

Scilab Textbook Companion for
Thermodynamics
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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 1

Introduction

Scilab code Exa 1.1 example 1

```
1 clc
2 // Initialization of variables
3 d=8 //in
4 ir=16 //in
5 MW=28.97
6 T=70+460 //R
7 P=30+14.7 //psia
8 // calculations
9 V=%pi^2 *d^2 *(d+ir)/4
10 V=V*10/12^3
11 Rair=1545/MW
12 m=P*144*V/(Rair*T)
13 // results
14 printf("Mass of air = %.2 f lbm",m)
```

Scilab code Exa 1.2 example 2

```
1 clc
```

```

2 //Initialization of variables
3 V=4 //in^3
4 P=30 //psia
5 T=500//R
6 MW=32
7 //calculations
8 disp("Metric unit conversion,")
9 V=V*2.54^3 *10^-3
10 P=30*4.448/(2.54^2 *10^-4)
11 T=5*(T-32)/9 +273
12 n=P*V/(8314.5*T)
13 eta=n*1000
14 N=eta*6.025*10^23
15 m=eta*MW
16 //results
17 printf("No. of molecules of oxygen = %.3e molecules"
    ,N)
18 printf("\n Mass of molecules = %.1f g",m)
19 //The answer in the textbook is a bit different due
    to rounding off error

```

Scilab code Exa 1.3 example 3

```

1 clc
2 //Initialization of variables
3 P=14.7 //psia
4 T=70+460 //R
5 M=32
6 //calculations
7 Ro=1545/M
8 V2=3*Ro*T
9 V2=V2*32.174
10 vrms=sqrt(V2)
11 //results
12 printf("rms velocity = %d ft/sec",vrms)

```


Chapter 2

The first law of Thermodynamics

Scilab code Exa 2.1 example 1

```
1 clc
2 // Initialization of variables
3 P1=200 //psia
4 P2=15 //psia
5 V1=1 //ft^3
6 g=1.3
7 //calculations
8 V2=V1*(P1/P2)^(1/g)
9 W=-((144*(P2*V2 - P1*V1))/(g-1))
10 //results
11 printf("Work done = %.2e ft. lbf",W)
```

Scilab code Exa 2.2 example 2

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

```

3 L=0.305 //m
4 v=4.58 //m/s
5 i=10 //A
6 B=1 //W/m^2
7 //calculations
8 F=i*B*L
9 W=F*v
10 //results
11 printf("Force necessary = %.2f N",F)
12 printf("\n Work per unit time = %.2f W",W)

```

Scilab code Exa 2.3 example 3

```

1 clc
2 //Initialization of variables
3 U=2545 //B/hr
4 m=50 //lbm
5 cv=1
6 //calculations
7 dT=U/(m*cv)
8 //results
9 printf("Change in temperature = %.1f F",dT)

```

Scilab code Exa 2.4 example 4

```

1 clc
2 //Initialization of variables
3 P1=14.7 //psia
4 V1=1 //ft^3
5 P2=14.7 //psia
6 M=28.97
7 T1=70+460 //R
8 T2=500+460 //R

```

```

9 cp=0.24 //B/lbm F
10 //calculations
11 m=P1*144*V1*M/(1545*T1)
12 Qp=m*cp*(T2-T1)
13 V2=V1*P1*T2/(P2*T1)
14 W=P1*144*(V2-V1)
15 W=-W/778
16 dU=Qp+W
17 //results
18 printf("Work done = %.2f Btu",W)
19 printf("\n Heat added = %.2f Btu",Qp)
20 printf("\n Change in internal energy = %.2f Btu",dU)

```

Scilab code Exa 2.5 example 5

```

1 clc
2 //Initialization of variables
3 l=20
4 b=25
5 h=8
6 Vp=2.5
7 n=20
8 P=14.7 //psia
9 T=530 //R
10 t=15 //min
11 Qp=375 //B/hr
12 cv=0.1715 //B/lbm F
13 //calculations
14 Vroom=l*b*h
15 Vair=Vroom-Vp*n
16 m=P*Vair*144/(53.35*T)
17 dU=n*Qp
18 U=t*dU/60
19 dT=U/(m*cv)
20 //results

```

```
21 printf(" Air temperature rise = %d F",dT+1)
```

Chapter 3

Macroscopic properties of pure substances

Scilab code Exa 3.1 example 1

```
1  clc
2  // Initialization of variables
3  V=1 //ft^3
4  m=30 //lbm
5  // calculations
6  v=V/m
7  vf1=0.01665
8  vfg1=32.38 //ft^3/lbm
9  x1=0.000515
10 uf1=169.92
11 ufg1=904.8
12 u1=uf1+x1*ufg1
13 vfg=0.0216
14 vfg2=0.4240
15 v2=v
16 x2=0.0277
17 uf2=538.4
18 ufg2=571
19 u2=uf2+x2*ufg2
```



```
20 Q=m*(u2-u1)
21 //results
22 printf("Heat transfer = %d Btu",Q)
```

Scilab code Exa 3.2 example 2

```
1  clc
2  //Initialization of variables
3  V2=2.5 //ft^3
4  V1=0.5 //ft^3
5  P=100 //psia
6  x1=0.5
7  //calculations
8  W=-P*144*(V2-V1)
9  vf1=0.01774
10 vfg1=4.414
11 v1=vf1+x1*vfg1
12 m=V1/v1
13 v2=V2/m
14 disp("From tables ,")
15 uf1=298.08
16 ufg1=807.1
17 u1=uf1+x1*ufg1
18 h2=1747.9
19 u2=h2-P*144*v2/778
20 Q=m*(u2-u1)
21 //results
22 printf("Amount of heat = %d Btu",Q)
23 //The answer for u2 is given wrong in the textbook.
    Please use a calculator to find it
```

Scilab code Exa 3.3 example 3

```

1  clc
2  // Initialization of variables
3  V1=1.735*10^-4 //ft^3
4  v1=0.016080 //ft^3/lbm
5  h1=70.61 //B/lbm
6  P1=100 //psia
7  V2=1 //ft^3
8  //calculations
9  u1=h1-P1*v1*144/778
10 m=V1/v1
11 v2=V2/m
12 vf2=0.01613
13 vfg2=350.3
14 x2=(v2-vf2)/vfg2
15 hf2=67.97
16 hfg2=1037.2
17 h2=hf2+x2*hfg2
18 P2=0.9492
19 u2=h2- P2*144*v2/778
20 Q=m*(u2-u1)
21 //results
22 printf("Enthalpy change = %.2 f Btu",Q)

