

Scilab Textbook Companion for  
Thermodynamics  
by Obert<sup>1</sup>

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# Book Description

**Title:** Thermodynamics

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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	4
1 Survey of dimensions and units	5
2 Fundamental concepts	8
3 The first law	10
4 The reversible process	12
5 The second law	13
6 Properties of fluids	18
7 Characteristics of gases	24
8 Approximate calculations for real gases	29
9 The flow of fluids	39
10 Mixtures of gases and vapors	50
11 Thermochemical calculations	66
12 Power cycles vapor	79

13 Power cycles gas	89
14 Refrigeration	93

# List of Scilab Codes

Exa 1.1	Example 1 . . . . .	5
Exa 1.2	Example 2 . . . . .	5
Exa 1.3	Example 3 . . . . .	6
Exa 1.4	Example 4 . . . . .	6
Exa 1.5	Example 5 . . . . .	6
Exa 1.6	Example 6 . . . . .	7
Exa 2.1	Example 1 . . . . .	8
Exa 2.3	Example 2 . . . . .	8
Exa 3.1	Example 1 . . . . .	10
Exa 3.2	Example 2 . . . . .	11
Exa 4.2	Example 1 . . . . .	12
Exa 5.1	Example 1 . . . . .	13
Exa 5.2	Example 2 . . . . .	13
Exa 5.3	Example 3 . . . . .	14
Exa 5.4	Example 4 . . . . .	15
Exa 5.5	Example 5 . . . . .	15
Exa 5.7	Example 6 . . . . .	16
Exa 5.8	Example 7 . . . . .	16
Exa 6.1	Example 1 . . . . .	18
Exa 6.2	Example 2 . . . . .	18
Exa 6.3	Example 3 . . . . .	19
Exa 6.4	Example 4 . . . . .	19
Exa 6.5	Example 5 . . . . .	20
Exa 6.6	Example 6 . . . . .	20
Exa 6.7	Example 7 . . . . .	21
Exa 6.8	Example 8 . . . . .	21
Exa 6.10	Example 9 . . . . .	22
Exa 6.11	Example 10 . . . . .	23

Exa 7.2	Example 1 . . . . .	24
Exa 7.3	Example 3 . . . . .	24
Exa 7.4	Example 4 . . . . .	25
Exa 7.5	Example 5 . . . . .	25
Exa 7.6	Example 6 . . . . .	26
Exa 7.7	Example 7 . . . . .	26
Exa 7.8	Example 8 . . . . .	27
Exa 7.9	Example 9 . . . . .	27
Exa 8.1	Example 1 . . . . .	29
Exa 8.2	Example 2 . . . . .	29
Exa 8.3	Example 3 . . . . .	30
Exa 8.4	Example 4 . . . . .	30
Exa 8.5	Example 5 . . . . .	31
Exa 8.7	Example 7 . . . . .	31
Exa 8.8	Example 8 . . . . .	32
Exa 8.9	Example 9 . . . . .	32
Exa 8.10	Example 10 . . . . .	33
Exa 8.11	Example 11 . . . . .	33
Exa 8.12	Example 12 . . . . .	34
Exa 8.13	Example 13 . . . . .	35
Exa 8.14	Example 14 . . . . .	36
Exa 8.15	Example 15 . . . . .	36
Exa 8.16	Example 16 . . . . .	37
Exa 9.1	Example 1 . . . . .	39
Exa 9.2	Example 2 . . . . .	40
Exa 9.3	Example 3 . . . . .	40
Exa 9.4	Example 4 . . . . .	41
Exa 9.5	Example 5 . . . . .	42
Exa 9.6	Example 6 . . . . .	43
Exa 9.8	Example 8 . . . . .	43
Exa 9.9	Example 9 . . . . .	44
Exa 9.10	Example 10 . . . . .	45
Exa 9.11	Example 11 . . . . .	45
Exa 9.12	Example 12 . . . . .	46
Exa 9.13	Example 13 . . . . .	47
Exa 9.14	Example 14 . . . . .	47
Exa 9.15	Example 15 . . . . .	48
Exa 9.16	Example 16 . . . . .	48

Exa 9.17	Example 17 . . . . .	49
Exa 10.1	Example 1 . . . . .	50
Exa 10.2	Example 2 . . . . .	51
Exa 10.3	Example 3 . . . . .	52
Exa 10.4	Example 4 . . . . .	53
Exa 10.5	Example 5 . . . . .	53
Exa 10.6	Example 6 . . . . .	54
Exa 10.7	Example 7 . . . . .	54
Exa 10.8	Example 8 . . . . .	55
Exa 10.9	Example 9 . . . . .	56
Exa 10.10	Example 10 . . . . .	57
Exa 10.11	Example 11 . . . . .	57
Exa 10.12	Example 12 . . . . .	58
Exa 10.13	Example 13 . . . . .	59
Exa 10.14	Example 14 . . . . .	59
Exa 10.15	Example 15 . . . . .	60
Exa 10.16	Example 16 . . . . .	60
Exa 10.17	Example 17 . . . . .	61
Exa 10.18	Example 18 . . . . .	61
Exa 10.19	Example 19 . . . . .	62
Exa 10.20	Example 20 . . . . .	63
Exa 10.21	Example 21 . . . . .	64
Exa 11.1	Example 1 . . . . .	66
Exa 11.2	Example 2 . . . . .	66
Exa 11.3	Example 3 . . . . .	67
Exa 11.4	Example 4 . . . . .	67
Exa 11.5	Example 5 . . . . .	68
Exa 11.6	Example 6 . . . . .	68
Exa 11.7	Example 7 . . . . .	69
Exa 11.8	Example 8 . . . . .	69
Exa 11.9	Example 9 . . . . .	70
Exa 11.10	Example 10 . . . . .	70
Exa 11.11	Example 11 . . . . .	71
Exa 11.12	Example 12 . . . . .	72
Exa 11.13	Example 13 . . . . .	72
Exa 11.14	Example 14 . . . . .	72
Exa 11.15	Example 15 . . . . .	73
Exa 11.16	Example 16 . . . . .	74



Exa 11.17	Example 17 . . . . .	74
Exa 11.18	Example 18 . . . . .	75
Exa 11.19	Example 19 . . . . .	75
Exa 11.20	Example 20 . . . . .	76
Exa 11.21	Example 21 . . . . .	76
Exa 11.22	Example 22 . . . . .	77
Exa 11.23	Example 23 . . . . .	78
Exa 12.1	Example 1 . . . . .	79
Exa 12.2	Example 2 . . . . .	80
Exa 12.3	Example 3 . . . . .	81
Exa 12.4	Example 4 . . . . .	82
Exa 12.5	Example 5 . . . . .	83
Exa 12.6	Example 6 . . . . .	84
Exa 12.7	Example 7 . . . . .	84
Exa 12.8	Example 8 . . . . .	85
Exa 12.9	Example 9 . . . . .	86
Exa 12.10	Example 10 . . . . .	87
Exa 12.11	Example 11 . . . . .	87
Exa 13.1	Example 1 . . . . .	89
Exa 13.2	Example 2 . . . . .	90
Exa 13.3	Example 3 . . . . .	91
Exa 14.1	Example 1 . . . . .	93
Exa 14.3	Example 3 . . . . .	94
Exa 14.4	Example 4 . . . . .	95
Exa 14.5	Example 5 . . . . .	95
Exa 14.6	Example 6 . . . . .	96
Exa 14.7	Example 7 . . . . .	97

# Chapter 1

## Survey of dimensions and units

Scilab code Exa 1.1 Example 1

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

---

Scilab code Exa 1.2 Example 2

```
1 clc
2 // Initialization of variables
3 z1=1/5280
4 z2=1/3600
5 v=88 //ft/s
6 //calculations
7 v2= v*z1/z2
8 //results
9 printf(" velocity in mph = %d mph",v2)
```

---

**Scilab code Exa 1.3 Example 3**

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

---

**Scilab code Exa 1.4 Example 4**

```
1 clc
2 // Initialization of variables
3 m=10 //lbm
4 a=32.1739 //ft/sec^2
5 g=32.1739
6 // calculations
7 F=m*a/g
8 // results
9 printf("Force required = %d lbf",F)
```

---

**Scilab code Exa 1.5 Example 5**

```
1 clc
2 // Initialization of variables
3 F=5e-9 //lbf/ft^2 hr
```

```
4 g=32.1739
5 //calculations
6 F2=F*3600*g
7 //results
8 printf("Force without dimensions = %.2e lbm/ft sec",
        F2)
```

---

#### Scilab code Exa 1.6 Example 6

```
1 clc
2 //Initialization of variables
3 g=32.1739
4 gam=62.305
5 //calculations
6 rho=gam/g
7 //results
8 printf("Density in FLtheta system = %.3f slugs/ft^2"
        ,rho)
```

---

# Chapter 2

## Fundamental concepts

Scilab code Exa 2.1 Example 1

```
1 clc
2 // Initialization of variables
3 m=32.1739 //lbm
4 z=100 //ft
5 g=32.1739
6 // calculations
7 PE=m*z
8 PE2=m*z/g
9 // results
10 printf("Potential energy = %.2f g/g0 ft lbf",PE)
11 printf("\\n in other units , Potential energy = %d g
    ft slug",PE2)
```

---

Scilab code Exa 2.3 Example 2

```
1 clc
2 // Initialization of variables
3 u=100 //Btu/lbm
```

```
4 P=100 //psia
5 v=5 //ft^3
6 //calculations
7 h=u + P*v*144/778.16
8 //results
9 printf("Enthalpy of unit mass of fluid = %.1f Btu/
    lbm",h)
```

