4)

//If the fluid is oil(SG=0.8))
z_oil=P/(dens_water*SG_oil*g)
mprintf("The height in oil column is %f m of oil", z_oil*10^4)
```

**Scilab code Exa 2.5** height of water

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.5

//Given Data Set in the Problem
SG_oil=0.9
z_oil=40
dens_water=1000
g=9.81

//Calculations
dens_oil=SG_oil*dens_water
//Using pressure=density * g * heighjt of column
p_oil=dens_oil*g*z_oil
z_water=p_oil/(dens_water*g)
mprintf("The corresponding height of water column is %f m of water",z_water)
```

**Scilab code Exa 2.6** pressure at points

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.6

//Given Data Set in the Problem
z1=2
z2=1
S_o=0.9
dens1=1000
dens2=0.9*1000
g=9.81

//Calculations
//At interface (that is , at A)
p_A=dens2*g*z2
mprintf("The Pressure at interface of the liquids is
     %f N/cm^2\n",p_A/10^4)

//At the bottom
p_B=dens2*g*z2+dens1*g*z1
mprintf("The Pressure at bottom of the tank is %f N/
    cm^2",p_B/10^4)
```

**Scilab code Exa 2.7** load lifted

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.7

//Given Data Set in the Problem
d=3
a=%pi/4*d^2
D=10
```

```
A=%pi/4*D^2
f=80
dens=1000
g=9.81

//Calculations
//When pistons are at same level
F=f/a*A
mprintf("The force on the large piston in level with
    the small piston  is %f N\n",F)

//When smaller piston is 40 cm above tha large
   piston
p=(dens*g*40/100)/10^4                              //
   pressure due to 40 cm of the liquid
F_=(f/a+p)*A
mprintf("The force on the large piston 40 cm below
   small piston is %f N\n",F_)
```

**Scilab code Exa 2.8** gauge and absolute pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.8

//Given Data Set in the Problem
z1=3
dens1=1.53*10^3
z0=750/1000
g=9.81
dens_w=1000
SG=13.6

//Calculations
```

```
//Using , p=density * g * height
p_atm=SG*dens_w*g*z0
p_gauge=dens1*g*z1
p=p_gauge+p_atm
mprintf("The Gauge Pressure is %f N/m^2 \n",p_gauge)
mprintf("The Absolute Pressure is %f N/m^2",p)
```

**Scilab code Exa 2.9** `Fluid pressure in pipe`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.9

//Given Data Set in the Problem
SG1=0.9
SG2=13.6
g=9.81

//Calculations
dens1=SG1*1000
dens2=SG2*1000
h2=20/100
h1=h2-12/100
//Equating pressure at 20 cm below th right arm of
   the tube
p=((dens2*g*h2)-(dens1*g*h1))
mprintf("The Pressure  of fluid in the pipe is %f N/
   cm^2",p*10^-4)
```

**Scilab code Exa 2.10** `vacuum pressure in pipe`

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.10

//Given Data Set in the Problem
SG1=0.8
SG2=13.6
dens1=SG1*1000
dens2=13.6*1000
g=9.81
h2=40/100
h1=15/100

//Calculations
//Since , (dens2*g*h2)+(dens1*g*h1)+p=0
p=-((dens2*g*h2)+(dens1*g*h1))
mprintf("The vacuum pressure in the pipe is %f N/cm^2 ",p*10^-4)
```

**Scilab code Exa 2.11** Difference in mercury level

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.11

//Given Data Set in the Problem
h=0.1
dens=1000
SG=13.6
g=9.81

//calculations
//1)
```

```
//we know that P_B=P_C
//P_B=P_A+Pressure due to 0.1m column length
P_col=dens*g*h
//P_C=P_D+Pressure doe to 10cm mercury
P_C=0+SG*dens*g*h
//hence;
P_A=P_C-P_col
mprintf("The pressure at A is %f N/m^2\n",P_A)
//2)
//If P_A=9810
P_A=9810
//Using f(x)=P_B-P_C
function [f]=F(x)
    f=(P_A+dens*g*(10-x)/100)-(0+SG*dens*g*(10-2*x)
       /100)
endfunction
x=10;
y=fsolve(x,F)
mprintf("The new difference in mercury is %f cm\n"
   ,10-2*y)
```

**Scilab code Exa 2.12** Manometer reading

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.12

//Given Data Set in the Problem
h2=20/100
SG2=13.6
SG1=1
dens1=1000
dens2=13.6*dens1
g=9.81
```

```

//Calculations
//equating pressure above the datum line;
function [f]=F(h1)
    f=(dens2*g*h2)-(dens1*g*h1)
endfunction
h1=10;
H1=fsolve(h1,F)
//When vessel is completely filled with wter;
//Equating pressure in the two limbs
function [g]=G(y)
    g=(dens2*g*(0.2+2*y/100))-(dens1*g*(3+H1+y/100))
endfunction
y=10;
Y=fsolve(y,G)
mprintf("The difference in the mercury level in the
   two limbs is %f cm\n",(20+2*Y))
```

---

**Scilab code Exa 2.13** `fluid displacement`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.13
clc
clear
//Given Data Set in the Problem
d1=1000
d2=900
g=9.81
A=10
a=0.25
h=1
//Equating pressures
function [f]=F(k)
```

```
    f(1)=(d1*g)*(k(1)+k(2)+k(1)*a/A)-(d2*g)*(k(1)+k
       (3)-k(1)*a/A)-98.1
    f(2)=k(2)-(d2*g*k(3))/(d1*g)
    f(3)=0
endfunction
k=[1 1 10];
y=fsolve(k,F);
mprintf("The displacement of the surface of
   separation is %.4f m\n",y(1))
```

**Scilab code Exa 2.14** pressure in the pipe

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.14

//Given Data Set in the Problem
g=9.81
sg1=0.9
dens1=sg1*1000
sg2=13.6
dens2=sg2*1000
h1=20/100
h2=40/100
a_A=1/100
//calculations
pA=(a_A)*(h2*dens2*g-h2*dens1*g)+h2*dens2*g-h1*dens1
   *g
mprintf("The pressure in the pipe is %f N/cm^2\n",pA
   *10^-4)
```

**Scilab code Exa 2.15** Pressure difference across two points

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.15

//Given Data Set in the Problem
SG1=0.9
SG2=13.6
dens=1000
h=15/100
g=9.81

//Calculations
dens2=SG2*dens
dens1=SG1*dens
delta_p=g*h*(dens2-dens1)
mprintf("The pressure difference is %f N/m^2\n",
   delta_p)
```

---

**Scilab code Exa 2.16** `Difference in mercury level`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.16

//Given Data Set in the Problem
sg1=1.5
sg2=0.9
g=9.81
dens1=sg1*1000
dens2=sg2*1000

//calculations
pA=1*10^4*g
```

```
pB=1.8*10^4*g
//pressure above X-X in left limb is p_left=13.6*1000*g*h+dens1*g*(2+3)+pA and p_right=dens2*g*(h+2)+p
function [f]=F(h)
    f=13.6*1000*g*h+dens1*g*(2+3)+pA-(dens2*g*(h+2)+pB)
endfunction
h0=10;
h=fsolve(h0,F)
mprintf("\nTHE DIFFERENCE IN MERCURY LEVELS IS %f cm\n",h*100)
```

---

**Scilab code Exa 2.17** Absolute pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.17

//Given Data Set in the Problem
B=9.81
g=9.81
dens=1000
pB=B*10^4
dens_oil=0.9*dens
dens_mercury=13.6*dens
//Pressure above X-X in right limb;
p_right=dens*g*60/100+pB
//Pressure above X-X in left limb;
//since ;p_left=dens_mercury*g*10/100+dens_oil*g*20/100+pA....
//and p_left=p_right.,..........hence
pA=(p_right)-(dens_mercury*g*10/100+dens_oil*g*20/100)
```

```
mprintf("The absolte pressure at A is %f N/cm^2",pA*10^-4)
```

