# Scilab Textbook Companion for Thermal Engineering by S. l. Somasundaram[1]

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# Book Description

**Title:** Thermal Engineering

**Author:** S. l. Somasundaram

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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

# Thermal Engineering

**Scilab code Exa 1.1** example 1

```

clc
//initialisation of variables
clear
t1=300 //K
t3=1900 //K
r=15
g=1.4
p1=1 //bar
cp=1.005
cv=0.718
R=0.287 //kj/kgk
//CALCULATIONS
t2=t1*r^(g-1)
p2=p1*r^(g)
p3=p2
t4=t3*0.143^(g-1)
p4=p3*(0.143)^(g)
qs=cp*(t3-t2)
qr1=cv*(t4-t1)
wo=qs-qr1
```

```
ef=wo/qs
v1=R*t1/p1
v2=v1/r
sv=v1-v2
cl=v2/(v1-v2)
mep=wo/sv
printf('mean effective pressure is %2f',mep)
```

**Scilab code Exa 1.2** example 2

```
clc
//initialisation of variables
tl=279 //k
ta=294 //k
th=393 //k
re=0.14
//CALCULATIONS
cop=(tl*(th-ta))/((ta-tl)*th)
acop=cop*re
//RESULTS
printf('actual COP is %2f',acop)
```

**Scilab code Exa 1.3** example 3

```
clc
//initailisation variables
d=20 //cm
l=25 //cm
cv=1400 //cc
g=1.4
//CALCULATIONS
sv=(22/7*d^2*l)/4
tv=sv+cv
```

```
r=tv/cv
e=1-1/(r)^(g-1)
printf('otto efficiency is %2f',e)
```

**Scilab code Exa 1.4** example 4

```

clc
//initialisation of variables
t1=305 //K
t3=1920 //K
r=7
g=1.4
p1=1 //bar
cv=0.718
R=0.287 //kj/kgk
//CALCULATIONS
t2=t1*r^(g-1)
p2=p1*r^(g)
p3=p2*(t3/t2)
t4=t3*1/r^(g-1)
p4=p3*(1/r)^(g)
qs=cv*(t3-t2)
qr1=cv*(t4-t1)
wo=qs-qr1
ef=wo/qs
v1=R*t1/p1
v2=v1/r
sv=v1-v2
cl=v2/(v1-v2)
mep=wo/sv
printf('mean effective pressure is %2f',mep)
```

**Scilab code Exa 1.5** example 5

```
clc
//initialisation of variables
r=14
g=1.4
x=1.78 //x=v3/v2
//CALCULATIONS
oef=1-(1/14)^(g-1)
def=1-((1/(14)^(g)*1.4))*((x^(g) -1)/(x-1))
printf('otto efficiency is %2f',oef)
```

---

**Scilab code Exa 1.6** example 6

```
clc
//initialisation of variables
t1=300 //temparature in k
r=10 //compression ratio
p1=1 //pressure in bar
g=1.4
p3=40 //pressure in bar
x=0.166 //x=v4/v5=t4/v1=(v4/v2)*(v2/v1)
t4=2000 //temparature in k
p4=40 //pressure in bar
cv=0.718 //calorific value(const volume)
cp=1.005 //calorific value(const preussure)
R=0.287
r=10
//CALCULATIONS
t2=(t1*(r)^(g-1))
p2=(p1*(r)^(g))
t3=t2*(p3/p2)
t5=t4*(x)^(g-1)
p5=p4*(x)^(g)
q23=cv*(t3-t2)
```

```
q34=cp*(t4-t3)
q44=cv*(t5-t1)
nwd=q23+q34-q44
ef=nwd/(q23+q34)
v1=(R*t1)/(p1*100)
v2=v1/r
mep=nwd/(v1-v2)
effo=1-(1/(r)^(g-1))
v3=(R*t4)/(p2*100)
cr=v3/v2
effd=1-((1/(r)^(g-1))*(1/g)*((cr)^(g)-1)/(cr-1))
//RESULTS
printf('temparature 2,3,5 and pressure 2,5 are %2fk,
    %2fk,%2fk and %2fbar,%2fbar',t2,t3,t5,p2,p5)
printf('\nheat supplied at const volume is %2fkj/kg/
    cycle',q23)
printf('\nheat supplied at const pressure is %2fkj/
    kg/cycle',q34)
printf('\nnet work output is %2f',nwd)
printf('\nefficiency is %2f',ef)
printf('\notto efficiency is %2f',effo)
printf('\ndiesel efficiency is %2f',effd)
```

**Scilab code Exa 1.7** example 7

```
clc
//initialisation of variables
t1=295 //temparature in k
r=5.25
g=1.4
t3=923 //temparature in k
tc=511 //temparature in k
tt=633 //temparature in k
//CALCULATIONS
t2=t1*(r)^((g-1)/g)
```

```
t4=t3/(r)^((g-1)/g)
effb=1-((t4-t1)/(t3-t2))
wt=t3-t4
wc=t2-t1
wr1=(1-(t2-t1)/(t3-t4))
ctwr1=(t2-t1)/(t3-t4)
effc=(t2-t1)/(tc-t1)
efft=(t3-tt)/(t3-t4)
effbr=1-((tt-t1)/(t3-tc))
wr2=1-((tc-t1)/(t3-tt))
ctwr2=(tc-t1)/(t3-tt)
//RESULTS
printf('work ratio and compressed turbine wrok ratio
    in first part of problem are %2f and %2f',wr1,
   ctwr1)
printf('\nwork ratio and compressed turbine wrok
   ratio in second part of problem are %2f and %2f',
   wr2,ctwr2)
```

# Chapter 4

# Thermal Engineering

**Scilab code Exa 4.1** example 1

```
clc
//initialisation of variables
t1=523.3 //temparature under p1=40 bar in k
t2=314.5 //temparature under p2=0.80 bar in k
s4=2.797 //entropy under p1=40 bar
s1=6.070 //entropy under p1=40 bar
sf3=0.593 //entropy under p2=0.08 bar
sfg3=7.634 //entropy under p2=0.08 bar
h4=1087 //kj/kg
h1=2801 //kj/kg
hf3=174 //kj/kg under p2=0.08bar
hfg3=2402 //kj/kg under p2=0.08bar
//CALCULATIONS
eff=(t1-t2)/t1
x3=(s4-sf3)/sfg3
x2=(s1-sf3)/sfg3
h3=hf3+(x3*hfg3)
h2=hf3+(x2*hfg3)
wt=h1-h2
cw=h4-h3
wr=(wt-cw)/wt
```

```
//RESULTS
printf('efficiency of carnot cycle is %2f',eff)
printf('\nquality is %2f',x3)
printf('\ngross work of expansion is %2f',wt)
printf('\nwork ratio is %2f',wr)
```

**Scilab code Exa 4.2** example 2

```
clc
//initialisation of variables
v=0.1008*10^-2
p1=40 //pressure in bar
p2=0.08 //pressure in bar
wt=903.8 //kj/kg
wp=4.02 //kj/kg
h1=2801 //kj/kg
h3=174 //kj/kg
//CALCULATIONS
pw=v*(p1-p2)
wn=wt-wp
qs=h1-(h3+wp)
reff=wn/qs
wr=wn/wt
//RESULTS
printf('heat supplied is %2f',qs)
printf('\nrankine efficiency and work ratio is %2f
    and %2f',reff,wr)
```

**Scilab code Exa 4.3.a** example 3a

```
clc
//initialisation of variables
h1=2801 //kj/kg
```

```
h3=867.5 //kj/kg
h4=1087 //kj/kg
ieff=0.50 //isentropic efficiency of compression
wt=903.8 //kj/kg
feff=0.75 //furnace efficiency
ieeff=0.85//isentropic expansion efficiency
//CALCULATIONS
hx=((h4-h3)/0.5)+867.5
wr=hx-h3
atu=ieeff*wt
hs=h1-hx
nwo=atu-wr
eff=nwo/hs
oeff=eff*feff
wrt=nwo/atu
ssc=3600/nwo
hr=3600/oeff
//RESULTS
printf('steam and heat rates are %2fkg/kwh and %2fkj
    /kwh',ssc,hr)
```

**Scilab code Exa 4.3.b** example 3 b

```
clc
//initialisation of variables
h3=174 //kj/kg
h4=178.02 //kj/kg
ieff=0.50 //isentropic efficiency of compression
wt=903.8 //kj/kg
feff=0.75 //furnace efficiency
ieeff=0.85//isentropic expansion efficiency
wp=4.02 //kj/kg
h1=2801 //kj/kg
//CALCULATIONS
hx=((h4-h3)/0.5)+174
```

```
wr=wp/ieff
atu=ieeff*wt
hs=h1-hx
nwo=atu-wr
eff=nwo/hs
oeff=eff*feff
wrt=nwo/atu
ssc=3600/nwo
hr=3600/oeff
//RESULTS
printf('steam and heat rates are %2fkg/kwh and %2fkj
   /kwh',ssc,hr)
```

**Scilab code Exa 4.4** example 4

```
clc
//initialisation of variables
h1=3221.6 //kj/kg
s1=7.399 //kj/kgk
sf2=0.521 //kj/kgk
sfg2=7.808 //kj/kgk
hf2=152 //kj/kg
hfg2=2415 //kj/kg
t1=653 //temp in k
t2=309.2 //temp in k
v=0.1006*10^-2
p1=10 //pressure in bar
p2=0.06 //pressure in bar
h3=152 //kj/kg
x=110
y=639.7
z=610
a=2015
//CALCULATIONS
x2=(s1-sf2)/sfg2
```

```
h2=hf2+(x2*hfg2)
wo=h1-h2
hs=h1-h3
theff=wo/hs
sr1=3600/wo
ceff=(t1-t2)/t1
wp=v*(p1-p2)
h4=h3+wp
reff=(x+y)/(z+a)
sr2=3600/(x+y)
hr=3600/reff
printf('steam rate and carnot efficiency are %2fkg/
   kwh and %2f',sr1,ceff)
printf('\nsteam rate and heat rate are %2fkg/kwh and
    %2f',sr2,hr)
```