```

Scilab code Exa 3.4 example 4

```

1  clc
2  // Initialization of variables
3  P=20 //psia
4  V=1 //ft^3
5  T=560 //R
6  cv=0.1715
7  Q=10//Btu
8  //calculations
9  m=P*144*V/(53.35*T)
10 T2=Q/(m*cv) +T

```

```
11 P2=m*53.35*T2/V
12 //results
13 printf("Fina pressure = %d lbf/ft^2",P2)
```

Scilab code Exa 3.5 example 5

```
1 clc
2 //Initialization of variables
3 T1=560 //R
4 T2=3460 //R
5 m=28.02 //lb
6 cv=0.248
7 //calculations
8 function [q]=fun(T)
9     q=9.47 - 3.29*10^3 /T +1.07*10^6 /T^2
10 endfunction
11 Q1=intg(T1,T2,fun)
12 Q2=m*cv*(T2-T1)
13 Error=(Q1-Q2)/Q1
14 //results
15 printf("Percentage error = %.1f percent",Error*100)
```

Scilab code Exa 3.6 example 6

```
1 clc
2 //Initialization of variables
3 rate=20 //gal/min
4 P1=20 //psia
5 P2=1000 //psia
6 T=100+460 //R
7 //calculations
8 vf=0.01613
9 disp("From table A-8")
```

```
10 dv=-5.2*10^-5 // ft^3/lbm
11 K=-dv/(vf*P2*144)
12 wt=K*vf*(P2^2 - P1^2)*144*144*10^4 /2
13 m=rate*8.33
14 Wt=wt*m
15 Wthp=Wt/33000
16 // results
17 printf("Pump power required = %d hp",Wthp)
```

Chapter 4

principles of energy analysis

Scilab code Exa 4.1 example 1

```
1 clc
2 // Initialization of variables
3 m=1
4 he=1148.8 //B/lbm
5 hi=1357 //B/lbm
6 Ve=100 //ft/sec
7 Vi=800 //ft/sec
8 // calculations
9 dW= m*(he-hi) + m*(Ve^2 - Vi^2)/(2*32.2*778)
10 dWhr=dW*3600
11 hp=-dWhr/2545
12 // results
13 printf("Horsepower output = %d hp",hp+1)
```

Scilab code Exa 4.2 example 2

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

```

3 rate=80 //lbm/min
4 T1=100 //F
5 P1=100 //psia
6 P2=1000 //psia
7 //calculations
8 disp("From the tables ,")
9 v=0.01613 //ft^3/lbm
10 W=rate*(P2-P1)*144*v
11 //results
12 printf("Work done = %.2f ft-lbf/min",W)

```

Scilab code Exa 4.3 example 3

```

1 clc
2 //Initialization of variables
3 disp("from saturated steam tables ,")
4 hi=1279.1 //B/lbm
5 //calculations
6 u2=hi
7 T2=564 //F
8 //results
9 printf("Temperature of steam = %d F",T2)

```

Scilab code Exa 4.4 example 4

```

1 clc
2 //Initialization of variables
3 P1=20 //psia
4 P2=100 //psia
5 V=3 //ft^3
6 T=560 //R
7 ma=0.289
8 //calculations

```

```

9 ma=P1*V/(53.35*T)
10 Wa=-ma*53.35*T*log(P1/P2)
11 Qa=-Wa
12 Va2=3/5
13 V2s=V-Va2
14 hi=1279.1 //B/lbm
15 T2s=536 //F
16 //results
17 printf("Final temperature = %d F",T2s)

```

Scilab code Exa 4.5 example 5

```

1 clc
2 //Initialization of variables
3 P1=200 //psia
4 P2=100 //psia
5 T1=300+460 //R
6 g=1.4
7 cp=0.24
8 //calculations
9 T2=(T1)*(P2/P1)^((g-1)/g)
10 V2=sqrt(2*32.2*778*cp*(T1-T2))
11 //results
12 printf("Final velocity = %d ft/sec",V2)

```

Scilab code Exa 4.6 example 6

```

1 clc
2 //Initialization of variables
3 T1=500+460 //R
4 P1=50 //psia
5 P2=15 //psia
6 g=1.4

```

```

7 cp=0.24
8 //calculations
9 T2=T1*(P2/P1)^((g-1)/g)
10 W=cp*(T2-T1) + (T1-460)^2 / (2*32.2*778)
11 //results
12 printf("Net work output from turbine = %.1f B/lbm",W
)

```

Scilab code Exa 4.7 example 7

```

1 clc
2 //Initialization of variables
3 T1=150+460 //R
4 T1=40+460 //R
5 //calculations
6 disp("from freon tables,")
7 h2=43.850 //B/lbm
8 hf2=17.273
9 hfg2=64.163
10 x2=(h2-hf2)/hfg2
11 //results
12 printf("Quality of freon vapor = %.3f",x2)

```

Chapter 5

principles of statistical thermodynamics

Scilab code Exa 5.1 example 1

```
1 clc
2 // Initialization of variables
3 N1=1
4 N2=1
5 N3=3
6 N4=1
7 // calculations
8 N=N1+N2+N3+N4
9 sig=factorial(N) /(factorial(N1) *factorial(N2)*
    factorial(N3)*factorial(N4))
10 // results
11 printf("No. of ways of arranging = %d ",sig)
```

Scilab code Exa 5.2 example 2

```
1 clc
```

```

2 //Initialization of variables
3 N=6
4 g=4
5 //calculations
6 sig=factorial(g+N-1)/(factorial(g-1)*factorial(N))
7 //results
8 printf("No. of ways of arranging = %d ",sig)

```

Scilab code Exa 5.3 example 3

```

1 clc
2 //Initialization of variables
3 N=6
4 g=8
5 //calculations
6 sig=factorial(g)/(factorial(N)*factorial(g-N))
7 //results
8 printf("No. of ways = %d ",sig)

