Scilab Textbook Companion for Thermodynamics for Engineers by J. S. Doolittle[1]

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Book Description

Title: Thermodynamics for Engineers

Author: J. S. Doolittle

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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 5

Actual Gases

Scilab code Exa 5.1 `Volume calculations`

```
clc
clear
//Initialization of variables
m=20 //lbm
P=1000 //psia
T=580 //R
R=35.12
//calculations
disp("From table 5-2,")
z=0.667
V=z*m*R*T/(P*144)
vt=0.0935
vtt=vt*m
//results
printf("Volume occupied = %.3f cu ft",V)
printf("\n Tablulated value for volume = %.2f cu ft"
    ,vtt)
```

Scilab code Exa 5.2 `Pressure calculations`

```
clc
clear
//Initialization of variables
m=90 //lbm
T=200+459.7 //R
Tc=232.7+459.7 //R
R0=1545
M=120.9
V=30 //cu ft
//calculations
R=R0/M
disp("From fig 5.5")
z=0.883
P=z*R*m*T/V/144
vc=V/m
P2=156.1 //psia
//results
printf("Pressure obtained = %.2f psia",P)
printf("\n Theoretical pressure = %.1f psia",P2)
```

Scilab code Exa 5.3 Heat calculations

```
clc
clear
//Initialization of variables
T1=140+460 //R
T2=240 +460 //R
N=1
//calculations
Q=N*(9.47*(T2-T1)-3.47*10^3 *log(T2/T1) -1.16*10^6
    *(1/T2-1/T1))
Tm=(T1+T2)/2
Cp=9.47-3.47*10^3 /Tm +1.16*10^6 /Tm^2
Q2=N*Cp*(T2-T1)
//results
```

```
printf("Heat added in case 1 = %d Btu",Q)
printf("\n Heat added in case 2 = %.1f Btu",Q2)
```

Scilab code Exa 5.4 Heat calculations

```
clc
clear
//Initialization of variables
Rj=1.985
N=1
T1=540+460 //R
T2=3540+460 //R
//calculations
Q=N*(14.215*(T2-T1)-6.53*10^3 *log(T2/T1) -1.41*10^6
    *(1/T2-1/T1))
Tm=(T1+T2)/2
Cv=14.215-6.53*10^3 /Tm +1.41*10^6 /Tm^2
Q2=N*Cv*(T2-T1)
//results
printf("Heat added in case 1 = %.1f Btu",Q)
printf("\n Heat added in case 2 = %.1f Btu",Q2)
```

Chapter 7

Entropy

Scilab code Exa 7.1 `Change in Entropy`

```
clc
clear
//Initialization of variables
T2=920 //R
T1=520 //R
P1=14 //psia
P2=84 //psia
J=778
R=53.35
cv=0.1715
N=1
//calculations
k= log(T2/T1) /log(P2/P1)
n=1/(1-k)
cx=cv+R/(J*(1-n))
dS=N*cx*log(T2/T1)
//results
printf("Change in entropy  = %.5f unit of entropy",
   dS)
```

Chapter 8

Availability of Energy

Scilab code Exa 8.1 Energy loss calculations

```
clc
clear
//Initialization of variables
q=1000 //Btu
th=1140 //F
tl=40 //F
ts=940 //F
//calculations
Q1=q*(th-tl)/(th+460)
Q2=q*(ts-tl)/(ts+460)
dif=Q1-Q2
//results
printf("Available energy loss = %d Btu",dif)
```

Scilab code Exa 8.2 Energy loss calculations

```
clc
clear
```

```
//Initialization of variables
ma=200000 //lb
cpa=0.26
T2g=1200 //F
T1g=300 //F
T1w=200 //F
mw=250000 //lb
cpw=1.02
Tl=560  //R
cx=1.01
//calculations
T2w=T1w+ ma*cpa*(T2g-T1g)/(mw*cpw)
Qun=Tl*ma*cpa*log((T2g+460)/(T1g+460))
Qtr=ma*cpa*(T2g-T1g)
Qav=Qtr-Qun
Qun2=Tl*mw*cx*log((T2w+460)/(T1w+460))
Qav2=Qtr-Qun2
ht1=Qav-Qav2
//results
printf("For gas, Untransferred energy = %d Btu/hr",Qun)
printf("\n For gas, transferred energy = %d Btu/hr",Qtr)
printf("\n For gas, available energy = %d Btu/hr",Qav)
printf("\n For water, Untransferred energy = %d Btu/hr",Qun2)
printf("\n For water, available energy = %d Btu/hr",Qav2)
printf("\n Loss of available energy = %d Btu/hr",ht1)
disp('The answers are a bit different due to rounding off error in textbook')
```

Chapter 10

Vapors

Scilab code Exa 10.1 `Enthalpy calculations`

```
clc
clear
//Initialization of variables
p=3000 //psia
T=250 //F
//calculations
disp("From table 1, keenan and keynes,")
vf=0.01700
disp("From table 4,")
dvf=-18.3*10^-5
v=vf+dvf
disp("From table 1,")
hf=218.48
disp("From table 4,")
dhf=6.13
h=hf+dhf
sf=0.3675
dsf=-4.34*10^-3
s=sf+dsf
//results
printf("Specific volume = %.5f cu ft/lb",v)
```

```
printf("\n Enthalpy = %.2f Btu/lb",h)
printf("\n Entropy  = %.4f Btu/lb per deg R",s)
```

Scilab code Exa 10.2 Moisture content calculation

```
clc
clear
//Initialization of variables
h=1100 //Btu/lb
P=100 //psia
//calculations
disp("From table 2 of keenan and keynes,")
hg=1187.2 //Btu/lb
hfg=888.8 //Btu/lb
y=-(h-hg)/hfg
//results
printf("The state is %d psia with a moisture content
    of %.2f percent",P,y*100)
```

Scilab code Exa 10.3 State calculations

```
clc
clear
//Initialization of variables
disp("From table 1 of keenan and keynes,")
v1=0.2688
//calculations
v2=3.060
p2=200 //psia
t2=600 //F
//results
printf("State of steam is %d psia and %d F",p2,t2)
```

Scilab code Exa 10.4 State calculations

```
clc
clear
//Initialization of variables
disp("From table 2 of keenan and keynes,")
t1=439.60 //F
u1=1118.4 //Btu/lb
//calculations
p2=380 //psia
//results
printf("The state of steam is saturated at %d psia
    and %.2f F",p2,t1)
```

Scilab code Exa 10.5 State calculations

```
clc
clear
//Initialization of variables
disp("From table 2 of keenan and keynes,")
p1=1 //in of Hg
s=1.9812
//calculations
sf=2.0387
sfg=1.9473
y=-(s-sf)/sfg
//results
printf("The state is %d in of Hg with a moisture
    content of %.2f percent",p1,y*100)
```

Scilab code Exa 10.6 State Enthalpy calculations

```
clc
clear
//Initialization of variables
disp("From table 1 of keenan and keynes,")
h1=1204.8 //Btu/lb
q=174 //Btu/lb
//calculations
h2=h1+q
p2=30 //psia
t2=720 //F
//results
printf("Final state of steam is %d psia and %d F",p2
    ,t2)
printf("\n Final enthalpy is %.1f Btu/lb",h2)
```

Scilab code Exa 10.7 volume state calculations

```
clc
clear
//Initialization of variables
disp("From table 1 of keenan and keynes,")
p=70 //psia
x=0.1
p2=198 //psia
//calculations
v1=6.206
v2=0.017
vx=v1-x*(v1-v2)
t2=1400 //F
//results
printf("Final specific volume = %.3f cu ft",vx)
printf("\n Final state is %d psia and %d F",p2,t2)
```

Scilab code Exa 10.8 State calculations

```
clc
clear
//Initialization of variables
disp("From table 1 of keenan and keynes,")
p=400 //psia
t1=700 //F
p2=85 //psia
//calculations
s2=1.6398 //units/lb
t2=350 //F
//results
printf("Final state of steam is %d psia and %d F",p2
   ,t2)
```

Scilab code Exa 10.9 Work and heat calculations

```
clc
clear
//Initialization of variables
p1=20 //psia
p2=140 //psia
J=778
t2=150 //F
t1=30 //F
//calculations
disp("From Table A-3,")
v1=2.0884 //cu ft/lb
v2=0.33350 //cu ft/lb
h2=95.709
h1=81.842
```

```
n=log(p2/p1)/log(v1/v2)
W=(p2*v2-p1*v1)*144/(1-n)
du=h2-h1 + (p1*v1-p2*v2)*144/J
Q=du+W/J
s2=0.17718
s1=0.18126
Q2=((t2+t1)/2 +460) *(s2-s1)
//results
printf("Work of compression = %d ft-lb",W)
printf("\n Heat removed per pound of refrigerant = %.3f Btu/lb",Q)
printf("\n Heat removed in case 2 = %.4f Btu",Q2)
```

Scilab code Exa 10.10 Enthalpy calculations

```
clc
clear
//Initialization of variables
disp("From table 1 of keenan and keynes,")
in=440000 //lb/hr
out=255000 //lb/hr
p1=400 //psia
t1=700 //F
p2=35 //psia
t2=290 //F
vel=500 //ft/s
hp=44000 //hp
ent=1362.7 //Btu/lb
//calculations
ein=ent*in
eout=hp*2544 + out*1183 + 925000
h2= (ein-eout)/185000
//results
printf("Specific enthalpy of exhaust steam = %d Btu/lb",h2)
```

