Scilab Textbook Companion for Basic Fluid Mechanics And Hydraulic Machines by Z. Husain[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Dimensions and systems of units

Scilab code Exa 1.1 To absolute pressure in the tank

```

// determine the absolute pressure in the tank
clc
patom=47.2 // pressure of an atom
pg=40 // pressure at 40kpa from table
pa=patom-pg
mprintf('\n absoulte pressure in the tank is %f kPa'
    ,pa)
```

Scilab code Exa 1.2 determine height of water rise in capillary

```

// determine the height that the water will rise to
    capillary action in the tube
clc
sigma=0.073 // sigma of pipe
```

```
gamma1=9800 // gammma constant
D=2e-3// diameter of the pipe
h=(4*sigma)/(gamma1*D) // height of the water rise in capillary
mprintf('\n height of water rise in capillary is given by %f meter',h)
```

Scilab code Exa 1.3 determine mach number

```
// determine mach number
clc
Z=10000 //  altitude meter
T=223.3 // temperature in kelvin
k=1.4 // constant of
R=287 // constant
d=800*1000 // speed of aircraft flies
c1=3600 // minutes and second
c=sqrt(k*T*R)
mprintf('\n velocity of sound  C = %f m/s',c)
v=d/c1
mprintf('\n speed of aircraft  V = %f m/s',v)
M=v/c
mprintf('\n Mach number M =V/C = %f ',M)
```

Scilab code Exa 1.4 determine the value of reynolds number in si units

```

// to calculATE REYNOLD'S NUMBER IN SI UNITS
clc
S=0.91 // specfic gravity
d=1000 // density of water
d1=25e-3 //diameter of pipe
v=2.6 //volume
```

```
u=0.38 // viscosity Ns/m2
p=(S*d)
mprintf('\n fluid density specific gravity %f Kg/m3'
  ,p)
Re=(p*d1*v)/u
mprintf('\n Reynold s value Re= %f',Re)
mprintf('Reynolds value is dimensionless,no unit')
```

Scilab code Exa 1.5 determine density of air and weight of air in the tank

```
// to calculate pressure of air at the nozzle
clc
R=1e-3 // radius in meter
sigma= 72.7e-3// N/m
p=(2*sigma)/R
mprintf('\n Excess pressure p= %f N/m2',p)
```

Scilab code Exa 1.6 calculate pressure air at the nozzle

```
//  to design  shear stress no calculations is there
    in this chapter only formula
clc
mprintf('\n shear stress t=u(dv/dr)=u.B/4u(-2r)')
mprintf('\n for r=D/2; t=-BD/4')
mprintf('\n r=D/4 ; t =-BD/8')
```

Scilab code Exa 1.7 to calculate shear stress

```

```

```
// to determine density of air ,weight of air in the
    tank
clc
p1=101.3 // absolute pressure in the tank in kpa
Ab=(3*p1)+(p1)
mprintf('\n Absolute pressure in the tank in kPa =
    %f kPa',Ab)
R=287 // constant value
T=288 // temperature in kelvin
d=Ab/(R*T)
mprintf('\n Density  p = %e Kg/m3',d*10^3)
m=0.85 // mass in m3
g=9.8 // gammma constant
W=(d*m*g)
mprintf('\n Weight of air W=mg= %f Kg',W*10^3)
```

Chapter 2

Fluid flow

Scilab code Exa 2.1 Determine pressure at station point 2

```

// to determine pressure at station point 2
// applying bernoullis equation
// ex 2.1 pgno.39
clc;
p1=50 // pressure at point 1
v1=5// velocity
g=9.8// constant
p2=p1+((v1^2)/(2*g)) //ipressure equation according to bernoullis equation
mprintf('%f Pascal',p2)// displaying pressure
psw=1.03e3// specific gravity in kg/m3
P2=psw*g*p2 // calculating pressure at station 2
mprintf('\n P2= %e Pascal',P2)
```

Scilab code Exa 2.2 Determine pressure at point 2 for flow rate

```
// to determine pressure at point 2
```

```
clc
p1=4.4 // bar
d1=15e-2 //cm
z1=3.2 // m
z2=1.2// m
d2=22.5e-2// cm
Q=0.05 // VOLUME FLOW RATE AT m3/s
a1=(%pi/4)*d1^2 // area at d1
a2=(%pi/4)*d2^2 // area at d2
mprintf('a1 = %e m2',a1)
mprintf('\n a2= %e m2',a2)
V1=Q/a1 // volume at different area
V2=Q/a2 // volume at different area a2
mprintf(' \n V1 = %e m/s',V1)
mprintf('\n  V2 = %e m/s',V2 )
// specific weight  ofx benzene =8.82x 103 kg/m3
g1=9.8
gamma1=8.82e3 // specific  weight of benzene
P2=((p1*10^5)/(g1))+((V1^2)/(2*g1))+z1-((V2^2)/(2*g1
   ))-z2
p21=P2*gamma1
mprintf('\n  P2=  %f Pa',p21)
```

Scilab code Exa 2.3 determine flow rate of oil from syphon and also the pressure

```
// determine flow rate of oil from syphon and also
   the pressure at point 2
clc
g=9.8 // constant
k=1.1
v3=sqrt(2*g*k)
mprintf('\n therefore V3= %f m/s',v3)
a=50e-3
Q=(3.14/4)*a^2*v3
```

```
mprintf('\n Q = %e m3/s',Q)
sp=820 //specifc gravity
gam=3.1
P2=sp*gam*g
mprintf('\n P2 = %f Pa(negative)',P2)
```

