# Scilab Textbook Companion for Introduction To Thermodynamics And Heat Transfer by D. A. Mooney[1]

Created by
Devika Raj Rachavelpula
Electronics and Communication Enginnering
Electronics Engineering
RVR n JC College of Engineering
College Teacher
Na
Cross-Checked by
Ganesh R

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# Book Description

**Title:** Introduction To Thermodynamics And Heat Transfer

**Author:** D. A. Mooney

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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 2

# Work

**Scilab code Exa 2.1** chapter 2 example 1

```
clc
//initialisation of variables
P= 100 //psia
V= 3 //cu ft
P1= 20 //psia
n= 1.4
//CALCULATIONS
V1= V*(P/P1)^(1/n)
W= (P1*V1*144-P*V*144)/(1-n)
//RESULTS
printf ('P dV work for this process= %.f ft lb',W)
```

**Scilab code Exa 2.2** chapter 2 example 2

```
clc
//initialisation of variables
W= 1 //hp
P= 69.4 //psia
```

```
V2= 3 //cu
V1= 1 //cu
//CALCULATIONS
Wb=  -W*33000
Wa= P*(V2-V1)*144
Q= Wa+Wb
//RESULTS
printf ('Total system work during the 1 minute
   period= %.f ft lb',Q)
```

**Scilab code Exa 2.3** chapter 2 example 3

```
clc
//initialisation of variables
r= 11 //in
l= 15 //in
A= 1.6 //in
l1= 2.4 //in
//CALCULATIONS
a= %pi*r^2/4
L= l/12
Pm= (A/l1)*80
W= a*L*Pm
//RESULTS
printf ('Net work done by the fluid in the cylinder=
    %.f ft lb',W)
```

# Chapter 3

# Temperature and Heat

**Scilab code Exa 3.1** chapter 3 example 1

```
clc
//initialisation of variables
T2w= 100 //F
T1w= 75 //F
cw= 1 //Btu/lb F
T2i= 100 //F
T1i= 500 //F
ci= 0.12 //Btu/lb F
mi= 1
//CALCULATIONS
Mw= -mi*ci*(T2i-T1i)/(cw*(T2w-T1w))
//RESULTS
printf ('Pounds of water needed per pound of iron= %
   .2f lb water/lb iron',Mw)
```

**Scilab code Exa 3.2** chapter 3 example 2

```
clc
```

```
//initialisation of variables
m=5 //lb
T1=1540 +460 //R
T2=540+460 //R
//CALCULATIONS
function [cp]=cp(T)
    cp=0.248+0.448*10^-8 *T*T
endfunction
Q=m*intg(T1,T2,cp)
//Results
printf ('Net heat transferred to the system = %.2f
    Btu',Q)
```

**Scilab code Exa 3.3** chapter 3 example 3

```
clc
//initialisation of variables
m= 10 //lb
cp= 0.180 //Btu/lb F
cp1= 0.235 //Btu/lb F
L= 15.8 //btu/lb
L1= 120 //btu/lb
T1= 70 //F
T2= 235 //F
T3= 832 //F
//CALCULATIONS
Qa= m*cp*(T2-T1)
Qb= m*L
Qc= m*cp1*(T3-T2)
Qd= m*L1
Q= Qa+Qb+Qc+Qd
//RESULTS
printf ('Heat required= %.f Btu',Q)
```

**Scilab code Exa 3.4** `chapter 3 example 4`

```
clc
//initialisation of variables
m= 40 //lb
m1= 10 //lb
cp= 1.00 //Btu/lb F
cp1= 0.501 //Btu/lb F
cp2= 0.092 //Btu/lb F
L= 143.3 //btu/lb
L1= 120 //btu/lb
T1= 22 //F
T2= 32 //F
T3= 40 //F
T4= 70 //F
//CALCULATIONS
Qa= cp1*(T2-T1)
Qb= L
Qc= cp*(T3-T2)
Qd= m*cp*(T3-T4)
mi= -Qd/(Qa+Qb+Qc)
Qe= m1*cp2*(T3-T4)
mi1= -Qe/(Qa+Qb+Qc)
//RESULTS
printf ('Ice weight= %.2f lb of ice',mi)
printf (' \n Additional ice required= %.3f lb of ice
    ',mi1)
```

# Chapter 5

# First Law of Thermodynamics

**Scilab code Exa 5.1** Chapter 5 example 1

```
clc
//initialisation of variables
p= 15 //psia
V2= 5 //cu
V1= 10 //cu
E= 34.7 //Btu
//CALCULATIONS
dE= -E-((p*(V2-V1)*144)/(778))
//RESULTS
printf ('Change in internal enenrgy of the gas= %.2f
    Btu',dE)
```

---

**Scilab code Exa 5.2** chapter 5 example 2

```
clc
//initialisation of variables
m= 2 //lb
T2= 35 //F
```

```
cv= 1.2 //Btu/lb F
Q= 34 //Btu
//CALCULATIONS
U= m*cv*T2
W= Q-U
//RESULTS
printf ('Change in internal enenrgy = %.f Btu',W)
```

**Scilab code Exa 5.3** chapter 5 example 3

```
clc
//initialisation of variables
p= 500 //psia
V2= 0.9278 //cu ft/lb
V1= 0.0197 //cu ft/lb
h= 1204.4 //Btu/lb
h1= 449.4 //Btu/lb
//CALCULATIONS
W= p*144*(V2-V1)
U= h-h1-(W/778)
//RESULTS
printf ('Change in internal enenrgy = %.1f Btu',U)
```