---

# Chapter 3

## The first law

Scilab code Exa 3.1 Example 1

```
1  clc
2  // Initialization of variables
3  f=5 //lbm/s
4  h2=1020 //B/lbm
5  h1=1000 //B/lbm
6  v2=50 //ft/s
7  v1=100 //ft/s
8  J=778
9  g=32.2
10 z2=0
11 z1=100
12 gc=32.2
13 Q=50 //Btu/s
14 // calculations
15 W=Q/f - (h2-h1) - (v2^2 -v1^2)/(2*J*gc) - g/gc *(z2-
    z1)/J
16 power = W*f
17 // results
18 printf("Work done = %.1 f Btu/lbm",W)
19 printf("\n Power = %.1 f Btu/s",power)
```

---

### Scilab code Exa 3.2 Example 2

```
1  clc
2  // Initialization of variables
3  m=5 //lbm
4  v=15 //ft^3/lbm
5  V=100 //ft/s
6  // calculations
7  A=m*v/V
8  D=(4*A/%pi)^(0.5)
9  // results
10 printf("Diameter = %.1f in",D*12)
```

---



# Chapter 4

## The reversible process

Scilab code Exa 4.2 Example 1

```
1 clc
2 // Initialization of variables
3 T1=100 //F
4 T2=500 //F
5 // calculations
6 function y=cp(t)
7     y=0.239 + 0.00003*t
8 endfunction
9 cpavg= 1/(T2-T1) *(intg(T1,T2,cp))
10 // results
11 printf("average value of Cp = %.3f Btu/lbm F",cpavg)
```

---

# Chapter 5

## The second law

Scilab code Exa 5.1 Example 1

```
1 clc
2 // Initialization of variables
3 Tr=500 //R
4 Ta=1000 //R
5 dt=100 //R
6 // calculations
7 n1=1- Tr/Ta
8 n2= 1-Tr/(Ta+dt)
9 n3 = 1- (Tr-dt)/Ta
10 // results
11 printf(" Efficiency in case 1 = %.1f percent",n1
        *100)
12 printf(" \n Efficiency in case 3 = %.1f percent",n2
        *100)
13 printf(" \n Efficiency in case 3 = %.1f percent",n3
        *100)
```

---

Scilab code Exa 5.2 Example 2

```

1  clc
2  // Initialization of variables
3  Tr=500 //R
4  Ta=2500 //R
5  Q=1000 //Btu
6  Ta2=1000 //R
7  // calculations
8  n1=1-Tr/Ta
9  w1=n1*Q
10 n2=1-Tr/Ta2
11 w2=n2*Q
12 dw=w1-w2
13 // results
14 printf("Work done in case 1 = %d Btu",w1)
15 printf("\\nWork done in case 2 = %d Btu",w2)
16 printf("\\n Excess work done in case 1 = %d Btu",dw)

```

---

### Scilab code Exa 5.3 Example 3

```

1  clc
2  clear
3  // Initialization of variables
4  Tr=1000 //R
5  Ta=3000 //R
6  Q=300 //Btu/min
7  p=5 //hp
8  J=778
9  // calculations
10 n1=1-Tr/Ta
11 nt=p*33000/(J*Q)
12 // results
13 printf("Theoretical efficiency = %.3f",nt)
14 printf("\\n Claimed efficiency = %.3f",n1)
15 if n1>nt then
16     printf("\\n Inventor claims are true")

```

```
17 else
18     printf("\n Inventor claims are false")
19 end
```

---

#### Scilab code Exa 5.4 Example 4

```
1 clc
2 // Initialization of variables
3 W=14.5 //B/lbm
4 Q=141.7 //B/lbm
5 Tr=520 //R
6 Ta=1040 //R
7 // calculations
8 n1=W/Q
9 n2=1-Tr/Ta
10 Wc=n2*Q
11 // results
12 printf("Thermal efficiency = %.2f percent",n1*100)
13 printf("\n Work done in carnot cycle = %.1f Btu/lbm"
    ,Wc)
```

---

#### Scilab code Exa 5.5 Example 5

```
1 clc
2 // Initialization of variables
3 cp=0.25
4 T1=3460 //R
5 T2=520 //R
6 // calculations
7 Q=cp*(T2-T1)
8 ds=cp*log(T2/T1)
9 G= Q - T2*ds
10 eta= G/Q
```

```
11 //results
12 printf("Thermal efficiency = %.1f percent",eta*100)
```

---

#### Scilab code Exa 5.7 Example 6

```
1 clc
2 //Initialization of variables
3 T1=60+460 //R
4 T2=100+460 //R
5 m=1 //lbm
6 cp=1 //Btu/lbm F
7 //calculations
8 ds= m*cp*log(T2/T1)
9 //results
10 printf("Change in entropy = %.3f Btu/lbm R",ds)
```

---

#### Scilab code Exa 5.8 Example 7

```
1 clc
2 //Initialization of variables
3 t1=32 //F
4 t2=80 //F
5 m1=1 //lbm
6 m2=5 //lbm
7 hlf=144 //Bru/lbm
8 cp=1 //B/lbm F
9 //calculations
10 te=(-hlf+t1*m1+t2*cp*m2)/(m2+m1)
11 dsi= hlf/(t1+460) + cp*log((460+te)/(460+t1))
12 dsw= m2*cp*log((460+te)/(460+t2))
13 dss=dsi+dsw
14 LE=-(t1+460)*dss
```

```
15 G1=m2*cp*(te-t2) - m2*(460+t1)*log((460+te)/(460+t2)
    )
16 G2=m1*cp*(te-t1) - m1*(460+t1)*log((460+te)/(460+t1)
    )
17 G=G1+G2
18 //results
19 printf("Entropy change of the system = %.4f Btu/R",
    dss)
20 printf("\n Loss of available energy = %.1f Btu",LE)
21 printf("\n Net change in available energy = %.1f Btu
    ",G)
22 //The asnwer is a bit different due to rounding off
    error in textbook
```

---

# Chapter 6

## Properties of fluids

Scilab code Exa 6.1 Example 1

```
1 clc
2 // Initialization of variables
3 m=1 //lbm
4 T=32+460 //R
5 //calculations
6 disp("From steam tables")
7 hf=0
8 p=0.08854 //psi
9 vf=0.01602 //ft^3
10 u = hf - p*vf*144/778.16
11 //results
12 printf("Internal energy = %.7f Btu/lbm", u)
```

---

Scilab code Exa 6.2 Example 2

```
1 clc
2 // Initialization of variables
3 T=35+459.6 //R
```

```

4 //calculations
5 disp("From steam tables,")
6 hfg=1074.1 //Btu/lbm
7 ds=hfg/T
8 //results
9 printf("Change in entropy = %.4f Btu/lbm R",ds)

```

---

### Scilab code Exa 6.3 Example 3

```

1 clc
2 //Initialization of variables
3 p=3 //psi
4 x=0.35
5 //calculations
6 printf("From steam tables,")
7 p=3 //psi
8 vf=0.01630 //ft^3/lbm
9 vg=118.71 //ft^3/lbm
10 hf=109.37 //Btu/lbm
11 hfg=1013.2 //Btu/lbm
12 vx=vf+x*(vg-vf)
13 hx=hf+x*(hfg)
14 //results
15 printf("specific volume = %.1f ft^3/lbm",vx)
16 printf("\n specific enthalpy = %.1f Btu/lbm",hx)

```

---

### Scilab code Exa 6.4 Example 4

```

1 clc
2 //Initialization of variables
3 disp("From steam tables,")
4 T1=355.21 //F
5 T2=500 //F

```



```

6 hg=1193.4 //Btu/lbm
7 h=1274.8 //Btu/lbm
8 //calculations
9 Qrev=h-hg
10 //results
11 printf("Heat transferred = %.1f Btu/lbm",Qrev)

```

---

#### Scilab code Exa 6.5 Example 5

```

1 clc
2 //Initialization of variables
3 Qrev=81.4 //Btu/lbm
4 T1=355.21 //F
5 T2=500 //F
6 cp=0.562
7 //calculations
8 cp=Qrev/(T2-T1)
9 ds=cp*(log((460+T2)/(460+T1)))
10 s1=1.5728
11 s2=s1+ds
12 //results
13 printf("Change in entropy = %.4f Btu/lbm F",ds)
14 printf("\n Final entropy = %.4f Btu/lbm F",s2)

```

---

#### Scilab code Exa 6.6 Example 6

```

1 clc
2 //Initialization of variables
3 m=1 //lbm
4 P1=144 //psia
5 P2=150 //psia
6 t1=360 //F
7 J=778.16

```

```

8 //calculations
9 disp("From steam tables ,")
10 v1=3.160 //ft ^3/lbm
11 h1=1196.5 //Btu/lbm
12 u1=h1-P1*v1*144/J
13 h2=1211.4 //Btu/lbm
14 u2=h2 - P2*144*v1/J
15 Qrev=u2-u1
16 //results
17 printf("Heat transferred = %.1f Btu/lbm",Qrev)

```

---

#### Scilab code Exa 6.7 Example 7

```

1 clc
2 //Initialization of variables
3 sf=0.12948
4 dt=0.32 //F
5 t1=100 //F
6 x=0.6
7 //calculations
8 t2=t1+dt
9 hf=67.97
10 ht=2.7
11 hp=0.3
12 h2=hf+ht+hp
13 Wrev=hf-h2
14 Wact=Wrev/x
15 //results
16 printf("Actual work done = %.1f Btu/lbm",Wact)

```

---

#### Scilab code Exa 6.8 Example 8

```

1 clc

```

```

2 //Initialization of variables
3 p1=1000 //psia
4 t1=100.32 //F
5 h1=70.97 //Btu/lbm
6 p2=1000 //psia
7 t2=544.61 //F
8 h2=1191.8 //Btu/lbm
9 //calculations
10 Qrev=h2-h1
11 //results
12 printf("Heat transferred = %.1f Btu/lbm",Qrev)

