

Scilab Textbook Companion for  
Thermodynamics for Engineers  
by J. S. Doolittle<sup>1</sup>

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# Book Description

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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.

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# Chapter 5

## Actual Gases

Scilab code Exa 5.1 Volume calculations

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

---

Scilab code Exa 5.2 Pressure calculations

```

1  clc
2  clear
3  // Initialization of variables
4  m=90 //lbm
5  T=200+459.7 //R
6  Tc=232.7+459.7 //R
7  R0=1545
8  M=120.9
9  V=30 //cu ft
10 // calculations
11 R=R0/M
12 disp("From fig 5.5")
13 z=0.883
14 P=z*R*m*T/V/144
15 vc=V/m
16 P2=156.1 //psia
17 // results
18 printf("Pressure obtained = %.2f psia",P)
19 printf("\n Theoretical pressure = %.1f psia",P2)

```

---

### Scilab code Exa 5.3 Heat calculations

```

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

```

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

---

#### Scilab code Exa 5.4 Heat calculations

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

---

# Chapter 7

## Entropy

Scilab code Exa 7.1 Change in Entropy

```
1  clc
2  clear
3  // Initialization of variables
4  T2=920 //R
5  T1=520 //R
6  P1=14 //psia
7  P2=84 //psia
8  J=778
9  R=53.35
10 cv=0.1715
11 N=1
12 // calculations
13 k= log(T2/T1) /log(P2/P1)
14 n=1/(1-k)
15 cx=cv+R/(J*(1-n))
16 dS=N*cx*log(T2/T1)
17 // results
18 printf("Change in entropy = %.5f unit of entropy",
        dS)
```

---

# Chapter 8

## Availability of Energy

Scilab code Exa 8.1 Energy loss calculations

```
1 clc
2 clear
3 //Initialization of variables
4 q=1000 //Btu
5 th=1140 //F
6 t1=40 //F
7 ts=940 //F
8 //calculations
9 Q1=q*(th-t1)/(th+460)
10 Q2=q*(ts-t1)/(ts+460)
11 dif=Q1-Q2
12 //results
13 printf("Available energy loss = %d Btu",dif)
```

---

Scilab code Exa 8.2 Energy loss calculations

```
1 clc
2 clear
```

```

3 //Initialization of variables
4 ma=200000 //lb
5 cpa=0.26
6 T2g=1200 //F
7 T1g=300 //F
8 T1w=200 //F
9 mw=250000 //lb
10 cpw=1.02
11 Tl=560 //R
12 cx=1.01
13 //calculations
14 T2w=T1w+ ma*cpa*(T2g-T1g)/(mw*cpw)
15 Qun=Tl*ma*cpa*log((T2g+460)/(T1g+460))
16 Qtr=ma*cpa*(T2g-T1g)
17 Qav=Qtr-Qun
18 Qun2=Tl*mw*cx*log((T2w+460)/(T1w+460))
19 Qav2=Qtr-Qun2
20 ht1=Qav-Qav2
21 //results
22 printf("For gas, Untransferred energy = %d Btu/hr",
        Qun)
23 printf("\n For gas, transferred energy = %d Btu/hr",
        Qtr)
24 printf("\n For gas, available energy = %d Btu/hr",
        Qav)
25 printf("\n For water, Untransferred energy = %d Btu/
        hr", Qun2)
26 printf("\n For water, available energy = %d Btu/hr",
        Qav2)
27 printf("\n Loss of available energy = %d Btu/hr", ht1
        )
28 disp('The answers are a bit different due to
        rounding off error in textbook')

```

---

# Chapter 10

## Vapors

Scilab code Exa 10.1 Enthalpy calculations

```
1  clc
2  clear
3  // Initialization of variables
4  p=3000 //psia
5  T=250 //F
6  // calculations
7  disp("From table 1, keenan and keynes,")
8  vf=0.01700
9  disp("From table 4,")
10 dvf=-18.3*10^-5
11 v=vf+dvf
12 disp("From table 1,")
13 hf=218.48
14 disp("From table 4,")
15 dhf=6.13
16 h=hf+dhf
17 sf=0.3675
18 dsf=-4.34*10^-3
19 s=sf+dsf
20 // results
21 printf("Specific volume = %.5f cu ft/lb",v)
```



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

---

### Scilab code Exa 10.2 Moisture content calculation

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

---

### Scilab code Exa 10.3 State calculations

```
1 clc
2 clear
3 //Initialization of variables
4 disp("From table 1 of keenan and keynes,")
5 v1=0.2688
6 //calculations
7 v2=3.060
8 p2=200 //psia
9 t2=600 //F
10 //results
11 printf("State of steam is %d psia and %d F",p2,t2)
```

---

#### Scilab code Exa 10.4 State calculations

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

---

#### Scilab code Exa 10.5 State calculations

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

---

### Scilab code Exa 10.6 State Enthalpy calculations

```
1 clc
2 clear
3 // Initialization of variables
4 disp("From table 1 of keenan and keynes,")
5 h1=1204.8 //Btu/lb
6 q=174 //Btu/lb
7 // calculations
8 h2=h1+q
9 p2=30 //psia
10 t2=720 //F
11 // results
12 printf("Final state of steam is %d psia and %d F",p2
    ,t2)
13 printf("\n Final enthalpy is %.1f Btu/lb",h2)
```

---

### Scilab code Exa 10.7 volume state calculations

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

---

### Scilab code Exa 10.8 State calculations

```
1  clc
2  clear
3  // Initialization of variables
4  disp("From table 1 of keenan and keynes,")
5  p=400 //psia
6  t1=700 //F
7  p2=85 //psia
8  //calculations
9  s2=1.6398 //units/lb
10 t2=350 //F
11 //results
12 printf("Final state of steam is %d psia and %d F",p2
        ,t2)
```

---

### Scilab code Exa 10.9 Work and heat calculations

```
1  clc
2  clear
3  // Initialization of variables
4  p1=20 //psia
5  p2=140 //psia
6  J=778
7  t2=150 //F
8  t1=30 //F
9  //calculations
10 disp("From Table A-3,")
11 v1=2.0884 //cu ft/lb
12 v2=0.33350 //cu ft/lb
13 h2=95.709
14 h1=81.842
```

```

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

```

---

#### Scilab code Exa 10.10 Enthalpy calculations

```

1 clc
2 clear
3 //Initialization of variables
4 disp("From table 1 of keenan and keynes,")
5 in=440000 //lb/hr
6 out=255000 //lb/hr
7 p1=400 //psia
8 t1=700 //F
9 p2=35 //psia
10 t2=290 //F
11 vel=500 //ft/s
12 hp=44000 //hp
13 ent=1362.7 //Btu/lb
14 //calculations
15 ein=ent*in
16 eout=hp*2544 + out*1183 + 925000
17 h2= (ein-eout)/185000
18 //results
19 printf("Specific enthalpy of exhaust steam = %d Btu/
    lb",h2)

```

---

**Scilab code Exa 10.11** Loss calculations

```
1 clc
2 clear
3 // Initialization of variables
4 disp("From table 1 of keenan and keynes,")
5 h1=1351.1 //Btu/lb
6 p1=600 //psia
7 t1=700 //F
8 p2=234 //psia
9 h2=1.6865
10 h1=1.5875
11 t3=101.74
12 //calculations
13 t2=660 //F
14 loss= (h2-h1)*(t3+459.69)
15 //results
16 printf("Final state of steam is %d psia and %d F",p2
    ,t2)
17 printf("\\n Loss of available energy = %.1f Btu/lb",
    loss)
```

---

**Scilab code Exa 10.12** State calculations

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

```

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

```

---

### Scilab code Exa 10.13 Mean state calculations

```

1 clc
2 clear
3 //Initialization of variables
4 ps=216 //psig
5 pb=29.12 //in of Hg
6 p2=0.4 //in
7 t2=244 //F
8 //calculations
9 pa=0.491*pb
10 pabs=pa + p2*0.491
11 plb=pa+ ps
12 hcal=1166.5 //Btu/lb
13 h2=1200.1 //Btu/lb
14 h3=831.9 //Btu/lb
15 y=-(hcal-h2)/h3
16 //results
17 printf("Mean state in the line is %.1f psia with a
        moisture content of %.2f percent",plb,y*100)

```

---

# Chapter 11

## Thermodynamics of Fluid flow

Scilab code Exa 11.1 Reynolds Number

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

---

Scilab code Exa 11.2 Pressure calculations



```

1  clc
2  clear
3  //Initialization of variables
4  eps=0.00015
5  D=2.067/12 //ft
6  l=100 //ft
7  P=20 //psia
8  R=53.35
9  T=600 //R
10 mu=0.0486 //lb /ft.hr
11 v=50 //ft/s
12 g=32.17 //ft/s^2
13 //calculations
14 rho=P*144/(R*T)
15 Re=D*v*rho*3600/(mu)
16 ed=eps/D
17 disp("From figure 11.5")
18 f=0.0235
19 dp=f*l*rho*v^2 /(2*D*g) /144
20 change=dp/P *100
21 //results
22 printf("Change in pressure = %.2f psi",dp)
23 printf("\n Percentage change in pressure = %.2f
    percent",change)