**Scilab code Exa 5.4** chapter 5 example 4

```
clc
//initialisation of variables
m= 3 //lb
V1= 6 //cu ft
p1= 75. //psia
p2= 15 //psia
n= 1.2
Q1= 30 //Btu
```

```
//CALCULATIONS
V2= V1*(p1/p2)^(1/n)
disp(V2)
U= (m/3)*(0.480*p2*V2+35-0.480*p1*V1-35)
W= (p2*V2-p1*V1)/(1-n)
Q= U+W
W1= Q1-U
//RESULTS
printf ('Change in internal enenrgy = %.1f Btu',U)
printf (' \n Work done = %.f Btu',W)
printf (' \n Heat generated = %.f Btu',Q)
printf (' \n Work done = %.f Btu',W1)
//The answers given in the textbook are wrong.please
    calculate them personally.
```

# Chapter 6

# Flow Procesess First law analysis

**Scilab code Exa 6.1** Chapter 6 example 1

```
clc
//initialisation of variables
u1= 1111.9 //Btu/lb
p= 170 //psia
v1= 2.675 //cu ft/lb
V1= 6000 //ft/min
g0= 32.2 //ft/sec^2
g= 32.2 //ft/sec^2
z= 10 //ft
Q= 1000//Btu/hr
u2= 914.6 //Btu/lb
p1= 3 //psia
v2= 100.9 //cu ft/lb
V2= 300 //ft/sec
g0= 32.2 //ft/sec^2
g= 32.2 //ft/sec^2
z1= 0 //ft
//CALCULATIONS
Wx= (u1+(p*v1*144/778)+((V1/60)^2/(2*g*778))+(z/778)
```

```
-(Q/2500)-u2-(p1*v2*144/778)-((V2^2)/(2*g*778)))
   *2500
//RESULTS
printf ('Poweroutput = %.f hp',Wx*0.000393014779)
//It is the conversion factor from btu/hr to hp
```

**Scilab code Exa 6.2** chapter 6 example 2

```
clc
//initialisation of variables
w1= 500 //lb/min
h1= 132.9 //Btu/lb
h2= 1150 //Btu/lb
h3= 180 //Btu/lb
//CALCULATIONS
w2= w1*(h3-h1)*60/(h2-h3)
//RESULTS
printf ('Steam supplied to the hater = %.f lb/hr',w2
   )
```

**Scilab code Exa 6.3** chapter 6 example 3

```
clc
//initialisation of variables
h1= 1227.6 //Btu/lb
h2= 1223.9 //Btu/lb
g= 32.2 //ft/sec^2
v1= 4.937 //cu ft/lb
d= 2/12 //in
A1=%pi*d^2 /4.
//CALCULATIONS
V1= sqrt((2*g*(h1-h2)*778)/((1.1)^2-1))
V2= 1.1*V1
```

```
w=A1*V1/v1
//RESULTS
printf ('Average velovity at section1 = %.f fps',V1)
printf (' \n Average velovity at section2 = %.f fps'
    ,V2)
printf ('\n rate of flow =%.2f lb/sec', w)
```

# Chapter 8

# Basic applications of the second law

**Scilab code Exa 8.1** Chapter 8 example 1

```
clc
//initialisation of variables
T1= 85 //F
T2= 50 //F
//CALCULATIONS
n= (T1-T2)/(T1+460)
n1= n*100
//RESULTS
printf ('Maximum thermal efficiency  = %.1f percent'
   ,n1)
```

---

**Scilab code Exa 8.2** chapter 8 example 2

```
clc
//initialisation of variables
T1= 1050 //F
```

```
T2= 90 //F
//CALCULATIONS
n= (T1-T2)/(T1+460)
n1= n*100
//RESULTS
printf ('Maximum thermal efficiency  = %.f percent',
   n1)
```

**Scilab code Exa 8.3** chapter 8 example 3

```
clc
//initialisation of variables
m= 1 //lb
cp= 0.240 //btu/lb F
T2= 150 //F
T1= 50 //F
//CALCULATIONS
S= m*cp*(log(460+T2)-log(460+T1))
//RESULTS
printf ('Entropy change = %.4f Btu/Fabs',S)
```

**Scilab code Exa 8.4** chapter 8 example 4

```
clc
//initialisation of variables
m= 1 //lb
cp= 0.240 //btu/lb F
T2= 150 //F
T1= 50 //F
//CALCULATIONS
S= m*cp*(log(460+T2)-log(460+T1))
//RESULTS
printf ('Entropy change = %.4f Btu/Fabs',S)
```

```
//This result is same as the above since change in
   entropy does not depend on the process involved
// but only on the initial and final states
```

**Scilab code Exa 8.5** chapter 8 example 5

```
clc
//initialisation of variables
Q= 826 //Btu/lb
T= 400 //F
T1= 1000 //F
T2= 2000 //F
//CALCULATIONS
Sw= Q/(T+460)
Sg= (Q/T1)*(log(T1+460)-log(T2+460))
S= Sw+Sg
//RESULTS
printf ('Total Entropy change = %.3f Btu/R',S)
```