**Scilab code Exa 2.18** pressure at points

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.18

//Given Data Set in the Problem
dens=1000
g=9.81
A=2
dens1=1000
h1=30/100
h2=10/100
SG2=0.8
dens2=SG2*dens1
h3=12/100

//calculations
pA=dens*g*A
//pressure below X-X in left limb is pA-(dens1*g*h1)
p_left=pA-dens1*g*h1
//pressure below X-X in right  limb is pA-(dens1*g*h1)
                //p_right=pB-dens1*g*h2-dens2*g*h3
                //and ... P_left=P_right
pB=p_left+dens1*g*h2+dens2*g*h3
mprintf("The pressure in pipe B is %f N/cm^2\n",pB*10^-4)
```

**Scilab code Exa 2.19** Pressure difference across two points

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.19

//Given Data Set in the Problem
dens=1000
g=9.81
sg_oil=0.8
h1=20/100
h2=30/100
h3=30/100

//calculations
dens_oil=sg_oil*dens
dl=h1+h2-h3
//Pressure in left limb below X-X=pA-dens*g*h2
//Pressure in left limb below X-X=pB-dens*g*h3-
    sg_oil*dens*h1
pB_pA=dens*g*h3+sg_oil*dens*g*h1-dens*g*h2
mprintf("The difference in the pressures is equal to
     %f N/m^2\n",pB_pA)
```

**Scilab code Exa 2.20** Difference in oil level

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.20

//Given Data Set in the Problem
dens=1000
g=9.81
```

```
SG1=1.2
SG2=1.0
dens1=SG1*dens
dens2=SG2*dens
SG_oil=0.7
dens_oil=SG_oil*dens
p=poly(0,"p")
pA=p
pB=p
x1=30/100

//calculations
//equating pressure in left and rght limbs ,we get;
function [f]=F(h)
    f=(pA-dens1*g*x1-dens_oil*g*h)-(pB-dens2*g*(h+x1
       ))
endfunction
h=10;
y=fsolve(h,F)
mprintf("The reading h is %f cm\n",y*100)
```

**Scilab code Exa 2.21** Difference in mercury level

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.21

//Given Data Set in the Problem
dens=1000
g=9.81
h1=0.35
h2=0.3
SG=0.8

```

```
//calculations
//pC=pD
//pC=pA-dens*g*h1.....adn pD=pB-dens*g*h1-dens*g*h2
pB_pA=SG*dens*g*h2
mprintf("The difference of pressure between the pipes is %f N/m^2\n",pB_pA)
```

**Scilab code Exa 2.22** `pressure at points`

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.22

//Given Data Set in the Problem
dens=1000
g=9.81
p0=10.143*10^4
Z=2500

//calculations
//1) pressure by hydrostatic law
dens0=1.208
p=p0-integrate("dens0*g","z",0,Z)
mprintf("The pressure by hydrostatic law at 2500m height is %f N/cm^2\n",p*10^-4)
//2)PRESSURE BY ISOTHERMAL LAW
//p=p0*e^(-gZ/RT)
p=p0*exp(-g*Z*dens0/p0)
mprintf("The pressure BY ISOTHERMAL LAW at 2500m height is %f N/cm^2\n",p*10^-4)
```

**Scilab code Exa 2.23** `elevation of the top`

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.23
clc
clear
//Given Data Set in the Problem
dens=1000
g=9.81
sg=13.6
dens_air=1.2

//calculations
p0=760/1000*sg*dens*g
p=735/1000*sg*dens*g
//the height "h" at which the pressure equals p is
    given by
h=(p0-p)/(dens_air*g)
mprintf("The height is %.2f m at which the pressure
    equals %.2f  mm Hg\n",h,735 )
```

**Scilab code Exa 2.24** pressure at a height

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.24

//Given Data Set in the Problem
dens=1000
g=9.81
Z=7500
p0=10.143*10^4
t0=15
T0=t0+273.15
```

```
dens0=1.285

//calculations
//1)incompressible
p=p0-integrate("dens0*g","z",0,Z)
mprintf("The pressure when air is incompressible is
   %f N/cm^2\n",p*10^-4)
//2)isothermal
p=p0*exp(-g*Z*dens0/p0)
mprintf("The pressure when air follows isothermal
   law is %f N/cm^2\n",p*10^-4)
//3)adiabatic
k=1.4
p=p0*(1-(k-1)/k*g*Z*dens0/p0)^(k/(k-1))
mprintf("The pressure when air follows adiabatic law
    is %f N/cm^2\n",p*10^-4)
```

---

**Scilab code Exa 2.25** Pressure and density

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.25
clc
clear
//Given Data Set in the Problem
dens=1000
g=9.81
Z=4000
p0=10.143*10^4
t0=15
T0=t0+273.15
L=-0.0065
dens0=1.285
R=p0/(dens0*T0);
```

```
function f=F(k)
f=L+(g/R)*((k-1)/k);
endfunction
k=1;
y=fsolve(k,F);
k=y;
//1) Pressure at 4000m is given by
P=p0*(1-((k-1)/k*g*Z*dens0/p0))^(k/(k-1))
mprintf("The Pressure at 4000 m is %.3f N/cm^2\n",P
    *10^-4)
//2) Density
t=t0+L*Z;
T=273+t;
density=P/(R*T);
mprintf(" The density at 4000 m is %.2f kg/m^3",
    density)
```

**Scilab code Exa 2.26** Pressure around the aeroplane

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 2.19

//Given Data Set in the Problem
dens=1000
g=9.81
Z=5000
p0=10.143*10^4
t0=15
T0=t0+273.15
dens0=1.285
L=-0.0065

//calculations
```

```
R=p0/(dens0*T0)
//we know L=dT/dZ=-g(k-1)/(Rk)
k=g/(L*R+g)
p=p0*(1-(k-1)/k*g*Z*dens0/p0)^(k/(k-1))
mprintf("The pressure when air follows adiabatic law
    is %f N/cm^2\n",p*10^-4)
```

# Chapter 3

# Hydrostatic Forces on surfaces

**Scilab code Exa 3.1** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.1

//Data given in the Problenm
w=2
d=3
dens=1000
g=9.81

//Calculations
//Upper edge coincides with water surface
A=w*d
H=d/2
F=dens*g*A*H
I_G=w*d^3/12                //MOI about the CG of the area of the surface
h=I_G/(A*H)+H
mprintf("The position of COP when Upper edge coincides with water surface is %fm\n",h)
```

```
mprintf( "And the Pressure on the area is %f N \n",F
   )

//Upper edge is 2.5m below  water surface
H=d/w+2.5
F=dens*g*H*A
h=I_G/(A*H)+H
mprintf("The position of COP when Upper edge is 2.5m
    belowh water surface is %f m\n",h)
mprintf( "And the Pressure on the area is %f N \n",F
   )
```

**Scilab code Exa 3.2** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.2

//Data given in the Problem
d=1.5
g=9.81
dens=1000
h=3

//Calculations
A=%pi*d*d/4
F=dens*g*A*h
mprintf("The Total Pressure on the circular plate is
    %f N\n",F)
//Position of Centre of Presusre
I_G=%pi*d/64
H=h+I_G/(A*h)
mprintf("The position of the centre of Pressure is
   %f m ",H)
```

**Scilab code Exa 3.3** Theoretical Proof

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.3

//Data given in the Problem
//depth of gate=d m
//width of gate=b m
//depth of CG from surface=p m

//solution:
//Depth of COP from free surface=(I/(A*h_CG))+h_gate
//Since I=(b*d^3)/12;
//h_COP=(b*d^3/12/b/d/p)+p=d^2/12+p
//The depth of COP from free surface is (d^2/12)+p "
```