```

Scilab code Exa 5.4 example 4

```

1 clc
2 //Initialization of variables
3 N0=1
4 //calculations
5 N1=3/%e
6 N2=6/%e^2
7 N3=10/%e^3
8 N=N0+N1+N2+N3
9 ei=[0 1 2 3]
10 eid=ei+1
11 f0=N0/N
12 f1=N1/N

```

```
13 f2=N2/N
14 f3=N3/N
15 fi=[f0 f1 f2 f3]
16 //results
17 printf("fractional population of level 0 = %.3f",f0)
18 printf(" \n fractional population of level 1 = %.3f"
    ,f1)
19 printf(" \n fractional population of level 2 = %.3f"
    ,f2)
20 printf(" \n fractional population of level 3 = %.3f"
    ,f3)
21 xtitle('fractional populations vs Energy levels ','
    Energy levels ei ','fractional population Ni/N')
22 bar(ei,fi,0.1)
```

Chapter 6

The second law of thermodynamics

Scilab code Exa 6.1 example 1

```
1 clc
2 // Initialization of variables
3 m=5 //lbm
4 P=50 //psia
5 T=500 + 460 //R
6 // calculations
7 disp("From saturated steam tables,")
8 s1=0.4110 //B/lbm R
9 s2=1.7887 //B/lbm R
10 dS=m*(s2-s1)
11 // results
12 printf("Change in entropy = %.3f B/R",dS)
```

Scilab code Exa 6.2 example 2

```
1 clc
```

```

2 //Initialization of variables
3 P=20 //psia
4 T=227.96+ 459.69 //R
5 //calculations
6 disp("from saturation tables ,")
7 sfg=1.3962 //B/ R lbm
8 Q=T*sfg
9 //results
10 printf("heat transfer = %.1f B/lbm",Q)

```

Scilab code Exa 6.3 example 3

```

1 clc
2 //Initialization of variables
3 T1=100+460 //R
4 P1=15//psia
5 P2=50 //psia
6 n=1.3
7 cp=0.24
8 //calculations
9 T2=T1*(P2/P1)^((n-1)/n)
10 dS=cp*log(T2/T1) - 53.35/778 *log(P2/P1)
11 //results
12 printf("Change in entropy = %.3f B/lbm R",dS)
13 //the answer given in textbook is wrong. Please
    check it using a calculator

```

Scilab code Exa 6.4 example 4

```

1 clc
2 //Initialization of variables
3 T1=85+460 //R
4 T2=T1

```

```

5 cp=0.24
6 P2=15 //psia
7 P1=30 //psia
8 //calculations
9 dS=cp*log(T2/T1) - 53.35/778 *log(P2/P1)
10 //results
11 printf("Change in entropy = %.4f B/lbm R",dS)

```

Scilab code Exa 6.5 example 5

```

1 clc
2 //Initialization of variables
3 Qh=-1000 //Btu
4 Ql=1000 //Btu
5 Th=1460 //R
6 Tl=960 //R
7 //calculations
8 Sh=Qh/Th
9 Sl=Ql/Tl
10 S=Sh+Sl
11 //results
12 printf("Change in entropy of the universe = %.3f B/R
    ",S)

```

Scilab code Exa 6.6 example 6

```

1 clc
2 //Initialization of variables
3 disp("from steam tables,")
4 h1=1416.4 //B/lbm
5 s1=1.6842 //B/lbm R
6 //calculations
7 s2=s1

```

```
8 P2=50 //psia
9 T2=317.5 //F
10 h2=1193.7
11 W=h2-h1
12 //results
13 printf("Work calculated = %.1f B/lbm",W)
```

Chapter 7

equations of state and general thermodynamic relations

Scilab code Exa 7.1 example 1

```
1 clc
2 // Initialization of variables
3 disp(" Using gas tables ,")
4 T1=1160 //R
5 h1=281.14 //B/lbm
6 Pr1=21.18
7 P2=30 //psia
8 P1=100 //psia
9 // calculations
10 Pr2=Pr1*P2/P1
11 T2=833 //R
12 h2=199.45 //B/lbm
13 dh=h2-h1
14 // results
15 printf(" Change in enthalpy = %.2 f B/lbm" ,dh)
```

Scilab code Exa 7.2 example 2

```
1 clc
2 // Initialization of variables
3 T2=860 //R
4 phi1=0.78767
5 phi2=0.71323
6 P2=30 //psia
7 P1=100 //psia
8 // calculations
9 dS=phi2-phi1- 53.35/778 *log(P2/P1)
10 // results
11 printf("Net change of entropy = %.5 f B/lbm R", dS)
```

Scilab code Exa 7.3 example 3

```
1 clc
2 // Initialization of variables
3 T1=540 //R
4 T2=960 //R
5 disp("From gas tables,")
6 h2=231.06 //B/lbm
7 h1=129.06 //B/lbm
8 cp=0.24
9 // calculations
10 W=h2-h1
11 dh=cp*(T2-T1)
12 // results
13 printf("Change in enthalpy = %.1 f B/lbm", dh)
```

Scilab code Exa 7.4 example 4

```
1 clc
```

```

2 //Initialization of variables
3 T1=420 //R
4 T2=380 //R
5 hig=1221.2
6 P1=0.0019
7 //calculations
8 lnp=hig*778*(1/T1 - 1/T2)/85.6
9 pra=exp(lnp)
10 P2=pra*P1
11 //results
12 printf("Final pressure = %.3e psia",P2)

```

Scilab code Exa 7.5 example 5

```

1 clc
2 //Initialization of variables
3 disp("from critical constant tables")
4 pc=482//psia
5 Tc=227 //R
6 vc=1.44 //ft^3/lbm mol
7 P=600 //psia
8 T=310 //R
9 //calculations
10 Pr=P/pc
11 Tr=T/Tc
12 disp("From Z tables,")
13 Z=0.83
14 v=Z*55.12*T/(P*144)
15 rho=1/v
16 //results
17 printf("Density = %.1f lbm/ft^3",rho)