```

---

#### Scilab code Exa 6.10 Example 9

```

1 clc
2 //Initialization of variables
3 h1=1220.4 //Btu/lbm
4 s1=1.6050 //Btu/lbm R
5 s2=1.6050 //Btu/lbm R
6 p2=3 //psia
7 sf=0.2008 //Btu/lbm R
8 hf=109.37
9 sfg=1.6855 //Btu/lbm R
10 hfg=1013.2 //Btu/lbm
11 eta=0.7
12 //calculations
13 x= (s2-sf)/sfg
14 h2=hf+ x*hfg
15 Wrev= h1-h2
16 w=eta*Wrev
17 //results
18 printf("Work done = %d Btu/lbm",Wrev)
19 printf("\n Work done in case 2 = %.1f Btu/lbm",w)
20 //The answer is a bit different due to rounding off
    error int he textbook

```

---

Scilab code Exa 6.11 Example 10

```
1 clc
2 // Initialization of variables
3 disp("From steam tables ,")
4 hb=1192.8 //Btu/lbm
5 ha=hb
6 hf=330.51 //Btu/lbm
7 hfg=863.6 //Btu/lbm
8 // calculations
9 x=(ha-hf)/hfg
10 // results
11 printf("Quality of wet steam = %.1f percent",x*100)
```

---

# Chapter 7

## Characteristics of gases

Scilab code Exa 7.2 Example 1

```
1 clc
2 // Initialization of variables
3 x=1545 //ft lbf/ R mol
4 z=2120
5 //calculations
6 y=x/z
7 //results
8 printf("y = %.3f atm ft^2 /R mol",y)
```

---

Scilab code Exa 7.3 Example 3

```
1 clc
2 // Initialization of variables
3 P=14.7 //psi
4 t=60+460 //R
5 R0=10.73 //psia ft^3/mol R
6 //calculations
7 v=R0*t/P
```

```
8 m=28.96
9 //results
10 printf("volume = %d ft^3/mol",v)
11 printf("\n Mass = %.2f lbm",m)
```

---

#### Scilab code Exa 7.4 Example 4

```
1 clc
2 //Initialization of variables
3 p=20 //psi
4 t=100+460 //R
5 R0=10.73
6 M=28
7 //calculations
8 rho=p/(R0/M *t)
9 //results
10 printf("density of nitrogen = %.4f lbm/ft^3",rho)
```

---

#### Scilab code Exa 7.5 Example 5

```
1 clc
2 //Initialization of variables
3 T1=1000 //R
4 T2=2000 //R
5 //calculations
6 function y =cp(t)
7     y=9.47 -3.47*10^3 /t + 1.16*10^6 /t^2
8 endfunction
9 cp2= 1/(T2-T1) *(intg(T1,T2, cp))
10 //results
11 printf(" Specific heat = %.2f Btu/mol R", cp2)
```

---

### Scilab code Exa 7.6 Example 6

```
1 clc
2 // Initialization of variables
3 R=0.73
4 v=0.193*44 //ft^3/mol
5 T=672 //R
6 a=924.2 //atm ft^6 /mol^2
7 b=0.685 //ft^3/mol
8 //calculations
9 p1= R*T/(v-b) - a/v^2
10 p2=R*T/v
11 //results
12 printf("Ideal gas law , pressure = %.1f atm",p2)
13 printf("\\n Vanderwaals law , pressure = %.1f atm",p1)
```

---

### Scilab code Exa 7.7 Example 7

```
1 clc
2 // Initialization of variables
3 Z=1.39
4 R=0.73
5 T=492 //R
6 p=500 //atm
7 M=28 //lbm
8 //calculations
9 v=Z*R*T/(p*M)
10 //results
11 printf("volume = %.4f ft^3/lbm",v)
```

---

### Scilab code Exa 7.8 Example 8

```
1 clc
2 // Initialization of variables
3 p=50 //atm
4 pc= 73 //atm
5 t= 459.7+212 //R
6 tc=459.7+87.9 //R
7 R=0.73
8 M=44
9 v=0.193 //ft^3/lbm
10 //calculations
11 pr=p/pc
12 tr=t/tc
13 z=0.88 //from compressibility charts
14 p2= z*R*t/v/M
15 //results
16 printf(" pressure = %.1 f atm" ,p2)
```

---

### Scilab code Exa 7.9 Example 9

```
1 clc
2 // Initialization of variables
3 pc=45.8 //atm
4 tc=343.9 //R
5 t=515 //R
6 v=2.2
7 R=0.73
8 //calculations
9 tr=t/tc
10 vr= pc*v/(R*tc)
11 //from compressibility charts
12 z=0.803
13 pr=3
14 p=pr*pc
```



```
15 p2= R*t/v
16 err= (p2-p)/p
17 //results
18 printf("pressure = %d atm",p)
19 printf("\n percentage error = %d percent ",err*100)
20 //the answer varies a bit due to rounding off error
```

---

# Chapter 8

## Approximate calculations for real gases

Scilab code Exa 8.1 Example 1

```
1 clc
2 // Initialization of variables
3 R=1.986 //B/mol R
4 t2=1100 //R
5 t1=1000 //R
6 // calculations
7 wrev=R*(t2-t1)
8 // results
9 printf("work done = %.1f Btu/mol",wrev)
```

---

Scilab code Exa 8.2 Example 2

```
1 clc
2 // Initialization of variables
3 p1=20 //psia
4 p2=40 //psia
```

```

5 t1= 460+40 //R
6 m=28
7 R=1.986
8 cp=0.246 //B/lbm R
9 //calculations
10 t2= t1*p2/p1
11 cv=cp- (R/m)
12 Qrev=cv*(t2-t1)
13 ds= cv*log(t2/t1)
14 //results
15 printf("heat transferred = %.1f Btu/lbm",Qrev)
16 printf("\n change in entropy = %.3f Btu/lbm R",ds)

```

---

#### Scilab code Exa 8.3 Example 3

```

1 clc
2 //Initialization of variables
3 t1=500 //R
4 t2=1000 //R
5 //calculations
6 function y = cp1(t)
7     y= 7.484 - 3.47*10^3 /t + 1.16*10^6 /t^2
8 endfunction
9 function y = cp2(t)
10    y = 7.484/t - 3.47*10^3 /t^2 + 1.16*10^6 /t^3
11 endfunction
12 Q=intg(t1,t2,cp1)
13 ds=intg(t1,t2,cp2)
14 //results
15 printf("heat transferred = %d Btu/mole",Q)
16 printf("\n change in entropy = %.3f Btu/mole R",ds)

```

---

#### Scilab code Exa 8.4 Example 4

```

1  clc
2  // Initialization of variables
3  v1=20.9 //ft ^3/mol
4  v2=23.2 //ft ^3/mol
5  p=500 //psia
6  w1=198.6 //Btu/mol
7  // calculations
8  w=p*(v2-v1)*144/100*0.1285
9  err = (w-w1)/w
10 // results
11 printf("Work done in this case = %d Btu/mol",w)
12 printf("\\n error = %.2f percent",err*100)

```

---

#### Scilab code Exa 8.5 Example 5

```

1  clc
2  // Initialization of variables
3  R=1.986
4  T=1000 //R
5  vr=2
6  // calculations
7  Q= R*T*log(vr)
8  // results
9  printf("heat transferred = work = %d Btu/mol",Q)

```

---

#### Scilab code Exa 8.7 Example 7

```

1  clc
2  // Initialization of variables
3  v2=41.8 //ft ^3/mol
4  v1=20.9 //ft ^3/mol
5  b=0.685 //ft ^3/mol
6  R=0.73 //atm ft ^3 / R mol

```

```

7 a=924.2
8 T=1000 //R
9 //calculations
10 vr= log((v2-b)/(v1-b))
11 W= R*T*vr + a*(1/v2 - 1/v1)
12 //results
13 printf("Work done = %.1f atm ft^3/mol",W)

```

---

#### Scilab code Exa 8.8 Example 8

```

1 clc
2 //Initialization of variables
3 R=1545
4 n=1.3
5 T1=520 //R
6 p2=125 //psia
7 p1=14.7 //psia
8 M=29
9 cv=0.171
10 k=1.4
11 //calculations
12 Wrev= R*T1/M/(1-n) *((p2/p1)^((n-1)/n) -1)
13 T2= T1*(p2/p1)^((n-1)/n)
14 Qrev= cv*((k-n)/(1-n))*(T2-T1)
15 //results
16 printf("Work done = %d ft lbf/lbm",Wrev)
17 printf("\n Heat transferred = %.1f Btu/lbm",Qrev)

```

---

#### Scilab code Exa 8.9 Example 9

```

1 clc
2 //Initialization of variables
3 k=1.38

```

```

4 R=1.986
5 T1=900 //R
6 M=29
7 pr=0.1
8 Wrev=50 //Btu/lbm
9 //calculations
10 KE = k*R*T1/M/(1-k) *(pr^((k-1)/k) -1) -Wrev
11 //results
12 printf("Change in kinetic energy = %d Btu/lbm",KE)

```

---

#### Scilab code Exa 8.10 Example 10

```

1 clc
2 //Initialization of variablesk=1.38
3 R=1.986
4 T1=900 //R
5 M=29
6 pr=0.1
7 Wrev=50 //Btu/lbm
8 cp=0.245
9 k=1.3
10 //calculations
11 KE = -cp*T1*(pr^((k-1)/k) -1) -Wrev
12 //results
13 printf("Change in kinetic energy = %d Btu/lbm",KE)

```

---

#### Scilab code Exa 8.11 Example 11

```

1 clc
2 //Initialization of variables
3 n=1.3
4 p2=125 //psia
5 m=1 //lbm

```

```

6 c=0.04
7 cv=0.171
8 k=1.4
9 p1=14.7 //psia
10 T2=852 //R
11 T1=520 //R
12 //calculations
13 eta=1+c-c*((p2/p1)^(1/n))
14 md=m/eta
15 m12=md*(c+1)
16 m34=m12-m
17 Q12=m12*cv*((k-n)/(1-n))*(T2-T1)
18 Q34=m34*cv*((k-n)/(1-n))*(T1-T2)
19 Q=Q12+Q34
20 //results
21 printf("Net heat transfer from air = %.1f Btu/lbm ",
        Q)

