Scilab Textbook Companion for Thermodynamics by B. L . Singhal[1]

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Book Description

Title: Thermodynamics

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

Thermodynamics Concepts

Scilab code Exa 1.4 Kinetic and Potential Energy

```
//Exa 1.4
clc;
clear;
close;
format('v',9);

//Given Data :
m=500;//Kg
g=7.925;//m/s^2
Z=40;//Km
C=2400;//Kmph
PE=m*g*Z*1000;//Nm
disp("Relative to earth.");
disp(PE,"Potential Energy in Nm : ");
KE=m*(C*1000/3600)^2/2;//Nm
disp(KE,"Kinetic Energy in Nm : ");
disp("Relative to moon.");
w=2.94*m;//Nm
PE=w*Z*1000;//Nm
disp(PE,"Potential Energy in Nm : ");
KE=m*(C*1000/3600)^2/2;//Nm
```

```
disp(KE,"Kinetic Energy in Nm : ");
```

Scilab code Exa 1.5 Absolute Pressure

```
//Exa 1.5
clc;
clear;
close;
format('v',7);

//Given Data :
VGR=57;//KN/m^2
Patm=765;//mm of Hg
//101.325KN/m^2=760 mm of Hg
VGR=VGR*760/101.325;//mm og Hg
Pabs=Patm-VGR;//mm of Hg
disp(Pabs,"Absolute pressure in mm of Hg : ");
```

Scilab code Exa 1.6 Determine the pressure

```
//Exa 1.6
clc;
clear;
close;
format('v',8);

//Given Data :
g=9.81;//m/s^2
rho_o=0.825*10^3;//Kg/m^3
rho_w=1*10^3;//Kg/m^3
rho_Hg=13.45*10^3;//Kg/m^3
h_o=50/100;//m
h_w=65/100;//m
```

```
h_Hg=45/100; //m
Patm=1.01325; //bar
P_Hg=rho_Hg*g*h_Hg; //N/m^2
P_w=rho_w*g*h_w; //N/m^2
P_o=rho_o*g*h_o; //N/m^2
Pbase=(Patm*10^5+P_Hg+P_o+P_w); //N/m^2
disp(Pbase,"Pressure at the base of column in N/m^2
    : ");
P_OilWater=Patm*10^5+P_o; //N/m^2
disp(P_OilWater,"Pressure at the oil-water surface
    in N/m^2 : ");
P_WaterMercury=Patm*10^5+P_o+P_w; //N/m^2
disp(P_WaterMercury,"Pressure at the water-mercury
    surface in N/m^2 : ");
//Answer in the book is not accurate.
```

Scilab code Exa 1.7 Water level and mass change

```
//Exa 1.7
clc;
clear;
close;
format('v',7);

//Given Data :
rho=1000; //Kg/m^3
d=0.3; //m
C=1.5; //m/s
h=4.5; //m
FlowRate=2000; //Kg/min
d2=15/100; //diameter of discharging line in meter
t=15; //min
r=3; //m
WaterDischarge=rho*%pi/4*(d/2)^2*C*t*60; //Kg
WaterReceived=FlowRate*t; //Kg
```

```
NetWaterReceived=WaterReceived-WaterDischarge;//Kg
disp(NetWaterReceived,"Mass change in tank in Kg : "
   );
//m=rho*A*h
h=NetWaterReceived/rho/(%pi/4*r^2);//m
disp(h,"Water level in meter : ");
```

Scilab code Exa 1.8 Absolute pressure of steam

```
//Exa 1.8
clc;
clear;
close;
format('v',7);

//Given Data :
Pmercury=10;//cm of Hg
Patm=76;//cm of Hg
Pwater=3.5/13.6;//cm of Hg
Pabs=Pmercury+Patm-Pwater;//cm of Hg
Pabs=Pabs/76*1.01325;//bar
disp(Pabs,"Absolute pressure of steam in bar : ");
```

Scilab code Exa 1.9 Height of fluid

```
//Exa 1.9
clc;
clear;
close;
format('v',7);

//Given Data :
Pmercury=10;//cm of Hg
```

```
Patm=760;//mm of Hg
Patm=1.01325;//bar
Pabs=1.2;//bar
sg_oil=0.8;
sg_water=13.6;
sg_mercury=13.6;
rho_w=1000;//Kg.m^3
g=9.81;//gravity constant
deltaP=Pabs-Patm;//bar
deltaP=deltaP*10^5;//N/m^2
//deltaP=rho_o*g*h_o
rho_o=sg_oil*rho_w;//kg/m^3
h_o=deltaP/rho_o/g;//m
disp(h_o,"Height of fluid in oil manometer in meter
    : ");
h_w=deltaP/rho_w/g;//m
disp(h_w,"Height of fluid in water manometer in
    meter : ");
rho_m=sg_mercury*rho_w;//kg/m^3
h_m=deltaP/rho_m/g;//m
disp(h_m,"Height of fluid in mercury manometer in
    meter : ");
```

Scilab code Exa 1.10 Absolute pressure of gas

```
//Exa 1.10
clc;
clear;
close;
format('v',9);

//Given Data :
Patm=75;//mm of Hg
Patm=Patm*1.01325/76;//bar
rho=800;//Kg.m^3
```

```
h=30/100;//m
g=9.81;//gravity constant
deltaP=rho*g*h*10^-5;//bar
Pabs=deltaP+Patm;//bar
disp(Pabs,"Absolute pressure of gas in bar : ");
```

Scilab code Exa 1.11 Absolute pressure in KPa

```
//Exa 1.11
clc;
clear;
close;
format('v',7);

//Given Data :
h1=5.1/100;//m
h2=10/100;//m
Patm=75.5;//mm of Hg
Patm=Patm*1.01325/76*10^5;//bar
sg_k=0.8;
sg_Hg=13.6;
rho_w=1000;//Kg/m^3
g=9.81;//gravity constant
P_kerosine=sg_k*rho_w*g*h1;//N/m^2
P_Hg=sg_Hg*rho_w*g*h2;//N/m^2
Pabs=P_Hg+Patm-P_kerosine;//Nm^2
disp(Pabs/1000,"Absolute pressure of gas in KPa : ")
    ;
```

Scilab code Exa 1.12 Temperature corresponding to Thermometric Property

```
//Exa 1.12
```

```
clc;
clear;
close;
format('v',7);

//Given Data :
t_ice=0;//degree centigrade
p_ice=1.5;
t_steam=100;//degree centigrade
p_steam=7.5;
//t=a*log(p)+b
//solving for a and b by matrix
A=[log(p_ice) 1;log(p_steam) 1];
B=[t_ice;t_steam];
X=A^-1*B;
a=X(1);
b=X(2);
p=3.5;//bar
t=a*log(p)+b;//degree C
disp(t,"Temperature scale in degree C : ");
```

Scilab code Exa 1.13 temperature in degree C

```
//Exa 1.13
clc;
clear;
close;
format('v',7);

//Given Data :
theta1_p1=273.16;//K
p_gauge1=32;//mm of Hg
p_atm=752;//mm of Hg
p_gauge2=76;//mm of Hg
P1=p_gauge1+p_atm;//mm of Hg
```

```
P2=p_gauge2+p_atm;//mm of Hg
theta2_p2=theta1_p1*(P2/P1);//in K
theta2_p2=theta2_p2-273;//degree C
disp(theta2_p2,"Temperature in degree C : ");
```

Scilab code Exa 1.14 Calculate the temperature

```
//Exa 1.14
clc;
clear;
close;
format('v',7);

//Given Data :
R0=2.8;//ohm
t0=0;//degree C
R1=3.8;//ohm
t1=100;//degree C
R2=5.8;//ohm\
//R=R0*(1+alfa*t)
alfa=(R1/R0-1)/t1;
t2=(R2/R0-1)/alfa;//degree C
disp(t2,"Temperature at R2 in degree C : ");
```

Scilab code Exa 1.16 Temperature of fluid

```
//Exa 1.16
clc;
clear;
close;
format('v',7);

//Given Data :
```

```
//F=2*C;
FbyC=2;
disp("(F-32)/9=C/5");
C=32/(FbyC-9/5);//degree C
F=C*FbyC;//degree F
disp(F+460,"Temperature fluid in degree R : ");
disp(C+273,"Temperature fluid in degree K : ");
```

Scilab code Exa 1.17 Calculate the temperature

```
//Exa 1.17
clc;
clear;
close;
format('v',7);

//Given Data :
T1=0;//degree centigrade
K1=1.83;
T2=100;//degree centigrade
K2=6.78;
//T=a*log(K)+b
//solving for a and b by matrix
A=[log(K1) 1;log(K2) 1];
B=[T1;T2];
X=A^-1*B;
a=X(1);
b=X(2);
K=2.42;//bar
T=a*log(K)+b;//degree C
disp(T,"Temperature in degree C : ");
```

Scilab code Exa 1.18 Temperature

```
//Exa 1.18
clc;
clear;
close;
format('v',6);

//Given Data :
//t=N/30-100/3
//t=N
N=(-100/3)/(1-1/30);//degree C
disp(N,"Temperatur at which degree C equals to
    degree N(degree C) : ");
```

Scilab code Exa 1.19 Thermometer Reading

```
//Exa 1.19
clc;
clear;
close;
format('v',6);

//Given Data :
//epsilon=0.2*t-5*10^-4*t^2;//mV
t_ice=0;//degree C
epsilon_ice=0.2*t_ice-5*10^-4*t_ice^2;//mV
t_steam=100;//degree C
epsilon_steam=0.2*t_steam-5*10^-4*t_steam^2;//mV
//At t=60;
t=60;//degree C
epsilon=0.2*t-5*10^-4*t^2;//mV
reading=(t_steam-t_ice)/(epsilon_steam-epsilon_ice)
    *(epsilon-epsilon_ice)
disp(reading,"Thermometer will read(degree C) : ");
```

Scilab code Exa 1.20 Reading of thermometers

```
//Exa 1.20
clc;
clear;
close;
format('v',7);

//Given Data :
tA1=0;//degree centigrade
tB1=0;//degree centigrade
tA2=100;//degree centigrade
tB2=100;//degree centigrade
//tA=l+m*tB+n*tb^2
l=0;//by putting tA and tB equals to zero
//tA=m*tB+n*tB^2
//Thermometer immersed in oil bath
tA1=51;//degree centigrade
tB1=50;//degree centigrade
//solving for m and n by matrix
A=[tB1 tB1^2;tB2 tB2^2];
B=[tA1;tA2];
X=A^-1*B;
m=X(1);
n=X(2);
tA=25;//degree centigrade
P=[n m -tA];//polynomial for calculation of tB
tB=roots(P);
tB=tB(2);//neglecting +ve sign
disp(tB,"When A reads 25 degree C, B reading in
    degree C : ");
//let tB=25;//degree C
tB=25;//degree C
tA=l+m*tB+n*tB^2;//degree C
```

```
disp(tA,"When B reads 25 degree C, A reading in
    degree C : ");
disp("B is correct. A shows error greater than B.")
//Answer is not accurate in the book.
```

Scilab code Exa 1.21 Specific Volume and Density

```
//Exa 1.21
clc;
clear;
close;
format('v',7);

//Given Data :
p=10;//bar
T=327+273;//K
M=42.4;
m=1;//Kg
Rdegree=8314.3;//Nm/KgK
R=Rdegree/M;//Nm/KgK
V=m*R*T/p/10^5;//m^3/Kg
disp(V,"Specific volume in m^3/Kg ; ");
rho=m/V;//Kg/m^3
disp(rho,"Density of gas in Kg/m^3 : ");
```

Scilab code Exa 1.22 Mass of oxygen used

```
//Exa 1.22
clc;
clear;
close;
format('v',6);

```

```
//Given Data :
Rdegree=8314.3;//Universal Gas Constant
M=32;//Molecular weight of gas
p1=3*10^6;//N/m^2
V1=250*10^-3;//m^3
T1=20+273;//K
p2=1.8*10^6;//N/m^2
V2=V1;//m^3
T2=16+273;//K
R=Rdegree/M;//Nm/KgK
m1=p1*V1/R/T1;//Kg
m2=p2*V2/R/T2;//Kg
mass_used=m1-m2;//Kg
disp(mass_used,"Mass of oxygen used in Kg : ");
```

Scilab code Exa 1.23 Mass and No of moles of air

```
//Exa 1.23
clc;
clear;
close;
format('v',8);

//Given Data :
Rdegree=8314.3;//Universal Gas Constant
r=12;//meter
Patm=75;//cm of Hg
Patm=Patm/76*1.01325*10^5;//N/m^2
V=4/3*%pi*r^3;//m^3
M_air=28.97;
M_H2=2
Tair=18+273;//K
g=9.81;//gravity constant
Rair=Rdegree/M_air;//Nm/KgK
RH2=Rdegree/M_H2;//Nm/KgK
```

```
//p*V=m*R*T
m_air=Patm*V/Rair/Tair;//Kg
disp(m_air,"Mass of air in kg : ");
n_air=m_air/M_air;//moles
disp(n_air,"No. of moles : ");
m_H2=n_air*M_H2;//Kg
disp(m_H2,"Mass of H2 in kg : ");
Load=g*(m_air-m_H2);//N
disp(Load,"Load balloon can lift in N ; ");
```

Scilab code Exa 1.24 Mass of air

```
//Exa 1.24
clc;
clear;
close;
format('v',6);

//Given Data :
p1=1;//bar
p2=0.45;//bar
R=287;//KJ/KgK
V=40;//m^3
V1=40;//m^3
V2=40;//m^3
T1=35+273;//K
T2=5+273;//K
m=p1*10^5*V1/R/T1-p2*10^5*V2/R/T2
disp(m,"Mass of air removed in Kg : ");
```

Scilab code Exa 1.26 Specific heat of metal

```
//Exa 1.26
```

```
clc;
clear;
close;
format('v',6);

//Given Data :
m=1;//Kg
t=80;//degree C
mw=10;//Kg
t1=25;//degree C
delta_t=5;//degree C
t2=delta_t+t1;//degree C
Sw=4.187;//Kj/KgK
//m*S*(t-t2)=mw*Sw*(t2-t1)
S=mw*Sw*(t2-t1)/m/(t-t2);//Kj/KgK
disp(S,"Specific heat of metal in KJ/KgK :  ");
```

Scilab code Exa 1.27 Time required for cooling

```
//Exa 1.27
clc;
clear;
close;
format('v',6);

//Given Data :
m=500;//Kg
t1=45;//degree C
t0=5;//degree C
CP=4.18;//KJ/Kg-degree C
Qdot=41.87;//MJ/hr
Q=m*CP*(t1-t0);//KJ
Q=Q/1000;//MJ
Time=Q/Qdot;//hrs
disp(Time,"Time required in hours : ");
```

Scilab code Exa 1.28 Amount of work will be done

```
//Exa 1.28
clc;
clear;
close;
format('v',7);

//Given Data :
V1=2;//m^3
V2=4;//m^3
W=integrate('10^5*(V^2+6*V)','V',V1,V2);//Nm or J
W=W/1000;//KJ
disp(W,"Work done in KJ : ");
```

Scilab code Exa 1.29 Workk done by the fluid

```
//Exa 1.29
clc;
clear;
close;
format('v',7);

//Given Data :
p1=3;//bar
V1=0.18;//m^3/Kg
p2=0.6;//bar
C=p1*10^5*V1^2;//Nm
V2=sqrt((p1/p2)*V1^2);//m^3Kg
W=integrate('C/V^2','V',V1,V2);//Nm/Kg
W=W/1000;//KJ/Kg
disp(W,"Work done in KJ/Kg : ");
```