**Scilab code Exa 3.4** Force and torque on disc

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.4

//Data given in the Problem
d=3
A=%pi*d^2/4
h=4
g=9.81
dens=1000
```

```
//Calculations
//1)Force on disc
F=dens*g*A*h
mprintf("The Force on the disc is %f kN\n",10^-3*F)

//2)Torque required
IG=%pi/64*d^4
H=(IG/A/h)+h
T=F*(H-h)
mprintf("The Torque required to maintain the disc in
    edulirium is %f Nm ",T)
```

**Scilab code Exa 3.5** Force exerted by oil

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.5

//Data given in the Problem
d=4
A=%pi/4*d
SG=0.87
dens=SG*1000
g=9.81

//Calculations
w=dens*g
p=19.6*10^4
p_head=p/w
//1)Force exerted
F=dens*g*4*%pi*p_head
mprintf("The Force exerted is %f MN\n",F*10^-6)
//2)centre of Pressure
IG=%pi/64*d^4
```

```
h=IG/(A*p_head)+p_head
mprintf("the Position of COP is %f m",h)
```

**Scilab code Exa 4.5** density of metallic block

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.5

//Given Data Set in the Problem
dens=1000
g=9.81
SG=13.6
v_m=0.4
v_w=0.6
V=poly(0,"V")

//calculations
//For equilibrium of the body ,toatl buoyancy=weight of the body
//buoyancy due to water
F_w=dens*g*0.6*V
//buoyancy due to mercury
F_m=SG*dens*g*0.4*V

//Total force
F_tot=F_m+F_w
dens_body=(F_tot/(V*g))
mprintf("The density of the body is %f kg/m^3\n",horner(dens_body,1))
```

**Scilab code Exa 3.6** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.6

//Data given in the Problem
b=4
h=4
A=b*h/2
SG=0.9
g=9.81
dens=SG*1000

//Calculations
H=1/3*h      //Distance of CG from the free surface
   of the oil
F=dens*g*A*H
,printf("The Total pressure is %f N\n",F)
IG=b*h^3/36
COP=IG/(A*H)+H
mprintf("The Centre of pressure is given by %f m",
   COP)
```

**Scilab code Exa 3.7** Force and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.7

//Data given in the Problem
b=2
d=1.2
SG1=1.45
dens=1000
```

```
g=9.81

//Calculations
//1)
A=b*d
dens1=SG1*dens
h1=1.5+(d/2)
F1=dens1*g*A*h1
dens2=1000
h2=1/2*d
F2=dens2*g*A*h2
F=F1-F2
mprintf("The resultant force on the gate is %f N\n",F)

//2)
IG=b*d^3/12
H1=IG/(A*h1)+h1
//The distance of F1 from the hinge is ((1.5+1.2)-H1) metres
x1=((1.5+1.2)-H1)
//F2 acts at a depthth H2 from the surface
H2=IG/(A*h2)+h2
//x2 is distance of F2 from hinge
x2=d-H2
//Resultant force F1-F2 acts at a distance equal to d_res
d_res=(F1*x1-F2*x2)/(F1-F2)
mprintf("Resultant force acts at %f m above the hinge \n",d_res)

//3)
//WE Know that F*d=(F1*x1-F2*x2) for the gate to just open
F=(F1*x1-F2*x2)/d
mprintf("The force required to open tha gate is %f N",F)
```

**Scilab code Exa 3.8** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.8

//Data given in the Problem
a=10
b=16
d=6
dens=1000
g=9.81

//Calculations
A=(a+b)/2*d
//x is the distance of the CG from the trapezoidal channel from the surface
x=((2*a+b)/(a+b))*(d/3)
h=x            //This also equals the dist. of CG of the trapezoidla from free surface
F=dens*g*A*h
mprintf("The total pressure id %f N\n",F)

//For centre of pressure
IG=(a^2+4*a*b+b^2)/(36*(a+b))*d^3
H=IG/(A*h)+h
mprintf("The centre of pressure if at %f m \n",H)
```

**Scilab code Exa 3.9** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.9

//Data given in the Problem
a=2
b=4
d=1
g=9.81
dens=1000

//calculations
//1)Total Presusre
A=(a+b)/2*d                 //Area of trapezoid
h=((2*a+b)/(a+b))*(d/3)     //distance od CG from AD
   surface
F=dens*g*A*h
mprintf("The total pressure is %f N\n",F)

//2)
IG=(a^2+4*a*b+b^2)/(36*(a+b))*d^3
H=IG/(A*h)+h          //H is the COP position
mprintf("The centre of pressure if at %f m \n",H)
```

**Scilab code Exa 3.10** Thrust and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.10

//Data given in the Problem
d1=2
d2=2
```

```
g=9.81
dens=1000
SG=1.15
h=1.5


//calculations
A=1/2*d1*d2
//1)thrust on plate
F=SG*dens*g*A*h
mprintf("The thrust on the plate is %f N\n",F)

//2)Centre of pressure
IG=((d1*(d2/2)^3)/12)+((d2*(d1/2)^3)/12)
H=IG/(A*h)+h
mprintf("The cente ofpressure is at %f m ",H)
```

**Scilab code Exa 3.11** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.11

//Data given in the Problem
d=0.5
D=1
SG=0.8
dens=1000
dens1=SG*dens
w=2
g=9.81

//calculations
//1)total pressure
```

```
pA=0
pD=dens1*g*D
pB=pD+dens*g*d        //Pressure on the base
F1=1/2*D*pD*w
F2=(d*pD)*w
F3=1/2*d*(pB-pD)*2
F=F1+F2+F3
mprintf("The total pressure on one side of the wall
   is %f N\n",F)

//Centre of pressure
//we know , from geometry that
h=((F1*2/3*D)+(F2*(D+0.5*d))+(F3*(D+2/3*d)))/F
mprintf("The centre of pressure is %f m from the top
   ",h)
```

**Scilab code Exa 3.12** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.12

//Data given in the Problem
d=0.6
a=1.5
SG=0.9
dens=1000
g=9.81

//Calculations
dens1=SG*dens
h=a-d
pA=0
pD=dens1*g*h
```

```
pB=dens1*g*h+dens*g*d
//In the diagram ,DE=pD ,BC=pB ,FC=pB−pD

//1) Total pressure
F1=(1/2*h*pD)*a
F2=(d*pD)*a
F3=(1/2*d*(pB-pD))*a
F=F1+F2+F3
mprintf("The total pressure is %f N\n",F)

//2) Position of Centre of Pressure
h=(F1*d+F2*(a-d/2)+(F3*(a-d+2/3*d)))/F        //Taking
    moments of all forces
mprintf("The position of centre of pressure is %f m
    from A ",h)
```

**Scilab code Exa 3.13** Pressure and weight of water

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines − By R K Bansal
// Chapter 3−Hydrostatic Forces on surfaces
// Problem 3.13

//Data given in the Problem
h1=3+0.6
w=2
l=4
A=w*l
dens=1000
g=9.81

//Calculations
//1) total pressure at the bottom
F=dens*g*A*h1
mprintf("The total pressure at the bottom is %f N \n
```

```
",F)