```

---

### Scilab code Exa 8.12 Example 12

```

1 clc
2 //Initialization of variables
3 stroke=14 //in
4 n=1.3
5 rpm=130
6 pa=14.7 //psia
7 ta=80+460 //R
8 c=0.03
9 p1=pa
10 p4=200 //psia
11 R=53.3
12 cap=400 //cfm
13 m=29.4
14 cp=0.24
15 //calculations

```

```

16 pi=sqrt(pa*p4)
17 nv=1+c-c*(pi/p1)^(1/n)
18 D1=cap/nv
19 vd1=D1/(2*rpm)
20 d1=sqrt(vd1*1728*4/(%pi*stroke))
21 vh=cap*p1/pi
22 Dh=vh/nv
23 vdh=Dh/(2*rpm)
24 dh=sqrt(vdh*1728*4/(%pi*stroke))
25 m=p1*144*cap/R/ta
26 T2=ta*(pi/p1)^((n-1)/n)
27 Q=m*cp*(T2-ta)
28 //results
29 printf("diameter of cylinder 1 = %d in",d1)
30 printf("\n diameter of cylinder 2 = %.2f in",dh)
31 printf("\n Heat transferred = %d Btu/min",Q)

```

---

### Scilab code Exa 8.13 Example 13

```

1 clc
2 //Initialization of variables
3 Pr=10
4 n=1.3
5 T1=900 //R
6 W=50 //Btu/lbm
7 //calculations
8 T2=T1/Pr^((n-1)/n)
9 h1=120.86
10 h2=30.69
11 dh=h2-h1
12 ke=-dh-W
13 //results
14 printf("Change in kinetic energy = %.2f Btu/lbm",ke)

```

---



Scilab code Exa 8.14 Example 14

```
1  clc
2  // Initialization of variables
3  T1=900 //R
4  p1=100 //psia
5  p2=10 //psia
6  w=50 //Btu/lbm
7  // calculations
8  h1=120.86 //Btu/lbm
9  pr1=17.374
10 pr2=pr1*p2/p1
11 disp("From equilibrium charts,")
12 T2=468 //R
13 h2=16.3 //Btu/lbm
14 ke=h1-h2-w
15 // results
16 printf("Change in kinetic energy = %.2f Btu/lbm",ke)
```

---

Scilab code Exa 8.15 Example 15

```
1  clc
2  // Initialization of variables
3  p1=100 //psi
4  p2=10 //psia
5  pa=14.7 //psi
6  T2=468 //R
7  T2r=528 //R
8  R=1.986
9  M=29
10 // calculations
11 disp("From air tables,")
```

```

12 phi1=0.06657
13 phi2=0.03762
14 ds=phi1-phi2
15 phi11=0.19569
16 phi12=0.06657
17 ds2= phi12-phi11 - R/M *log(p2/p1)
18 //results
19 printf("In case 1, change in entropy = %.5f Btu/lbm
    R",ds)
20 printf("\n In case 2, change in entropy = %.5f btu/
    lbm R",ds2)
21 //the answer is a bit different due to rounding off
    error in textbook

```

---

#### Scilab code Exa 8.16 Example 16

```

1  clc
2  //Initialization of variables
3  T1=520 //R
4  disp("From air table ,")
5  vr1=5192
6  u1=-6.87 //Btu/lbm
7  pr1=2.504
8  vrat=6
9  p1=14.7
10 R=1.986
11 M=29
12 //calculations
13 vr2=vr1/vrat
14 T2=1050 //R
15 u2=86.1 //Btu/lbm
16 pr2=30.35
17 p2=p1*pr2/pr1
18 W=u1-u2
19 k=1.39

```

```
20 p22=p1*vrat^(k)
21 T22=T1*(vrat)^(k-1)
22 W2=R*(T22-T1)/(1-k)/M
23 //results
24 printf("in case 1, Final pressure = %d psia",p2)
25 printf("\n in case 1, final temperature = %d R",T2)
26 printf("\n in case 1, work done = %.2f Btu/lbm",W)
27 printf("\n in case 2, Final pressure = %d psia",p22)
28 printf("\n in case 2, final temperature = %d R",T22)
29 printf("\n in case 2, work done = %.2f Btu/lbm",W2)
30 //The answers are a bit different due to rounding
    off error in textbook
```

---

# Chapter 9

## The flow of fluids

Scilab code Exa 9.1 Example 1

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

```
22 //The initial values of velocity and area are 0 and
    infinity respectively
```

---

### Scilab code Exa 9.2 Example 2

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

---

### Scilab code Exa 9.3 Example 3

```
1  clc
```

```

2 //Initialization of variables
3 rpt=0.569
4 b=0.8
5 p1=50 //psia
6 cp=0.24
7 T1=520 //R
8 k=1.4
9 v2=12.2
10 v1=3.86
11 m=1
12 //calculations
13 pt=p1*rpt
14 Vtrev=223.77*sqrt(cp*T1*(1- rpt^((k-1)/k)) /(1- b^4
    *(v1/v2)^2))
15 vt=(p1/pt)^(1/k) *v1
16 At=m*vt/Vtrev
17 //results
18 printf("Area of throat = %.5f ft^2",At)

```

---

#### Scilab code Exa 9.4 Example 4

```

1 clc
2 //Initialization of variables
3 J=778
4 g=32.2
5 pc=54.6 //psia
6 h1=1329.1 //Btu/lbm
7 h2=1265 //btu/lbm
8 V2rev=1790 //ft/s
9 cv=0.99
10 m=1 //lbm
11 cv2=0.96
12 //calculations
13 V2d=cv*V2rev
14 hd=cv^2 *(h1-h2)

```

```

15 h2d=h1-hd
16 v2d=9.946
17 A2d=m*v2d/V2d
18 dh=-154.3
19 V3=2775 //ft/s
20 V3d=cv2*V3
21 h3d= h1+ cv2^2 *dh
22 v3d=22.05 //ft^3/lbm
23 A3d=m*v3d/V3d
24 //results
25 printf("Throat area in case 2 = %.4f ft^2",A2d)
26 printf("\n Throat area in case 3 = %.5f ft^2",A3d)

```

---

#### Scilab code Exa 9.5 Example 5

```

1 clc
2 //Initialization of variables
3 p2=26.4 //psia
4 p1=50 //psia
5 p3=10 //psia
6 V2rev=1017 //ft/s
7 cv=0.99
8 J=778
9 g=32.2
10 cp=0.24
11 T1=460+60 //R
12 k=1.4
13 R=1545/29
14 m=1
15 cv2=0.92
16 //calculations
17 V2d=cv*V2rev
18 dhr= (V2rev^2 - V2d^2)/(2*g*J)
19 dtr=dhr/cp
20 T2=T1*(p2/p1)^((k-1)/k)

```

```

21 T2d=T2+dtr
22 v2d=R*T2d/(p2*144)
23 A2d= m*v2d/V2d
24 V3=1515
25 V3d=V3*cv2^0.5
26 T3=T1*(p3/p1)^((k-1)/k)
27 dhr2=(V3^2 - V3d^2)/(2*J*g)
28 dtr2=dhr2/cp
29 T3d=T3+dtr2
30 v3d=R*T3d/(p3*144)
31 A3d=m*v3d/V3d
32 //results
33 printf("Area = %.5f ft^2",A2d)
34 printf("\n Area in case 2= %.5f ft^2",A3d)

```

---

#### Scilab code Exa 9.6 Example 6

```

1 clc
2 //Initialization of variables
3 mum=0.0000121 //lbm/ft sec
4 D=1.820 //in
5 m=1.173 //lbm/sec
6 //calculations
7 Re=1.27*m*12/(D*mum)
8 //results
9 printf("Reynolds number = %d ",Re)
10 //The answer is a bit different due to rounding off
    error in textbook

```

---

#### Scilab code Exa 9.8 Example 8

```

1 clc
2 //Initialization of variables

```



```

3 pt=54.6 //psia
4 dh=64.1 //Btu/lbm
5 dh2=154.3 //Btu/lbm
6 vt=9.844 //ft ^3/lbm
7 vt2=21.279 //ft ^3/lbm
8 C=0.98
9 J=778
10 g=32.17
11 m=1 //lbm/sec
12 //calculations
13 At=m/C *sqrt(vt^2 /(2*g*J*dh))
14 A2=m/C *sqrt(vt2^2 /(2*g*J*dh2))
15 //results
16 printf("Throat area = %.4f ft ^2",At)
17 printf("\n Area at part 2 = %.5f ft ^2",A2)

```

---

#### Scilab code Exa 9.9 Example 9

```

1 clc
2 //Initialization of variables
3 k=1.4
4 D2=1.820
5 D1=6.065
6 p2=20.18 //psia
7 p1=30 //psia
8 g=32.2
9 G=13.59
10 zm=20
11 R=1545/29
12 C=0.68
13 T=520 //R
14 //calculations
15 dp=0.03609*G*zm
16 rp=p2/p1
17 bet=D2/D1

```

```

18 v1=R*T/(p1*144)
19 A2=%pi*D2^2 /(4*144)
20 m=C*A2/sqrt(1 - bet^4 *rp^(1.43)) *sqrt(2*g*k*p1
      *144/(k-1)/v1 *(rp^(2/k) - rp^((k+1)/k)))
21 //results
22 printf("Mass flow rate = %.3f lbm/sec",m)
23 //The answer is a bit different due to rounding off
      error in textbook

```

---

#### Scilab code Exa 9.10 Example 10

```

1  clc
2  //Initialization of variables
3  K=0.6007
4  Y1=0.91
5  D1=6.065
6  D2=1.820
7  rho1=0.156
8  p1=30
9  p2=20.18
10 //calculations
11 bet=D2/D1
12 m=0.525*K*Y1^2 *D2^2 *sqrt(rho1*(p1-p2))
13 C=K*sqrt(1-bet^4)
14 //results
15 printf("mass flow rate = %.2f lbm/sec",m)
16 printf("\n Coefficient of discharge = %.3f",C)