```

---

### Scilab code Exa 11.3 Final pressure calculations

```

1  clc
2  clear
3  //Initialization of variables
4  v1=60 //ft/s
5  d1=10 //in
6  d2=15 //in
7  P=15 //psia
8  R=53.35

```

```

9 T=540 //R
10 g=32.17 //ft/s^2
11 v1=60 //ft/s
12 //calculations
13 v2=v1*d1^2 /d2^2
14 rho=P*144/(R*T)
15 dp=rho*(v2^2 -v1^2)/(2*g) /144
16 p2=P-dp
17 //results
18 printf("Final pressure = %.3f psia",p2)

```

---

#### Scilab code Exa 11.4 Change in Entropy

```

1 clc
2 clear
3 //Initialization of variables
4 J=778 //ft.lb/Btu
5 D=2.067/12 //ft
6 l=100 //ft
7 P=20 //psia
8 R=53.35
9 T=600 //R
10 mu=0.0486 //lb /ft.hr
11 v=50 //ft/s
12 g=32.17 //ft/s^2
13 //calculations
14 f=0.0235
15 ds=f*v^2 *l /(J*2*D*g*T)
16 //results
17 printf("Change in entropy = %.6f Btu/lbm R",ds)

```

---

#### Scilab code Exa 11.5 Enthalpy and entropy calculations

```

1  clc
2  clear
3  // Initialization of variables
4  v=210 //ft/s
5  g=32.17 //ft/s^2
6  p=200 //psia
7  z=5 //ft
8  x=2.361
9  h=1210.3
10 J=778
11 //calculations
12 P0=p + v^2 / (2*g*144*x) + z/(144*x)
13 h0=h + v^2 / (2*J*g) + z/J
14 S=1.5594 //units/lb
15 S0=S
16 t0=401.9 //F
17 v0=2.342 //cu ft/lb
18 rho0=1/v0
19 //results
20 printf(" Pressure = %d psia",P0)
21 printf(" \n Enthalpy = %.2 f Btu/lb",h0)
22 printf(" \n Entropy = %.4 f units/lb",S0)
23 printf(" \n Temperature = %.1 f F",t0)
24 printf(" \n Density = %.3 f lb/cu ft",rho0)

```

---

### Scilab code Exa 11.6 Temperature calculations

```

1  clc
2  clear
3  // Initialization of variables
4  p1=40 //psia
5  t1=80 //F
6  p2=30 //psia
7  ar=0.5 //sq ft
8  v1=200 //ft/s

```

```

9 R=53.35
10 cp=0.24
11 g=32.17
12 J=778
13 //calculations
14 rho1=144*p1/(R*(t1+460))
15 G=rho1*v1
16 h10= cp*t1 + p1^2 / (2*g*rho1^2 *J)
17 t2=78 //F
18 h2=cp*t2
19 g2=h10-h2
20 rho2=sqrt(p1^2 / (2*g*g2*J))
21 P2=rho2*R*(t2+460)/144
22 ds2=cp*log((t2+460)/(t1+460)) - R/J *log(P2/p1)
23 t3=77 //F
24 h3=cp*t3
25 g3=h10-h3
26 rho3=sqrt(p1^2 / (2*g*g3*J))
27 P3=rho3*R*(t3+460)/144
28 ds3=cp*log((t3+460)/(t1+460)) - R/J *log(P3/p1)
29 t4=79 //F
30 h4=cp*t4
31 g4=h10-h4
32 rho4=sqrt(p1^2 / (2*g*g4*J))
33 P4=rho4*R*(t4+460)/144
34 ds4=cp*log((t4+460)/(t1+460)) - R/J *log(P4/p1)
35 h5=18.62
36 t5=h5/cp
37 Gv=[h4 h2 h3]
38 Pv=[P4 P2 P3]
39 Sv=[ds4 ds2 ds3]
40 scf(1)
41 xtitle("Fanno line diagram , Enthalpy vs Entropy",
        "Entropy", "Enthalpy Btu/lb")
42 plot(Sv, Gv)
43 scf(2)
44 xtitle("Fanno line diagram , Pressure vs Entropy",
        "Entropy", "Pressure psia")

```

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

---

#### Scilab code Exa 11.7 Velocity calculations

```
1 clc
2 clear
3 //Initialization of variables
4 p1=40 //psia
5 t1=80 //F
6 p2=30 //psia
7 ar=0.5 //sq ft
8 v1=200 //ft/s
9 R=53.35
10 cp=0.24
11 g=32.17
12 J=778
13 t2=78 //F
14 //calculations
15 G=40 //lb/sq ft/sec
16 rho2=144*p2/(R*(t2+460))
17 v2=p1/rho2
18 //results
19 printf("Velocity = %d ft/s",v2)
```

---

#### Scilab code Exa 11.8 velocity and density calculations

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

```

6 p1=200 //psia
7 t1=240+460 //R
8 cp=0.24
9 J=778
10 gc=32.2
11 R=53.35
12 m=4 //lb/sec
13 //calculations
14 pr=p1./ P2
15 prr=pr^((k-1)/k)
16 T2=t1 ./prr
17 dt=t1 -T2
18 dh=dt*cp
19 v2=sqrt(2*gc*J*dh)
20 vol=(R*T2) ./ (P2*144)
21 A2=m*vol*144 ./v2
22 dia=sqrt(4/ %pi *A2)
23 rad=dia/2
24 den=1 ./vol
25 scf(1)
26 xtitle('Velocity vs pressure','Pressure in psia','
    velocity in ft/s')
27 plot(P2,v2)
28 scf(2)
29 xtitle('specific volume vs pressure','Pressure in
    psia','specific volume in cu ft/lb')
30 plot(P2,vol)
31 scf(3)
32 xtitle('Radius vs Pressure' , 'Pressure in psia', '
    Radius in in')
33 plot(P2,rad)
34 //results
35 disp('Velocity in ft/s')
36 disp(v2)
37 disp('Specific volume in cu ft/lb')
38 disp(vol)
39 disp('Density in lb/cu ft')
40 disp(den)

```

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

---

### Scilab code Exa 11.9 Exit area calculation

```
1 clc
2 clear
3 // Initialization of variables
4 p1=200 //psia
5 t1=480 //F
6 eff=0.95
7 g=32.2 //ft/s^2
8 J=778
9 mf=3.4 //lb/s
10 // calculations
11 disp("From steam tables ,")
12 h1=1257.8
13 h2=1210.5
14 dh=eff*(h1-h2)
15 ve=sqrt(2*g*J*dh)
16 h3=h1-dh
17 vs=3.961
18 Ae=mf*vs/ve *144
19 // results
20 printf("Nozzle exit area = %.3f sq.in",Ae)
```

---

### Scilab code Exa 11.10 Pressure and velocity calculations

```
1 clc
2 clear
3 // Initialization of variables
4 R=53.35
5 v=300 //ft/s
```

```

6 p=100 //psia
7 t1=200 //F
8 q=500 //Btu/s
9 gc=32.2 //ft/s^2
10 J=778
11 //calculations
12 rho1=p*144/(R*(460+t1))
13 x=poly(0,"x")
14 s=x^2 -0.206*x+0.00535
15 vec=roots(s)
16 rho2=vec(1)
17 t2=(236.6 - 0.301/rho2^2)/0.248
18 P2=rho2*R*(t2+462) /144
19 v2=sqrt(2*gc*J*(236.6-0.248*t2))
20 v22=rho1*v/rho2
21 //results
22 printf("Final temperature = %.1f F",t2)
23 printf("\n Final pressure = %.1f psia",P2)
24 printf("\n Exit velocity in case 1 = %.1f ft/s",v2)
25 printf("\n Exit velocity in case 2 = %.1f ft/s",v22)

```

---



# Chapter 12

## Heat Transfer

Scilab code Exa 12.1 Temperature calculation

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

---

### Scilab code Exa 12.2 Heat flow calculations

```
1 clc
2 clear
3 // Initialization of variables
4 th=350 //F
5 tc=150 //F
6 od1=4.5
7 id1=4.026
8 od2=6.5
9 id2=4.5
10 k1=32
11 k2=0.042
12 // calculations
13 Q=2*%pi*(th-tc)/(log(od1/id1) /k1 + log(od2/id2) /k2
    )
14 r1=log(od1/id1) /k1
15 rt=log(od1/id1) /k1 + log(od2/id2) /k2
16 ti=th-r1/rt*(th-tc)
17 // results
18 printf("Heat flow = %.1f Btu/hr",Q)
19 printf("\n Interface temperature = %.2f F",ti)
```

---

### Scilab code Exa 12.3 Energy exchange calculations

```
1 clc
2 clear
3 // Initialization of variables
4 Fa=0.045
5 l=4 //m
6 b=4 //m
7 Fe=1
```

```

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

```

---

#### Scilab code Exa 12.4 Energy Exchange calculation

```

1 clc
2 clear
3 //Initialization of variables
4 ea=0.8
5 eb=0.7
6 Fa=0.045
7 l=4 //m
8 b=4 //m
9 Fe=1
10 Ta=540+460 //R
11 Tb=1540+460 //R
12 //calculations
13 A=l*b
14 ef=ea*eb
15 Q=0.173*A*Fa*Fe*ef*((Tb/100)^4 -(Ta/100)^4)
16 //results
17 printf("Net energy exchange = %d Btu/hr",Q)
18 disp('The answers are a bit different due to
        rounding off error in textbook')

