Scilab Textbook Companion for Thermodynamics by Gaggioli and Obert[1]

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June 9, 2016

Book Description

Title: Thermodynamics

Author: Gaggioli and Obert

Publisher: Tata McGraw-Hill

Edition: 3

Year: 1987

ISBN: 0486603611

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

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Chapter 1

Survey of Units and Dimensions

Scilab code Exa 1.1 Force calculation

```
1  clc
2  clear
3  // Initialization of variables
4  gc =32.1739 //lbm ft/lbf s^2
5  m=10 //lbm
6  a=10 //ft/s^2
7  // calculations
8  F=m*a/gc
9  // results
10 printf("Force to accelerate = %.3f lbf",F)
```

Scilab code Exa 1.2 Force calculation

```
1  clc
2  clear
3  // Initialization of variables
```

```
4  gc =32.1739 // lbm ft / lbf s ^2
5  m =10 // lbm
6  a=gc // ft / s ^2
7  // calculations
8  F=m*a/gc
9  // results
10 printf (" Force to accelerate = %d lbf " ,F)
```

Scilab code Exa 1.3 velocity calculation

```
1  clc
2  clear
3  // Initialization of variables
4  v =88 // ft / s
5  // calculations
6  v2=v*3600/5280
7  // results
8  printf (" velocity = %d mph " ,v2)
```

Scilab code Exa 1.4 velocity calculation

```
1  clc
2  clear
3  // Initialization of variables
4  v =88 // ft / s
5  // calculations
6  v2=v*1/5280*3600
7  // results
8  printf (" velocity = %d mph " ,v2)
```

10

Scilab code Exa 1.5 Force calculation

```
1  clc
2  clear
3  //Initialization of variables
4  F=5e-9  //lbf/ft^2 hr
5  g=32.1739
6  //calculations
7  F2=F*3600*g
8  //results
9  printf("Force without dimensions = %.2e lbm/ft sec",
       F2)
```

Scilab code Exa 1.6 density calculation

```
1  clc
2  clear
3  //Initialization of variables
4  rho=62.305  //lbf/ft^2
5  g=32.1739  //ft/s^2
6  //calculations
7  gam=rho/g
8  //results
9  printf("Density of water in this system = %.3f lbf/
       ft^2",gam)
10 printf("\n Specific weight = %.3f lbf/ft^2",rho)
```

Chapter 2

Fundamental Concepts

Scilab code Exa 2.1 Potential energy calculation

```
1 clc
2 clear
3 // Initialization of variables
4 z=100 // ft
5 m=32.1739 //lbm
6 // calculations
7 PE=m*z
8 // results
9 printf("Potential energy = %.2f ft-lbm",PE)
```

Scilab code Exa 2.2 Absolute energy calculation

```
1 clc
2 clear
3 // Initialization of variables
4 m0=18.016 //lbm
5 gc=32.1739 //lbm ft/lbf sec^2
6 c=186000*5280
```

```
7  dU=94.4*10^6  //ft-lbf
8  //calculations
9  U=m0/gc *c^2
10 dm= -dU*gc/c^2
11 //results
12 printf("Absolute  energy  of  this  mixture = %.2e  ft-
      lbf",U)
13 printf("\n In  case  b,  there  is  no  change  in  mass")
14 printf("\n Change  in  mass = %.2e  lbm",dm)
15 disp("The  answers  are  a  bit  different  due  to
      rounding  off  error  in  textbook.")
```

Chapter 3

Temperature and the Ideal gas

Scilab code Exa 3.2 volume calculation

```
1  clc
2  clear
3  //Initialization of variables
4  p=14.7 //psia
5  R0=1545
6  t=460 +60 //R
7  //calculations
8  v=R0*t/(p*144)
9  //results
10 printf("Volume = %.1f ft^3/mol",v)
```

Scilab code Exa 3.3 density calculation

```
1  clc
2  clear
3  //Initialization of variables
4  p=20 //psia
5  R0=1545
```

```
 6  t =460 +100  //R
 7  M =28
 8  // calculations
 9  v = R0 * t /( p *144* M )
10  rho =1/ v
11  // results
12  printf (" density  of  nitrogen  = %.4 f  lbm / ft ^3" , rho )
```

Chapter 5

The first law and the dynamic open system

Scilab code Exa 5.2 work done and power calculation

```
1  clc
2  clear
3  //Initialization of variables
4  rate= 5 //lbm/sec
5  Q=50 //Btu/s
6  h2=1020 //Btu/lbm
7  h1=1000 //Btu/lbm
8  V2=50 //ft/s
9  V1=100 //ft/s
10 J=778
11 g=32.2 //ft/s^2
12 gc=g
13 Z2=0
14 Z1=100 //ft
15 //calculations
16 dw=Q/rate -(h2-h1) -(V2^2- V1^2)/(2*gc*J) -g/gc *(Z2
     -Z1)/J
17 power=dw*rate
18 //results
```

```
19 printf ("work done by the system = %.1 f Btu/lbm", dw)
20 printf ("\n Power = %.1 f Btu/s", power )
```

Scilab code Exa 5.3 Area calculation

```
1 clc
2 clear
3 //Initialization of variables
4 V=100 //ft/s
5 v=15 //lbm/ft^3
6 m=5 //lbm/s
7 //calculations
8 A=m*v/V
9 //results
10 printf ("Area of inlet pipe = %.2 f ft^2", A)
```

Scilab code Exa 5.4 Temperature calculation

```
1 clc
2 clear
3 //Initialization of variables
4 P=100 //psia
5 //calculations
6 disp ("From table B-4")
7 h=1187.2 //Btu/lbm
8 t1=328 //F
9 t2=540 //F
10 dt=t2-t1
11 //results
12 printf ("Final temperature of the steam = %d F", t2)
13 printf ("\n Change in temperature = %d F", dt)
```

Chapter 7

The Second law

Scilab code Exa 7.2 Entropy and efficiency calculation

```
1  clc
2  clear
3  //Initialization of variables
4  cv=0.175 //Btu/lbm R
5  R0=1.986
6  M=29
7  T2=1040 //R
8  T1=520 //R
9  //calculations
10 cp=cv+R0/M
11 sab=cv*log(T2/T1)
12 sac=cp*log(T2/T1)
13 dqab=cv*(T2-T1)
14 dqca=cp*(T1-T2)
15 dqrev=T2*(sac-sab)
16 eta=(dqab+dqrev+dqca)/(dqab+dqrev)
17 //results
18 printf("Entropy in ab part = %.4f Btu/lbm R",sab)
19 printf("\n Entropy in ac part = %.4f Btu/lbm R",sac)
20 printf("\n Efficiency = %.2f percent",eta*100)
21 disp("The answers are a bit different due to
```

18

Scilab code Exa 7.3 Entropy calculation

```
1  clc
2  clear
3  //Initialization of variables
4  tc=32 //F
5  th=80 //F
6  mw=5 //lbm
7  mi=1 //lbm
8  P=14.7 //psia
9  cp=1
10 //calculations
11 t= (-144*mi+tc*mi+th*mw)/(mw+mi)
12 ds1=144/(tc+460)
13 ds2=cp*log((460+t)/(460+tc))
14 dsice=ds1+ds2
15 dswater=mw*cp*log((t+460)/(460+th))
16 ds=dsice+dswater
17 //results
18 printf("Change in entropy of the process = %.4f Btu/
      R",ds)
19 disp("The answer is a bit different due to rounding
      off error in textbook")
```

Scilab code Exa 7.4 Energy calculations

```
1  clc
2  clear
3  //Initialization of variables
4  cp=1
5  T2=60 //F
```

```
6  T1=100 //F
7  ta=32 //F
8  //calculations
9  dq=cp*(T2-T1)
10 ds=cp*log((460+T2)/(460+T1))
11 dE=dq-ds*(ta+460)
12 dec=dq-dE
13 //results
14 printf("Change in available energy = %.1f Btu/lbm",
       dE)
15 printf("\n The available energy of the isolated
       system decreased in the amount of %.1f Btu/lbm",
       dec)
16 disp("The answer is a bit different due to rounding
       off error in textbook")
```

Chapter 8

Second and Third law topics

Scilab code Exa 8.1 PvsS calculation

```
1  clc
2  clear
3  //Initialization of variables
4  P=500  //psia
5  T=700  //F
6  J=778
7  //calculations
8  dpds=1490 *144/J
9  //results
10 printf("dp by ds at constant volume = %d F/ft^3/lbm"
       ,dpds)
11 disp("The answer is a bit different due to rounding
       off error in textbook")
```

Scilab code Exa 8.2 Thermal efficiency calculation

```
1  clc
2  clear
```

21

```
 3 // Initialization of variables
 4 cp=0.25 //Btu/lbm R
 5 T0=520 //R
 6 T1=3460 //R
 7 // calculations
 8 dq=cp*(T0-T1)
 9 ds=cp*log(T0/T1)
10 dE=dq-T0*ds
11 eta=dE/dq
12 // results
13 printf("Thermal efficiency = %.1f percent",eta*100)
```

Scilab code Exa 8.3 Loss of available energy calculation

```
 1 clc
 2 clear
 3 // Initialization of variables
 4 cp=0.25 //Btu/lbm R
 5 T0=520 //R
 6 T1=3460 //R
 7 dG=21069 //Btu/lbm
 8 dH=21502 //Btu/lbm
 9 // calculations
10 dq=cp*(T0-T1)
11 ds=cp*log(T0/T1)
12 dE=dq-T0*ds
13 eta=dE/dq
14 dw=eta*dH
15 de=-dG+dw
16 // results
17 printf("Loss of available energy = %d Btu/lbm",de)
18 disp("The answer is a bit different due to rounding
      off error in textbook")
```

Chapter 9

Properties of the pure substance

Scilab code Exa 9.1 Internal energy calculation

```
1  clc
2  clear
3  //Initialization of variables
4  T=32  //F
5  m=1  //lbm
6  J=778.16
7  //calculations
8  disp("From steam tables ,")
9  hf=0
10 p=0.08854  //psia
11 vf=0.01602  //ftˆ3/lbm
12 u=hf-p*144*vf/J
13 //results
14 printf("Internal energy = %.7f Btu/lbm",u)
```

Scilab code Exa 9.2 Entropy calculation

```
1  clc
2  clear
3  //Initialization of variables
4  P=40 //psia
5  //calculations
6  disp("from steam tables,")
7  hf=200.8 //Btu/lbm
8  hg=27 //Btu/lbm
9  T=495  //R
10 ds=(hf-hg)/T
11 //results
12 printf("Change in entropy = %.3f Btu/lbm R",ds)
```