**Scilab code Exa 4.5** example 5

```
clc
//initialisation of variables
h1=3157 //kj/kg
h2=2725 //kj/kg
h3=3299 //kj/kg
h4=2257.9 //kj/kg
h5=1940.3 //kj/kg
h6=152 //kj/kg
x4=0.872
x5=0.7405
v=0.1006*10^-2 //volume
p1=100 //pressure in bar
p2=0.06 //pressure in bar
//CALCULATIONS
wp=v*(p1-p2)*100
h7=h6+wp
wt1=h1-h5
```

```
wn1=wt1-wp
qs1=h1-h7
wr1=wn1/wt1
reff=wn1/qs1
//reheat cycle
wt2=(h1-h2)+(h3-h4)
wn2=wt2-wp
wr2=wn2/wt2
qs2=h1-h7+h3-h2
teff=wn2/qs2
pd=wn2/3600
pdi=(pd-0.3352)/0.3352
df=1-pdi
//RESULTS
printf('work ratio and rakine efficiency of rankine
   cycle is %2f and %2f',wr1,reff)
disp('dryness fraction of steam is 0.872')
printf('\nheat supplied is %2f',qs1)
printf('\npower developed is %2f',pd)
printf('\npower developed per kg of steam is %2f',
   pdi)
```

**Scilab code Exa 4.6** example 6

```
clc
//initialisation of variables
h1=2979 //kj/kg
h2=2504.3 //kj/kg
h3=1987.4 //kj/kg
h4=152 //kj/kg
h6=561 //kj/kg
//CALCULATIONS
m=(h6-h4)/(h2-h4)
wo=(h1-h2)+(1-m)*(h2-h3)
qs=h1-h6
```

```
teff=wo/qs
ssc=3600/wo
//RESULTS
printf('work output is %2fkj/kg',wo)
printf('\nheat supplied is %2fkj/kg',qs)
printf('\nthermal efficiency is %2f',teff)
printf('\nspecific steam consumption is %2fkg/kwh',
    ssc)
```

**Scilab code Exa 4.7.a** example 7a

```
clc
//initialisation of variables
h1=3222.5 //kj/kg
h2=3127.5 //kj/kg
h3=2692.5 //kj/kg
h4=2406.7 //kj/kg
h5=360 //kj/kg
h6=360 //kj/kg
h7=584 //kj/kg
h8=962 //kj/kg
//CALCULATIONS
m1=(h8-h7)/(h2-h7)
m2=((1-m1)*(h7-h5))/(h3-h5)
wo=(h1-h2)+(1-m1)*(h2-h3)+(1-m1-m2)*(h3-h4)
qs=h1-h8
teff=wo/qs
sr=3600/wo
//RESULTS
printf('work output is %2fkj/kg',wo)
printf('\nheat supplied is %2fkj/kg',qs)
printf('\nthermal efficiency is %2f',teff)
printf('\nsteam rate is %2fkg/kwh',sr)
```

**Scilab code Exa 4.7.b** example 7b

```
clc
//initialisation of variables
h1=3222.5 //kj/kg
h2=3127.5 //kj/kg
h3=2692.5 //kj/kg
h4=2406.7 //kj/kg
h5=360 //kj/kg
h6=360 //kj/kg
h7=584 //kj/kg
h8=962 //kj/kg
//CALCULATIONS
m1=(h8-h7)/(h2-h8)
m2=((h7-h6)-m1*(h8-h7))/(h3-h7)
wo=(h1-h2)+(1-m1)*(h2-h3)+(1-m1-m2)*(h3-h4)
qs=h1-h8
teff=wo/qs
sr=3600/wo
//RESULTS
printf('work output is %2fkj/kg',wo)
printf('\nheat supplied is %2fkj/kg',qs)
printf('\nthermal efficiency is %2f',teff)
printf('\nsteam rate is %2fkg/kwh',sr)
```

---

**Scilab code Exa 4.8** example 8

```
clc
//initialisation of variables
h1=2990 //kj/kg
h2=2710 //kj/kg
h3=2325 //kj/kg
```

```
h4=152 //kj/kg
h5=152 //kj/kg
h7=505 //kj/kg
wo=612 //kj/kg
qs=2485 //kj/kg
//CALCULATIONS
m=(h7-h4)/(h2-h4)
mph=m*30000
ip=((h1-h2)+(1-m)*(h2-h3))*(30000/3600)
teff=wo/qs
//when there is no feeding
eff=(h1-h3)/(h1-h4)
sc=(3600/(h1-h3))*ip
//RESULTS
printf('internal powers is %2fkw',ip)
printf('\nthermal efficiency when feeding is there
    is %2f',teff)
printf('\nwhen there is no feeding,thermal
    efficiency is %2f',eff)
printf('\nsteam consumption is %2fkg/h',sc)
```

**Scilab code Exa 4.10** example 10

```
clc
//no 4.9 printed in the book....print mistake
//initialisation of variables
//for the mercury cycle
ha=360.025 //kj/kg
sa=0.50625 //kj/kgk
sfb=0.0961 //kj/kgk
sfgb=0.5334 //kj/kgk
hfb=38.05 //kj/kg
hfgb=294.02 //kj/kg
//for the steam cycle
h5=2801 //kj/kg
```

```
h3=163 //kj/kg
hb=264.2 //kj/kg
h1=2963 //kj/kg
s1=6.364 //kj/kgk
sf2=0.559 //kj/kgk
sfg2=7.715 //kj/kgk
qs=3916.2 //kj/kg
hf2=163 //kj/kg
hfg2=2409 //kj/kg
//CALCULATIONS
xb=(sa-sfb)/sfgb
hb=hfb+(xb*hfgb)
m1=(h5-h3)/(hb-hfb)
x2=(s1-sf2)/sfg2
h2=hf2+(x2*hfg2)
wn=m1*(ha-hb)+(h1-h2)
teff1=wn/qs
hx=ha-(0.8*(ha-hb))
hy=h1-(0.8*(h1-h2))
m2=(h5-h3)/(hx-hfb)
wo=m2*(ha-hx)+(h1-hy)
qs=m2*(ha-hfb)+(h1-h5)
teff2=wo/qs
//RESULTS
printf('thermal efficiency of steam cycle is %2f',
   teff1)
printf('\nwork output of plant is %2fkj/kg',wo)
printf('\nheat supplied is %2fkj/kg',qs)
printf('\nthermal efficiency of the plant is %2f',
   teff2)
```

**Scilab code Exa 4.11** example 11

```
clc
//initialisation of variables
```

```
ha=360.025 //kj/kg
hfb=38.05 //kj/kg
hb=264.2 //kj/kg
h1=2963 //kj/kg
h2=1974.6 //kj/kg
h3=163 //kj/kg
h4=1087 //kj/kg
h=1714 //kj/kg
//CALCULATIONS
m=h/(hb-hfb)
wo=7.58*(ha-hb)+(h1-h2)
qs=7.58*(ha-hfb)+(h4-h3)+(h1-h)
teff=(wo/qs)
//RESULTS
printf('thermal efficiency is %2f',teff)
```

**Scilab code Exa 4.12** example 12

```
clc
//initialisation of variables
ha=359.11 //under 10 bar pressure in kj/kg
sa=0.5089 //under 10 bar pressure in kj/kgk
sfb=0.0870 //under 0.08 bar pressure in kj/kgk
sfgb=0.57 //under 0.08 bar pressure in kj/kgk
hfb=33.21 //under 0.08 bar pressure in kj/kg
hfgb=294.7 //under 0.08 bar pressure in kj/kg
h=1840.5 //kj/kg
h1=3350 //under 25 bar pressure and 723 k in kj/kg
s1=7.183 //under 25 bar pressure and 723 k in kj/kgk
sf2=0.476 //under 25 bar pressure and 723 k in kj/
    kgk
sfg2=7.918 //under 25 bar pressure and 723 k in kj/
    kgk
hf2=138 //under 25 bar pressure and 723 ki n kj/kg
hfg2=2423 //under 25 bar pressure and 723 k in kj/kg
```

```
h5=964 //kj/kg
//CALCULATIONS
xb=(sa-sfb)/(sfgb)
hb=hfb+(xb*hfgb)
m=h/(hb-hfb)
x2=(s1-sf2)/sfg2
h2=hf2+(x2*hfg2)
wo=8.47*(ha-hb)+(h1-h2)
qs=8.47*(ha-hfb)+(h5-138)+(h1-2802.5)
teff=(wo/qs)*100
//RESULTS
printf('work output is %2f',wo) //textbook ans
    slightly varies
printf('\nheat supplied to the plant is %2f',qs)
printf('\nthermal efficiency is %2f',teff)
```

# Chapter 5

# Thermal Engineering

**Scilab code Exa 5.1** example 1

```
clc
//initialisation of variables
c=300 //velocity in m/s
cp=1.005 //kj/kgk
g=1.4
t=478 //static temparature in k
p=15 //static pressure in bar
//CALCULATIONS
t0=t+((c)^2/(2*cp*1000))
x=(t0/t)^(g/(g-1))*p
//RESULTS
printf('stagnation temparature and stagnation
   pressure is %2fk and %2fbar',t0,x)
```

---

**Scilab code Exa 5.2** example 2

```
clc
//initialisation of variables
```

```
hg=2803.4 //kj/kg
c=300 //m/s
sg=6.1253 //kj/kgk
h2=2090.0 //kj/kg
//CALCULATIONS
h0=hg+((c)^2)/2000
c2=44.72*(h0-h2)^0.5
//RESULTS
printf('total enthalpy is %2fkj/kg',h0) //textbook
    answer is wrong
printf('\nfinal stream is %2fm/s',c2) //textbook
    answer is wrong
```