**Scilab code Exa 8.6** chapter 8 example 6

```
clc
//initialisation of variables
Q= 826 //Btu/lb
T= 400 //F
T1= 1000 //F
T2= 2000 //F
T3= 80 //F
//CALCULATIONS
Sw= Q/(T+460)
Sg= (Q/T1)*(log(T1+460)-log(T2+460))
S= Sw+Sg
Q1= (T3+460)*S
```

```
Q2= Q+(T3+460)*Sg
n= Q1/Q2
n1= n*100
//RESULTS
printf ('Loss percent = %d ',n1+1)
```

# Chapter 10

# Tabulated properties Steam Tables

**Scilab code Exa 10.1** `Chapter 10 example 1`

```
clc
//initialisation of variables
p= 100//psia
vg= 4.432 //cu ft/lb
vf= 0.01744 //cu ft/lb
T= 327.8 //F
sfg= 1.1286 //Bu/lb R
//CALCULATIONS
Q=(T+460)*sfg
//RESULTS
printf ('Heat of vaourisation= %.f Btu/lb',Q)
```

---

**Scilab code Exa 10.2** `chapter 10 example 2`

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

```
S= 1.6315 //Btu/lb R
//CALCULATIONS
P= 70 //psia
t= 302.92 //F
h= 1180.6 //Btu/lb
//RESULTS
printf ('Pressure= %.2f Psia',P)
printf (' \n Temperature = %.2f F',t)
printf (' \n Enthalpy= %.1f Btu/lb',h)
```

**Scilab code Exa 10.3** chapter 10 example 3

```
clc
//initialisation of variables
T= 250 //F
hg= 1164.0 //Btu/lb
P= 29.825 //Psia
Vg= 13.821 //cu ft/lb
//CALCULATIONS
ug= hg-(P*Vg*144/778)
//RESULTS
printf ('Internal energy= %.1f Btu/lb',ug)
```

**Scilab code Exa 10.4** chapter 10 example 4

```
clc
//initialisation of variables
P= 100 //psia
n= 40
vf= 0.01774 //cu ft/lb
vg= 4.432 //cu ft/lb
hf= 298.4 //Btu/lb
hfg= 888.8 //Btu/lb
```

```
sg= 1.6026 //Btu/lb R
sfg= 1.1286 //Btu/lb R
//CALCULATIONS
vx= (n/100)*vf+(1-(n/100))*vg
hx= hf+(1-(n/100))*hfg
sx= sg-(n/100)*sfg
//RESULTS
printf ('Volume= %.2f cu ft/lb',vx)
printf (' \n Entropy = %.2f Btu/lb R',sx)
printf (' \n Enthalpy= %.1f Btu/lb',hx)
```

**Scilab code Exa 10.5** chapter 10 example 5

```
clc
//initialisation of variables
P= 100 //psia
n= 0.97
hf= 298.4 //Btu/lb
hfg= 888.8 //Btu/lb
hg= 1187.2 //Btu/lb
//CALCULATIONS
hx= hf+n*hfg
hx1= hg-(1-n)*hfg
//RESULTS
printf ('Enthalpy= %.f Btu/lb',hx)
printf (' \n Precise Enthalpy= %.1f Btu/lb',hx1)
```

**Scilab code Exa 10.6** chapter 10 example 6

```
clc
//initialisation of variables
P= 15 //psia
sx= 1.7050 //Btu/lb R
```

```
sg= 1.7549 //btu/lb R
sfg= 1.4415 //Bru/lb R
hg= 1150.8 //btu/lb
hfg= 969.7 //Btu/lb
vg= 26.29 //cu ft/lb
vfg= 26.27 //cu ft/lb
//CALCULATIONS
n= (sg-sx)/sfg
sx= sg-n*sfg
hx= hg-n*hfg
vx= vg-n*vfg
//RESULTS
printf ('Volume= %.2f cu ft/lb',vx)
printf (' \n Entropy = %.2f Btu/lb R',sx)
printf (' \n Enthalpy= %.1f Btu/lb',hx)
```

**Scilab code Exa 10.10** chapter 10 example 10

```
 clc
//initialisation of variables
T= 100 //F
P= 1000 //psia
dv= -5.1*10^-5 //cu ft/lb
dh= 2.70 //Btu/lb
vf= 0.01613 //cu ft/lb
hf= 67.97 //Btu/lb
//CALCULATIONS
h= dh+hf
v= dv+vf
//RESULTS
printf ('Volume= %.5f cu ft/lb',v)
printf (' \n Enthalpy= %.2f Btu/lb',h)
```

**Scilab code Exa 10.11** chapter 10 example 11

```
clc
//initialisation of variables
h1= 1183.2 //Btu/lb
hg= 1198.4 //Btu/lb
hfg= 843.0 //Btu/lb
//CALCULATIONS
n= 1-((hg-h1)/hfg)
//RESULTS
printf ('quality= %.3f ',n)
```

# Chapter 11

# Properties of Gases

**Scilab code Exa 11.1** Chapter 11 example 1

```
clc
//initialisation of variables
P= 15 //psia
T= 80 //F
m= 3 //lb
P1= 25 //psia
T1= 75 //F
//CALCULATIONS
r= (P*(460+T1))/(P1*(T+460))
m2= m/(1-r)
V2= (m2*55.16*(460+T1))/(P1*144)
//RESULTS
printf ('Volume of the apparatus= %.1f cu ft',V2)
```