Scilab code Exa 1.30 Final Pressure and Volume

```
//Exa 1.30
clc;
clear;
close;
format('v',7);

//Given Data :
W=160;//kJ
W=W*1000;//J
V1=800;//litres
V1=V1/1000;//m^3
//p=7-3*V
//[7*(V2-V1)-1.5*(V2^2-V1^2)]-W/10^5=0;//Nm or J
//7*V2-7*V1-1.5*V2^2+1.5*V1^2-W/10^5;//Nm or J
//P=[-10^5*1.5 10^5*7 -10^5*7*V1+10^5*1.5*V1^2-W]
P=[-1.5 7 -7*V1+1.5*V1^2-W/10^5];
V2=roots(P);//m^3
V2=V2(2);//(V2(1) gives -ve value which is not possible)
disp(V2,"Final Volume in m^3 : ");
P2=7-3*V2;//bar
disp(P2,"Final Pressure in bar : ");
//Answer is wrong in the book as calculation is wrong for V2.
```

Scilab code Exa 1.31 Work done by the system

```
//Exa 1.31
clc;
```

```
clear;
close;
format('v',7);

//Given Data :
p0=1;//bar
p0=p0*10^5;//N/m^2
V1=0;//m^3
V2=0.7;//m^3
//No p.dV work for cylinder as boundaries are
W=p0*integrate('1','V',V1,V2);
W=W/1000;//KJ/Kg
disp(W,"Workdone by the system  in KJ : ");
```

Scilab code Exa 1.32 Work done by the air

```
//Exa 1.32
clc;
clear;
close;
format('v',7);

//Given Data :
p0=101.3;//KPa
V1=1.2;//m^3
V2=0;//m^3
//No p.dV work by rigid boundary
W=p0*integrate('1','V',V1,V2);
disp(W,"Workdone by the air  in KJ : ");
```

Scilab code Exa 1.33 Change in enthalpy and internal energy

```
//Exa 1.33
```

```
clc;
clear;
close;
format('v',9);

//Given Data :
T1=300;//K
T2=2300;//K
Gamma=1.5;
m=1;//Kg
//Cp=0.85+0.0004*T+50*10^-5*T^2
H2subH1=integrate('m*(0.85+0.00004*T+5*10^-5*T^2)','
    T',T1,T2);//KJ/Kg
disp(H2subH1,"Change in enthalpy in KJ/Kg : ");
U2subU1=integrate('m*(0.85+0.00004*T+5*10^-5*T^2)/
    Gamma','T',T1,T2);//KJ/Kg
disp(U2subU1,"Change in internal energy in KJ : ");
```

Scilab code Exa 1.34 Pressure of O2

```
//Exa 1.34
clc;
clear;
close;
format('v',9);

//Given Data :
m=1;//Kg
v=1;//m^3
T=127+273;//K
a=138;//KNm^4/(Kgmol)^2
a=a*10^3;//Nm^4/(Kgmol)^2
M_O2=32;//
vm=v*M_O2;//m^3/Kgmol
//p*v=n*R*T
```

```
n=1;
R=8314.3;//gas constant
p=n*R*T/vm;//N/m^2
disp(p,"Pressure using perfect gas equation in N/m^2
    : ");
//[p+a/vm^2]*[vm-b]=R*T
b=0.0318;
p=R*T/(vm-b)-a/vm^2;//N/m^2
disp(p,"Pressure using Vander Walls equation in N/m
   ^2 : ");
```

Scilab code Exa 1.35 Pressure exerted by CO2

```
//Exa 1.35
clc;
clear;
close;
format('v',7);

//Given Data :
m=22;//Kg
T=300;//K
V=5;//m^3
M=44;//Kg/Kgmol
a=362.9;//KNm^4/Kgmol^2
b=0.0314;//m^3/Kgmol
Rdash=8314.3;//gas constant
R=Rdash/M;//Nm/KgK
p=m*R*T/V;//Pa
p=p/10^5;//bar
disp(p,"Pressure, when gas behaves like a perfect
   gas in bar : ");
Vdash=V/m*M;//m^3/Kgmole
//[p+a/vm^2]*[vm-b]=R*T
p=Rdash*T/(Vdash-b)-a*10^3/Vdash^2;//N/m^2
```

```
disp(p/10^5,"Pressure using Vander Walls equation in
    bar : ");
```

Scilab code Exa 1.36 Pressure exerted by air

```
//Exa 1.36
clc;
clear;
close;
format('v',7);

//Given Data :
pc=37.7;//bar
Tc=132.5;//K
vc=0.093;//m^3Kgmol
R=287;//Nm/KgK
m=10;//Kg
T=300;//K
V=0.3;//m^3
a=27*R^2*Tc^2/64/pc/10^5;
b=R*Tc/8/pc/10^5;//
//(p+a/V^2)*(V-b)=R*T
p=R*T/(V-b)-a/V^2;//N/m^2
p=p/10^5;//bar
disp(p,"Pressure exerted by air in bar : ");
```

Scilab code Exa 1.37 Determine specific Volume

```
//Exa 1.37
clc;
clear;
close;
format('v',8);
```

```
//Given Data :
pc=221.2;//bar
Tc=374.15+273;//K
p=100;//bar
T=400+273;//K
R=462;//Nm/KgK
//p*v=R*T
v=R*T/p/10^5;//m^3/Kg
disp(v,"Specific volume, v by perfect gas equation
    in m^3/Kg : ");
pr=p/pc;
Tr=T/Tc;
Z=0.84;//From compressibility chart
v=Z*R*T/p/10^5
disp(v,"Specific volume, v by compressibility chart
    in m^3/Kg : ");
```

Scilab code Exa 1.38 Pressure and Temperature of Gas

```
//Exa 1.38
clc;
clear;
close;
format('v',8);

//Given Data :
pr=5;
Z=0.8;
pc=46.4;//bar
Tc=191.1;//K
Tr=1.44;//
p=pr*pc;//bar
disp(p,"Pressure in bar : ");
T=Tr*Tc;//K
```

```
disp(T,"Temperature in K : ");
```

Scilab code Exa 1.39 Temperature of cylinder

```
//Exa 1.39
clc;
clear;
close;
format('v',7);

//Given Data :
V=0.01653;//m^3
m=5.6;//Kg
M=28;//Kg/Kgmol
p=200;//bar
Z=0.605;
Rdash=8314.3;//J/Kgk
R=Rdash/M;//J/Kgk
//p*V=m*Z*R*T
T=p*10^5*V/m/Z/R;//K
disp(T,"Temperature in K : ");
```

Scilab code Exa 1.40 Partial Pressure of each constituent

```
//Exa 1.40
clc;
clear;
close;
format('v',7);

//Given Data :
mCO=0.45;//Kg
mAir=1;//Kg
```

```
V=0.4;//m^3
T=15+273;//K
MCO=28;//Kg/Kgmo
MO2=32;//Kg/Kgmol
MN2=28;//Kg/Kgmol
mO2=23.3/100*mAir;//Kg
mN2=76.7/100*mAir;//Kg
Rdash=8314.3;//J/Kgk
//p*V=m*Z*R*T
pCO=mCO*Rdash/MCO*T/V/10^5;//bar
pO2=mO2*Rdash/MO2*T/V/10^5;//bar
pN2=mN2*Rdash/MN2*T/V/10^5;//bar
disp(pCO,"Pressure of CO in bar : ");
disp(pO2,"Pressure of O2 in bar : ");
disp(pN2,"Pressure of N2 in bar : ");
p=pCO+pO2+pN2;//bar
disp(p,"Total pressure in vessel in bar : ");
```

Scilab code Exa 1.41 Partial pressure of each gas

```
//Exa 1.41
clc;
clear;
close;
format('v',7);

//Given Data :
ma=0.4;//Kg
mb=0.8;//Kg
Ma=44;
Mb=29;
V=0.4;//m^3
T=300;//K
Rdash=8314.3;//J/Kgk
Ra=Rdash/Ma;//Nm/KgK
```

```
Rb=Rdash/Mb;//Nm/KgK
na=ma/Ma;//moles
nb=mb/Mb;//moles
//p*V=n*R*T
pa=na*Rdash/1000*T/V;//bar
pb=nb*Rdash/1000*T/V;//bar
disp(pa,"Pressure of container A in KPa : ");
disp(pb,"Pressure of container B in KPa : ");
p=pa+pb;//Kpa
disp(p,"Pressure of mixture in KPa : ");
//Ans of Pb is wrong in the book.
```

Scilab code Exa 1.42 Gas Constant Molecular weight

```
//Exa 1.42
clc;
clear;
close;
format('v',8);

//Given Data :
Rdash=8314.3;//J/Kgk
mO2=23.15/100;
mN2=75.52/100;
mArgon=1.29/100;
mCO2=0.04/100;
MO2=32;
MN2=28;
MArgon=40;
MCO2=44;
RO2=Rdash/MO2;//J/KgK
RN2=Rdash/MN2;//J/KgK
RArgon=Rdash/MArgon;//J/KgK
RCO2=Rdash/MCO2;//J/KgK
R=(mO2*RO2+mN2*RN2+RArgon*mArgon+RCO2*mCO2)/(mO2+mN2
```

```
    +mArgon+mCO2);//J/KgK
disp(R,"Characteristic gas constant for air in J/KgK
    : ");
M=Rdash/R;//Kg/Kgmol
disp(M,"Molecular weight of air in Kg/Kgmol : ");
p=1.013;//bar
nO2=mO2/MO2;//moles
nCO2=mCO2/MCO2;//moles
nN2=mN2/MN2;//moles
nArgon=mArgon/MArgon;//moles
n=nO2+nN2+nArgon+nCO2;
pO2=nO2/n*p;//bar
pN2=nN2/n*p;//bar
pArgon=nArgon/n*p;//bar
pCO2=nCO2/n*p;//bar
disp(pO2,"Pressure of O2 in bar : ");
disp(pN2,"Pressure of N2 in bar : ");
disp(pArgon,"Pressure of Argon in bar : ");
disp(pCO2,"Pressure of CO2 in bar : ");
```

Scilab code Exa 1.43 Molecular mass Gas constant Pressure

```
//Exa 1.43
clc;
clear;
close;
format('v',7);

//Given Data :
yO2=0.3;
yN2=0.5;
yCO2=0.2;
V=1;//m^3
T=27+273;//K
m=8;//Kg
```

```
MO2=32;
MN2=28;
MCO2=44;
M=1/(yO2/MO2+yN2/MN2+yCO2/MCO2);//Kg/Kgmol
disp(M,"Molecular mass for mixture in Kg/Kgmol : ");
Rdash=8314.3;//J/Kgk
R=Rdash/M;//Nm/KgK
disp(R,"Gas constant R of mixture in Nm/KgK : ");
p=m*R*T/V/10^5;//bar
disp(p,"Pressure exerted by gases in bar : ");
nO2=yO2/MO2*m;//moles
nCO2=yCO2/MCO2*m;//moles
nN2=yN2/MN2*m;//moles
disp(nO2,"Mole fraction of O2(moles) : ");
disp(nN2,"Mole fraction of N2(moles) : ");
disp(nCO2,"Mole fraction of CO2(moles) : ");
```

Scilab code Exa 1.44 Specific heats of gases

```
//Exa 1.44
clc;
clear;
close;
format('v',7);

//Given Data :
mN2=4;//Kg
mO2=2.4;//Kg
mCO2=1.6;//Kg
MO2=32;
MN2=28;
MCO2=44;
Gamma=1.4;
//Rdash=Cpdash*(1-1/Gamma)
Rdash=8.3143;//J/KgK
```

```
Cpdash=Rdash*Gamma/(Gamma-1);//KJ/KgmolK
Cvdash=Cpdash/Gamma;//KJ/KgmolK
CpO2=Cpdash/MO2;//KJ/KgmolK
CpN2=Cpdash/MN2;//KJ/KgmolK
CpCO2=Cpdash/MCO2;//KJ/KgmolK
CvO2=Cvdash/MO2;//KJ/Kg
CvN2=Cvdash/MN2;//KJ/Kg
CvCO2=Cvdash/MCO2;//KJ/Kg
disp("Specific heat of gases : ");
disp("For N2, Cp is "+string(CpN2)+" KJ/Kg & Cv is "
    +string(CvN2)+" KJ/Kg.");
disp("For O2, Cp is "+string(CpO2)+" KJ/Kg & Cv is "
    +string(CvO2)+" KJ/Kg.");
disp("For CO2, Cp is "+string(CpCO2)+" KJ/Kg & Cv is
     "+string(CvCO2)+" KJ/Kg.");
Cp=(mO2*CpO2+mN2*CpN2+mCO2*CpCO2)/(mO2+mN2+mCO2);//
    KJ/KgK
disp(Cp,"Specific heat of mixture, Cp in KJ/KgK : ")
    ;
Cv=(mO2*CvO2+mN2*CvN2+mCO2*CvCO2)/(mO2+mN2+mCO2);//
    KJ/KgK
disp(Cv,"Specific heat of mixture, Cv in KJ/KgK : ")
    ;
```

Chapter 2

First Law of Thermodynamics

Scilab code Exa 2.1 Calculate Equillibrium temperature

```
//Exa 2.1
clc;
clear;
close;
format('v',7);

//Given Data :
mc=10;//Kg
Cpc=0.4;//KJ/KgK
Cpw=4.187;//KJ/KgK(Specific heat of water)
tc=90;//degree_centigrade
Vw=0.35;//m^3
tw=30;//degree_centigrade
density_water=1000;//Kg/m^3
mw=Vw*density_water;//Kg
//mc*Cpc*(tc-t)=mw*Cpw*(t-tw)
t=(mw*Cpw*tw+mc*Cpc*tc)/(mw*Cpw+mc*Cpc);//
    degree_centigrade
disp(t,"Equillibrium temperature in
    degree_centigrade : ");
```

Scilab code Exa 2.2 Steam flow rate

```
//Exa 2.2
clc;
clear;
close;
format('v',7);

//Given Data
Q1=2500;//KJ/Kg
Q2=1800;//KJ/Kg
Pdev=210;//MW
//Power developed = Heat transfered: Pdev=m*(Q1-Q2)
m=Pdev*1000/(Q1-Q2);//mass flow rate of steam in Kg/
    s
disp(m,"Mass flow rate of steam in Kg/s : ");
```

Scilab code Exa 2.3 Change in internal energy

```
//Exa 2.3
clc;
clear;
close;
format('v',7);

//Given Data
WA=20;//KJ
QA=15;//KJ
QB=10;//KJ
U2subU1=QA-WA;//change in internal energy in KJ
disp(U2subU1,"Change in internal energy in KJ : ");
```

Scilab code Exa 2.4 Net work for cycle

```
//Exa 2.4
clc;
clear;
close;
format('v',7);

//Given Data
Q1=120;//KJ
Q2=-16;//KJ
Q3=-48;//KJ
Q4=12;//KJ
W1=60000;//N-m
W2=68000;//N-m
W3=120000;//N-m
W4=44000;//N-m
Net_work=Q1+Q2+Q3+Q4;//KJ
disp(Net_work*1000,"Net Work in N-m :  ");
disp("Option (ii) is true.")
```