```

---

**Scilab code Exa 12.5** Inside film coefficient calculation

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

---

**Scilab code Exa 12.6** Inside film coefficient calculation

```
1 clc
2 clear
3 //Initialization of variables
4 d=0.5 //in
5 tm=1000 //F
6 v=5//ft/s
7 k=38.2
8 den=51.2
9 mu=0.3
```

```

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

```

---

**Scilab code Exa 12.7** convective film coefficient calculation

```

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

```

---

**Scilab code Exa 12.8** Outer film coefficient calculation

```

1 clc

```

```

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

```

---

**Scilab code Exa 12.9** Boiling film coefficient calculation

```

1 clc
2 clear
3 //Initialization of variables
4 tf=225 //F
5 a=190
6 b=0.043
7 ti=212 //F
8 //calculations
9 hc=a/(1-b*(tf-ti))
10 hcti=hc*1.25
11 //results
12 printf("For a flat copper plate , boiling film
        coefficient = %.1f Btu/sq ft hr F",hc)
13 printf("\n For an inclined copper plate , boiling
        film coefficient = %d Btu/sq ft hr F",hcti)

```

---

### Scilab code Exa 12.10 Heat calculation

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

---

### Scilab code Exa 12.11 Temperature calculation

```
1  clc
2  clear
3  // Initialization of variables
4  Do=2.375 //in
5  hi=1200
6  Di=2.067 //in
7  km=29.2
8  h0=1500
9  L=2.375 //in
```

```

10 t1=220 //F
11 t4=140 //F
12 //calculations
13 Re=Do/(Di*hi)
14 R0=Do/(Di*hi) + (Do/12 *log(Do/Di) /(2*km)) + 1/h0
15 td=Re/R0 *(t1-t4)
16 ti=t4+td
17 Req=1/h0
18 td2=Req/R0 *(t1-t4)
19 to=t1-td2
20 //results
21 printf("The temperature of the inner surface of pipe
    = %.1f F",ti)
22 printf("\n The temperature of the outer surface of
    pipe = %.1f F",to)

```

---

#### Scilab code Exa 12.12 LMTD Calculation

```

1 clc
2 clear
3 //Initialization of variables
4 th1=800 //F
5 th2=300 //F
6 tc1=100 //F
7 tc2=400 //F
8 //calculations
9 lmtd= ((th1-tc2) - (th2-tc1) )/(log((th1-tc2)/(th2-
    tc1)))
10 //results
11 printf("Logarithmic Mean temperature difference = %d
    F",lmtd)

```

---

#### Scilab code Exa 12.13 True MTD Calculation



```
1 clc
2 clear
3 //Initialization of variables
4 th1=200 //F
5 th2=100 //F
6 tc1=80 //F
7 tc2=110 //F
8 //calculations
9 disp("From the lmtd graph,")
10 R=(tc1-tc2)/(th2-th1)
11 P=(th2-th1)/(tc1-th1)
12 F=0.62
13 lmtd= F* ((th1-tc2) - (th2-tc1) )/(log((th1-tc2)/(
    th2-tc1)))
14 //results
15 printf("True Mean temperature difference = %.1f F",
    lmtd)
```

---

# Chapter 13

## Non reactive and reactive gaseous mixtures

Scilab code Exa 13.1 Mass calculations

```
1 clc
2 clear
3 //Initialization of variables
4 P=70 //psia
5 Pt=110 //psia
6 V=20 //cu ft
7 R0=1545 //Universal gas constant
8 T=540 //R
9 M=32 //Molecular weight of Oxygen
10 M2=28 //Molecular weight of Nitrgoen
11 //calculations
12 N=P*V*144/(R0*T)
13 mo=M*N
14 Pn=Pt-P
15 N2=Pn*V*144/(R0*T)
16 mn=N2*M2
17 Vo=N*R0*T/(144*Pt)
18 Vn=N2*R0*T/(144*Pt)
19 Vn2=V-Vo
```

```

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

```

---

### Scilab code Exa 13.2 Change in Entropy calculation

```

1  clc
2  clear
3  //Initialization of variables
4  P=50 //psia
5  V=4 //cu ft
6  dv=3 //cu ft
7  J=778
8  T=560 //R
9  //calculation
10 ds= 144*P*V*log((V+dv)/V) /(J*T)
11 //results
12 printf("Change in entropy = %.3f unit",ds)

```

---

### Scilab code Exa 13.3 Change in Entropy calculation

```

1  clc
2  clear
3  //Initialization of variables
4  p1=50 //psia
5  t1=100+460 //R
6  R1=48.3

```

```

7 R2=55.2
8 v1=4 //cu ft
9 p2=100 //psia
10 v2=3 //cu ft
11 t2=200+460 //R
12 cv1=0.157
13 cv2=0.177
14 cpm=0.219
15 J=778
16 //calculations
17 m1=144*p1*v1/(R1*t1)
18 m2=144*p2*v2/(R2*t2)
19 tf=(m1*cv1*(t1-460) + m2*cv2*(t2-460))/(m1*cv1+m2*
    cv2)
20 Po2=v1/(v1+v2) *(tf+460)/t1 *p1
21 ds=cpm*log((tf+460)/t1) - R1/J *log(Po2/p1)
22 dss=ds*m1
23 //results
24 printf("Change in entropy = %.4f unit",dss)

```

---

#### Scilab code Exa 13.4 Change in Entropy calculation

```

1 clc
2 clear
3 //Initialization of variables
4 p1=30 //psia
5 t1=80+460 //R
6 R1=48.3
7 R2=55.2
8 m1=20 //lb/min
9 p2=50 //psia
10 m2=35 //lb/min
11 t2=160+460 //R
12 cp1=0.219
13 cp2=0.248

```

```

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

```

---

### Scilab code Exa 13.5 Weight calculations

```

1 clc
2 clear
3 //Initialization of variables
4 x=[0.15 0.08 0.77]
5 M=[44 32 28]
6 //calculations
7 y=x ./M
8 yt=sum(y)
9 mt=y/yt
10 per=mt*100
11 wt=1/yt
12 R=1545/wt
13 //results
14 printf("Volumetric analysis")
15 disp('percent by volume')
16 format('v',6);per
17 disp(per)
18 printf("Weight per mole = %.1f lb",wt)
19 printf("\n Gas constant = %.1f ",R)

```

---

### Scilab code Exa 13.6 Dry analysis calculations

```

1  clc
2  clear
3  //Initialization of variables
4  x1=0.885 //mole fraction of Ch4
5  x2=0.115 //mole fraction of c2h6
6  x3=0.4/100 //mole fraction of N2
7  n1=2 //Moles of Ch4
8  n2=3.5 //Moles of c2h6
9  n3=1 //moles of ch4 in case 2
10 n4=2 //moles of c2h6 in case 2
11 //calculations
12 y1=n1*x1
13 y2=n2*x2
14 y=y1+y2
15 vec2=[y1 y2]
16 air=y/0.21
17 y3=n3*x1
18 y4=n4*x2
19 yy=y3+y4
20 vec3=[y3 y4]
21 air2=y/0.21 *0.79
22 //results
23 printf("Theoretical air = %.2f moles of air per mole
        of fuel",air)
24 disp("Oxygen analysis")
25 disp(vec2)
26 printf("\n Amount of nitrogen = %.2f moles of
        nitrogen per mole of fuel",air2)
27 disp("Dry analysis")
28 disp(vec3)
29 printf('total = %.3f moles ',yy)

```

---

Scilab code Exa 13.7 Air fuel ratio calculations

```

1  clc

```

```

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

```

---

**Scilab code Exa 13.8** Air fuel ratio calculations

```

1 clc
2 clear
3 //Initialization of variables
4 o2=12.5 //moles of O2
5 h20=9 //moles of H2O
6 x=0.21 //Mole fraction of Oxygen in air
7 M=28.97 //Molar mass of air
8 M2=56 //molar mass of C4H8
9 M1=8*12+18 //molecular mass of c8h18
10 //calculations
11 air=o2/x
12 pound=air*M
13 AR=pound/M1
14 y1=h20/M2 *100
15 y2=o2*(79/21) /M2 *100
16 //results

```

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

---

**Scilab code Exa 13.9** volumetric analysis

```
1 clc
2 clear
3 //Initialization of variables
4 x=18.5 //Moles of O2
5 c=12 //Moles of CO2
6 vap=13 //moles of H2O
7 P=15 //psia
8 R=1545 //Universal gas constant
9 //calculations
10 excess=x*0.5
11 M=12*12+2*vap
12 n2=(x+excess)*79/21
13 nt=n2+excess+c
14 dry=[c x/2 n2]/nt *100
15 wet=nt+vap
16 fue=100/(M)
17 mol=wet*fue
18 vol=mol*R*1460/(144*P)
19 //results
20 disp("Volumetric analysis in percentage")
21 disp('          CO2          O2          N2')
22 disp(dry)
23 printf("Volume of wet products = %d cfm",vol)
```