**Scilab code Exa 11.2** chapter 11 example 2

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

```
R= 48.3 //ft lb/lb R
T= 100 //F
T1= 500 //F
T2= 1500 //F
k= 1.4
k1= 1.36
k2= 1.31
//CALCULATIONS
dc= R/778
cp= (k/(k-1))*dc
cv= cp/k
cp1= (k1/(k1-1))*dc
cv1= cp/k1
cp2= (k2/(k2-1))*dc
cv2= cp2/k2
//RESULTS
printf ('cp= %.3f Btu/lb R',cp)
printf (' \n cv= %.3f Btu/lb R',cv)
printf (' \n cp1= %.3f Btu/lb R',cp1)
printf (' \n cv1= %.3f Btu/lb R',cv1)
printf (' \n cp2= %.3f Btu/lb R',cp2)
printf (' \n cv2= %.3f Btu/lb R',cv2)
```

**Scilab code Exa 11.4** chapter 11 example 4

```
clc
//initialisation of variables
P= 10 //psia
P1= 100 //psia
T= 140 //F
k= 1.4
R= 55.16 //ft lb/lb R
//CALCULATIONS
dh= (k*R*(T+460)/(k-1))*((P/P1)^((k-1)/k)-1)
   *(72/56000)
```

```
//RESULTS
printf ('Enthalpy change= %.1f Btu/lb',dh)
```

**Scilab code Exa 11.5** `chapter 11 example 5`

```
clc
//initialisation of variables
P= 100 //psia
P1= 15 //psia
T= 2000 //F
k= 1.4
R= 53.34 //ft lb/lb R
cp= 0.240 //Btu/lb R
//CALCULATIONS
v1= (R*(T+460)/(P*144))*(P/P1)^(1/k)
disp(v1)
T1= (T+460)*(P1*v1/(P*(R*(T+460)/(P*144))))
dh= cp*(T1-T)
dv= v1-(R*(T+460)/(P*144))
disp('case 1')
printf ('change in volume = %.2f', dv)
disp('case 2')
T2=1500 //F
v2=R*(T+460)/(P*144)/0.241
disp(v2)
T2=(T2+460)*(P1*v2/(P*(R*(T2+460)/(P*144))))
deltah=0.276*(T2-460-T)
dv2=v2-(R*(T+460)/(P*144))
printf ('change in volume = %.2f cu ft/lb', dv2)
disp('At T1=2460 R, from table 1, case 3')
h1=634.34
pr1=407.3
pr2=pr1*P1/P
T2=1075 //F
h2=378.44
```

```
deltah=h2-h1
v2=53.34*(T2+460)/(P1*144)
disp(v2)
dv3=v2-(R*(T+460)/(P*144))
printf ('change in volume = %.2f cu ft/lb',dv3)
```

# Chapter 12

# Properties of Gaseous Mixtures

**Scilab code Exa 12.1** `Chapter 12 example 1`

```
clc
//initialisation of variables
P= 15.0 //psia
T= 55 //F
P1= 0.2141 //psia
ma= 29 //lb
mb= 18 //lb
P2= 0.2141 //psia
P3= 0.3631 //psia
//CALCULATIONS
dp= P-P1
r= (dp*ma)/(P1*mb)
r1= r/(r+1)
r2= 1/(r+1)
r4= r2/r1
P= P2/P3
//RESULTS
printf ('relative humidity= %.2f ',P)
printf (' \n specific humidity= %.4f lb vapour/lb
    air',r4)
```

**Scilab code Exa 12.2** chapter 12 example 2

```
clc
//initialisation of variables
h= 29.5 //in
n= 75
T= 80 //F
h1= 10 //in
mw= 0.380*18
ma= 14.47*29
d= 13.6 //kg/m^3
P= 0.5069 //psi
//CALCULATIONS
Pw= (n/100)*P
P= (h+(h1/d))*(0.491)
pa= P-Pw
r= mw/ma
//RESULTS
printf ('Pounds of water vapour enter the furnance
   per pound of dry air= %.4f lb vapour/lb air',r)
```

**Scilab code Exa 12.3** chapter 12 example 3

```
clc
//initialisation of variables
n= 0.5
T= 75 //F
P= 14.7 //psia
pg= 0.4298 //psia
pw= 0.2149 //psia
//CALCULATIONS
pw1= n*pg
```

```
pa= P-pw1
r= 0.622*pw/pa
//RESULTS
printf ('relative humidity= %.5f lb water/lb dry air
    ',r)
```

**Scilab code Exa 12.4** chapter 12 example 4

```
clc
//initialisation of variables
r2= 0.0078 //lb water /lb dry air
r1= 0.0032 //lb water /lb dry air
h2= 25.33 //Btu/lb
h1= 12.9 //Btu/lb
pg= 0.1217 //psia
p= 14.7 //psia
h3= 13 //Btu/lb
n= 60
t2=70
t1=40
cpa=0.240
R2= 0.00788 //lb/lb of dry sir
w1= 0.00477 //lb/lb of dry sir
//CALCULATIONS
disp('Method 1')
w= r2-r1
q= h2-h1-w*h3
printf ('In method 1, Enthalpy =%.2f Btu/lb of dry
    air',q)
disp('Method 2')
R1= 0.622*(n/100)*(pg/(p-pg))
R2=0.00788
w2=R2-R1
//All constants are obtained from steam tables
Q=cpa*(t2-t1)+R2*(1092.6)-R1*(1079.6) -w2*h3
```

```
printf ('In method 2, Enthalpy = %.2f btu/lb of dry
    air',Q)
```