Scilab code Exa 9.3 Enthalpy calculation

```
1  clc
2  clear
3  //Initialization of variables
4  x=0.35
5  T=18 //F
6  //calculations
7  disp("From table B-14,")
8  hf=12.12 //Btu/lbm
9  hg=80.27 //Btu.lbm
10 hfg=-hf+hg
11 h=hf+x*hfg
12 //results
13 printf("specific enthalpy = %.1f Btu/lbm",h)
```

Scilab code Exa 9.4 Heat calculation

```
1  clc
2  clear
```

```
 3  // Initialization  of  variables
 4  x=0.35
 5  T=18  //F
 6  T2=55.5  //F
 7  // calculations
 8  disp("From  table  B-14,")
 9  hf=12.12  //Btu/lbm
10  hg=80.27  //Btu.lbm
11  hfg=-hf+hg
12  h=hf+x*hfg
13  h2=85.68  //Btu/lbm
14  dh=h2-h
15  // results
16  printf("Heat  required  =  %.2f  Btu/lbm",dh)
```

Scilab code Exa 9.5 Enthalpy and Quality calculation

```
 1  clc
 2  clear
 3  // Initialization  of  variables
 4  P=1460  // psia
 5  T=135  //F
 6  P2=700  // psia
 7  // calculations
 8  disp("From  mollier  chart ,")
 9  h=120  //Btu/lbm
10  x=0.83
11  // results
12  printf("enthalpy  =  %d  Btu/lbm",h)
13  printf("\n  Qulaity  =  %.2f",x)
```

Scilab code Exa 9.6 Heat calculation

25

```
1  clc
2  clear
3  //Initialization of variables
4  m=1 //lbm
5  P1=144 //psia
6  P2=150 //psia
7  T1=360 //F
8  J=778.16
9  //calculations
10 disp("From table 3,")
11 v1=3.160 //ft^3/lbm
12 h1=1196.5 //Btu/lbm
13 u1=h1-P1*144*v1/J
14 h2=1211.4 //Btu/lbm
15 u2=h2-P2*144*v1/J
16 dq=u2-u1
17 //results
18 printf("Heat transferred = %.1f Btu/lbm",dq)
```

Scilab code Exa 9.7 Work calculation

```
1  clc
2  clear
3  //Initialization of variables
4  T1=100 //F
5  P2=1000 //psia
6  x=0.6
7  J=778.16
8  //calculations
9  disp("From table 3,")
10 v=0.01613 //ft^3/lbm
11 P1=0.9 //psia
12 wrev=-v*(P2-P1)*144/J
13 dv=0.000051 //ft^3/lbm
14 wcomp=(P2+P1)/2 *dv*144/J
```

```
15  wact=wrev/x
16  // results
17  printf("Work done = %.1 f Btu/lbm",wrev)
18  printf("\n In case 2, work required = %.1 f Btu/lbm",
        wact)
```

Scilab code Exa 9.8 Heat calculation

```
1  clc
2  clear
3  // Initialization of variables
4  pa=1000 //atm
5  ta=100 //F
6  // calculations
7  hf=67.97 //Btu/lbm
8  w=3 //Btu/lbm
9  ha=hf+w
10 disp("from steam table 2,")
11 hc=1191.8 //Btu/lbm
12 qrev=hc-ha
13 // results
14 printf("Heat transferred = %.1 f Btu/lbm",qrev)
```

Scilab code Exa 9.9 Work done calculation

```
1  clc
2  clear
3  // Initialization of variables
4  P1=144 // psia
5  T1=400 //F
6  y=0.7
7  // calculations
8  disp("From steam tables ,")
```

```
9  h1 =1220.4  //Btu/lbm
10 s1 =1.6050  //Btu/lbm R
11 s2 =1.6050  //Btu/lbm R
12 P2 =3  // psia
13 sf =0.2008  //Btu/lbm R
14 sfg =1.6855  //Btu/lbm R
15 x =( s1 - sf ) / sfg
16 hf =109.37  //Btu/lbm
17 hfg =1013.2  //Btu /;bm
18 h2 = hf + x * hfg
19 work = h1 - h2
20 dw = y * work
21 h2d = h1 - dw
22 // results
23 printf ( " Work  done  = %d  Btu/lbm " , work )
24 printf ( " \n  work  done  in  case  2  = %.1 f  Btu/lbm " , dw )
25 printf ( " \n  Final  state  pressure  = %d  psia " , P2 )
26 disp ( " The  answer  is  a  bit  different  due  to  rounding
        off  error  in  textbook " )
```

Scilab code Exa 9.10 Quality calculation

```
1  clc
2  clear
3  // Initialization  of  variables
4  pb =14.696  // psia
5  pa =150  // psia
6  tb =300  //F
7  // calculations
8  disp ( " From  steam  tables , " )
9  hb =1192.8  //Btu/lbm
10 ha = hb
11 hf =330.51  //Btu/lbm
12 hfg =863.6  //Btu/lbm
13 x =( ha - hf ) / hfg
```

```
14  // results
15  printf("Quality of wet steam = %.1f percent",x*100)
```

Chapter 10

The Pvt relationships

Scilab code Exa 10.1 Pressure calculations

```
1
2 clc
3 clear
4 //Initialization of variables
5 m=1 //lbm
6 T1=212+460 //R
7 sv=0.193 //ft^3/lbm
8 M=44
9 a=924.2 //atm ft^2 /mole^2
10 b=0.685 //ft^3/mol
11 R=0.73 //atm ft^3/R mol
12 //calculations
13 v=sv*M
14 p=R*T1/v
15 p2=R*T1/(v-b) -a/v^2
16 //results
17 disp("For ideal gas case, Table B-6 and for
       vanderwaals case, Table B-8 have been used")
18 printf("\n In vanderwaals equation, pressure = %.1 f
       atm",p2)
19 printf("\n In ideal gas case, pressure = %.1 f atm",p
```

)

Scilab code Exa 10.2 volume calculation

```
1  clc
2  clear
3  //Initialization of variables
4  m=1  //lbm
5  p=50.9  //atm
6  t=212+460  //R
7  R=0.73
8  //calculations
9  pc=72.9  //atm
10 tc=87.9 +460  //R
11 pr=p/pc
12 Tr=t/tc
13 z=0.88
14 v=z*R*t/p
15 //results
16 printf("volume = %.3f ft^3/mole",v)
```

Scilab code Exa 10.3 Pressure calculations

```
1  clc
2  clear
3  //Initialization of variables
4  t=212+460  //R
5  v=0.193  //ft^3/lbm
6  M=44
7  R=0.73
8  //calculations
9  tc=87.9+460  //F
10 zc=0.275
```

```
11  vc=1.51  //ft^3/mol
12  tr=t/tc
13  vr=v*M/vc
14  vrd=vr*zc
15  z=0.88
16  p=z*R*t/(M*v)
17  //results
18  printf("Pressure = %.1f atm",p)
```

Chapter 11

The Ideal gas and mixture relationships

Scilab code Exa 11.1 Work calculation

```scilab
1  clc
2  clear
3  // Initialization of variables
4  n=1.3
5  T1=460+60  //R
6  P1=14.7  // psia
7  P2=125  // psia
8  R=1545
9  M=29
10  // calculations
11  T2=T1*(P2/P1)^((n-1)/n)
12  wrev=R/M *(T2-T1)/(1-n)
13  // results
14  printf("Work done = %d ft-lbf/lbm",wrev)
15  disp("The answer is a bit different due to rounding
        off error in textbook")
```

Scilab code Exa 11.2 Kinetic energy calculation

```
1  clc
2  clear
3  // Initialization of variables
4  P2=10 // psia
5  P1=100 // psia
6  T1=900 //R
7  w=50 //Btu/lbm
8  k=1.39
9  cp=0.2418
10 // calculations
11 T2=T1*(P2/P1)^((k-1)/k)
12 T2=477
13 KE=-w-cp*(T2-T1)
14 // results
15 printf("Change in kinetic energy = %.1f Btu/lbm",KE)
```

Scilab code Exa 11.3 Temperature calculation

```
1  clc
2  clear
3  // Initialization of variables
4  T1=900 //R
5  P1=100 // psia
6  P2=10 // psia
7  // calculations
8  disp("From table B-9")
9  pr1=8.411
10 pr2=pr1*P2/P1
11 T2=468 //R
12 // results
13 printf("Final temperature = %d R ",T2)
```

Scilab code Exa 11.4 Temperature work and Enthalpy calculations

```
1  clc
2  clear
3  //Initialization of variables
4  cr=6
5  p1=14.7 //psia
6  t1=60.3 //F
7  M=29
8  R=1.986
9  //calculations
10 disp("from table b-9")
11 vr1=158.58
12 u1=88.62 //Btu/lbm
13 pr1=1.2147
14 vr2=vr1/cr
15 T2=1050 //R
16 u2=181.47 //Btu/lbm
17 pr2=14.686
18 p2=p1*(pr2/pr1)
19 dw=u1-u2
20 h2=u2+T2*R/M
21 //results
22 printf("final temperature = %d R",T2)
23 printf("\n final pressure = %.1f psia",p2)
24 printf("\n work done = %.2f Btu/lbm",dw)
25 printf("\n final enthalpy = %.1f Btu/lbm",h2)
```

Scilab code Exa 11.5 Weight calculations

```
1  clc
2  clear
```

```
3  //Initialization of variables
4  m1=10  //lbm
5  m2=15  //lnm
6  p=50  //psia
7  t=60+460  //R
8  M1=32
9  M2=28.02
10 R0=10.73
11 //calculations
12 n1=m1/M1
13 n2=m2/M2
14 x1=n1/(n1+n2)
15 x2=n2/(n1+n2)
16 M=x1*M1+x2*M2
17 R=R0/M
18 V=(n1+n2)*R0*t/p
19 rho=p/(R0*t)
20 rho2=M*rho
21 p1=x1*p
22 p2=x2*p
23 v1=x1*V
24 v2=x2*V
25 //results
26 disp("part a")
27 printf("Mole fractions of oxygen and nitrogen are %
       .3f and %.3f respectively",x1,x2)
28 disp("part b")
29 printf("Average molecular weight = %.1f ",M)
30 disp("part c")
31 printf("specific gas constant = %.4f psia ft^3/lbm R
       ",R)
32 disp("part d")
33 printf("volume of mixture = %.1f ft^3",V)
34 printf("density of mixture is %.5f mole/ft^3 and %.2
       f lbm/ft^3",rho,rho2)
35 disp("part e")
36 printf("partial pressures of oxygen and nitrogen are
        %.2f psia and %.2f psia respectively" ,p1,p2)
```

```
37  clc
38  clear
39  //Initialization of variables
40  m1=10  //lbm
41  m2=15  //lnm
42  p=50  //psia
43  t=60+460  //R
44  M1=32
45  M2=28.02
46  R0=10.73
47  //calculations
48  n1=m1/M1
49  n2=m2/M2
50  x1=n1/(n1+n2)
51  x2=n2/(n1+n2)
52  M=x1*M1+x2*M2
53  R=1545/M
54  V=(n1+n2)*R0*t/p
55  rho=p/(R0*t)
56  rho2=M*rho
57  p1=x1*p
58  p2=x2*p
59  v1=x1*V
60  v2=x2*V
61  pt=p1+p2
62  vt=v1+v2
63  //results
64  disp("part a")
65  printf("Mole fractions of oxygen and nitrogen are %
        .3f and %.3f respectively",x1,x2)
66  disp("part b")
67  printf("Average molecular weight = %.1f ",M)
68  disp("part c")
69  printf("specific gas constant = %.4f lbf ft/lbm R",R
        )
70  disp("part d")
71  printf("volume of mixture = %.1f ft^3",V)
72  printf("\n density of mixture is %.5f mole/ft^3 and
```

```
        %.3 f  lbm/ ft ^3" , rho , rho2 )
73  disp ( " part  e " )
74  printf ( " partial  pressures  of  oxygen  and  nitrogen  are
        %.2 f  psia  and  %.2 f  psia  respectively "  , p1 , p2 )
75  printf ( " \n  partial  volumes  of  oxygen  and  nitrogen
        are  %.2 f  ft ^3  and  %.2 f  ft ^3  respectively " , v1 , v2 )
76  printf ( " \n  Net  partial  pressure  in  case  of  oxygen  =
        %.2 f  psia " , pt )
77  printf ( " \n  Net  partial  volume  =%.2 f  ft ^3 " , vt )
```