---

**Scilab code Exa 13.10** volumetric analysis



```

1  clc
2  clear
3  //Initialization of variables
4  A=[1 1; 0.5 1]
5  B=[1; 0.9]
6  x=0.9
7  //calculations
8  N2=x*79/21
9  C=A\B
10 vec= [ C(1) C(2) N2]
11 su=sum(vec)
12 vec2=vec/su *100
13 //results
14 printf("Volumetric analysis")
15 disp('CO      CO2      N2')
16 disp(vec2)

```

---

**Scilab code Exa 13.11** Moles of dry products calculations

```

1  clc
2  clear
3  //Initialization of variables
4  c=0.74
5  ref=0.02
6  co2=0.12
7  co=0.1/100
8  M=12
9  //calcualtions
10 carbon=c-ref
11 car2=co2+co
12 wt=car2*M
13 amount=carbon/wt
14 //results
15 printf("Moles of dry products per pound of coal = %
      .3f mole",amount)

```

---

**Scilab code Exa 13.12** Moles of dry products calculations

```
1 clc
2 clear
3 //Initialization of variables
4 x1=0.128
5 x2=0.035
6 x3=0.002
7 M=12
8 N=26
9 //calculations
10 c=x1+x3
11 mole=12/c
12 wt=M*M+N
13 num=mole/wt
14 //results
15 printf("Number of moles of dry products per pound of
        fuel = %.3f mole",num)
```

---

**Scilab code Exa 13.13** Weight of dry air calculations

```
1 clc
2 clear
3 //Initialization of variables
4 c=0.74
5 ref=0.02
6 co2=0.12
7 co=0.1/100
8 o2=0.065
9 M=12
10 x=0.79
```

```
11 M=28.97
12 // calculations
13 n2=1-(co2+co+o2)
14 mol=n2/x
15 wt=mol*M
16 wt2=0.496
17 pou=wt2*wt
18 ta=10.27
19 EA=(pou-ta)/ta *100
20 // results
21 printf("Weight of air per pound of fuel = %.2f lb",
        pou)
22 printf("\n Excess air percentage = %.1f percent",EA)
```

---

# Chapter 14

## Energies associated with chemical reactions

Scilab code Exa 14.1 Heating value calculations

```
1  clc
2  clear
3  //Initialization of variables
4  lhs=8.5 //moles of reactants
5  rhs=6 //moles of CO2
6  n=3 //moles of H2O
7  R=1545 //Universal gas constant
8  R2=18.016 //molar mass of water
9  J=778 //Work conversion constant
10 T=537 //R
11 T2=1050.4 //R
12 T3=991.3 //R
13 Qhp=1417041 //Btu/mol
14 //calculations
15 Qhpv=(lhs-rhs)*R*T/J
16 Qhv=Qhp-Qhpv
17 hfg=(rhs-n)*R2*T2
18 Qlp=Qhp-hfg
19 Qlpv=(lhs-rhs-n)*R/J *T
```

```

20 Q1v=Q1p-Q1pv
21 Qh1v=(rhs-n)*R2*T3
22 Q1v3=Qhv-Qh1v
23 //results
24 printf("Higher heating value at constant volume = %d
      Btu/mol",Qhv)
25 printf("\n Lower heating value at constant pressure
      = %d Btu/mol",Q1p)
26 printf("\n In case 1,Lower heating value at constant
      volume = %d Btu/mol",Q1v)
27 printf("\n In case 2,Lower heating value at constant
      volume = %d Btu/mol",Q1v3)
28 disp("The answers might differ a bit from textbook
      due to rounding off error.")

```

---

#### Scilab code Exa 14.2 Heating value calculations

```

1  clc
2  clear
3  //Initalization of variables
4  disp("From table 5-4,")
5  no=7.5
6  n1=3
7  n2=6
8  Q=1360805 //Btu/mol
9  //calculations
10 Uo=337+no*85
11 Uf=n1*104+n2*118
12 del= Q-(Uo-Uf)
13 Uo2=1656+no*402
14 Uf2=n1*490+n2*570
15 Qv=Uo2-Uf2+del
16 //results
17 printf("Change in chemical energy during complete
      combustion = %d Btu/mol",del)

```

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

---

### Scilab code Exa 14.3 Heat removed calculations

```
1 clc
2 clear
3 //Initialization of variables
4 disp("From table 5-4,")
5 a=1 //moles of C6H6
6 b=7.5 //moles of O2 in reactant
7 c=1.875 //moles of excess O2
8 d=35.27 //moles of N2
9 e=3 //moles of H2O
10 flow=40 //lb/min
11 w=1360850 //Btu/mol
12 //calculations
13 U11=a*337
14 U12=(b+c)*85
15 U13=d*82
16 U14=(a+b+c+d)*1066
17 Ua1=U11+U12+U13+U14
18 U21=c*2539
19 U22=d*2416
20 U23=e*3009
21 U24=2*e*3852
22 U25=(c+d+e+2*e)*1985
23 Ua2=U21+U22+U23+U24+U25
24 Q=Ua1+w-Ua2
25 fuel=flow/(6*12+2*e)
26 Q2=Q*fuel
27 //results
28 printf("Heat removed = %d Btu/min", Q2)
29 disp("The answers might differ a bit from textbook
    due to rounding off error.")
```

---

**Scilab code Exa 14.4** Furnace efficiency calculations

```
1 clc
2 clear
3 //Initialization of variables
4 rate=10700 //lb/min
5 t2=97.90
6 t1=33.05
7 r1=46 //lb/min
8 //calculations
9 disp("From steam tables ,")
10 Hv=1417041
11 Qw=rate*(t2-t1)
12 Q=r1/(12*6+6) *Hv
13 eff=Qw/Q*100
14 //results
15 printf("Furnace efficiency = %.1f percent",eff)
```

---

**Scilab code Exa 14.5** Thermal efficiency calculations

```
1 clc
2 clear
3 //Initialization of variables
4 rate=94 //lb/hr
5 hp=197 //hp
6 c=8
7 h=18
8 Lv=17730 //Btu/hr
9 H=2368089 //Btu/hr
10 //calculations
11 amount=rate*c/12 +h
```

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

---

#### Scilab code Exa 14.6 Thermal efficiency calculations

```
1 clc
2 clear
3 //Initialization of variables
4 rate=94 //lb/hr
5 hp=197 //hp
6 c=8
7 h=18
8 mole=9
9 H=2350359 //Btu/hr
10 //calculations
11 amount=rate*c/12 +h
12 amount=0.824
13 Lv=H-mole*18.016*1050.4
14 eff=hp*2544/(amount*Lv) *100
15 //results
16 printf("Thermal efficiency = %.2f percent",eff)
17 disp("The answer in the textbook is a different due
to rounding off error")
```

---

#### Scilab code Exa 14.7 Total available energy calculations

```
1 clc
2 clear
3 //Initialization of variables
4 hv=14000 //Btu/lb
```



```

5 ef=0.4
6 tmin=80 //F
7 tmid=300 //F
8 m=13 //lb
9 c=0.27
10 tmean=2300 //F
11 //calculations
12 heat=ef*hv
13 Qavail=heat*(tmean-tmin)/(tmean+460)
14 Q=m*c*(tmean-tmid)
15 Q2=Q- (tmin+460)*m*c*log((tmean+460)/(tmid+460))
16 tot=Qavail+Q2
17 //results
18 printf("Total available energy = %d Btu/lb of fuel",
        tot)
19 disp("The answer is a bit different due to rounding
        off error in textbook")

```

---

#### Scilab code Exa 14.8 Max amount of work calculations

```

1 clc
2 clear
3 //Initialization of variables
4 disp("From table 14-2,")
5 G1=55750 //Btu/mol
6 co2=-169580 //Btu/mol
7 h2o=-98290 //Btu/mol
8 //calculations
9 G2=6*co2+3*h2o
10 avail=G1-G2
11 //results
12 printf("Max. amount of work = %d Btu/mol",avail)

```

---

# Chapter 15

## Thermodynamics of chemical reactions

Scilab code Exa 15.1 Dissociation calculations

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

---

### Scilab code Exa 15.2 Max temperature calculations

```
1  clc
2  clear
3  //Initialization of variables
4  U=121200 //Btu/mol
5  Uco2=51635 //Btu/mol
6  Un2=27589 //Btu/mol
7  Uco22=57875 //Btu/mol
8  Un22=21036 //Btu/mol
9  T1=5000 //R
10 T2=5500 //R
11 //calculations
12 Ut1=Uco2+1.88*Un2
13 Ut2=Uco22 + 1.88*Un22
14 disp("By extrapolation ,")
15 Tx=5710 //R
16 //results
17 printf("Max. Temperature reached = %d R",Tx)
18 disp("The calculation for Ut2 is wrong in textbook.
      Please use a calculator.")
```

---

### Scilab code Exa 15.3 Max temperature calculation

```
1  clc
2  clear
3  //Initialization of variables
4  disp("By trial and error ,")
5  X=0.201
6  X1=0.2
7  R=59.3 //universal gas constant
8  T=5000 //R
9  U=121200 //Btu/mol
10 Uco2=51635 //Btu/mol
11 Un2=27907 //Btu/mol
```