Scilab code Exa 2.5 Change in internal energy

```
//Exa 2.5
clc;
clear;
close;
format('v',7);

//Given Data
T1=100;//degree_centigrade
T1=T1+273;//kelvin
```

```
T2=200;//degree_centigrade
T2=T2+273;//kelvin

delQbydelT=1.005;//KJ/k
//delWbydelT=(4-0.12*T);//KJ/k
Q=integrate('1.005','T',T1,T2);
W=integrate('4-0.12*T','T',T1,T2);
U2subU1=Q-W;//change in internal energy in KJ
disp(U2subU1,"Change in internal energy in KJ : ");
```

Scilab code Exa 2.6 DeltaU DeltaPE DeltaKE

```
//Exa 2.6
clc;
clear;
close;
format('v',7);

//Given Data
m=20;//Kg
mw=200;//Kg
Z1=15;//m
Z2=0;//m
g=9.81;//gravity constant

disp("(i) Stone is about to enter the water");
deltaPE=m*g*(Z2-Z1)/1000;//KJ
Q=0;//Heat Transfer
W=0;//Work Transfer
deltaE=Q-W;//Energy Transfer
//deltaE=deltaU+deltaKE+deltaPE
deltaU=0;//no change in temperature
deltaKE= deltaE-deltaU-deltaPE;//KJ
disp(deltaU,"deltaU in KJ : ");
disp(deltaPE,"deltaPE in KJ : ");
```

```
disp(deltaKE,"deltaKE in KJ : ");
disp(Q,"Q in KJ : ");
disp(W,"W in KJ : ");

disp("(ii) Stone has come to rest near the tank.");
Q=0;//Heat Transfer
W=0;//Work Transfer
deltaE=Q-W;//Energy Transfer
deltaKE=0;//rest condition
//deltaE=deltaU+deltaKE+deltaPE
deltaU= deltaE-deltaKE-deltaPE;//KJ
disp(deltaU,"deltaU in KJ : ");
disp(deltaPE,"deltaPE in KJ : ");
disp(deltaKE,"deltaKE in KJ : ");
disp(Q,"Q in KJ : ");
disp(W,"W in KJ : ");

disp("(iii) Heat is transfered to surroundings.");
deltaKE=0;//Energy Transfered to water
deltaPE=0;
W=0;
deltaE=deltaU+deltaKE+deltaPE
Q=deltaE+W;//KJ
disp(deltaU,"deltaU in KJ : ");
disp(deltaPE,"deltaPE in KJ : ");
disp(deltaKE,"deltaKE in KJ : ");
disp(Q,"Q in KJ : ");
disp(W,"W in KJ : ");
```

Scilab code Exa 2.7 Rate of work in KW

```
//Exa 2.7
clc;
clear;
close;
```

```
format('v',7);

//Given Data
SigmaW=30;//KJ
n=10;//cycles/min
Q1_2=50;//KJ
//Q2_3=0;//KJ
//Q3_1=0;//KJ
//W1_2=0;//KJ
W2_3=30;//KJ
//W3_1=0;//KJ
deltaU1_2=20;//KJ
deltaU2_3=-10;//KJ
//deltaU3_1=0;//KJ
//Q-W=deltaU
//For Proess 1-2 :
W1_2=Q1_2-deltaU1_2;//KJ
disp(W1_2,"W1-2 in KJ : ");
//For Proess 2-3
Q2_3=W2_3+deltaU2_3;//KJ
disp(Q2_3,"Q2-3 in KJ :  ");
//For Proess 3-1
W3_1=SigmaW-W1_2-W2_3;//KJ
disp(W3_1,"W3-1 in KJ : ");
SigmaQ=SigmaW;//KJ
Q3_1=SigmaQ-Q1_2-Q2_3;//KJ
disp(Q3_1,"Q3-1 in KJ : ");
deltaU3_1=Q3_1-W3_1;//KJ
disp(deltaU3_1,"U1-U3 or deltaU3-1 in KJ : ");
RateOfWork=SigmaW*n;//KJ/min
RateOfWork=RateOfWork/60;//KJ/sec or KW
disp(RateOfWork,"Rate of work in KW : ");
```

Scilab code Exa 2.8 Change in internal energy

```
//Exa 2.8
clc;
clear;
close;
format('v',9);

//Given Data :
m=50;//Kg
C1=10;//m/s
C2=30;//m/s
Z2subZ1=40;//m
Q=30000;//J
W1=-4500;//J
W2=0.002;//KWh
g=9.81;//gravity constant
W2=W2*3600*1000;//J
//sigmaQ-sigmaW=E2-E1=(U2-U1)+(C2^2-C1^2)/2+g*(Z2-Z1
   )
U2subU1=Q-(W1+W2)-(C2^2-C1^2)/2-g*(Z2subZ1);//J
disp(U2subU1,"Change in Internal energy in J : ");
```

Scilab code Exa 2.9 Net heat transfer

```
//Exa 2.9
clc;
clear;
close;
format('v',7);

//Given Data
deltaU=-4000;//KJ
W=-1.2;//KWh
W=W*3600;//KJ
Q=W+deltaU;//KJ/hr
disp(Q,"Net heat transfer in KJ/hr : ");
```

Scilab code Exa 2.10 Change in internal energy

```
//Exa 2.10
clc;
clear;
close;
format('v',6);

//Given Data
mw=100;//Kg
T=30;//min
T=T*60;//sec
P=1;//KW
Q=-50;//KJ
Sw=4.19;//KJ/KgK(Specific heat of water)
W=-P*T;//KJ
//Q=W+deltaU
deltaU=Q-W;//KJ
disp(deltaU,"Chnge in internal energy in  kJ : ");
delta_t=deltaU/mw/Sw;//sec
disp(delta_t,"Rise in temperature in degree C : ");
```

Scilab code Exa 2.11 Heat transfer across the system

```
//Exa 2.11
clc;
clear;
close;
format('v',6);

//Given Data
```

```
V=12;//Volt
I=6;//Ampere
t=1.5;//hr
t=t*3600;//sec
deltaU=-750;//KJ
W=V*I*t/1000;//KJ
Q=W+deltaU;//KJ
disp(Q,"Heat transfer in KJ  : ");
```

Scilab code Exa 2.12 Final temperature of gas

```
//Exa 2.12
clc;
clear;
close;
format('v',6);

//Given Data
Q=82;//KJ
p1=4;//bar
m=1;//Kg
V1=0.21;//m^3
T2=127;//degree Centigrade
R=300;//Nm/KgK
W=0;//because V is constant.
disp(W,"Work done in KJ : ");
//Q-W=deltaU
deltaU=Q-W;//KJ
disp(deltaU,"Change in internal energy in KJ  : ");
//p1*V1=m*R*T1
T1=p1*10^5*V1/m/R;//kelvin
T1=T1-273;//degree centigrade
delta_t=T2-T1;//degree centigrade
Cv=deltaU/delta_t;//KJ/KgK
disp(Cv,"Specific Heat in KJ/KgK  : ");
```

Scilab code Exa 2.13 Mass of oxygen used

```
//Exa 2.13
clc;
clear;
close;
format('v',7);

//Given Data :
V1=250;//litres
V2=250;//litres
p1=3;//Mpa
t1=20;//degree_centigrade
p2=1.8;//Mpa
t2=16;//degree_centigrade
Gamma=1.4;//
rho=1.43;//Kg/m^3
p=0.1013;//Mpa

V1=V1/1000;//m^3
V2=V2/1000;//m^3
T1=t1+273;//Kelvin
T2=t2+273;//Kelvin
//p=rho*R*T
T=0+273;//Kelvin
R=p*10^6/rho/T;//Nm/KgK
//p*V=m*R*T
m1=p1*10^6*V1/R/T1;//Kg
m2=p2*10^6*V2/R/T2;//Kg
Mass_oxygen=m1-m2;//Kg
disp(Mass_oxygen,"Mass of oxygen used in Kg : ");
//Cv*(Gamma-1)=R
Cv=R/(Gamma-1);//Nm/KgK
Q=m2*Cv*(t1-t2);//J
```

```
disp(Q,"Heat transfered in J : ");
```

Scilab code Exa 2.14 Specific heat gas constant and density

```
//Exa 2.14
clc;
clear;
close;
format('v',7);

//Given Data :
m=50/1000;//Kg
t1=14;//degree_centigrade
t2=74;//degree_centigrade
t_heating=300;//sec
Pheater=10.04;//Watts
Gamma=1.4;


Q=Pheater*t_heating;//J
//Q=m*Cp*(t2-t1)
Cp=Q/m/(t2-t1);//J/KgK
disp(Cp,"Specific heat of air in J/KgK : ");
//Cp*(1-1/Gamma)=R
R=Cp*(1-1/Gamma);//Gas Constant in Nm/KgK
disp(R,"Gas constant of air in Nm/KgK : ");
//p=rho*R*T
p=0.1;//Mpa
T=0+273;//kelvin
rho=p*10^6/R/T;//Kg/m^3
disp(rho,"Density of air in Kg/m^3 : ");
```

Scilab code Exa 2.15 Heat added Work done temperature

```
//Exa 2.15
clc;
clear;
close;
format('v',7);

//Given Data :
m=1;//Kg
V1=0.3;//m^3
p=3.2*100;//Kpa
p1=3.2*100;//Kpa
p2=3.2*100;//Kpa
V2=2*V1;//m^3
Cp=1.003;//KJ/KgK
R=0.2927;//KJ/kgK
//p*V=m*R*T
T1=p1*V1/m/R;//kelvin
T2=p2*V2/m/R;//kelvin
Q=m*Cp*(T2-T1);//KJ
disp(Q,"Heat Added in KJ : ");
W=p*(V2-V1);//KJ
disp(W,"Work done in KJ : ");
disp(round(T1),"Initial temperature of air in kelvin
    : ");
disp(round(T2),"Final temperature of air in kelvin :
    ");
```

Scilab code Exa 2.16 Heat Work Energy Enthalpy

```
//Exa 2.16
clc;
clear;
close;
format('v',7);

```

```
//Given Data :
p=105;//Kpa
p1=105;//Kpa
p2=105;//Kpa
V1=0.25;//m^3
V2=0.45;//m^3
T1=10+273;//kelvin
T2=240+273;//kelvin

Q=integrate('0.4+18/(T+40)','T',T1,T2);//KJ
disp(Q,"Heat Transfer in KJ : ");
W=p*(V2-V1);//KJ
disp(W,"Work Transfer in KJ : ");
deltaU=Q-W;//KJ
disp(deltaU,"Change in internal energy in KJ L ; ");
deltaH=Q;//KJ
disp(deltaH,"Change in enthalpy in KJ :");
```

Scilab code Exa 2.17 Find the distance

```
//Exa 2.17
clc;
clear;
close;
format('v',6);

//Given Data :
N=250;//rpm
tau=10;//min
Q1=-5;//KJ
deltaU=2;//KJ
p=1.2;//bar
p=p*100;//KJ
E=24;//volt
I=0.45;//Ampere
```

```
A=0.1;//m^2
T=0.5;//Nm
Q2=E*I*tau*60/1000;//KJ
Q=Q1+Q2;//KJ
//Consider piston moves through a distance y
//Q-(W1+W2)=deltaU where W1=p*A*y
W2=-T*2*%pi*N*tau;//Nm
W2=W2/1000;//KJ
y=(Q-W2-deltaU)/A/p;//meter
disp(y*100,"Distance in cm : ");
//Ans is wrong in the book.
```

Scilab code Exa 2.18 Heat transfer and workdone

```
//Exa 2.18
clc;
clear;
close;
format('v',8);

//Given Data :
m=0.8;//Kg
p1=1;//bar
p2=5;//bar
T1=25+273;//kelvin
R=287;//KJ/kgK

W=m*R*T1*log(p1/p2);//J
disp(W/1000,"Work done in KJ : ");
U2subU1=0;//change in internal energy
Q=W+U2subU1;//J
disp(Q/1000,"Heat Transfer in KJ : ");
```

Scilab code Exa 2.19 Net workdone

```
//Exa 2.19
clc;
clear;
close;
format('v',8);

//Given Data :
m=1;//Kg
p1=100;//Kpa
T1=300;//kelvin
V_ratio=1/2;//V2/V1
T=1;//Nm
tau=1;//hr
tau=tau*60;//min
N=400;//rpm
R=0.287;//KJ/kgK

W1=m*R*T1*log(V_ratio);//KJ
W2=-T*2*%pi*N*tau/1000;//KJ
W=W1+W2;//KJ
disp(W,"Net work transfer in KJ : ");
```

Scilab code Exa 2.20 Find specific heat

```
//Exa 2.20
clc;
clear;
close;
format('v',8);

//Given Data :
m=2;//Kg
T1=125+273;//kelvin
```

```
T2=30+273;//kelvin
W=152;//KJ
deltaH=-212.8;//KJ
Q=0;//KJ(For adiabatic process)
//Q=W+m*Cv*(T2-T!)
Cv=(Q-W)/m/(T2-T1);//KJ/KgK
disp(Cv,"Specific heat at constant volume in KJ/KgK : ");
//deltaH=m*Cp*(T2-T1);
Cp=deltaH/m/(T2-T1);//KJ/KgK
disp(Cp,"Specific heat at cinstant pressure in KJ/KgK : ");
R=Cp-Cv;//KJ/KgK
disp(R,"Characteristic gas constyant in KJ/KgK : ");
```

Scilab code Exa 2.21 Mass Index Workdone Heat

```
//Exa 2.21
clc;
clear;
close;
format('v',7);

//Given Data :
V1=0.5;//m^3
p1=1.5;//bar
T1=100+273;//kelvin
V2=0.125;//m^3
p2=9;//bar
R=287;//KJ/KgK

m=p1*10^5*V1/R/T1;//Kg
disp(m,"Mass of air in Kg : ");
//p1*V1^n=p2*V2^n
n=log(p2/p1)/log(V1/V2);//
```

```
disp(n,"Value of index : ");
W=(p1*V1-p2*V2)*10^5/(n-1);//Nm
disp(W/1000,"Work done in KJ : ");
```

Scilab code Exa 2.22 Workdone and final pressure

```
//Exa 2.22
clc;
clear;
close;
format('v',7);

//Given Data :
p1=1;//bar
V1=0.14;//m^3
V2=0.07;//m^3
R=287;//KJ/KgK

//p*V=R*k1*V^(-2/5) or p*V^(7/5)=K
K=p1*10^5*V1^(7/5);//Nm/Kg
W=integrate('K*V^(-7/5)','V',V1,V2);//Nm
disp(W,"Work done in Nm : ");
p2=K*V2^(-7/5);//N/m^2
p2=p2/10^5;//bar
disp(p2,"Final pressure in bar : ");
//Ans in the book is wrong.
```

Scilab code Exa 2.23 Work transfer and change in energy

```
//Exa 2.23
clc;
clear;
close;
```

```
format('v',7);

//Given Data :
m=2;//Kg
Q=0;//KJ(because of adiabatic process)
p1=1;//Mpa
p1=p1*10^6/1000;//Kpa
t1=200;//degree centigrade
T1=t1+273;//kelvin
p2=100;//Kpa
n=1.2;
R=0.196;//KJ/KgK

T2=T1*(p2/p1)^((n-1)/n);//kelvin
t2=T2-273;//degree centigrade
u1=196+0.718*t1;//KJ
u2=196+0.718*t2;//KJ
deltau=u2-u1;//KJ
deltaU=m*deltau;//KJ
disp(deltaU,"Change in internal energy in KJ : ");
W=Q-deltaU;//KJ
disp(W,"Work transfer in KJ : ");
W1=m*R*(T1-T2)/(n-1);//KJ
disp(W1,"Displacement work in KJ : ");
```