//2)Weight of water in tank
Vol=3*0.4*2+4*0.6*2
w=dens*g*(Vol)
mprintf("The weight of water in tank is %f N",w)
```

**Scilab code Exa 3.14** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.14

                                        //Problem a)
//Data given in the Problem
b=2
d=3
theta=30
dens=1000
g=9.81

//Calculations
//1)total pressure
A=b*d
h=1.5+1.5*sin(30/180*%pi)
F=dens*g*A*h
mprintf("Part a)\nThe total pressure is %f N\n",F)
//2)
IG=(b*(d^3))/12
H=IG*sin((30/180*%pi))^2/(A*h)+h
mprintf("The COP is %f m \n",H)

                                         //Problem b)
//Data given in the Problem
```

```
b=3
d=4
theta=30
dens=1000
A=b*d
h=2+2*sin(theta/180*%pi)

//Calculations
//1)
F=dens*g*A*h
mprintf("Part b)\nThe total pressure is %f N\n",F)
//2)
//2)
IG=(b*(d^3))/12
H=IG*sin((30/180*%pi))^2/(A*h)+h
mprintf("The COP is %f m \n",H)
```

**Scilab code Exa 3.15** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.15
clc
clear                                          //Part a)
//Data given in the Problem
d=3
A=%pi/4*d^2
DC=1.5
BC=d
dens=1000
g=9.81
//Calculations
//1)
sin_theta=((4-DC)/BC)
```

```
h=DC+DC*sin_theta
F=dens*g*A*h
mprintf("Part A)\nThe total pressure is %.2f N \n",F
    )
//2)
IG=%pi/64*d^4
H=IG*(sin_theta)^2/(A*h)+h
mprintf("The COP is %.3f m \n",H)
                                              //Part b)
//Data given in the Problem
d=3
Ao=%pi/4*d^2
d0=1.5
DC=1.5
BC=d
dens=1000
g=9.81
//Calculations
//1)
Ap=Ao-(%pi/4*1.5^2)
sin_theta=((4-DC)/BC)
h=DC+DC*sin_theta
F=dens*g*Ap*h
mprintf("Part B)\nThe total pressure is %.2f N \n",F
    )
//2)
IG=%pi/64*(d^4-d0^4)
H=IG*(sin_theta)^2/(Ap*h)+h
mprintf("The COP is %.3f m \n",H)
```

**Scilab code Exa 3.16** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
```

```
// Problem 3.16

//Data given in the Problem
d=3
A=%pi/4*3*3
DC=1
BC=3
BE=2
CG=1.5
g=9.81
dens=1000

//Calculations
//1)
sin_theta=(BE-DC)/BC
h=DC+CG*sin_theta
F=dens*g*A*h
mprintf("The total pressure is %f N \n",F)
//2)
IG=%pi/64*d^4
H=IG*sin_theta^2/(A*h)+h
mprintf("The Centre of pressure is %f m",H)
```

**Scilab code Exa 3.17** Depth of water

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.17

//Data given in the Problem
l=5
w=2
theta=60
g=9.81
```

```
W=5000*g
dens=1000

//Calculations
h=poly(0,"h")              //depth of the CG  of the body
AD=h/sin (theta*%pi/180)
A=AD*w
H=h/2                    //depth of CG of the immersed area
F0=dens*g*A*H
IG=w*AD^3/(12)
COP=IG*(sin(60/180*theta))^2/(A*H)+H          //COP of the immersed surface
//Using Geometry,
CH=COP
CD=CH/sin(theta/180*%pi)
AC=AD-CD
//Taking the moments about the hinge(
function f=F(h)
    f=(W*l-(dens*g*w*h/sin(theta/180*%pi)*h/2*2/(3^1.5)*h));
endfunction
h=1
y=fsolve(h,F)
mprintf("The value of h is %f m \n",y)
```

**Scilab code Exa 3.18** Normal force on gate

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.18

//Data given in the Problem
```

```
b=5
d=1.2
A=b*d
dens=1000
g=9.81

//Calculations
h=5-0.6*sin(45/180*%pi)
F=dens*g*A*h
IG=b*d^3/12
H=IG/(A*h)+h                //depth of centre of
    pressure
//from figure)
OH=H/sin(45/180*%pi)
BO=b/sin(45/180*%pi)
BH=BO-OH
AH=d-BH
//Now taking the moments
P=F*AH/d
mprintf("The Normal force applied to the gate at B
    is %f N\n",P)
```

**Scilab code Exa 3.19** height of water

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.19
//Data given in the Problem
theta=60;
s=sin(theta/180*%pi);
hh=poly(0,"hh");
AC=hh/s;
H=hh/2;
b=1;
```

```
d=AC;
IG=b*d^3/12;
//COP=(IG/(A*H)+H)
//COP=(h/sin(theta/180*%pi)^3/12/(h/sin(theta*%pi
    /180)/(h/2)+h/2
//We know that COP is equal to (h-3),THAT IS ,the
    depth of centre of pressure
//hence
function f=F(hh)
f=((hh/s)^3/12*s^2/(hh/s*hh/2))+(hh/2)-(hh-3);
endfunction
hh=100;
y=fsolve(hh,F);
mprintf("The height of water for tipping the gate is
     %f m",y)
```

**Scilab code Exa 3.20** height of water

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.20

//Data given in the Problem
b=2
l=3
A=b*l
W=343350
dens=1000
g=9.81
theta=45


//Calculations
h=poly(0,"h")
```

```
H=horner(h,0)
H=h-(3*sin(theta/180*%pi)-0.6*tan(theta/180*%pi))
F=dens*g*A*H
IG=b*l^3/12
H0=IG*(sin (theta*%pi/180))^2/(A*H)+H
//Taking moments about the hinge,
AK=W*0.6*sin(theta/180*%pi)/F
//but AK = H0-AC=H0-(CD-AD)
//Therefore,
CD=h
AD=l*sin (theta/180*%pi)
AC=CD-AD
//Hence.AK=H-(CD-AD)
ak=H0-AC
//We know ak=AK
//hence,solving AK-ak=0
function [f]=F(h)
    f=(b*l^3/12*(sin (theta*%pi/180))^2/(A*h-(3*sin(
        theta/180*%pi)-0.6*tan(theta/180*%pi)))+(h
        -(3*sin(theta/180*%pi)-0.6*tan(theta/180*%pi)
        ))-(h-l*sin (theta/180*%pi)))-W*0.6*sin(theta
        /180*%pi)/(dens*g*A*(h-(3*sin(theta/180*%pi)
        -0.6*tan(theta/180*%pi))))
endfunction
h=10
h=fsolve(h,F)
mprintf("The height of water that just causes the
    gate to open is %f m.\n",h)
```

**Scilab code Exa 3.21** Pressure and Centre of pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.21
```

```
clc
clear
//Data given in the Problem
b=2
h=3
A=b*h/2
theta =60
dens=1000
g=9.81

//calculations
x=1/3*h               //x=AG distance
H=2.5 + (x * sin (theta*%pi/180))
//1)
F=dens*g*A*H
mprintf("The total pressure  is %f N\n",F)
//2)
IG=b*h^3/36
COP=IG*(sin (theta*%pi/180))^2/(A*H)+H
mprintf(" The COP is at %.3f m \n",COP)
```

**Scilab code Exa 3.22** Horizontal and vertical force

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.22

//Data given in the Problem
w=1
r=2
AO=2
dens=1000
g=9.81

```

```
//calculations
//For F in x dir:
A=w*r        //Projected are of curved surface on
   vertical wall
//h=depth of CG of OC from free surface
h=1.5+AO/2                //since AO=OB
F_x=dens*g*A*h
mprintf("The Force in th x directions is %f N \n",
   F_x)

//For F in y direction;
AD=1.5
W_DAOC=dens*g*(AD*AO*1)
W_AOB=dens*g*%pi/4*AO^2
F_y=(W_DAOC+W_AOB)              //weight of DAOC +AOB
mprintf("The Force in th y directions is %f N \n",
   F_y)
```