---

**Scilab code Exa 5.3.a** example 3a

```
clc
//initialisation of variables
R=0.2897 //kj/kgk
g=1.4
t1=313 //temparature in k
p1=20 //pressure in bar
p2=13 //pressure im bar
cp=1.0138 //kj/kgk
a=5*10^-4
//CALCULATIONS
rc=(2/(g+1))^(g/0.4)
t2=t1*(p2/p1)^((g-1)/g)
c2=44.72*(cp*(t1-t2))^(0.5)
rho=p2*100/(R*t2)
m=rho*c2*a
//RESULTS
printf('mass f;ow rate and velocity of air at exit
    are %2fkg/s and %2fkg/m*m*m',m,rho) //textbook
    answer slightly varies
```

---

**Scilab code Exa 5.3.b** example 3 b

```
clc
//initialisation of variables
R=0.2897 //kj/kgk
g=1.4
t1=313 //temparature in k
p1=20 //pressure in bar
p2=10.56 //pressure im bar
cp=1.0138 //kj/kgk
a=5*10^-4
//CALCULATIONS
rc=(2/(g+1))^(g/0.4)
t2=t1*(p2/p1)^((g-1)/g)
c2=44.72*(cp*(t1-t2))^(0.5)
rho=p2*100/(R*t2)
m=rho*c2*a
//RESULTS
printf('mass flow rate and velocity of air at exit
    are %2fkg/s and %2fkg/m*m*m',m,rho)
```

---

**Scilab code Exa 5.4** example 4

```
clc
//initialisation of variables
x=100 //x=h1-h* in kj/kg
m=120 //mass in kg
pi=(22/7)
y=501.5 //y=h1-h2 in kj/kg
v1=0.607 //volume
v2=6.477 //volume
//CALCULATIONS
```

```
c1=44.72*(x)^(0.5)
a1=m*v1/(c1*60)
d1=(4*a1/pi)^0.5
c2=44.72*(y)^(0.5)
a2=m*v2/(c2*60)
d2=(4*a2/pi)^0.5
//RESULTS
printf('area of cross section of throat and diameter
    of throat are %2fm*m and %2fm',a1,d1)
printf('\narea of cross section at exit and diameter
    at exit are %2fm*m and %2fm',a2,d2)
```

**Scilab code Exa 5.5** example 5

```

clc
//initialisation of variables
clear
t1=593 //temparature in k
p2=1.05 //pressure in bar
p1=7 //pressure in bar
cp=1.005
p3=3.696 //pressure in bar
r=0.287 //kj/kgk
a=6.25*10^-4
g= 32.2 //ft/sec^2
R= 8.314
//CALCULATIONS
t2=t1*(p2/p1)^((g-1)/g)
c2=44.72*(cp*(t1-t2))^(0.5)
rho2=p2*100/(r*t2)
m2=rho2*c2*a
t3=t1*(p3/p1)^((g-1)/g)
c3=44.72*(cp*(t1-t3))^(0.5)
rho3=p3*100/(R*t3)
```

```
a3=m2/(rho3*c3)
//RESULTS
printf('exit velocity and mass flow rate are %2fm/s
   and %2fkg/s',c2,m2)
printf('\nthroat area is %2fm*m',a3)
```

**Scilab code Exa 5.6** example 6

```

clc
//initialisation of variables
clear
g=1.4 //gamma-const value
p1=4.5 //pressure in bar
p3=1.1 //pressure in bar
cp=1.005 //kj/kgk
rho4=0.5405 //density
rho3=0.9725 //density
t1=1023 //temparature in k
t2=852.16 //temparature in k
r=0.287 //cp-cv=const value
m=0.5 //mass
ieff=0.85 //isentropic efficiency
R= 8.314
//CALCULATIONS
p2=0.528*p1
t2=0.833*t1
c2=44.72*(cp*(t1-t2))^(0.5)
rho2=p2*100/(R*t2)
a2=m/(rho3*c2)
t3=t2*(p3/p2)^((g-1)/g)
t4=t2-(ieff*(t2-t3))
c3=44.72*(cp*(t1-t4))^(0.5)
rho3=p2*100/(R*t4)
a3=m/(rho4*c3)
```

```
//RESULTS
printf('throat area is %2fm*m',a2)
printf('\nvelocity at exit,area at exit are %2fm/s and %2fm*m',c3,a3)
```

**Scilab code Exa 5.7** example 7

```
clc
//initialisation of variables
p1=5 //pressure in bars
h1=2709 //kj/kg
h2=2649.5 //kj/kg
v2=0.6059 //volume flowrate in m*m*m/kg
m=2 //mass in kg
v3=6.5098 //volume flowrate in m*m*m/kg
h1=2714.0 //kj/kg
h2=2649.5 //kj/kg
h3=2247.4 //kj/kg
eff=0.9 //efficiency
//CALCULATIONS
p2=0.578*p1
c2=44.72*(h1-h2)^(0.5)
a2=m*v2/c2
x=eff*(h1-h3) //x=h1-h3
c3=44.72*(x)^(0.5)
a3=m*v3/c3
//RESULTS
printf('velocity and area at throat are %2fm/s and %2fm*m',c2,a2)
printf('\nvelocity and area at exit are %2fm/s and %2fm*m',c3,a3)
```

**Scilab code Exa 5.8** example 8

```
clc
//initialisation of variables
clear
t1=323 //temp in k
c1=300 //velocity in m/s
c2=100 //velocity in m/s
cp=1.005 //kj/kgk
p1=10 //pressure in bar
p3=14 // pressure in bar
g= 32.2 //ft/sec^2
//CALCULATIONS
t2=t1+(((c1)^2)+(c2)^2)/(2*cp)
p2=p1*(t2/t1)^(g/(g-1))
t2=t1*(p3/p1)^((g-1)/g)
h3=cp*t2
x=(0.5*((c1)^2-(c2)^2))/1000 //x=h2-h1
h1=cp*t1
eff=(h3-h1)/(x)
//RESULTS
printf('diffuser efficiency is %2f',eff)
```

---

**Scilab code Exa 5.9** example 9

```
clc
//initialisation of variables
t1=323 //temparature in k
t2=362.8 //temparature in k
c1=300 //velocity in m/s
c2=100 //velocity in m/s
cp=1.005 //kj/kgk
p1=10 //pressure in bar
p3=14 // pressure in bar
g=1.4
//CALCULATIONS
```

```
tx=t1+((c1)^2/(2*cp*1000))
po1=p1*(tx/t1)^(g/(g-1))
po2=p3*(tx/t2)^(g/(g-1))
tpr=po2/po1
rrr=(po2-p1)/(po1-p1)
//RESULTS
printf('total pressure ratio and ram recovery ratio
    are %2f and %2f',tpr,rrr)
```

**Scilab code Exa 5.10** example 10

```
clc
//initialisation of variables
h1=2724.7 //kj/kg under 3 bar pressure
s1=6.991 //kj/kgk under 3 bar pressure
sf2=1.530 //kj/kgk
sfg2=5.597 //kj/kgk
hf2=504.7 //kj/kg
hfg2=2201.6 //kj/kg
vg2=0.8854
a2=3*10^-4 //area in m*m
v1=0.6056 //m*m*m/kg
p1=3 //bar
p2=2 //bar
n=1.3
t1=406.54 //temparature in k
ps=0.917 //bar
v2=0.8273 //m*m*m/kg
//CALCULATIONS
x2=(s1-sf2)/(sfg2)
h2=hf2+(x2*hfg2)
v2=x2*vg2
c2=44.72*(h1-h2)^(0.5)
m1=a2*c2/v2
v2=v1*(p1/p2)^(1/n)
```

```
c3=((-2*n/n-1)*p1*v1*((p2/p1)^((n-1)/n)-1))
   ^0.5*543.53
m2=a2*c3/v2
t2=t1*(p2/p1)^((n-1)/n)
de=2/ps
//RESULTS
printf('mass flow rate is %2f',m2)
printf('\ndegree of super saturation is %2f',de)
```

# Chapter 6

# Thermal Engineering

**Scilab code Exa 6.1** example 1

```
clc
//initialisation of variables
c=400 //steam speed in m/s
alpla=12 //angle in degrees
cwo=0
pi=(22/7)
//CALCULATIONS
u=c*cos(12*(pi/180))/2
cwi=c*cos(12*(pi/180))
cfi=c*sin(12*(180/pi))
thetha=atan(cfi/(cwi-u))*(pi/180)
cro=sqrt((cfi)^2+(cwi-u)^2)
phi=acos(u/cro)*(180/pi)
wo=(cwi-cwo)*u
ke=(c)^2/2
eff=wo/ke
//RESULTS
printf('blade efficiency is %2f',eff)
```

**Scilab code Exa 6.2** example 2

```
clc
//initialisation of variables
hd=159 //heat drop in kj/kg
eff=0.89 //and its corresponding efficiency is
    mentioned
ra=0.4 //ratio of blade speed to steam speed
sp=3000 //rotational speed of an impulse turbine
    wheel in revolutions
a=20 //angle is 20 degrees
beff=0.76 //blade efficiency
cwo=5.4 //m/s
pi=(22/7)
bvc=0.82 //blade velocity coefficient
m=15 //mass is 15 kgs
//CALCULATIONS
ci=44.72*sqrt(eff*hd)
u=ci*ra
dm=(60*u)/(sp*0.3184)
cfi=ci*sin(20*(pi/180))
cwi=ci*cos(20*(pi/180))
cri=sqrt((cwi-u)^2+(cfi)^2)
cro=bvc*cri
x=(beff*(ci)^2)/(2*u) //x=cwi-cwo
theta=atan((cfi/(cwi-u)))*(180/pi)
cfo=sqrt((cro)^2-(cwo+u)^2)
co=sqrt((cwo)^2+(cfo)^2)
bet=(asin(cfo/co))*(180/pi)
pd=(m*x*u)/1000
re=hd-(pd/15)
phi=asin((cfo/cro))*(180/pi)
//RESULTS
printf('mean blade ring diameter is %2fm',dm) //
    textbook answer is wrong
printf('\npower developed is %2fkw',pd)
printf('\nresidual energy at out let foe friction
    and nozzle efficiency is %2fkw/kg',re)
```

```
printf('\nblade angles are %2f,%2f,%2f',theta,bet,
    phi)
```