```

---

#### Scilab code Exa 9.11 Example 11

```

1  clc
2  //Initialization of variables
3  zm=0.216

```

```

4 pm=62.3 //lbm/ft ^2
5 p1=0.0736 //lbm/ft ^2
6 g=32.2
7 d=4
8 //calculations
9 H=zm*(pm-p1)/12/p1
10 V=sqrt(2*g*H)
11 m=%pi/4 *d^2 *V*p1
12 //results
13 printf("average velocity = %.1f ft/sec",V)
14 printf("\n mass flow rate = %.1f lbm/sec",m)

```

---

#### Scilab code Exa 9.12 Example 12

```

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

```

---

### Scilab code Exa 9.13 Example 13

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

---

### Scilab code Exa 9.14 Example 14

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

```
9 D=sqrt(A*4/%pi)
10 //results
11 printf("Area = %.3 f in^2",A)
12 printf("\n diameter = %.2 f in",D)
```

---

#### Scilab code Exa 9.15 Example 15

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

---

#### Scilab code Exa 9.16 Example 16

```
1 clc
2 //Initialization of variables
3 p1=100 //psia
4 p2=14.7 //psia
5 k=1.4
```

```

6 T1=700 //R
7 R=10.73/29
8 V=50
9 cv=0.171
10 cp=0.24
11 R2=1.986/29
12 //calculations
13 T2=T1/ (p1/p2)^((k-1)/k)
14 T2=358 //R
15 m1=p1*V/(R*T1)
16 m2=p2*V/(R*T2)
17 Wrev= cv*(m1*T1 - m2*T2) - (m1-m2)*(T2)*cp
18 Wrev2=m1*cv*(T1-T2) - m1*R2*(T2-p2/p1*T1)
19 //results
20 printf("Work done in case 1 = %d Btu",Wrev)
21 printf("\n Work done in case 2 = %d Btu",Wrev2)

```

---

#### Scilab code Exa 9.17 Example 17

```

1 clc
2 //Initialization of variables
3 hf=1187.2 //Btu/lbm
4 p2=100 //psia
5 //calculations
6 t=328 //F
7 u2=hf
8 disp("from steam table,")
9 t2=540 //F
10 p2=100 //psia
11 dt=t2-t
12 //results
13 printf("Rise in temperature = %d F",dt)

```

---

# Chapter 10

## Mixtures of gases and vapors

Scilab code Exa 10.1 Example 1

```
1  clc
2  // Initialization of variables
3  m1=10 //lbm
4  m2=15 //lnm
5  p=50 //psia
6  t=60+460 //R
7  M1=32
8  M2=28.02
9  R0=10.73
10 // calculations
11 n1=m1/M1
12 n2=m2/M2
13 x1=n1/(n1+n2)
14 x2=n2/(n1+n2)
15 M=x1*M1+x2*M2
16 R=R0/M
17 V=(n1+n2)*R0*t/p
18 rho=p/(R0*t)
19 rho2=M*rho
20 p1=x1*p
21 p2=x2*p
```

```

22 v1=x1*V
23 v2=x2*V
24 //results
25 disp(" part a")
26 printf("Mole fractions of oxygen and nitrogen are %
    .3f and %.3f respectively",x1,x2)
27 disp(" part b")
28 printf("Average molecular weight = %.1f ",M)
29 disp(" part c")
30 printf("specific gas constant = %.4f psia ft^3/lbm R
    ",R)
31 disp(" part d")
32 printf("volume of mixture = %.1f ft^3",V)
33 printf("density of mixture is %.5f mole/ft^3 and %.2
    f lbm/ft^3",rho,rho2)
34 disp(" part e")
35 printf("partial pressures of oxygen and nitrogen are
    %.2f psia and %.2f psia respectively" ,p1,p2)
36 printf("\n partial volumes of oxygen and nitrogen
    are %.2f ft^3 and %.2f ft^3 respectively",v1,v2)

```

---

### Scilab code Exa 10.2 Example 2

```

1  clc
2  //Initialization of variables
3  m1=5.28
4  m2=1.28
5  m3=23.52
6  //calculations
7  m=m1+m2+m3
8  x1=m1/m
9  x2=m2/m
10 x3=m3/m
11 C=12/44 *m1/ m
12 O=(32/44 *m1 + m2)/m

```



```

13 N=m3/m
14 //results
15 printf("From gravimetric analysis , co2 = %.1f
    percent , o2 = %.1f percent and n2 = %.1f percent
    ",x1*100,x2*100,x3*100)
16 printf("\n From ultimate analysis , co2 = %.2f
    percent , o2 = %.2f percent and n2 = %.2f percent
    ",C*100,O*100,N*100)

```

---

### Scilab code Exa 10.3 Example 3

```

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

```

---

#### Scilab code Exa 10.4 Example 4

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

---

#### Scilab code Exa 10.5 Example 5

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

```

14 V1= n1*R0*(t1+460)/p1
15 V2=n2*R0*(t2+460)/p2
16 V=V1+V2
17 pm=(n1+n2)*R0*(t+460)/V
18 //results
19 printf("Pressure of mixture = %.1f psia",pm)

```

---

#### Scilab code Exa 10.6 Example 6

```

1 clc
2 //Initialization of variables
3 T2=546.6 //R
4 T1=520 //R
5 T3=560 //R
6 v2=1389.2
7 v1=186.2
8 R0=1.986
9 c1=5.02
10 c2=4.97
11 n1=1
12 n2=2
13 v3=1203
14 //calculations
15 ds1=n1*c1*log(T2/T1) + n1*R0*log(v2/v1)
16 ds2=n2*c2*log(T2/T3)+n2*R0*log(v2/v3)
17 ds=ds1+ds2
18 //results
19 printf("Net change in entropy = %.3f Btu/R",ds)
20 //The answer is a bit different due to rounding off
    error in the textbook

```

---

#### Scilab code Exa 10.7 Example 7

```

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

```

---

### Scilab code Exa 10.8 Example 8

```

1  clc
2  //Initialization of variables

```

```

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

```

---

### Scilab code Exa 10.9 Example 9

```

1 clc
2 //Initialization of variables
3 ps=0.64 //psia
4 p=14.7 //psia
5 M=29
6 M2=46
7 //calculations
8 xa=ps/p
9 mb=xa*9/M *M2/(1-xa)
10 //results
11 printf("percentage = %d percent",mb*100)

```

---

### Scilab code Exa 10.10 Example 10

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

---

### Scilab code Exa 10.11 Example 11

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

```

17 pa=p-pw
18 rhoa= pa*144/(Ra*t1)
19 w=rhow/rhoa
20 //results
21 disp("part a")
22 printf("partial pressure of water = %.5f psia",pw)
23 printf("\n dew temperature = %d F",tdew)
24 disp("part b")
25 printf("density of water = %.6f lbm/ft ^3",rhow)
26 printf("\n in case 2, density of water = %.6f lbm/ft
    ^3",rhow2)
27 printf("\n density of air = %.6f lbm/ft ^3",rhoa)
28 disp("part c")
29 printf("specific humidity = %.4f lbm steam/lbm air"
    ,w)

```

---

#### Scilab code Exa 10.12 Example 12

```

1 clc
2 //Initialization of variables
3 p=14.696 //psia
4 ps=0.0505 //psia
5 ps2=0.5067 //psia
6 phi2=0.5
7 phi=0.6
8 grain=7000
9 //calculations
10 pw=phi*ps
11 w1=0.622*pw/(p-pw)
12 pw2=phi2*ps2
13 w2=0.622*pw2/(p-pw2)
14 dw=w2-w1
15 dwg=dw*grain
16 //results
17 printf("change in moisture content = %.6f lbm water/

```

```
    lbm dry air",dw)
18 printf("\n in grains , change = %.3f grains water/lbm
    dry air",dwg)
```

---

#### Scilab code Exa 10.13 Example 13

```
1  clc
2  //Initialization of variables
3  t1=80 //F
4  t2=60 //F
5  p=14.696 //psia
6  ps=0.5069 //psia
7  pss=0.2563 //psia
8  cp=0.24
9  //calculations
10 pw= pss- (p-pss)*(t1-t2)/(2830- 1.44*t2)
11 phi=pw/ps
12 w=0.622*pw/(p-pw)
13 ws=0.0111
14 hfg=1059.9
15 hw=1096.5
16 hf=28
17 w2= (cp*(t2-t1)+ ws*hfg)/(hw-hf)
18 //results
19 printf("relative humidity = %d percent",phi*100)
20 printf("\n humidity ratio = %.5f",w)
21 printf("\n in case 2, humidity ratio = %.4f ",w2)
```

---

#### Scilab code Exa 10.14 Example 14

```
1  clc
2  //Initialization of variables
3  pw=0.15//psia
```



```

4 disp("using psychrometric charts,")
5 tdew=46 //F
6 //calculations
7 va=13.74 //ft^3/lbm dry air
8 rhoa=1/va
9 V=13.74
10 mw=45/7000
11 rhow=mw/V
12 w=0.00643
13 //results
14 disp("part a")
15 printf("partial pressure of water = %.2f psia",pw)
16 printf("\n dew temperature = %d F",tdew)
17 disp("part b")
18 printf("density of water = %.6f lbm/ft^3",rho_w)
19 printf("\n density of air = %.4f lbm/ft^3",rho_a)
20 disp("part c")
21 printf("specific humidity = %.5f lbm steam/lbm air"
,w)

```

---

#### Scilab code Exa 10.15 Example 15

```

1 clc
2 //Initialization of variables
3 t=80 //F
4 phi=0.3
5 w=0.00643
6 //calculations
7 H=0.24*t+ w*(1061+0.444*t)
8 //results
9 printf("enthalpy = %.2f Btu/lbm dry air",H)