Scilab code Exa 2.4 Maximum pressure experience by the person on the hand

```
//page no 42 to find maximum pressure experienced by
    the person on the hand
clc;
p=101.3e3 // specific gravity
p1=1.225 // stagnation pressure
v= ((90*1000)/3600)
P0=p+((p1*v*v)/2)
mprintf('The maximum pressure = %f kPa',P0)
```

Scilab code Exa 2.5 determine pressure at the end of the artery

```
//Example Non 2.5 Determine the pressure at the end
    of the artery when the head is//
clc
Bh=1.8    //in m
Ah=2.4    // in m
rhoHg=13.6
gHg=1000
Hhg=0.212
rhoBlood=1
gBlood=1000
gama=1000*9.8
z1=0
z2=2.4
```

```
//Calculation
hBlood=(rhoHg*gHg*Hhg)/(rhoBlood*gBlood)
P2=(hBlood+(z1-z2))*gama
//when the head is 1.8m below the heart
z3=0
z4=-1.8
P3=(hBlood+(z3-z4))*gama
printf("hBlood=%f m\n",hBlood);
printf("P2=%f pa\n",P2);
printf("P3=%f pa\n",P3);
```

Scilab code Exa 2.7 Calculate the air velocity assuming density of air

```
//  to calculate air velocity assuming density of
   air 1.2kg/m3
clc;
gammma=9800 // constant gammma
h=4e-3 // height of water in mm
pair=1.2 // air velocity of air in kg/m3
deltap=h*gammma
V=sqrt((2*deltap)/pair)
mprintf('V =%f m/s',V)
```

Scilab code Exa 2.8 calculate the force acting

```
// to calculate force acting on 1mx 2m
// ex 2.8 pgno.46
clc
A=1*2 // velocity of the wind
v=(100*1000)/3600 // 100km/hr
mprintf('Velocity of the wind = %f m/s',v)
density=1.2 // in kg/m3
```

```
p0=(density*v^2)/2 //pressure
mprintf(' \n P0= %d N/m2',p0)
F=p0*A // fource
mprintf('\n Force F=p0A = %d N',F)
```

Scilab code Exa 2.9 calculate the mach number

```
// calculate the mach number
//ex 2.9 pgno 46
clc
patm=101000 //  applying ideal characteristic
   equation
p=9800//static presure
t=0.016 //temperature
p1=(p*t)+patm//stagnatio presure
mprintf('P= Pg+Patm = %e k Pa',p1)
R=287 // Radius
T=273 // temperature
t1=T+20
P=p1/(R*t1)
mprintf(' \n p = %f kg/m3',P)
p0=0.032
p11=0.016
V=sqrt((2*(p0-p11)*p)/(1.2))//velocity
mprintf(' \n V= %f m/s',V)
K=1.4//Radius
C=sqrt(K*R*t1)//velocity of sound
mprintf('\n velocity of sound C= %d  m/s',C)
M=V/C//mach number
mprintf(' \n Mach number M= V/C = %f',M)
mprintf(' \n The flow is incompressible as macho
   number is less than 0.3')
```

Scilab code Exa 2.10 determine the difference of pressure between inlet and throat

```
// determine the flow rate from the nozzle and power
    required to drive the pump
//ex 2.10 pgno.47
clc
v=8.31 // velocity at c
a= (%pi*(75e3)^2)/4
Q=a*v // flow rate
mprintf('Q = %e /s',Q)
g=9.8 // constant gamma
zc=32 // elevation
Hp= (v^2/(2*g))+zc // heat developed by pump
mprintf(' \n Hp= %f m ',Hp)
gammma=9800// constant gammma
P=gammma*Q*Hp  //power required
mprintf('\n P= %e W',P)
```

Scilab code Exa 2.11 determine the difference of pressure between inlet and throat of the venturimeter

```
// difference between pressure inlet and throat of
    the venturimeter
// ex 2.11 pgno.48
clc
a2=0.06 // diameter of the throat
a1=0.1 // diameter of the pipe
p=0.85*1000 // kerosene fo sp. gravity
q=0.05 // flow rate
a=a2/a1
a3=1-a**4
P=(q*q*p*a3)/(2*((3.14/4)*a2*a2)^2) // presssure
mprintf('P1-P2 = %e Pa',P)
```

Scilab code Exa 2.12 calculate inlet angle and outlet angle of the vane for no shock entry and exit

```
// to calculate inlet angle and outlet angle of the
   vane for no shock entry and exit
//ex 2.14 pgno.49
clc
v1=36 //m/s
u=15 //m/s
d=100 //mm
alpha1=30 // degree
alpha2=90 // degree
B=(v1*sind(30))/(v1*cosd(30)-u)
mprintf(' \n tan B1 =%f',B)
B1=atand(B) // beta in  degreee
mprintf(' \n tan in degree %d',atand(B))
vr1=(v1*sind(30))/(sind(B1)) // inlet triangle
mprintf('\n Vr1 = %f m/s',vr1)
vr2=0.85*vr1
mprintf('\n Vr2 = %f',vr2)
B2=u/vr2
B21=acosd(B2)
mprintf(' \n CosB= %d degree',B21)
//part b   to find force and velocity

p=1000//presure
d=0.1//diameter
v1=36 //velocity
m=p*((%pi*d*d)/4)*v1//mass
mprintf('\n \n \n part b  \n \n \n ')
mprintf('\n m = %f kg/s',m)
v1x=v1*0.866
mprintf('\n V1x == %f m/s',v1x)
v2=1
```

```
v2x=v2*cosd(90)
mprintf(' \n V2x = V2cos90 =%d ',v2x)
F=m*(v1x-v2x)//fource
mprintf('\n Force on the direction of motion F=m(V1x-V2x) %d N',F)
```