**Scilab code Exa 6.3** example 3

```
clc
//initialisation of variables
alpha=20 //angle in degrees
theta=27 //angle in degrees
m=10 //kgs
vs=0.4799 //specific volume in m*m*m/kg
pi=(22/7)
u=100 //blade speed in m/s
//CALCULATIONS
ci=u*tan(27*(pi/180))/(cos(20*(pi/180))*tan(27*(pi
    /180))-sin(20*(pi/180)))
x=2*ci*cos(20*(pi/180))-u
pd=m*x*u
cf=ci*sin(20*(pi/180))
a=(m*vs)/cf
dm=sqrt(a/(0.08*pi))
h=0.08*dm
//RESULTS
printf('power developed is %2fw',pd)
printf('\narea of flow is %2fm*m',a)
printf('\nblade height is %2fm',h)
```

**Scilab code Exa 6.4** example 4

```
clc
//initialisation of variables
sp=1500 //rotational speed of an impulse turbine
    wheel in revolutions
```

```
pi=(22/7)
dm=1.5 //diameter in m
ra=0.8 //ratio of blade speed to steam speed
x=159 //x=cwi-cwo in m/s
m=10 //kgs mass
cf=50.4 //m*m*m/kg
vs=1.159 //
//CALCULATIONS
u=(pi*dm*sp)/60
ci=u/ra
pd=(m*x*u)/1000
a=(m*vs)/cf
h=a/(pi*dm)
//RESULTS
printf('power developed for steam flow is %2fkw',pd)
printf('\nheight of the blade is %2fm',h)
```

**Scilab code Exa 6.5** example 5

```
clc
//initialisation of variables
u=170 //blade velocity in m/s
ra=0.2 //ratio of blade speed to steam speed
cril=696 //m/s
co1=0.84 //velocity coefficient
co2=0.87 //velocity coefficient
co3=0.90 //velocity coefficient
cri2=232 //m/s
//CALCULATIONS
ci=u/ra
crol=cril*co1
ci2=crol*co2
cro2=cri2*co3
wd=(1176+344)*u*10^-3
beff=wd*1000*2/(ci^2)
```

```
//RESULTS
printf('work developed in the blade is %2fkj/kg',wd)
printf('\nblading efficiency is %2f',beff)
```

**Scilab code Exa 6.6** example 6

```
clc
//initialisation of variables
u=250 //blade speed in m/s
theta=80 //angle in degrees
alpha=20 //angle in degrees
oed=786.7 //overall enthalpic drop in kj/kg
sp=3000 //rotational speed of an impulse turbine
    wheel in revolutions
p=6000 //power developed in kw
rf=1.04 //reheat factor
ie=2993.4 //kj/kg
vs=9.28 //m*m*m/kg
pi=(22/7)
//CALCULATIONS
ci=(u*sin(100*(pi/180)))/sin(60*(pi/180))
x=(2*ci*cos(20*(pi/180)))-u //x=cwi-cwo
wd=x*u*10^-3
ed=wd*10
teff=ed/oed
seff=teff/rf
m=p/ed
ae=ie-ed
cf=ci*sin(20*(pi/180))
a=(m*vs)/cf
dm=(60*u)/(pi*sp)
h=a/(pi*dm)
//RESULTS
printf('enthalpy drop is %2fkj/kg',ed)
printf('\nturbine efficiency is %2f',teff)
```

```
printf('\nstage efficiency is %2f',seff)
printf('\nmass flow of steam is %2fkg/s',m)
printf('\nblade height us %2fm',h)
```

**Scilab code Exa 6.7** example 7

```
clc
//initialisation of variables
x1=3025 // according to 20 bar pressure and 300
    degrees temp
x2=2262 //according to 20 bar pressure and 300
    degrees temp
x3=2039 //according to 20 bar pressure and 300
    degrees temp
x4=2896 //according to 20 bar pressure and 300
    degrees temp
x5=2817 //according to 20 bar pressure and 300
    degrees temp
x6=2728 //according to 20 bar pressure and 300
    degrees temp
x7=2699 //according to 20 bar pressure and 300
    degrees temp
x8=2592 //according to 20 bar pressure and 300
    degrees temp
x9=2525 //according to 20 bar pressure and 300
    degrees temp
x10=2430 //according to 20 bar pressure and 300
    degrees temp
x11=2398 //according to 20 bar pressure and 300
    degrees temp
x12=2262 //according to 20 bar pressure and 300
    degrees temp
x13=2192 //according to 20 bar pressure and 300
    degrees temp
//CALCULATIONS
```

```
ieff=(x1-x2)/(x1-x3)
feff=(x1-x4)/(x1-x5)
seff=(x4-x6)/(x4-x7)
teff=(x6-x8)/(x6-x9)
oeff=(x8-x10)/(x8-x11)
yeff=(x10-x12)/(x10-x13)
ced=(x1-x5)+(x4-x7)+(x6-x9)+(x8-x11)+(x10-x13)
rf=ced/(x1-x3)
//RESULTS
printf('cumulative enthaloy drop is %2f',ced)
printf('\nreheat factor is %2f',rf)
```

# Chapter 7

# Thermal Engineering

**Scilab code Exa 7.1** example 1

```
clc
//initialisation of variables
ps=0.024853 //at 21 degress
phi=0.34 //relative humidity
p=1.013 //pressure in bar
//CALCULATIONS
pv=ps*phi
w=0.622*(pv/(p-pv))
tdew=4.5 //at 0.00845 bar
//RESULTS
printf('specific humidity is %2fkg/kg of da',w)
disp('dew point temp is 4.5 degrees',tdew)
```

**Scilab code Exa 7.2** example 2

```
clc
//initialisation of variables
t1=26 //temp in degrees
```

```
t2=32 //temp in degrees
pvs=0.033597 //pressure in bar
ps=0.047534 //pressure in bar
p=1.013 //pressure in bar
a=6.6*10^-4
//CALCULATIONS
pv=pvs-(p*a*(t2-t1))
w=(0.622*pv)/(p-pv)
phi=pv/ps
//RESULTS
printf('specific humidity is %2fkg/kg of da',w)
printf('\nrelative humidity is %2f',phi)
disp('dew point temp is 23.5 degrees') //from steam
    tables
```

**Scilab code Exa 7.3** example 3

```
clc
//initialisation of variables
ps=0.042415 //under 30 degrees temp in bar
vg=32.929 //m*m*m/kg
phi=0.3 //relative humidity
p=1.01325 //bar
pv=0.012725^10^2 //pressure
rv=0.4615
t=313 //temp in k
pa=1.005*10^2
ra=0.287
//CALCULATIONS
pv=phi*ps
w1=0.622*(pv/(p-pv))
rhos=1/vg
rhov=phi*rhos
rho=pv/(rv*t)
pa=p-pv
```

```
rhoa=pa*100/(ra*t)
w2=rhov/rhoa
ds=phi*((p-ps)/(p-pv))
//RESULTS
printf('partial pressure of water vapour is %2fbar',
    pv)
printf('\ndensity of dry air is %2fkg/m*m*m',rhoa)
disp('dew point temp is 10.5 degrees')
printf('\nspecific humidity is %2fkg/kg of da',w2)
    //textbook answer slightly varies
printf('\ndegree of saturation is %2f',ds)
```

**Scilab code Exa 7.4** example 4

```
clc
//initialisation of variables
ps=0.035636 //pressure in bar
pvw=0.018168 //pressure in bar
p=1.01325 //pressure in bar
a=6.6*10^-4
w=0.00667
td=27 //temparature in degrees
tw=16 //temparature in degrees
//CALCULATIONS
pv=pvw-(p*a*(td-tw))
w=0.622*(pv/(p-pv))
phi=pv/ps
h=(1.005*td+w*(2500+1.86*td))
//RESULTS
printf('humidity ratio is %2fkg/kg of da',w)
printf('\nrelative humidity is %2f',phi)
disp('dew point temparature is 8 degrees')
printf('\nenthalphy of moist air is %2fkg/kg of da',
    h)
```

**Scilab code Exa 7.5** example 5

```
clc
//initialisation of variables
p=1.01325 //pressure in bar
pv=0.020 //pressure in bar at 21 degrees temp
ws=0.0154 //kg/kg of da
w=0.0123 //kg/kg of da
vs=0.86 //under 21 degrees temp m*m*m/kg
w1=0.0074
//CALCULATIONS
pa=p-pv
sr=w/ws
rho=1/vs
avc=0.0163-w1
//RESULTS
printf('partial pressure of vapour and dry air are
    %2fbar and %2fbar',pv,pa)
disp('dew point temp is 17.4 degrees')
disp('specific humidity is 0.0123 kg/kg of da')
printf('\nsaturation ratio is %2f',sr)
printf('\ndensity of misture is %2fkg/m*m*m',rho)
printf('\namount of water vapour condensed is %2fkg/
    kg of da',avc)
```

**Scilab code Exa 7.6** example 6

```
clc
//initialisation of variables
p=1.01325 //pressure in bar
w1=0.01468
td=20 //temp in degrees
```

```
tw=40 //temp in degrees
//CALCULATIONS
ha=(1.005*td+w1*(2500+1.86*td))
w2=(ha-(1.005*tw))/(2500+1.86*tw)
//RESULTS
printf('humidity rate is %2fkg/kg of da',ha)
printf('\nw2 is %2fkg/kg of da',w2)
```