```

---

#### Scilab code Exa 10.16 Example 16

```

1  clc
2  //Initialization of variables
3  disp("From psychrometric charts,")
4  va1=13 //ft^3/lbm dry air
5  va2=13.88 //ft^3/lbm dry air
6  flow=2000 //cfm
7  //calculations
8  ma1= flow/va1
9  ma2=flow/va2
10 t=71// F
11 phi=t //percent
12 //results
13 printf("humidity = %d percent",phi)

```

---

#### Scilab code Exa 10.17 Example 17

```

1  clc
2  //Initialization of variables
3  t=90 //F
4  ts=67.2 //F
5  phi=0.3
6  per=0.8
7  //calculations
8  dep=t-ts
9  dt=dep*per
10 tf=t-dt
11 disp("from psychrometric charts,")
12 phi2=0.8
13 //results
14 printf("Dry bulb temperature = %.2 f F",tf)
15 printf("\n percent humidity = %.2 f",phi2)

```

---

#### Scilab code Exa 10.18 Example 18

```

1  clc
2  //Initialization of variables
3  m=1 //lbm
4  disp("From psychrometric charts,")
5  t1=82 //F
6  phi1=0.4
7  H1=30 //Btu/lbm dry air
8  w1=65 //grains/lbm dry air
9  w2=250 //grains/lbm dry air
10 //calculations
11 dmf3=(w2-w1)*0.0001427
12 hf3=68
13 hf4=43
14 H2=62.2
15 H1=30
16 mf4= (H1-H2+ dmf3*hf3)/(hf4-hf3)
17 per=dmf3/(dmf3+mf4)
18 //results
19 printf("amount of water cooled per pound of dry air
    = %.3f lbm dry air/lbm dry air",mf4)
20 printf("\n percentage of water lost by evaporation =
    %.2f percent",per*100)

```

---

#### Scilab code Exa 10.19 Example 19

```

1  clc
2  //Initialization of variables
3  R0=0.73 //atm ft^3/mol R
4  a1=578.9
5  a2=3675
6  b1=0.684
7  b2=1.944
8  n1=0.396 //mol
9  n2=0.604 //mol
10 V=8.518 //ft^3

```

```

11 T=460+460 //R
12 //calculations
13 p1=R0*n1*T/(V-n1*b1) - a1*n1^2 /V^2
14 p2= R0*n2*T/(V-n2*b2) -a2*n2^2 /V^2
15 p=p1+p2
16 pa=(n1+n2)*R0*T/V
17 err=(pa-p)/p
18 pb=58.7 //atm
19 err2= (p-pb)/p
20 //results
21 printf("Pressure = %.1f atm",p)
22 printf("\n error in ideal case = %.1f percent",err
    *100)
23 printf("\n error in case 2 = %.1f percent",err2
    *100)
24 //The answer is a bit different due to rounding off
    error in textbook

```

---

#### Scilab code Exa 10.20 Example 20

```

1 clc
2 //Initialization of variables
3 p1=45.8 //atm
4 p2=36 //atm
5 t1=343.3 //R
6 t2=766.8 //R
7 n1=0.396 //mol
8 n2=0.604 //mol
9 V=8.518 //ft^3
10 R0=0.73
11 T=920 //R
12 //calcualtions
13 vr1=p1*(V/n1)/(R0*t1)
14 vr2=p2*(V/n2)/(R0*t2)
15 tr1=T/t1

```

```

16 tr2=T/t2
17 disp("From compressibility charts,")
18 z1=1
19 z2=0.79
20 Z=n1*z1+n2*z2
21 p=Z*R0*T/V
22 p2=62 //atm
23 err=(p-p2)/p
24 //results
25 printf("In case 1, pressure = %.1f atm",p)
26 printf("\n In case 2, pressure using trail and error
        method = %d atm",p2)

```

---

#### Scilab code Exa 10.21 Example 21

```

1  clc
2  // Initialization of variables
3  t1=343.3 //R
4  t2=766.8 //R
5  n1=0.396 //mol
6  n2=0.604 //mol
7  V=8.518 //ft ^3
8  p1=45.8 //atm
9  p2=36 //atm
10 R0=0.73
11 T=920 //R
12 // calculations
13 tcd=n1*t1+n2*t2
14 pcd=n1*p1+n2*p2
15 Tr=T/tcd
16 Vr=pcd*V/(R0*tcd)
17 Z=0.87
18 p=Z*R0*T/V
19 // results
20 printf("Pressure = %.1f atm",p)

```



# Chapter 11

## Thermochemical calculations

Scilab code Exa 11.1 Example 1

```
1 clc
2 // Initialization of variables
3 per=87
4 // calculations
5 a=per/12
6 b=12
7 ad=4*a
8 bd=4*b
9 // results
10 printf(" Molecule is C %d H %d",ad,bd)
```

---

Scilab code Exa 11.2 Example 2

```
1 clc
2 // Initialization of variables
3 per=0.071
4 // calculations
5 O2=8.74
```

```
6 N2=per/2 + 3.76*O2
7 //results
8 printf("Oxygen = %.2f and Nitrogen = %.2f",O2,N2)
```

---

### Scilab code Exa 11.3 Example 3

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

---

### Scilab code Exa 11.4 Example 4

```
1 clc
2 //Initialization of variables
3 m1=322.3
4 m2=2
5 m3=926
6 basis=121.94
7 //calculations
8 m=m1+m2+m3
```



```

9 ratio=m/basis
10 dh=5776.6 //Btu/mol
11 h1=dh*7.364
12 h2=14064.3
13 h3=130565.5
14 H=h1+h2+h3
15 hrat=H/basis
16 //results
17 printf("Mass of dry flue gases = %.2f lbm dry flue
    gas/lbm fuel ash and moisture free",ratio)
18 printf("\n Energy carried away = %.1f btu/mol coal
    as fired = %.1f Btu/lbm mol coal ",H, hrat)

```

---

#### Scilab code Exa 11.5 Example 5

```

1 clc
2 //Initialization of variables
3 ns=2
4 n=100
5 nco=10
6 nn=88
7 //calculations
8 xs=ns/n
9 conden=(ns-(nn+ns)*xs)/(1-xs)
10 co2=nco/(nn+nco) *100
11 //results
12 printf("Percentage of condensed H2O = %.3f percent",
    conden)
13 printf("\n percent of co2 in original mixture = %.3f
    percent",co2)

```

---

#### Scilab code Exa 11.6 Example 6

```

1  clc
2  // Initialization of variables
3  n1=2 //moles
4  n2=10.52 //moles
5  P=14.7 //psia
6  // calculations
7  pp=n1/n2 *P
8  disp("from s=psychrometric charts,")
9  dew=139 //F
10 // results
11 printf("dew point = %d F",dew)

```

---

#### Scilab code Exa 11.7 Example 7

```

1  clc
2  // Initialization of variables
3  p=14.7 //psia
4  ps=0.363 //psia
5  n2=7.52 //moles
6  n1=1 //moles
7  // calculations
8  x= (n1+n2)*ps/p /(1-ps/p)
9  // results
10 printf("Final orsat composition is %d CO2 + %.2f H2O
    + %.2f N2",n1, x, n2)

```

---

#### Scilab code Exa 11.8 Example 8

```

1  clc
2  // Initialization of variables
3  p=14.7 //psia
4  ps=0.363 //psia
5  n2=7.52 //moles

```

```

6 n1=1 //moles
7 //calculations
8 x= (n1+n2)*ps/p /(1-ps/p)
9 n=n1+n2+x
10 y1=n1/n
11 y2=n1/(n1+n2)
12 //results
13 printf("Percentage of co2 on a wet basis = %.1f
        percent",y1*100)
14 printf("\n percentage of co2 on a dry basis = %.2f
        percent",y2*100)

```

---

#### Scilab code Exa 11.9 Example 9

```

1 clc
2 //Initialization of variables
3 basis=100 //lbm
4 x1=0.6
5 ash=12 //lbm
6 N2=79.7
7 M=29
8 //calculations
9 x=ash/x1
10 C=(1-x1)*x
11 O2=N2/3.76
12 a= (14.6+0.2)/(5.83-0.75)
13 AF=(O2+N2)*M/(a*100)
14 //results
15 printf("Air fuel ratio = %.2f lbm air/lbm fuel as
        fired",AF)

```

---

#### Scilab code Exa 11.10 Example 10

```

1  clc
2  // Initialization of variables
3  N2=79.7
4  M=29
5  ba=2.12
6  x4=0.3
7  x5=3.7
8  x6=14.7
9  // calculations
10 O2=N2/3.76
11 c=14.7
12 b= x4*4 + x5*2 + x6*2
13 a=b/ba
14 AF=(O2+N2)*M/(a*12 + b)
15 // results
16 printf("Air fuel ratio = %.1f lbm air/lbm fuel",AF)

```

---

#### Scilab code Exa 11.11 Example 11

```

1  clc
2  // Initialization of variables
3  x1=8.7
4  x2=8.9
5  x3=0.3
6  x4=0.3
7  x5=3.7
8  x6=14.7
9  // calculations
10 a=x1+x2+x3
11 b= x4*4 + x5*2 + x6*2
12 // results
13 printf("Molecule is C %.1f H %d + 20.8 O2 + 78.1 N2"
    ,a,b)

```

---

Scilab code Exa 11.12 Example 12

```
1 clc
2 // Initialization of variables
3 co=1.2
4 // calculations
5 H2=co/2
6 ch4=0.3
7 N2=88-H2-ch4
8 // results
9 printf("Nitrogen = %.1f percent",N2)
```

---

Scilab code Exa 11.13 Example 13

```
1 clc
2 // Initialization of variables
3 dn=-0.5
4 R0=1.986
5 T=537 //R
6 Qp=-121664
7 // calculations
8 Qv= Qp- dn*R0*T
9 // results
10 printf("Heat of reaction at constant volume = %d Btu
    /mol",Qv)
```