Scilab code Exa 10.11 Loss calculations

```
clc
clear
//Initialization of variables
disp("From table 1 of keenan and keynes,")
h1=1351.1 //Btu/lb
p1=600 //psia
t1=700 //F
p2=234 //psia
h2=1.6865
h1=1.5875
t3=101.74
//calculations
t2=660 //F
loss= (h2-h1)*(t3+459.69)
//results
printf("Final state of steam is %d psia and %d F",p2
    ,t2)
printf("\n Loss of available energy = %.1f Btu/lb",
    loss)
```

Scilab code Exa 10.12 State calculations

```
clc
clear
//Initialization of variables
disp("From table 2 of keenan and keynes,")
p1=98.87 //psia
p2=31.78 //psia
t1=80 //F
```

```
h2=26.365 //btu/lb
h1=11.554 //btu/lb
hfg=67.203 //btu/lb
//calculations
x=(h2-h1)/hfg
//results
printf("The state of vapor leaving is %.2f psia
   with a quality of %.2f percent",p2,x*100)
```

Scilab code Exa 10.13 `Mean state calculations`

```
clc
clear
//Initialization of variables
ps=216 //psig
pb=29.12 //in of Hg
p2=0.4 //in
t2=244 //F
//calculations
pa=0.491*pb
pabs=pa + p2*0.491
plb=pa+ ps
hcal=1166.5 //Btu/lb
h2=1200.1 //Btu/lb
h3=831.9 //Btu/lb
y=-(hcal-h2)/h3
//results
printf("Mean state in the line is %.1f psia with a
   moisture content of %.2f percent",plb,y*100)
```

Chapter 11

Thermodynamics of Fluid flow

Scilab code Exa 11.1 Reynolds Number

```
clc
clear
//Initialization of variables
d=2.067 //in
P=20 //psia
R=53.35
T=600 //R
mu=0.0486 //lb /ft.hr
v=50 //ft/s
//calculations
rho=P*144/(R*T)
Re=d*v*rho*3600/(12*mu)
//results
printf("Reynolds number = %d ",Re)
disp('The answers are a bit different due to
   rounding off error in textbook')
```

Scilab code Exa 11.2 Pressure calculations

```
clc
clear
//Initialization of variables
eps=0.00015
D=2.067/12 //ft
l=100 //ft
P=20 //psia
R=53.35
T=600 //R
mu=0.0486 //lb /ft.hr
v=50 //ft/s
g=32.17 //ft/s^2
//calculations
rho=P*144/(R*T)
Re=D*v*rho*3600/(mu)
ed=eps/D
disp("From figure 11.5")
f=0.0235
dp=f*l*rho*v^2 /(2*D*g) /144
change=dp/P *100
//results
printf("Change in pressure = %.2f psi",dp)
printf("\n Percentage change in pressure = %.2f
    percent",change)
```

Scilab code Exa 11.3 Final pressure calculations

```
clc
clear
//Initialization of variables
v1=60 //ft/s
d1=10 //in
d2=15 //in
P=15 //psia
R=53.35
```

```
T=540 //R
g=32.17 //ft/s^2
v1=60 //ft/s
//calculations
v2=v1*d1^2 /d2^2
rho=P*144/(R*T)
dp=rho*(v2^2 -v1^2)/(2*g) /144
p2=P-dp
//results
printf("Final pressure = %.3f psia",p2)
```

Scilab code Exa 11.4 `Change in Entropy`

```
clc
clear
//Initialization of variables
J=778 //ft.lb/Btu
D=2.067/12 //ft
l=100 //ft
P=20 //psia
R=53.35
T=600 //R
mu=0.0486 //lb /ft.hr
v=50 //ft/s
g=32.17 //ft/s^2
//calculations
f=0.0235
ds=f*v^2 *l /(J*2*D*g*T)
//results
printf("Change in entropy = %.6f Btu/lbm R",ds)
```

Scilab code Exa 11.5 `Enthalpy and entropy calculations`

```
clc
clear
//Initialization of variables
v=210 //ft/s
g=32.17 //ft/s^2
p=200 //psia
z=5 //ft
x=2.361
h=1210.3
J=778
//calculations
P0=p + v^2 /(2*g*144*x) + z/(144*x)
h0=h + v^2 /(2*J*g) +z/J
S=1.5594 //units/lb
S0=S
t0=401.9 //F
v0=2.342 //cu ft/lb
rho0=1/v0
//results
printf("Pressure = %d psia",P0)
printf("\n Enthalpy = %.2f Btu/lb",h0)
printf("\n Entropy  = %.4f units/lb",S0)
printf("\n Temperature = %.1f F",t0)
printf("\n Density = %.3f lb/cu ft",rho0)
```

Scilab code Exa 11.6 Temperature calculations

```
clc
clear
//Initialization of variables
p1=40 //psia
t1=80 //F
p2=30 //psia
ar=0.5 //sq ft
v1=200 //ft/s
```

```
R=53.35
cp=0.24
g=32.17
J=778
//calculations
rho1=144*p1/(R*(t1+460))
G=rho1*v1
h10= cp*t1 + p1^2 /(2*g*rho1^2 *J)
t2=78 //F
h2=cp*t2
g2=h10-h2
rho2=sqrt(p1^2 /(2*g*g2*J))
P2=rho2*R*(t2+460)/144
ds2=cp*log((t2+460)/(t1+460)) - R/J *log(P2/p1)
t3=77 //F
h3=cp*t3
g3=h10-h3
rho3=sqrt(p1^2 /(2*g*g3*J))
P3=rho3*R*(t3+460)/144
ds3=cp*log((t3+460)/(t1+460)) - R/J *log(P3/p1)
t4=79 //F
h4=cp*t4
g4=h10-h4
rho4=sqrt(p1^2 /(2*g*g4*J))
P4=rho4*R*(t4+460)/144
ds4=cp*log((t4+460)/(t1+460)) - R/J *log(P4/p1)
h5=18.62
t5=h5/cp
Gv=[h4 h2 h3]
Pv=[P4 P2 P3]
Sv=[ds4 ds2 ds3]
scf(1)
xtitle("Fanno line diagram , Enthalpy vs Entropy","
    Entropy","Enthalpy Btu/lb")
plot(Sv,Gv)
scf(2)
xtitle("Fanno line diagram , Pressure vs Entropy","
    Entropy","Pressure psia")
```

```
plot(Sv,Pv)
//results
printf("Temperature at exit = %.1f F",t5)
```

Scilab code Exa 11.7 Velocity calculations

```
clc
clear
//Initialization of variables
p1=40 //psia
t1=80 //F
p2=30 //psia
ar=0.5 //sq ft
v1=200 //ft/s
R=53.35
cp=0.24
g=32.17
J=778
t2=78 //F
//calculations
G=40 //lb/sq ft/sec
rho2=144*p2/(R*(t2+460))
v2=p1/rho2
//results
printf("Velocity = %d ft/s",v2)
```

Scilab code Exa 11.8 velocity and density calculations

```
clc
clear
//Initialization of variables
P2=[180 160 140 120 100 80 60 40 20]
k=1.4
```

```
p1=200 //psia
t1=240+460 //R
cp=0.24
J=778
gc=32.2
R=53.35
m=4 //lb/sec
//calculations
pr=p1./ P2
prr=pr^((k-1)/k)
T2=t1 ./prr
dt=t1 -T2
dh=dt*cp
v2=sqrt(2*gc*J*dh)
vol=(R*T2) ./(P2*144)
A2=m*vol*144 ./v2
dia=sqrt(4/ %pi *A2)
rad=dia/2
den=1 ./vol
scf(1)
xtitle ('Velocity vs pressure','Pressure in psia','
    velocity in ft/s')
plot(P2,v2)
scf(2)
xtitle('specific volume vs pressure','Pressure in
    psia','specific volume in cu ft/lb')
plot(P2,vol)
scf(3)
xtitle('Radius vs Pressure' ,'Pressure in psia','
    Radius in in')
plot(P2,rad)
//results
disp('Velocity in ft/s')
disp(v2)
disp('Specific volume in cu ft/lb')
disp(vol)
disp('Density in lb/cu ft')
disp(den)
```

```
disp('Diameter of nozzle in in')
disp(dia)
```

Scilab code Exa 11.9 Exit area calculation

```
clc
clear
//Initialization of variables
p1=200 //psia
t1=480 //F
eff=0.95
g=32.2 //ft/s^2
J=778
mf=3.4 //lb/s
//calculations
disp("From steam tables,")
h1=1257.8
h2=1210.5
dh=eff*(h1-h2)
ve=sqrt(2*g*J*dh)
h3=h1-dh
vs=3.961
Ae=mf*vs/ve *144
//results
printf("Nozzle exit area = %.3f sq.in",Ae)
```

Scilab code Exa 11.10 Pressure and velocity calculations

```
clc
clear
//Initialization of variables
R=53.35
v=300 //ft/s
```

```
p=100 //psia
t1=200 //F
q=500 //Btu/s
gc=32.2 //ft/s^2
J=778
//calculations
rho1=p*144/(R*(460+t1))
x=poly(0,"x")
s=x^2 -0.206*x+0.00535
vec=roots(s)
rho2=vec(1)
t2=(236.6 - 0.301/rho2^2)/0.248
P2=rho2*R*(t2+462) /144
v2=sqrt(2*gc*J*(236.6-0.248*t2))
v22=rho1*v/rho2
//results
printf("Final temperature = %.1f F",t2)
printf("\n Final pressure = %.1f psia",P2)
printf("\n Exit velocity in case 1 = %.1f ft/s",v2)
printf("\n Exit velocity in case 2 = %.1f ft/s",v22)
```