Scilab code Exa 11.6 Analysis calculations

```
 1
 2  clc
 3  clear
 4  // Initialization  of  variables
 5  m1 =5.28
 6  m2 =1.28
 7  m3 =23.52
 8  // calculations
 9  m=m1+m2+m3
10  x1=m1/m
11  x2=m2/m
12  x3=m3/m
13  C=12/44  *m1/  m
14  O=(32/44  *m1  +  m2 )/m
15  N=m3/m
16  sum1 =(x1+x2+x3 )*100
17  sum2 =(C+N+O )*100
18  // results
19  printf ( " From  gravimetric  analysis ,  co2  =  %.1 f
        percent  ,  o2  =  %.1 f  percent  and  n2  =  %.1 f  percent
        " , x1 *100 , x2 *100 , x3 *100)
20  printf ( " \n  From  ultimate  analysis ,  co2  =  %.2 f
        percent  ,  o2  =  %.2 f  percent  and  n2  =  %.2 f  percent
```

```
     ",C*100,O*100,N*100)
21 printf("\n Sum in case 1 = %.1f percent",sum1)
22 printf("\n Sum in case 2 = %.1f percent",sum2)
```

Scilab code Exa 11.7 Entropy calculations

```
1  clc
2  clear
3  //Initialization of variables
4  x1=1/3
5  n1=1
6  n2=2
7  x2=2/3
8  p=12.7  //psia
9  cp1=7.01  //Btu/mole R
10 cp2=6.94  //Btu/mole R
11 R0=1.986
12 T2=460+86.6  //R
13 T1=460  //R
14 p0=14.7  //psia
15 //calculations
16 p1=x1*p
17 p2=x2*p
18 ds1= cp1*log(T2/T1) - R0*log(p1/p0)
19 ds2= cp2*log(T2/T1) - R0*log(p2/p0)
20 S=n1*ds1+n2*ds2
21 //results
22 printf("Entropy of mixture = %.2f Btu/R",S)
23 printf("\n the answer given in textbook is wrong.
       please check using a calculator")
```

Scilab code Exa 11.8 Internal energy and entropy calculations

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```
1  clc
2  clear
3  //Initialization of variables
4  c1=4.97 //Btu/mol R
5  c2=5.02 //Btu/mol R
6  n1=2
7  n2=1
8  T1=86.6+460 //R
9  T2=50+460 //R
10 //calculations
11 du=(n1*c1+n2*c2)*(T2-T1)
12 ds=(n1*c1+n2*c2)*log(T2/T1)
13 //results
14 printf("Change in internal energy = %d Btu",du)
15 printf("\n Change in entropy = %.3f Btu/R",ds)
```

Scilab code Exa 11.9 Pressure and temperature calculations

```
1  clc
2  clear
3  //Initialization of variables
4  n1=1
5  n2=2
6  c1=5.02
7  c2=4.97
8  t1=60 //F
9  t2=100 //F
10 R0=10.73
11 p1=30 //psia
12 p2=10 //psia
13 //calcualtions
14 t=(n1*c1*t1+n2*c2*t2)/(n1*c1+n2*c2)
15 V1= n1*R0*(t1+460)/p1
16 V2=n2*R0*(t2+460)/p2
17 V=V1+V2
```

```
18  pm=(n1+n2)*R0*(t+460)/V
19  //results
20  printf("Pressure of mixture = %.1f psia",pm)
21  printf("\n Mixing temperature = %.1f F",t)
```

Scilab code Exa 11.10 Entropy calculations

```
1  clc
2  clear
3  //Initialization of variables
4  T2=546.6 //R
5  T1=520 //R
6  T3=560 //R
7  v2=1389.2
8  v1=186.2
9  R0=1.986
10 c1=5.02
11 c2=4.97
12 n1=1
13 n2=2
14 v3=1203
15 //calculations
16 ds1=n1*c1*log(T2/T1) + n1*R0*log(v2/v1)
17 ds2=n2*c2*log(T2/T3)+n2*R0*log(v2/v3)
18 ds=ds1+ds2
19 ds3=n1*c1*log(T2/T1)+n2*c2*log(T2/T3)
20 ds4=n2*R0*log(v2/v3)+ n1*R0*log(v2/v1)
21 dss=ds3+ds4
22 //results
23 printf("Change in  entropy for gas 1 = %.3f Btu/R",
       ds1)
24 printf("\n Change in  entropy for gas 1 = %.3f Btu/R
       ",ds2)
25 printf("\n Net change in entropy = %.3f Btu/R",ds)
26 printf("\n In case 2, change in entropy = %.3f Btu/R
```

```
      ",dss)
27  disp("The answer is a bit different due to rounding
      off error in the textbook")
```

Scilab code Exa 11.11 Entropy calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  m1=1  //lbm
 5  m2=0.94  //lbm
 6  M1=29
 7  M2=18
 8  p1=50  //psia
 9  p2=100  //psia
10  t1=250 +460  //R
11  R0=1.986
12  cpa=6.96
13  cpb=8.01
14  //calculations
15  xa = (m1/M1)/((m1/M1)+ m2/M2)
16  xb=1-xa
17  t2=t1*(p2/p1)^(R0/(xa*cpa+xb*cpb))
18  d=R0/(xa*cpa+xb*cpb)
19  k=1/(1-d)
20  dsa=cpa*log(t2/t1) -R0*log(p2/p1)
21  dSa=(m1/M1)*dsa
22  dSw=-dSa
23  dsw=dSw*M2/m2
24  //results
25  printf("Final remperature = %d R",t2)
26  printf("\n Change in entropy of air = %.3f btu/mole
      R and %.5f Btu/R",dsa,dSa)
27  printf("\n Change in entropy of water = %.4f btu/
      mole R and %.5f Btu/R",dsw,dSw)
```

```
28 disp("The answers are a bit different due to
       rounding off error in textbook")
```

Scilab code Exa 11.12 Volume and mass calculations

```
1  clc
2  clear
3  // Initialization of variables
4  T=250 + 460 //R
5  p=29.825 // psia
6  pt=50 // psia
7  vg=13.821 // ft ^3/lbm
8  M=29
9  R=10.73
10 // calculations
11 pa=pt-p
12 V=1/M *R*T/pa
13 ma=V/vg
14 xa=p/pt
15 mb=xa/M *18/(1-xa)
16 // results
17 printf("In case 1, volume occupied = %.2f ft ^3",V)
18 printf("\n In case 1, mass of steam = %.2f lbm steam
       ",ma)
19 printf("\n In case 2, mass of steam = %.3f lbm steam
       ",mb)
```

Scilab code Exa 11.13 Percentage calculation

```
1  clc
2  clear
3  // Initialization of variables
4  ps=0.64 // psia
```

```
 5  p=14.7 // psia
 6  M=29
 7  M2=46
 8  // calculations
 9  xa=ps/p
10  mb=xa*9/M *M2/(1-xa)
11  // results
12  printf(" percentage = %.1f percent",mb*100)
```

Scilab code Exa 11.14 Partial Pressure calculations

```
 1  clc
 2  clear
 3  // Initialization of variables
 4  ps=0.5069 // psia
 5  p=20 // psia
 6  m1=0.01
 7  m2=1
 8  M1=18
 9  M2=29
10  // calculations
11  xw= (m1/M1)/(m1/M1+m2/M2)
12  pw=xw*p
13  // results
14  printf(" partial pressure of water vapor = %.3f psia"
        ,pw)
```

Chapter 12

Non steady flow friction and availability

Scilab code Exa 12.1 Work done calculation

```
1  clc
2  clear
3  //Initialization of variables
4  p1=100  //psia
5  p2=14.7  //psia
6  k=1.4
7  T1=700  //R
8  R=10.73/29
9  V=50
10 cv=0.171
11 cp=0.24
12 R2=1.986/29
13 //calculations
14 T2=T1/ (p1/p2)^((k-1)/k)
15 m1=p1*V/(R*T1)
16 m2=p2*V/(R*T2)
17 Wrev= cv*(m1*T1 - m2*T2) - (m1-m2)*(T2)*cp
18 //results
19 printf("Work done in case 1 = %d Btu",Wrev)
```

Scilab code Exa 12.2 Friction calculations

```
1  clc
2  clear
3  //Initialization of variables
4  p1=100 //psia
5  p2=10 //psia
6  n=1.3
7  T1=800 //R
8  cv=0.172
9  R=1.986/29
10 T0=537 //R
11 cp=0.24
12 //calculations
13 T2=T1*(p2/p1)^((n-1)/n)
14 dwir=cv*(T1-T2)
15 dwr=R*(T2-T1)/(1-n)
16 dq=dwr-dwir
17 dI=-T0*(cp*log(T2/T1) - R*log(p2/p1))
18 //results
19 printf("The friction of the process per pound of air
      = %.1f Btu/lbm",dq)
20 printf("\n Loss of available energy = %.2f Btu/lbm",
      dI)
```