```

Scilab code Exa 7.6 example 6

```

1  clc
2  // Initialization of variables
3  T=-150+460 //R
4  v=0.6 //ft^3/lbm
5  vc=1.44
6  Tc=227 //R
7  Pc=482 //psia
8  // calculations
9  disp("From tables of z")
10 vr=v/vc
11 Tr=T/Tc
12 Pr=1.75
13 P=Pr*Pc
14 // results
15 printf("Final pressure = %d psia",P)

```

Scilab code Exa 7.7 example 7

```

1  clc
2  // Initialization of variables
3  disp("Critical tables suggest,")
4  Tc=344 //R
5  Pc=673 //psia
6  P1=20 //psia
7  P2=500 //psia
8  M=16
9  T=560 //R
10 // calculations
11 pr1=P1/Pc
12 pr2=P2/Pc
13 Tr=T/Tc
14 dh2=0.65*Tc
15 dsp=0.35 //B/lbm mol R
16 dsp2=0.018-dsp- 1545/778 *log(P2/P1)
17 W=dh2-dsp2*T

```

```
18 W2=W/M
19 //results
20 printf("Work per pound mass = %d B/lbm",W2)
21 //The answer is a bit different due to rounding off
    error
```

Scilab code Exa 7.8 example 8

```
1  clc
2  //Initialization of variables
3  P=1000 //psia
4  T1=100 + 460 //R
5  T2=800+460 //R
6  //calculations
7  pc=1070 //psia
8  Tc=548 //R
9  pr1=P/pc
10 Tr1=T1/Tc
11 Tr2=T2/Tc
12 M=44
13 disp("from fig 7.7")
14 h1=4235.8 //B/lbm mol
15 h2=11661 //B/lbm mol
16 h2bar=3.5 //B/lbm mol
17 h1bar=0.48 //B/lbm mol
18 dhbar=Tc*(h2bar-h1bar) + h2-h1
19 Q=dhbar/M
20 cp=0.202 //B/lbm F
21 Q2=cp*(T2-T1)
22 Error=(Q-Q2)/Q
23 //results
24 printf("Error in calculation = %d percent",Error
    *100)
```

Chapter 8

applications of statistical thermodynamics

Scilab code Exa 8.1 example 1

```
1 clc
2 // Initialization of variables
3 T=70 //K
4 Tr=85.5 //K
5 // calculations
6 disp("From fig 8.2")
7 cvrot=1.1
8 cvtra=1.5
9 cv=cvtra+cvrot
10 // results
11 printf("Cv total = %.1f R",cv)
```

Scilab code Exa 8.2 example 2

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

```
3 T=2000 //K
4 Tr=3340 //K
5 //calculations
6 disp("From fig 8.2")
7 cvrot=0.85
8 cvtra=1.5
9 cvvib=1
10 cv=cvtra+cvrot+cvvib
11 //results
12 printf("Cv total = %.2f R",cv)
```

Scilab code Exa 8.3 example 3

```
1 clc
2 //Initialization of variables
3 T=200 //K
4 the=398 //K
5 //calculations
6 ratio=T/the
7 disp("from fig 8.6")
8 cv=4.9
9 //results
10 printf("Specific heat of aluminium = %.1f cal/g mol
    K",cv)
```

Scilab code Exa 8.4 example 4

```
1 clc
2 //Initialization of variables
3 T=10 //K
4 td=315 //K
5 //calculations
6 cv=464.4 *(T/td)^3
```

```
7 //results
8 printf("specific heat of copper = %.5f cal/g mol K",
        cv)
```

Scilab code Exa 8.5 example 5

```
1 clc
2 //Initialization of variables
3 N0=6.025*10^23
4 M=63.57
5 d=8.94 //g/cc
6 h=6.624*10^-27
7 me=9.1*10^-28
8 //calculations
9 NbyV=N0*d/M
10 mu0=h^2 *(3*NbyV/ %pi)^(2/3) /(8*me)
11 e0=0.6*mu0*10^-7
12 Teq=2*e0/(3*1.38*10^-23)
13 //results
14 printf("Equivalent temperature = %d K",Teq)
```

Scilab code Exa 8.6 example 6

```
1 clc
2 //Initialization of variables
3 T=300 //K
4 mu=1.13*10^-18
5 k=1.38*10^-23
6 //calculations
7 cv=%pi^2 *k*T/(2*mu)
8 //results
9 printf("Electron contribution = %.4f R",cv)
```

Scilab code Exa 8.7 example 7

```
1  clc
2  // Initialization of variables
3  sig=5.668*10^-5
4  T1=1000 //K
5  T2=2000 //K
6  // calculations
7  Eb1=sig*T1^4 *10^-7
8  Eb2=sig*T2^4 *10^-7
9  // results
10 printf("total energy emitted in case 1 = %.3f Watts/
    cm^2",Eb1)
11 printf("\n total energy emitted in case 2 = %.3f
    Watts/cm^2",Eb2)
```

Chapter 9

Kinetic theory and transport phenomena

Scilab code Exa 9.1 example 1

```
1  clc
2  // Initialization of variables
3  N0=6.025*10^26
4  M=32
5  k=1.38*10^-23
6  T=300 //K
7  // calculations
8  m=M/N0
9  vavg=sqrt(8*k*T/(%pi*m))
10 vrms=sqrt(3*k*T/m)
11 vm=sqrt(2*k*T/m)
12 // results
13 printf("Average velocity = %d m/sec",vavg)
14 printf("\\n RMS velocity = %d m/sec",vrms)
15 printf("\\n Most probable velocity = %d m/sec",vm)
```

Scilab code Exa 9.2 example 2

```
1  clc
2  //Initialization of variables
3  T=300 //K
4  dv=0.02
5  vm=395 //m/s
6  m=5.32*10^-26 //kg
7  k=1.38*10^-23
8  vrms=483 //m/s
9  //calculations
10 N1=sqrt(2/%pi) *(m/(k*T))^(3/2) *vm^2 *exp(-1) *dv*
    vm
11 N2=sqrt(2/%pi) *(m/(k*T))^(3/2) *vrms^2 *exp(-3/2) *
    dv*vrms
12 //results
13 printf("Fraction of oxygen molecules at v most
    probable speed = %.4f ",N1)
14 printf("\n Fraction of oxygen molecules at v rms
    speed = %.4f ",N2)
```