Scilab code Exa 2.13 to calculate force is necessary to hold the deflector in place

```
// force is necessary to hold the defelector inplace in 32kg/s
//ex 2.13 pgno.51
clc
m=32 // MASS FLOW RATE
p=1000 // PRESURE
l=0.02//length
b=0.04//width
v1=m/(p*l*b)//velocity
mprintf('The velocity V1 = %d m/s',v1)
v2=40
Fx=m*(v1-v2*cosd(30))//fource
mprintf('\n Fx= %d N',Fx)
Fy=m*(v1-v2*sind(30))
mprintf('\n Fx= %d N',Fy)
```

Scilab code Exa 2.14 example

```
// mass flow rate is calculated on velocity
clc
vr1=5 //m/s
p=1000
A=0.02*0.4
m=vr1*p*A
```

```
mprintf('m= pAVr1= %d kg/s',m)
vrlx=5
vr2=5
Fx=m*(vrlx-vr2*cosd(30))
mprintf('\n  Fx= %f N',Fx)
vly=0// given vrly=0
Fy=-m*vr2*sind(30)
mprintf('\n Fy= %f N',Fy)
```

Scilab code Exa 2.26 Determine power available to the turbine when the flow rate is given

```
//Example No 2.6
pi=3.142
D2=2.7
Q=30
gamma1=9800
z1=20
z2=6
g=9.8

//Calculation
a2=(pi/4)*D2^2 // Area of exit pipe in m^2
V2=Q/a2   // from equation of continuity in m/s
Ht=(z1-V2^2/2*g-z2)  //head developed by turbine
P=gamma1*Q*Ht      //power developed by turbine

mprintf("\n a2=%f ",a2);
mprintf("\n V2=%f nm/s",V2);
mprintf("\n Ht=%f m",Ht);
mprintf("\n P=%f Kw",P);
```

Chapter 5

Pelton Turbine

Scilab code Exa 5.1 calculate volumetric flow rate diameter of the jet wheel diameter

```

// to find efficiency
// ex 5.1 pgno.115
clc
p=67.5*1000 // 67.5 kw to develop wheel
no=0.83 // efficiency of installation
gamma1=9800 // constant gamma
g=9.8 //gravitational acceleration
N=400 // rotates
H=60 // head of water 60 m
Q=p/(no*gamma1*H)// volume flow rate
printf(" Q= %.3f m3/s",Q)
v1=sqrt(2*g*H) // velocity of the jet
printf("\n V1 = %f m/s",v1)
d=sqrt((0.138*4)/(3.14*v1))
printf("\n %e m",d)
r=0.46 //  ratio of bucket speed in rev/min
u=v1*r //velocity
printf("\n %f m/s",u)
D=(H*u)/(%pi*N)
```

```
printf("\n %f m",D)
w=(2*N*%pi)/(H) //specific speed of trubine
mprintf('\n specific speed of turbine %f rad/s',w)
wt=(w*((p/1000)^(0.5)))/((g*H)^((5)/(4)))
mprintf('\n  wt  = %f',wt)
```

Scilab code Exa 5.2 flow rate and shaft power

```
// to find flow rate and shaft power develpoed by
   the turbine
// ex 5.2 pgno 116
clc
g=9.8 // gravitional acceleration
H=400 // head
hf=23.6 // penstock and nozzle
d=80e-3 // diameter of the jet
u=40 // bucket speed
k=.85 // ratio of heat
deg=165 // degree
n1=0.9 // rotational speed
V1=sqrt(2*g*(H-hf)) // velocity of jet
mprintf('\n  velocity of jet v1= %f m/s',V1)
E=u/g*((V1-u)*(1-(k*cosd(deg)))) // eulers head
mprintf('\n eulers head E = %f m',E)
Q=(%pi/4)*d^2*V1 // flow rate
mprintf('\n Flow Rate Q = %f m3/s',Q)
Pe=g*Q*E // power developed by the runner
mprintf(' \n power developed by the runner =Pe= %f
   kw',Pe)
P=Pe*n1 // nint
mprintf('\n nint = %f kw',P)
```

Scilab code Exa 5.3 find hydraulic efficiency

```

// a pelton wheel hydraulic efficiency and over all efficiency
// ex 5.3 pgno. 117
clc
D=1.45 // diameter of the wheel
N=375 // shaft running
u=(%pi*D*N)/60 // peripheral velocity
k=0.9 // coefficient of the bucket
p=3750 //peripherial velocity
hf=200*0.1 // head availabe
mprintf('\n  peripherial velocity u =%f m/s',u)
mprintf('\n Total Head = %d m',hf)

h1=200  // total head
l=20 // losses
H=h1-l  //effective head
g=9.8 // gravity
mprintf('\n effective head H = %d m',H)
V1=sqrt(2*g*H) // velocity of the jet
mprintf('\n velocity of the jet V1= %f m/s',V1)
S=u/V1 // speed ratio
mprintf('\n Speed Ratio =u/V1= %f',S)
nh=2*((S)*(1-S)*(1-k*cosd(165))) // hydraulic efficiency
mprintf('\n  Hydraulic efficiency nh= %f percentage',(nh*100))
E=(u/g)*(V1-u)*(1-(k*cosd(165))) // euler's head
mprintf('\n E =%f m',E)
no=k*nh // realation between
mprintf('\n Relation between n0= %f',no)
hp=p/no // hydraulic power
mprintf('\n hydraulic power = %d kw',hp)
gamma1=9800 // constant gamma
Q=(1000*hp)/(2*gamma1*H) // flow rate
mprintf('\n Flow rate Q = %f m3/s',Q)
d=sqrt((4*Q)/(%pi*V1)) // diameter
mprintf('\n d = %f m',d)
```