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

---

# Chapter 16

## Gas cycles

Scilab code Exa 16.1 Temperature and pressure calculations

```
1  clc
2  clear
3  //Initialization of variables
4  cr=9
5  p1=14 //psia
6  t1=80+460 //R
7  n=1.4
8  heat=800 //Btu
9  c=0.1715
10 R=53.35
11 J=778
12 //calculations
13 p2=p1*(cr)^n
14 t2=t1*cr^(n-1)
15 t3=heat/c +t2
16 p3=p2*t3/t2
17 eff=(1-1/cr^(n-1))*100
18 t4=t3/cr^(n-1)
19 Qr=c*(t4-t1)
20 cyclework=heat-Qr
21 eff2= cyclework/heat *100
```

```

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

```

---

### Scilab code Exa 16.2 Temperature and pressure calculations

```

1  clc
2  clear
3  //Initialization of variables
4  t1=80+460 //R
5  p1=14 //psia
6  n=1.4
7  cr=16
8  heat=800 //Btu
9  cp=0.24
10 c=0.1715
11 //calculations
12 t2=t1*cr^(n-1)
13 p2=p1*(cr)^n
14 t3=t2 +heat/cp
15 v32=t3/t2
16 v43=cr/v32
17 t4=t3/v43^(n-1)
18 Qr=c*(t4-t1)
19 etat=(heat-Qr)/heat *100
20 //results

```

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

---

### Scilab code Exa 16.3 mep calculation

```
1 clc
2 clear
3 //Initialization of variables
4 eff=0.585
5 heat=800 //Btu
6 t1=80+460 //R
7 p1=14 //psia
8 n=1.4
9 R=53.35
10 cr=9
11 cp=0.24
12 J=778
13 //calculations
14 W=eff*heat
15 v1=R*t1/(144*p1)
16 v2=v1/cr
17 t2=1301 //R
18 t3=t2+ heat/cp
19 v3=v2*t3/t2
20 v4=cr*v3
21 mep=W*J/(144*(v4-v2))
22 //results
23 printf("Mean effective pressure = %.1f psia",mep)
```

---

### Scilab code Exa 16.4 mep calculation

```
1 clc
```

```

2 clear
3 //Initialization of variables
4 eff=0.585
5 heat=500 //Btu
6 heat1=300 //Btu
7 t1=80+460 //R
8 p1=14 //psia
9 n=1.4
10 R=53.35
11 cr=9
12 J=778
13 c=0.1715
14 cp=0.24
15 t2=1301 //R
16 p2=308 //psia
17 //calculations
18 t3=t2+ heat/c
19 p3=p2*t3/t2
20 t4=t3+ heat1/cp
21 v43=t4/t3
22 v54=cr/v43
23 t5=t4/(v54)^(n-1)
24 Qr=c*(t5-t1)
25 etat=(heat+heat1-Qr)/(heat+heat1) *100
26 mep=(heat+heat1-Qr)*J/(12.69*144)
27 //results
28 printf("Max. Temperature = %d R",t4)
29 printf("\n Max. Pressure = %d psia",p3)
30 printf("\n Thermal efficiency = %.1f percent",etat)
31 printf("\n Mean effective pressure = %.1f psia",mep)
32 disp("The calculations are a bit different due to
      rounding off error in textbook")

```

---



# Chapter 17

## Internal combustion engines

Scilab code Exa 17.1 Indicated efficiency calculations

```
1  clc
2  clear
3  //Initialization of variables
4  hp1=2000 //bhp
5  m=792 //lb/hr
6  ex=0.5
7  hp2=210
8  hv=18900 //Btu/lb
9  etth=51.3
10 //calculations
11 ihp=hp1+hp2
12 ietat= ihp*2544/(m*hv) *100
13 betat=ietat*hp1/ihp
14 betat2=hp1*2544/(m*hv) *100
15 ietae=ietat/etth *100
16 betae=betat/etth *100
17 brake= ietae*hp1/ihp
18 //results
19 printf("Indicated efficiency = %.1f percent",ietat)
20 printf("\n Brake thermal efficiency = %.1f percent",
    betat)
```

```

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

```

---

### Scilab code Exa 17.2 Indicated mep calculations

```

1  clc
2  clear
3  //Initialization of variables
4  J=778
5  o2=12.5
6  theo=0.95
7  N=56.5
8  R0=1545
9  T=540 //R
10 p=14 //psia
11 LHV=2368089 //Btu/lb
12 ther=39.4
13 iep=0.78
14 ve=0.8
15 //calculations
16 Ar=o2/0.21 *theo
17 vol=N*R0*T/(144*p)
18 hv=(LHV -17730)/LHV
19 ithep=iep*ther
20 pd=ithep/100 *ve *100.5
21 mep=J*pd
22 //results
23 printf("Indicated mep = %d lb/sq ft",mep)

```

---

# Chapter 18

## Gas Compressors

Scilab code Exa 18.1 Horsepower calculation

```
1 clc
2 clear
3 //Initialization of variables
4 q=200 //cfm
5 p2=90 //psia
6 p1=14.5 //psia
7 n=1.36
8 //calculations
9 hpp=n/(n-1) *144*p1*q/33000 *(1- (p2/p1))((n-1)/n)
10 //results
11 printf("Theoretical horse power required = %.1f hp",
        hpp)
12 disp("The answer given in textbook is wrong. Please
        verify with a calculator")
```

---

Scilab code Exa 18.2 Horsepower calculations

```
1 clc
```

```

2 clear
3 //Initialization of variables
4 q=350 //cfm
5 eff=0.78
6 x=0.95
7 p2=120 //psia
8 p1=14.3 //psia
9 //calculations
10 cal=p1*144*q/550 *log(p2/p1) /100
11 ihp= cal/eff
12 shp=ihp/x
13 //results
14 printf("Indicated hp = %.1f hp",ihp)
15 printf("\n Shaft hp = %.1f hp",shp)

```

---

### Scilab code Exa 18.3 Piston displacement calculations

```

1 clc
2 clear
3 //Initialization of variables
4 n=1.35
5 p1=14.2
6 q=400 //cfm
7 p2=200 //psia
8 p1=14.2 //psia
9 ve=0.75
10 t1=530 //R
11 //calculations
12 thp=-n/(n-1) *144 *p1*q/33000 *(1- (p2/p1)^((n-1)/n)
    )
13 pd=q/ve
14 Tmax=t1*(p2/p1)^((n-1)/n)
15 //results
16 printf("Theoretical hp = %.1f hp",thp)
17 printf("\n Piston displacement = %d cfm",pd)

```

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

---

#### Scilab code Exa 18.4 Piston displacement calculations

```
1 clc
2 clear
3 //Initialization of variables
4 n=1.35
5 p1=14.2 //psia
6 p3=200 //psia
7 q=400 //cfm
8 ve=0.78
9 t1=530 //R
10 //calculations
11 p2=sqrt(p3*p1) //psia
12 thp=-2*n/(n-1) *144 *p1*q/33000 *(1- (p2/p1)^((n-1)/
    n))
13 pd=q/ve
14 pd2=q*p1/p2 /ve
15 Tmax=t1*(p2/p1)^((n-1)/n)
16 //results
17 printf("Theoretical hp = %.1f hp", thp)
18 printf("\n For low pressure case, Piston
    displacement = %.1f cfm", pd)
19 printf("\n For high pressure case, Piston
    displacement = %.1f cfm", pd2)
20 printf("\n Max. Temperature = %.1f R", Tmax)
21 disp('The answers are a bit different due to
    rounding off error')
```

---

#### Scilab code Exa 18.5 Pressure calculations

```
1 clc
```

```

2 clear
3 //Initialization of variables
4 dia=2 //ft
5 rpm=6000 //rpm
6 p=14.2 //psia
7 t=75 //F
8 g=32.17
9 n=1.4
10 R=53.35
11 //calculations
12 v=2*pi*rpm/60
13 wbym=v^2 /g
14 T=t+460
15 pr=1+ wbym*(n-1)/n /(R*T)
16 pr2=pr^(n/(n-1))
17 p2=pr2*p
18 //results
19 printf("Theoretical pressure at exit = %.1f psia",p2
)

```

---

### Scilab code Exa 18.6 Pressure calculations

```

1 clc
2 clear
3 //Initialization of variables
4 pa=14.7 //psia
5 p1=12 //psia
6 t1=560 //R
7 n=1.4 //gamma
8 J=778 //constant conversion
9 g=32.2 //ft/s^2
10 cp=0.24 //heat capacity
11 eff=0.7 //efficiency
12 m1=1.8
13 m3=1

```

```

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

```

---

### Scilab code Exa 18.7 Pressure required

```

1 clc
2 clear
3 //Initialization of variables
4 v2=1180 //ft/s
5 etan=0.95
6 cp=0.24
7 n=1.4
8 p2=12
9 // calculations
10 dh=v2^2 /(etan*223.8^2)
11 dt=dh/cp
12 t2d=560 //R
13 t1=t2d+ etan*dt
14 t2=554 //R
15 pr=(t1/t2)^(n/(n-1))
16 p1=p2*pr
17 // results
18 printf(" Pressure required = %.2f psia",p1)