Scilab code Exa 9.3 example 3

```
1  clc
2  //Initialization of variables
3  p=1.013*10^5 //N/m^2
4  k=1.38*10^-23
5  T=300 //K
6  v=445 //m/s
7  A=0.001*10^-6 //m^2
8  //calculations
9  n=p/(k*T)
10 J=n*v/4
11 escaping=J*A
12 //results
```

```
13 printf("No. of molecules escaping per unit time = %  
    .2e mol/sec", escaping)
```

Scilab code Exa 9.4 example 4

```
1 clc  
2 // Initialization of variables  
3 d=3.5*10^-10 //m  
4 n=2.45*10^25  
5 // calculations  
6 sig=%pi*d^2  
7 lambda=1/(sqrt(2) *sig*n)  
8 frac=exp(-2)  
9 // results  
10 printf("Mean free path = %.2e m", lambda)  
11 printf("\n fraction of molecules = %.3f", frac)
```

Scilab code Exa 9.5 example 5

```
1 clc  
2 // Initialization of variables  
3 P=1 //atm  
4 T=300 //K  
5 // calculations  
6 cv=4.97  
7 vavg=1580 //ft/s  
8 sig=4.13*10^-18 //ft^2  
9 N0=6.025*10^26 *0.4536  
10 K=vavg*3600*cv/(3*N0*sig)  
11 // results  
12 printf("Thermal conductivity = %.2e B/hr ft F", K)
```

Scilab code Exa 9.6 example 6

```
1 clc
2 //Initialization of variables
3 m=5.32*10^-26 //kg
4 v=445 //m/s
5 sigma=3.84*10^-19 //m^2
6 //calculations
7 mu=m*v/(3*sigma)
8 //results
9 printf("Dynamic viscosity of oxygen = %.2e newton
    sec/m^2",mu)
```

Chapter 10

Gaseous Mixtures

Scilab code Exa 10.1 example 1

```
1 clc
2 // Initialization of variables
3 m=2
4 M=28
5 M2=32
6 PN=300 //psia
7 Pt=400 //psia
8 //calculations
9 nN=m/M
10 P0=Pt-PN
11 n0=nN*P0/PN
12 m0=M2*n0
13 //results
14 printf("Mass of oxygen added = %.3 f lbm",m0)
```

Scilab code Exa 10.2 example 2

```
1 clc
```

```

2 //Initialization of variables
3 n=0.0714
4 R=1545
5 T=560 //R
6 P=400 //psia
7 //clculations
8 VN=n*R*T/(P*144)
9 V0=(0.0238)*R*T/(P*144)
10 V=VN+V0
11 //results
12 printf("Total volume = %.3f ft ^3",V)

```

Scilab code Exa 10.3 example 3

```

1 clc
2 //Initialization of variables
3 m1=5
4 m2=2
5 cp1=0.248
6 cp2=0.203
7 T11=300 //F
8 T12=100 //F
9 P=10 //psia
10 Pi=20 //psia
11 Pf=15 //psia
12 //calculations
13 T2=(m1*cp1*T11 + m2*cp2*T12)/(m1*cp1+m2*cp2)
14 n1=m1/28
15 n2=m2/44
16 n=n1+n2
17 P1=P*n1/n
18 P2=P*n2/n
19 dS=m2*(cp2*log((T2+460)/(T12+460)) - 35.1/778 *log(
    P2/Pi)) +m2*(cp2*log((T2+460)/(T12+460)) -
    55.2/778 *log(P1/Pf))

```

```
20 //results
21 printf("change in enthalpy = %.2f B/R",dS)
```

Scilab code Exa 10.4 example 4

```
1 clc
2 //Initialization of variables
3 Pg=2.8886 //psia
4 P=25 //psia
5 phi=0.5
6 //calculations
7 pv=phi*Pg
8 pa=P-pv
9 w=0.622*pv/pa
10 x=(w)/(1+w)
11 //results
12 printf("Mass fraction of water vapor in the mixture
    = %.4f lbm vapor/ lvm mixture",x)
```

Scilab code Exa 10.5 example 5

```
1 clc
2 //Initialization of variables
3 pgw=0.5069 //psia
4 p=14.696 //psia
5 Td=100 //F
6 Tw=80 //F
7 //calculations
8 pv= pgw- (p-pgw)*(Td-Tw)/(2800-Tw)
9 pg=0.9492 //psia
10 phi=pv/pg
11 //results
```

```
12 printf("relative humidity of air stream = %.1f
    percent",phi*100)
```

Scilab code Exa 10.6 example 6

```
1 clc
2 //Initialization of variables
3 w1=0.0176 //lbm
4 w2=0.0093 //lbm
5 T2d=73//F
6 T2=55 //F
7 //calculations
8 disp("From steam tables ,")
9 hv1=1061+0.445*100
10 hv2=1061+0.445*55
11 hf=23.06
12 q1=20
13 q2=4.88
14 //results
15 printf("Heat removed in cooling section = %d Btu/lbm
    ",q1)
16 printf("Heat added in heating section = %.2f Btu/lbm
    ",q2)
```

Scilab code Exa 10.7 example 7

```
1 clc
2 //Initialization of variables
3 Tdb=115 //F
4 ph=0.05
5
6 Twb=67 //F
7 //results
```



```
8 disp("From steam tables , Twb=67 F")
```

Scilab code Exa 10.8 example 8

```
1 clc
2 //Initialization of variables
3 w1=206
4 w2=55
5 ma1=2
6 ma2=3
7 //calculations
8 w3= (ma1*w1 + ma2*w2)/(ma1+ma2)
9 disp("From psychrometric chart ,")
10 Tdb3=82 //F
11 TWb3=74.55 //F
12 phi3=70 //percent
13 //results
14 printf("relative humidity = %d percent",phi3)
15 printf("\n Dry bulb temperature = %d F",Tdb3)
16 printf("\n Wet bulb temperature = %.2f F",TWb3)
```