Chapter 12

Heat Transfer

Scilab code Exa 12.1 Temperature calculation

```
clc
clear
//Initialization of variables
km1=0.62
km2=0.16
km3=0.4
l1=8 //in
l2=4 //in
l3=4 //in
Tf=1600 //F
Tc=100 //F
//calculations
Rw=l1/12/km1 +l2/12/km2 +l3/12/km3
Rb=l1/12/km1
Ti=Tf-Rb/Rw *(Tf-Tc)
//results
printf("Interface temperature = %.1f F",Ti)
disp("The answers might differ a bit from textbook
   due to rounding off error.")
```

Scilab code Exa 12.2 Heat flow calculations

```
clc
clear
//Initialization of variables
th=350 //F
tc=150 //F
od1=4.5
id1=4.026
od2=6.5
id2=4.5
k1=32
k2=0.042
//calculations
Q=2*%pi*(th-tc)/(log(od1/id1) /k1 + log(od2/id2) /k2)
r1=log(od1/id1) /k1
rt=log(od1/id1) /k1 + log(od2/id2) /k2
ti=th-r1/rt*(th-tc)
//results
printf("Heat flow = %.1f Btu/hr",Q)
printf("\n Interface temperature = %.2f F",ti)
```

Scilab code Exa 12.3 Energy exchange calculations

```
clc
clear
//Initialization of variables
Fa=0.045
l=4 //m
b=4 //m
Fe=1
```

```
Ta=540+460 //R
Tb=1540+460 //R
//calculations
A=l*b
Q=0.173*A*Fa*Fe*((Tb/100)^4 -(Ta/100)^4)
Q2=416000
//results
printf("In case 1, Net energy exchange = %d Btu/hr",Q)
printf("\n In case 2, Net energy exchange = %d Btu/hr",Q2)
disp('The answers are a bit different due to rounding off error in textbook')
```

Scilab code Exa 12.4 `Energy Exchange calculation`

```
clc
clear
//Initialization of variables
ea=0.8
eb=0.7
Fa=0.045
l=4 //m
b=4 //m
Fe=1
Ta=540+460 //R
Tb=1540+460 //R
//calculations
A=l*b
ef=ea*eb
Q=0.173*A*Fa*Fe*ef*((Tb/100)^4 -(Ta/100)^4)
//results
printf("Net energy exchange = %d Btu/hr",Q)
disp('The answers are a bit different due to rounding off error in textbook')
```

Scilab code Exa 12.5 Inside film coefficient calculation

```
clc
clear
//Initialization of variables
den=61.995 //lb/cu ft
vel=6 //ft/s
t1=100 //F
t2=160 //F
de=2.067 //in
mu=1.238
pr=3.3
//calculations
G=den*vel*3600
tm=(t1+t2)/2
hc=0.023*0.377/(de/12) *(de/12 *G/mu)^0.8 *(pr)^0.4
//results
printf("Inside film coefficient = %d Btu/sq ft hr F"
    ,hc)
```

Scilab code Exa 12.6 Inside film coefficient calculation

```
clc
clear
//Initialization of variables
d=0.5 //in
tm=1000 //F
v=5//ft/s
k=38.2
den=51.2
mu=0.3
```

```
//calculations
Nu=7+ 0.025*(d/12 *v*den*mu/k*3600)^0.8
h=Nu*k/(d/12)
//results
printf("Inside film coefficient = %d Btu/sq ft hr F"
    ,h)
```

Scilab code Exa 12.7 convective film coefficient calculation

```
clc
clear
//Initialization of variablesdo=2 //in
tf=120 //F
ti=80 //F
rho=0.0709
g=32.17
bet=1/560
cp=0.24
mu=0.0461
k=0.0157
d=2 //in
Cd=0.45
//calculations
GrPr=(d/12)^3 *rho^2 *g*3600^2 *bet*(tf-ti)*cp/(mu*k
    )
hc=Cd*k/(d/12)^(1/4) *GrPr^(1/4)
//results
printf("Convective film coefficient = %.3f Btu/sq ft
     hr F",hc)
```

Scilab code Exa 12.8 Outer film coefficient calculation

```
clc
```

```
clear
//Initialization of variables
tf=220 //F
ti=200 //F
d=2 //in
C=103.7
k=0.394
rho=59.37
hfg=965.2
mu=0.70
//calculations
h=C*(k^3 *rho^2 *hfg/((d/12) *mu*(tf-ti)))^(1/4)
//results
printf("Outer film coefficient = %d Btu/sq ft hr F",
    h)
```

Scilab code Exa 12.9 Boiling film coefficient calculation

```
clc
clear
//Initialization of variables
tf=225 //F
a=190
b=0.043
ti=212 //F
//calculations
hc=a/(1-b*(tf-ti))
hcti=hc*1.25
//results
printf("For a flat copper plate, boiling film
    coefficient = %.1f Btu/sq ft hr F",hc)
printf("\n For an inclined copper plate, boiling
    film coefficient = %d Btu/sq ft hr F",hcti)
```

Scilab code Exa 12.10 Heat calculation

```
clc
clear
//Initialization of variables
Do=2.375 //in
hi=1200
Di=2.067 //in
km=29.2
h0=1500
L=2.375 //in
t1=220 //F
t4=140 //F
//calculations
U0= 1/(Do/(Di*hi) + (Do/12 *log(Do/Di) /(2*km)) + 1/
    h0)
Q=U0*L*%pi*(t1-t4)/12
//results
printf("Heat transferred per foot length of pipe =
    %d btu/hr",Q)
```

Scilab code Exa 12.11 Temperature calculation

```
clc
clear
//Initialization of variables
Do=2.375 //in
hi=1200
Di=2.067 //in
km=29.2
h0=1500
L=2.375 //in
```

```
t1=220 //F
t4=140 //F
//calculations
Re=Do/(Di*hi)
R0=Do/(Di*hi) + (Do/12 *log(Do/Di) /(2*km)) + 1/h0
td=Re/R0 *(t1-t4)
ti=t4+td
Req=1/h0
td2=Req/R0 *(t1-t4)
to=t1-td2
//results
printf("The temperature of the inner surface of pipe = %.1f F",ti)
printf("\n The temperature of the outer surface of pipe = %.1f F",to)
```

Scilab code Exa 12.12 LMTD Calculation

```
clc
clear
//Initialization of variables
th1=800 //F
th2=300 //F
tc1=100 //F
tc2=400 //F
//calculations
lmtd= ((th1-tc2) - (th2-tc1) )/(log((th1-tc2)/(th2-tc1)))
//results
printf("Logarithmic Mean temperature difference = %d F",lmtd)
```

Scilab code Exa 12.13 True MTD Calculation

```
clc
clear
//Initialization of variables
th1=200 //F
th2=100 //F
tc1=80 //F
tc2=110 //F
//calculations
disp("From the lmtd graph,")
R=(tc1-tc2)/(th2-th1)
P=(th2-th1)/(tc1-th1)
F=0.62
lmtd= F* ((th1-tc2) - (th2-tc1) )/(log((th1-tc2)/(
    th2-tc1)))
//results
printf("True Mean temperature difference = %.1f F",
    lmtd)
```

Chapter 13

Non reactive and reactive gaseous mixtures

Scilab code Exa 13.1 Mass calculations

```
clc
clear
//Initialization of variables
P=70 //psia
Pt=110 //psia
V=20 //cu ft
R0=1545 //Universal gas constant
T=540 //R
M=32 //Molecular weight of Oxygen
M2=28 //Molecular weight of Nitrgoen
//calculations
N=P*V*144/(R0*T)
mo=M*N
Pn=Pt-P
N2=Pn*V*144/(R0*T)
mn=N2*M2
Vo=N*R0*T/(144*Pt)
Vn=N2*R0*T/(144*Pt)
Vn2=V-Vo
```

```
//results
printf("Mass of oxygen = %.2f lb",mo)
printf("\n Mass of nitrogen = %.2f lb",mn)
printf("\n Partial volume of oxygen = %.2f cu ft",Vo)
printf("\n Partial volume of nitrogen = %.2f cu ft",Vn)
printf("\n In case 2, Partial volume of nitrogen = %.2f cu ft",Vn2)
```

Scilab code Exa 13.2 `Change in Entropy calculation`

```
clc
clear
//Initialization of variables
P=50 //psia
V=4 //cu ft
dv=3 //cu ft
J=778
T=560 //R
//calculation
ds= 144*P*V*log((V+dv)/V) /(J*T)
//results
printf("Change in entropy = %.3f unit",ds)
```

Scilab code Exa 13.3 `Change in Entropy calculation`

```
clc
clear
//Initialization of variables
p1=50 //psia
t1=100+460 //R
R1=48.3
```

```
R2=55.2
v1=4 //cu ft
p2=100 //psia
v2=3 //cu ft
t2=200+460 //R
cv1=0.157
cv2=0.177
cpm=0.219
J=778
//calculations
m1=144*p1*v1/(R1*t1)
m2=144*p2*v2/(R2*t2)
tf=(m1*cv1*(t1-460) + m2*cv2*(t2-460))/(m1*cv1+m2*
   cv2)
Po2=v1/(v1+v2) *(tf+460)/t1 *p1
ds=cpm*log((tf+460)/t1) - R1/J *log(Po2/p1)
dss=ds*m1
//results
printf("Change in entropy = %.4f unit",dss)
```