**Scilab code Exa 3.23** resultant force on a gate in fluid

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.23

//Data given in the Problem
r=2
w=1
dens=1000
g=9.81

//calculations
//For F_x
A=r*w
h=1/2*r
```

```
F_x=dens*g*A*h
//For F_y
F_y=dens*g*%pi/4*r^2*w
//Net F
F=(F_x^2+F_y^2)^(1/2)
//Angle maded my the resultant force
theta=(atan(F_y/F_x))/%pi*180
mprintf("The resultant Force is %f N at an angle of
    %f with horizontal\n",F,theta)
```

**Scilab code Exa 3.24** Horizontal and vertical force

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.24

//Data given in the Problem
d=4
R=2
l=8
dens=1000
g=9.81

//calculations
A=d*l
h=d/2
F_x=dens*g*A*h
V_ACB=%pi/2*R^2*l            //volume of portion ACB
F_y=dens*g*V_ACB
//Net F
F=(F_x^2+F_y^2)^(1/2)
//Angle maded my the resultant force
theta=(atan(F_y/F_x))/%pi*180
mprintf("The resultant Force is %f N at an angle of
```

```
%f with horizontal\n",F,theta)
```

**Scilab code Exa 3.25** Horizontal and vertical pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.25

//Data given in the Problem
R=4
dens=1000
g=9.81
theta=45
AO=4
BO=4

//calculations
A=2*R*sin(theta*%pi/180)
h=(2*4*sin(theta/180*%pi))/2          //h=Ab/2 and AB
   =2AD where AD=Rsin(45)
F_x=dens*g*A*h
//For F_y
A_ACBOA=%pi/4*R^2
A_ABO=AO*BO/2
F_y=dens*g*(A_ACBOA-A_ABO)
mprintf("The resultant Force is %f N in x and %f N
   in y direction\n",F_x,F_y)
```

**Scilab code Exa 3.26** Horizontal and vertical pressure

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
```

```
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.26

//Data given in the Problem
dens=1000
g=9.81
theta=30
w=4
R=8

//calculations
h=w/2
A=w*1         //Area
F_x=dens*g*w*h
W_CBDC=dens*g*(theta/360*%pi*R^2-w/2*8*cos(theta*%pi
   /180))
F_y=W_CBDC
mprintf("The resultant Force is %f N in x and %f N
   in y direction\n",F_x,F_y)
```

**Scilab code Exa 3.27** Force by water and minimum weight of the cylinder

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.27

//Data given in the Problem
dens=1000
g=9.81
d=4
r=2

//Calculations
A1=d*r
```

```
h=d/2
F_x1=dens*g*A1*h
W_ABCOA=dens*g*%pi/2*r^2*2
F_y1=W_ABCOA
//Right side of cylinder
A2=r*2
h2=r/2
F_x2=dens*g*A2*h2
W_DOCD=dens*g*%pi/4*r^2*r
F_y2=W_DOCD
//Net Force
F_x_net=F_x1-F_x2
F_y_net=F_y1+F_y2
//F=net pressure
F=(F_x_net^2+F_y_net^2)^0.5
theta =(atan(F_y_net/F_x_net))/%pi*180
mprintf("The resultant Force is %f N at an angle of %f degrees \n",F,theta)

//Location of resultannt force
//for position of F_x....
//F_x1 acts at r*d/3=2.67 and F_x2 acts at r*2/3=1.33 m from free surface on right of cylinder
y=(F_x1*(d-2.67)-F_x2*(r-1.33))/F_x_net     //F_x_net acts at at y metres from bottom
//F_y1 acts at 4R/(3pi) from AOC=0.8488
//F_y2 also acts at 4R/(3pi) from AOC=0.8488 towards right side
x=(F_y1*0.8488-F_y2*0.8488)/F_y_net  //F_y_net acts at at x metres from bottom
mprintf("F_y net acts at %f m from AOC and F_x_net acts at %f m from bottom \n",x,y)

//Least weight of culinder
//net upward force should be the least weight of the cylinder hence, W_least=F_y_net
mprintf("the Least weight of the cylinder is %f N\n"
```

```
,F_y_net)
```

---

**Scilab code Exa 3.28** Horizontal and vertical force

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.28

//Data given in the Problem
dens=1000
g=9.81
R=1
l=2
p=0.2*g*10^4
BO=1
OD=2.5
AO=1
OH=AO*cos(30/180*%pi)
AH=2.5-2
AE=2

//calculations
h=p/(dens*g)
//1)horizontal force component
A=1.5*l
H=h+1.5/2
F_x=dens*g*A*H
mprintf("The horizontal Force is %f N in X \n",F_x)
//2)Vertical
//Fy=W_CODFBC-W_AEFB
W_CODFBC=dens*g*(%pi/4*R^2+BO*OD)*l
//For area of AEFB,
A_ABH=%pi*R^2*30/360-AH*OH/2
AG=BO-OH
```

```
A_AEFB=AE*AG+AG*AH-A_ABH
W_AEFB=dens*g*A_AEFB*1
F_y=W_CODFBC-W_AEFB
mprintf("The Force in y drection is %f N \n",F_y)
```

**Scilab code Exa 3.29** Resultant force on a dam

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.29

//Data given in the Problem
dens=1000
g=9.81
h=10
b=1
BC=10

//calculations
A=BC*1
H=h/2
F_x=dens*g*A*H
F_y=dens*g*integrate('3*y^0.5','y',0,10)
F=(F_x^2+F_y^2)^0.5
theta =(atan(F_y/F_x))*180/%pi
mprintf("The Resultant force is %f kN at an angle of
    %f degrees \n",F*10^-3,theta)
```

**Scilab code Exa 3.30** Horizontal and vertical force

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
```

```
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.30

//Data given in the Problem
dens=1000
g=9.81
b=1
y0=9

//Calculations
//1)
h=y0/2
A=y0*1
F_x=dens*g*A*h
mprintf("The  thrust is %f N in x direction \n",F_x)
//2)
F_y=dens*g*integrate("2*y^0.5","y",0,9)
mprintf("The  thrust is %f N in y direction \n",F_y)
F=(F_x^2+F_y^2)^0.5
theta =(atan(F_y/F_x))*180/%pi
mprintf("The Resultant force is %f kN at an angle of
    %f degrees \n",F*10^-3,theta)
```

**Scilab code Exa 3.31** Horizontal and vertical reaction

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.31

//Data given in the Problem
dens=1000
g=9.81
d=3
l=4
```

```
W=196.2*1000
BOC=3
R=d/2

//calculations
h=d/2
A=BOC*l
F_y=dens*g*%pi/2*R^2*l
//Horizontal rxn at A
F_x=dens*g*A*h
R_x=F_x
mprintf("The  reaction  is %f N in x direction \n",R_x)
//Vertical reaction at B
R_y=W-F_y            //the difference of weight of cylinder and the upward thrust
mprintf("The  reaction  is %f N in y direction \n",R_y)
```

**Scilab code Exa 3.32** Force on gate hinges by water

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.32

//Data given in the Problem
dens=1000
g=9.81
h=6
theta1=30
w=5
l=2.5/cos(theta1/180*%pi)
theta=120
H1=4
```

```
H2=2

//calculations
A1=H1*l
h1=H1/2
F1=dens*g*A1*h1      //f1 acts at H1/3 from bottom
A2=H2*l
h2=H2/2
F2=dens*g*A2*h2      //F2 acts at H2/3 from bottom
F=F1-F2
//equating moment of forces ,
x=(F1*H1/3-F2*H2/3)/F
//Also , ,P=F/(2sin theta)
P=F/(2*sin (theta1/180*%pi))
//We know thta R_T+R_B=R   and R=P
R=P
//Taking movement of honge reactions;R_T*6+R_B*0=R *1.55
R_T=R*1.55/6
R_B=R-R_T
mprintf("The reaction on the top hinge is %f N and on the bottom hinge is %f N \n",R_T,R_B)
```