Chapter 11

Chemical Thermodynamics and Equilibrium

Scilab code Exa 11.1 example 1

```
1  clc
2  // Initialization of variables
3  x=1.5
4  P=14.696 //psia
5  m=28.96
6  // calculations
7  mf=114 // lbm/mol fuel
8  ma=x*12.5*(1+3.76)*m
9  AF=ma/mf
10 n1=8
11 n2=9
12 n3=(x-1)*12.5
13 n4= x*3.76*12.5
14 np=n1+n2+n3+n4
15 x1=n1/np
16 x2=n2/np
17 x3=n3/np
18 x4=n4/np
19 ph=x2*P
```

```

20 Td=113.5 //F
21 //results
22 printf("Air fuel ratio = %.1f lbm air/lbm fuel",AF)
23 printf("\n Mole fraction of CO2 = %.2f percent",x1)
24 printf("\n Mole fraction of H2O = %.2f percent",x2)
25 printf("\n Mole fraction of O2 = %.2f percent",x3)
26 printf("\n Mole fraction of N2 = %.2f percent",x4)
27 disp("From tables of saturation pressure")
28 printf("Dew point = %.1f F",Td)

```

Scilab code Exa 11.2 example 2

```

1  clc
2  //Initialization of variables
3  x1=9
4  x2=1.2
5  x3=1.5
6  x4=88.3
7  //calculations
8  a=x1+x2
9  b=2*a
10 x0=(2*x1 + x2+ 2*x3 + b)/2
11 xN=x4/3.76
12 ratio=x0/a
13 percent=ratio/2 *100
14 //results
15 printf("Percent theoretical air = %.1f percent",
    percent)

```

Scilab code Exa 11.3 example 3

```

1  clc
2  //Initialization of variables

```

```

3 T=440 //F
4 //calculations
5 disp("From steam tables,")
6 h1=-169290
7 h2=7597.6
8 h3=4030.2
9 ht=h1+h2-h3
10 //results
11 printf("Molal enthalpy of CO2 = %d Btu/lbm mole",ht)

```

Scilab code Exa 11.4 example 4

```

1 clc
2 //Initialization of variables
3 T=77 //F
4 //calculations
5 Hr=-36420 //B
6 hc=-169290 //B/lb mol
7 hh=-122970 //B/lb mol
8 Hp=2*hc+3*hh
9 Q=Hp-Hr
10 //results
11 printf("Heat transfer = %d B/mol fuel",Q)

```

Scilab code Exa 11.5 example 5

```

1 clc
2 //Initialization of variables
3 T2=440 //F
4 T1=77 //F
5 Mch4=16
6 Mw=18
7 //calculations

```

```

8 h77=3725.1
9 ht=6337.9
10 ht2=7597.6
11 h772=4030.2
12 hwt=1260.3
13 h77w=45.02
14 hr77=-383040 //B/lbm mol
15 dHR=1*Mch4*0.532*(T1-T2) + 2*(h77-ht)
16 dHp=1*(ht2-h772) + 2*Mw*(hwt - h77w)
17 hrp=dHp+hr77+dHR
18 //results
19 printf("Enthalpy of combustion of gaseous methane =
    %d B/lbm mol fuel",hrp)
20 //The calculation in textbook is wrong Please check
    it using a calculator.

```

Scilab code Exa 11.6 example 6

```

1 clc
2 //Initialization of variables
3 Hr=-107530 //B/mol fuel
4 disp("By iteration of temperatures , T=2700 R")
5 T=2700 //R
6 //results
7 printf("Adiabatic flame temperature = %d R",T)

```

Scilab code Exa 11.7 example 7

```

1 clc
2 //Initialization of variables
3 Kp=0.668
4 y=Kp^2
5 //calculations

```

```

6 x=poly(0,"x")
7 vec=roots(x^3 + y*x^3 + 2*y*x^2 -y*x -2*y)
8 eps=vec(1)
9 x1=(1-eps)/(1+ eps/2)
10 x2=eps/(1+eps/2)
11 x3=eps/2/(1+ eps/2)
12 //results
13 printf("degree of reaction = %.3f ",eps)
14 printf("\n Equilibrium concentration of CO2 = %.3f "
, x1)
15 printf("\n Equilibrium concentration of CO = %.3f ",
x2)
16 printf("\n Equilibrium concentration of O2 = %.3f ",
x3)
17 //the answers are a bit different due to
approximation in textbook

```

Scilab code Exa 11.8 example 8

```

1 clc
2 //Initialization of variables
3 Kp=15.63
4 y=Kp
5 //calculations
6 x=poly(0,"x")
7 vec=roots(x^2 + y*x^2 - y)
8 eps=vec(1)
9 x1=(1-eps)/(1+eps)
10 x2=eps/(1+eps)
11 x3=eps/(1+eps)
12 //results
13 printf(" Equilibrium concentration of Cs = %.4f ",x1
)
14 printf("\n Equilibrium concentration of Cs+ = %.4f "
,x2)

```

```
15 printf("\n Equilibrium concentration of e- = %.4f ",  
    x3)  
16 //the answers are a bit different due to  
    approximation in textbook
```

Chapter 12

conventional power and refrigeration cycles

Scilab code Exa 12.1 example 1

```
1 clc
2 // Initialization of variables
3 disp("From Mollier diagram,")
4 h1=1357 //500 psia , 700 F
5 h2=935 //P2=2 psia
6 h3=93.99 //sat liq at 2 psia
7 vf=0.01613
8 P4=500 //psia
9 P3=2 //psia
10 // calculations
11 dh4=vf*(P4-P3)*144/778
12 h4=h3+dh4
13 eta= ((h1-h2)-(h4-h3))/(h1-h4)
14 // results
15 printf("Thermal efficiency = %.1f percent ",eta*100)
```

Scilab code Exa 12.2 example 2

```
1 clc
2 //Initialization of variables
3 disp("From molier diagram,")
4 h1=1357 //500 psia 700F
5 h2=1194 //P2=100 psia
6 h3=1379 //100 psia , 700 F
7 h4=1047 //p4=2 psia
8 h5=93.99 //sat liq at 2 psia
9 h6=95.02 //example 12.1
10 //calculations
11 W=h1-h2+h3-h4-(h6-h5)
12 Q=(h1-h6)+(h3-h2)
13 eta=W/Q
14 //results
15 printf("Thermal efficiency = %.2f percent",eta*100)
```