Scilab code Exa 13.4 Change in Entropy calculation

```
clc
clear
//Initialization of variables
p1=30 //psia
t1=80+460 //R
R1=48.3
R2=55.2
m1=20 //lb/min
p2=50 //psia
m2=35 //lb/min
t2=160+460 //R
cp1=0.219
cp2=0.248
```

```
J=778
//calculations
tf=(m1*cp1*(t1-460) + m2*cp2*(t2-460))/(m1*cp1+m2*
    cp2)
Po2=m1/32/(m1/32+m2/28) *p1
ds=cp1*log((tf+460)/t1) - R1/J *log(Po2/p1)
dss=ds*m1
//results
printf("Change in entropy = %.4f units/min",dss)
```

Scilab code Exa 13.5 `Weight calculations`

```
clc
clear
//Initialization of variables
x=[0.15 0.08 0.77]
M=[44 32 28]
//calculations
y=x ./M
yt=sum(y)
mt=y/yt
per=mt*100
wt=1/yt
R=1545/wt
//results
printf("Volumetric analysis")
disp('percent by volume')
format('v',6);per
disp(per)
printf("Weight per mole = %.1f lb",wt)
printf("\n Gas constant = %.1f ",R)
```

Scilab code Exa 13.6 `Dry analysis calculations`

```
clc
clear
//Initialization of variables
x1=0.885 //mole fraction of Ch4
x2=0.115 //mole fraction of c2h6
x3=0.4/100 //mole fraction of N2
n1=2 //Moles of Ch4
n2=3.5 //Moles of c2h6
n3=1 //moles of ch4 in case 2
n4=2 //moles of c2h6 in case 2
//calculations
y1=n1*x1
y2=n2*x2
y=y1+y2
vec2=[y1 y2]
air=y/0.21
y3=n3*x1
y4=n4*x2
yy=y3+y4
vec3=[y3 y4]
air2=y/0.21 *0.79
//results
printf("Theoretical air = %.2f moles of air per mole
    of fuel",air)
disp("Oxygen analysis")
disp(vec2)
printf("\n Amount of nitrogen = %.2f moles of
   nitrogen per mole of fuel",air2)
disp("Dry analysis")
disp(vec3)
printf('total = %.3f moles',yy)
```

Scilab code Exa 13.7 Air fuel ratio calculations

```
clc
```

```
clear
//Initialization of variables
x=[0.74 0.06 0.01] //mole fraction of C, H and S
    respectively
y=[8/3 8 1] //Pounds O2 per pound substance of C,H
    and S respectively
oxy=0.08 //Oxygen in coal
z=0.232 //mass of coal
//calculations
pou=x.*y
tot=sum(pou)
oxy2=tot-oxy
air=oxy2/z
//results
printf("Theoretical air fuel ratio = %.2f lb of air
    per pound of coal",air)
```

Scilab code Exa 13.8 Air fuel ratio calculations

```
clc
clear
//Initialization of variables
o2=12.5 //moles of O2
h20=9 //moles of H2O
x=0.21 //Mole fraction of Oxygen in air
M=28.97 //Molar mass of air
M2=56 //molar mass of C4H8
M1=8*12+18 //molecular mass of c8h18
//calculations
air=o2/x
pound=air*M
AR=pound/M1
y1=h20/M2 *100
y2=o2*(79/21) /M2 *100
//results
```

```
printf("Air fuel ratio = %.2f lb of air per pound of
    fuel",AR)
printf("\n Molal or volumetric analysis is %.2f
   percent of CO2 and %.2f percent N2",y1,y2)
```

Scilab code Exa 13.9 volumetric analysis

```
clc
clear
//Initialization of variables
x=18.5 //Moles of O2
c=12 //Moles of CO2
vap=13 //moles of H2O
P=15 //psia
R=1545 //Universal gas constant
//calculations
excess=x*0.5
M=12*12+2*vap
n2=(x+excess)*79/21
nt=n2+excess+c
dry=[c x/2 n2]/nt *100
wet=nt+vap
fue=100/(M)
mol=wet*fue
vol=mol*R*1460/(144*P)
//results
disp("Volumetric analysis in percentage")
disp('        CO2           O2            N2')
disp(dry)
printf("Volume of wet products = %d cfm",vol)
```

Scilab code Exa 13.10 volumetric analysis

```
clc
clear
//Initialization of variables
A=[1 1; 0.5 1]
B=[1; 0.9]
x=0.9
//calculations
N2=x*79/21
C=A\B
vec= [ C(1) C(2) N2]
su=sum(vec)
vec2=vec/su *100
//results
printf("Volumetric analysis")
disp('CO        CO2        N2')
disp(vec2)
```

Scilab code Exa 13.11 Moles of dry products calculations

```
clc
clear
//Initialization of variables
c=0.74
ref=0.02
co2=0.12
co=0.1/100
M=12
//calcualtions
carbon=c-ref
car2=co2+co
wt=car2*M
amount=carbon/wt
//results
printf("Moles of dry products per pound of coal = %
    .3f mole",amount)
```

Scilab code Exa 13.12 Moles of dry products calculations

```
clc
clear
//Initialization of variables
x1=0.128
x2=0.035
x3=0.002
M=12
N=26
//calculations
c=x1+x3
mole=12/c
wt=M*M+N
num=mole/wt
//results
printf("Number of moles of dry products per pound of
    fuel = %.3f mole",num)
```

Scilab code Exa 13.13 Weight of dry air calculations

```
clc
clear
//Initialization of variables
c=0.74
ref=0.02
co2=0.12
co=0.1/100
o2=0.065
M=12
x=0.79
```

```
M=28.97
//calcualtions
n2=1-(co2+co+o2)
mol=n2/x
wt=mol*M
wt2=0.496
pou=wt2*wt
ta=10.27
EA=(pou-ta)/ta *100
//results
printf("Weight of air per pound of fuel = %.2f lb",
   pou)
printf("\n Excess air percentage = %.1f percent",EA)
```

Chapter 14

Energies associated with chemical reactions

Scilab code Exa 14.1 Heating value calculations

```
clc
clear
//Initalization of variables
lhs=8.5 //moles of reactants
rhs=6 //moles of CO2
n=3 //moles of H2O
R=1545 //Universal gas constant
R2=18.016 //molar mass of water
J=778 //Work conversion constant
T=537 //R
T2=1050.4 //R
T3=991.3 //R
Qhp=1417041 //Btu/mol
//calculations
Qhpv=(lhs-rhs)*R*T/J
Qhv=Qhp-Qhpv
hfg=(rhs-n)*R2*T2
Qlp=Qhp-hfg
Qlpv=(lhs-rhs-n)*R/J *T
```

```
Qlv=Qlp-Qlpv
Qhlv=(rhs-n)*R2*T3
Qlv3=Qhv-Qhlv
//results
printf("Higher heating value at constant volume = %d
    Btu/mol",Qhv)
printf("\n Lower heating value at constant pressure
    = %d Btu/mol",Qlp)
printf("\n In case 1,Lower heating value at constant
    volume = %d Btu/mol",Qlv)
printf("\n In case 2,Lower heating value at constant
    volume = %d Btu/mol",Qlv3)
disp("The answers might differ a bit from textbook
    due to rounding off error.")
```

Scilab code Exa 14.2 `Heating value calculations`

```
clc
clear
//Initalization of variables
disp("From table 5-4,")
no=7.5
n1=3
n2=6
Q=1360805 //Btu/mol
//calculations
Uo=337+no*85
Uf=n1*104+n2*118
del= Q-(Uo-Uf)
Uo2=1656+no*402
Uf2=n1*490+n2*570
Qv=Uo2-Uf2+del
//results
printf("Change in chemical energy during complete
    combustion = %d Btu/mol",del)
```

```
printf("\n Lower heating value at constant volume = %d Btu/mol",Qv)
```

Scilab code Exa 14.3 Heat removed calculations

```
clc
clear
//Initalization of variables
disp("From table 5-4,")
a=1 //moles of C6H6
b=7.5 //moles of O2 in reactant
c=1.875 //moles of excess O2
d=35.27 //moles of N2
e=3 //moles of H2O
flow=40 //lb/min
w=1360850 //Btu/mol
//calculations
U11=a*337
U12=(b+c)*85
U13=d*82
U14=(a+b+c+d)*1066
Ua1=U11+U12+U13+U14
U21=c*2539
U22=d*2416
U23=e*3009
U24=2*e*3852
U25=(c+d+e+2*e)*1985
Ua2=U21+U22+U23+U24+U25
Q=Ua1+w-Ua2
fuel=flow/(6*12+2*e)
Q2=Q*fuel
//results
printf("Heat removed = %d Btu/min",Q2)
disp("The answers might differ a bit from textbook
   due to rounding off error.")
```

Scilab code Exa 14.4 Furnace efficiency calculations

```
clc
clear
//Initalization of variables
rate=10700 //lb/min
t2=97.90
t1=33.05
r1=46 //lb/min
//calculations
disp("From steam tables,")
Hv=1417041
Qw=rate*(t2-t1)
Q=r1/(12*6+6) *Hv
eff=Qw/Q*100
//results
printf("Furnace efficiency = %.1f percent",eff)
```

Scilab code Exa 14.5 Thermal efficiency calculations

```
clc
clear
//Initalization of variables
rate=94 //lb/hr
hp=197 //hp
c=8
h=18
Lv=17730 //Btu/hr
H=2368089 //Btu/hr
//calculations
amount=rate*c/12 +h
```

```
amount=0.824
Lvv=H-Lv
eff=hp*2544/(amount*Lvv) *100
//results
printf("Thermal efficiency = %.2f percent",eff)
```