Scilab code Exa 12.3 Energy loss calculations

```
1  clc
2  clear
3  //Initialization of variables
4  ms=10 //lbm
```

```
 5  den =62.3  // lbm / f t ^3
 6  A1 =0.0218  // f t ^2
 7  A2 =0.00545  // f t ^2
 8  p2=50  // psia
 9  p1 =100  // psia
10  gc =32.2  // f t / s ^2
11  dz =30  // f t
12  T0 =537  //R
13  T1 =620  //R
14  T2 =420  //R
15  // calculations
16  V1=ms /( A1*den )
17  V2=ms /( A2*den )
18  df = -144/ den *(p2 -p1 ) - (V2^2 -V1^2)/(2* gc ) - dz
19  dI=-T0/T1 *df
20  dI2=  -T0/T2 *df
21  // results
22  printf (" Friction  = %.1 f  ft -lbf /lbm",df )
23  printf ("\n Available  energy  loss  in  case  a  = %.1 f  ft
        -lbf /lbm",dI )
24  printf ("\n Available  energy  loss  in  case  b  = %.1 f  ft
        -lbf /lbm",dI2 )
```

Scilab code Exa 12.4 Pressure drop calculation

```
 1  clc
 2  clear
 3  // Initialization  of  variables
 4  r=2.5  // in
 5  mf =160  // cfm
 6  rho =1/14
 7  mu =0.0000121
 8  v=14  // f t ^3/ lbm
 9  g=32.2  // f t / s ^2
10  z=100  // f t
```

```
11  // calculations
12  A =3.14*( r /12) ^2
13  V = mf / A /60
14  Re =(2* r /12) *V* rho / mu
15  disp ("From fig 12.4 ,")
16  f =0.0225/4
17  dp =4* f *( rho ) *( V / v ) ^2 /(2* g *(2* r /12)) *z
18  // dp =2.32
19  // results
20  printf ("Pressure drop = %.2 f lbf / ft ^2 100 ft", dp )
21  disp ("The answer in the textbook is wrong. Please
         use a calculator to verify it .")
```

Scilab code Exa 12.5 Mass rate calculation

```
 1  clc
 2  clear
 3  // Initialization of variables
 4  D =0.0724 // ft
 5  gc =32.2 // ft / s ^2
 6  rho =1/14
 7  L =100 // ft
 8  mu2 =1.46*10^( -10)
 9  dp =2.32
10  dia =5 // in
11  rho2 =48500
12  vol =14 // ft ^3/ lbm
13  // calculations
14  ref = D ^3 *2* dp * gc * rho /( mu2 *L)
15  mf = rho2 *% pi /4 *( dia /12) * sqrt ( mu2 )
16  mfr = mf * vol *60
17  // results
18  printf ("Mass rate of air flow = %d cfm", mfr )
19  disp ("The answer is a bit different due to rounding
         off error in textbook")
```

Scilab code Exa 12.6 Loss and effectiveness calculations

```
1  clc
2  clear
3  //Initialization of variables
4  cp=0.25
5  T=3460 //R
6  T0=520 //R
7  dG=1228 //Btu/lbm
8  //calculations
9  hf=cp*(T-T0)-T0*cp*log(T/T0)
10 dC=hf-dG
11 Ec=hf/dG
12 //results
13 printf("Loss of available energy = %d Btu/lbm
       mixture ",dC)
14 printf("\n Effectiveness of combustion = %.3f ",Ec)
```

Scilab code Exa 12.7 Loss and effectiveness calculations

```
1  clc
2  clear
3  //Initialization of variables
4  cp1=0.25
5  T=3460 //R
6  T0=946.2 //R
7  T00=520 //R
8  dG=1228 //Btu/lbm
9  cp=0.45
10 //calculations
11 dqa=cp1*(T-T0)
```

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```
12  w=cp*dqa
13  hf=cp1*(T-T00)-T00*cp1*log(T/T00)
14  heat=w-hf
15  eff=w/hf
16  epower=w/dG
17  //results
18  printf("Loss of available energy = %.1f Btu/lbm
        mixture ",heat)
19  printf("\n Efficiency of cycle = %.3f ",eff)
20  printf("\n Effectiveness of overall cycle = %.2f",
        epower)
21  disp("The answer is a bit different due to rounding
        off error in textbook")
```

Scilab code Exa 12.8 Loss and effectiveness calculations

```
1  clc
2  clear
3  //Initialization of variables
4  p1=400 //psia
5  t1=600 //F
6  h1=1306.9 //Btu/lbm
7  b1=480.9 //Btu/lbm
8  p2=50 //psia
9  h2=1122 //Btu/lbm
10  h3=1169.5 //Btu/lbm
11  b3=310.9 //Btu/lbm
12  //calculations
13  disp("All the values are obtained from Mollier chart
        ,")
14  dw13=h1-h3
15  dw12=h1-h2
16  dasf=b3-b1
17  etae=dw13/dw12
18  eta=abs(dw13/dasf)
```

```
19  dq=dw13+dasf
20  //results
21  printf(" Engine efficiency = %.1 f percent",etae*100)
22  printf("\n Effectiveness = %.1 f percent",eta*100)
23  printf("\n Loss of available energy = %.1 f Btu/lbm"
       ,dq)
```

Chapter 13

Fluid Flow

Scilab code Exa 13.1 Velocity and area calculations

```
1  clc
2  clear
3  //Initialization of variables
4  h1=1329.1  //Btu/lbm
5  v1=6.218  //ft^3/lbm
6  J=778
7  g=32.174
8  m=1
9  //calculations
10 p=[80 60 54.6 40 20]
11 h=[ 1304.1 1273.8 1265 1234.2 1174.8]
12 v=[ 7.384 9.208 9.844 12.554 21.279]
13 Fc=1
14 V2=Fc*sqrt(2*J*g*(h1-h))
15 A=m*v ./V2
16 V2=[0 V2]
17 A=[0 A]
18 //results
19 disp('velocity (ft/s)= ')
20 disp(V2 )
21 disp('Area (ft^2)= ')
```

```
22  disp(A)
23  disp('The initial values of velocity and area are 0
        and infinity respectively. Since, Infinity in
        calculations stops the code to display an error.
        It has been mentioned separately.')
```

Scilab code Exa 13.2 Area calculations

```
1  clc
2  clear
3  //Initialization of variables
4  n=1.4
5  p1=50  //psia
6  J=778
7  cp=0.24
8  T1=520  //R
9  k=n
10 R=1545/29
11 m=1
12 p2=10  //psia
13 //calculations
14 rpt=(2/(n+1))^(n/(n-1))
15 pt=p1*rpt
16 Vtrev=223.77*sqrt(cp*T1*(1- rpt^((k-1)/k)))
17 v1=R*T1/p1/144
18 vt=v1*(p1/pt)^(1/k)
19 At=m*vt/Vtrev
20 V2rev=223.77*sqrt(cp*T1*(1-(p2/p1)^((k-1)/k)))
21 v2=v1*(p1/p2)^(1/k)
22 A2=m*v2/V2rev
23 //results
24 printf("Area required = %.5f ft^2",At)
25 printf("\n Area in case 2 at the exit= %.5f ft^2",A2
        )
```

Scilab code Exa 13.3 Area calculations

```
1  clc
2  clear
3  // Initialization of variables
4  J=778
5  g=32.2
6  pc=54.6 // psia
7  h1=1329.1 // Btu/lbm
8  h2=1265 // btu/lbm
9  V2rev=1790 // ft/s
10 cv=0.99
11 m=1 // lbm
12 cv2=0.96
13 // calculations
14 V2d=cv*V2rev
15 hd=cv^2 *(h1-h2)
16 h2d=h1-hd
17 v2d=9.946
18 A2d=m*v2d/V2d
19 // results
20 printf("Throat area= %.4f ft^2",A2d)
```

Scilab code Exa 13.4 velocity and flow rate calculations

```
1  clc
2  clear
3  // Initialization of variables
4  zm=0.216
5  pm=62.3 // lbm/ft^2
6  p1=0.0736 // lbm/ft^2
7  g=32.2
```

```
 8  d=4
 9  //calculations
10  H=zm*(pm-p1)/12/p1
11  V=sqrt(2*g*H)
12  m=%pi/4 *d^2 *V*p1
13  //results
14  printf("average velocity = %.1f ft/sec",V)
15  printf("\n mass flow rate = %.1f lbm/sec",m)
```

Scilab code Exa 13.5 Area calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  p0=50  //psia
 5  T0=520  //R
 6  rho0=0.259 //lbm/ft^3
 7  p2=10  //psia
 8  mf=1  //lbm
 9  //calculations
10  disp("From table B-17,")
11  pr=0.528
12  Tr=0.833
13  rhor=0.634
14  ps=pr*p0
15  Ts=Tr*T0
16  rhos=rho0*rhor
17  Vs=49.1*sqrt(Ts)
18  As=mf/(Vs*rhos)
19  p2r=p2/p0
20  M2=1.71
21  V2=1.487*Vs
22  T2=0.632*Ts
23  A2=As*1.35
24  rho2=rhos*0.317
```

```
25 // results
26 printf("Area of throat = %.5f ft^2",As)
27 printf("\n Area of exit = %.5f ft^2",A2)
```

Scilab code Exa 13.6 Length calculation

```
1  clc
2  clear
3  // Initialization of variables
4  M1 =0.2
5  M2 =0.4
6  D=0.5   // ft
7  f=0.015
8  // calculations
9  f1 =14.5
10 f2 =2.31
11 dl =(f1 -f2)*D/f
12 // results
13 printf("Length of pipe = %.1f ft",dl)
```

Scilab code Exa 13.7 Change in entropy calculation

```
1  clc
2  clear
3  // Initialization of variables
4  py =20 // psia
5  px =3.55 // psia
6  R=1.986/29
7  // calculations
8  pr =py/px
9  disp("from table B-19")
10 Mx =2
11 My =0.577
```

```
12  pr2 =0.721
13  ds=R*log (1/ pr2 )
14  // results
15  printf (" Change  in  entropy  =  %.4 f  Btu/lbm  R",ds )
```

Scilab code Exa 13.8 Pressure calculation

```
1   clc
2   clear
3   // Initialization  of  variables
4   pi =50  // psia
5   pe =34.6  // psia
6   // calculations
7   disp (" From  table  B−18  and  B−17,")
8   pr1 =1.35
9   p0f = pi / pr1
10  pfs =0.528* p0f
11  per = pe / pfs
12  Me =0.6
13  p0e =1.19
14  pyx = p0e / pr1
15  Mx =1.64
16  My =0.658
17  px =0.22* pi
18  py =32.9  // psia
19  p2yx =0.852
20  pe2 =1.65* pfs
21  // results
22  printf (" Mach  numbers  before  and  after  are  %.2 f  and  %
        .3 f  respectively ",Mx ,My )
23  printf ("\n  Pressure  before  and  after  are  %.1 f  psia
        and  %.1 f  psia ",px ,py )
24  printf ("\n  Exhaust  pressure  =  %.1 f  psia ",pe2 )
```