```

---

# Chapter 19

## Gas turbines

Scilab code Exa 19.1 Efficiency calculations

```
1  clc
2  clear
3  //Initialization of variables
4  n=1.4
5  t1=540 //R
6  tmax=1200 //F
7  tmax2=1500 //F
8  pr=5
9  cp=0.24
10 //calculations
11 t2=t1*(pr)^((n-1)/n)
12 work=cp*(t2-t1)
13 t4=(tmax+460) /pr^((n-1)/n)
14 twork=cp*(tmax+460-t4)
15 net=twork-work
16 eff=1- 1/pr^((n-1)/n)
17 Qs=cp*(tmax+460-t2)
18 ett=net/Qs *100
19 t42=(tmax2+460)/pr^((n-1)/n)
20 twork2=cp*(tmax2+460-t42)
21 net2=twork2-work
```



```

22 Qs2=cp*(tmax2+460-t2)
23 eff3=net2/Qs2 *100
24 //results
25 printf("Compressor work = %.1f Btu/lb",work)
26 printf("\n Turbine work = %.1f Btu/lb",twork)
27 printf("\n Net work = %.1f Btu/lb",net)
28 printf("\n Thermal efficiency = %.1f percent",eff
    *100)
29 printf("\n In case 2, Thermal efficiency = %.1f
    percent",ett)
30 printf("\n In case 2, Turbine work = %.1f Btu/lb",
    twork2)
31 printf("\n In case 2, Net work = %.1f Btu/lb",net2)
32 printf("\n In case 3, Thermal efficiency = %.1f
    percent",,eff3)

```

---

### Scilab code Exa 19.2 Work and efficiency calculations

```

1  clc
2  clear
3  //Initalization of variables
4  work=75.9 //Btu/lb
5  twork=173.5 //Btu/lb
6  eta=0.8
7  t2=856 //R
8  t1=540 //R
9  t4=1960 //R
10 cp=0.24
11 //calculations
12 cwork=work/eta
13 internal=twork*eta
14 net=-cwork+internal
15 t2d=(t2-t1)/eta + t1
16 Qs=cp*(t4-t2d)
17 eff=net/Qs *100

```

```

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

```

---

### Scilab code Exa 19.3 Work and efficiency calculations

```

1 clc
2 clear
3 //Initalization of variables
4 eff=0.97
5 c1=94.9 //Btu/lb
6 c2=138.8 //Btu/lb
7 ntee=246 //Btu/lb
8 //calculations
9 cwork=c1/eff
10 twork=c2*eff
11 net=twork-cwork
12 etat=net/ntee *100
13 //results
14 printf("Compressor work = %.1f Btu/lb",cwork)
15 printf("\n Turbine work = %.1f Btu/lb",twork)
16 printf("\n Net work = %.1f Btu/lb",net)
17 printf("\n Thermal efficiency = %.1f percent",etat)

```

---

### Scilab code Exa 19.4 Thermal efficiency calculation

```

1 clc
2 clear
3 //Initalization of variables
4 pr=5

```

```

5 p1=14 //psia
6 pd=3 //psi
7 pen=70 //psia
8 tin=1960 //R
9 n=1.4
10 cp=0.24
11 Qs=265 //Btu/lb
12 //calculations
13 p2=p1*pr
14 pe=pen-pd
15 prt=pe/p1
16 tex=tin/prt^((n-1)/n)
17 twork=cp*(tin-tex)
18 net=twork-75.9
19 eff=net/Qs *100
20 //results
21 printf("Thermal efficiency = %.1f percent",eff)

```

---

### Scilab code Exa 19.5 Thermal efficiency calculation

```

1 clc
2 clear
3 //Initialization of variables
4 pr=5
5 p1=14 //psia
6 pd=3 //psi
7 pen=70 //psia
8 tin=1960 //R
9 n=1.4
10 cp=0.24
11 Qs=265
12 ef=0.95
13 //calculations
14 p2=p1*pr
15 pe=pen-pd

```

```

16 prt=pe/p1
17 tex=tin/prt^((n-1)/n)
18 twork=cp*(tin-tex)
19 net=twork-75.9
20 Qs2=Qs/ef
21 eff=net/Qs2 *100
22 //results
23 printf("Thermal efficiency = %.1f percent",eff)

```

---

#### Scilab code Exa 19.6 Pressure calculation

```

1 clc
2 clear
3 //Initialization of variables
4 pr1=1.0590
5 pr2=4.396
6 p1=14 //psia
7 //calculations
8 prr=pr2/pr1
9 p2=p1*prr
10 //results
11 printf("Final pressure = %.1f psia",p2)

```

---

#### Scilab code Exa 19.7 Compressor work

```

1 clc
2 clear
3 //Initialization of variables
4 t1=540 //R
5 h1=129.06
6 pr1=1.386
7 cr=5
8 //calculations

```

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

---

#### Scilab code Exa 19.8 Turbine work

```
1 clc
2 clear
3 //Initalization of variables
4 cr=5
5 pr3=176.73 //psia
6 h3=14580.3 //Btu/mol
7 M=28.9
8 //calculations
9 pr4=pr3/cr
10 h4=9409
11 twork=h3-h4
12 turb=twork/M
13 //results
14 printf("Turbine work = %.1 f Btu/lb",turb)
```

---

#### Scilab code Exa 19.9 Air fuel ratio

```
1 clc
2 clear
3 //Initalization of variables
4 chem=19000 //Btu/lb
5 m1=204.63 //Btu/lb
6 M=28.9
7 w=14580.3
```

```

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

```

---

**Scilab code Exa 19.10** Thermal efficiency calculation

```

1 clc
2 clear
3 //Initalization of variables
4 cp=0.24
5 h=138.8
6 t3=1960 //R
7 //calculations
8 t4d=t3-h/cp
9 Qs=cp*(t3-t4d)
10 work=43.9 //Btu/lb
11 etat=work/Qs *100
12 //results
13 printf("Thermal efficiency of the unit = %.1f
    percent",etat)

```

---

**Scilab code Exa 19.11** Thermal efficiency calculation

```

1 clc
2 clear
3 //Initalization of variables
4 n=1.4
5 t1=540 //R
6 tmax=1500 //F
7 pr=5
8 cp=0.24
9 p1=14 //psia

```

```

10 p3=70 //psia
11 //calculations
12 pint=p1*sqrt(pr)
13 t2=t1*(pint/p1)^((n-1)/n)
14 t4=t1*(p3/pint)^((n-1)/n)
15 w=cp*(t4-t1)
16 w2=2*w
17 t6=(tmax+460)/(p3/pint)^((n-1)/n)
18 t8=(tmax+460)/(pint/p1)^((n-1)/n)
19 work=cp*(tmax+460-t6)
20 w22=2*work
21 net=w22-w2
22 Qa=cp*(tmax+460-t2)
23 Qb=cp*(tmax+460-t6)
24 Qt=Qa+Qb
25 eta=net/Qt*100
26 //results
27 printf("Thermal efficiency = %.2f percent",eta)

```

---

### Scilab code Exa 19.12 Thermal efficiency calculation

```

1 clc
2 clear
3 //Initialization of variables
4 n=1.4
5 t1=540 //R
6 tmax=1500 //F
7 pr=5
8 cp=0.24
9 p1=14 //psia
10 p3=70 //psia
11 w2=75.9 //Btu/lb
12 Qa=265 //Btu/lb
13 //calculations
14 pint=p1*sqrt(pr)

```

```

15 t6=(tmax+460)/(p3/pint)^((n-1)/n)
16 t8=(tmax+460)/(pint/p1)^((n-1)/n)
17 work=cp*(tmax+460-t6)
18 w22=2*work
19 net=w22-w2
20 Qb=cp*(tmax+460-t6)
21 Qt=Qa+Qb
22 eta=net/Qt*100
23 //results
24 printf("Thermal efficiency = %.1f percent",eta)

```

---

### Scilab code Exa 19.13 Thermal efficiency calculation

```

1  clc
2  clear
3  //Initialization of variables
4  n=1.4
5  t1=540 //R
6  tmax=1500 //F
7  pr=5
8  cp=0.24
9  t3=1558 //R
10 net=125.8 //Btu/lb
11 //calculations
12 Q=cp*(tmax+460-t3)
13 Qt=2*Q
14 eta=net/Qt*100
15 //results
16 printf("Thermal efficiency = %.1f percent",eta)

```

---



# Chapter 20

## Vapor power cycles

Scilab code Exa 20.1 Thermal efficiency calculation

```
1  clc
2  clear
3  //Initialization of variables
4  Qs=825.1 //Btu/lb
5  ds=0.9588
6  t1=101.74 //F
7  th=400.95 //F
8  //calculations
9  Qr=ds*(t1+459.69)
10 work=Qs-Qr
11 eta=work/Qs*100
12 eta2=(th-t1)/(th+459.69) *100
13 //results
14 printf("In case 1, Thermal efficiency = %.2f percent
        ",eta)
15 printf("\n In case 2, Thermal efficiency = %.2f
        percent",eta2)
```