Scilab code Exa 12.3 example 3

```
1 clc
2 //Initialization of variables
3 P=100 //psia
4 //calculations
5 disp("From mollier diagram,")
6 h1=1357 //500 psia , 700F
7 h2=1194 //100 psia
8 h3=935//2 psia
9 h4=93.99 //sat liq at 2 psia
10 vf=0.01613
11 vf2=0.01774
12 P5=100 //psia
13 P4=2 //psia
14 dh4=vf*(P5-P4)*144/778
15 h5=h4+dh4
```

```

16 h6=298.4
17 P7=500 // psia
18 P6=100 // psia
19 dh6=vf2*(P7-P6)*144/778
20 h7=dh6+h6
21 m=(h6-h5)/(h2-h5)
22 W=h1-h2 + (1-m)*(h2-h3) - (1-m)*(h5-h4) -(h7-h6)
23 Q=h1-h7
24 etath=W/Q
25 // results
26 printf("Thermal efficiency = %.1f percent",etath
        *100)

```

Scilab code Exa 12.4 example 4

```

1 clc
2 // Initialization of variables
3 x=0.8
4 // calculations
5 disp("From molier diagram,")
6 h1=1357 //500 psia 700F
7 h2=1194 //P2=100 psia
8 h3=1379 //100 psia , 700 F
9 h4=1047 //p4=2 psia
10 h5=93.99 //sat liq at 2 psia
11 h6=95.02 //example 12.1
12 h2d=h1- x*(h1-h2)
13 h4d=h3- x*(h3-h4)
14 W=(h1-h2d) +(h3-h4d) - (h6-h5)
15 Q=(h1-h6) + (h3-h2d)
16 eta=W/Q
17 // results
18 printf("Thermal efficiency = %d percent",eta*100+1)

```

Scilab code Exa 12.5 example 5

```
1  clc
2  //Initialization of variables
3  P4=50 //psia
4  P1=14.7 //psia
5  P3=50 //psia
6  P2=14.7 //psia
7  g=1.4
8  //calculations
9  V1r=(P4/P1)^(1/g)
10 V2r=(P3/P2)^(1/g)
11 //After solving ,
12 V4=5.38 //ft^3/min
13 V1=12.9 //ft^3/min
14 V2=112.9 //ft^3/min
15 PD=V2-V4
16 etavol=(V2-V1)/(V2-V4)
17 W32=g*P2*144*V2*((P3/P2)^((g-1)/g) -1 )/(1-g)
18 W41=g*P4*144*V4*((P1/P4)^((g-1)/g) -1 )/(1-g)
19 Wt=W32+W41
20 //results
21 printf("Total work = %.2e ft-lbf /min",Wt)
22 //The answer given in textbook is wrong . please
    verify it using a calculator
```

Scilab code Exa 12.6 example 6

```
1  clc
2  //Initialization of variables
3  P1=14.7 //psia
4  P4=100 //psia
```

```

5 T1=530 //R
6 T3=T1
7 g=1.4
8 m=10 //lbm
9 cp=0.24
10 //calculations
11 P2=sqrt(P1*P4)
12 T2=T1*(P2/P1)^((g-1)/g)
13 T4=T2
14 W=2*cp*(T2-T1)
15 Wt=W*m
16 hp=Wt*60/2545
17 Q=m*cp*(T2-T3)
18 T4=T1*(P4/P1)^((g-1)/g)
19 W2=m*cp*(T4-T1)
20 //results
21 printf("Work required in case 1 = %d Btu/min",Wt+1)
22 printf("\n Work required in case 2 = %d Btu/min",W2
+1)

```

Scilab code Exa 12.7 example 7

```

1 clc
2 //Initialization of variables
3 g=1.4
4 r1=10
5 r2=12
6 r3=15
7 T1=530 //R
8 Th=1960 //R
9 //calculations
10 eta1=1- (r1)^(1-g)
11 eta2=1- (r2)^(1-g)
12 eta3=1- (r3)^(1-g)
13 etac=1-T1/Th

```

```

14 //results
15 printf("Efficiency in case 1 = %.1f percent",eta1
    *100)
16 printf("\n Efficiency in case 2 = %.1f percent",eta2
    *100)
17 printf("\n Efficiency in case 3 = %.1f percent",eta3
    *100)
18 printf("\n Carnot efficiency = %.2f percent",etac
    *100)

```

Scilab code Exa 12.8 example 8

```

1  clc
2  //Initialization of variables
3  T1=70+460 //R
4  P1=14.7 //psia
5  g=1.4
6  r=15
7  rc=2
8  cp=0.24
9  cp2=0.1715
10 //calculations
11 T2=T1*(r)^(g-1)
12 T3=rc*T2
13 T4=T3*(rc/r)^(g-1)
14 Qh=cp*(T3-T2)
15 Ql=cp2*(T4-T1)
16 W=Qh-Ql
17 eta=W/Qh
18 //results
19 printf("Work output = %d B/lbm",W)
20 printf("\n Efficiency = %.1f percent",eta*100)

```

Scilab code Exa 12.9 example 9

```
1  clc
2  // Initialization of variables
3  P1=14.7 //psia
4  P4=14.7 //psia
5  T1=530 //R
6  T3=1960 //R
7  P2=60 //psia
8  P3=P2
9  g=1.4
10 eta1=0.85
11 eta2=0.9
12 // calculations
13 T2=T1*(P2/P1)^((g-1)/g)
14 T4=T3*(P4/P3)^((g-1)/g)
15 T2d=(T2-T1)/eta1 + T1
16 T4d=-eta2*(T3-T4) +T3
17 Wact=0.24*(T3-T4d - (T2d-T1))
18 Qh=0.24*(T3-T2d)
19 etath=Wact/Qh
20 // results
21 printf("Thermal efficiency = %.1f percent",etath
    *100)
```

Scilab code Exa 12.10 example 10

```
1  clc
2  // Initialization of variables
3  e=0.83
4  // calculations
5  T1=530 //R
6  T2d=838 //R
7  T6d=T2d
8  T3=1960 //R
```

```

9 T4d=1375 //R
10 T5d=T4d
11 T5=e*(T5d-T2d) +T2d
12 W=0.24*((T3-T4d)- (T2d-T1))
13 Q=0.24*(T3-T5)
14 eta=W/Q
15 //results
16 printf("Thermal efficiency = %d percent",eta*100+1)