**Scilab code Exa 3.33** Resultant force and reaction and forces on each hinge of a ga

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 3-Hydrostatic Forces on surfaces
// Problem 3.33

//Data given in the Problem
dens=1000
g=9.81
h=9
theta=120
```

```
theta1=(180-theta)/2
W=10
w=W/2/cos(theta1*%pi/180)
H1=8
H2=4


//Calculations
//1)
A1=w*H1
h1=H1/2
F1=dens*g*A1*h1
A2=w*H2
h2=H2/2
F2=dens*g*A2*h2
F=F1-F2          //Resultant force as a diference
mprintf("Resultant water prssure is %f N \n",F)
//2)
//Reaction between the gates
R=F/(2*sin(theta1*%pi/180))
mprintf("Reaction between the gates is %f N \n",F)
//3)Force on each hinge
//we know R_T+R_B=R
//Taking moments of forces;
x=(F1*H1/3-F2*H2/3)/F
//also taking moments of reactions,
R_T=R*(x-1)/(6-1)
R_B=R-R_T
mprintf("The tension is %f N for top and %f N for
   the bottom hinge\n",R_T,R_B)
```

**Scilab code Exa 3.34** total force by water in a moving tank

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
```

```
// Chapter 2 - Pressure and its measurements
// Problem 3.34

//Given Data Set in the Problem
dens=1000
g=9.81
a=2.4
l=6
w=2.5
d=2
h=1
x=3

//calculation
//1)
tan_theta=a/g
theta=(atan(a/g))/%pi*180
mprintf("\nThe angle of water surface to the
    horizontla is %f degrees downwards\n\n",theta)
//2)
h1=h-x*tan_theta
h2=h+x*tan_theta
p_max=dens*g*h2
p_min=dens*g*h1
mprintf("The maximum and minimum pressues at the
    bottom are %f and %f N/m^2 respective;y\n\n",
    p_max,p_min)
//3)
A1=h1*w                 //BD=h1
H1=h1/2
F1=dens*g*A1*H1
A2=h2*w
H2=h2/2
F2=dens*g*A2*H2
F=F2-F1             //resultant force
mprintf("The resultant force due to water acting on
    each end of the tank is %f N\n",F)
```

**Scilab code Exa 3.35** Total forces in a tank

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 3.35
clc
clear
//Given Data Set in the Problem
dens=1000
g=9.81
L=6
b=2.5
d=2
h=1.5
FD=1

//Calculations
                    //1) horizontal accn imparted
 //a)
   tan_theta=(d-h)/(L/2)
   a=g*tan_theta
 //b)
    CE=2
    ED=1
    FD=1
    h1=d/2
    A1=d*b
    F1=dens*g*A1*h1
    A2=FD*b
    h2=FD/2
    F2=dens*g*A2*h2
    //c)
    F=F1-F2
```

```
F_prove=L*b*(CE+FD)/2*dens*a;
//this too can be used ,,calulate colume V=L*b*h
//then.....F_=dens*V*a      //Force required to accelerate the mass of water in the tank
mprintf("Part 1)\nThe acceleration is %.2f m/s^2",a)
mprintf("\nThe Force on ends CE and FD are %.2f N and %.2f N respectively",F1,F2)
mprintf("\nForce required to accelerate the mass of water in the tank is %.2f N \n",F)
mprintf("Using Volume in tank and its acceleration , Force found is also %.2f N. Hence, proved\n",F_prove)
                    //2) horizontal accn when front bottom corner is just exposed
//a)
CE=2
ED=6
FD=0
tan_theta=CE/ED
a=g*tan_theta               //acceleration
//b)
h1=CE/2
A1=CE*b
F1=dens*g*A1*h1
F2=0
//c)
F=F1-F2
F_prove=L*b*(CE+FD)/2*dens*a;
mprintf("Part 2)\nThe acceleration is %.2f m/s^2",a)
mprintf("\nThe Force on ends CE and FD are %.2f N and %.2f N respectively",F1,F2)
mprintf("\nForce required to accelerate the mass of water in the tank is %.2f N \n",F)
mprintf("Using Volume in tank and its acceleration , Force found is also %.2f N.
```

```
        Hence, proved\n",F_prove)
                    //2) horizontal accn when front
                        bottom in half exposed
    //a)
    CE=2
    ED=3
    FD=0
    tan_theta=CE/ED
    a=g*tan_theta           //acceleration
    //b)
    h1=CE/2
    A1=CE*b
    F1=dens*g*A1*h1
    F2=0
    //c)
    F=F1-F2
     F_prove=(L/2)*b*(CE+FD)/2*dens*a;
      mprintf("Part 3)\nThe acceleration is %.2f m/s
        ^2 ",a)
      mprintf("\nThe Force on ends CE and FD are %.2
        f N and %.2f N respectively",F1,F2)
    mprintf("\nForce required to accelerate the mass
        of water in the tank is %.2f N \n",F)
    mprintf("Using Volume in tank and its
        acceleration, Force found is also %.2f N.
        Hence, proved\n",F_prove)
```

**Scilab code Exa 3.36** `Volume of water spilled in a moving tank`

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 3.36

//Given Data Set in the Problem
```

```
dens=1000
g=9.81
L=6
b=2.5
H=2
a=2.4
AB=L

//calculations
tan_theta=a/g
BC=AB*tan_theta
Vol=(1/2*AB*BC)*b              //vol of spilled water
mprintf("The volume of spilled water is %f m^3\n",
   Vol)
```

**Scilab code Exa 3.37** Force by water on sides of a tank

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 3.37

//Given Data Set in the Problem
dens=1000
g=9.81
h=500/1000
a=2.45
b=2
AB=h

//calculations
pB=dens*g*h*(1+a/g)
BC=pB
F_AB=(1/2*AB*BC)*b                 //force on side AB
mprintf("The force on side AB when it is moving
```

```
    upward with a const accn is %f N\n",F_AB)
//1)tank is moving vertically downward
pB=dens*g*h*(1-a/g)
BC=pB
F_AB=(1/2*AB*BC)*b                    //force on side AB
mprintf("The force on side AB when it is moving
    downward with a const accn is %f N\n",F_AB)
//1)tank is stationary
pB=dens*g*h
BC=pB
F_AB=(1/2*AB*BC)*b                    //force on side AB
mprintf("The force on side AB when it is moving
    upward with a const accn is %f N\n",F_AB)
```

**Scilab code Exa 3.38** Pressure at tank bottom and angle made by tank on incline

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 2 - Pressure and its measurements
// Problem 3.38

//Given Data Set in the Problem
dens=1000
g=9.81
h=1.5
L=4
b=2
a=4
alpha=30

//calculations
//1)
a_x=a*cos(alpha/180*%pi)
a_y=a*sin(alpha/180*%pi)
theta=(atan(a_x/(a_y+g)))/%pi*180
```

```
mprintf("The angle made by the free surface of water
    withg horizontal is %f degrees\n",theta)
//2)
EO=2
ED=h
CE=EO*(a_x/(g+a_y))
h2=ED+CE
AF=h
BF=CE
h1=AF-BF
//Calculating pressure at tank bottom at rear end
pD=dens*g*h2*(1+a_y/g)
pA=dens*g*h1*(1+a_y/g)
mprintf("The Pressure at tank bottom at rear end is
   %f N\nThe Pressure at the front end is %f N \n",
   pD,pA)
```