Scilab code Exa 2.24 Work done in expansion

```
//Exa 2.24
clc;
clear;
close;
format('v',7);

//Given Data :
m=1.5;//Kg
```

```
V1=0.06;//m^3
p1=5.6*10;//Kpa
t2=240;//degree centigrade
T2=t2+273;//kelvin
a=0.946;
b=0.662;
K=10^-4;

//p*V=m*R*T=m*(a-b)*T
T1=p1*10^5*V1/m/(a-b)/1000;//Kelvin
U2subU1=integrate('m*(b+K*T)','T',T1,T2);//KJ
Q=0;//isentropic process
W=Q-U2subU1;//KJ
disp(W,"Work done in KJ : ");
//Answer in the book is wrong.
```

Scilab code Exa 2.25 heat transfer and maximum internal energy

```
//Exa 2.25
clc;
clear;
close;
format('v',7);

//Given Data :
m=1.5;//Kg
p1=1000;//Kpa
p2=200;//Kpa
V1=0.2;//m^3
V2=1.2;//m^3
//p=a+b*v
//solving for a and b by matrix
A=[1 V1;1 V2];
B=[p1;p2];
X=A^-1*B;
```

```
a=X(1);
b=X(2);
W=integrate('a+b*V','V',V1,V2);//KJ/Kg
disp(W,"Work transfer in KJ/Kg : ");
u2SUBu1=(1.5*p2*V2+35)-(1.5*p1*V1+35);//KJ/Kg
disp(u2SUBu1,"Change in internal energy in KJ/Kg : "
   );
q=W+u2SUBu1;//KJ/Kg
disp(q,"Heat transfer in KJ/Kg : ");
//u=1.5*(a+b*V)*V+35;
//1.5*a+2*V*1.5*b=0;//for max value putting du/dV=0
V=-1.5*a/2/1.5/b;//m^3/Kg
p=a+b*V;//KPa
u_max=1.5*p*V+35;//KJ/Kg
disp(u_max,"Maximum internal energy in KJ/Kg : ");
//Answer in the book is wrong because a is 1160
   instead of 1260.
```

Scilab code Exa 2.26 Net work done

```
//Exa 2.26
clc;
clear;
close;
format('v',7);

//Given Data :
V1=5;//m^3
p1=2;//bar
t1=27;//degree centigrade
T1=t1+273;//kelvin
p2=6;//bar
p3=p1;//bar
R=287;//KJ/KgK
n=1.3;
```

```
//p*V^(1/3)=C
V2=V1*(p1/p2)^(1/1.3);//m^3
//p*V=m*R*T1
m=p1*10^5*V1/R/T1;//Kg
W1_2=10^5*(p1*V1-p2*V2)/(n-1);//Nm
W1_2=W1_2/1000;//KJ
Gamma=1.4;//for air
//p*V^Gamma=C
V3=(p2/p3)^(1/Gamma)*V2;//m^3
W2_3=10^5*(p2*V2-p3*V3)/(Gamma-1);//Nm
W2_3=W2_3/1000;//KJ
W=W1_2+W2_3;//KJ
disp(W,"Net work done in KJ : ");
```

Scilab code Exa 2.27 Amount of work

```
//Exa 2.27
clc;
clear;
close;
format('v',8);

//Given Data :
Q1_2=85;//KJ
Q2_3=-90;//KJ
W2_3=-20;//KJ

Q3_1=0;//Adiabatic process
W1_2=0;//constant volume process
//integrate(dQ)=integrate(dW)
W3_1=Q1_2+Q2_3+Q3_1-W1_2-W2_3;//KJ
disp(W3_1,"Direction is 3-1 and work in KJ : ");
```

Scilab code Exa 2.28 Work done and index

```
//Exa 2.28
clc;
clear;
close;
format('v',5);

//Given Data :
V1=200/1000;//m^3
p1=4;//bar
T1=400;//K
p2=1;//bar
H3subH2=72;//KJ
Cp=1;//KJ/KgK
Cv=0.714;//KJ/KgK

Gamma=Cp/Cv;
R=Cp-Cv;//KJ/KgK
//p*V=m*R*T
m=p1*10^5*V1/R/1000/T1;//Kg
T2=T1*(p2/p1)^((Gamma-1)/Gamma);//K
V2=p1*V1/T1*T2/p2;//m^3
W1_2=m*R*(T1-T2)/(Gamma-1);//KJ
disp(W1_2,"Work done W1-2 in KJ : ");
//H3subH2=m*Cp(T3-T2);
T3=(H3subH2+m*Cp*T2)/m/Cp;//K
W2_3=m*R*(T3-T2);//KJ
W=W1_2+W2_3;//KJ
disp(W,"Workdone in KJ : ");
//W=m*R*(T1-T3)/(n-1)
n=m*R*(T1-T3)/W+1;//
disp(n,"Index of expansion : ");
```

Scilab code Exa 2.29.a Q DeltaU and W

```
//Exa 2.29A
clc;
clear;
close;
format('v',9);

//Given Data :
m=5;//Kg
//u=3.62*p*v

p1=550;//KPa
p2=125;//KPa
V1=0.25;//m^3
//p*V^(1/2)=C
n=1.2;
V2=(p1/p2)^(1/n)*V1;//m^3/Kg
W=(p1*V1-p2*V2)*10^5/(n-1)/1000;//KJ
delta_u=(3.62*p2*V2)-(3.62*p1*V1);//KJ/Kg
deltaU=m*delta_u;//KJ
disp(deltaU,"Change in internal energy in KJ : ");
Q=W+deltaU;//KJ
Q=Q/1000;//MJ
disp(Q,"Heat transfer in MJ : ");
```

Scilab code Exa 2.29 Max Temperature Work done heat transfer

```
//Exa 2.29
clc;
clear;
close;
```

```
format('v',9);

//Given Data :
p1=10;//bar
p2=2;//bar
V1=0.1;//m^3
V2=0.9;//m^3
R=300;//Nm/Kg-K
m=1;//Kg
//p=a*v+b
//solving for a and b by matrix
A=[V1 1;V2 1];
B=[p1;p2];
X=A^-1*B;
a=X(1);
b=X(2);
//p=a*v+b=a*R*T/p+b
//2*p-b=0;//on differentiating
p=b/2;//bar
//p=a*v+b
v=(p-b)/a;//m^3/Kg
T=p*10^5*v/R;//K
disp(T,"Maximum temperature in K : ");
W=integrate('(a*v+b)*10^5','v',V1,V2);//Nm/Kg
W=W/10^3;//KJ/KgK
disp(W,"Work done in KJ : ");
T1=p1*10^5*V1/R;//K
T2=p2*10^5*V2/R;//K
Gamma=1.4;
Cv=R/(Gamma-1);//Nm/KgK
Cv=Cv/1000;//KJ/KgK
deltaU=m*Cv*(T2-T1);//KJ/Kg
Q=W+deltaU;//KJ
disp(-Q,"Net Heat transfer in KJ ; ");
```

Scilab code Exa 2.30 Density and mass flow rate

```
//Exa 2.30
clc;
clear;
close;
format('v',6);

//Given Data :
Vdot=0.032;//m^3/s
d=1.5;//m
L=4.2;//m
m=3500;//Kg
V=%pi/4*d^2*L;//m^3
rho=m/V;//Kg/m^3
disp(rho,"Density of liquid in Kg/m^3 : ");
m_dot=rho*Vdot;//Kg/s
disp(m_dot,"Mass flow rate in Kg/s : ");
```

Scilab code Exa 2.31 Workdone heat transfer and internal energy

```
//Exa 2.31
clc;
clear;
close;
format('v',8);

//Given Data :
p1=1;//bar
T1=20+273;//K
p2=6;//bar
m=1;//Kg
R=287;//Nm/Kg
Gamma=1.4;
Cp=1.005;//KJ/KgK
```

```
Cv=0.7175;//KJ/KgK
//T2=T1 : Isothermal compression
T2subT1=0;
deltaU=m*Cv*(T2subT1);//KJ
disp("Isothermal :");
disp(deltaU,"Change in internal energy in KJ : ");
Wsf=m*R/1000*T1*log(p1/p2);//KJ/Kg
disp(Wsf,"Work done in KJ/Kg : ");
p2V2subp1V1=0;//isothermal process
Q=Wsf+deltaU+p2V2subp1V1;//KJ/Kg
disp(Q,"Heat transfer in KJ/Kg : ");
disp("Isentropic :");
T2=T1*(p2/p1)^((Gamma-1)/Gamma);//K
U2subU1=m*Cv*(T2-T1);//KJ/Kg
disp(U2subU1,"Change in internal energy in KJ/Kg : "
   );
H2subH1=m*Cp*(T2-T1);//KJ/Kg
disp(H2subH1,"Change in heat in KJ/Kg : ");
Q=0;//adiabatic process
disp(Q,"Heat transfer in KJ/Kg : ");
Wsf=Q-H2subH1;//KJ/Kg
disp(Wsf,"Work done in KJ/Kg : ");
disp("Polytropic : ");
n=1.25;//index
T2=T1*(p2/p1)^((n-1)/n);//K
deltaU=m*Cv*(T2-T1);//KJ/Kg
disp(deltaU,"Change in internal energy in KJ/Kg : ")
   ;
H2subH1=m*Cp*(T2-T1);//KJ/Kg
Wsf=(n/(n-1))*m*R/1000*(T1-T2);//KJ/Kg
disp(Wsf,"Work done in KJ/Kg : ");
Q=Wsf+H2subH1;//KJ/Kg
disp(Q,"Heat transfer in KJ/Kg : ");
//Answer of chane in internal energy for last part
   is wrong in the book.
```

Scilab code Exa 2.32 Calculate power required

```
//Exa 2.32
clc;
clear;
close;
format('v',6);

//Given Data :
p1=5;//bar
p2=50;//bar
V=0.001;//m^3/Kg
m_dot=10;//Kg/s
wsf=integrate('-V',"p",p1*10^5,p2*10^5);//J/kg
wsf=wsf/1000;//KJ/Kg
Wsf=abs(wsf)*m_dot;//KW(leaving -ve sign as it is to
    indiacte heat is supplied)
disp(Wsf,"Power required in KW : ");
```

Scilab code Exa 2.33 Work done Internal energy heat transfer

```
//Exa 2.33
clc;
clear;
close;
format('v',7);

//Given Data :
p1=10^5;//Pa
p2=5*10^5;//Pa
T1=25+273;//K
V1=1.8;//m^3/Kg
```

```
V2=p1/p2*V1;//m^3/Kg
W=-p1*V1*log(p2/p1);//J/kg
W=W/1000;//KJ/Kg
disp(W,"Workdone in KJ : ");
deltaU=0;//As in a isothermal process T2-T1 =0
disp(deltaU,"Change in internal energy in KJ : ");
Q=-W;//KJ/Kg(As in a isothermal process T2-T1 =0 )
disp(Q,"Heat Transfered in KJ/Kg : ");
```

Scilab code Exa 2.34 Temperature of air

```
//Exa 2.34
clc;
clear;
close;
format('v',7);

//Given Data :
p=6;//bar
m=18;//Kg
v=260;//m/s
rho=4;//Kg/m^3
Q=42;//KJ/Kg
W=261;//KW
Cv=0.715;//KJ/KgK
pA=1;//bar
vA=60;//m/s
mdotA=14;//Kg/s
CvA=0.835;//m^3/Kg
TA=115+273;//K
pB=5.5;//bar
vB=15;//m/s
mdotB=4;//Kg/s
CvB=0.46;//m^3/Kg
TB=600+273;//K
```

```
v1=1/rho;//m^3/Kg
//m*(Cv*T+p*10^5*v1/1000+v^2/2000)+Q*rho-W=mdotA*(Cv*TA+pA*10^5*CvA/1000+vA^2/2000)+m_dotB*(Cv*TB+pB*10^5*CvB/1000+vB^2/2000);
T=(((mdotA*(Cv*TA+pA*10^5*CvA/1000+vA^2/2000)+mdotB*(Cv*TB+pB*10^5*CvB/1000+vB^2/2000))+W-Q*rho)/m-v^2/2000-p*10^5*v1/1000)/Cv;//K
disp(T,"Temperature of air at inlet in K : ");
//Answer in the book is wrong.
```

Scilab code Exa 2.35 Velocity Mass flow rate Diameter

```
//Exa 2.35
clc;
clear;
close;
format('v',7);

//Given Data :
h1=3000;//KJ/Kg
C1=60;//m/s
h2=2762;//KJ/Kg
Q=0;//KJ
m=1;//Kg
W=0;//in case of nozzle
//Q-W=m*[(h2-h1)+(C2^2-C1^2)/2/1000+g*(Z2-Z1)/1000]
Z2subZ1=0;//as Z1=Z2 for horizontal nozzle
C2=sqrt(-(h2-h1)*2*1000+C1^2);//m/s
disp(C2,"Velocity at exit of nozzle in m/s : ");
A1=0.1;//m^3
v1=0.187;//m^3/Kg
mdot=A1*C1/v1;//Kg/s
disp(mdot,"Mass flow rate through the nozzle in Kg/s : ");
v2=0.498;//m^3/Kg
```

```
//mdot=A2*C2/v2=%pi/4*d^2*C2/v2
d2=sqrt(mdot/%pi*4*v2/C2);//m
disp(d2,"Diameter of nozzle at exit in meter : ");
```

Scilab code Exa 2.36 Heat transfered per Kg of air

```
//Exa 2.36
clc;
clear;
close;
format('v',6);

//Given Data :
p1=4;//bar
p2=1;//bar
T1=40+273;//K
T2=2.5+273;//K
C1=40;//m/s
C2=200;//m/s
W=52;//KJKg
m=1;//Kg
Cp=1.005;//KJ/KgK
Z2subZ1=0;//as Z1=Z2
Q=W+m*[Cp*(T2-T1)+(C2^2-C1^2)/2/1000];//KJ/Kg
disp(Q,"Heat transfered per Kg of air in KJ/Kg : ");
```

Scilab code Exa 2.37 Enthalpy of second exit stream

```
//Exa 2.37
clc;
clear;
close;
format('v',8);
```

```

//Given Data :
m1dot=0.01;//Kg/s
h1=2950;//KJ/Kg
C1=20;//m/s
m2dot=0.1;//Kg/s
h2=2565;//KJ/Kg
C2=120;//m/s
m3dot=0.001;//Kg/s
h3=421;//KJ/Kg
C3=0;//m/s
C4=0;//m/s
Wsf_dot=25;//KW
Qdot=0;//KJ
//m1dot+m2dot=m3dot+m4dot
m4dot=m1dot+m2dot-m3dot;//Kg/s
//m1dot*(h1+C1^2/2/1000)+m2dot*(h2+C2^2/2/1000)=
    m3dot*(h3+C3^2/2/1000)+m4dot*(h4+C4^2/2/1000)+
    Wsf_dot
h4=(m1dot*(h1+C1^2/2/1000)+m2dot*(h2+C2^2/2/1000)-
    m3dot*(h3+C3^2/2/1000)-Wsf_dot)/m4dot-C4
    ^2/2/1000;//KJ/Kg
disp(h4,"Enthalpy of 2nd exit stream in KJ/Kg : ");
```