```

Scilab code Exa 12.11 example 11

```

1 clc
2 //Initialization of variables
3 T1=420 //R
4 T11=530 //R
5 T3=2460 //R
6 V1=300 //ft/sec
7 P1=5 //psia
8 P5=P1
9 P2=50 //psia
10 P3=5 //psia
11 P4=50 //psia
12 g=1.4
13 cp=0.24
14 m=1
15 //calculations
16 T2=T1*(P2/P1)^((g-1)/g)
17 T4=T3-T2+T11
18 T5=T3*(P3/P4)^((g-1)/g)
19 V5=sqrt(2*32.2*cp*(T4-T5)*778)
20 T=m*(V1-V5)/32.2
21 Qh=cp*(T3-T2)
22 P=-T*V1
23 //results
24 printf("Thrust = %.1f lbf",T)

```

```
25 printf("\n Heat input = %d B/lbm",Qh)
26 printf("\n Power = %d ft-lbf /sec",P)
```

Scilab code Exa 12.12 example 12

```
1  clc
2  // Initialization of variables
3  h1=80.419 //B/lbm
4  h3=36.013 //B/lbm
5  h4=h3
6  P3=172.35 //psia
7  P2=P3
8  m=5 //tons
9  Q=12000
10 // calculations
11 h2=91.5 //B/lbm
12 disp("From superheated steam tables,")
13 COP=(h1-h4)/(h2-h1)
14 W=h2-h1
15 md=m*Q/(h1-h4)
16 Wt=md*(h2-h1)
17 Wt2=Wt/2545
18 // results
19 printf("Coefficient of performance = %.1f",COP)
20 printf("\n Input work = %.1f hp",Wt2)
```

Chapter 13

Thermodynamics of irreversible processes

Scilab code Exa 13.1 example 1

```
1 clc
2 // Initialization of variables
3 Eab1=0
4 Eab2=5.87 //mV
5 T1=150 //F
6 T2=200 //F
7 // calculations
8 Eab= -1.12+ 0.035*T1
9 pi1=0.035*(T1+460)
10 pi2=0.035*(T2+460)
11 // results
12 printf("Thermocouple reading at %d F = %.2 f mv",T1,
    Eab)
13 printf("\\n Peltier coefficient at %d F = %.1 f mv",T1
    ,pi1)
14 printf("\\n Peltier coefficient at %d F = %.1 f mv",T2
    ,pi2)
```

Scilab code Exa 13.2 example 2

```
1  clc
2  // Initialization of variables
3  T=0 //C
4  // calculations
5  de1=-72 //mV/C
6  de2=500 //mv/C
7  alpha=de1-de2
8  pi=-(T+273)*alpha
9  // results
10 printf(" Peltier coefficient at %d C = %d mv" ,T,pi
    /1000)
```

Chapter 14

direct energy conversion

Scilab code Exa 14.1 example 1

```
1  clc
2  // Initialization of variables
3  T=25+273 //K
4  F=23060
5  // calculations
6  H=-68317
7  G=-56690
8  Er=-G/(2*F)
9  eta=G/H
10 W=-G
11 Q=H-G
12 // results
13 printf("Voltage output of the cell = %.3f volts",Er)
14 printf("\n Efficiency = %d percent",eta*100 +1)
15 printf("\n Electrical Work output = %d cal/mol H2",W
)
16 printf("\n Heat transfer to the surroundings = %d
cal/mol H2",Q)
```

Scilab code Exa 14.2 example 2

```
1  clc
2  // Initialization of variables
3  x1=0.75
4  x2=0.25
5  an=-190*10^-6 // volt/C
6  rn=1.45*10^-3 //ohm cm
7  zn=2*10^-3 //K^-1
8  ap=190*10^-6 // volt/C
9  rp=1.8*10^-3 //ohm cm
10 zp=1.7*10^-3 //K^-1
11 T=200+273 //K
12 Tc=373 //K
13 Th=573 //K
14 // calculations
15 Ktn=an^2/(rn*zn)
16 Ktp=ap^2/(rp*zp)
17 Z=(an-ap)^2 /(sqrt(rn*Ktn) + sqrt(rp*Ktp))^2
18 Ap=sqrt(Ktn*rp/Ktp/rn)
19 An=1
20 K=Ktn*An+ Ktp*Ap
21 R=rn/An + rp/Ap
22 mopt=sqrt(1+ Z*T)
23 RL=mopt*R
24 nopt=(T-273)*(mopt-1)/(Th*(mopt+ Tc/Th))
25 nmax=T/(Th*(1+1- T/Th/2 + 4/Th/Z))
26 nmax=0.0624
27 dT=T-273
28 Popt=(an-ap)^2 *dT^2 /((1+mopt)^2 *RL)
29 Pmax=(an-ap)^2 *dT^2 /((1+1)^2 *R)
30 // results
31 printf("Optimum efficiency = %.2f percent",nopt*100)
32 printf("\n Max. efficiency = %.2f percent",nmax*100)
33 printf("\n Optimum power = %.3f Watt",Popt)
34 printf("\n Maximum power = %.3f Watt",Pmax)
```

Scilab code Exa 14.3 example 3

```
1  clc
2  // Initialization of variables
3  phic=2.5 //V
4  phia=2 //V
5  phip=0.1 //V
6  Th=2000 //K
7  Tc=1000 //K
8  eff=0.2
9  k=1.38*10^-23
10 e=1.6*10^-19
11 sigma=5.67*10^-12
12 // calculations
13 V=phic-phia-phip
14 Jc=1.2*10^6 *Th^2 *exp(-e*phic/(k*Th))
15 Ja=1.2*10^6 *Tc^2 *exp(-e*phia/(k*Tc))
16 J=Jc
17 Qc1=J*(phic + 2*k*Th/e) + eff*sigma*10^4 *(Th^4 - Tc
    ^4)
18 eta1=J*0.4/Qc1
19 eta2=(Th-Tc)/Th
20 // results
21 printf("Efficiency of the device = %.1f percent",
    eta1*100)
22 printf("\n Carnot efficiency = %d percent",eta2*100)
```