Scilab code Exa 13.9 Heat calculation

```
1  clc
2  clear
3  //Initialization of variables
4  T1=550 //R
5  T2=2660 //R
6  ts1=0.207
7  ts2=0.833
8  cp=0.24
9  //calculations
10 Ts=T1/ts1
11 Ts0=T2/ts2
12 disp("From table B-20")
13 tr1=0.529
14 tr2=0.174
15 dq=cp*Ts0*(tr1-tr2)
16 //results
17 printf("Heat required = %d Btu/lbm",dq)
```

Scilab code Exa 13.10 Thrust calculation

```
1  clc
2  clear
3  //Initialization of variables
4  M1=0.5
5  M2=1
6  A1=0.5 //ft^2
7  A2=1 //ft^2
8  p1=14.7 //psia
9  p2=14.7 //psia
10 k=1.4
```

```
11 // calculations
12 thru=p2*144*A2*(1+k*M2^2)-p1*144*A1*(1+k*M1^2)
13 net=thru-p1*144*(A2-A1)
14 // results
15 printf("Internal thrust = %d lbf",thru)
16 printf("\n Net thrust = %d lbf",net)
17 disp("The answers are a bit different due to
        rounding off error in textbook")
```

Scilab code Exa 13.11 Mass flow rate calculation

```
1  clc
2  clear
3  // Initialization of variables
4  p1=50  // psia
5  pr=0.58
6  // calculations
7  p=p1*pr
8  s1=1.6585
9  h1=1174.1  // Btu/lbm
10 sf=0.3680
11 sfg=1.3313
12 hfg=945.3
13 vg=13.746
14 hf=218.82
15 x= (s1-sf)/sfg
16 v2=vg*x
17 h2=hf+x*hfg
18 V2rev=223.77*sqrt(h1-h2)
19 m=%pi/4 *1/144 *V2rev/v2
20 // results
21 printf("mass flow rate = %.3f lbm/sec",m)
```

Scilab code Exa 13.12 Mass flow rate calculation

```
1  clc
2  clear
3  //Initialization of variables
4  k=1.31
5  p1=7200 //lbf/ft^2
6  v1=8.515 //ft^3/lbm
7  pr=0.6
8  m1=0.574
9  T1=741 //R
10 //calculations
11 V2rev=8.02*sqrt(k/(k-1) *p1*v1*(1- (pr)^((k-1)/k)))
12 v2=v1*(1/pr)^(1/k)
13 m=%pi/4 *1/144 *V2rev/v2
14 C=m/m1
15 T2=T1*(0.887)
16 t=250+460 //R
17 dt=t-T2
18 //results
19 printf("Mass flow rate = %.3f lbm/sec",m)
20 printf("\n Meta stable under cooling = %d F",dt)
```

Scilab code Exa 13.13 Area calculations

```
1  clc
2  clear
3  //Initialization of variables
4  C=0.98
5  m=1
6  v=12.55 //ft^3/lbm
7  V=1372 //ft/s
8  //calculations
9  A=m*v/(C*V) *144
10 D=sqrt(A*4/%pi)
```

```
11  //results
12  printf("Area = %.3f in^2",A)
13  printf("\n diameter = %.2f in",D)
```

Scilab code Exa 13.14 Area calculations

```
1  clc
2  clear
3  //Initialization of variables
4  nn=0.95
5  p1=50  //psia
6  p2=30  //psia
7  v1=8.515
8  m=1  //lbm
9  //calculations
10  cv=sqrt(nn)
11  V2rev=1372
12  V2act=cv*V2rev
13  n=1.283
14  v2=v1*(p1/p2)^(1/n)
15  A=m*v2/V2act *144
16  D=sqrt(A*4/%pi)
17  //results
18  printf("Area = %.2f in^2",A)
19  printf("\n diameter = %.3f in",D)
```

Scilab code Exa 13.15 Area of discharge calculation

```
1  clc
2  clear
3  //Initialization of variables
4  dFf=110.5  //ft-lbf/lbm
5  Vd=1028  //ft/s
```

```
6  gc=32.2  //ft/s^2
7  p0=100  //psia
8  k=1.4
9  v0=2.08
10 p1=55  //psia
11 p2=99.2  //psia
12 //calculations
13 dFe=0.01*Vd^2 /(2*gc)
14 dF=dFf+dFe
15 V2ig=(p0*144)^(1/k) *v0/(1-1/k) *((p1*144)^(1-1/k)
      -(p2*144)^(1-1/k))
16 C2=(V2ig+dF)/V2ig
17 C=sqrt(C2)
18 //results
19 printf("Coefficient of discharge = %.3f ",C)
```

Scilab code Exa 13.16 Pressure drop calculation

```
1  clc
2  clear
3  //Initialization of variables
4  dL=1/6  //ft
5  mf=0.430  //lbm/sec
6  rho=62.4
7  gc=32.2  //ft/s^2
8  d=0.81/12  //ft
9  //calculations
10 V=mf*4/(rho*%pi)
11 VD=V/dL^2
12 Vd=1.92  //ft/s
13 dFf=0.031/(2*gc) *2.31
14 dFe=0.04*Vd^2 /(2*gc)
15 dF=dFf+dFe
16 dp=rho*(3.5/(2*gc) +dF)
17 vd22=(2*gc)/rho *dp /(1-(d/dL)^4)
```

```
18  vd2 = sqrt ( vd22 )
19  C = Vd / vd2
20  // results
21  printf ( " Pressure drop in the nozzle = %.2 f lbf / ft ^2"
       , dp )
22  printf ( "\n Coefficient of discharge = %.3 f ",C)
```

Scilab code Exa 13.17 Mass flow rate calculation

```
 1  clc
 2  clear
 3  // Initialization of variables
 4  K =0.6003
 5  Y1 =0.91
 6  D1 =6.065
 7  D2 =1.820
 8  rho1 =0.156
 9  p1 =30
10  p2 =20.18
11  // calculations
12  bet = D2 / D1
13  m =0.525* K * Y1 * D2^2 * sqrt ( rho1 *( p1 - p2 ))
14  C = K * sqrt (1 - bet ^4)
15  // results
16  printf ( " mass flow rate = %.3 f lbm / sec ",m)
17  printf ( "\n Coefficient of discharge = %.3 f",C)
```

Chapter 14

Psychrometrics

Scilab code Exa 14.1 Pressure and density calculations

```
1  clc
2  clear
3  //Initialization of variables
4  t1=80+460  //R
5  ps=0.5069  //psia
6  disp("from steam tables,")
7  vs=633.1  //ft^3/lbm
8  phi=0.3
9  R=85.6
10 Ra=53.3
11 p=14.696
12 //calculations
13 tdew=46  //F
14 pw=phi*ps
15 rhos=1/vs
16 rhow=phi*rhos
17 rhow2= pw*144/(R*t1)
18 pa=p-pw
19 rhoa= pa*144/(Ra*t1)
20 w=rhow/rhoa
21 mu=phi*(p-ps)/(p-pw)
```

```
22  Ws=0.622*(ps/(p-ps))
23  mu2=w/Ws
24  //results
25  disp("part a")
26  printf("partial pressure of water = %.5f psia",pw)
27  printf("\n dew temperature = %d F",tdew)
28  disp("part b")
29  printf("density of water = %.6f lbm/ft^3",rhow)
30  printf("\n in case 2, density of water = %.6f lbm/ft
        ^3",rhow2)
31  printf("\n density of air = %.6f lbm/ft^3",rhoa)
32  disp("part c")
33  printf("specific humidity  = %.4f lbm steam/lbm air"
        ,w)
34  disp("part d")
35  printf("In method 1, Degree of saturation = %.3f",mu
        )
36  printf("\n In method 2, Degree of saturation = %.3f"
        ,mu2)
```

Scilab code Exa 14.2 Moisture content calculation

```
1  clc
2  clear
3  //Initialization of variables
4  p=14.696 //psia
5  ps=0.0808   //psia
6  ps2=0.5069 //psia
7  phi2=0.5
8  phi=0.6
9  grain=7000
10  //calculations
11  pw=phi*ps
12  w1=0.622*pw/(p-pw)
13  pw2=phi2*ps2
```

```
14 w2=0.622*pw2/(p-pw2)
15 dw=w2-w1
16 dwg=dw*grain
17 // results
18 printf("change in moisture content = %.6f lbm water/
       lbm dry air",dw)
19 printf("\n in grains, change = %.2f grains water/lbm
        dry air",dwg)
20 disp("The answers are a bit different due to
       rounding off error in textbook")
```

Scilab code Exa 14.3 Humidity calculations

```
1 clc
2 clear
3 // Initialization of variables
4 t1=80 //F
5 t2=60 //F
6 p=14.696 // psia
7 ps=0.507 // psia
8 pss=0.256 // psia
9 cp=0.24
10 disp("From steam tables ,")
11 // calculations
12 ws=0.622*pss/(p-pss)
13 w=(cp*(t2-t1) + ws*1060)/(1060+ 0.45*(t1-t2))
14 pw=w*p/(0.622+w)
15 phi=pw/ps
16 td=46 //F
17 // results
18 printf("\n humidity ratio = %.4f lbm/lbm dry air",w)
19 printf("\n relative humidity = %.1f percent",phi
       *100)
20 printf("\n Dew point = %d F",td)
```

Scilab code Exa 14.4 Enthalpy and sigma function calculations

```
1  clc
2  clear
3  //Initialization of variables
4  W=0.0065   //lbm/lbm of dry air
5  t=80 //F
6  td=60 //F
7  //calculations
8  H=0.24*t+W*(1060+0.45*t)
9  sig=H-W*(td-32)
10 Ws=0.0111
11 H2=0.24*td+Ws*(1060+0.45*td)
12 sig2=H2-Ws*(td-32)
13 //results
14 printf("In case 1, enthalpy = %.2f Btu/lbm dry air",
       H)
15 printf("\n In case 1, sigma function = %.2f Btu/lbm
       dry air",sig)
16 printf("\n In case 2, enthalpy = %.2f Btu/lbm dry
       air",H2)
17 printf("\n In case 2, sigma function = %.2f Btu/lbm
       dry air",sig2)
```

Scilab code Exa 14.5 Enthalpy calculations

```
1  clc
2  clear
3  //Initialization of variables
4  t1=30 //F
5  t2=60 //F
6  t3=80 //F
```

```
 7  W1 =0.00206
 8  W2 =0.01090
 9  // calculations
10  cm1 =0.24+0.45* W1
11  H1 = cm1 * t1 + W1 *1060
12  cm2 =0.24+0.45* W2
13  H2 = cm2 * t3 + W2 *1060
14  hf = t2 -32
15  dq = H2 - H1 -( W2 - W1 )* hf
16  // results
17  printf (" In  case  1 ,  Enthalpy  = %.2 f  Btu/lbm  dry  air ",
        H1)
18  printf ("\n  In  case  2 ,  Enthalpy  = %.2 f  Btu/lbm  dry
        air ",H2)
19  printf ("\n  Heat  added  = %.2 f  Btu/lbm  dry  air ",dq)
```