Scilab code Exa 2.38 Change in enthalpy and rate of workdone

```
//Exa 2.38
clc;
clear;
close;
format('v',7);

//Given Data :
mdot=0.5;//kg/s
p1=1.4;//bar
```

```
rho1=2.5;//kg/m^3
u1=920;//kJ/kg
C1=200;//m/s
p2=5.6;//bar
rho2=5;//kg/m^3
u2=720;//kJ/kg
C2=180;//m/s
Qdot=-60;//kW
Z21=60;//m
g=9.81;//gravity constant
h21=u2-u1+(p2*10^5/(rho2*1000)-p1*10^5/(rho1*1000));
    //kJ/kg(change in enthalpy)
H21=mdot*h21;//kW(total change in enthalpy)
disp(H21,"Change in enthalpy, H2-H1 in kW :  ");
Wsf=Qdot-mdot*[h21+(C2^2-C1^2)/2/1000+g*(Z21)/1000];
    //kW
disp(Wsf,"Rate of workdone, Wsf in kW : ");
```

Scilab code Exa 2.39 Power required to drive the compressor

```
//Exa 2.39
clc;
clear;
close;
format('v',8);

//Given Data :
mdot=0.4;//Kg/s
C1=6;//m/s
p1=1;//bar
p1=p1*100;//KPa
V1=0.16;//m^3/Kg
u2subu1=88;//KJ/Kg
Qdot=-59;//W
Qdot=Qdot/1000;//KJ/s
```

```
W=0.059;//KJ/
Gamma=1.4;
Z2subZ1=0;
h2subh1=Gamma*u2subu1;//KJ
Wdot=Qdot-mdot*(h2subh1);//As C1=C2, C2^2-C1^2=0 &
    Z2-Zi=0
disp(Wdot,"Power in KW : ");
```

Scilab code Exa 2.40 Output of turbine

```
//Exa 2.40
clc;
clear;
close;
format('v',5);

//Given Data :
mdot=1;//Kg/s
p1=40;//bar
T1=1047+273;//K
C1=200;//m/s
C2=100;//m/s
p2=1;//bar
Qdot=0;//W
Cp=1.05;//KJ/KgK
R=300;//Nm/KgK
Gamma=1.4;
//p*v=m*R*T
v1dot=mdot*R*T1/p1/10^5;//m^3/s
v2dot=(p1/p2)^(1/Gamma)*v1dot;//m^3/s
T2=p2*v2dot/p1/v1dot*T1;//K
Wsf_dot=Qdot-mdot*[Cp*(T2-T1)+(C2^2-C1^2)/2/1000];//
    KJ/s or KW
disp(Wsf_dot,"Output of turbine in KJ/s or KW : ");
```

Scilab code Exa 2.41 Flow of work Mass flow rate

```
//Exa 2.41
clc;
clear;
close;
format('v',7);

//Given Data :
A1C1=0.7;//m^3/s
p1=85;//KPa
p2=650;//KPa
v1=0.35;//m^3/Kg
v2=0.1;//m^3/Kg
d1=10/100;//m
d2=6.25/100;//m

mdot=A1C1/v1;//Kg/s
p2v2SUBp1v1=mdot*(p2*v2-p1*v1);//KJ/s
disp(p2v2SUBp1v1,"Change in flow work in KJ/s : ");
disp(mdot,"Mass flow rate in Kg/s : ");
C1=A1C1/(%pi/4*d1^2);//m/s
A2C2=mdot*v2;//m^3/s
C2=A2C2/(%pi/4*d2^2);//m/s
C2subC1=C2-C1;//m/s
disp(C2subC1,"Velocity change in m/s : ");
```

Scilab code Exa 2.42 Power required and ratio of diameter

```
//Exa 2.42
clc;
clear;
```

```
close;
format('v',7);

//Given Data :
m=12/60;//Kg/s
C1=12;//m/s
p1=1*100;//KPa
v1=0.5;//m^3/Kg
C2=90;//m/s
p2=8*100;//KPa
v2=0.14;//m^3/Kg
deltah=150;//KJ/Kg
Qdot=-700/60;//KJ/s
//Assuming deltaPE=0=g*(Z2-Z1)
//Qdot-Wdot=mdot*(deltah+(C2^2-C1^2)/2/1000+g*(Z2-Z1
    )/1000)
Wdot=Qdot-m*(deltah+(C2^2-C1^2)/2/1000);//KW
disp(abs(Wdot),"Power required to drive the
    compressor in KW : ");
//A1C1/v1=A2C2/v2
d1BYd2=sqrt(C2/v2*v1/C1);
disp(d1BYd2,"Ratio of inlet to outlet pipe diameter
    : ");
```

Scilab code Exa 2.43 Mass flow rate and specific enthalpy

```
//Exa 2.43
clc;
clear;
close;
format('v',8);

//Given Data :
h1=160;//KJ/Kg
h2=2380;//KJ/Kg
```

```
m1dot=10; //Kg/s
m2dot=0.8; //Kg/s
Qdot=10; //KJ/s
Wdot=0; //KJ
deltaKE=0;
deltaPE=0;
m3dot=m1dot+m2dot; //Kg/s
disp(m3dot,"Mass flow of heated water in Kg/s : ");
//m1dot*h1+m2dot*h2=m3dot*h3+Qdot
h3=(m1dot*h1+m2dot*h2-Qdot)/m3dot; //KJ/Kg
disp(h3,"Specific enthalpy of heated water in KJ/Kg : ");
```

Scilab code Exa 2.44 Power required to drive the pump

```
//Exa 2.44
clc;
clear;
close;
format('v',8);

//Given Data :
v=0.001; //m^3/Kg
DisRate=10/60; //m^3/s
p1=100; //KN/m^2
p2=300; //KN/m^2
Z1=3; //m
Z2=9; //m
d1=0.25; //m
d2=0.17; //m
Qdot=0; //KJ/s(Adiabatic process)
//A1*C1=A2*C2=DisRate
C1=DisRate/(%pi/4*d1^2); //m/s
C2=DisRate/(%pi/4*d2^2); //m/s
mdot=DisRate/v; //Kg/s
```

```
g=9.81;//gravity constant
delta_u=0;
//Qdot-Wdot=mdot*(delta_u+p2*v2-p1*v1+C2^2-C1^2+g*(Z2-Z1))
Wdot=mdot*(delta_u+p2*10^3*v-p1*10^3*v+(C2^2-C1^2)/2+g*(Z2-Z1))-Qdot;//J/s
Wdot=Wdot/1000;//KJ/s or KW
disp(Wdot,"Power required to drive the pump in KW : ");
```

Scilab code Exa 2.45 Exit temperature of air

```
//Exa 2.45
clc;
clear;
close;
format('v',8);

//Given Data :
mdot=5;//Kg/s
T1=27+273;//K
//Z1=Z2
deltaPE=0;
Wdot=-100;//KW
C1=60;//m/s
C2=150;//m/s
q=-2;//KJ/Kg
Cp=1.05;//KJ/Kg
Qdot=mdot*q;//KJ/s
delta_h=Cp;//KJ/Kg
//Qdot-Wdot=mdot*(delta_h*(T2-T1)+(C2^2-C1^2)/2/1000+g*(Z2-Z1))/1000)
T2=((Qdot-Wdot)/mdot-(C2^2-C1^2)/2/1000)/delta_h+T1;//K
disp(T2,"Exit temperature in K : ");
```

Scilab code Exa 2.46 Rate of flow of water

```
//Exa 2.46
clc;
clear;
close;
format('v',7);

//Given Data :
t1=90;//degreeC
t2=30;//degreeC
modot=3;//Kg/s
//h=1.7*t+11*10^-4*t^2
h1=1.7*t1+11*10^-4*t1^2;//KJ/Kg
h2=1.7*t2+11*10^-4*t2^2;//KJ/Kg
tw1=27;//degreeC
tw2=67;//degreeC
Cp=4.2;//KJ/KgK
//h=Cp*tw;//KJ/Kg
hw1=Cp*tw1;//KJ/Kg
hw2=Cp*tw2;//KJ/Kg
//modot*(h1-h2)=mwdot*(hw2-hw1)
mwdot=modot*(h1-h2)/(hw2-hw1);//Kg/s
disp(mwdot,"Rate of flow of water in Kg/s : ");
```

Scilab code Exa 2.47 Amount of discharged air

```
//Exa 2.47
clc;
clear;
close;
```

```
format('v',6);

//Given Data :
V1=6;//m^3
p1=20*100;//Kpa
T1=37+273;//K
p2=10*100;//Kpa
V2=V1;//m^3
R=0.287;//KJ/KgK
m1=p1*V1/R/T1;//Kg
//T2=T1*(p2/p1)^((Gamma-1)/Gamma)
Gamma=1.4;
T2=T1*(p2/p1)^((Gamma-1)/Gamma);//K
m2=p2*V2/R/T2;//Kg
m=m1-m2;//mass of air discharged in Kg
disp(m,"Mass of air discharged in Kg : ");
```

Scilab code Exa 2.48 Work done by the air

```
//Exa 2.48
clc;
clear;
close;
format('v',7);

//Given Data :
V1=1.5;//m^3
V2=0;//m^3
p=1.02;//bar
W=p*10^5*integrate('1','V',V1,V2);//J
disp(W/1000,"Work done by the air in KJ : ");
```

Chapter 3

Second Law of Thermodynamics

Scilab code Exa 3.1 Determine COP

```
//Exa 3.1
clc;
clear;
close;
format('v',7);

//Given Data :
Q2=1800;//KJ/hr
Q2=Q2/3600;//KJ/sec or KW
W=0.35;//KW
COP=Q2/W;
disp(COP,"COP is : ");
```

Scilab code Exa 3.2 COP Temperature and Heat Rejected

```
//Exa 3.2
```

```
clc;
clear;
close;
format('v',7);

//Given Data :
Q2=1;//KJ/sec or KW
W=0.4;//KW
T2=-30+273;//K
COP=Q2/W;
disp(COP,"COP of refrigerator is : ");
T1=T2*(1+COP)/COP;//K
disp(T1,"Temperature at which heat is rejected in K
    : ");
Q1=Q2*(1+COP)/COP;//KW
disp(Q1,"Heat rejected per KW of cooling(KW) :  ");
```

Scilab code Exa 3.3 Power Input COP

```
//Exa 3.3
clc;
clear;
close;
format('v',6);

//Given Data :
Q2=100;//KJ/sec or KW
T2=-20+273;//K
T1=35+273;//K
COP=T2/(T1-T2);
disp(COP,"COP  is : ");
W=Q2/COP;//KW
disp(W,"Power input in KJ/s or KW : ");
COPheatpump=T1/(T1-T2);//
disp(COPheatpump,"COP as heat pump : ");
```

```
Eta_engine=(1-T2/T1)*100;
disp(Eta_engine,"Efficiency as an engine in % : ");
```

Scilab code Exa 3.4 COP and Heat transfer rate

```
//Exa 3.4
clc;
clear;
close;
format('v',6);

//Given Data :
Q2dot=12000;//KJ/hr
Wdot=0.75;//KW
Wdot=Wdot*3600;//KJ/hr
COP=Q2dot/Wdot;
disp(COP,"Coefficient of Performance is : ");
Q1dot=Q2dot+Wdot;//KJ/hr
disp(Q1dot,"Heat transfer rate in condenser in KJ/hr
    : ");
```

Scilab code Exa 3.5 Source and sink temperature

```
//Exa 3.5
clc;
clear;
close;
format('v',6);

//Given Data :
Eta1=25/100;//efficiency
deltaT=20;//degree centigrade
//T2dash=T2-20;//K
```

```
//T1dash=T1;//K
deltaEta1=30/100;
Eta_dash=30/100;//efficiency
//Eta1/Eta_dash=(1-T2dash/T1dash)/(1-T2/T1)
//T1-T2=100;
//0.75*T1-T2=0;
A=[1 -1;0.75 -1];
B=[100;0];
X=A^-1*B;
//Solution for T1 and T2 by matrix
T1=X(1);//K
T2=X(2);//K
disp(T1,"Source temperature in K : ");
disp(T2,"Sink temperature in K : ");
```

Scilab code Exa 3.6 Power required to heat pump

```
//Exa 3.6
clc;
clear;
close;
format('v',6);

//Given Data :
T1=23+273;//K
COP_HP=2.5;
HeatLost=60000;//KJ/hr
HeatGenerated=4000;//KJ/hr
Q1=HeatLost-HeatGenerated;//KJ/hr
W=Q1/COP_HP;//KJ/hr
W=W/3600;//KJ/s or KW
disp(W,"Power input in KW : ");
```

Scilab code Exa 3.7 Operation in which engine delivers more power

```
//Exa 3.7
clc;
clear;
close;
format('v',7);

//Given Data :
T1=400+273;//K
T2=20+273;//K
T3=100+273;//K
T4=T2;//K
Q1=12000;//KW
Q3=25000;//KW
Eta1=1-T2/T1;//Efficiency
W1=Eta1*Q1;//KW
disp(W1,"Power of Engine 1, W1 in KW : ");
Eta2=1-T4/T3;//Efficiency
W2=Eta2*Q3;//KW
disp(W2,"Power of Engine 2, W2 in KW : ");
disp("W1>W2, The engine 1 delivers more power.");
```

Scilab code Exa 3.8 Temperature of cold space

```
//Exa 3.8
clc;
clear;
close;
format('v',6);

//Given Data :
Wdot=200;//W
t1=40;//degree centigrade
//Q2dot=20*(t1-t2);//W
```

```
//COP=Q2dot/W2dot=T2/(T1-T2)
//(t1-t2)/(W2dot/20)=(t1+273)/(t1-t2)
//20*t1^2+20*t2^2-20*2*t1*t2-t1*Wdot-273*Wdot
//(t2+273)/(t1-t2)=(t1-t2)/(Wdot/20)
//t2^2-(2*t1+(Wdot/20))*t2 -273*(Wdot/20)+t1^2
P=[1 -(2*t1+(Wdot/20)) -273*(Wdot/20)+t1^2];
t2=roots(P);
t2=t2(2);//degree C
//Taken only -ve value as t2 cant be greater than t1
disp(t2,"Temperature of cold space(degree C)");
```

Scilab code Exa 3.10 Time required to freeze water

```
//Exa 3.10
clc;
clear;
close;
format('v',7);

//Given Data :
m=0.8;//Kg
hi=335;//KJ/Kg-water
T1=24+273;//K
T2=0+273;//K
Wdot=400;//W
Wdot=Wdot/1000;//KW
Q2=m*hi;//KJ
ActualCOP=T2/(T1-T2)*30/100;
Q2dot=ActualCOP/Wdot;//KJ/s
T=Q2/Q2dot;//sec
disp(T,"Time required to freeze the water in sec : ");
```

Scilab code Exa 3.11 Possibilty of claim

```
//Exa 3.11
clc;
clear;
close;
format('v',7);

//Given Data :
T1=727+273;//K
T2=27+273;//K
Wdot=76;//KW
FuelBurned=4;//Kg/hr
FuelBurned=4/3600;//Kg/sec
FuelHeatingValue=75000;//KJ/Kg
Q1dot=FuelBurned*FuelHeatingValue;//KJ/s or KW
Eta=Wdot/Q1dot*100;//%
disp(Eta,"Actual Efficiency of Engine in % : ");
Eta_c=(1-T2/T1)*100;//%
disp(Eta_c,"Carnot Efficiency of Engine in % : ");
disp("Claim of inventor is wrong as actual
    efficiency is greater than carnot efficiency.");
```