**Scilab code Exa 12.5** chapter 12 example 5

```
clc
//initialisation of variables
P= 1//atm
n= 70
T= 75 //F
T1= 70 //F
r1= 0.0131 //lb water/lb dry air
r2= 0.0093 //lb water/lb dry air
h1= 32.36 //Btu/lb dry air
h2= 27.03 //Btu/lb dry air
hd2= 23.40 //Btu/lb dry air
hf= 23.4 //Btu/lb dry liquid
hg= 1094.5 //Btu/lb dry liquid
//CALCULATIONS
R1= r1-r2
Qc= hd2-h1+R1*hf
Qh= h2-hd2
x= R1*(hg-hf)
y= x/(-Qc)
//RESULTS
printf ('Fraction of heat removed in the coil= %.2f
    ',y)
```

# Chapter 13

# Vapor cycles

**Scilab code Exa 13.1** `Chapter 13 example 1`

```
clc
//initialisation of variables
P= 1 //psia
P1= 200 //psia
T= 750 //F
v3= 0.01614 //cu ft/lb
h1= 1399.2 //Bu/lb
h2= 976 //Btu/lb
h3= 69.7 //Btu/lb
//CALCULATIONS
dh= v3*(144/778)*(P1-P)
h4= h3+dh
Q1= h1-h4
Wt= h1-h2
Wp= h4-h3
n= (Wt-Wp)/Q1
w= 2545/Wt
//RESULTS
printf ('cycle efficency = %.3f ',n)
printf (' \n steam rate= %.2f lb steam per hphr',w)
```

**Scilab code Exa 13.2** chapter 13 example 2

```
clc
//initialisation of variables
wt= 8 //lb/hphr
h1= 1399.2 //Btu/lb
h2s= 976 //Btu/lb
h2= 976 //Btu/lb
//CACLAULATIONS
Wt= 2545/wt
nt= Wt/(h1-h2s)
h21= h1-Wt
//RESULTS
printf ('Engine efficency = %.3f ',nt)
printf (' \n state  of the exhaust steam= %.3f Btu/
   lb',h21)
```

---

**Scilab code Exa 13.3** chapter 13 example 3

```
clc
//initialisation of variables
h1=1474.5 //btu/lb
s1=1.5603 //btu/lb R
h2s=1277.5 //btu/lb
//Calculations and printfing
h2=h1-0.85*(h1-h2s)
printf ('h2= %.2f Btu/lb',h2)
h3=1522.4  //btu/lb
s3=1.7623 //btu/lb R
h4s=948 //btu/lb
h4=h3- 0.85*(h3-h4s)
printf ('\n h4= %.2f Btu/lb',h4)
```

```
h5=47.6 //btu/lb
h6=53.5 //btu/lb
disp('For the first rankine cycle')
h7s=840 //btu/lb
h7=h1-0.85*(h1-h7s)
printf ('h7= %.2f Btu/lb',h7)
disp('For the second rankine cycle')
h8=1493.2 //btu/lb
s8=1.6903 //btu/lb R
h9s=866 //btu/lb
h9=h8-0.85*(h8-h9s)
printf ('h9= %.2f Btu/lb',h9)
h11=51.5 //btu/lb
n1=0.401
n2=0.375
n3=0.366
e1=(n1-n2)/n2
printf ('\n Percentage Efficiency of reheat cycle
    compared to Rankine cycle for the first case = %
    .2f',e1*100)
e2=(n1-n3)/n3
printf ('\n Percentage Efficiency of reheat cycle
    compared to Rankine cycle for the second case = %
    .2f',e2*100)
```

**Scilab code Exa 13.4** chapter 13 example 4

```
clc
//initialisation of variables
h1= 1371 //Btu/lb
h2s= 1149 //Btu/lb
h3= 118 //Btu/lb
Q1= 1253 //Btu/lb
W= 156 //Btu/lb
Qw= 680 //Btu/lb
```

```
//CALCULATIONS
Qh= h1-W-h3
y= W+0.9*Qh
r= y/Q1
x= Qh+Qw
z= y/x
//RESULTS
printf ('Fraction of energy supplied = %.2f ',r)
printf (' \n Fraction of energy supplied= %.2f ',z)
```

# Chapter 14

# Combustion Processes First law analysis

**Scilab code Exa 14.1** Chapter 14 example 1

```
clc
//initialisation of variables
M= 114 //lb
Mo= 32 //lb
Mn= 28 //lb
Mc= 44 //lb
Mw= 18 //lb
//CALCULATIONS
Ma= (12.5*Mo+(12.5)*(79/21)*Mn)/114
//RESULTS
printf ('Theoritical air for combustion= %.1f lb air
    per lb C8H18 ',Ma)
```

**Scilab code Exa 14.4** chapter 14 example 4

```
clc
```

```
//initialisation of variables
mO2=1.33 //lb
mCO2=3.67 //lb
CvO2=0.155 //Btu/lb F
CvCO2=0.165 //Btu/lb F
Cc=0.170 //Btu/lb F
t2=1000 //F
tB=68 //F
t=300 //F
mC=1
mO=4
//Calculations
deltaE1=mO2*CvO2*(t2-tB) + mCO2*CvCO2*(t2-tB)
deltaE2=mC*Cc*(tB-t) + mO*CvO2*(tB-t)
E= -14087 //Btu
Q=deltaE1+E+deltaE2
//Results
printf ('Heat Transfer from the system = %.2f',Q)
```