---

Scilab code Exa 11.14 Example 14

```
1 clc
```

```

2 //Initialization of variables
3 m=2362 //g
4 cp=1 //Btu/lbm F
5 T=0.83 //F
6 mass=0.1 //g
7 //calculations
8 Qm=m*cp*T/mass
9 Qv=-Qm
10 //results
11 printf("Heat transferred = %d Btu/lbm fuel",Qv)

```

---

#### Scilab code Exa 11.15 Example 15

```

1 clc
2 //Initialization of variables
3 y=13
4 x=12
5 M2=18
6 M=170
7 p=0.4593
8 vfg=694.9
9 J=778.2
10 m=1.375
11 U=-19650 //Btu/lbm fuel
12 //calculations
13 z=y*M2/M
14 hfg=1050.4 //Btu/lbm
15 ufg= hfg- p*vfg*144/J
16 dU=ufg*m //Btu/lbm
17 Ud=dU+U
18 //results
19 printf("Lower heating value = %d Btu/lbm",Ud)

```

---

### Scilab code Exa 11.16 Example 16

```
1  clc
2  // Initialization of variables
3  H=-2199548 //Btu/mole
4  H1=18900 //Btu/mole
5  H2=-17784 //Btu/mole
6  // calculations
7  Hf=H-9*H1
8  Hl=Hf-H2
9  // results
10 printf("Higher heating value of gas = %d Btu/mole",
        Hf)
11 printf("\n Higher heating value of liquid = %d Btu/
        mole",Hl)
```

---

### Scilab code Exa 11.17 Example 17

```
1  clc
2  // Initialization of variables
3  n1=8
4  n2=9
5  n3=1
6  n4=12.5
7  U11=3852
8  U12=118
9  U21=3009
10 U22=104
11 U31=24773
12 U32=640
13 U41=2539
14 U42=85
15 H=-2203279
16 // calculations
17 dU1=n1*(U11-U12)+n2*(U21-U22)
```

```
18 dU2=n3*(U31-U32)+n4*(U41-U42)
19 Q=H+dU1-dU2
20 //results
21 printf("Heat of reaction = %d Btu/mole",Q)
```

---

#### Scilab code Exa 11.18 Example 18

```
1 clc
2 //Initialization of variables
3 n1=8
4 n2=9
5 n3=47
6 h1=118
7 h2=104
8 h3=82.5
9 Q=2203279 //Btu
10 //calculations
11 U11=n1*h1+n2*h2+n3*h3
12 U12=U11+Q
13 T2=5271 //R
14 //results
15 printf("Upon interpolating , T2 = %d R",T2)
```

---

#### Scilab code Exa 11.19 Example 19

```
1 clc
2 //Initialization of variables
3 n1=0.95
4 n2=0.05
5 n3=0.025
6 P=147 //psia
7 pa=14.7 //psia
8 //calculations
```



```

9 n=n1+n2+n3
10 p1=n1/n *P/pa
11 p2=n2/n *P/pa
12 p3=n3/n *P/pa
13 Kp1= p1/(p2*p3^0.5)
14 Kp2= p1^2 /(p2^2 *p3)
15 //results
16 printf("In case 1, Equilibrium constant = %.1f ",Kp1
)
17 printf("\n In case 2, Equilibrium constant = %.1f ",
Kp2)

```

---

#### Scilab code Exa 11.20 Example 20

```

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

```

---

#### Scilab code Exa 11.21 Example 21

```

1 clc
2 //Initialization of variables

```

```

3 x=poly(0,"x")
4 vec=roots(24*x^3 +48*x^2 + 7*x -4)
5 x=vec(3)
6 //results
7 printf("degree of dissociation = %.2f",x)

```

---

### Scilab code Exa 11.22 Example 22

```

1 clc
2 //Initialization of variables
3 T=77+460 //R
4 x1=0.21
5 x2=1-x1
6 G=-169557 //Btu/mole
7 n1=1
8 n2=3.76
9 R0=1.986
10 v=0.0885
11 pi=14.7
12 J=778
13 //calculations
14 dg1=-n1*R0*T*log(x1)
15 dg2=-n2*R0*T*log(x2)
16 dg=dg1+dg2
17 dG=dg+G
18 W=-dG
19 W2=-G
20 p=0.0004 //atm
21 G1=-n1*R0*T*log(1/p)
22 W3= -(dg1+G+G1)
23 dgf=v*pi*144/J
24 //results
25 printf("In case 1,Work done = %d Btu/mole C",W)
26 printf("\n In case 2,Work done = %d Btu/mole C",W2)
27 printf("\n In case 3,Work done = %d Btu/mole C",W3)

```

```
28 printf("\n In case 4, Work done = %.2f Btu/mole C" ,  
    dgf)
```

---

**Scilab code Exa 11.23 Example 23**

```
1 clc  
2 // Initialization of variables  
3 H=-169182 //Btu/mole  
4 s1=1.3609 //Btu/mole R  
5 s2=49.003 //Btu/mole R  
6 s3=51.061 //Btu/mole R  
7 T=537 //R  
8 // calculations  
9 dG=H-T*(s3-s2-s1)  
10 // results  
11 printf("Change in Gibbs energy = %d Btu/mole carbon"  
    ,dG)
```

---

# Chapter 12

## Power cycles vapor

Scilab code Exa 12.1 Example 1

```
1  clc
2  // Initialization of variables
3  p1=600 //psia
4  p2=0.2563 //psia
5  t1=486.21 //F
6  t2=60 //F
7  // calculations
8  disp("from steam tables ,")
9  h1=1203.2
10 hf1=471.6
11 hfg1=731.6
12 h2=1088
13 hf2=28.06
14 hfg2=1059.9
15 s1=1.4454
16 sf1=0.6720
17 sfg1=0.7734
18 s2=2.0948
19 sf2=0.0555
20 sfg2=2.0393
21 xd=(s1-sf2)/sfg2
```

```

22 hd=hf2+xd*hfg2
23 xa=0.3023
24 ha=hf2+xa*hfg2
25 wbc=0
26 wda=0
27 wcd=h1-hd
28 wab=ha-hf1
29 W=wab+wcd+wbc+wda
30 Wrev=hfg1- (t2+459.7)*sfg1
31 etat=(t1-t2)/(t1+459.7)
32 etac=W/Wrev
33 etae=W/Wrev
34 Wr=Wrev/(wcd)
35 //results
36 printf("Thermal efficiency = %d percent",etat*100)
37 printf("\n Compression efficiency = %d percent",etac
    *100)
38 printf("\n Expansion efficiency = %d percent",etae
    *100)
39 printf("\n Work ratio = %.2f ",Wr)

```

---

#### Scilab code Exa 12.2 Example 2

```

1  clc
2  //Initialization of variables
3  dhab=-122.6
4  ha=348.5
5  eta=0.85
6  hf=471.6
7  hfg=731.6
8  hc=1203.2
9  dhcd=384.4
10 hf2=28.06
11 hfg2=1059.9
12 //calculations

```

```

13 hbd= ha - dhab/eta
14 x=(hbd-hf)/hfg
15 sbd=0.6944
16 hdd=hc- dhcd/eta
17 xdd=(hdd-hf2)/hfg2
18 sdd=1.5768
19 Qa=hc-hbd
20 etat=(dhcd+dhab/eta)/Qa
21 W=dhcd+dhab/eta
22 rw= W/dhcd
23 //results
24 printf("theoretical efficiency = %.1f percent",etat
        *100)
25 printf("\n Work ratio = %.3f",rw)

```

---

### Scilab code Exa 12.3 Example 3

```

1  clc
2  //Initialization of variables
3  vf=0.01604 //ft^3/lbm
4  p1=600 //psia
5  p2=0.2563 //psia
6  J=778.16
7  //calculations
8  W=-vf*(p1-p2)*144/J
9  disp("From steam tables")
10 ha=28.06
11 hb=29.84
12 hd=1203.2
13 he=750.5
14 sa=0.0555
15 sb=0.0555
16 sd=1.4454
17 se=1.4454
18 Qa=hd-hb

```

```

19 Qr=ha-he
20 W2=Qr+Qa
21 Wt=hd-he
22 Wp=ha-hb
23 etat=W2/Qa
24 rw= W2/(Wt)
25 //results
26 printf("theoretical efficiency = %.1f percent",etat
    *100)
27 printf("\n Work ratio = %.3f",rw)

```

---

#### Scilab code Exa 12.4 Example 4

```

1  clc
2  //Initialization of variables
3  Wisen=-1.78
4  eta=0.85
5  t2=60 //F
6  t1=486.21 //F
7  //calculations
8  Wact=Wisen/eta
9  dsabd= (Wact+Wisen)/(t2+459.7)
10 disp("From steam tables,")
11 ha=28.06
12 hb=30.15
13 hd=1203.2
14 he=818.4
15 sa=0.0555
16 sb=0.0561
17 sd=1.4454
18 se=1.576
19 Qa=hd-hb
20 Qr=ha-he
21 W2=Qr+Qa
22 Wt=hd-he

```

```

23 Wp=ha-hb
24 etat=W2/Qa
25 rw= W2/(Wt)
26 //results
27 printf("theoretical efficiency = %.1f percent",etat
        *100)
28 printf("\n Work ratio = %.3f",rw)

```

---

### Scilab code Exa 12.5 Example 5

```

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

```



```
25 printf("\n Thermal efficiency in case 1= %.1f
    percent", etat*100)
26 printf("\n High pressure work = %.1f Btu/lbm", Whp)
27 printf("\n Low pressure work = %.1f Btu/lbm", Wlp)
```