Scilab code Exa 14.6 Thermal efficiency calculations

```
clc
clear
//Initalization of variables
rate=94 //lb/hr
hp=197 //hp
c=8
h=18
mole=9
H=2350359 //Btu/hr
//calculations
amount=rate*c/12 +h
amount=0.824
Lvv=H-mole*18.016*1050.4
eff=hp*2544/(amount*Lvv) *100
//results
printf("Thermal efficiency = %.2f percent",eff)
disp("The answer in the textbook is a different due
    to rounding off error")
```

Scilab code Exa 14.7 Total available energy calculations

```
clc
clear
//Initalization of variables
hv=14000 //Btu/lb
```

```
ef=0.4
tmin=80 //F
tmid=300 //F
m=13 //lb
c=0.27
tmean=2300 //F
//calculations
heat=ef*hv
Qavail=heat*(tmean-tmin)/(tmean+460)
Q=m*c*(tmean-tmid)
Q2=Q- (tmin+460)*m*c*log((tmean+460)/(tmid+460))
tot=Qavail+Q2
//results
printf("Total available energy = %d Btu/lb of fuel",
    tot)
disp("The answer is a bit different due to rounding
    off error in textbook")
```

Scilab code Exa 14.8 Max amount of work calculations

```
clc
clear
//Initalization of variables
disp("From table 14-2,")
G1=55750 //Btu/mol
co2=-169580 //Btu/mol
h2o=-98290 //Btu/mol
//calculations
G2=6*co2+3*h2o
avail=G1-G2
//results
printf("Max. amount of work = %d Btu/mol",avail)
```

Chapter 15

Thermodynamics of chemical reactions

Scilab code Exa 15.1 Dissociation calculations

```
clc
clear
//Initalization of variables
kp=10^(1.45)
//calculations
x=poly(0,"x")
s=(1-x)^2 *(2+x) -kp^2 *x^(3)
vec=roots(s)
X=vec(3)
xper=X*100
//results
printf("Amount of dissociaton = %.1f percent",xper)
printf("\n Of each original mole of CO2, there will
    be %.3f mole of CO , %.3f mol of Oxygen and %.3f
    mol of CO2",X,X/2,(1-X))
```

Scilab code Exa 15.2 Max temperature calculations

```
clc
clear
//Initalization of variables
U=121200 //Btu/mol
Uco2=51635 //Btu/mol
Un2=27589 //Btu/mol
Uco22=57875 //Btu/mol
Un22=21036 //Btu/mol
T1=5000 //R
T2=5500 //R
//calculations
Ut1=Uco2+1.88*Un2
Ut2=Uco22 + 1.88*Un22
disp("By extrapolation,")
Tx=5710 //R
//results
printf("Max. Temperature reached = %d R",Tx)
disp("The calculation for Ut2 is wrong in textbook.
   Please use a calculator.")
```

Scilab code Exa 15.3 Max temperature calculation

```
clc
clear
//Initalization of variables
disp("By trial and error,")
X=0.201
X1=0.2
R=59.3 //universal gas constant
T=5000 //R
U=121200 //Btu/mol
Uco2=51635 //Btu/mol
Un2=27907 //Btu/mol
```

```
U3=29616 //Btu/mol
U4=27589 //Btu/mol
//calculations
kp1=R*(1-X1)/X1^1.5 /T^0.5
kp2=R*(1-X)/X^1.5 /T^0.5
q=(1-X)*Uco2 + X*Un2+ X/2 *U3 +1.88*U4 + X*U
disp("Interpolating between T=4500 R and T=5000 R,
    we get")
T2=4907 //R
//results
printf("Max. obtainable temperature = %d R",T2)
```

Chapter 16

Gas cycles

Scilab code Exa 16.1 Temperature and pressure calculations

```
clc
clear
//Initalization of variables
cr=9
p1=14 //psia
t1=80+460 //R
n=1.4
heat=800 //Btu
c=0.1715
R=53.35
J=778
//calculations
p2=p1*(cr)^n
t2=t1*cr^(n-1)
t3=heat/c +t2
p3=p2*t3/t2
eff=(1-1/cr^(n-1))*100
t4=t3/cr^(n-1)
Qr=c*(t4-t1)
cyclework=heat-Qr
eff2= cyclework/heat *100
```

```
V1=R*t1/(144*p1)
pd=(1-1/cr)*V1
mep=cyclework*J/(pd*144)
//results
printf("Max. temperature = %d R",t3)
printf("\n Max. pressure = %d psia",p3)
printf("\n In method 1,Thermal efficiency = %.1f
    percent",eff)
printf("\n In method 2,Thermal efficiency = %.1f
    percent",eff2)
printf("\n Mean effective pressure mep = %.1f psia",
    mep)
```

Scilab code Exa 16.2 Temperature and pressure calculations

```
clc
clear
//Initalization of variables
t1=80+460 //R
p1=14 //psia
n=1.4
cr=16
heat=800 //Btu
cp=0.24
c=0.1715
//calculations
t2=t1*cr^(n-1)
p2=p1*(cr)^n
t3=t2 +heat/cp
v32=t3/t2
v43=cr/v32
t4=t3/v43^(n-1)
Qr=c*(t4-t1)
etat=(heat-Qr)/heat *100
//results
```

```
printf("Max. Temperature = %d R",t3)
printf("\n Max. Pressure = %d psia",p2)
printf("\n Thermal efficiency = %.1f percent",etat)
```

Scilab code Exa 16.3 mep calculation

```
clc
clear
//Initalization of variables
eff=0.585
heat=800 //Btu
t1=80+460 //R
p1=14 //psia
n=1.4
R=53.35
cr=9
cp=0.24
J=778
//calculations
W=eff*heat
v1=R*t1/(144*p1)
v2=v1/cr
t2=1301 //R
t3=t2+ heat/cp
v3=v2*t3/t2
v4=cr*v3
mep=W*J/(144*(v4-v2))
//results
printf("Mean effective pressure = %.1f psia",mep)
```

Scilab code Exa 16.4 mep calculation

```
clc
```

```
clear
//Initalization of variables
eff=0.585
heat=500 //Btu
heat1=300 //Btu
t1=80+460 //R
p1=14 //psia
n=1.4
R=53.35
cr=9
J=778
c=0.1715
cp=0.24
t2=1301 //R
p2=308 //psia
//calculations
t3=t2+ heat/c
p3=p2*t3/t2
t4=t3+ heat1/cp
v43=t4/t3
v54=cr/v43
t5=t4/(v54)^(n-1)
Qr=c*(t5-t1)
etat=(heat+heat1-Qr)/(heat+heat1) *100
mep=(heat+heat1-Qr)*J/(12.69*144)
//results
printf("Max. Temperature = %d R",t4)
printf("\n Max. Pressure = %d psia",p3)
printf("\n Thermal efficiency = %.1f percent",etat)
printf("\n Mean effective pressure = %.1f psia",mep)
disp("The calculations are a bit different due to
   rounding off error in textbook")
```

Chapter 17

Internal combustion engines

Scilab code Exa 17.1 Indicated efficiency calculations

```
clc
clear
//Initalization of variables
hp1=2000 //bhp
m=792 //lb/hr
ex=0.5
hp2=210
hv=18900 //Btu/lb
etth=51.3
//calculations
ihp=hp1+hp2
ietat= ihp*2544/(m*hv) *100
betat=ietat*hp1/ihp
betat2=hp1*2544/(m*hv) *100
ietae=ietat/etth *100
betae=betat/etth *100
brake= ietae*hp1/ihp
//results
printf("Indicated efficiency = %.1f percent",ietat)
printf("\n Brake thermal efficiency = %.1f percent",
   betat)
```

```
printf("\n In case 2, Brake thermal efficiency = %.1f percent",betat2)
printf("\n Indicated thermal efficiency = %.1f percent",ietae)
printf("\n Brake engine efficiency = %.1f percent",betae)
printf("\n In case 2, Brake engine efficiency = %.1f percent",brake)
```

Scilab code Exa 17.2 `Indicated mep calculations`

```
clc
clear
//Initalization of variables
J=778
o2=12.5
theo=0.95
N=56.5
R0=1545
T=540 //R
p=14 //psia
LHV=2368089 //Btu/lb
ther=39.4
iep=0.78
ve=0.8
//calculations
Ar=o2/0.21 *theo
vol=N*R0*T/(144*p)
hv=(LHV -17730)/LHV
ithep=iep*ther
pd=ithep/100 *ve *100.5
mep=J*pd
//results
printf("Indicated mep = %d lb/sq ft",mep)
```

Chapter 18

Gas Compressors

Scilab code Exa 18.1 `Horsepower calculation`

```
clc
clear
//Initalization of variables
q=200 //cfm
p2=90 //psia
p1=14.5 //psia
n=1.36
//calculations
hpp=n/(n-1) *144*p1*q/33000 *(1- (p2/p1))^((n-1)/n)
//results
printf("Theoretical horse power required = %.1f hp",
    hpp)
disp("The answer given in textbook is wrong. Please
    verify with a calculator")
```

Scilab code Exa 18.2 `Horsepower calculations`

```
clc
```

```
clear
//Initalization of variables
q=350 //cfm
eff=0.78
x=0.95
p2=120 //psia
p1=14.3 //psia
//calculations
cal=p1*144*q/550 *log(p2/p1) /100
ihp= cal/eff
shp=ihp/x
//results
printf("Indicated hp = %.1f hp",ihp)
printf("\n Shaft hp = %.1f hp",shp)
```