Scilab code Exa 14.6 Humidity calculations

```
 1  clc
 2  clear
 3  // Initialization  of  variables
 4  pw =0.15 // psia
 5  disp (" using  psychrometric  charts ,")
 6  tdew =46  //F
 7  // calculations
 8  va =13.74  // ft ^3/lbm  dry  air
 9  rhoa =1/ va
10  V =13.74
11  mw =46/7000
12  rhow = mw /V
13  w =0.00657
14  // results
15  disp (" part  a")
16  printf (" partial  pressure  of  water  = %.2 f  psia ",pw)
17  printf ("\n  dew  temperature  = %d  F",tdew)
```

```
18  disp("part b")
19  printf("density of water = %.6f lbm/ft^3",rhow)
20  printf("\n density of air = %.4f lbm/ft^3",rhoa)
21  disp("part c")
22  printf("specific humidity = %.5f lbm water/lbm air"
        ,w)
```

Scilab code Exa 14.7 Enthalpy change calculations

```
1   clc
2   clear
3   //Initialization of variables
4   W1=0.00206 //lbm/lbm dry air
5   W2=0.01090 //lbm/lbm dry air
6   t=60 //F
7   disp("From humidity charts,")
8   //calculations
9   dw=W1-W2
10  hs=144.4
11  hs2=66.8-32
12  w1=14.4 //Btu/lbm
13  ws1=20 //Btu/lbm
14  w2=76.3 //Btu/lbm
15  ws2=98.5 //Btu/lbm
16  dwh1=-(w1-ws1)/7000 *hs
17  H1=9.3+dwh1
18  dwh2=(w2-ws2)/7000 *hs2
19  H2=31.3+dwh2
20  dwc=dw*(t-32)
21  dq=H2-H1+dwc
22  //results
23  printf("Enthalpy change = %.2f Btu/lbm dry air",dq)
```

Scilab code Exa 14.8 Enthalpy and temperature calculations

```scilab
1  clc
2  clear
3  //Initialization of variables
4  disp("From psychrometric charts at 50 F and 80 F,")
5  va1=13 //ft^3/lbm dry air
6  va2=13.88 //ft^3/lbm dry air
7  flow=2000 //cfm
8  //calculations
9  ma1= flow/va1
10 ma2=flow/va2
11 disp("The two initial states have been multiplied by
        108/262 and distance 2-3 is located")
12 t=62.5// F
13 phi=0.83 //percent
14 //results
15 printf("humidity = %.2f ",phi)
16 printf("\n Temperature = %.1f F",t)
```

Scilab code Exa 14.9 Dry bulb calculations

```scilab
1  clc
2  clear
3  //Initialization of variables
4  t=90 //F
5  ts=67.2 //F
6  phi=0.3
7  per=0.8
8  //calculations
9  dep=t-ts
10 dt=dep*per
11 tf=t-dt
12 disp("from psychrometric charts,")
13 phi2=0.8
```

```
14 // results
15 printf("Dry bulb temperature = %.2f F",tf)
16 printf("\n percent humidity = %.2f",phi2)
```

Scilab code Exa 14.10 Approach calculations

```
1  clc
2  clear
3  //Initialization of variables
4  m=1  //lbm
5  t1=100  //F
6  t2=75  //F
7  db=65  //F
8  disp("From psychrometric charts ,")
9  t11=82  //F
10 phi1=0.4
11 H1=30  //Btu/lbm dry air
12 w1=65  //grains/lbm dry air
13 w2=250  //grains/lbm dry air
14 //calculations
15 cr=t1-t2
16 appr=t2-db
17 dmf3=(w2-w1)*0.0001427
18 hf3=68
19 hf4=43
20 H2=62.2
21 H1=30
22 mf4= (H1-H2+ dmf3*hf3)/(hf4-hf3)
23 per=dmf3/(dmf3+mf4)
24 //results
25 printf("cooling range = %d F",cr)
26 printf("\n Approach = %d F",appr)
27 printf("\n amount of water cooled per pound of dry
        air = %.3f lbm dry air/lbm dry air",mf4)
28 printf("\n percentage of water lost by evaporation =
```

```
        %.2 f  p e r c e n t ",per *100)
```

Scilab code Exa 14.11 Heat calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  mfr =1
 5  water =900 //gallons
 6  t2 =110 //F
 7  t1 =80 //F
 8  cp1 =1
 9  //calculations
10  mfa=mfr*water*8.33*60
11  mfc=mfa/(60*0.075)
12  qa=mfa*(t2-t1)
13  dH=qa/(mfc*4.5)
14  dH2=mfr*cp1*(t2-t1)
15  H1 =23.73
16  H2 =5.08
17  f =3.309
18  lnmean=(H1-H2)/log(H1/H2)
19  dtt=(t2-t1)/lnmean
20  per =25
21  //results
22  printf("flow rate of air = %d lbm/hr.It is equal to
        %d cfm",mfa,mfc)
23  printf("\n Total heat transferred = %d Btu/hr",qa)
24  printf("\n Enthalpy = %.1 f Btu/lbm dry air",dH)
25  printf("\n Using second method, Enthalpy = %.1 f Btu/
        lbm",dH2)
26  printf("\n Performance factor = %.3 f ",f)
27  printf("\n logrithamic mean enthalpy difference = %
        .2 f . Estimated low percentage = %d low",dtt,per)
28  disp("The answers are a bit different due to
```

rounding off error in textbook.")

Chapter 15

Vapor cycles and processes

Scilab code Exa 15.1 Efficiency calculations

```
1  clc
2  clear
3  //Initialization of variables
4  p1=600  //psia
5  p2=0.2563  //psia
6  t1=486.21  //F
7  t2=60  //F
8  fur=0.75
9  //calculations
10 disp("from steam tables,")
11 h1=1203.2
12 hf1=471.6
13 hfg1=731.6
14 h2=1088
15 hf2=28.06
16 hfg2=1059.9
17 s1=1.4454
18 sf1=0.6720
19 sfg1=0.7734
20 s2=2.0948
21 sf2=0.0555
```

```
22  sfg2 =2.0393
23  xd =( s1 - sf2 ) / sfg2
24  hd = hf2 + xd * hfg2
25  xa =0.3023
26  ha = hf2 + xa * hfg2
27  wbc =0
28  wda =0
29  wcd = h1 - hd
30  wab = ha - hf1
31  W = wab + wcd + wbc + wda
32  Wrev = hfg1 - ( t2 +459.7) * sfg1
33  etat =( t1 - t2 ) /( t1 +459.7)
34  eta = fur * etat
35  // results
36  printf (" Thermal efficiency = %d percent ", etat *100)
37  printf ("\n Furnace efficiency = %.1 f percent ", eta
        *100)
```

Scilab code Exa 15.2 Efficiency calculations

```
 1  clc
 2  clear
 3  // Initialization of variables
 4  dhab = -123.1
 5  etac =0.5
 6  ha =348.5
 7  etaf =0.75
 8  eta =0.85
 9  hf =471.6
10  hfg =731.6
11  hc =1203.2
12  dhcd =452.7
13  // calculations
14  dwabs = dhab / etac
15  hbd = ha - dwabs
```

```
16  dwcds=dhcd*eta
17  dqa=hc-hbd
18  etat=(dwcds+dwabs)/dqa
19  eta=etat*etaf
20  //results
21  printf("Thermal efficiency = %.1f percent",etat*100)
22  printf("\n Overall efficiency = %.1f percent",eta
        *100)
```

Scilab code Exa 15.3 Efficiency calculations

```
1  clc
2  clear
3  //Initialization of variables
4  t=60  //F
5  J=778.16
6  p1=600  //psia
7  p2=0.2563  //psia
8  etaf=0.85
9  //calculations
10  disp("From steam tables ,")
11  vf=0.01604  //ft^3/lbm
12  dw=-vf*(p1-p2)*144/J
13  ha=28.06  //Btu/lbm
14  hb=29.84  //Btu/lbm
15  hd=1203.2  //Btu/lbm
16  he=750.5  //Btu/lbm
17  dqa=hd-hb
18  dqr=ha-he
19  dw=dqa+dqr
20  dwturb=hd-he
21  dwpump=ha-hb
22  etat=dw/dqa
23  eta=etat*etaf
24  //results
```

```
25  printf(" Thermal efficiency = %.1f percent",etat*100)
26  printf("\n Overall efficiency = %.1f percent",eta
       *100)
```

Scilab code Exa 15.4 Efficiency calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  dhab=-1.78
 5  etac=0.5
 6  ha=28.06
 7  eta=0.85
 8  hf=471.6
 9  hfg=731.6
10  hd=1203.2
11  dhcd=452.7
12  //calculations
13  dwabs=dhab/etac
14  hbd=ha-dwabs
15  dwcds=dhcd*eta
16  dqa=hd-hbd
17  etat=(dwcds+dwabs)/dqa
18  eta=etat*eta
19  //results
20  printf(" Thermal efficiency = %.1f percent",etat*100)
21  printf("\n Overall efficiency = %.1f percent",eta
       *100)
```

Scilab code Exa 15.5 Efficiency and pressure calculations

```
 1  clc
 2  clear
```

```
3  //Initialization of variables
4  sh=1.6070
5  ph=94.8 //psia
6  th=324 //F
7  tr=60 //F
8  hh=1186.2
9  pi=94.8 //psia
10 hi=1399.5
11 si=1.8265
12 //calculations
13 Q=hi-hh
14 Hr=-(tr+459.7)*(si-sh)
15 work= Q+Hr
16 eff=work/Q
17 Qa1=1557.5
18 W1=637.1
19 etat=W1/Qa1
20 he=1374
21 hj=948
22 Whp=he-hh
23 Wlp=hi-hj
24 Wnet=Whp+Wlp
25 //results
26 printf("Thermal efficiency in case 1= %.1f percent",
       eff*100)
27 printf("\n Thermal efficiency in case 1= %.1f
       percent",etat*100)
28 printf("\n High pressure work = %.1f Btu/lbm",Whp)
29 printf("\n Low pressure work = %.1f Btu/lbm",Wlp)
30 printf("\n Net work = %.1f Btu/lbm",Wnet)
```