**Scilab code Exa 14.5** chapter 14 example 5

```
clc
//initialisation of variables
HV=4344 //Btu/lb
m=56 //lb
R=1.986 //Btu/lb mol R
Tb=530 //R
//Calculations
HR=m*HV
Eb=-HR-R*Tb*(2-3)
printf ('Constant pressure heating value = %.1f Btu/
   lb formula wt',Eb)
```

**Scilab code Exa 14.6** chapter 14 example 6

```
clc
//initialisation of variables
mC=1 //lb
mO2=2.67 //lb
mN2=8.78 //lb
mCO2=3.67 //lb
mN2=8.78 //lb
tB=77 //F
deltaH=14087 //Btu/lb
CpCO2=0.196 //Btu/lb F
CpCO2f=0.3 //Btu/lb F
CpN2=0.248 //Btu/lb F
CpN2f=0.285 //Btu/lb F
//Calculations
t2= tB+ deltaH/(mCO2*CpCO2 + mN2*CpN2)
t2f=tB+ deltaH/(mCO2*CpCO2f + mN2*CpN2f)
//Results
printf ('In case 1, t2 = %.1f F',t2)
printf ('\n In case 2, t2f = %.1f F',t2f)
```

---

**Scilab code Exa 14.7** chapter 14 example 7

```
clc
//initialisation of variables
HR=14087 //Btu
HRC=3952 //Btu
x1=0.9
x2=0.05
//Calculations
HR1=x1*HR
HR2=x2*HRC
e=(HR2+HR1)/HR
//Results
```

```
printf ('Efficiency = %.3f',e)
```

**Scilab code Exa 14.8** `chapter 14 example 8`

```
clc
//initialisation of variables
h= 19500 //Btu
w= 700 //lb/hr
Q= 10240000
//CALCULATIONS
Q1= w*h
e= Q/Q1
//RESULTS
printf ('Efficiency= %.2f ',e)
```

# Chapter 15

# Gas cycles

**Scilab code Exa 15.1** Chapter 15 example 1

```
clc
//initialisation of variables
p= 15 //psia
p1= 75 //psia
T= 550 //R
T1= 1700 //R
k= 1.4
//CALCULATIONS
Ta= T*(p1/p)^((k-1)/k)
Tc= T1/((p1/p)^((k-1)/k))
cp= 0.24
Q1= cp*(T1-Ta)
Q2= cp*(Tc-T)
Wnet= Q1-Q2
n= Wnet/Q1
hb= 422.59 //Btu/lb
hc= 269.27 //Btu/lb
ha= 208.41 //Btu/lb
hd= 131.46 //btu/lb
Q1i= hb-ha
Q2i= hc-hd
```

```
Wnet1= Q1i-Q2i
n1= Wnet1/Q1i
//RESULTS
printf ('Efficiency = %.2f ',n)
printf ( 'Efficiency = %.3f ',n1)
```

**Scilab code Exa 15.2** chapter 15 example 2

```
clc
//initialisation of variables
p= 15 //psia
p1= 75 //psia
T= 550 //R
T1= 1700 //R
k= 1.4
n= 75
cp= 0.24
//CALCULATIONS
Ta= T*(p1/p)^((k-1)/k)
Tc= T1/((p1/p)^((k-1)/k))
Ta1= (n/100)*(Tc-Ta)+Ta
Tc1= Ta+Tc-Ta1
Q1= cp*(T1-Ta1)
Q2= cp*(Tc1-T)
Wnet= Q1-Q2
n1= Wnet/Q1
//CALCULATIONS
printf ('Efficiency = %.2f ',n1)
```

**Scilab code Exa 15.3** chapter 15 example 3

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

```
h1= 124.27 //Btu/lb
Pr1= 1.2147 //psia
r= 6
p4= 15 //psia
p1= 15 //psia
h2s= 197.5 //Btu/lb
Wnet= 48.9 //Btu/lb air
hs= 18500 //Btu/lb
wfbywa= 0.0146 //lb fuel/lb sir
W= 2545 //Btu/lb air
dh=-91.5 //Btu/lb
Wc= 91.5 //Btu/lb air
//CALCULATIONS
n= Wnet/(wfbywa*hs)
n1= W/Wnet
n2= Wc/Wnet
//RESULTS
printf ('Efficiency = %.3f ',n)
printf (' \n air rate= %.1f lb air/hphr',n1)
printf (' \n back work ratio= %.2f ',n2)
```

# Chapter 16

# Fluid Flow Nozzles and Turbines

**Scilab code Exa 16.1** chapter 16 example 1

```
clc
//initialisation of variables
h1=1279.1 //Btu/lb
s1=1.7085 //Btu/lb R
p1= 100 //psia
p2=10 //psia
h2=1091.7 //Btu/lb
s2=s1
V1=100 //fps
v2=36.41 //cu ft/lb
w=1 //lb/sec
//Calculations
a2=w*v2/(sqrt(V1*V1 + 2*24956.243*(h1-h2)))
printf ('Exit area = %.5f sq. ft',a2)
pt=0.55*p1
ht=1221.5 //Btu/lb
vt=8.841 //cu ft/lb
at=w*vt/(sqrt(V1*V1 + 2*24956.243*(h1-ht)))
printf ('\n Exit area in case 2 = %.5f sq. ft',at)
```