---

Scilab code Exa 20.2 Thermal efficiency calculation

```

1  clc
2  clear
3  //Initalization of variables
4  s2=1.5263
5  sfg=1.8456
6  sf=1.9782
7  h2=1201.1 //Btu/lb
8  hf=1106 //Btu/lb
9  hfg=1036.3 //Btu/lb
10 v=0.01616 //m^3/kg
11 p2=250 //psia
12 p1=1//psia
13 J=778
14 //calculations
15 x3=1+ (s2-sf)/sfg
16 h3=hf-(1-x3)*hfg
17 h4=69.7
18 Wp=v*144*(p2-p1)/J
19 h1=h4+Wp
20 etat=((h2-h3)-Wp)/(h2-h1) *100
21 eta2=(h2-h3)/(h2-h4)*100
22 //results
23 printf("\\n In case 1, Efficieny = %.2f percent",etat
   )
24 printf("\\n In case 2, Efficieny = %.2f percent",eta2
   )

```

---

### Scilab code Exa 20.3 Enthalpy calculations

```

1  clc
2  clear
3  //Initalization of variables
4  p=40000 //kW
5  ef=0.98
6  rate=302000 //lb

```

```

7 s3=1.6001
8 h2=1490.1
9 loss=600
10 v=400 //ft/s
11 g=32.2 //ft/s^2
12 J=778
13 //calculations
14 out=p/(0.746*ef)
15 srate=rate/out
16 X=-(s3-1.9782)/1.8456
17 h3=1106 - X*1036.3
18 theoturb=h2-h3
19 intturb=(out+loss)*2544/rate
20 Ie=intturb/theoturb *100
21 h3d=h2-intturb-v^2 /(2*g*J)
22 hex=h3d+ v^2 /(2*g*J)
23 excess=rate*(hex-h3)
24 //results
25 printf("Steam rate = %.2f lb/shaft hp-hr",srate)
26 printf("\n Internal engine efficiency = %.1f percent
",Ie)
27 printf("\n Enthalpy of exhaust steam = %.1f Btu/lb",
h3d)
28 printf("\n Excess heat to be removed = %d Btu/hr",
excess)
29 disp("The answers are a bit different due to
rounding off error in textbook")

```

---

#### Scilab code Exa 20.4 Thermal efficiency calculation

```

1 clc
2 clear
3 //Initalization of variables
4 s2=1.5263
5 sf=1.6993

```

```

6  sfg=1.3313
7  hf=1164.1 //Btu/lb
8  hfg=945.3 //Btu/lb
9  h2=1201.1 //Btu/lb
10 h1=852.3 //Btu/lb
11 // calculations
12 X3=-(s2-sf)/sfg
13 h3=hf-X3*hfg
14 h4=218.82
15 h6=h4
16 h5=69.7
17 x=(h4-h5)/(h3-h5)
18 W= h2-h3+ (1-x)*(h3-h1)
19 Qs=h2-h4
20 eff=W/Qs *100
21 // results
22 printf("Thermal efficiency = %.2f percent",eff)

```

---

### Scilab code Exa 20.5 Thermal efficiency calculation

```

1  clc
2  clear
3  // Initialization of variables
4  h6=157.933 //Btu/lb
5  s2=0.11626
6  sf=0.16594
7  sfg=0.14755
8  hf=139.095 //Btu/lb
9  hfg=126.98 //Btu/lb
10 h5=12.016 //Btu/lb
11 h2=1201.1 //Btu/lb
12 h1=69.7 //Btu/lb
13 w=348.8 //Btu/lb
14 m=0.0745 //lb
15 // calculations

```

```

16 x7=-(s2-sf)/sfg
17 h7=hf-x7*hfg
18 dh6=h6-h7
19 mr=(h7-h5)/(h2-h1)
20 work=w*m
21 tw=work+dh6
22 dh65=h6-h5
23 eff=tw/dh65 *100
24 //results
25 printf("Thermal efficiency = %.2f percent",eff)

```

---

#### Scilab code Exa 20.6 Heat transferred

```

1  clc
2  clear
3  //Initialization of variables
4  m=1 //lb
5  cp=0.26
6  t2=1800+460 //R
7  t1=400.95+460 //R
8  x=0.6
9  sink=100+460 //R
10 tm=2600+460 //R
11 //calculations
12 Q=m*cp*(t2-t1)
13 ds=m*cp*log((t2/t1))
14 tds=ds*(sink)
15 avail=Q-tds
16 hf=Q*x/(1-x)
17 av2=hf*(tm-sink)/(tm)
18 Qt=Q+hf
19 av=avail+av2
20 per=av/Qt *100
21 //results
22 printf("Available portion of heat transferred = %.1f

```

percent",per)

---

# Chapter 21

## Steam turbines

Scilab code Exa 21.1 Rate of flow calculation

```
1  clc
2  clear
3  //Initialization of variables
4  p2=190 //psia
5  p1=110 //psia
6  v1=2.456
7  k=1.3
8  J=778
9  A2=1.2 //in^2
10 //calculations
11 v2=v1*(p2/p1)^(1/k)
12 dh=k/(k-1) *144/J *(p2*v1-p1*v2)
13 Vex=223.8*sqrt(dh)
14 m=A2*Vex/(144*v2)
15 //results
16 printf("Rate of flow = %.2f lb/sec",m)
```

---

Scilab code Exa 21.2 Rate of flow calculation

```

1  clc
2  clear
3  //Initialization of variables
4  h1=1205.8 //Btu/lb
5  s2=1.5594
6  sf=1.5948
7  sfg=1.1117
8  hf=1188.9 //Btu/lb
9  hfg=883.2 //Btu/lb
10 vf=4.049
11 vfg=vf-0.018
12 k=1.3
13 J=778
14 A2=1.2 //in^2
15 //calculations
16 x2=-(s2-sf)/sfg
17 h2=hf-x2*hfg
18 v2=vf-x2*vfg
19 dh=h1-h2
20 Vex=223.8*sqrt(dh)
21 m=A2*Vex/(144*v2)
22 //results
23 printf("Rate of flow = %.2f lb/sec",m)

```

---

### Scilab code Exa 21.3 Blade work and efficiency

```

1  clc
2  clear
3  //Initialization of variables
4  alp=14 //degrees
5  vb=900 //ft/s
6  v1=2200 //ft/s
7  g=32.17 //ft/s^2
8  //calculations
9  vrc=v1*cosd(alp) - vb

```



```

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

```

---

#### Scilab code Exa 21.4 Blade work and efficiency

```

1  clc
2  clear
3  //Initalization of variables
4  v1=1234 //ft/s
5  v2=532 //ft/s
6  kb=0.92
7  alp=20 //degrees
8  ve=900 //ft/s
9  r=2200 //ft/s
10 g=32.17 //ft/s^2
11 //calculations
12 vr=sqrt(v1^2 +v2^2)
13 vr2=vr*kb
14 vrc=vr2*cosd(alp)
15 W=(v1+vrc)*ve/g
16 eta=W/(r^2 / (2*g)) *100
17 //results
18 printf("Blade work = %d ft-lb/lb",W)
19 printf("\n Efficiency = %.1f percent",eta)
20 disp('The answers are a bit different due to
        rounding off error')

```

---

### Scilab code Exa 21.5 Blade reheat calculation

```
1  clc
2  clear
3  //Initialization of variables
4  v1=1234
5  v2=532
6  kb=0.92
7  alp=20 //degrees
8  ve=900
9  r=2200 //ft/s
10 g=32.17 //ft/s^2
11 J=778
12 w=67000
13 //calculations
14 vr=sqrt(v1^2 +v2^2)
15 vr2=vr*kb
16 vrc=vr2*cosd(alp)
17 reheat=(vr^2 - vr2^2)/(2*g*J)
18 v22=sqrt((vrc-ve)^2 +(vr2*sind(alp))^2)
19 ein=r^2/(2*g*J)
20 eout=w/J + v22^2/(2*g*J)
21 re2=ein-eout
22 //results
23 printf("\n In case 1, Blade reheat = %.2f Btu/lb",
        reheat)
24 printf("\n In case 2, Blade reheat = %.1f Btu/lb",
        re2)
```

---

### Scilab code Exa 21.6 Pressure calculation

```
1  clc
```

```

2 clear
3 //Initialization of variables
4 h1=1416.4
5 s1=1.6842
6 sf=1.7319
7 sfg=1.3962
8 fac=1.05
9 x2=0.7
10 //calculations
11 x6=-(s1-sf)/sfg
12 h6=1156.3 - x6*960.1
13 dh6=h1-h6
14 drop= fac*h6/2
15 h2=h1-drop
16 first=(1-x2)*drop
17 h3=1264.1 +first
18 h4=1157 //Btu/lb
19 fac2=(drop+153)/dh6
20 disp("From air charts,")
21 p2=107 //psia
22 //results
23 printf("Intermediate pressure = %d psia",p2)

```

---

### Scilab code Exa 21.7 Shaft output and efficiency calculation

```

1 clc
2 clear
3 //Initialization of variables
4 reh=1.047
5 dh6=292.8
6 x2=0.7
7 flow=98000 //lb/hr
8 loss=200 //hp
9 //calculations
10 intwork=reh*dh6*x2