**Scilab code Exa 7.7** example 7

```
clc
//initialisation of variables
ps1=0.006566 //bar pressure
phi1=0.6 //relative humidity
td2=21 //temp in degrees
td1=1 //temp in degrees
ps2=0.02486 //pressure in bar
td3=26 //temp in degrees
p=1.013 //pressure in bar
//CALCULATIONS
pv1=(phi1*ps1)
w=0.622*(pv1/(p-pv1))
q=(td2-td1)*(1.005+(1.86*w))
phi2=pv1/ps2
cbf=(td3-td2)/(td3-td1)
cf=1-cbf
//RESULTS
printf('heat supplied to air is %2fkg/kg of da',q)
printf('\nfinal relative humidity is %2fkg/kg of da'
    ,phi2)
printf('\ncoil bypass factor is %2f',cbf)
printf('\ncontact factor is %2f',cf)
```

**Scilab code Exa 7.8** example 8

```
clc
//initialisation of variables
ps1=0.056216 //bar pressure
phi1=0.2 //relative humidity
td1=35 //temp in degrees
p=1.01325 //pressure in bar
td2=25 //temp in degrees
ps2=0.03166 //bar
//CALCULATIONS
pv1=phi1*ps1
w1=0.622*(pv1/(p-pv1))
ha=(1.005*td1+w1*(2500+1.86*td1))
w2=(ha-(1.005*td2))/(2500+1.86*td2)
pv2=(w2*p)/(w2+0.622)
phi2=pv2/ps2
//RESULTS
printf('relative humidity rate is %2fkg/kg of da',ha
    )
printf('\nrelative humidity is %2f',phi2)
printf('\namount of water to be added is %2fkg/kg of
    da',w2)
```

**Scilab code Exa 7.9** example 9

```
clc
//initialisation of variables
ps1=0.056216 //bar pressure
ps3=0.023366 //bar pressure
phi1=0.6 //relative humidity
td3=20 //temp in degress
td1=35 //temp in degrees
td2=12 //temp in degrees
r=0.287
```

```
p=1.01325 //pressure in bar
x1=90.12 //kj/kg
x2=34.08 //kj/kg
x3=42.25 //kj/kg
hf=0.4 //kj/kg
w1=0.02142
w2=0.00873
//CALCULATIONS
pv1=phi1*ps1
w1=0.622*(pv1/(p-pv1))
h1=(1.005*td1+w1*(2500+1.86*td1))
pv3=phi1*ps3
w3=0.622*(pv3/(p-pv3))
h3=(1.005*td3+w3*(2500+1.86*td3))
h2=(1.005*td2+0.0073*(2500+1.86*td2))
ma=((p-pv1)*100*2.5)/(r*(td1+273))
q1=ma*(x2-x1)+(w1-w2)*hf
q2=(ma*(x3-x2))
//RESULTS
printf('mass of dry air is %2fkg/s',ma)
printf('\ncooler load on the dehumidyfier is %2fkw',
    q1)
printf('\nheating load of the heater is %2fkw',q2)
```

**Scilab code Exa 7.10** example 10

```
clc
//initialisation of variables
x1=90.12 //kj/kg
x3=42.25 //kj/kg
ps3=0.023366 //bar pressure
td3=35 //temp in degrees
phi1=0.6 //relative humidity
p=1.01325 //pressure in bar
//CALCULATIONS
```

```
pv3=phi1*ps3
w3=0.622*(pv3/(p-pv3))
h3=(1.005*td3+w3*(2500+1.86*td3))
qs=h3-x3
ql=x1-h3
shf=qs/(qs+ql)
//RESULTS
printf('sensible heat removed is %2fkj/kg of da',qs)
printf('\nlatent heat removed is %2fkj/kg of da',ql)
printf('\nsensible heat factor is %2f',shf)
```

**Scilab code Exa 7.11** example 11

```
clc
//initialisation of variables
ps1=0.010720 //bar pressure
phi1=0.3 //relative humidity
td1=8 //temp in degrees
td2=32 //temp in degrees
td3=30 //temp in degrees
ps3=0.042415 //bar pressure
phi3=0.5 //relative humidity
hf=762.6 //kj/kg
hfg=2013.6 //kj/kg
p=1.01325 //pressure in bar
//CALCULATIONS
pv1=phi1*ps1
w1=0.622*(pv1/(p-pv1))
h1=(1.005*td1+w1*(2500+1.86*td1))
h2=(1.005*td2+w1*(2500+1.86*td2))
ha=h2-h1
pv3=phi3*ps3
w3=0.622*(pv3/(p-pv3))
h3=(1.005*td3+w3*(2500+1.86*td3))
wa=w3-w1
```

```
hw=(h3-h2)/(w3-w1)
x=(hw-hf)/hfg
//RESULTS
printf('heat added is %2fkj/kg of da',ha)
printf('\nwater added is %2fkg/kg of da',wa)
disp('temp os steam supplied is 179.88 degrees') //
    at 10 bar pressure
printf('\nsteam required is %2fkj/kg of steam',hw)
printf('\nquality of steam at 10 bar is %2f',x)
```

**Scilab code Exa 7.12** example 12

```
clc
//initialisation of variables
ps1=0.023366 //bar pressure
phi1=0.4//relative humidity
td1=20 //temp in degrees
m1=40 //kg/s
ps2=0.01227 //bar pressure
phi2=0.8//relative humidity
td2=10 //temp in degrees
m2=20 //kg/s
p=1.01325 //pressure in bar
//CALCULATIONS
pv1=phi1*ps1
w1=0.622*(pv1/(p-pv1))
h1=(1.005*td1+w1*(2500+1.86*td1))
ma1=m1/(1+w1)
pv2=phi2*ps2
w2=0.622*(pv2/(p-pv2))
h2=(1.005*td2+w2*(2500+1.86*td2))
ma2=m2/(1+w2)
w3=((ma1*w1)+(ma2*w2))/(ma1+ma2)
h3=((ma1*h1)+(ma2*h2))/(ma1+ma2)
td3=((ma1*td1)+(ma2*td2))/(ma1+ma2)
```

```
//RESULTS
printf('specific humidity is %2fkj/kg of da',w3)
printf('\ntemparature of air leaving chamber is
    %2fdegrees',td3)
```

**Scilab code Exa 7.13** example 13

```

clc
//initialisation of variables
clear
ps1=0.062739 //bar pressure
phi1=0.9 //relative humidity
td1=37 //temp in degrees
td3=10.7 //dew point temparature
ps4=0.02366 //bar pressure
phi4=0.55 //relative humidity
td4=20 //temp in degrees
w12=1.5 //work input in kw
v4=50 //
t4=310 //temp  in k
r= 1
w2= 1
w3= 1
hf3= 2
p=1.01325 //pressure in bar
//CALCULATIONS
pv1=phi1*ps1
w1=0.622*(pv1/(p-pv1))
h1=(1.005*td1+w1*(2500+1.86*td1))
pv4=phi4*ps4
w4=0.622*(pv4/(p-pv4))
h4=(1.005*td4+w4*(2500+1.86*td4))
h3=(1.005*td3+w4*(2500+1.86*td3))
pa4=p-pv4
```

```
ma=(pa4*v4*100)/(r*t4)
q12=(w12*60)/ma
h2=h1+q12
q23=((h3+(w2-w3)*hf3)-h2)
Q23=-1*q23*ma
q34=h4-h3
Q34=q34*ma
//RESULTS
printf('enthalpy rate 1 is %2fkj/kg of da',h1)
printf('\nenthalpy rate 4 is %2fkj/kg of da',h4)
printf('\nenthalpy rate 3 is %2fkj/kg of da',h3)
printf('\nmass of dry air is %2fkg/min',ma)
printf('\nenthalpy rate 2 is %2fkj/kg of da',h2)
printf('\ncapacity od cooling coil q23 is %2fkj/min',Q23)
printf('\ncapacity od cooling coil q34 is %2fkj/min',Q34)
```

**Scilab code Exa 7.14** example 14

```
clc
//initialisation of variables
td3=15 //dew point temparature
ps3=0.017039 //bar pressure
phi3=0.55 //relative humidity
p=1 //bar pressure
ps4=0.029821 //bar pressure
phi4=1 //relative humidity
td4=24 //temp in degrees
mw1=1000 //kg/min
hf1=109 //kj/kg
hf2=50.4 //kj/kg
w4=0.01912
w3=0.00588
//CALCULATIONS
```

```
pv3=phi3*ps3
w1=0.622*(pv3/(p-pv3))
h3=(1.005*td3+w3*(2500+1.86*td3))
pv4=phi4*ps4
w4=0.622*(pv4/(p-pv4))
h4=(1.005*td4+w4*(2500+1.86*td4))
ma=mw1*(hf1-hf2)/(h4-h3-(w4-w3)*hf2)
x=ma*(w4-w3) //mw1-mw2
mf=ma+x
pl=(x/mw1)*100
//RESULTS
printf('mass of dry air is %2f',ma)
printf('\nmass cooling water loss by evoporation is
    %2f',x)
printf('\nmass flow of moist air is %2f',mf)
printf('\npercentage loss by evoporation is %2f',pl)
```

**Scilab code Exa 7.15** example 15

```
clc
//initialisation of variables
td3=17 //dew point temparature
ps3=0.019362 //bar pressure
phi3=0.6 //relative humidity
p=0.98 //bar pressure
t3=290 //temp in k
ps4=0.042415 //bar pressure
phi4=1 //relative humidity
td4=30 //temp in degrees
mw2=80
v=110 //volume
ma=127.98
w4=0.02814
w3=0.007464
r=0.287
```

```
hf1=209.3
//CALCULATIONS
pv3=phi3*ps3
w3=0.622*(pv3/(p-pv3))
h3=(1.005*td3+w3*(2500+1.86*td3))
pa3=p-pv3
m=(pa3*v*100)/(r*t3)
h2=h3+(240/ma)
pv4=phi4*ps4
w4=0.622*(pv4/(p-pv4))
h4=(1.005*td4+w4*(2500+1.86*td4))
mw1=mw2+ma*(w4-w3)
hf2=((mw1*hf1)+(ma*h2)-(ma*h4))/mw2
//RESULTS
printf('mass of dry air is %2fkg/min',m)
printf('\nenthalpy rate 3 is %2fkj/kg of da',h3)
printf('\nenthalpy rate 2 is %2fkj/kg of da',h2)
printf('\nenthalpy rate 4 is %2fkj/kg of da',h4)
printf('\nenthalpy rate  is %2fkj/kg of da',hf2)
disp('temparature of water leaving the tower is 27.1
    degrees')
```