---

#### Scilab code Exa 12.6 Example 6

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

---

#### Scilab code Exa 12.7 Example 7

```

1  clc
2  // Initialization of variables
3  cp=0.25
4  t2=3460 //R
5  t1=946.2 //R
6  etat=0.45
7  Q=-489
8  t3=520 //R
9  etat2=0.384
10 // calculations
11 Qa=cp*(t2-t1)
12 w=etat*Qa
13 eps=-w/Q
14 I=w+Q
15 Qa2= cp*(t2-t3)
16 W2=etat2*Qa2
17 eps2=-W2/Q
18 I2=W2+Q
19 // results
20 printf("In case 1, Effectiveness of cycle = %d
    percent", eps*100)
21 printf("\n in case 1, loss in available energy = %d
    Btu/lbm", I)
22 printf("\n in case 2, loss in available energy = %d
    Btu/lbm", I2)

```

---

#### Scilab code Exa 12.8 Example 8

```

1  clc
2  // Initialization of variables
3  W=481 //Btu/lbm
4  hh=1374
5  hd=243.7
6  sh=1.6070
7  sd=0.4

```

```

8 t=519.7 //R
9 //calculations
10 Q=(hh-hd) - t*(sh-sd)
11 eta=W/Q
12 I=-Q+W
13 //resu;ts
14 printf("Efficiency = %.1f percent",eta*100)
15 printf("\n Energy = %.1f Btu/lbm",I)

```

---

### Scilab code Exa 12.9 Example 9

```

1 clc
2 clear
3 //Initialization of variables
4 b1=480.9
5 h1=1306.9
6 s1=1.5894
7 h2=1122
8 s2=s1
9 s3=1.6522
10 b3=310.9
11 h3=1169.5
12 //calculations
13 W=h3-h1
14 db=b3-b1
15 dh=h1-h2
16 etae=abs(W/dh)
17 eps=abs(W/db)
18 I=db-W
19 //results
20 printf("Engine efficiency = %.1f percent",etae*100)
21 printf("\n Effectiveness = %.1f percent",eps*100)
22 printf("\n Loss of available energy = %.1f Btu/lbm",
    I)

```

---

### Scilab code Exa 12.10 Example 10

```
1  clc
2  // Initialization of variables
3  ha=348.5
4  hb=471.6
5  sa=0.6720
6  sb=sa
7  sbd=0.6944
8  hbd=492.7
9  etac=0.85
10 T0=60+460
11 // calculations
12 eps=abs(((hbd-ha)-T0*(sbd-sa))/(-(hbd-ha)))
13 I=(hbd-ha)-T0*(sbd-sa)-(hbd-ha)
14 // results
15 printf(" Effectiveness = %.1f percent",eps*100)
16 printf("\n loss of available energy = %.1f btu/lbm",
    I)
```

---

### Scilab code Exa 12.11 Example 11

```
1  clc
2  // Initialization of variables
3  y=0.195
4  bc=34.07
5  bb=-0.65
6  bi=290.85
7  // calculations
8  eps=abs(((1-y)*(bc-bb))/(y*(bc-bi)))
9  I=(1-y)*(bc-bb)+ (y*(bc-bi))
10 // results
```

```
11 printf(" Effectiveness = %.1f percent",eps*100)
12 printf("\n loss of available energy = %.1f btu/lbm",
    I)
```

---

# Chapter 13

## Power cycles gas

Scilab code Exa 13.1 Example 1

```
1  clc
2  // Initialization of variables
3  ta=780 //F
4  tr=80 //F
5  Qa=195 //Btu
6  pd=14.7 //psia
7  R=1.986/29
8  k=1.4
9  J=778
10 g=32.174
11 // calculations
12 etat=(ta-tr)/(ta+459.7)
13 W=etat*Qa
14 vd=R*(tr+460)/pd
15 va=vd*exp(-(Qa-W)/R/(tr+460))
16 vb=va*((tr+460)/(ta+460))^(1/(k-1))
17 vc=vd/va*vb
18 rv=vd/vb
19 rv2=vc/vb
20 rv3=va/vb
21 imep= W*J/(144*(vd-vb))/5.77
```

```

22 //5.77 is conversion factor
23 //results
24 printf("cycle expansion ratio = %.1f ",rv)
25 printf("\n isothermal expansion ratio = %.1f",rv2)
26 printf("\n isentropic expansion ratio = %.1f",rv3)
27 printf("\n imep = %.1f lbf/in^2",imep)

```

---

### Scilab code Exa 13.2 Example 2

```

1  clc
2  //Initialization of variables
3  rv=8
4  k=1.4
5  Qa=1280
6  pa=14.7 //psia
7  R=10.73/29
8  Ta=540 //R
9  J=778
10 cv=0.17 //Btu/lbm R
11 //calculations
12 etat=1-1/rv^(k-1)
13 W=etat*Qa
14 va=R*Ta/pa
15 vb=va/rv
16 Tb=Ta*rv^(k-1)
17 dt=Qa/cv
18 Tc=Tb+dt
19 pb=pa*(rv)^(k-1)
20 pc= Tc*pb/Tb
21 Td=Tc*(1/rv)^(k-1)
22 pd=pa*Td/Ta
23 imep = W*J/144/(va-vb)
24 //results
25 printf("Thermal efficiency = %.1f percent",etat*100)
26 printf("\n Work done = %d btu/lbm air",W)

```

```

27 printf("\n Imep = %d lbf/in^2",imep)
28 printf("\n Pressure and temperature at A = %.1f psia
    and %d R",pa,Ta)
29 printf("\n Pressure and temperature at B = %d psia
    and %d R",pb,Tb)
30 printf("\n Pressure and temperature at C = %d psia
    and %d R",pc,Tc)
31 printf("\n Pressure and temperature at D = %d psia
    and %d R",pd,Td)
32 printf("\n The pressures given in textbook are wrong
    . Please check using a calculator")

```

---

### Scilab code Exa 13.3 Example 3

```

1  clc
2  clear
3  //Initialization of variables
4  ha=1033
5  hbd=1403+1589
6  hc=7823
7  hdd=5142
8  lhv=2733000
9  M=29
10 //calculations
11 wt=hc-hdd
12 wc=ha-hbd
13 wnet=wt+wc
14 heat=hc-hbd
15 etat=wnet*100/heat
16 mr=heat/lhv *142/M
17 AF=1/mr
18 //results
19 printf("Thermal efficiency = %.1f percent",etat)
20 printf("\n Air fuel ratio = %.1f lbm air/lbm fuel",
    AF)

```





# Chapter 14

## Refrigeration

Scilab code Exa 14.1 Example 1

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

---

### Scilab code Exa 14.3 Example 3

```
1  clc
2  // Initialization of variables
3  hc=613.3//btu/lbm
4  hb=138.9//btu/lbm
5  ha=138.9//btu/lbm
6  hd=713.4 //btu/lbm
7  ta=464.7 //R
8  t0=545.7 //R
9  v=8.150 //ft^3/lbm
10 // calculations
11 Qa=hc-hb
12 Qr=ha-hd
13 Wcd=Qa+Qr
14 cop=abs(Qa/Wcd)
15 hp=abs(4.71/cop)
16 carnot=abs(ta/(t0-ta))
17 rel=abs(cop/carnot)
18 mass=200/Qa
19 C=mass*v
20 // results
21 printf("Work done = %.1f Btu/lbm",Wcd)
22 printf("\\n horsepower required per ton of
    refrigeration = %.3f hp/ton refrigeration",hp)
23 printf("\\n Coefficient of performance actual = %.2f
    ",cop)
24 printf("\\n Ideal cop = %.3f",carnot)
25 printf("\\n relative efficiency = %.3f",rel)
26 printf("\\n Mass flow rate = %.3f lbm/min ton",mass)
27 printf("\\n Compressor capacity = %.2f cfm/ton",C)
```

---

#### Scilab code Exa 14.4 Example 4

```
1  clc
2  // Initialization of variables
3  k=1.29
4  R=1.986/17.024
5  T1=464.7
6  pr=4.94
7  // calculations
8  Wrev= k*R*T1/(1-k) *(pr^((k-1)/k) -1)
9  Wold=-100.1 //Btu/lbm
10 err=(Wrev-Wold)/Wrev
11 // results
12 printf("Work done = %.1f Btu/lbm",Wrev)
13 printf("\\n error = %.1f percent",err*100)
```

---

#### Scilab code Exa 14.5 Example 5

```
1  clc
2  // Initialization of variables
3  hc=73.5
4  hb=26.28
5  hd=91.58
6  hc2=190.7
7  hd2=244.3
8  hb2=44.4
9  m1=1 //lbm
10 m2=0.461 //lbm
11 hc1=73.5
12 hd1=83.35
13 hc2=197.58
14 hd2=224
15 hb1=12.55
16 // Calculations
17 w1=hc-hd
```

```

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

```

---

Scilab code Exa 14.6 Example 6

```

1  clc
2  // Initialization of variables
3  ha=44.36
4  hc=18.04
5  hj=197.58
6  hh=213.5
7  hd=hc
8  he=190.66
9  hk=241.25
10 // calculations
11 m=(hc-ha)/(ha-hj)
12 hi=(m*hj+hh)/(1+m)
13 Qa=he-hd
14 W=he-hh + (1+m)*(hi-hk)
15 cop=abs(Qa/W)
16 hp=4.71/cop
17 // results
18 printf("\n horsepower required per ton of
        refrigeration = %.3f hp/ton refrigeration",hp)
19 printf("\n Coefficient of performance actual = %.2f
        ",cop)

```

---

#### Scilab code Exa 14.7 Example 7

```

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

```

```

12 m2=m/0.01602 *0.1388 //Conversion of units
13 m2=1670
14 dh=15.02
15 Qa=m2*(h1-h2)
16 h3=h2 + qual*hw
17 m3=Qa/(h3-h1)
18 v=0.016+ qual*2444
19 C=m3*v
20 //results
21 printf(" Pressure ratio = %.2f",rp)
22 printf("\n Heat = %d Btu/min",Qa)
23 printf("\n Water make up required = %.2f lbm/min",m3
)
24 printf("\n Volume of vapor entering ejector = %d ft
^3/min",C)
25 //The answers are a bit different due to rounding
off error in textbook

```

---