**Scilab code Exa 16.2** chapter 16 example 2

```
clc
//initialisation of variables
w=10000 //lb/hr
p0=250 //psia
T1=500 //F
Pf=1 //psia
vc=0.949
dc=1
h0=1263.4 //btu/lb
s0=1.5949 //btu/lb R
v2=276 //cu ft/lb
//Calculations
pt=0.55*p0
disp('from tables')
hts=1208.2 //btu/lb
vts=3.415 //cu ft/lb
h2s=891. //btu/lb
Vts=sqrt(2*32.174*778*(h0-hts))
w=w/3600 //lb/sec
cw=1
at=w*vts/(cw*Vts)
printf ('Throat area = %.5f ft^2',at)
V2=sqrt(2*32.174*778*(h0-h2s))
eta=0.9
h2=h0-eta*(h0-h2s)
a2s=w*v2/(cw*V2)
printf ('\n Exit area = %.5f ft^2',a2s)
```

**Scilab code Exa 16.3** chapter 16 example 3

```
clc
//initialisation of variables
k=1.4
ptbyp0=0.53
T0=800 //R
cp=778
R=0.0425864
P0=150 //psia
Pt=15 //psia
w=1 //lb/sec
cw=1.0043782
//Calculations
Pt2=ptbyp0*Pt
Tts=T0*(ptbyp0)^((k-1)/k)
Vts=sqrt(2*32.174*cp*0.24*(T0-Tts))
printf ('Exit velocity case 1= %.2f fps',Vts)
vts=3.12 //cu ft/lb
at=w*vts/(cw*Vts)
printf ('\n Throat Area = %.5f ft^2', at)
T2s=T0*(Pt/P0)^((k-1)/k)
eta=0.88
T2=T0-eta*(T0-T2s)
V2=sqrt(2*32.174*cp*0.24*(T0-T2))
printf ('\n Exit velocity = %.2f fps', V2)
v2=11.4 //cu ft/lb
a2=w*v2/V2
printf('\n Exit area = %.5f ft^2',a2)
```

# Chapter 17

# Gas compression

**Scilab code Exa 17.1** `chapter 17 example 1`

```
clc
//initialisation of variables
R= 53.31
T= 80 //F
P2= 90//psia
P1= 15 //psia
n= 1.4
n1= 1.3
cv= 0.171
//CALCULATIONS
Wk= (n/(n-1))*R*(T+460)*((P2/P1)^((n-1)/n)-1)
Wn= (n1/(n1-1))*R*(T+460)*((P2/P1)^((n1-1)/n1)-1)
Wt= R*(T+460)*log(P2/P1)
Q= cv*0.778*((n-n1)/(1-n1))*(T+460)*((P2/P1)^((n-1)/
   n)-1)
//RESULTS
printf ('Heat transfered from the airin each case= %
   .1f Btu/lb',Q)
```

**Scilab code Exa 17.2** chapter 17 example 2

```
clc
//initialisation of variables
R= 53.31
T= 80 //F
P2= 90//psia
P1= 15 //psia
n= 1.4
n1= 1.3
cv= 0.171
//CALCULATIONS
Wk= (n/(n-1))*R*(T+460)*((P2/P1)^((n-1)/n)-1)
Wn= (n1/(n1-1))*R*(T+460)*((P2/P1)^((n1-1)/n1)-1)
Wt= R*(T+460)*log(P2/P1)
nc= Wt/Wn
nc1=Wk/Wn
////RESULTS
printf ('Thermal effeciency= %.2f ',nc)
printf (' \n Isothermal effeciency= %.2f ',nc1)
```

**Scilab code Exa 17.3** chapter 17 example 3

```
clc
//initialisation of variables
R= 53.31
T= 80 //F
P2= 90//psia
P1= 15 //psia
n= 1.4
cp= 0.240
nc= 0.95
n1= 1.3
//CALCULATIONS
Wk= (n/(n-1))*(R)*(T+460)*((P2/P1)^((n-1)/n)-1)
```

```
Wx= -Wk/nc
dh= cp*(T+460)*((P2/P1)^((n1-1)/n1)-1)
Q= dh+(Wx/778)
//RESULTS
printf ('Heat transferred= %.1f Btu/lb ',Q)
```

**Scilab code Exa 17.4** chapter 17 example 4

```
clc
//initialisation of variables
P1= 83.5//psia
P2= 5 //psia
n= 3 //percent
n1= 1.25
//CALCULATIONS
nv= 1-(n/100)*((P1/P2)^(1/n1)-1)
nv1= 1-(n/100)*(sqrt((P1/P2)^(1/n1))-1)
//RESULTS
printf ('single-stage compression = %.3f ',nv)
printf (' \n two-stage compression = %.3f ',nv1)
```

# Chapter 18

# Refrigeration

**Scilab code Exa 18.1** chapter 18 example 1

```
clc
//initialisation of variables
T2 = 0 //F
T1= 76  //F
h1= 611.8 //Btu/lb
h4= 127.4 //Btu/lb
h2= 704.4 //Btu/lb
x= 10000 //Btu/hr
v1= 9.116 //cu ft/lb
n=70
//CALCULATIONS
CP= (T2+460)/(T1-T2)
CP1= (h1-h4)/(h2-h1)
w= (x/60)/(h1-h4)
PD=(w*v1)/(n/100)
//RESULTS
printf ('CP1 = %.2f ',CP)
printf (' \n CP2 = %.2f ',CP1)
printf (' \n PD = %.2f cu ft/min',PD)
```