Scilab code Exa 18.3 Piston displacement calculations

```
clc
clear
//Initalization of variables
n=1.35
p1=14.2
q=400 //cfm
p2=200 //psia
p1=14.2 //psia
ve=0.75
t1=530 //R
//calculations
thp=-n/(n-1) *144 *p1*q/33000 *(1- (p2/p1)^((n-1)/n))
pd=q/ve
Tmax=t1*(p2/p1)^((n-1)/n)
//results
printf("Theoretical hp = %.1f hp",thp)
printf("\n Piston displacement = %d cfm",pd)
```

```
printf("\n Max. Temperature = %d R",Tmax)
```

Scilab code Exa 18.4 Piston displacement calculations

```
clc
clear
//Initalization of variables
n=1.35
p1=14.2 //psia
p3=200 //psia
q=400 //cfm
ve=0.78
t1=530 //R
//calculations
p2=sqrt(p3*p1) //psia
thp=-2*n/(n-1) *144 *p1*q/33000 *(1- (p2/p1)^((n-1)/n))
pd=q/ve
pd2=q*p1/p2 /ve
Tmax=t1*(p2/p1)^((n-1)/n)
//results
printf("Theoretical hp = %.1f hp",thp)
printf("\n For low pressure case, Piston displacement = %.1f cfm",pd)
printf("\n For high pressure case, Piston displacement = %.1f cfm",pd2)
printf("\n Max. Temperature = %.1f R",Tmax)
disp('The answers are a bit different due to rounding off error')
```

Scilab code Exa 18.5 Pressure calculations

```
clc
```

```
clear
//Initalization of variables
dia=2 //ft
rpm=6000 //rpm
p=14.2 //psia
t=75 //F
g=32.17
n=1.4
R=53.35
//calculations
v=2*%pi*rpm/60
wbym=v^2 /g
T=t+460
pr=1+ wbym*(n-1)/n /(R*T)
pr2=pr^(n/(n-1))
p2=pr2*p
//results
printf("Theoretical pressure at exit = %.1f psia",p2
   )
```

Scilab code Exa 18.6 Pressure calculations

```
clc
clear
//Initalization of variables
pa=14.7 //psia
p1=12 //psia
t1=560 //R
n=1.4 //gamma
J=778 //constant conversion
g=32.2 //ft/s^2
cp=0.24 //heat capacity
eff=0.7 //efficiency
m1=1.8
m3=1
```

```
//calculations
t5=t1*(pa/p1)^((n-1)/n)
v4=sqrt(2*g*J*cp*(t5-t1)/eff)
v3=(m1+m3)/m1 *v4
//results
printf("Velocity of air = %.1f ft/s",v3)
```

Scilab code Exa 18.7 Pressure required

```
clc
clear
//Initalization of variables
v2=1180 //ft/s
etan=0.95
cp=0.24
n=1.4
p2=12
//calculations
dh=v2^2 /(etan*223.8^2)
dt=dh/cp
t2d=560 //R
t1=t2d+ etan*dt
t2=554 //R
pr=(t1/t2)^(n/(n-1))
p1=p2*pr
//results
printf("Pressure required = %.2f psia",p1)
```

Chapter 19

Gas turbines

Scilab code Exa 19.1 Efficiency calculations

```
clc
clear
//Initalization of variables
n=1.4
t1=540 //R
tmax=1200 //F
tmax2=1500 //F
pr=5
cp=0.24
//calculations
t2=t1*(pr)^((n-1)/n)
work=cp*(t2-t1)
t4=(tmax+460) /pr^((n-1)/n)
twork=cp*(tmax+460-t4)
net=twork-work
eff=1- 1/pr^((n-1)/n)
Qs=cp*(tmax+460-t2)
ett=net/Qs *100
t42=(tmax2+460)/pr^((n-1)/n)
twork2=cp*(tmax2+460-t42)
net2=twork2-work
```

```
Qs2=cp*(tmax2+460-t2)
eff3=net2/Qs2 *100
//results
printf("Compressor work = %.1f Btu/lb",work)
printf("\n Turbine work = %.1f Btu/lb",twork)
printf("\n Net work = %.1f Btu/lb",net)
printf("\n Thermal efficiency = %.1f percent",eff
    *100)
printf("\n In case 2, Thermal efficiency = %.1f
    percent",ett)
printf("\n In case 2, Turbine work = %.1f Btu/lb",
    twork2)
printf("\n In case 2, Net work = %.1f Btu/lb",net2)
printf("\n In case 3, Thermal efficiency = %.1f
    percent,",eff3)
```

Scilab code Exa 19.2 `Work and efficiency calculations`

```
clc
clear
//Initalization of variables
work=75.9 //Btu/lb
twork=173.5 //Btu/lb
eta=0.8
t2=856 //R
t1=540 //R
t4=1960 //R
cp=0.24
//calculations
cwork=work/eta
internal=twork*eta
net=-cwork+internal
t2d=(t2-t1)/eta + t1
Qs=cp*(t4-t2d)
eff=net/Qs *100
```

```
//results
printf("Indicated compressor work = %.1f Btu/lb",cwork)
printf("\n Internal work = %.1f Btu/lb",internal)
printf("\n Net work = %.1f Btu/lb",net)
printf('\n Thermal efficiency = %.2f percent",eff)
```

Scilab code Exa 19.3 Work and efficiency calculations

```
clc
clear
//Initalization of variables
eff=0.97
c1=94.9 //Btu/lb
c2=138.8 //Btu/lb
ntee=246 //Btu/lb
//calculations
cwork=c1/eff
twork=c2*eff
net=twork-cwork
etat=net/ntee *100
//results
printf("Compressor work = %.1f Btu/lb",cwork)
printf("\n Turbine work = %.1f Btu/lb",twork)
printf("\n Net work = %.1f Btu/lb",net)
printf("\n Thermal efficiency = %.1f percent",etat)
```

Scilab code Exa 19.4 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
pr=5
```

```
p1=14 //psia
pd=3 //psi
pen=70 //psia
tin=1960  //R
n=1.4
cp=0.24
Qs=265 //Btu/lb
//calculations
p2=p1*pr
pe=pen-pd
prt=pe/p1
tex=tin/prt^((n-1)/n)
twork=cp*(tin-tex)
net=twork-75.9
eff=net/Qs *100
//results
printf("Thermal efficiency = %.1f percent",eff)
```

Scilab code Exa 19.5 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
pr=5
p1=14 //psia
pd=3 //psi
pen=70 //psia
tin=1960  //R
n=1.4
cp=0.24
Qs=265
ef=0.95
//calculations
p2=p1*pr
pe=pen-pd
```

```
prt=pe/p1
tex=tin/prt^((n-1)/n)
twork=cp*(tin-tex)
net=twork-75.9
Qs2=Qs/ef
eff=net/Qs2 *100
//results
printf("Thermal efficiency = %.1f percent",eff)
```

Scilab code Exa 19.6 Pressure calculation

```
clc
clear
//Initalization of variables
pr1=1.0590
pr2=4.396
p1=14 //psia
//calculations
prr=pr2/pr1
p2=p1*prr
//results
printf("Final pressure = %.1f psia",p2)
```

Scilab code Exa 19.7 Compressor work

```
clc
clear
//Initalization of variables
t1=540 //R
h1=129.06
pr1=1.386
cr=5
//calculations
```

```
pr2=pr1*cr
disp("From air tables,")
h2=204.63
cwork=h2-h1
//results
printf("Compressor work = %.2f Btu/lb",cwork)
```

Scilab code Exa 19.8 `Turbine work`

```
clc
clear
//Initalization of variables
cr=5
pr3=176.73 //psia
h3=14580.3 //Btu/mol
M=28.9
//calculations
pr4=pr3/cr
h4=9409
twork=h3-h4
turb=twork/M
//results
printf("Turbine work = %.1f Btu/lb",turb)
```

Scilab code Exa 19.9 `Air fuel ratio`

```
clc
clear
//Initalization of variables
chem=19000 //Btu/lb
m1=204.63 //Btu/lb
M=28.9
w=14580.3
```

```
//calculations
ma=(chem-w/M)/(w/M -m1)
//results
printf("Air fuel ratio = %.1f lb air/lb fuel",ma)
```

Scilab code Exa 19.10 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
cp=0.24
h=138.8
t3=1960 //R
//calculations
t4d=t3-h/cp
Qs=cp*(t3-t4d)
work=43.9 //Btu/lb
etat=work/Qs *100
//results
printf("Thermal efficiency of the unit = %.1f
    percent",etat)
```

Scilab code Exa 19.11 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
n=1.4
t1=540 //R
tmax=1500 //F
pr=5
cp=0.24
p1=14 //psia
```

```
p3=70 //psia
//calculations
pint=p1*sqrt(pr)
t2=t1*(pint/p1)^((n-1)/n)
t4=t1*(p3/pint)^((n-1)/n)
w=cp*(t4-t1)
w2=2*w
t6=(tmax+460)/(p3/pint)^((n-1)/n)
t8=(tmax+460)/(pint/p1)^((n-1)/n)
work=cp*(tmax+460-t6)
w22=2*work
net=w22-w2
Qa=cp*(tmax+460-t2)
Qb=cp*(tmax+460-t6)
Qt=Qa+Qb
eta=net/Qt*100
//results
printf("Thermal efficiency = %.2f percent",eta)
```