Scilab code Exa 3.12 Power required to run the heat pump

```
//Exa 3.12
clc;
clear;
close;
format('v',5);

//Given Data :
T1=24+273;//K
T2=10+273;//K
Q1=1500;//kJ/min
```

```
Q1=Q1/60;//kW
COP_ideal=T1/(T1-T2);
ActualCOP=COP_ideal*30/100;
W=Q1/ActualCOP;//kW
disp(W,"Power required in kW : ");
//Answer is wromg in the book as calculation for Q1
    is wrong.
```

Scilab code Exa 3.13 Patent of engine

```
//Exa 3.13
clc;
clear;
close;
format('v',5);

//Given Data :
T1=450;//K
T2=280;//K
Q1=1200;//KJ
W=0.15;//KWh
W=W*3600;//KJ
Eta_a=W/Q1*100;//%
disp(Eta_a,"Actual Efficiency of Engine in % : ");
Eta_c=(1-T2/T1)*100;//%
disp(Eta_c,"Carnot Efficiency of Engine in % : ");
disp("We would not issue a patent as actual
    efficiency is greater than carnot efficiency.");
```

Scilab code Exa 3.14 Heat rejected Work done and Efficiency

```
//Exa 3.14
clc;
```

```
clear;
close;
format('v',7);

//Given Data :
T1=1000;//K
T3=100;//K
Q1=1680;//KJ
//Eta_a=Eta_b : 1-T2/T1=1-T3/T2
T2=sqrt(T1*T3);//K
Eta_a=1-T2/T1;
Eta_b=Eta_a;
W1=Eta_a*Q1;//KJ
Q2=Q1-W1;//KJ
Q3=(1-Eta_b)*Q2;//KJ
disp(Q3,"Heat rejected by engine B in KJ : ");
disp(T2,"Temperature at which heat is rejected by engine A in K :  ");
disp(W1,"Workdone by engine A in KJ ; ");
W2=Eta_b*Q2;//KJ
disp(W2,"Workdone by engine B in KJ ; ");
//If W1=W2
//Q/T=constant
T2=(T1+T3)/2;//K
Eta_a=(1-T2/T1)*100;//%
Eta_b=(1-T3/T2)*100;//%
disp("If Engine A & B deliver equal work.")
disp(Eta_a,"Efficiency of Engine A in % : ");
disp(Eta_b,"Efficiency of Engine B in % : ");
```

Scilab code Exa 3.15 Heat absorbed by the refrigerant

```
//Exa 3.15
clc;
clear;
```

```
close;
format('v',8);

//Given Data :
T1=800+273;//K
T2=30+273;//K
T3=30+273;//K
T4=-15+273;//K
Q1=1900;//KJ
W2=290;//KJ
//Eta=1-T2/T1=W1/Q1
W1=(1-T2/T1)*Q1;//KJ
Q2=Q1-W1;//KJ
W3=W1-W2;//KJ
//COP=T4/(T3-T4)=Q4/W3
Q4=T4/(T3-T4)*W3;//KJ
disp(Q4,"Heat absorbed by refrigerant in KJ : ");
Q3=W3+Q4;//KJ
TotalHeat=Q2+Q3;//KJ
disp(TotalHeat,"Total Heat transferred to reservoir
    at 30 degree centigrade in KJ : ");
```

Scilab code Exa 3.16 Rate of heat supply and heat rejection

```
//Exa 3.16
clc;
clear;
close;
format('v',6);

//Given Data :
T1=840+273;//K
T2=60+273;//K
T3=5+273;//K
W3=30;//KW
```

```
Q3=17;//KJ/s
//Q3/T3=Q4/T4
T4=T2;//K
Q4=Q3/T3*T4;//KJ/s
W2=Q4-Q3;//KJ/s
W1=W2+W3;//KJ/s
Q1subQ2=W1;//KJ/s
//Q1/T1=Q2/T2
Q1ByQ2=T1/T2;
//Q1subQ2=Q1subQ2*Q2-Q2
Q2=Q1subQ2/(Q1ByQ2-1);//KW
Q1=Q1ByQ2*Q2;//KW
disp(Q1,"Rate of heat supply from 800 degree C
   source in KW : ");
disp(Q2+Q4,"Rate of heat rejection to sink in KW : "
   );
```

Scilab code Exa 3.17 Inventors Claim

```
//Exa 3.17
clc;
clear;
close;
format('v',6);

//Given Data :
T1=27+273;//K
T2=-23+273;//K
W=1;//KW
Q2=20000;//KJ/hr
Q2=Q2/3600;//KJ/s
ActualCOP=Q2/W;
disp(ActualCOP,"Actual COP of machine : ");
IdealCOP=T2/(T1-T2);
disp(IdealCOP,"Ideal COP of machine : ");
```

```
disp("ActualCOP>IdealCOP, Inventor claim is wrong.")
    ;
```

Scilab code Exa 3.18 Max Power and Max Temperature

```
//Exa 3.18
clc;
clear;
close;
format('v',8);

//Given Data :
//Heat Pump in winter
Q1=2400;//KJ/hr/degree temperature difference
t1=20;//degreeC
t2=0;//degreeC
Q1=Q1*(t1-t2)/3600;//KJ/s
T1=t1+273;//K
T2=t2+273;//K
COP=T1/(T1-T2);
W=Q1/COP;//KW
disp(W,"Power required to drive heat pump in KW : ")
    ;
//Refrigerating unit in summer
T4=20+273;//K
//Q4=2400*(T3-T4)/3600;//KJ/s
Q3subQ4=W;//KJ
//COP=Q4/(Q3subQ4)=T4/(T3-T4);
//T3^2-2*T3*T4+T4^2-T4*3600/2400*(Q3subQ4)=0
P=[1 -2*T4 T4^2-T4*3600/2400*(Q3subQ4)]
T3=roots(P);
T3=T3(1);//K(Maximum outside temperature)
disp(T3,"Maximum outside temperature in K : ");
disp(T3-273,"or in degree C :");
```

Scilab code Exa 3.20 Expansion Ratio

```
//Exa 3.20
clc;
clear;
close;
format('v',5);

//Given Data :
VcByVa=14;//Overall expansion ratio
T1=257+273;//K
T2=27+273;//K
Gamma=1.4;
Ta=T1;//K
Tb=T1;//K
Tc=T2;//K
Td=T2;//K
VcByVb=(Tb/Tc)^(1/(Gamma-1));//Expansion ratio for
    Adiabatic Process :
disp(VcByVb,"Expansion ratio for adiabatic process :
    ");
VbByVa=VcByVa/VcByVb;//Expansion ratio for
    Isothermal Process :
disp(VbByVa,"Expansion ratio for Isothermal process
    : ");
Eta=(1-T2/T1)*100;//%
disp(Eta,"Thermal Efficiency of carnot cycle in % :
    ");
```

Scilab code Exa 3.21 Minimum Theoretical area

```
//Exa 3.21
```

```
clc;
clear;
close;
format('v',7);

//Given Data :
W=10;//KW
//For flat plate collector
T1=90+273;//K
T2=27+273;//K
Tmax=T1;//K
IE=1;//KW/m^2 incident energy
EtaCollection=60/100;
//Eta=1-T2/T1=W/Q1
Q1=W/(1-T2/T1);//KJ/s
A1=Q1/IE/EtaCollection;//m^2
disp(A1,"Solar Collector Area required in m^2 : ");
//For parabolic collector
T3=250+273;//K
T4=27+273;//K
Tmax=T3;//K
IE=1;//KW/m^2 incident energy
EtaCollection=50/100;
//Eta=1-T2/T1=W/Q1
Q3=W/(1-T4/T3);//KJ/s
A2=Q3/IE/EtaCollection;//m^2
disp(A2,"Parabolic Solar Collector Area required in
    m^2 : ");
//Answer of 2nd part is wrong in the book.
```

Scilab code Exa 3.24 COP and Work input

```
//Exa 3.24
clc;
clear;
```

```
close;
format('v',7);

//Given Data :
T1=40+273;//K
T2=5+273;//K
T3=400+273;//K
T4=T1;//K
Q2=1500;//KJ/min
COP_R=T2/(T1-T2);
disp(COP_R,"COP of refrigerator is : ");
Q2dot=Q2/60;//KJ/s
Wdot=Q2dot/COP_R;//KW
disp(Wdot,"Work Input to refrigerator in KW : ");
Eta=(1-T4/T3);//%
Q3dot=Wdot/Eta;//KW
OverallCOP=Q2dot/Q3dot;//
disp(OverallCOP,"Overall COP of refrigerator : ");
//Ans of overall COP is wrong in the book.
```

Scilab code Exa 3.25 Determine the COP

```
//Exa 3.25
clc;
clear;
close;
format('v',7);

//Given Data :
T1=1500;//K
T2=450;//K
T3=150;//K
Q3=250;//KJ
COP_CR=T3/(T2-T3);
disp(COP_CR,"COP of cold refrigerator is : ");
```

```
COP_HR=T2/(T1-T2);
disp(COP_HR,"COP of hotter refrigerator is : ");
COP=T3/(T1-T3);
disp(COP,"COP of composite system is : ");
```

Scilab code Exa 3.26 Heat Supplied and efficiency

```
//Exa 3.26
clc;
clear;
close;
format('v',7);

//Given Data :
T1=870;//K
T2=580;//K
T3=290;//K
Wdot=85;//KW
Q3=3000;//KJmin
Q3=Q3/60;//KJ/s
Q1plusQ2=Wdot+Q3;//KJ
//sigma(Q/T)=0
//Q1/T1+Q2/T2=Q3/T3
//Q1/T1+(Q1plusQ2-Q1)/T2-Q3/T3=0
Q1=(-Q3*T1*T2/T3+Q1plusQ2*T1)/(T1-T2);//KW
disp(Q1,"Heat Supplied by source1 in KW : ");
Q2=Q1plusQ2-Q1;//KW
disp(Q2,"Heat Supplied by source2 in KW : ");
Eta=Wdot/(Q1+Q2)*100;//%
disp(Eta,"Efficiency of engine in % :");
```

Chapter 4

Entropy

Scilab code Exa 4.1 Clausias Inequality

```
//Exa 4.1
clc;
clear;
close;
format('v',8);

//Given Data :
T1=400;//Kelvin
T2=300;//Kelvin
Q1=4800;//KJ
Q2=-4800;//KJ
//Q1/T1+Q2/T2<=0
LHS=Q1/T1+Q2/T2;//
disp(LHS,"Q1/T1+Q2/T2 = ");
disp("It is less than zero. Process is irreversible"
    )
```

Scilab code Exa 4.2 Classify the cycle

```
//Exa 4.2
clc;
clear;
close;
format('v',8);

//Given Data :
T1=290+273;//Kelvin
T2=8.5+273;//Kelvin
Q1=300;//KJ
//Case 1 :
Q2=-215;//KJ
sigmaQbyT=Q1/T1+Q2/T2
disp(sigmaQbyT,"(i) Q1/T1+Q2/T2 = ");
disp("It is less than zero. Cycle is irreversible")
//Case 2 :
Q2=-150;//KJ
sigmaQbyT=Q1/T1+Q2/T2
disp(sigmaQbyT,"(ii) Q1/T1+Q2/T2 = ");
disp("It is equal to zero. Cycle is reversible");
//Case 3 :
Q2=-75;//KJ
sigmaQbyT=Q1/T1+Q2/T2
disp(sigmaQbyT,"(iii) Q1/T1+Q2/T2 = ");
disp("It is greater than zero. Cycle is impossible."
    );
```

Scilab code Exa 4.3 Entropy Change

```
//Exa 4.3
clc;
clear;
close;
format('v',6);

```

```
//Given Data :
V1=10;//m^3
T1=175+273;//Kelvin
T2=36+273;//Kelvin
p1=5;//bar
p2=1;//bar
R=287;//KJ/KgK
Cp=1.005;//KJ/KgK
//p*V=m*R*T
m=p1*10^5*V1/R/T1;//Kg
deltaS=m*Cp*log(T2/T1)+m*R/1000*log(p1/p2);//KJ/K
disp(deltaS,"Entropy change in KJ/K : ");
```

Scilab code Exa 4.4 Efficiency and Lowest temperature

```
//Exa 4.4
clc;
clear;
close;
format('v',6);

//Given Data :
deltaS=5;//KJ/KgK
W=2000;//KJ/Kg
T1=327+273;//Kelvin
Q1=deltaS*T1;//KJ/Kg
Q2=Q1-W;//KJ/Kg
Eta=W/Q1*100;//%
disp(Eta,"Efficiency in % : ");
T2=Q2/Q1*T1;//K
disp(T2,"Lowest temperature in Kelvin : ");
```

Scilab code Exa 4.5 Change in entropy

```
//Exa 4.5
clc;
clear;
close;
format('v',8);

//Given Data :
mc=0.5;//Kg
Tc=100+273;//K
Cpc=0.393;//KJ/KgK
Tw=10+273;//K
Cpw=4.2;//KJ/KgK
Q=integrate('mc*Cpc','T',Tc,Tw);//KJ
deltaSc=integrate('mc*Cpc/T','T',Tc,Tw);//KJ/K
deltaSw=abs(Q)/Tw;//KJ/K
deltaSuniverse=deltaSc+deltaSw;//Kj/K
disp(deltaSuniverse,"Part (i) Chane in entropy in KJ
    /K : ");
T1=383;//K
T2=283;//K
T=(T1+T2)/2;//K
deltaSuniverse=mc*Cpc*[integrate('1/T','T',T1,T)+
    integrate('1/T','T',T2,T)];//KJ/K
disp(deltaSuniverse,"Part (ii) Chane in entropy in
    KJ/K : ");
```

Scilab code Exa 4.6 Change in entropy

```
//Exa 4.6
clc;
clear;
close;
format('v',7);

//Given Data :
```

```
Tc=35+273;//K
W=500;//KJ
T1=308;//K
T2=308;//K
T0=15+273;//K
Q=W;//KJ
deltaS1=0;//as heat supplied is zero
deltaS2=Q/T0;//KJ/K
disp(deltaS2,"Change in entropy in KJ/K : ");
```

Scilab code Exa 4.7 Change in entropy

```
//Exa 4.7
clc;
clear;
close;
format('v',7);

//Given Data :
mi=0.5;//Kg
Ti=-10+273;//K
Cpi=2;//KJ/KgK
Cpw=4.2;//KJ/KgK
Li=334;//KJ/Kg
mc=5;//Kg
Tc=80+273;//K
Cpc=0.5;//KJ/KgK
T0=0+273;//K
//mi*[Cpi*(T0-Ti)+Li+Cpw*(T-T0)]=mc*Cpc*(Tc-T)
T=(mc*Cpc*Tc-mi*Cpi*(T0-Ti)-mi*Li+mi*Cpw*T0)/(mi*Cpw
   +mc*Cpc);//K
deltaSi=mi*Cpi*log(T0/Ti)+Li/T0+mi*Cpw*log(T/T0);//
   KJ/K
disp(deltaSi,":Entropy chane of Ice in KJ/K : ");
deltaSc=mc*Cpc*log(T/Tc);//KJ/K
```

```
disp(deltaSc,":Entropy chane of Copper in KJ/K : ");
deltaSsurr=0;//No heat transfer between system &
   Surrounding
deltaSuniverse=deltaSi+deltaSc+deltaSsurr;//KJ/K
disp(deltaSuniverse,":Entropy chane of universe in
   KJ/K : ");
```