Scilab code Exa 15.6 Efficiency calculations

```
1  clc
2  clear
```

```
 3  //Initialization of variables
 4  p2=600 //psia
 5  p1=44 //psia
 6  te=486.21 //F
 7  tb=273.1 //F
 8  J=778.16
 9  p3=0.25 //psia
10  //calculations
11  hc=241.9
12  hj=834.6
13  y=1-0.805
14  v1=0.0172
15  v2=0.016
16  ha=28.06
17  hd=hc+v1*(p2-p1)*144/J
18  hb=ha+v2*(p1-p3)*144/J
19  hh=1374
20  Qa=hh-hd
21  Qr=(ha-hj)*(1-y)
22  etat=(Qa+Qr)/Qa
23  //results
24  printf("thermal efficiency = %.1f percent",etat*100)
```

Chapter 16

Combustion

Scilab code Exa 16.1 Molecule formulation

```
1  clc
2  clear
3  //Initialization of variables
4  per =85
5  //calculations
6  a=per/12
7  b=100-per
8  ad=1.13*a
9  bd=1.13*b
10 //results
11 printf("Molecule is C %d H %d",ad,bd+1)
```

Scilab code Exa 16.2 Molecule formulation

```
1  clc
2  clear
3  //Initialization of variables
4  per=0.071 //mass fraction of nitrogen
```

```
 5  //calculations
 6  O2=8.74
 7  N2=per/2 + 3.76*O2
 8  Nin=32.85
 9  CO2=7.333
10  H2o=3
11  So2=0.0312
12  //results
13  printf("Oxygen = %.2f and Nitrogen = %.2f",O2,N2)
14  printf("\n Equation is C %.3f H %d + %.2f O2 + %.2f
        N2 = %.3f CO2 + %d H2O + %.5f SO2 + %.2f N2",CO2
        ,2*H2o,O2,Nin,CO2,H2o,So2,N2)
```

Scilab code Exa 16.3 Air fuel ratio calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  M=29
 5  m1=8.74
 6  m2=32.85
 7  fuel=100  //lbm
 8  //calculations
 9  mass=M*(m1+m2)
10  AF=mass/fuel
11  a2=9.75
12  b2=12.19
13  AF2=mass/(fuel+a2+b2)
14  //results
15  printf("Air fuel ratio = %.2f lbm air/lbm fuel",AF)
16  printf("\n In dry air, Air−fuel ratio = %.1f lbm air
        /lbm fuel as fired",AF2)
```

Scilab code Exa 16.4 Mass and energy calculations

```
1  clc
2  clear
3  //Initialization of variables
4  m1=322.3 //Mass of Co2
5  m2=2 //Mass of SO2
6  m3=926 //Mass of N2
7  basis=121.94 //Basis taken
8  //calculations
9  m=m1+m2+m3
10 ratio=m/basis
11 dh=5777 //Btu/mol
12 h1=dh*7.364
13 h2=14037
14 h3=130501
15 H=h1+h2+h3
16 hrat=H/basis
17 //results
18 printf("Mass of dry flue gases = %.2f lbm dry flue
        gas/lbm fuel ash and moisture free",m/100)
19 printf("\n Mass of dry flue gases = %.2f lbm dry
        flue gas/lbm fuel as fired ",ratio)
20 printf("\n Energy carried away = %.1f btu/mol coal
        as fired which is same as  = %.1f Btu/lbm mol
        coal ",H, hrat)
21 disp("The answers are a bit different due to
        rounding off errors in textbook")
```

Scilab code Exa 16.6 Percentage calculations

```
1  clc
2  clear
3  //Initialization of variables
4  p=14.7 //psia
```

```
 5  ps=0.363  //psia
 6  n2=7.52  //moles
 7  n1=1  //moles
 8  //calculations
 9  x= (n1+n2)*ps/p /(1-ps/p)
10  n=n1+n2+x
11  y1=n1/n
12  y2=n1/(n1+n2)
13  //results
14  printf("Final orsat composition is %d CO2 + %.2f H20
        + %.2f N2",n1, x, n2)
15  printf("\n Percentage of co2 on a wet basis = %.1f
        percent",y1*100)
16  printf("\n percentage of co2 on a dry basis = %.2f
        percent",y2*100)
```

Scilab code Exa 16.7 Air fuel ratio calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  N2=78.1
 5  M=29
 6  co2=8.7
 7  co=8.9
 8  x4=0.3
 9  x5=3.7
10  x6=14.7
11  //calculations
12  O2=N2/3.76
13  Z=(co2+co+x4)/8
14  AF=(O2+N2)*M/(Z*113)
15  //results
16  printf("Air fuel ratio = %.1f lbm air/lbm fuel",AF)
```

Scilab code Exa 16.8 Air fuel ratio calculations

```
1  clc
2  clear
3  //Initialization of variables
4  basis=100 //lbm
5  x1=0.6
6  ash=12 //lbm
7  N2=79.7
8  M=29
9  //calculations
10 x=ash/x1
11 C=(1-x1)*x
12 O2=N2/3.76
13 a= (14.6+0.2)/(5.83-0.66)
14 AF=(O2+N2)*M/(a*100)
15 //results
16 printf("Air fuel ratio = %.1f lbm air/lbm fuel as
       fired",AF)
```

Scilab code Exa 16.9 Air fuel ratio calculations

```
1  clc
2  clear
3  //Initialization of variables
4  N2=78.1 //Moles of Nitrogen
5  M=29 //Molar mass of Air
6  ba=2.12 //Basis
7  x4=0.3 //Moles of Ch4
8  x5=3.7 //Moles of H2
9  x6=14.7 //moles of H2o
10 //calculations
```

```
11  O2=N2 /3.76
12  O2=N2 /3.76
13  Z=(x4*4+x5*2+x6*2)/17
14  AF=(O2+N2)*M/(Z*113)
15  // results
16  printf("Air fuel ratio = %.1f lbm air/lbm fuel",AF)
```

Scilab code Exa 16.10 Air fuel ratio calculations

```
1  clc
2  clear
3  // Initialization of variables
4  N2=78.1 // Moles of Nitrogen
5  M=29 // Molar mass of Air
6  ba=2.12 // Basis
7  x4=0.3 // Moles of Ch4
8  x5=3.7 // Moles of H2
9  x6=14.7 // moles of H2o
10  // calculations
11  O2=N2 /3.76
12  c=14.7
13  b= x4*4 + x5*2 + x6*2
14  a=b/ba
15  AF=(O2+N2)*M/(a*12 + b)
16  // results
17  printf("Air fuel ratio = %.1f lbm air/lbm fuel",AF)
```

Scilab code Exa 16.11 Air fuel ratio calculations

```
1  clc
2  clear
3  // Initialization of variables
4  co2=8.7 // Moles of CO2
```

```
5  co =8.9  // Moles  of  CO
6  N2 =78.1  // Moles  of  Nitrogen
7  M=29  // Molar  mass  of  Air
8  ba =2.12  // Basis
9  x4 =0.3  // Moles  of  Ch4
10  x5 =3.7  // Moles  of  H2
11  x6 =14.7  // moles  of  H2o
12  // calculations
13  O2 = N2 /3.76
14  c =14.7
15  Z =2.238
16  X =( Z *17 - x4 *4 - x5 *2) /2
17  a = co2 + co /2+ x4 + x6 /2
18  b =3.764* a
19  AF =( O2 + N2 )* M /( Z *113)
20  // results
21  printf ( " Air  fuel  ratio  =  %.1 f  lbm  air / lbm  fuel " ,AF )
```

Scilab code Exa 16.12 Air fuel ratio calculations

```
1  clc
2  clear
3  // Initialization  of  variables
4  x1 =8.7  // Moles  of  Co2
5  x2 =8.9  // Moles  of  CO
6  x3 =0.3  // Moles  of  O2
7  N =78.1  // Moles  of  N2
8  z =113  // Af  factor
9  M=29  // Molar  mass  of  air
10  // calculations
11  co2 =( x1 + x2 + x3 ) *100/( N + x1 + x2 + x3 )
12  a =2.325
13  AF =103* M /( a * z )
14  // results
15  printf ( " Air  fuel  ratio  =  %.2 f " ,AF )
```

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Scilab code Exa 16.13 Equation formulation

```
1  clc
2  clear
3  // Initialization of variables
4  co=1.2 // Moles of CO
5  co2=10.8 // Moles of CO2
6  // calculations
7  H2=co/2
8  ch4=0.3
9  N2=88-H2-ch4
10 // results
11 printf("Nitrogen = %.1f percent",N2)
12 printf("\n Equation is a(96 CH4 + 3 H2+ 1 CO) + %.1f
       /3.76 O2 + %.1f N2 = %.1f CO2 + %.1f CO + %.1f H2
       + %.1f CH4 + %.1f N2",N2,N2,co2,co,H2,ch4,N2)
```

Scilab code Exa 16.14 Higher heating value

```
1  clc
2  clear
3  // Initialization of variables
4  dH=-2369859 // Btu
5  r=1.986 // Gas constant
6  dn=5.5 // Change in number of moles
7  T=536.7 // R
8  // calculations
9  dQ=dH+dn*r*T
10 // results
11 printf("Higher heating value = %d Btu",dQ)
```

Scilab code Exa 16.15 Lower heating value

```
1  clc
2  clear
3  //Initialization of variables
4  M2=18 //Molar mass of water
5  M=170 //Molar mass of octane
6  p=0.4593 //Pressure of octane //psia
7  disp("from steam tables,")
8  vfg=694.9
9  J=778.2
10 m=9*18 //Mass of water
11 u1=-2363996 //Btu
12 //calculations
13 hfg=1050.4 //Btu/lbm
14 ufg= hfg- p*vfg*144/J
15 dU=ufg*m
16 Lhv=u1+dU
17 //results
18 printf("Lower heating value = %d Btu/lbm",Lhv)
19 disp("The answers are a bit different due to
        rounding off error in textbook.")
```

Scilab code Exa 16.16 Heat of reaction

```
1  clc
2  clear
3  //Initialization of variables
4  n1=8 //Moles of CO2
5  n2=9 //Moles of H2O
6  n3=1 //Moles of Octane
7  n4=12.5 //Moles of Oxygen
```

```
 8  disp("From Table B−10,")
 9  U11=3852 //Internal energy at 1000 R of CO2
10  U12=115 //Internal energy at 537 R of CO2
11  U21=3009 //Internal energy at 1000 R of H2O
12  U22=101 //Internal energy at  537 R of H2O
13  U31=24773 //Internal energy at 1000 R of Octane
14  U32=640 //Internal energy at 537 R of Octane
15  U41=2539 //Internal energy at 1000 R of Oxygen
16  U42=83 //Internal energy at 537 R of Oxygen
17  H=-2203389 //heat Btu
18  //calculations
19  dU1=n1*(U11-U12)+n2*(U21-U22)
20  dU2=n3*(U31-U32)+n4*(U41-U42)
21  Q=H+dU1-dU2
22  //results
23  printf("Heat of reaction = %d Btu",Q)
24  disp("The answers are a bit different due to
        rounding off error in textbook.")
```