Scilab code Exa 19.12 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
n=1.4
t1=540 //R
tmax=1500 //F
pr=5
cp=0.24
p1=14 //psia
p3=70 //psia
w2=75.9 //Btu/lb
Qa=265 //Btu/lb
//calculations
pint=p1*sqrt(pr)
```

```
t6=(tmax+460)/(p3/pint)^((n-1)/n)
t8=(tmax+460)/(pint/p1)^((n-1)/n)
work=cp*(tmax+460-t6)
w22=2*work
net=w22-w2
Qb=cp*(tmax+460-t6)
Qt=Qa+Qb
eta=net/Qt*100
//results
printf("Thermal efficiency = %.1f percent",eta)
```

Scilab code Exa 19.13 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
n=1.4
t1=540 //R
tmax=1500 //F
pr=5
cp=0.24
t3=1558 //R
net=125.8 //Btu/lb
//calculations
Q=cp*(tmax+460-t3)
Qt=2*Q
eta=net/Qt*100
//results
printf("Thermal efficiency = %.1f percent",eta)
```

Chapter 20

Vapor power cycles

Scilab code Exa 20.1 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
Qs=825.1 //Btu/lb
ds=0.9588
t1=101.74 //F
th=400.95 //F
//calculations
Qr=ds*(t1+459.69)
work=Qs-Qr
eta=work/Qs*100
eta2=(th-t1)/(th+459.69) *100
//results
printf("In case 1, Thermal efficiency = %.2f percent
   ",eta)
printf("\n In case 2, Thermal efficiency = %.2f
   percent",eta2)
```

Scilab code Exa 20.2 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
s2=1.5263
sfg=1.8456
sf=1.9782
h2=1201.1 //Btu/lb
hf=1106 //Btu/lb
hfg=1036.3 //Btu/lb
v=0.01616 //m^3/kg
p2=250 //psia
p1=1//psia
J=778
//calculations
x3=1+ (s2-sf)/sfg
h3=hf-(1-x3)*hfg
h4=69.7
Wp=v*144*(p2-p1)/J
h1=h4+Wp
etat=((h2-h3)-Wp)/(h2-h1) *100
eta2=(h2-h3)/(h2-h4)*100
//results
printf("\n In case 1, Efficieny = %.2f percent",etat
    )
printf("\n In case 2, Efficieny = %.2f percent",eta2
    )
```

Scilab code Exa 20.3 Enthalpy calculations

```
clc
clear
//Initalization of variables
p=40000 //kW
ef=0.98
rate=302000 //lb
```

```
s3=1.6001
h2=1490.1
loss=600
v=400 //ft/s
g=32.2 //ft/s^2
J=778
//calculations
out=p/(0.746*ef)
srate=rate/out
X=-(s3-1.9782)/1.8456
h3=1106 - X*1036.3
theoturb=h2-h3
intturb=(out+loss)*2544/rate
Ie=intturb/theoturb *100
h3d=h2-intturb-v^2 /(2*g*J)
hex=h3d+ v^2 /(2*g*J)
excess=rate*(hex-h3)
//results
printf("Steam rate = %.2f lb/shaft hp-hr",srate)
printf("\n Internal engine efficiency = %.1f percent
   ",Ie)
printf("\n Enthalpy of exhaust steam = %.1f Btu/lb",
   h3d)
printf("\n Excess heat to be removed = %d Btu/hr",
   excess)
disp("The answers are a bit different due to
   rounding off error in textbook")
```

Scilab code Exa 20.4 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
s2=1.5263
sf=1.6993
```

```
sfg=1.3313
hf=1164.1 //Btu/lb
hfg=945.3 //Btu/lb
h2=1201.1 //Btu/lb
h1=852.3 //Btu/lb
//calculations
X3=-(s2-sf)/sfg
h3=hf-X3*hfg
h4=218.82
h6=h4
h5=69.7
x=(h4-h5)/(h3-h5)
W= h2-h3+ (1-x)*(h3-h1)
Qs=h2-h4
eff=W/Qs *100
//results
printf("Thermal efficiency = %.2f percent",eff)
```

Scilab code Exa 20.5 Thermal efficiency calculation

```
clc
clear
//Initalization of variables
h6=157.933 //Btu/lb
s2=0.11626
sf=0.16594
sfg=0.14755
hf=139.095 //Btu/lb
hfg=126.98 //Btu/lb
h5=12.016 //Btu/lb
h2=1201.1 //Btu/lb
h1=69.7  //Btu/lb
w=348.8 //Btu/lb
m=0.0745 //lb
//calculations
```

```
x7=-(s2-sf)/sfg
h7=hf-x7*hfg
dh6=h6-h7
mr=(h7-h5)/(h2-h1)
work=w*m
tw=work+dh6
dh65=h6-h5
eff=tw/dh65 *100
//results
printf("Thermal efficiency = %.2f percent",eff)
```

Scilab code Exa 20.6 Heat transferred

```
clc
clear
//Initalization of variables
m=1 //lb
cp=0.26
t2=1800+460 //R
t1=400.95+460 //R
x=0.6
sink=100+460 //R
tm=2600+460 //R
//calculations
Q=m*cp*(t2-t1)
ds=m*cp*log((t2/t1))
tds=ds*(sink)
avail=Q-tds
hf=Q*x/(1-x)
av2=hf*(tm-sink)/(tm)
Qt=Q+hf
av=avail+av2
per=av/Qt *100
//results
printf("Available portion of heat transferred = %.1f
```

```
percent",per)
```

Chapter 21

Steam turbines

Scilab code Exa 21.1 Rate of flow calculation

```
clc
clear
//Initalization of variables
p2=190 //psia
p1=110 //psia
v1=2.456
k=1.3
J=778
A2=1.2 //in^2
//calculations
v2=v1*(p2/p1)^(1/k)
dh=k/(k-1) *144/J *(p2*v1-p1*v2)
Vex=223.8*sqrt(dh)
m=A2*Vex/(144*v2)
//results
printf("Rate of flow = %.2f lb/sec",m)
```

Scilab code Exa 21.2 Rate of flow calculation

```
clc
clear
//Initalization of variables
h1=1205.8 //Btu/lb
s2=1.5594
sf=1.5948
sfg=1.1117
hf=1188.9 //Btu/lb
hfg=883.2 //Btu/lb
vf=4.049
vfg=vf-0.018
k=1.3
J=778
A2=1.2 //in^2
//calculations
x2=-(s2-sf)/sfg
h2=hf-x2*hfg
v2=vf-x2*vfg
dh=h1-h2
Vex=223.8*sqrt(dh)
m=A2*Vex/(144*v2)
//results
printf("Rate of flow = %.2f lb/sec",m)
```

Scilab code Exa 21.3 Blade work and efficiency

```
clc
clear
//Initalization of variables
alp=14 //degrees
vb=900 //ft/s
v1=2200 //ft/s
g=32.17 //ft/s^2
//calculations
vrc=v1*cosd(alp) - vb
```

```
W=(2*vrc)/g *vb
eta=W/(v1^2/ (2*g)) *100
bet=atand(v1*sind(alp) /vrc)
//results
printf("Blade work = %d ft-lb/lb",W)
printf("\n Efficiency = %.1f percent",eta)
printf("\n Blade angle = %.1f degrees",bet)
disp('The answers are a bit different due to
    rounding off error')
```

Scilab code Exa 21.4 `Blade work and efficiency`

```
clc
clear
//Initalization of variables
v1=1234 //ft/s
v2=532 //ft/s
kb=0.92
alp=20 //degrees
ve=900 //ft/s
r=2200 //ft/s
g=32.17 //ft/s^2
//calculations
vr=sqrt(v1^2 +v2^2)
vr2=vr*kb
vrc=vr2*cosd(alp)
W=(v1+vrc)*ve/g
eta=W/(r^2 /(2*g)) *100
//results
printf("Blade work = %d ft-lb/lb",W)
printf("\n Efficiency = %.1f percent",eta)
disp('The answers are a bit different due to
    rounding off error')
```

Scilab code Exa 21.5 Blade reheat calculation

```
clc
clear
//Initalization of variables
v1=1234
v2=532
kb=0.92
alp=20 //degrees
ve=900
r=2200 //ft/s
g=32.17 //ft/s^2
J=778
w=67000
//calculations
vr=sqrt(v1^2 +v2^2)
vr2=vr*kb
vrc=vr2*cosd(alp)
reheat=(vr^2 - vr2^2 )/(2*g*J)
v22=sqrt((vrc-ve)^2 +(vr2*sind(alp))^2)
ein=r^2 /(2*g*J)
eout=w/J + v22^2 /(2*g*J)
re2=ein-eout
//results
printf("\n In case 1, Blade reheat = %.2f Btu/lb",
   reheat)
printf("\n In case 2, Blade reheat = %.1f Btu/lb",
   re2)
```

Scilab code Exa 21.6 Pressure calculation

```
clc
```

```
clear
//Initalization of variables
h1=1416.4
s1=1.6842
sf=1.7319
sfg=1.3962
fac=1.05
x2=0.7
//calculations
x6=-(s1-sf)/sfg
h6=1156.3 - x6*960.1
dh6=h1-h6
drop= fac*h6/2
h2=h1-drop
first=(1-x2)*drop
h3=1264.1 +first
h4=1157 //Btu/lb
fac2=(drop+153)/dh6
disp("From air charts,")
p2=107 //psia
//results
printf("Intermediate pressure = %d psia",p2)
```

Scilab code Exa 21.7 Shaft output and efficiency calculation