Scilab code Exa 5.4 To find coefficient of velocity speed ratio jet diameter

```
// to find coefficient of velocity speed ratio ,jet
   diameter
//ex 5.5 pgno119
clc
cv=0.98//velocity of volume
g=9.8//gravity
h=130//head loss
V1=cv*(sqrt(2*g*h))//velocity of jet
mprintf('\n velocity of the jet = %f m/s',V1)
s=0.46//specific gravity
u=s*V1//velocity
mprintf('\n u = %f m/s',u)
N=200//Rotational speed
D=(60*u)/(%pi*N)//Diameter
mprintf('\n  peripherial velocity u =%f m',D)
d=D/9
mprintf('\n d =%f m',d)
p=8e6//petlon turbine
no=0.87//eficiency
gamma1=9800//constant gamma
Q=(p/(no*gamma1*h))//volume flow rate
mprintf('\n Q = %f m3/s',Q)
n=(Q*4)/(%pi*d*d*V1)//
mprintf('\n number of jets n =%d',n)
Z=(D/(2*d))+15
mprintf('\n number of buckets %f ',Z)
```

Scilab code Exa 5.6 to find efficiencies of pelton turbine

```
// to find pelton turbine completely
// ex 5.6 pgno.120
clc
P=100/4 //power each unit
mprintf('\n power output of each unit P = %d MW',P)
gammma=9800 //constant gammma
Q=6.85 //flow rate
H=580 //head
g1=9.8
N=428 // speed
t1=60 // temperature
n=2 // types of turbine
k=0.95 //ratio of head
Hp=(gammma*Q*H)/(1000*1000) // hydraulic efficiency
mprintf('\n hydraclic power = %f MW',Hp)
on=P/Hp // overall efficiency
mprintf('\n Overall efficiency = %f',on)
sp=0.46 // assuming speed ratio
V1=sqrt(2*g1*H) // velocity of jet
mprintf('\n velocity of the jet V1 =%f m/s',V1)
u=V1*sp // peripherial velocity
mprintf('\n u =%f m/s',u)
D=(t1*u)/(%pi*N)// peripherial velocity
mprintf('\n  peripherial velocity %f m',D)
d=sqrt(((Q)/((%pi/4)*V1*n)))
mprintf('\n %f m',d)
Z=((D)/(2*d))+15 //number of buckets
mprintf('\n number of bukets Z =%f m',Z)
m=D/d // jet ratio
mprintf('\n jet ratio = m= %f',m)
L=2.5*d // length
mprintf('\n Radial length of bucket L = %f m',L)
B=4*d // width
mprintf('\n width of bucket B =%f m',B)
mprintf('\n Depth of bucket hyrauclic efficiency %f m',d)
nb=2*(u/V1)*(1-(u/V1))*(1-cosd(160))
mprintf('\n %f',nb)
```

```
nm=on/nb
mprintf('\n nm =%f',nm)
```

Scilab code Exa 5.7 to determine flow rate number of jets required

```

// to find flow rate wheel diameter of each jet
// ex 5.7 pgno.121
clc
p=4.5e6 //pelton wheel develop
no=0.8 // wheel diameter
g=9800 //gravitional acceleration
h=120 //head loss
g1=9.8
p1=1000 // over all efficiency
N=200 //  rotational speed
Q=p/(no*g*h) // flow rate
mprintf('\n overall efficiency no= %f m3/s',Q)
v1=sqrt(2*9.8*h) // velocity of the jet
mprintf('\n velocity of jet =%f m/s',v1)
u=v1*0.42 // peripherial velocity
mprintf('\n u =%f m/s',u)
N=200 // speed
D=(60*u)/(%pi*N) // diameter of the jet
mprintf('\n D =%f m',D)
d=D/8 // to find diameter
mprintf('\n diameter of jet = %f meter',d) // to
   display diameter
n=(Q*4)/(%pi*d*d*v1) // to calculate jets
mprintf('\n number of jets n = %d',n) // to display
   number of jets
w=(2*N*%pi)/60 // to calculate speed
wt=w*(((p/p1)^0.5)/((g1*h)^(5/4))) // specific speed
mprintf('\n wt =%f RPM',wt)
```

Chapter 6

Francis Turbine

Scilab code Exa 6.1 determine velocity of whirl at inlet and diameter of the wheel at inlet

```
// determine velocity of whirl at inlet and diameter
    of the wheel at inlet
// ex 6.1 pgno.143
clc
H=8 // head
g=9.8 // gravitional acceleration
t1=0.96 // peripheral volocity at inlet
t2=0.36 // flow velocity
u1=t1*sqrt(2*g*H)
mprintf('Peripheral velocity u1= %f m/s',round(u1))
vlf= t2*sqrt(2*g*H)
mprintf('\n Flow velocity V1f= %f m/s',vlf)
nh=0.85 // hydraulic efficiency
Vlw=(g*H*nh)/(u1)
mprintf(' \n  V1W= %f m/s',Vlw)
a1=vlf/Vlw // inlet angle tan
mprintf('\n alpha1 =%f ',a1)
mprintf('tan a1 = %d',atand(a1))
N=150 // runner speed
D1=(60*u1)/(%pi*N) // diameter
```

```
mprintf( '\n D1=  %f m',D1)
gamm =9800 // constant gamma
Q= (N*1000)/(gamm*H*nh) //flow rate
mprintf('\n Q = %f m3/s',Q)
```