# Chapter 4

# Buoyancy and Floatation

**Scilab code Exa 4.1** Volume of water displaced

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.1

//Given Data Set in the Problem
w=2.5
d=1.5
l=6
dens=650
g=9.81
//calculations
V=w*d*l
W_water=dens*V*g
W_dens=1000*g
V_disp=W_water/W_dens            //weight of wter displaced/weight density of water
mprintf("The Volume of water displaced is %f m^3\n",V_disp)
//Position of Centre of Buoyancy
h=V_disp/(w*l)
```

```
mprintf("The Centre of Buoyancy is at %f m from the
   base\n",h/2)
```

**Scilab code Exa 4.2** Depth of wooden log in water

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.2

//Given Data Set in the Problem
dens=1000
g=9.81
d=0.6
l=5
SG=0.7
r=0.3
//W=theta angle
//calculations

//Equating the Area of ADCA from using geometry,we
   get;
function[f] = F(W)
    f=0.1979-((%pi*0.3^2*(1-W/180))+0.3^2*cos(W/180*
       %pi)*sin(W/180*%pi))
endfunction
W= 10;
W = fsolve(W,F)
//so, h=r+r*cos(theta)
h=r+r*cos(W/180*%pi)
mprintf("\nThe depth of wooden log in water is %f m\
   n",h)
```

**Scilab code Exa 4.3** `Volume of stone and specific gravity`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.3

//Given Data Set in the Problem
dens=1000
g=9.81
w_s_air=392.4
w_s_water=196.2

//calculations
vol_disp=w_s_water/(dens*g)
mprintf("The colume of stone is %f m^3 \n",vol_disp)
dens_stone=(w_s_air/g)/vol_disp          //finding
   stones density
sg=dens_stone/dens
mprintf("The  SG of stone is %f \n",sg)
```

---

**Scilab code Exa 4.4** `Specific Gravity`

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.4

//Given Data Set in the Problem
dens=1000
g=9.81
v_body=1.5*1*2
w_body=196.2

//calculations
```

```
w_disp=dens*g *v_body
//weight of body in air=wight of water displaced +
   weight in water.hence
w_air=w_body+w_disp
mass=w_air/g
dens_body=mass/v_body
SG=dens_body/dens
mprintf("The Specific Gravity of the body is %f \n",
   SG)
```

**Scilab code Exa 4.5** Density of a metallic body

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.5

//Given Data Set in the Problem
dens=1000
g=9.81
SG=13.6
v_m=0.4
v_w=0.6
V=poly(0,"V")

//calculations
//For equilibrium of the body ,toatl buoyancy=weight
    of the body
//buoyancy due to water
F_w=dens*g*0.6*V
//buoyancy due to mercury
F_m=SG*dens*g*0.4*V

//Total force
F_tot=F_m+F_w
```

```
dens_body=(F_tot/(V*g))
mprintf("The density of the body is %f kg/m^3\n",horner(dens_body,1))
```

**Scilab code Exa 4.6** Weight of the float

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.6

//Given Data Set in the Problem
dens=1000
g=9.81
sg=0.8
theta=135
d=15
P=9.81
OB=50
OD=35

//calculations
//Let h is the depth
h=OB*sin((180-theta)*%pi/180)-(OD)          //in cms
//volume of oil displaced
v_disp=2/3*%pi*(d/2)^3+h*%pi*(d/2)^2
F_buoy=sg*dens*g*v_disp*10^-6
//taking moment about the hinge
//P*20=(F_buoy-W_float)*(OB*cos 45)
function[f] = F(W)
    f = P*20-(F_buoy-W)*(OB*cos((180-theta)/180*%pi))
endfunction
W= 10;
W = fsolve(W,F)
```

```
//Weight of the float
mprintf("The weight of the float is %f N\n",W)
```

**Scilab code Exa 4.7** Meta centric height

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.7

//Given Data Set in the Problem
dens=1000
g=9.81
d_p=5*3*1.2
d_i=0.8
AG=0.6
AB=1/2*d_i
dens_sw=1025

//Calculations
I_yy=1/12*5*3^3        //MOI about y-y axis
V_sub=3*d_i*5
//hence GM is
BG=AG-AB
GM=I_yy/V_sub-BG
mprintf("The meta centric height is %f m \n",GM)
```

**Scilab code Exa 4.8** Meta centric height and weight

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.8
```

```

//Given Data Set in the Problem
dens=1000
g=9.81
d=3*2*1
d_i=0.8
AG=1/2
AB=d_i/2

//calculations
//1)Weight of the body
w=dens*g*(3*2*d_i)
mprintf("The Weight of the Body is %f N\n",w)
//2)Meta centric height
I_yy=1/12*3*2^3          //MOI about y-y axis
V_sub=3*2*0.8
BG=AG-AB
//Hence meta centric height is
GM=I_yy/V_sub-BG
mprintf("The meta centric height is %f m \n",GM)
```

**Scilab code Exa 4.9** Meta centric height

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
// Problem 4.9

//Given Data Set in the Problem
dens=1000
g=9.81
V=2*1*0.8
sg=0.7

//calculations
```

```
h=poly(0,"h")
w_d=dens*g*2*1*h
//we know thtat at equilibrium; weight of wooden
    piece =weight of wter displaced
w_w=sg*dens*g*2*1*0.8
function[f] = F(h)
f=w_w-(dens*g*2*1*h)                //w_wood-w_displaced
endfunction
h=1
h=fsolve(h,F)
//For centre of buoyancy
AB=h/2
AG=0.8/2
BG=AG-AB
//Meta centric heinght
I_yy=1/12*2*1^3
v_sub=2*1*h
//hence GM is
GM=I_yy/v_sub-BG
mprintf("The Meta centric height is %f m\n",GM)
```

**Scilab code Exa 4.10** Meta centric height

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.10

//Given Data Set in the Problem
dens=1000
g=9.81
D=4
h=3
sg=0.6

```

```
//calculations
d=0.6*h
AB=d/2
AG=h/2
BG=AG-AB
//For meta centric height
I_yy=%pi/64*D^4
V_sub=%pi/4*D^2*d
GM=I_yy/V_sub-BG
mprintf("The meta centric height is at %f m\n",GM)
```

**Scilab code Exa 4.11** `Meta centric height`

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.11

//Given Data Set in the Problem
dens=1000
g=9.81
D=3
d=1.8
V_disp=0.6
CB1=1.95
CG=1.2
W_tot=3.9*1000*g
//For meta centric height
//Weight of water displaced=weight density of water*Volume of water displaced
x=poly(0,"x")
function [f]=F(x)            //solves for x=height of body above water surface
    f=W_tot-(dens*g*(%pi/4*D^2*(1.8-x)+V_disp))
endfunction
```

```
x=10
x=fsolve(x,F)
//Let B2 is the centre of buoyancy of the
   cylindrical part and B of the whole body
//for COB of the cylindrical part
CB2=x+0.5*(1.8-x)
//COB of the whole body is
V_cyl=%pi*(D/2)^2*(1.8-x)
CB=((V_disp*CB1)+(V_cyl*CB2))/(V_disp+V_cyl)
//For meta centric height
BG=CB-CG
I_yy=%pi/64*D^4
V_sub=V_disp+V_cyl
GM=I_yy/V_sub-BG
mprintf("The Meta centric height is at %f m\n",GM)
```

**Scilab code Exa 4.12** Equilibrium stability determination

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.12

//Given Data Set in the Problem
dens=1000
g=9.81
D=4
d=2.4
h=4
SG=0.6
AB=d/2
AG=h/2
BG= AG-AB

//Calculaions
```

```
I=%pi/64*D^4
Vol=%pi/4*D^2*d
GM=I/Vol-BG          //Meta centric height
mprintf("The meta centric height is %f m\n",GM)
```