**Scilab code Exa 7.16** example 16

```

clc
//initialisation of variables
clear
uw=2.5
aw=127.82
to=34 //temp in degrees
tr=26 //temp in degrees
ur=1.5
ar=90
ag=8.68
```

```
clf1=100
pvwo=0.037782
p=1.013 //pressure in bar
a=6.66*10^-4
phi=0.5
//CALCULATIONS
shgw=uw*aw*(to-tr)
shgr=ur*ar*(to-tr)
sg=ag*clf1
pvo=pvwo-(p*a*(to-tr))
wo=0.622*(pvo/(p-pvo))
ho=(1.005*to+wo*(2500+1.86*to))
pvr=phi*pvo
wr1=0.622*(pvr/(p-pvr))
hr=(1.005*tr+wr1*(2500+1.86*tr))
//RESULTS
disp('recommended indoor conditions are25.5-26.7 degrees and 50% rh and outdoor conditions are  26 degrees and 50%rh')
disp('area of the roof is 90 m*m')
disp('overall heat transfer coefficients are2.5 w/m*m')
printf('\nsensible heat gain through walls is %2f',shgw)
printf('\nsensible heat gain through roofs is %2f',shgr)
printf('\nsensible heat gain through windows is %2f',sg)
disp('sensible heat per adult male is 67.5w and latent heat is 55.7w')
printf('\nenthalpy rate o is %2f',ho)
printf('\nenthalpy rate r is %2f',hr)
disp('volume of air infiltered is 1.628 m*m*m/min')
disp('latent heat gain is 902.4w')
disp('sensible heat gain is 257.2w')
disp('room sensible heat factor is 0.803')
```

# Chapter 8

# Thermal Engineering

**Scilab code Exa 8.1** example 1

```
clc
//initialisation of variables
cc=12000 //btu/h
pi=1565 ///watts
ra=7 //btu/h/w
//CALCULATIONS
eer=cc/pi
p(1)=cc/ra
//RESULTS
printf('eer is %2f',eer)
printf('\npower consumption of first unit is
   %2fwatts',p(1))
```

**Scilab code Exa 8.2** example 2

```
clc
//initialisation of variables
t1=278 //temparature in k
```

```
t2=300 //temparature in k
hf2=21 //kj/kg
hfg2=2489.7 //kj/kg
h3=113.1 //under 300 k in kj/kg
x2=0.8
p=3.154 //power
//CALCULATIONS
cop=t1/(t2-t1)
h2=hf2+(x2*hfg2)
re=h2-h3
pr=p/cop
//RESULTS
printf('cop is %2f',cop)
printf('\npower required is%2fkw/ton of
    refrigeration',pr)
printf('\nrefrigeration effect is %2fkj/kg',re)
```

**Scilab code Exa 8.3** example 3

```
clc
//initialisation of variables
t1=253 //temp in k
t3=313 //temp in k
cp=1.005 //kj/kg
r=4 //bar
g=1.4
//CALCULATIONS
t2=(t1*(r)^((g-1)/g))
t4=(t3/(r)^((g-1)/g))
re=cp*(t1-t4)
wi=cp*((t2-t3)-(t1-t4))
cop=re/wi
ma=(3.5164*10)/re
p=ma*wi
//RESULTS
```

```
printf('cop is %2f',cop)
printf('\nmass of refrigeration is %2fkg/s',ma)
printf('\npower required to drive the unit is %2fkw'
    ,p)
```

**Scilab code Exa 8.4** example 4

```

clc
//initialisation of variables
t1=261 //temp in k
t3=310 //temp in k
cp=1.005 //kj/kg
r=5
//CALCULATIONS
t2=(t1*(r)^((g-1)/g))
t4=(t3/(r)^((g-1)/g))
re=cp*(t1-t4)
ma=(3.5164*3600)/re
woc=cp*(t2-t1)
woe=cp*(t3-t4)
nw=woc-woe
cop1=re/nw
cop2=t1/(t3-t1)
reff=cop1/cop2
//RESULTS
printf('temparature at states 2 and 4 are %2fk and
    %2fk',t2,t4)
printf('\nmass of air per hour is %2fkg/h',ma)
printf('\nnet work required is %2fkj/kg',nw)
printf('\ncoefficient of perfoemance is %2f',cop1)
printf('\nrelative efficiency is %2f',reff)
```

**Scilab code Exa 8.5** example 5

```
clc
//initialisation of variables
h1=176.48 //under -25 degrees temp in kj/kg
s1=0.7127 //under -25 degrees temp in kj/kgk
h2=215.17 //under 58 degrees temp in kj/kg
h3=79.71 //under 45 degrees temp in kj/kg
h4=79.71 //under 45 degrees temp in kj/kg
no=20 // number of tons
//CALCULATIONS
w=h2-h1
re=h1-h4
cop=re/w
ha=no*3.5164
cr=ha/re
pr=cr*w
//RESULTS
printf('the refrigeration effect is %2fkj/kg',re)
printf('\ncoefficient of performance is %2f',cop)
printf('\npower required is %2fkw',pr)
printf('\ncirculating rate of refrigerant is %2fkg/s
    ',cr)
```

**Scilab code Exa 8.6** example 6

```
clc
//initialisation of variables
h1=176.48 //under -25 degrees temp in kj/kg
h2=215.17 //kj/kg
h4=74.59 //kj/kg
//CALCULATIONS
re=h1-h4
w=h2-h1
cop=re/w
```

```
//RESULTS
printf('the refrigeration effect is %2fkj/kg',re)
printf('\ncoefficient of performance is %2f',cop)
```

**Scilab code Exa 8.7** example 7

```
clc
//initialisation of variables
h1=179.43 //under -25 degrees temp in kj/kg
h2=219.03 //kj/kg
h4=74.59 //kj/kg
//CALCULATIONS
re=h1-h4
w=h2-h1
cop=re/w
//RESULTS
printf('the refrigeration effect is %2fkj/kg',re)
printf('\ncoefficient of performance is %2f',cop)
```

**Scilab code Exa 8.8** example 8

```
clc
//initialisation of variables
h2=1472.6 //kj/kg
s2=4.898 //kj/kgk
sf1=0.510 //kj/kgk
sfg1=5.504 //kj/kgk
hf1=126.2 //kj/kg
hfg1=1304.3 //kj/kg
h4=362.1 //under 38 degrees in kj/kg
h2=1472.6 //kj/kg
h3=362.1 //under 38 degrees in kj/kg
t1=261 //temp in k
```

```
t2=311 //temp in k
//CALCULATIONS
x1=(s2-sf1)/sfg1
h1=hf1+(x1*hfg1)
re=h1-h4
w=h2-h1
cop=re/w
hr=h2-h3
ca=(2*re*50)/(3600*3.5164)
pom=100*w/3600
ccop=t1/(t2-t1)
rff=cop/ccop
//RESULTS
printf('coefficient of performance is %2f',cop)
printf('\nheat rejected in the condenser is%2fkj/kg'
    ,hr)
printf('\nrefrigerating effect is%2fkj/kg',re)
printf('\ncapacity of motor is%2frons of
    refrigeration',ca)
printf('\npower of motor is %2fkw',pom)
printf('\nrefrigerating befficiency is %2f',rff)
```

**Scilab code Exa 8.9** example 9

```

clc
//initialisation of variables
hf1=-7.53 //kj/kg
hfg1=245.8 //kj/kg
x1=0.6
sf1=-0.04187 //kj/kgk
t1=268 //temp in degrees
sf2=0.2513 //kj/kgk
hf2=81.25 //kj/kg
hfg2=121.5 //kj/kg
```

```
t2=298 //temp in k
h4=81.25 //under 20 degrees in kj/kg
h3=81.25 //under 20 degrees in kj/kg
sh=4.2 //kj/kgk
lt=335 //kj/kg
reff=0.5
sfg1= 1 //kj/kg
s2= 1 //kj/kg
//CALCULATIONS
h1=hf1+(x1*hfg1)
s1=sf1+(x1*sfg1)
x2=((s2-sf2)/hfg2)*t2
h2=hf2+(x2*hfg2)
re=h1-h4
are=re*reff
he=sh*10+lt
ma=(are*6*60)/he
//RESULTS
printf('refrigerating effect is%2fkj/kg',re)
printf('\nactual refrigerating effect is%2fkj/kg',
   are)
printf('\nheat to be extracted to produce 1kg of ice
    is %2fkj/kg of ice',he)
printf('\nmass of ice formed is %2fkg/day',ma)
```

**Scilab code Exa 8.10** example 10

```

clc
//initialisation of variables
ph=13.89 //pressure in bar under 36 degrees temp
p1=1.447 //pressure in bar under -26 degrees temp
h1=1411.4 //kj/kg
s1=5.718 //kj/kgk
h2=1561.7 //kj/kg
```

```
h3= 150 //kj/kg
h4=185.8 //kj/kg
h5=1445.5 //kj/kg
s5=5.327 //kj/kgk
s5=5.327 //kj/kgk
h6=1607.6 //kj/kg
r=25
//CALCULATIONS
pi=(p1*ph)^0.5
m1=(3.5164*r)/(h1-h4)
mh=m1*(h2-h3)/(h5-h1)
poc=m1*(h2-h1)
pohc=mh*(h6-h5)
pr=poc+pohc
re=h1-h4
wi=(h2-h1)+(h6-h5)
cop=re/wi
//RESULTS
printf('power of lp compressor is %2fkw',poc)
printf('\npower of hp compressor is %2fkw',pohc)
printf('\ntotal power required is %2fkw',pr)
printf('\nrefrigerating effect is%2fkj/kg',re)
printf('\ncoefficient of performance is %2f',cop)
```