Scilab code Exa 6.2 determine head and power output

```
// determine head and power output if angular
   velocity  from fig2=
// ex 6.2 pgno.142
clc
r1=300 // mm inlet radius
r2=150 //mm outer radius
Q=0.05 // m3/s flow rate
a1=30 //degree inlet guide blade
a2=80// degree angle
v1=6 // m/s velocity
v2=3//m/s velocity
t=25 // angular velocity
n=0.9
n1=0.8
g=9.8 //
gammam=9800 // constant gammma
u1=(r1/1000)*t // velocity
u2=(r2/1000)*t
mprintf('\n u1 = %f m/s',u1)
mprintf(' \n u2 = %f m/s',u2)
V1w= v1*cosd(a1)
mprintf('\n V1w = v1cos a1 = %f m/s',V1w)
V2w=v2*cosd(a2)
mprintf(' \n V2w = V2cos a2 = %f m/s',V2w)
E=((u1*V1w)-(u2*V2w))/(g) // Eduler's head
mprintf('\n E = %f m',E)
H=E/n // head
mprintf('\n H = %f m',H)
```

```
pin=(gammam*Q*H)/1000 // power input
mprintf('\n Power input= gQH = %f W',pin)
pout=pin*n1 // power out
mprintf('\n power output =effiency*pin =%f W',pout)
```

Scilab code Exa 6.3 to find flow velocity

```
// design a= francis turbine
// ex 6.3 pgno.146
clc
h=68 // head
x=0.15 // flow ratio
N1=750 // speed
n2=0.1 //  breadth to diameter ratio at inlet
p=330 //power output
ga=9800 //
g1=9.8
d2=((1/2)*600)
eh=0.94 // hydraulic efficiency
eo=0.85 // overall efficiency
ar=0.6 // area
k1=0.94 // ratio
Q1=(p*1000)/(eo*ga*h) // volume of flow rate
mprintf('Q= %f m3/s',Q1)
vf=(x*(sqrt(2*g1*h))) // velocity of flow
mprintf(' \n Vf= %f m/s',vf)
D=sqrt((Q1)/(eh*%pi*n2*vf)) // diameter
mprintf('\n D1 = %f m',D)
B1=D*n2 // width
mprintf('\n B1= %f m',B1)
u=(%pi*D*N1)/60
mprintf('\n u1 = piD1N/60 =%f m/s',u)
Vl=(g1*eh*h)/u
mprintf('\n  Vlw = %f m/s',Vl)
a=atand(vf/Vl)//area
```

```
mprintf(' \n tana1= %f degree ',a)
d1=1/2
U=(%pi*d2*N1)/60
mprintf('\n u2 = %e m/s',U)
b2=atand(vf/11.7)
mprintf('\n tanb2 = %f degree',b2)
// assume k1=k2 v1f=v2f
n3=(ar^2*n2)/(0.3^2)
mprintf('\n n2 = %f',n3)
B2=d2*n3
mprintf('\n B2 = %f mm',B2)
```

Scilab code Exa 6.4 Determine guide vane angle and runner vane

```
// determine guide vane angle and runner vane angle
   at exit for radial discharge
// ex 6.4 pgno.149
clc
H=12 // m
Q=0.28 //m3/s
Vf=0.15 // velocity flow
N=300 // rpm
nh=0.8 // percen
g=9.8 //gravitional acceleration
r2=1 // runner van
r1=2
V1f=Vf*(sqrt(2*g*H)) // velocity flow
v2f=V1f
mprintf(' velocity flow V1f=V2f = %f m/s',V1f)
V1w=sqrt((nh*g*H))
mprintf('  \n V1w = %f m/s',V1w)
u1=V1w
u2=u1*(r2/r1)
mprintf(' \n u2 = %f m/s',u2)
b2=atand(v2f/u2)
```

```
mprintf(' \n  tanb2= %f degree',b2)
a1=atand(V1f/u1)
mprintf(' \n tana1 = V1f/u1 = %f degree',a1)
```

Scilab code Exa 6.5 to determine shaft power hydraulic efficiency and specific speeds

```

//determine the shaft power hydraulic efficiency
//ex 6.5 pgno.151
clc
N=1260 // runner speed
Q=0.4 // flow rate
H=92 // head
g=9.8 //constant
a1=20 // van angle
R1=(2*600)/1000 // radius at inlet
r1=600/1000
B1=30/1000
p=1000 // power
hp=360e3
V1f=(Q/(%pi*R1*B1)) // velocity of flow
mprintf(' V1f  = %f m/s',V1f)
V1w = V1f/(tand(20)) // velocity of width
mprintf(' \n V1w = %f m/s',V1w)
T=Q*p*V1w*r1 // temperature
mprintf('\n  T = %d N-m',T)
w=(2*N*%pi)/60 // width
S=T*w // shaft power
mprintf('\n  shaft power %d Watts',S)
n=(S/hp)*100 //spped
mprintf('\n  overall efficiency = shaft power/ hydraulic power %f percentage',n)
Wt=(w*sqrt(S/1000))/((g*H)^(5/4))
mprintf('\n wt = %f',Wt)
```

```
Ns=(N*sqrt(S/1000))/(H^(5/4))
mprintf('\n Ns =  %f',Ns)
```