**Scilab code Exa 4.13** Floatation determination

```
// A Textbook of Fluid Mecahnics and Hydraulic Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.13

//Given Data Set in the Problem
dens=1000
g=9.81
D=10
L=40
l1=1
S1=6
dens1=6*dens
l2=L-l1
S2=0.6
dens2=S2*dens

//Calculations
AG=((%pi/4*D^2*l1*6*0.5)+(%pi/4*D^2*39*S2*(l1+39/2)))/(%pi/4*D^2*l1*6+%pi/4*D^2*39*S2)
//Finding meta centric point to know whther it can float vertically or not
//solving func for the value of h equating weight of cylinder to weight of the water displaced
function [f]=F(h)
    f=(%pi/4*D^2*39/100*dens2*g+%pi/4*D^2*l1/100*dens1*g-%pi/4*D^2*h/100*dens*g)
endfunction
```

```
h=10;
h=fsolve(h,F)
AB=h/2
BG=AG-AB
I=%pi/64*D^4
Vol=%pi/4*D^2*h
GM=I/Vol-BG
if (GM<=0) then mprintf("No,the body cannot float
    vertically in water\n");

end
if GM>=0 then mprintf("Yes,the body can float
    vertically in water\n");

end
```

**Scilab code Exa 4.14** Meta centric height

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.14
clc
clear
//Given Data Set in the Problem
dens=1000
g=9.81
W1=686.7*1000
D=5
W2=588.6*1000
w=10.104*10^3
L=10
b=7

//calculations
```

```
AG1=2.5/2
AG2=2.5+D/2
//dist of common centre of gravity from A is
AG=(W1*AG1+W2*AG2)/(W1+W2)
//Let h be the depth of immerison
//Total weight of ythe pontoon and the boiler =
    weight of the sea water displaced
function [f]=F(h)
    f=(W1+W2)-(w*L*b*h)
endfunction
h=10;
h=fsolve(h,F)        //depth of immersion
//also ,dist of common centre of buoyancy
AB=h/2
BG=AG-AB
//for meta centric height
I=1/12*L*b^3
Vol=L*b*h
GM=(I/Vol)-BG
mprintf("The meta centric height of both the
    pontoonm and the boiler is %.3f m \n",GM)
```

**Scilab code Exa 4.15** L by D ratio for the cylinder

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.15
clc
clear
//Given Data Set in the Problem
dens=1000
g=9.81
SG1=0.6
SG2=0.9
```

```
//calculations
L=poly(0,"L")
d=poly(0,"d")
AG=L/2
h=%pi/4*SG1*dens*g*L/(%pi/4*SG2*dens*g)
AB=h/2
BG=AG-AB
//for ,meta centric height ;
I=%pi/64*d^4
ratio=coeff(h)
function [f]=F(k)
  f(1)=(%pi*(k(1)^4)/64)/(%pi*(k(1)^2/4)*ratio(2)*k
    (2))-k(2)/6
  f(2)=0            //k(1)=d and k(2)=L
endfunction
k=[0.1 0.1];
y=fsolve(k,F);
mprintf("The ratio of L/D has to be less than %.2f \
  n",y(2)/y(1))
```

**Scilab code Exa 4.16** Force to keep the body vertical

```
// A Textbook of Fluid Mecahnics and Hydraulic
  Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.16

//Given Data Set in the Problem
dens=1000
g=9.81
D=1
H=2
w=7.848*10^3
dens1=1030
```

```


//calculations
//1) to show that it cannot float vertically
function [f]=F(h)
    f=w-dens1*g*%pi/4*D^2*h
endfunction
h=1
h=fsolve(h,F)
//distance of the centre of gravity G,from A is AG
AB=h/2
AG=H/2
BG=AG-AB
//now ,meta centric height is equal to
I=%pi/64*D^4
Vol=%pi/4*D^2*h
GM=I/Vol-BG
mprintf("The meta centric height is at %f m \n",GM)
if GM<0 then mprintf("Since M lies below G,Hence,The body cannot float vertically \n")
    else mprintf("Since M lies above G,Hence,The body can float vertically \n")
end
//2)
T=poly(0,"T")
F_d=w+T
//equating the total downward force to weight of awter displaced
h0=(F_d)/(dens1*g*%pi/4*D^2)
AB=h0/2
//Combined CG due to weight of cylinder and the rension in the chain is
AG=(w*H/2+T*0)/(w+T)
BG=AG-AB
//the metacentric height is GM
I=%pi/64*D^4
function [g]=G(T)
    g=(%pi/64*D^4)/(%pi/4*D^2*(w+T)/(dens1*g*%pi/4*D
```

```
^2))-((w*H/2+T*0)/(w+T))+((w+T)/2/(dens1*g*
%pi/4*D^2))
endfunction
T=1
T=fsolve(T,G)
mprintf("The Force necessary in the chain to keep it
    vertical is minimum %f N \n",T)
```

**Scilab code Exa 4.17** Least apex angle of cone for stable equilibrium

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.17

//Derivation asked(Theoretical Work)
```

**Scilab code Exa 4.18** Proof for stable equilibrium

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.18

//Derivation required(Theoretical Work)
```

**Scilab code Exa 4.19** Meta centric height

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
```

```
// Chapter 4-Buoyancy and Floatation
//// Problem 4.19

//Given Data Set in the Problem
dens=1000
g=9.81
L=70
b=10
w=19620*10^3
theta =6
sw=10104
w1=343.35*10^3
x=6
COB=2.25
H=2.25

//calculations
//1)
//Meta centric height
GM=w1*x/w/tan(theta /180*%pi)
mprintf("The meta centric height is %f m \n",GM)

//2)
//Position of centre of gravity
I=0.75*(1/12*L*10^3)          //MOI
Vol=w/sw              //vol of water displaced
//from equation for meta centric height ,we get ,
BG=I/Vol-GM
mprintf("The distance of G from the free water
    surface is %f m \n",H-BG)
```

**Scilab code Exa 4.20** Meta centric height of pontoon

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
```

```
// Chapter 4-Buoyancy and Floatation
//// Problem 4.20

//Given Data Set in the Problem
dens=1000
g=9.81
W=15696
w1=245.25
x=8
theta=4

//Calculations
GM=w1*x/(W*tan (theta/180*%pi))
mprintf("The meta centric height is %f m \n",GM)
```

**Scilab code Exa 4.21** Time period of oscillation of the ship

```
// A Textbook of Fluid Mecahnics and Hydraulic
   Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.21

//Given Data Set in the Problem
dens=1000
g=9.81
K=8
GM=70/100

//calculations
T=2*%pi*(K^2/GM/g)^0.5
mprintf("The Time period of Oscillation is %f
   seconds\n",T)
```

**Scilab code Exa 4.22** Radius of gyration of the ship

```
// A Textbook of Fluid Mecahnics and Hydraulic
    Machines - By R K Bansal
// Chapter 4-Buoyancy and Floatation
//// Problem 4.22

//Given Data Set in the Problem
dens=1000
g=9.81
T=10
I=10000
BG=1.5
W=29430*10^3
SG=10100

//calculations
Vol=W/SG        //vol of water displaced
//for meta centric height
GM=I/Vol-(BG)
//Using the formula to calculate th eradius of
    gyration
function [f]=F(K)
    f=T-2*%pi*(K^2/GM/g)^0.5
endfunction
K=1
K=fsolve(K,F)
mprintf("The Radius of gyration is %f m \n",K)
```