```
clc
clear
//Initalization of variables
reh=1.047
dh6=292.8
x2=0.7
flow=98000 //lb/hr
loss=200 //hp
//calculations
intwork=reh*dh6*x2
```

```
inthp=intwork*flow/2544
sout=inthp-loss
swork=sout*2544/flow
seff=swork/290.1 *100
//results
printf("Shaft output = %d hp",sout)
printf("\n Shaft engine efficiency = %.1f percent",
   seff)
```

Scilab code Exa 21.8 Pressure at Exit calculation

```
clc
clear
//Initalization of variables
h1=1416.4 //Btu/lb
h2=214.5 //Btu/lb
//calculations
hex=h1-h2
disp("From Air tables,")
pe=20 //psia
te=321.5 //F
//results
printf("Exit Pressure = %d psia",pe)
printf("\n Exit temperature = %.1f F",te)
```

Scilab code Exa 21.9 Steam rate calculation

```
clc
clear
//Initalization of variables
flow=98000 //lb/hr
loss=200 //hp
x= 0.11 //percent
```

```
shp=3000 //hp
//calculations
sflow = x*flow
sflow2= sflow + (flow-sflow)*shp/8060
srate=sflow2/shp
//results
printf("Steam rate required = %.2f lb/hp-hr",srate)
```

Chapter 22

Refrigeration

Scilab code Exa 22.1 `cop calculations`

```
clc
clear
//Initalization of variables
t1=45+460 //R
th=70+460 //R
t2=-200+460 //R
th2=100+460 //R
//calculations
cp1=t1/(th-t1)
cp2=th/(th-t1)
cp3=t2/(th2-t2)
cp4=th2/(th2-t2)
//results
printf("In case 1, Refrigerator cp = %.1f",cp1)
printf("\n In case 1, Heat pump cp = %.1f",cp2)
printf("\n In case 2, Refrigerator cp = %.3f",cp3)
printf("\n In case 2, Heat pump cp = %.3f",cp4)
```

Scilab code Exa 22.2 `cop calculations`

```
clc
clear
//Initalization of variables
h3=85.282 //Btu/lb
s2=0.16392
sf=0.16798
//calculations
sfg=sf-0.023954
x3=-(s2-sf)/sfg
h2=78.335 - x3*67.651
h4=26.365 //Btu/lb
h1=h4
ref=h2-h1
work=h3-h2
cp1=ref/work
h2d=78.355
h1d=26.365 //Btu/lb
h3d=87.495 //Btu/lb
ref2=h2d-h1d
work2=h3d-h2d
cp2=ref2/work2
//results
printf("\n Coefficient of performance in wet
    compression = %.3f",cp1)
printf("\n Coefficient of performance in dry
    compression = %.3f",cp2)
```

Scilab code Exa 22.3 Tonnage calculations

```
clc
clear
//Initalization of variables
h1=24.973 //Btu/lb
h2=81.436 //Btu/lb
cfm=200 //cfm
```

```
v2=0.77357
v3=3.8750
h4=72.913
//calculations
mass=cfm/v2
ref=h2-h1
tonnage=mass*ref/cfm
mass2=cfm/v3
ref2=h4-h1
tonnage2=mass2*ref2/cfm
//results
printf("In case 1,Tonnage = %.1f tons",tonnage)
printf("\n In case 2,Tonnage = %.2f tons",tonnage2)
```

Scilab code Exa 22.4 Refrigeration and cop calculation

```
clc
clear
//Initalization of variables
h2d=93.410 //Btu/lb
h1=80.740 //Btu/lb
x=0.75
PD=160
vol=0.82
v1=1.7213
w2=80.156
w1=27.3
//calculations
twork=h2d-h1
swork=twork/x
flow=PD*vol/v1
ref=flow*(w2-w1)/200
shp= flow*swork/42.4
cop=(w2-w1)/swork
//results
```

```
printf("Refrigeration = %.1f tons",ref)
printf("\n Shaft hp= %.1f hp",shp)
printf("\n Coefficient of performance = %.2f ",cop)
```

Scilab code Exa 22.5 cop calculation

```
clc
clear
//Initalization of variables
mc=3000 //lb
hv=1080.2 //Btu/lb
hfe=26.06 //Btu/lb
hfp=10.05 //Btu/lb
x=0.7
//calculations
mv=(mc*hfp-mc*hfe)/(hfe-hv)
dh=145.4 //Btu/lb
chp=dh*mv/(x*42.4)
cop=mc*(hfe-hfp)/(chp*42.4)
//results
printf("Coefficient of performace = %.2f ",cop)
```

Scilab code Exa 22.6 Power calculation

```
clc
clear
//Initalization of variables
loss=80000 //Btu/lb
t=560 //R
//calculations
ratio=t/68
power=loss/(ratio*2544)
//results
```

```
printf("Power = %.2f hp",power)
```

Scilab code Exa 22.7 Power calculation

```
clc
clear
//Initalization of variables
loss=2*80000 //Btu/lb
tb=72 //F
to=12 //F
to2=42 //F
tf=104+460 //R
//calculations
ratio=tf/(tf-460)
power=loss/(2544*ratio)
//results
printf("Power = %.1f hp",power)
```

Chapter 23

Gas vapor mixtures

Scilab code Exa 23.1 Specific humidity calculation

```
clc
clear
//Initalization of variables
pv=0.3631 //psia
pa=14.7 //psia
cp=0.24
tw=70 //F
td=80 //F
hv1=1096.6 //Btu/lb
hfb=38.06 //Btu/lb
//calculations
sh=0.622*pv/(pa-pv)
sh1=(cp*tw -cp*td + sh*1054.3)/(hv1-hfb)
//results
printf("Specific humidity = %.5f lb/lb",sh1)
```

Scilab code Exa 23.2 RH calculation

```
clc
clear
//Initalization of variables
rel=0.9
p1=0.0396 //psia
p2=0.3631 //psia
//calculations
act=rel*p1
RH=act/p2 *100
//results
printf("Relative humidity = %.1f percent",RH)
```

Scilab code Exa 23.3 Temperature calculation

```
clc
clear
//Initalization of variables
pa=14.2
rel=0.9
sh=0.012 //lb/lb
//calculations
pv=(pa*sh)/(0.622-sh)
sat=pv/rel
tf=64.34 //F
//results
printf("From steam tables, by interpolation, Final
    temperature = %.2f F",tf)
```

Scilab code Exa 23.4 Heat calculations

```
clc
clear
//Initalization of variables
```

```
pa=14.7
pv=0.0356
pv2=0.04
cp=0.24
t1=70 //F
t2=15 //F
R=53.35
V=8000 //ft^3
//calculations
sh=0.622*pv/(pa-pv2)
hm2=cp*t1+ sh*1092.3
hm1=cp*t2+sh*1068.4
Q=hm2-hm1
m=144*(pa-pv2)*V/(R*(t2+460))
Q2=Q*m
//results
printf("Heat added per min = %d Btu/min",Q2)
disp("The answer is a bit different due to rounding
   off error in the textbook")
```

Scilab code Exa 23.5 Temperature calculation

```
clc
clear
//Initalization of variables
rel=0.45
p1=0.4747 //psia
disp("From steam table data,")
//calculations
act=rel*p1
t2=54.94 //F
//results
printf("Temperature = %.2f F",t2)
```

Scilab code Exa 23.6 Tonnage calculation

```
clc
clear
//Initalization of variables
rel=0.6
p1=0.6982 //psia
pa=14.7 //psia
t1=90 //F
t2=54.94 //F
cp=0.24
p2=0.2136 //psia
vol=4000 //ft
t3=538 //R
R=53.35
//calculations
act1=rel*p1
sh1=0.622*act1/(pa-act1)
hm1=cp*t1+sh1*1100.9
sh2=0.622*p2/(pa-p2)
hm2=cp*t2+sh2*1085.8
con=sh1-sh2
enth=con*23.01
heat=hm1-hm2-enth
mass=144*(pa-p2)*vol/(R*(t3))
tonnage=mass*heat/200
//results
printf("Tonnage = %.1f tons ",tonnage)
```

Scilab code Exa 23.7 Tonnage calculation

```
clc
```

```
clear
//Initalization of variables
p1=0.541 //psia
rel=0.48
pa=14.7 //psia
t1=82 //F
cp=0.24
m1=0.75 //lb
m2=0.25 //lb
hm4=23.15 //Btu/lb
mass=291 //lb
//calculations
p2=rel*p1
sh=0.622*p2/(pa-p2)
hm1=cp*t1 + sh*1097.5
hm2=m1*hm1
hm3=m2*41.67
heat=hm2+hm3-hm4
tonnage=heat*mass/200
//results
printf("Tonnage = %.2f tons",tonnage)
```

Scilab code Exa 23.8 Volume calculation

```
clc
clear
//Initalization of variables
ce=0.8
t1=115 //F
tc=75 //F
td=85 //F
pa=14.7 //psia
p1=0.43 //psia
p2=0.9492 //psia
m1=159600
```

```
m2=31.65
R=53.35
T=545 //R
//calculations
t2=t1-ce*(t1-tc)
Pv=0.4298- (pa-p1)*(td-tc)/(2800- 1.3*tc)
sh1=0.622*Pv/(pa-Pv)
sh2=0.622 *p2/(pa-p2)
mda=m1/m2
V=mda*R*T/(144*(pa-Pv))
amount=mda*(sh2-sh1)
//results
printf("Volume of entering air = %d cfm",V)
printf("\n Amount of make up water = %.1f lb/min",
   amount)
disp('The answers are a bit different due to
   rounding off error in textbook')
```