Chapter 7

Propeller and kaplan turbines

Scilab code Exa 7.1 to determine inlet and exit angles of blades

```
// determine inlet and exit angles of blades mean
    diameter
// ex 7.1 pgno. 169
clc
H=21.8 // head of turbine
P=21 // MW power
N=140 // number runs of rpm
D1=4.5 // diameter in m
Dh=2.0 // in meter
nh=0.94 // efficiency
nn= 0.88// efficiency in exit angles
g=9.8
M=(D1+Dh)/2 //mean diameter in m
mprintf('Mean Diameter  = %f m',M)
w=(2*N*%pi)/60
mprintf('\n w= %f rad/s',w)
u=(w*M)/2
mprintf('\n u=wr = %f m/s',u)
V1w=(nh*g*H)/u
mprintf('\n V1w = %f m/s',V1w)
Q=(P*1000*1000)/(nn*H*9800) // flow rate
```

```
mprintf('\n Q=%f m3/s',Q)
vf=(4*Q)/(%pi*((D1^2)-(Dh^2)))
mprintf('\n Vf = %f m/s',vf)// velocity in m/s
b1=vf/(u-Vlw) // tan b1
mprintf(' \n  tanb1 =%f degree ',atand(b1)) // inlet angles
b2=vf/u // tan b2
mprintf('\n b2= %f degree',atand(b2))// exit angles
```

Scilab code Exa 7.2 calculate axial velocity of blade flow rate eulers power

```
// calculate axial velocity ,flow rate ,exit blade angle,eulers power
// ex 7.2 pgno. 170
clc
D1=2 // m
Dh=0.8 // m
N=250 //rpm
alpha1 =42 // degree
beta1=148// degree
D=(D1+Dh)/2 // diameter
g=9.8
mprintf('\n D= %f m',D)
u=(%pi*D*N)/60 // peripherical velocity of blade
mprintf('\n u =%f m/s',u)
a=(180-148) //area
disp(a)
d=a*18.3 // diameter
disp(tan(d))

vlw=(tand(42)+tand(32))
disp(vlw)
Vlw=tand(d)/vlw
disp(Vlw)
vlw=7.5
```

```
vf=vlw*tand(alpha1) // inlet trangle of velocities
mprintf('\n Vf = %f m/s',vf)
Q=(%pi/4)*((D1^2-Dh^2)*vf) // flow rate
mprintf('\n Q = %f m3/s',Q)
E=(u*vlw)/g // euler's head
mprintf('\n Euler s Head E =%f m',E)
Ep=(9800*Q*E)/1000 // eulers power
mprintf('\n Eulers power = %e W',Ep)
b2=vf/u
mprintf('\n b2 = %f Degree',atand(b2))
```

Scilab code Exa 7.3 determine blade angles at hub mean and tip diameter

```
// determine blade angles at hub,mean and tip diameters
clc
Dt=4.5 // meter
Dh=2 // meter
p=20e6 //watts
N=150 // rpm
nh=0.94 // hydraulic efficiency
n0=0.88 // overall efficiency
h=21 // head
g=9.8
Q=(p)/(n0*h*9800) //
mprintf('\n Q =%f m3/s',Q)
vf=(4*Q)/(%pi*(Dt^2-Dh^2)) // velocity of flow
mprintf('\n Vf = %f m/s',vf)
Vw=(60*g*h*nh)/(2*N*%pi) // velocity of whirl
mprintf('\n rVw = %f',Vw)
D=(Dt+Dh)/2 // diameters
mprintf('\n D =%f',D)
rm=D/2
mprintf('\n rm =%f',rm)
Vm1=Vw/rm
```

```
mprintf('\n Vm1= %f m/s',Vm1)
rt=rm+0.625
Vm2=Vw/rt
mprintf('\n Vm2 =%f m/s',Vm2)
rt=rm-0.625
Vm3=Vw/rt
mprintf('\n Vm2 =%f m/s',Vm3)
uh=(%pi*Dh*N)/60
mprintf('\n uh=%f m/s',uh)
um=(%pi*D*N)/60
mprintf('\n um=%f m/s',um)
ut=(%pi*Dt*N)/60
mprintf('\n ut=%f m/s',ut)
b1h=vf/(uh-Vm3)
mprintf('      hub         :  ')
mprintf('\n tan(pi-beta1h)=  %f',b1h)
be=atand(b1h)
B1h=180-be
mprintf('\n B1h = %f degree',B1h)
B2=vf/uh
mprintf('\n B2h =%f degree  ',atand(B2))
mprintf('      mean         :  ')
b2h=vf/(um-Vm1)
mprintf('\n tan(pi-beta1h)=  %f',b2h)
be1=atand(b2h)
B2h=180-be1
mprintf('\n B1m = %f degree',B2h)
B2m=vf/um
mprintf('\n B1m =%f degree  ',atand(B2m))
mprintf('\     ')
mprintf('\     ')
mprintf('\     ')
mprintf('          Tip:            ')
b3h=vf/(ut-Vm2)
mprintf('\n                              tan(pi-beta1h)=  %f
   ',b3h)
be2=atand(b3h)
B3h=180-be2
```

```
mprintf('\n B1m = %f degree',B3h)
B3m=vf/ut
mprintf('\n B1m =%f degree ',atand(B3m))
```

Scilab code Exa 7.4 determine the mean speed and turbine

```
//determine the mean speed of turbine
// ex 7.4 pgno.174
clc
p=60e6 // power
h=40// meter
no=0.85 // overall efficiency
x=0.5 // flow ratio
g=9.8
Ku=1.6 // speed ratio
Q=p/(9800*no*h) // flow in kaplan turbine
mprintf('\n Q = %d m3/s',Q)
Vf=x*sqrt(2*g*h) // velocity of flow
mprintf('\n Vf = %d m/s',Vf)
d1=(%pi*(1-(0.35^2)))/4
d=d1*Vf // diameter
df=sqrt(180/d)
mprintf('\n D1 = %f m',df)
dh=0.35*df
mprintf('\n Dh = %f m',dh)
D=(dh+df)/2 // mean diameter
mprintf('\n mean diameter D= %f m',D)
N=(Ku*sqrt(2*g*h)*60)/(%pi*D) //rotational speed
mprintf('\n N = %f rev/min',N)
```