# Chapter 19

# Heat Transmission

**Scilab code Exa 19.2** `chapter 19 example 2`

```
clc
//initialisation of variables
t= 8 //in
t1= 1 //in
k= 0.50 //Btu/hr ft F
k1= 0.02 //Btu/hr ft F
A= 1 //ft^2
T= 60 //F
T1= -20 //F
//CALCULATIONS
Rc= (t/12)/(k*A)
Rf= (t1/12)/(k1*A)
R= Rc+Rf
q= (T-T1)/R
T2= (T+(Rc/Rf)*T1)/(1+(Rc/Rf))
//RESULTS
printf ('Rate of heat flow= %.1f Btu/hr',q)
printf (' \n Temperature at the interface= %.1f F',
   T2)
```

**Scilab code Exa 19.3** chapter 19 example 3

```
clc
//initialisation of variables
h1= 2500 //Btu/sq ft hr F
r= 10 //in
t= 0.375 //in
Ts= 500 //F
Ta= 80 //F
r2= 5.375 //in
r1= 5 //in
r3= 7.375 //in
kp= 26 //Btu ft/hr
ki= 0.045 //Btu ft/hr
h1= 2500 //Btu/sq ft hr F
h3= 1.6 //Btu/sq ft hr F
r4= 14.750
//CALCULATIONS
R1= 1/(h1*%pi*(r/12))
Rp= log(r2/r1)/(2*%pi*kp)
Ri= log(r3/r2)/(2*%pi*ki)
R3= 1/(h3*%pi*(r4/12))
R0= R1+Rp+Ri+R3
T3=Ta+ (Ts-Ta)*R3/R0
//RESULTS
printf ('Temperature at the interface= %.6f F',T3)
```

**Scilab code Exa 19.4** chapter 19 example 4

```
clc
//initialisation of variables
wh= 40000 //lb.hr
```

```
cph= 0.5 //Btu/lb F
th1= 170 //F
th2= 120 //F
cpc= 1 //Btu/lb F
tc2= 140 //F
tc1= 100 //F
t= 140 //F
U= 120 //Btu/sq ft hr F
//CALCULATIONS
dh= t-th2
dc= tc2-tc1
wc= (wh*cph*(th1-th2))/(cpc*dc)
dtm= (-(tc1-th2)-(th1-tc2))/log((tc1-th2)/(-th1+tc2))
q= wh*cph*(th1-th2)
A= q/(U*dtm)
th2= ((wh/wc)*(cph/cpc)*th1+tc1)/((wh/wc)*(cph/cpc)+1)
wc1= (wh*cph*(th1-th2))/(cpc*(th2-tc1))
//RESULTS
printf ('Water flow rate= %.f lb/hr',wc)
printf (' \n Area of heat transfer surface= %.f sq ft',A)
printf (' \n temperature of the oil= %.f F',th2)
printf (' \n flow rate= %.f lb/hr',wc1*2)
```

**Scilab code Exa 19.5** chapter 19 example 5

```
clc
//initialisation of variables
Tw= 200 //F
Ta= 600 //F
V= 100 //fps
Di= 0.902 //in
d= 0.0375 //lb/cu ft
```

```
u= 0.000020 //lbm/sec
cp= 0.25 //Btu/lb F
k= 0.027 //Btu/sq ft hr
//CALCULATIONS
NRe= (Di*V*d)/(u*12)
Npr= 0.66
h= k*0.023*NRe^0.8*Npr^0.4*12/Di
//RESULTS
printf ('Film coefficient = %.1f Btu/sq ft hr F',h)
```

**Scilab code Exa 19.6** chapter 19 example 6

```
clc
//initialisation of variables
Tw= 200 //F
Ta= 600 //F
cpb= 0.25 // Btu/lb F
tf= 0.68
uf= 0.000017 //lbm/sec ft
D= 0.902 //in
V= 100 //fps
d= 0.0375 //lb/cu ft
//CALCULATIONS
Nre= (D/12)*V*d/uf
Npr= 0.68
h= cpb*V*3600*d*0.023/(Nre^0.2*Npr^(2/3))
//RESULTS
printf ('Film coefficient = %.1f Btu/sq ft hr F',h)
```

**Scilab code Exa 19.7** chapter 19 example 7

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

```
A1= 0.916 //ft^2
e1= 0.8
s= 0.173 //BTU s^-1 in^-2 R^-4
T= 200 //F
T1= 70 //F
D= 0.292
//CALCULATIONS
q= (A1/10^6)*e1*s*(((T+460)^4/100)-((T1+460)^4/100))
hr= q/(A1*(T-T1))
hc= 0.27*((T-T1)/D)^0.25
//RESULTS
printf ('Heat loss= %.2f Btu/hr',q)
printf (' \n hr= %.2f Btu/sq ft hr F',hr)
printf (' \n hc= %.2f Btu/sq ft hr F',hc)
```

**Scilab code Exa 19.8** chapter 19 example 8

```
clc
//initialisation of variables
T= 120 //F
T1= 1500 //F
A= 64/144
F= 0.86
Fe= 1
s= 0.173 //BTU s^-1 in^-2 R^-4
//CALCULATIONS
q= (A/10^6)*F*Fe*s*(((T1+460)^4/100)-((T+460)^4/100)
  )
//RESULTS
printf ('Heat loss= %.f Btu/hr',q)
```