```

```

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

```

---

#### Scilab code Exa 21.8 Pressure at Exit calculation

```

1 clc
2 clear
3 //Initalization of variables
4 h1=1416.4 //Btu/lb
5 h2=214.5 //Btu/lb
6 //calculations
7 hex=h1-h2
8 disp("From Air tables,")
9 pe=20 //psia
10 te=321.5 //F
11 //results
12 printf("Exit Pressure = %d psia",pe)
13 printf("\n Exit temperature = %.1f F",te)

```

---

#### Scilab code Exa 21.9 Steam rate calculation

```

1 clc
2 clear
3 //Initalization of variables
4 flow=98000 //lb/hr
5 loss=200 //hp
6 x= 0.11 //percent

```

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

---

# Chapter 22

## Refrigeration

Scilab code Exa 22.1 cop calculations

```
1  clc
2  clear
3  //Initialization of variables
4  t1=45+460 //R
5  th=70+460 //R
6  t2=-200+460 //R
7  th2=100+460 //R
8  //calculations
9  cp1=t1/(th-t1)
10 cp2=th/(th-t1)
11 cp3=t2/(th2-t2)
12 cp4=th2/(th2-t2)
13 //results
14 printf("In case 1, Refrigerator cp = %.1f",cp1)
15 printf("\n In case 1, Heat pump cp = %.1f",cp2)
16 printf("\n In case 2, Refrigerator cp = %.3f",cp3)
17 printf("\n In case 2, Heat pump cp = %.3f",cp4)
```

---

Scilab code Exa 22.2 cop calculations

```

1  clc
2  clear
3  //Initialization of variables
4  h3=85.282 //Btu/lb
5  s2=0.16392
6  sf=0.16798
7  //calculations
8  sfg=sf-0.023954
9  x3=- (s2-sf)/sfg
10 h2=78.335 - x3*67.651
11 h4=26.365 //Btu/lb
12 h1=h4
13 ref=h2-h1
14 work=h3-h2
15 cp1=ref/work
16 h2d=78.355
17 h1d=26.365 //Btu/lb
18 h3d=87.495 //Btu/lb
19 ref2=h2d-h1d
20 work2=h3d-h2d
21 cp2=ref2/work2
22 //results
23 printf("\\n Coefficient of performance in wet
        compression = %.3f",cp1)
24 printf("\\n Coefficient of performance in dry
        compression = %.3f",cp2)

```

---

### Scilab code Exa 22.3 Tonnage calculations

```

1  clc
2  clear
3  //Initialization of variables
4  h1=24.973 //Btu/lb
5  h2=81.436 //Btu/lb
6  cfm=200 //cfm

```

```

7 v2=0.77357
8 v3=3.8750
9 h4=72.913
10 //calculations
11 mass=cfm/v2
12 ref=h2-h1
13 tonnage=mass*ref/cfm
14 mass2=cfm/v3
15 ref2=h4-h1
16 tonnage2=mass2*ref2/cfm
17 //results
18 printf("In case 1,Tonnage = %.1f tons",tonnage)
19 printf("\n In case 2,Tonnage = %.2f tons",tonnage2)

```

---

#### Scilab code Exa 22.4 Refrigeration and cop calculation

```

1 clc
2 clear
3 //Initalization of variables
4 h2d=93.410 //Btu/lb
5 h1=80.740 //Btu/lb
6 x=0.75
7 PD=160
8 vol=0.82
9 v1=1.7213
10 w2=80.156
11 w1=27.3
12 //calculations
13 twork=h2d-h1
14 swork=twork/x
15 flow=PD*vol/v1
16 ref=flow*(w2-w1)/200
17 shp= flow*swork/42.4
18 cop=(w2-w1)/swork
19 //results

```



```

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

```

---

#### Scilab code Exa 22.5 cop calculation

```

1  clc
2  clear
3  //Initialization of variables
4  mc=3000 //lb
5  hv=1080.2 //Btu/lb
6  hfe=26.06 //Btu/lb
7  hfp=10.05 //Btu/lb
8  x=0.7
9  //calculations
10 mv=(mc*hfp-mc*hfe)/(hfe-hv)
11 dh=145.4 //Btu/lb
12 chp=dh*mv/(x*42.4)
13 cop=mc*(hfe-hfp)/(chp*42.4)
14 //results
15 printf(" Coefficient of performace = %.2f ",cop)

```

---

#### Scilab code Exa 22.6 Power calculation

```

1  clc
2  clear
3  //Initialization of variables
4  loss=80000 //Btu/lb
5  t=560 //R
6  //calculations
7  ratio=t/68
8  power=loss/(ratio*2544)
9  //results

```

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

---

### Scilab code Exa 22.7 Power calculation

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

---

# Chapter 23

## Gas vapor mixtures

Scilab code Exa 23.1 Specific humidity calculation

```
1 clc
2 clear
3 //Initialization of variables
4 pv=0.3631 //psia
5 pa=14.7 //psia
6 cp=0.24
7 tw=70 //F
8 td=80 //F
9 hv1=1096.6 //Btu/lb
10 hfb=38.06 //Btu/lb
11 //calculations
12 sh=0.622*pv/(pa-pv)
13 sh1=(cp*tw -cp*td + sh*1054.3)/(hv1-hfb)
14 //results
15 printf(" Specific humidity = %.5 f lb/lb", sh1)
```

---

Scilab code Exa 23.2 RH calculation

```

1  clc
2  clear
3  //Initialization of variables
4  rel=0.9
5  p1=0.0396 //psia
6  p2=0.3631 //psia
7  //calculations
8  act=rel*p1
9  RH=act/p2 *100
10 //results
11 printf("Relative humidity = %.1f percent",RH)

```

---

### Scilab code Exa 23.3 Temperature calculation

```

1  clc
2  clear
3  //Initialization of variables
4  pa=14.2
5  rel=0.9
6  sh=0.012 //lb/lb
7  //calculations
8  pv=(pa*sh)/(0.622-sh)
9  sat=pv/rel
10 tf=64.34 //F
11 //results
12 printf("From steam tables, by interpolation, Final
    temperature = %.2f F",tf)

```

---

### Scilab code Exa 23.4 Heat calculations

```

1  clc
2  clear
3  //Initialization of variables

```

```

4 pa=14.7
5 pv=0.0356
6 pv2=0.04
7 cp=0.24
8 t1=70 //F
9 t2=15 //F
10 R=53.35
11 V=8000 //ft^3
12 //calculations
13 sh=0.622*pv/(pa-pv2)
14 hm2=cp*t1+ sh*1092.3
15 hm1=cp*t2+sh*1068.4
16 Q=hm2-hm1
17 m=144*(pa-pv2)*V/(R*(t2+460))
18 Q2=Q*m
19 //results
20 printf("Heat added per min = %d Btu/min",Q2)
21 disp("The answer is a bit different due to rounding
      off error in the textbook")

```

---

### Scilab code Exa 23.5 Temperature calculation

```

1 clc
2 clear
3 //Initalization of variables
4 rel=0.45
5 p1=0.4747 //psia
6 disp("From steam table data,")
7 //calculations
8 act=rel*p1
9 t2=54.94 //F
10 //results
11 printf("Temperature = %.2 f F",t2)

```

---

### Scilab code Exa 23.6 Tonnage calculation

```
1  clc
2  clear
3  // Initialization of variables
4  rel=0.6
5  p1=0.6982 //psia
6  pa=14.7 //psia
7  t1=90 //F
8  t2=54.94 //F
9  cp=0.24
10 p2=0.2136 //psia
11 vol=4000 //ft
12 t3=538 //R
13 R=53.35
14 // calculations
15 act1=rel*p1
16 sh1=0.622*act1/(pa-act1)
17 hm1=cp*t1+sh1*1100.9
18 sh2=0.622*p2/(pa-p2)
19 hm2=cp*t2+sh2*1085.8
20 con=sh1-sh2
21 enth=con*23.01
22 heat=hm1-hm2-enth
23 mass=144*(pa-p2)*vol/(R*(t3))
24 tonnage=mass*heat/200
25 // results
26 printf("Tonnage = %.1f tons ",tonnage)
```

---

### Scilab code Exa 23.7 Tonnage calculation

```
1  clc
```

```

2 clear
3 //Initialization of variables
4 p1=0.541 //psia
5 rel=0.48
6 pa=14.7 //psia
7 t1=82 //F
8 cp=0.24
9 m1=0.75 //lb
10 m2=0.25 //lb
11 hm4=23.15 //Btu/lb
12 mass=291 //lb
13 //calculations
14 p2=rel*p1
15 sh=0.622*p2/(pa-p2)
16 hm1=cp*t1 + sh*1097.5
17 hm2=m1*hm1
18 hm3=m2*41.67
19 heat=hm2+hm3-hm4
20 tonnage=heat*mass/200
21 //results
22 printf("Tonnage = %.2f tons",tonnage)

```

---

### Scilab code Exa 23.8 Volume calculation

```

1 clc
2 clear
3 //Initialization of variables
4 ce=0.8
5 t1=115 //F
6 tc=75 //F
7 td=85 //F
8 pa=14.7 //psia
9 p1=0.43 //psia
10 p2=0.9492 //psia
11 m1=159600

```

```

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

```

---