Scilab code Exa 16.17 Temperature calculations

```
 1  clc
 2  clear
 3  //Initialization of variables
 4  n1=8 //Moles of CO2
 5  n2=9 //Moles of H2O
 6  n3=47 //Moles of N2
 7  disp("from table B−10,")
 8  h1=118 //Enthalpy of CO2
 9  h2=104 //Enthalpy of H2O
10  h3=82.5 //Enthalpy of N2
11  Q=2203279 //Btu
12  //calculations
13  U11=n1*h1+n2*h2+n3*h3
14  U12=U11+Q
```

```
15  T2 =5271  //R
16  // results
17  printf (" Upon  interpolating ,  T2 = %d R",T2)
```

Scilab code Exa 16.18 Equilibrium calculations

```
1   clc
2   clear
3   // Initialization  of  variables
4   n1 =0.95
5   n2 =0.05
6   n3 =0.025
7   P =147  // psia
8   pa =14.7  // psia
9   // calculations
10  n=n1+n2+n3
11  p1=n1/n *P/pa
12  p2=n2/n *P/pa
13  p3=n3/n *P/pa
14  Kp1= p1/(p2*p3^0.5)
15  Kp2= p1^2 /(p2^2 *p3)
16  // results
17  printf ("In  case  1,  Equilibrium  constant = %.1 f  ",Kp1
        )
18  printf ("\n  In  case  2,  Equilibrium  constant = %.1 f  ",
        Kp2)
```

Scilab code Exa 16.19 Dissociation calculations

```
1   clc
2   clear
3   // Initialization  of  variables
4   kp =5
```

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```
 5  // calculations
 6  x=poly(0,"x")
 7  vec=roots(24*x^3 + 3*x-2)
 8  x=vec(3)
 9  y=poly(0,"y")
10  vec2=roots(249*y^3 +3*y-2)
11  y=vec2(3)
12  // results
13  printf("percentage of dissociation = %.1f percent",x
        *100)
14  printf("\n If pressure =10 . degree of dissociation
        = %d percent",y*100)
```

Scilab code Exa 16.20 Extent of reaction

```
1  clc
2  clear
3  // Initialization of variables
4  x=poly(0,"x")
5  vec=roots(24*x^3 +48*x^2 + 7*x -4)
6  x=vec(3) *100
7  // results
8  printf("Extent of reaction= %d percent",100-x)
```

Chapter 17

Gas cycles and processes

Scilab code Exa 17.1 Efficiency and air fuel ratio Equilibrium calculations

```
1 clc
2 clear
3 //Initialization of variables
4 ha=1033 //Btu/mol air
5 hbd=2992 //Btu/mol air
6 hc=7823 //Btu/mol air
7 hdd=5142 //Btu/mol air
8 Hv=2733000 //Btu/mol
9 M=29
10 //calculations
11 Wt=hc-hdd
12 Wc=ha-hbd
13 Net=Wt+Wc
14 Heat=hc-hbd
15 etat=Net*100/Heat
16 molair=Heat/Hv
17 mr=molair*142/M
18 Af=1/mr
19 //results
20 printf("\n Thermal efficiency = %.1f percent",etat)
21 printf("\n Moles of fuel burned per mol of air = %.5
```

```
        f mol fuel/mol air",molair)
22  printf("\n Mass ratio in pounds = %.5f lbm fuel/lbm
        air",mr)
23  printf("\n Air fuel ratio = %d lbm air/lbm fuel",Af)
```

Chapter 18

Refrigeration

Scilab code Exa 18.1 Work and cop calculations

```
1  clc
2  clear
3  //Initialization of variables
4  Ta=500 //R
5  Tr=540 //R
6  //calculations
7  cop=Ta/(Tr-Ta)
8  hp=4.71/cop
9  disp("From steam tables,")
10 ha=48.02
11 hb=46.6
12 hc=824.1
13 hd=886.9
14 Wc=-(hd-hc)
15 We=-(hb-ha)
16 //results
17 printf("Coefficient of performance = %.1f ",cop)
18 printf("\n horsepower required per ton of
        refrigeration = %.3f hp/ton refrigeration",hp)
19 printf("\n Work of compression = %.1f Btu/lbm",Wc)
20 printf("\n Work of expansion = %.2f Btu/lbm",We)
```

Scilab code Exa 18.2 cop calculation

```
1  clc
2  clear
3  //Initialization of variables
4  x=0.8
5  he=26.28 //Btu/lbm
6  hb=26.28 //Btu/lbm
7  pe=98.76 //psia
8  pc=51.68 //psia
9  hc=82.71 //Btu/lbm
10 hf=86.80+0.95
11 //calculations
12 dwisen=-(hf-hc)
13 dwact=dwisen/x
14 hd=hc-dwact
15 cop=(hc-hb)/(hd-hc)
16 //results
17 printf("Coefficient of performance = %.2f",cop)
```

Scilab code Exa 18.3 work done and cop calculations

```
1  clc
2  clear
3  //Initialization of variables
4  hc=613.3//btu/lbm
5  hb=138.9//btu/lbm
6  ha=138.9//btu/lbm
7  hd=713.4 //btu/lbm
8  ta=464.7 //R
9  t0=545.7 //R
```

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```
10  v=8.150  //ft^3/lbm
11  //calculations
12  Qa=hc-hb
13  Qr=ha-hd
14  Wcd=Qa+Qr
15  cop=abs(Qa/Wcd)
16  hp=abs(4.71/cop)
17  carnot=abs(ta/(t0-ta))
18  rel=abs(cop/carnot)
19  mass=200/Qa
20  C=mass*v
21  //results
22  printf("Work done = %.1f Btu/lbm",Wcd)
23  printf("\n horsepower required per ton of
        refrigeration = %.3f hp/ton refrigeration",hp)
24  printf("\n Coefficient of performance actual = %.2f
        ",cop)
25  printf("\n Ideal cop = %.3f",carnot)
26  printf("\n relative efficiency = %.3f",rel)
27  printf("\n Mass flow rate = %.3f lbm/min ton",mass)
28  printf("\n Compressor capacity = %.2f cfm/ton",C)
```

Scilab code Exa 18.4 Pressure ratio calculations

```
1   clc
2   clear
3   //Initialization of variables
4   pc=0.6982  //psia
5   pe=0.1217  //psia
6   m=200  //gal/min
7   qual=0.98
8   h1=23.07  //Btu/lbm
9   h2=8.05   //Btu/lbm
10  hw=1071.3
11  //calculations
```

```
12 rp=pc/pe
13 m2=m/0.01602 *0.1388 //Conversion of units
14 m2=1670
15 dh=15.02
16 Qa=m2*(h1-h2)
17 h3=h2 + qual*hw
18 m3=Qa/(h3-h1)
19 v=0.016+ qual*2444
20 C=m3*v
21 //results
22 printf("Pressure ratio = %.2f",rp)
23 printf("\n Heat = %d Btu/min",Qa)
24 printf("\n Water make up required = %.2f lbm/min",m3
      )
25 printf("\n Volume of vapor entering ejector = %d cfm
      ",C)
26 disp("The answers are a bit different due to
      rounding off error in textbook")
```

Scilab code Exa 18.5 Work done and heat calculations

```
1 clc
2 clear
3 //Initialization of variables
4 disp("From fig B-4,")
5 disp("Appropraite notation from textbook has been
      used")
6 disp("All are enthalpy values at different stages")
7 hc=73.5 //Btu/lbm
8 hb=26.28 //Btu/lbm
9 hd=91.58 //Btu/lbm
10 hc2=190.7 //Btu/lbm
11 hd2=244.3 //Btu/lbm
12 hb2=44.4 //Btu/lbm
13 m1=1 //lbm
```

```
14  m2=0.461  //lbm
15  hc1=73.5  //Btu/lbm
16  hd1=83.35  //Btu/lbm
17  hc2=190.7  //Btu/lbm
18  hd2=244.3  //Btu/lbm
19  hb1=12.55  //Btu/lbm
20  hc22=197.58  //Btu/lbm
21  hd22=224  //Btu/lbm
22  //Calculations
23  w1=hc-hd
24  qa1=hc-hb
25  cop1=abs(qa1/(w1))
26  hp1=4.71/cop1
27  w2=hc2-hd2
28  qa2=hc2-hb2
29  cop2=abs(qa2/(w2))
30  hp2=4.71/cop2
31  qa3=m1*(hc1-hb1)
32  w3=m1*(hc1-hd1) + m2*(hc22-hd22)
33  cop3=abs(qa3/w3)
34  hp3=4.71/cop3
35  //results
36  disp("part a")
37  printf("Work done = %.2f Btu/lbm",w1)
38  printf("\n Heat = %.2f Btu/lbm",qa1)
39  printf("\n horsepower required per ton of
        refrigeration = %.3f hp/ton refrigeration",hp1)
40  printf("\n Coefficient of performance actual = %.2f
        ",cop1)
41  disp("case 2")
42  printf("\n Work done = %.1f Btu/lbm",w2)
43  printf("\n Heat = %.2f Btu/lbm",qa2)
44  printf("\n horsepower required per ton of
        refrigeration = %.3f hp/ton refrigeration",hp2)
45  printf("\n Coefficient of performance actual = %.2f
        ",cop2)
46  disp("part b")
47  printf("\n Work done = %.1f Btu/lbm",w3)
```

```
48  printf("\n Heat = %.2 f Btu/lbm",qa3)
49  printf("\n horsepower required per ton of
        refrigeration = %.3 f hp/ton refrigeration",hp3)
50  printf("\n Coefficient of performance actual = %.2 f
        ",cop3)
```

Scilab code Exa 18.6 hp and cop calculations

```
1  clc
2  clear
3  //Initialization of variables
4  disp("From fig B−4,")
5  disp("Appropraite notation from textbook has been
        used")
6  disp("All are enthalpy values at different stages")
7  ha=44.36 //Btu/lbm
8  hc=18.04 //Btu/lbm
9  hj=197.58 //Btu/lbm
10 hh=213.5 //Btu/lbm
11 hd=hc //Btu/lbm
12 he=190.66 //Btu/lbm
13 hk=241.25 //Btu/lbm
14 //calculations
15 m=(hc-ha)/(ha-hj)
16 hi=(m*hj+hh)/(1+m)
17 Qa=he-hd
18 W=he-hh + (1+m)*(hi-hk)
19 cop=abs(Qa/W)
20 hp=4.71/cop
21 //results
22 printf("\n horsepower required per ton of
        refrigeration = %.3 f hp/ton refrigeration",hp)
23 printf("\n Coefficient of performance actual = %.2 f
        ",cop)
```