Scilab code Exa 7.5 to determine inlet and eulers head

```
// determine blade inlet angle and eulers head
```

```
// ex 7.5 pgno.175
clc
h=35 //meter
D=2 //m
N=145 //rev/min
alpa1=30// degree
g=9.8 //
b1=28// degree
H=32.6// 0.93*35 head
V1=sqrt(2*g*H) // inlet velocity
mprintf('\n inlet velocity V1 = %f m/s',V1)
u=(%pi*D*N)/60 //
mprintf('\n u = %f m/s',u)
Vr1=sqrt(V1^2+u^2-(2*u*V1*cosd(alpa1))) // inlet
    triangle of velocity
mprintf('\n Vr1 = %f m/s',Vr1)
v=(-u^2+Vr1^2+V1^2)
v1=2*Vr1*V1
V=v/v1
s=acosd(V)
B1=(180-s) // Beta
mprintf('\n Beta B1 = %f degree',B1)
Vlw=V1*cosd(alpa1)
mprintf('\n Vlw =% f m/s',Vlw)
E=(u*Vlw)/g // eulers head
mprintf('\n E =%f m',E)
```

Scilab code Exa 7.6 to determine overall efficiency

```
// design of bersia power station
// ex 7.6 pgno.178
clc
p=24.7e6// power watt
h=26.5 //m
N=187.5 // rev/min
```

```
Q=104 //m3/s
w=(2*N*%pi)/60
g=9.8
mprintf('\n  w= %f rad/s',w)
wt=(w*sqrt(p/10^3))/(g*h)^(5/4)
mprintf('\n wt =%f',wt)
Ns=(N*sqrt(p/10^3))/(h^(5/4)) // speed
mprintf('\n Ns =%f',Ns)
n0=p/(9800*Q*h) // overall efficiency
mprintf('\n Overall efficiency n0= %f percentage',n0
    *100)
mprintf('\n Based on specific speed values obtained
    kaplan turbine is selected with an overall
    efficiency of %f percentage',n0*100)
```

Scilab code Exa 7.7 to determine overall efficiency of termengor power station

```
// design of termengor power stations
// ex 7.7 pgno.178
 clc
 Q=125.4 // flow rate at m3/s
 H=101 // m
 N=214.3 // speed in rev/min
 p=90e6 // power to turbine in wattsr
 g=9.8
 w=(2*N*%pi)/60
 mprintf('\n Wt =%f rad/s',w)
 wt=(w*(sqrt(p/10^3)))/((g*H)^(5/4))
 mprintf('\n wt= %f',wt)
 Ns=(N*sqrt(90*1000))/((H)^(5/4))// specific speed
 mprintf('\n Ns = %f ',Ns)
 n0=p/(9800*Q*H) // overall efficiency
 mprintf('\n Over all efficiency n0= %f percentage',
    n0*100)
```

Scilab code Exa 7.8 to determine overall efficiency of jor power station

```
// to find JOR power station
// ex 7.8 pgno.179
clc
P=26.1e6 // power in mega watts
H=587.3 // m
N=428 // revloution /minutes
Q=6.85 // m3/s
w=(2*N*%pi)/60
g=9.8
mprintf('\n W= %f rad/s',w)
wt=(w*(sqrt(P/10^3)))/((g*H)^(5/4))
mprintf('\n wt =%f',wt)
Ns=(N*(sqrt(26.1e6)))/(H^(5/4)) // speed
mprintf('\n Ns = %f',Ns)
mprintf('\n error in text book they have taken p
   =26.1e3 instead of 26.1 e6')
n0=P/(9800*Q*H) // overall efficiency
mprintf(' \nOverall efficiency n0= %f percentage',n0
   *100)
```

Chapter 8

Turbo pumps

Scilab code Exa 8.1 to determine speed pump

```
// select pump deliver 1890 l/min
clc
Q=(1890e-3/60)
disp(Q)
p=448e3
N=3600 //rev/min
w=(2*N*%pi)/60
g=9.8
gammma=9800
mprintf('\n speed in rad/s = w= %f rad/s',w)
H=p/gammma
mprintf('\n head in meters H = %f m',H)
wp=((w*(sqrt(Q)))/((g*H)^(3/4)))
mprintf('\n specific speed of the pump giveb by Wp=
   %f',wp)
mprintf('Wp<1 therefore radial pump selected')
```

Scilab code Exa 8.2 determine the elevation

```
// elevation that the diameter pump can be situated
   above the water surface of suction
clc
patm=101e3
pv=1666
g=9800
npsh=7.4
z1=((patm-pv)/g)-npsh
mprintf('\n Z1= %f m',z1)
mprintf('\n the pump must be place at approximately
   %f m above the suction reservoir of water surface
   ',z1)
```

Scilab code Exa 8.3 determine the operating point of the pump and determine flow rate and head

```
// radial flow pump characteristic is given by
clc
a=196
b=-10.7
c=7.9
a1=(1/(2*a))
Q=a1*(-b+sqrt((b^2)+(4*a*c)))
mprintf('\n Operating point at  Q = %f m3/s',Q)
H=15+(85*Q^2)
mprintf('\n H = %f m',H)
```