Scilab code Exa 4.8 Increase in entropy

```
//Exa 4.8
clc;
clear;
close;
format('v',7);

//Given Data :
m1=5;//Kg
T1=200+273;//K
Cp1=0.4;//KJ/KgK
m2=100;//Kg
T2=30+273;//K
Cp2=2.1;//KJ/KgK
//m1*Cp1*(T1-T)=m2*Cp2*(T-T2)
T=(m1*Cp1*T1+T2*m2*Cp2)/(m2*Cp2+m1*Cp1);//K
deltaS1=integrate('m1*Cp1/T','T',T1,T);//KJ/K
deltaS2=integrate('m2*Cp2/T','T',T2,T);//KJ/K
deltaSsurr=0;//No heat transfer neglected
deltaSuniverse=deltaS1+deltaS2+deltaSsurr;//KJ/K
disp(deltaSuniverse,"Increase in Entropy of universe
    in KJ/K : ");
```

Scilab code Exa 4.9 Increase of entropy

```
//Exa 4.9
clc;
clear;
close;
format('v',7);

//Given Data :
HeatTransfer=2;//KJ/degreeCentigrade(it is d'Q/dT)
T1=27+273;//K
T2=127+273;//K
deltaS=integrate('HeatTransfer/T','T',T1,T2);//KJ/K
disp(deltaS,"Entropy change when heat is transfered
   to system in KJ/K : ");
disp(deltaS,"Entropy change when end states are
   achieved by stirring action in KJ/K : ");
```

Scilab code Exa 4.11 Increase in entropy

```
//Exa 4.11
clc;
clear;
close;
format('v',7);

//Given Data :
m1=2;//Kg
T1=80+273;//K
m2=3;//Kg
T2=30+273;//K
Cp=4.187;//KJ/KgK
//m1*Cp1*(T1-T)=m2*Cp2*(T-T2)
T=(m1*Cp*T1+T2*m2*Cp)/(m2*Cp+m1*Cp);//K
deltaS=integrate('m1*Cp/T','T',T1,T)+integrate('m2*
   Cp/T','T',T2,T);//KJ/K
disp(deltaS,"Total Entropy change due to mixing
```

```
process in KJ/K : ");
```

Scilab code Exa 4.14 Change in internal energy Work done Heat transfer

```
//Exa 4.14
clc;
clear;
close;
format('v',7);

//Given Data :
V1=4;//m^3
V2=4;//m^3
m=20;//Kg
p1=4*100;//KPa
p2=8*100;//KPa
Cp=1.005;//KJ/KgK
Cv=0.718;//KJ/KgK
R=Cp-Cv;//KJ/KgK
T1=p1*V1/m/R;//K
T2=p2*V2/m/R;//K
deltaU=m*Cv*(T2-T1);//KJ
disp(deltaU,"Change in internal energy in KJ : ");
W=0;//KJ
disp(W,"Since no movement, Work done in KJ : ");
Q=W+deltaU;//KJ
disp(Q,"Heat transfered in KJ : ");
deltaS=integrate('m*Cv/T','T',T1,T2);//KJ/K
disp(deltaS,"Entropy change  in KJ/K : ");
```

Scilab code Exa 4.15 Entropy change of universe

```
//Exa 4.15
```

```
clc;
clear;
close;
format('v',9);

//Given Data :
V1=4;//m^3
V2=4;//m^3
m=600/1000;//Kg
C=150;//J/K
T1=100+273;//K
T0=8+273;//K
Cp=C/1000;//KJ/K
deltaSblock=integrate('Cp/T','T',T1,T0);//KJ/K
Q=Cp*(T1-T0);//KJ
deltaSlake=Q/T0;//KJ/K
deltaSuniverse=deltaSblock+deltaSlake;//KJ/K
disp(deltaSuniverse,"Part (i) Entropy change of
    universe in KJ/K : ");
T1=8+273;//K
Z=100;//meter
g=9.81;//gravity constant
PE=m*g*Z/1000;//KJ
deltaT=PE/Cp;//degree centigrade
T2=T1+deltaT;//K
deltaSblock=-integrate('Cp/T','T',T1,T2);//KJ/K
deltaSlake=PE/T0;//KJ/K
deltaSuniverse=deltaSblock+deltaSlake;//KJ/K
disp(deltaSuniverse,"Part (ii) Entropy change of
    universe in KJ/K : ");
```

Scilab code Exa 4.17 Final temperature Work done heat transfer

```
//Exa 4.17
clc;
```

```
clear;
close;
format('v',7);

//Given Data :
m=1;//Kg
p1=1;//bar
T1=290;//K
p2=30;//bar
T2=290;//K
n=1.3;//constant
R=300;//Nm/KgK
Cv=0.72;//KJ/KgK
disp("part (a) Isothermally")
V1=R*T1/p1/10^5;//m^3/Kg
V2=p1*V1/p2;//m^3/Kg
w=p1*10^5*V1*log(V2/V1)/1000;//KJ/Kg
disp(w,"Workdone in KJ/Kg : ");
deltaU=m*Cv*(T2-T1);//KJ(as T1=T2)
disp(deltaU,"Change in internal energy in KJ : ");
q=w+deltaU;//KJ/Kg
disp(q,"Heat transfer in KJ/Kg : ");
S2subS1=m*R/1000*log(V2/V1)+m*Cv*log(T2/T1);//KJ/KgK
disp(S2subS1,"Change in entropy in KJ/KgK : ");

disp("part (b) Polytropically")
T2=T1*(p2/p1)^((n-1)/n);//K
disp(T2,"Temperature T2 in K : ");
V1=R*T1/p1/10^5;//m^3/Kg
V2=(p1/p2)^(1/n)*V1;//m^3/Kg
w= m*R/1000*(T1-T2)/(n-1);;//KJ/Kg
disp(w,"Workdone in KJ/Kg : ");
deltaU=m*Cv*(T2-T1);//KJ(as T1=T2)
q=w+deltaU;//KJ/Kg
disp(q,"Heat transfer in KJ/Kg : ");
S2subS1=m*R/1000*log(V2/V1)+m*Cv*log(T2/T1);//KJ/KgK
disp(S2subS1,"Change in entropy in KJ/KgK : ");
```

Scilab code Exa 4.18 Index Work done Specific entropy

```
//Exa 4.18
clc;
clear;
close;
format('v',7);

//Given Data :
P1=480;//kPa
T1=190+273;//K
T3=190+273;//K
P2=94;//kPa
P3=150;//kPa
T2=T3*P2/P3;//K
R=0.29;//KJ/KgK
m=1;//Kg
Cp=1.011;//KJ/KgK
//T2/T1=(P2/P1)^((Gamma-1)/Gamma)
//((Gamma-1)/Gamma)=log(T2/T1)/log(P2/P1);//
Gamma=1.402;//by trial method
disp(Gamma,"Index of adiabatic expansion :");
Cv=R/(Gamma-1);//KJ/KgK
W1_2=m*R*(T1-T2)/(Gamma-1);//KJ/Kg
disp(W1_2,"Work done, W1-2 per Kg of air in KJ/Kg :
   ");
W2_3=0;//Constant volume process
disp(W2_3,"Work done, W2-3 per Kg of air in KJ/Kg :
   ");
W3_1=m*R*T2*log(P3/P1);//KJ/Kg
disp(W3_1,"Work done, W1-2 per Kg of air in KJ/Kg :
   ");
W=W1_2+W2_3+W3_1;//KJ/Kg
disp(W,"Total Work done in KJ/Kg : ");
```

```
S2subS1=0;//adiabatic process
S3subS2=m*R*log(P2/P3)+m*Cp*log(T3/T2);//KJ/KgK
disp(S3subS2,"Change in specific entropy, S1-2 in KJ/KgK ; ");
S1subS3=-S2subS1-S3subS2;//KJ/KgK
disp(S1subS3,"Change in specific entropy, S3-1 in KJ/KgK ; ");
```

Scilab code Exa 4.21 Entropy Change

```
//Exa 4.21
clc;
clear;
close;
format('v',7);

//Given Data :
p1=5;//bar
T1=30+273;//K
p2=4;//bar
m=1;//Kg
R=0.287;//KJ/KgK
//deltaS=m*R*log(p1/p2)+m*Cp*log(T2/T1);//KJ/kgK
deltaS=m*R*log(p1/p2);//KJ/kgK(T2/T1 leads to 2nd term zero)
disp(deltaS,"Entropy Change in KJ/KgK : ");
```

Scilab code Exa 4.22 Change in entropy

```
//Exa 4.22
clc;
clear;
close;
```

```
format('v',7);

//Given Data :
Cpg=1.05;//KJ/KgK
t1=400;//degree centigrade
t2=360;//degree centigrade
T=30+273;//K
Q=Cpg*(t1-t2);//KJ/Kg
deltaSsurr=Q/T;//KJ/KgK
deltaSsystem=integrate('Cpg/T','T',t1+273,t2+273);//
    KJ/KgK
deltaSuniverse=deltaSsystem+deltaSsurr;//KJ/KgK
disp(deltaSuniverse,"Change in entropy of the
    universe in KJ/KgK : ");
```

Chapter 5

Properties of Steam

Scilab code Exa 5.1 Available and unavailable energy

```
//Exa 5.1
clc;
clear;
close;
format('v',7);

//Given Data :
deltaQ=1000;//KJ
T=1073;//Kelvin
T0=20+273;//Kelvin
deltaS=deltaQ/T;//KJ/K
A=deltaQ-T0*deltaS;//KJ
disp(A,"Available energy in KJ : ");
UA=T0*deltaS;//KJ
disp(UA,"Unavailable energy in KJ : ");
```

Scilab code Exa 5.2 Reversible work and Irreversibility

```
//Exa 5.2
clc;
clear;
close;
format('v',6);

//Given Data :
m=2;//Kg
T1=300+273;//Kelvin
T2=150+273;//Kelvin
T0=20+273;//Kelvin
Cp=0.45;//KJ/KgK
deltaQ=m*Cp*(T1-T2);//KJ
deltaS=m*Cp*log(T1/T2);//KJ/K
A=deltaQ-T0*deltaS;//KJ
disp(A,"Reversible work or Available energy in KJ :
   ");
UA=T0*deltaS;//KJ
disp(UA,"Irreversibility in KJ : ");
//Irreversibilty is not calculated in the book and
   asked in the question.
```

Scilab code Exa 5.3 Increase in available energy

```
//Exa 5.3
clc;
clear;
close;
format('v',6);

//Given Data :
m=5;//Kg
p=1;//bar
T0=20+273;//Kelvin
T1=23+273;//Kelvin
```

```
T2=227+273;//Kelvin
Cp=1.005;//J/KgK
deltaS=Cp*log(T1/T2);//KJ/KgK
deltaQ=Cp*(T2-T1);//KJ
A=m*(deltaQ+T0*deltaS);//KJ
disp(A,"Increase in availability due to heating in
   KJ : ");
```

Scilab code Exa 5.4 Availability and unavailable energy

```
//Exa 5.4
clc;
clear;
close;
format('v',6);

//Given Data :
Q1=400;//KJ
T1=1227+273;//Kelvin
T2=27+273;//Kelvin
A=Q1-T2*Q1/T1;//KJ
disp(A,"Availability of the system in KJ : ");
UA=Q1-A;//KJ
disp(UA,"Unavailable energy in KJ : ");
```

Scilab code Exa 5.5 Motor Capability

```
//Exa 5.5
clc;
clear;
close;
format('v',6);

```

```
//Given Data :
P=1;//KW or KJ/s
Q=6;//MJ/hr
Q=Q*1000/3600;//KJ/s
T1=26+273;//Kelvin
T2=3+273;//Kelvin
COP=T1/(T1-T2);
W=Q/COP;//KJ/s or KW
disp(W,"Work required to pump heat in KJ/s or KW : "
    );
disp("As P>W, required condition can be maintained."
    )
```

Scilab code Exa 5.6 Availability of heat energy and unavailable heat

```
//Exa 5.6
clc;
clear;
close;
format('v',6);

//Given Data :
T=727+273;//Kelvin
T0=17+273;//Kelvin
deltaQ=4000;//KJ
deltaS=deltaQ/T;//KJ/K
A=deltaQ-T0*deltaS;//KJ
disp(A,"Availability of heat energy in KJ : ");
UA=T0*deltaS;//KJ
disp(UA,"Unavailable heat energy in KJ : ");
```

Scilab code Exa 5.7 Available energy added to the system

```
//Exa 5.7
clc;
clear;
close;
format('v',7);

//Given Data :
deltaQ=850;//KJ
T=180+273;//Kelvin
T0=22+273;//Kelvin
deltaS=deltaQ/T;//KJ/K
A=deltaQ-T0*deltaS;//KJ
disp(A,"Available energy in KJ : ");
```

Scilab code Exa 5.8 Available and unavailable energy

```
//Exa 5.8
clc;
clear;
close;
format('v',7);

//Given Data :
deltaQ=850;//KJ
T1=1400+273;//Kelvin
T2=250+273;//Kelvin
T0=20+273;//Kelvin
Q=-1000;//KJ
deltaS1=Q/T1;//KJ/K(-ve as heat leaving)
deltaS2=abs(Q)/T2;//KJ/K(+ve Q as steam receives
   heat)
deltaS=deltaS1+deltaS2;//KJ/K
disp("Part (i) As energy leaves the hot gases : ");
A=(T1-T0)*deltaS1;//KJ
UA=T0*deltaS1;//KJ
```

```
disp(A,"Available energy in KJ : ");
disp(UA,"Unavailable energy in KJ : ");
disp("Part (ii) As energy enters the system : ");
A=(T2-T0)*deltaS2;//KJ
UA=T0*deltaS2;//KJ
disp(A,"Available energy in KJ : ");
disp(UA,"Unavailable energy in KJ : ");
```

Scilab code Exa 5.9 Heat abstracted Availability and Loss Availability

```
//Exa 5.9
clc;
clear;
close;
format('v',8);

//Given Data :
deltaQ=850;//KJ
T1=523;//Kelvin
T2=873;//Kelvin
T0=288;//Kelvin
dQ_by_dT=100;//KJ/K
deltaS=integrate('100/T','T',T1,T2);//KJ/K
deltaQ=integrate('100','T',T1,T2);//KJ
disp(deltaQ,"Total heat abstracted in KJ : ");
A=deltaQ-T0*deltaS;//KJ
disp(A,"Availability in KJ : ");
Loss=deltaQ-A;//KJ
disp(Loss,"Loss of availability in KJ : ");
```

Scilab code Exa 5.10 Availability of products

```
//Exa 5.10
```

```
clc;
clear;
close;
format('v',8);

//Given Data :
p0=1;//bar
T0=17+273;//Kelvin
T1=1817+273;//Kelvin
Cp=1;//KJ/KgK
deltaQ=Cp*(T1-T0);//KJ/Kg
deltaS=Cp*log(T0/T1);//KJ/KgK
deltaS_fluid=-deltaS;//KJ/KgK(As deltaS_surrounding
    =0)
A=deltaQ-T0*deltaS_fluid;//KJ
disp(A,"Availability of hot products in KJ : ");
```

Scilab code Exa 5.11 Change in entropy

```
//Exa 5.11
clc;
clear;
close;
format('v',8);

//Given Data :
T1=1200;//Kelvin
T2=400;//Kelvin
T0=300;//Kelvin
Qsource=-150;//KJ/s
Qsystem=150;//KJ/s
deltaS_source=Qsource/T1;//KJ/sK
deltaS_system=Qsystem/T2;//KJ/sK
deltaS_net=deltaS_source+deltaS_system;//KJ/sK
disp(deltaS_net,"Net change in entropy in KJ/sK : ")
```

```
    ;
A1=(T1-T0)*-deltaS_source;//KJ/s
disp(A1,"Available energy of heat source in KJ/s : "
    );
A2=(T2-T0)*deltaS_system;//KJ/s
disp(A2,"Available energy of system in KJ/s : ");
E_decrease=A1-A2;//KJ/s
disp(E_decrease,"Decrease in available energy in KJ/
    s : ");
```