**Scilab code Exa 8.11** example 11

```
clc
//initialisation of variables
h1=1411.4 //kj/kg
s1=5.718 //kj/kgk
s2=5.718 //kj/kgk
h2=1755.7 //kj/kg
h4=352.3 //under 13.89 bar in kj/kg
h3=352.3 //under 13.89 bar in kj/kg
//CALCULATIONS
```

```
m=(3.5164*25)/(h1-h4)
poc=m*(h2-h1)
cop=(h1-h4)/(h2-h1)
//RESULTS
printf('mass flow rate of refrigerant is %2fkg/s',m)
printf('\ncoefficient of performance is %2f',cop)
printf('\npower of compressor is %2fkw',poc)
```

**Scilab code Exa 8.12** example 12

```
clc
//initialisation of variables
h1=178.73 //under -20 degrees in kj/kg
h5=185.66 //under 5 degrees in kj/kg
h3=79.71 //under 10.84 degrees in kj/kg
h6=79.71 //under 10.84 degrees in kj/kg
h4=79.71 //under 10.84 degrees in kj/kg
h2=219.33 //kj/kg
//CALCULATIONS
m1=(7*211)/(h1-h4)
mh=(5*211)/(h5-h4)
h8=((m1*h1)+(mh*h5))/(m1+mh)
poc=(m1+mh)*(h2-h8)
cop=(12*211)/poc
//RESULTS
printf('power of compressor is %2fkj/min',poc)
printf('\nrefrigerant flow rate is %2fkg/min',mh)
printf('\ncoefficient of performance is %2f',cop)
```

**Scilab code Exa 8.13** example 13

```
clc
//initialisation of variables
```

```
h1=185.38 //under -5 degrees temp in kj/kg
s1=0.6991 //nder -5 degrees temp in kj/kgk
ps2=7.449 //under 30 degrees in bar
s2=0.6991 //under 30 degrees in bar
h2=203.9 //kj/kg
h3=64.59 //kj/kg
h4=64.59 //kj/kg
//CALCULATIONS
he=h2-h3
wi=h2-h1
cop1=he/wi
mf=84400/he
pr=(mf/3600)*(wi)
coe=pr*1
//RESULTS
printf('coefficient of performance is %2f',cop1)
printf('\nmass flow rate of refrigerant is %2fkg/h',
    mf)
printf('\npower required is %2fkw',pr)
printf('\ncost of electricity is %2frs',coe)
```

**Scilab code Exa 8.14** example 14

```
clc
//initialisation of variables
t1=1100 //K
t2=275 //K
g=1.4
pa=101.32
qs=250 //kj/kg
r=0.287 //kj/kgK
//CALCULATIONS
p1=(t1/t2)^(3.5)*pa //(g/g-1)=3.5
pb=2.2075*p1
va=(r*t2)/pa
```

```
vb=(r*t1)/pb
mep=(0.75*qs)/(va-vb)
printf('mean effective pressure is %2f units',mep)
```

**Scilab code Exa 8.15** example 15

```
clc
//initialisation of variables
ps2=0.008129 //under 4 degree temp in bar
ps3=0.047534 //under32 degree temp in bar
v=0.75 //volume in m*m*m
vf=0.001
h1=50.4 //under 12 degree temp in kj/kg
h2=16.8 //kj/kg
hf3=16.8 //kj/kg
hfg3=2492.1 //kj/kg
x3=0.98
vg3=157.27 //under 4 degree temparature
//CALCULATIONS
pr=ps3/ps2
mfr=v/vf
re=mfr*(h1-h2)
h3=hf3+(x3*hfg3)
mf3=re/(h3-h1)
vv=mf3*x3*vg3
//RESULTS
disp('pressures in flash chamber are ps2=0.008129
   and ps3=0.047534')
printf('\npressure ratio is %2f',pr)
printf('\nthe refrigeration effect is %2fkj/kg',re)
printf('\namount of makeup water is %2fkg/min',mf3)
printf('\nvolume of water entering the ejector is
   %2fm*m*m/min',vv)
```

**Scilab code Exa 8.16** example 16

```
clc
//initialisation of variables
h1=272.763 //under 300 k temp in kj/kg
s1=6.4125 //under 300 k temp in kj/kg
h2=230.347 //under 200 k temp in kj/kg1
s2=4.9216 //under 300 k temp in kj/kg
hf=-133.347 //kj/kg
t1=300 //temp in k
//CALCULATIONS
y=(h1-h2)/(h1-hf)
mw=(t1*(s2-s1))-(h2-h1)
x=mw/0.1044
//RESULTS
printf('fraction of oxygen condensed is %2f',y)
printf('\nwork required is %2f',x) //answer is wrong
    in tb
```

**Scilab code Exa 8.19** example 19

```
clc
//initialisation of variables
t1=300 //temp in k
sf=2.9409 //kj/kgk
s1=6.44125 //kj/kgk
hf=-133.347 //kj/kg
h1=272.763 //kj/kg
w=-4690.5
//CALCULATIONS
mw=(t1*(sf-s1)-(hf-h1))
fom=mw/w
```

```
//RESULTS
printf('minimum work is %2fkj/kg of o2 liquefied',mw
    )
printf('\nfigure of merit is %2f',fom)
//no 8.17 and 8.19 in tb print mistake
```

# Chapter 9

# Thermal Engineering

**Scilab code Exa 9.1** example 1

```
clc
//initialisation of variables
t1=305 //temp in k
r=0.287 //kj/kg
p2=6 //pressure in bar
p1=1.013 //pressure in bar
g=1.4 //const value
n=1.28
v1=100 //volume
//CALCULATIONS
rp=(p2/p1)
wiso=r*t1*log(p2/p1)
wadia=(g/(g-1))*r*t1*0.6623
wpoly=(n/(n-1))*r*t1*0.4756
m=(p1*v1*100)/(r*t1)
ipr=(wiso*m)/60
apr=(wadia*m)/60
//RESULTS
printf('work for isthermal compression is %2fknm/kg',wiso)
printf('\nwork for adiabatic compression is %2fknm/
```

```
    kg',wadia)
printf('\nwork for polytropic compression is %2fknm/
    kg',wpoly)
printf('\nmass of air compressed is %2fkg/min',m)
printf('\nisothermal power required is %2fkw',ipr)
printf('\nadiabatic power required is %2fkw',apr)
```

**Scilab code Exa 9.2** example 2

```
clc
//initialisation of variables
p2=135 //bar pressure
p1=1 //bar pressure
x=5 //x=p2/p1
//CALCULATIONS
s=log(p2)/log(x)
rp=(p2/p1)^0.25
//RESULTS
printf('s is %2f',s)
printf('\nrp is %2f',rp)
disp('number of stages are 4')
disp('1st intermediate pressure is 3.4087 bar')
disp('2nd intermediate pressure is 11.619 bar')
disp('3rd intermediate pressure is 39.605 bar')
```

**Scilab code Exa 9.3** example 3

```
clc
//initialisation of variables
p2=3.24 //pressure in bar
p1=1 //pressure in bar
v1=16 //volume in m*m*m
n=1.35
```

```
rp=3.24 //pressure
r=10.5
t1=294 //temparature in k
t2=294 //temparature in k
cp=1.005 //kj/kg
rx=0.287
//CALCULATIONS
w1=(2*n/(n-1))*p1*v1*100*0.35630 //(3.24)^0.2592-1
w2=(n/(n-1))*p1*v1*100*0.8396 //(10.5)^0.2592-1
pr1=w1/60
pr2=w2/60
tb=t1*(r)^(n-1/n)
t3=t2*(rp)^((n-1)/n)
m=(p1*v1*100)/(rx*t1)
hr=m*cp*(t3-t2)
ma=hr/(4.18*25)
//RESULTS
printf('minimum power required are %2fkw and %2fkw',
    pr1,pr2)
printf('\nmass of air compressed is %2fkg/min',m)
printf('\nheat rejected by air compressor is %2fkj/
    min',hr)
printf('\nmass of water is %2fkg/min',ma)
```

**Scilab code Exa 9.4** example 4

```
clc
//initialisation of variables
p2=4.08 //pressure in bar
p1=1 //pressure in bar
n=1.22
r=0.287
p=1.01325 //pressure in bar
v=145 //volume
t=288 //temparature in k
```

```
p3=17.5 //pressure in bar
t1=307 //temp in k
t2=313 //temp in k
//CALCULATIONS
wlp=5.54*r*t1*(((p2/p1)^((n-1)/n))-1)
whp=5.54*r*t2*(((p2/p1)^((n-1)/n))-1)
w=wlp+whp
m=(p*v)/(r*t)
pr=(w*m)/60
p2=(p1*p3)^0.5
x=(p2)^0.5 //x=d1/d2
//RESULTS
printf('total work required is %2fknm/kg',w)
printf('\nmass of free air is %2fkg/min',m)
printf('\npower required to drive the compressor is
    %2fkw',pr)
printf('\nratio of cylinder diameters is %2f',x)
```

**Scilab code Exa 9.5** example 5

```
clc
//initialisation of variables
c1=0.05 //percentage
c2=0.10 //percentage
c3=0.20 //percentage
rp=10
//CALCULATIONS
eff1=(1+c1-c1*(rp)^(0.78125))
eff2=(1+c2-c2*(rp)^(0.78125))
eff3=(1+c3-c3*(rp)^(0.78125))
//RESULTS
printf('volumetric effiency 1 is %2f',eff1)
printf('\nvolumetric effiency 2 is %2f',eff2)
printf('\nvolumetric effiency 3 is %2f',eff3)
```