Scilab code Exa 8.4 determine flow rate theoretical head and required power pressure across the impeller

```
// determine flow rate,theoretical head required
   power,pressure across the impeller
clc
```

```
b1=44
r1=21e-3 // mm
B=11e-3 // mm
r2=66e-3 //mm
b2=5e-3//mm
N=2500  //rpm
h1=0
g=9.8
alpha=90 // degree
D1=2
D2=2
u1=(2*%pi*N*r1)/60
gamm1=9800
p1=1000
mprintf('\n peripherial velocity at inlet u1=wR1 =%f
    m/s',u1)
u2=(2*%pi*N*r2)/60
mprintf('\n peripherial velocity at exit  u2= wR2=%f
    m/s',u2)
V1=tand(b1)*u1
mprintf('\n V1f = %f m/s',V1)
Q=%pi*2*r1*B*V1
mprintf('\n Q = %f m3/s',Q)
V2f=Q/(2*%pi*r2*b2)
mprintf('\n V2f =%f m/s',V2f)
V2w=V2f/(tand(30))
mprintf('\n u2-V2w = %f ',V2w)
v2w=u2-V2w
mprintf('\n V2w = %f m/s',v2w)
alpha2=atand(V2f/v2w)
mprintf('\n  alpha2 = %f degree',alpha2)
v2=v2w/cosd(18.9)
mprintf('\n  V2= %f m/s',v2)
H1=(u2*v2w)/g
mprintf('\n H1 = %f m',H1)
p=gamm1*Q*H1
mprintf('\n H1 = %f watt',p)
P2=(p1*g*H1)-((p1/2)*(v2^2-V1^2))
```

```
mprintf('\n p2-p1 = %e Pa',P2)
mprintf('\n p2-p1 = %f bar',P2/10^5)
```

Scilab code Exa 8.5 determine discharge and head with identical pumps operated in parallel

```
// determine  discharge and head with two identail
clc
f=0.025
l=70
D=0.3
k=2.5
g=9.8
m=((f*l/D)+k)/(2*g*(((%pi*D*D)/4)^2))
disp(m)
mprintf('\n H1 =15 +%d Q^2',m)
b=5.35
a=112.8
c=7.9
Q=(1/(2*a))*(b+sqrt((b^2)+(4*a*c)))
mprintf('\n Q= %f m3/s',Q)
H1=15+85*Q^2
mprintf('\n H1 = %f m',H1)
```

Scilab code Exa 8.6 dtermine the velocity of flow theoretical head and power required to drive pump

```
// Determine the velocity of flow theoretical head
   and power required to drive the pump
clc
Q=150e-3
d1=300e-3
d2=150e-3
```

```
n=500
g=9.8
Vf=(Q)/((%pi/4)*(d1^2-d2^2))
mprintf('\n Velocity of flow Vf=Q/A %f m/s',Vf)
D=(d1+d2)/2
mprintf('\n Peripherial velocity is calculated on
    the mean diameter D =%f m',D)
u=((2*%pi*n)/60)*(D/2)
H1=(u^2/g)-((u*Vf)/g)*(cotd(75)+cotd(70))
mprintf('\n Theoretical Head H = %f m',H1)
P=g*Q*H1
mprintf('\n Required power P = %f kw',P)
```

Scilab code Exa 8.7 determine the maximum height

```
// maximum height that the pump
clc
Q=3.5e-3
nphs=4.5
t=15
d=0.1
patm=101e3
g=9.8
k=20
V=(4*Q)/(%pi*d^2)
mprintf('\n Velocity in the suction pipe V =Q/A  %f
    m/s',V)
h1=(k*V^2)/(2*g)
mprintf('\n h1= %f m',h1)
pv=1666
z1=(patm/9800)-(h1)-(pv/9800)-nphs
mprintf('\n z1 = %f m',z1)
mprintf('\n the pump should be located higher than
    %f m above the water surface ',z1)
```

Chapter 9

Positive Displacement Pumps

Scilab code Exa 9.1 to calculate electrical power

```
//  to find hydralic power
// ex 9.1 pgno.215
clc;
p= 200e3 // pressure of water
g=9800
zs=0.1
pd=600e3
sp=0.85 // efficiency of the pump
h=((p/g)+zs)+((pd/g)+zs)
printf(" %f  m",h)
q=0.2 // increase the pressure
h1=81.6
hp=g*q*h1 // efficiency
printf("\n %e W",hp)
n=hp/sp // electrical power i e shaft power
printf("\n electrical power = %5e  W",n)
```

Scilab code Exa 9.2 determine the total head of the pump

```
//determine the total head of the pump
// ex 9.2  page no 215
clc;
q=37.5e-3*4 // water flow rate
A=3.14*0.15^2// area  of suction in 15cm in meter
V=q/A
printf("velocity at the suction Q/As=  %2.2f m/s",V)
Ad=3.14*0.125^2 // area of suction in 12.5cm
Vd=q/Ad
printf("\n  velocity at the discharge side Q/Ad=  %2
    .2f m/s",Vd)
ps=54e3
gamma1=9800// constant gamma
g=9.8
vs=2 // velocity of suction
pd=160e3 // power density
vd=3 // velocity of discharge side
H=((ps/gamma1)+(vs^2/(2*g)))+((pd/gamma1)+(vd^2/(2*g
    )))
disp(H)
```

Chapter 13

new

Scilab code Exa 1.1 to find energy

```
// to calculate force acting on 1mx 2m
clc
A=1*2
v=(100*1000)/3600 // 100km/hr
mprintf('Velocity of the wind = %f m/s',v)
density=1.2// in kg/m3
p0=(density*v^2)/2
mprintf(' \n P0= %d N/m2',p0)
F=p0*A
mprintf('\n Force F=p0A = %d N',F)
```