**Scilab code Exa 9.6** example 6

```
clc
//initialisation of variables
d=0.2 //diameter in m
lc=0.01 //linear clearance
l=0.3 //lenght
rp=7
n=1.25
pi=(22/7)
//CALCULATIONS
cv=((pi/4)*((d)^2)*lc)
sv=((pi/4)*(d)^2*l)
cr=cv/sv
veff=(1+cr-cr*(rp)^(1/n))
x=veff*sv
//RESULTS
printf('clearance ratio is %2f',cr)
printf('\nvolumetric efficiency is %2f',veff)
printf('\nvolume of air taken in is %2fm*m*/stroke',
   x)
```

---

**Scilab code Exa 9.7** example 7

```
clc
//initialisation of variables
n=1.2
r=0.287
t1=310 //temparature in degrees
p2=7 //pressure in bar
p1=1 //pressure in bar
//CALCULATIONS
```

```
rp=(p2/p1)
wr=((n/(n-1))*r*t1*((rp)^((n-1)/n)-1))
//RESULTS
disp('volumetric efficiency is 0.797')
disp('volumetric efficiency referred to atmospheric
   conditions is 0.73')
printf('work required is %2fknm/kg',wr)
```

**Scilab code Exa 9.8** example 8

```
clc
//initialisation of variables
veff=0.8 //efficiency
rp=7
n=1.2 //constant value
pi=(22/7)
//CALCULATIONS
c=(veff-1)/(1-(rp)^(1/n))
vs=2/c
d=((4*vs)/pi)^(1/3)
//RESULTS
printf('stroke volume is %2fm*m*m',vs)
printf('\nlenght of stroke is %2fm',d)
```

**Scilab code Exa 9.9** example 9

```
clc
//initialisation of variables
sp=1400 //speed in revolutions per min
ma=15 //mass in kgs
r=0.287
p1=1 //pressure in bar
t1=303 //temparature in k
```

```
p2=7 //pressure in bar
c=0.05 //clearance volume/stoke volume
pi=(22/7)
n=1.2
m1=15
meff=0.85 //mechanical efficinecy
//CALCULATIONS
rp=(p2/p1)
m=ma/sp
va=(m1*r*t1)/(p1*100)
eff1=(1+c-c*(rp)^(1/n))
vs=va/eff1
d1=((4*vs)/pi)^(1/3)
pr=((n/(n-1))*m1*r*t1*((rp)^((n-1)/n)-1))/60
prs=pr/meff
d2=((prs*4)/(7*100*pi*700))^0.333
//RESULTS
printf('volumetric efficiency is %2f',eff1)
printf('\nlengh of the stroke is %2fm',d1)
printf('\nindicated power is %2fkw',pr)
printf('\npower required at the shaft of the
    compressor is %2fkw',prs)
printf('\ndiameter of the piston is %2fm',d2)
```

**Scilab code Exa 9.10** example 10

```
clc
//initialisation of variables
sp=200 //mean speed m/s
//CALCULATIONS
d=(21/(0.7773*1.18*200))^0.5
l=1.5*d
s=200/(3*d)
//RESULTS
disp('volumetric efficiency is 0.7773')
```

```
printf('\ndiameter is %2fm',d)
printf('\nstroke is %2fm',l)
printf('\nspeed of compressor is %2frev/min',s)
```

**Scilab code Exa 9.11** example 11

```

clc
//initialisation of variables
r=0.287
p=1.01325 //pressure in bar
v=5 //volume in m*m*m
t=288 //temparature in k
t1=303 //temparature in k
t2=403 //temparature in k
p2=4.08 //pressure in bar
p1=0.98 //pressure in bar
p3=17 //pressure in bar
n=1.25
c=0.06 //clearance volume by swept volume
//CALCULATIONS
m=(p*v)/(r*t)
rp=p2/p1
t2s=(t1*(p2/p1)^((n-1)/n))
wr=(n/n-1)*r*(t2-t1)
wc=2*wr
veff=(1+c-c*(rp)^(1/n))
x=(p*100*v*t1)/(p1*100*t) //x=(v1-v4)
vs=x/veff
vsc=vs/125
d1=((4*vsc)/%pi)^(1/3)
//RESULTS
printf('volumetric efficiency is %2f',veff)
printf('\nstoke volume is %2fm*m*m/min',vs)
printf('\nstroke volume per cycle is %2fm*m*m',vsc)
```

```
printf('\nstoke of piston is %2f',d1)
```

**Scilab code Exa 9.12** example12

```
clc
//initialisation of variables
t1=303 //temparature in k
p2=4.08 //pressure in bar
p1=1 //pressure in bar
t5=303 //temparature in k
x=0.3247 //x=v2/v1 where the relation is v2=v1*(1/rp
    )^1/n
y=0.0385 //y=v3/v1
vo=0.2862 //vo=volume of air delivered/v1
vf=0.8299 //vf=vome of free air /v1
n=1.25
p3=17.5 //pressure in bar
r=0.287
tatm=2911 //temp in k
patm=1.02 //pressure in bar
w=291
//CALCULATIONS
t2=(t1*(p2/p1)^((n-1)/n))
veff=vf/(1-y)
a=(r*(t2-t1)*5)
t3=(t1*(p3/p2)^((n-1)/n))
hp=(5*r*(t3-t1))
iso=(r*tatm*log(p3/patm))/10 //its ln
ieff=iso/w
//RESULTS
printf('volumetric efficiency is %2f',veff)
printf('\nwork required for lp cyclinder is %2f',a)
printf('\nwork required for hp cyclinder is %2f',hp)
printf('\nwork required for isothermal is %2f',iso)
printf('\nisothermal efficiency is %2f',ieff)
```

**Scilab code Exa 9.13** exmaple 13

```
clc
//initialisation of variables
p2=1.5 //pressure in bar
p1=1 //pressure in bar
v=0.05 //volume in m*m*m
g=1.4
r=1.4
n=120 //number of cycles
//CALCULATIONS
wa=v*(p2-p1)*100
wi=3.5*100*p1*v*(((p2/p1)^((r-1)/r))-1)
reff=wi/wa
vo=v/4
pr=wa*n/60
//RESULTS
printf('roots efficiency is %2f',reff)
printf('\nvolume of air is %2fm*m*m/cycle',vo)
printf('\npower required is %2fkw',pr)
```

**Scilab code Exa 9.14** example 14

```
clc
//initialisation of variables
p2=1.5 //pressure in bar
p1=1 //pressure in bar
v=0.05 //volume in m*m*m
x=0.35 //increse in pressure
g=1.4
r=1.4
```

```
n=120 //number of cycles
//CALCULATIONS
wa=v*(p2-p1)*100
wi1=3.5*100*p1*v*(((p2/p1)^((r-1)/r))-1)
ceff=wi1/wa
vo=v/4
pr=wa*n/60
prs=x*(p2-p1)
p3=p1+prs
wi2=3.5*100*p1*v*(((p3/p1)^((r-1)/r))-1)
vi=v*(p1/p3)^(1/g)
w2=vi*(p2-p3)*100
tw=w2+wi2
comeff=wi1/tw
po=tw*2
//RESULTS
printf('compressor efficiency is %2f',ceff)
printf('\nwork required for internal compression is
    %2fknm/rev',wi2)
printf('\npower required is %2fkw',pr)
printf('\ncompressor efficiency 2 is %2f',comeff)
printf('\npower required 2 is %2fkw',po)
```

**Scilab code Exa 9.15** example 15

```
clc
//initialisation of variables
t1=295 //temp in k
p1=1.02 //pressure in bar
p2=7.14 //pressure in bar
cp=1.005 //kj/kg
g=1.4
wr=250 //kj/kg
//CALCULATIONS
t2s=t1*(p2/p1)^((g-1)/g)
```

```
wi=cp*(t2s-t1)
ieff=wi/wr
t2=(wr/cp)+t1
//RESULTS
printf('isentropic work is %2fkj/kg',wi)
printf('\nisentropic efficiency is %2f',ieff)
printf('\ntemparature 2 is %2fk',t2)
disp('index of compression is 1.46')
```

**Scilab code Exa 9.16** example16

```

clc
//initialisation of variables
t1=310 //temp in k
p1=1 //pressure in bar
p2=4 //pressure in bar
cp=1.005 //kj/kg
v1=28 //m*m*m volume
r=0.287
ce=0.7 //copression efficiency
g= 32.2 //ft/sec^2
//CALCULATIONS
t2s=t1*(p2/p1)^((g-1)/g)
wi=cp*(t2s-t1)
m=(p1*v1*100)/(r*t1)
apr=(m*wi)/60
iei=wi/ce
//RESULTS
printf('isentropic work is %2f',apr)
printf('\nadiabatic power required is %2f',m)
printf('\nindicated enthalpy increase is %2f',iei)
```

**Scilab code Exa 9.17** example 17

```

clc
//initialisation of variables
p2=6 //prressure in bar
p1=1 //pressure in bar
t1=313 //temp in k
a1=45 //angle in degrees
a2=10 //angle in degrees
a3=55 //angle in degrees
r=1.4
cp=1.005 //kj/kg
ieff=0.85 //isentropic efficiency
c=200 //m/s
//CALCULATIONS
t2s=(t1*(p2/p1)^((r-1)/r))
t2=(((t2s-t1)/ieff)+t1)
w=cp*(t2-t1)
cro=(c*(sin(45*(%pi/180))/sin(55*(%pi/180))))
cv=c-cro
n=w/cv
//RESULTS
printf('actual work is %2fkj/kg',w)
printf('\nchange in whirl velocities is %2fkj/kg/
    stage',cv)
printf('\nnumber of stages is %2fstages',n)
```