Scilab code Exa 5.12 Mass flow rate and other parameters

```
//Exa 5.12
clc;
clear;
close;
format('v',7);

//Given Data :
Tg1=1127+273;//Kelvin
Tg2=527+273;//Kelvin
T2=250+273;//Kelvin
T0=27+273;//Kelvin
Cpg=1;//KJ/KgK
mw=5;//Kg/s
hfg=1716.2;//KJ/Kg
//mg*Cpg*(Tg1-Tg2)=mw*hfg
mg=mw*hfg/Cpg/(Tg1-Tg2);//Kg/s
disp(mg,"Mass flow rate of gases in Kg/s : ");
deltaSg=mg*Cpg*log(Tg2/Tg1);//KJ/sK
disp(deltaSg,"Entropy change of gases in KJ/sK : ");
deltaSw=mw*hfg/T2;//KJ/sK
disp(deltaSw,"Entropy change of water in KJ/sK : ");
deltaSnet=deltaSg+deltaSw;//KJ/sK
disp(deltaSnet,"Net Entropy change in KJ/sK : ");
```

```
Q1=mw*hfg;//KJ/s
Sa_sub_Sb=-deltaSg;//KJ/sK
A1=Q1-T0*(Sa_sub_Sb);//KJ/s
disp(A1,"Availability of hot gases in KJ/s : ");
A2=Q1-T0*deltaSw;//KJ/s
disp(A2,"Availability of water in KJ/s : ");
UA1=T0*(Sa_sub_Sb);//KJ/s
disp(UA1,"Unavailable energy of hot gases in KJ/s :
    ");
UA2=T0*deltaSw;//KJ/s
disp(UA2,"Unavailable energy of water in KJ/s : ");
E_increase=T0*deltaSnet;//KJ/s
disp(E_increase,"Increase in unavailable energy in
    KJ/s : ");
```

Scilab code Exa 5.13 Loss of availability

```
//Exa 5.13
clc;
clear;
close;
format('v',6);

//Given Data :
mg=5;//Kg
p1=3;//bar
T1=500;//Kelvin
Q=500;//KJ
Cv=0.8;//KJ/Kg
T0=300;//Kelvin
T=1300;//Kelvin
//Q=mg*Cv*(T2-T1)
T2=Q/mg/Cv+T1;//Kelvin
A1=Q-T0*Q/T;//KJ
deltaSg=mg*Cv*log(T2/T1);//KJ/K
```

```
Ag=Q-T0*deltaSg;//KJ
Loss=A1-Ag;//KJ
disp(Loss,"Loss of Availability due to heat transfer
    in KJ : ");
```

Scilab code Exa 5.14 Loss in available energy

```
//Exa 5.14
clc;
clear;
close;
format('v',6);

//Given Data :
m=3;//Kg
p1=3;//bar
T1=450;//Kelvin
Q=600;//KJ
Cv=0.81;//KJ/Kg
T0=300;//Kelvin
T=1500;//Kelvin
deltaSsource=Q/T;//KJ/K
//Q=m*Cv*(T2-T1)
T2=Q/m/Cv+T1;//Kelvin
A1=Q-T0*deltaSsource;//KJ
deltaSg=m*Cv*log(T2/T1);//KJ/K
A2=Q-T0*deltaSg;//KJ
Loss=A1-A2;//KJ
disp(Loss,"Loss in available energy due to heat
   transfer in KJ : ");
```

Chapter 6

Properties of Steam

Scilab code Exa 6.e Find Specific Enthalpy

```
//Example :
clc;
clear;
close;
format('v',8);

//Given Data :
p1=0.02;//bar
hg1=2535.5;//KJ/Kg(at 0.02 bar)
p2=0.03;//bar
hg2=2545.6;//KJ/Kg(at 0.03 bar)
delta_h12=hg2-hg1;//KJ/KgK
p3=0.024;//bar
p4=0.02;//bar
delta_h=delta_h12/0.01*(p3-p4);//KJ/KgK
hg_dash=hg1+delta_h;//KJ/Kg
disp(hg_dash,"Specific enthalpy in KJ/Kg : ");
```

Scilab code Exa 6.1 Type of steam

```
//Exa 6.1
clc;
clear;
close;
format('v',7);

//Given Data :
m=2;//Kg
p=8;//bar
H=5535;//KJ
h=H/m;//KJ/Kg
hg=2767.5;//KJ/Kg
disp(h,"Specific Enthalpy in KJ/Kg : ");
disp(hg,"Given Enthalpy in KJ/Kg : ");
disp("Given enthalpy = specific enthalpy. System is
   dry saturated.");
m=1;//Kg
p=2550*10^3/10^5;//bar
v=0.2742;//m^3/Kg
disp(v,"Specific volume in m^3/Kg : ");
vg=0.078352;//m^3
disp(vg,"Given specific volume in m^3/Kg : ");
Ts=225+273;//K
disp("Since v>vg. System is super heated.");
Tsup=v/vg*Ts;//K
disp(Tsup-273,"Temperature of super heated steam in
   degree C : ");
m=1;//Kg
p=60;//bar
h=2470.73;//KJ/Kg
disp(h,"Enthalpy in KJ/Kg : ");
hg=2475;//KJ/Kg
disp(hg,"Given enthalpy in KJ/Kg : ");
disp("Since h>hg. System is in vapour state.");
//let x be the dryness fraction
//h=hf+x*hg
hf=1213.69;//KJ/Kg
hfg=1517.3;//KJ/Kg
```

```
x=(h-hf)/hfg;
disp(x,"Dryness fraction : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.2 Temperature Enthalpy and Specific Volume

```
//Exa 6.2
clc;
clear;
close;
format('v',8);

//Given Data :
p=5;//bar
x=0.98;
ts=151.84;//degree C
hf=652.8;//KJ/Kg
hfg=2098;//KJ/Kg
vg=0.373;//m^3/Kg
disp(ts,"Temperature of steam in degree C : ");
h=hf+x*hfg;//KJ/Kg
disp(h,"Enthalpy of steam in KJ/Kg : ");
v=x*vg;//m^3/Kg
disp(v,"Specific volume in m^3/Kg ; ");
//Steam table is used to get some data.
```

Scilab code Exa 6.3 Volume Enthalpy and Internal energy

```
//Exa 6.3
clc;
clear;
close;
format('v',8);
```

```
//Given Data :
m=1;//Kg
p=12;//bar
x=0.95;
ts=187.96;//degree C
vg=0.1632;//m^3/Kg
hf=814.7;//KJ/Kg
hfg=1970.7;//KJ/Kg
disp(ts,"Temperature of steam in degree C : ");
v=x*vg;//m^3/Kg
disp(v,"Specific volume in m^3/Kg ; ");
h=hf+x*hfg;//KJ/Kg
disp(h,"Enthalpy of steam in KJ/Kg : ");
u=h-p*10^5*v/1000;//KJ/Kg
disp(u,"Internal energy in KJ/Kg : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.4 Enthalpy Specific Volume and Entropy

```
//Exa 6.4
clc;
clear;
close;
format('v',8);

//Given Data :
m=1;//Kg
p=8;//bar
Tsup=280;//degree C
h1=2950.4;//KJ/Kg(at 250 degree C)
h2=3057.3;//KJ/Kg(at 300 degree C)
Tsup1=250;//degree C
Tsup2=300;//degree C
hsup=h1+(h2-h1)/(Tsup2-Tsup1)*(Tsup-Tsup1);//KJ/Kg
```

```
disp(hsup,"Specific enthalpy in KJ/Kg : ");
v1=0.293;//m^3/Kg(at 250 degree C)
v2=0.324;//m^3/Kg(at 300 degree C)
vsup=v1+(v2-v1)/(Tsup2-Tsup1)*(Tsup-Tsup1);//m^3/Kg
disp(vsup,"Specific volume in m^3/Kg : ");
S1=7.04;//KJ/KgK(at 250 degree C)
S2=7.235;//KJ/KgK(at 300 degree C)
Ssup=S1+(S2-S1)/(Tsup2-Tsup1)*(Tsup-Tsup1)
disp(Ssup,"Specific enthalpy in KJ/KgK : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.5 Ratio of mass flow rate

```
//Exa 6.5
clc;
clear;
close;
format('v',8);

//Given Data :
p1=0.1;//bar
p2=0.1;//bar
x1=0.95;
t3=20;//degree C
t2=35;//degree C
t4=45;//degree C
hf1=191.8;//KJ/Kg
hfg1=2397.9;//KJ/Kg
h1=hf1+x1*hfg1;//KJ/kg
h2=188.4;//KJ/Kg(at 45 degree C)
h3=83.9;//KJ/Kg(at 20 degree C)
h4=146.6;//KJ/Kg(at 35 degree C)
//m1*(h1-h2)=mw*(h4-h3)
mwBYm1=(h1-h2)/(h4-h3);//Kg of water/Kg of steam
disp(mwBYm1,"Ratio of mass flow rate of cooling
```

```
    water to condensing steam(Kg of water/Kg of steam
    ): ");
//Steam table is used to get some data.
```

Scilab code Exa 6.6 Enthalpy Energy and Mass

```
//Exa 6.6
clc;
clear;
close;
format('v',8);

//Given Data :
V=3;//m^3
t=200;//degree C
Pat=1;//bar
Pgauge=7;//bar
P=Pgauge+Pat;//bar
ts=170.41;//degree C
tsup=t;//degree C
vsup=0.261;//m^3/Kg
hsup=2838.6;//KJ/Kg
m=V/vsup;//Kg
H=m*hsup;//KJ
disp(H,"Total Enthalpy in KJ : ");
//H=U+p*V
U=H-P*10^5*V/1000;//KJ
disp(U,"Total internal energy of system in KJ ; ");
disp(m,"Mass of steam in Kg : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.7 Dryness fraction of steam

```
//Exa 6.7
clc;
clear;
close;
format('v',8);

//Given Data :
mw=1;//Kg
m_steam=39;//mass of dry steam in Kg
ms=mw+m_steam;//Kg
x=m_steam/ms;//dryness fraction
disp(x,"Dryness fraction ; ");
```

Scilab code Exa 6.8 Added heat

```
//Exa 6.8
clc;
clear;
close;
format('v',8);

//Given Data :
m=10;//Kg
p=10;//bar
x=0.9;
t1=20;//degree C
hf=762.6;//KJ/Kg
hfg=2013.6;//KJ/Kg
H=m*(hf+x*hfg);//KJ;
disp(H,"Enthalpy of wet steam in KJ : ");
hf1=83.9;//KJ/Kg(at 20 degree C)
Hf1=m*hf1;//KJ
HeatAdded=H-Hf1;//KJ
disp(HeatAdded,"Heat added in KJ : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.9 Required Heat

```
//Exa 6.9
clc;
clear;
close;
format('v',8);

//Given Data :
t=50;//degree C
p1=13;//bar
Cpw=4.187;//KJ/KgK
Cp=0.0535;//KJ/KgK
x1=0.97;
hf=Cpw*(t-0);//KJ/Kg
hf1=814.7;//KJ/Kg(at p1=13 bar)
hfg1=1970.7;//KJ/Kg(at p1=13 bar)
hg1=2785.4;//KJ/Kg(at p1=13 bar)
Q=hf1+x1*hfg1-hf;//KJ/Kg
disp(Q,"Heat required to produce steam in KJ/Kg : ")
    ;
Q1=hg1-hf;//KJ/Kg
disp(Q1,"Heat required to produce dry saturated
    steam in KJ/Kg : ");
tsup1SUBts1=40;//degree C
Q2=hg1+Cp*(tsup1SUBts1)-hf;//KJ/Kg
disp(Q2,"Heat required to produce super heated steam
     in KJ/Kg : ");
//Steam table is used to get some data.
//Ans is wrong in the book for last part.
```

Scilab code Exa 6.10 Workdone and latent heat of steam

```
//Exa 6.10
clc;
clear;
close;
format('v',7);

//Given Data :
p=8;//bar
x=0.8;
vf=0.001115;//m^3/kg
vg=0.24;//m^3/kg
hf=720.9;//kJ/kg(at p=8 bar)
hfg=2046.5;//kJ/kg(at p=8 bar)
m=1;//kg
We=100*p*(x*vg-vf);//kJ/kg
disp(We,"External workdone during evaporation in kJ/
    kg : ");
Q=x*hfg-We;//KJ
disp(Q,"External latent heat of steam in kJ: ")

//Steam table is used to get some data.
//Ans is wrong in the book for last part.
```

Scilab code Exa 6.11 Quality of steam

```
//Exa 6.11
clc;
clear;
close;
format("v",7);

//Given Data :
p1=20;//bar
Tsup1=350;//degree C
m1=1;//Kg
```

```
p2=20;//bar
m2=1;//Kg
p3=p1;//bar
Tsup3=250;//degree C
m3=m1+m2;//Kg
Cp=2.25;//KJ/Kg
hg1=2797.2;//KJ/Kg(at p=20 bar)
hg2=hg1;//KJ/Kg(at p=20 bar)
hg3=hg1;//KJ/Kg(at p=20 bar)
ts1=212.37;//degree C
ts2=ts1;//degree C
ts3=ts1;//degree C
//m1*h1+m2*h2=m3*h3
h2=(m3*(hg3+Cp*(Tsup3-ts3))-m1*(hg1+Cp*(Tsup1-ts1)))/m2;//KJ/Kg
disp(h2,"Enthalpy of boiler2 in KJ/Kg :  ");
disp(hg2,"hg2(KJ/Kg)  : ");
disp("steam is wet because h2<hg2")
//h2=hf2+x2*hfg2// as steam is wet because h2<hg2
hf2=908.6;//KJ/Kg
hfg2=1888.6;//KJ/Kg
x2=(h2-hf2)/hfg2;//
disp(x2,"Dryness : ");
//Steam table is used to get some data.
//Ans is wrong in the book.
```

Scilab code Exa 6.12 Enthalpy Internal Energy Entropy

```
//Exa 6.12
clc;
clear;
close;
format('v',8);

//Given Data :
```

```
m=2;//Kg
p=8;//bar
x=0.8;
hf=720.9;//KJ/Kg(at p=8 bar)
hfg=2046.5;//KJ/Kg(at p=8 bar)
h=hf+x*hfg;//KJ/Kg
H=m*h;//KJ
disp(H,"Total enthalpy of steam in KJ : ");
Vg=0.227;//m^3/Kg
V=m*x*Vg;//m^3
disp(V,"Volume in m^3 : ");
We=p*10^5*V/1000;//KJ
disp(We,"External work of evaporation in KJ : ");
U=H-We;//KJ
disp(U,"Total internal energy in KJ : ");
Sf=2.061;//KJ/K
Sfg=4.578;//KJ/K
S=m*(Sf+x*Sfg);//KJ/K
disp(S,"Total entropy in KJ/K : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.13 Temperature and Pressure

```
//Exa 6.13
clc;
clear;
close;
format('v',6);

//Given Data :
p1=600;//KPa
p1=p1/100;//bar
T1=200;//degree C
Vsup1=0.352;//m^3/Kg(at 6 bar)
V1=Vsup1;//m^3/Kg
```

```
V2=V1;//m^3(system is at constant volume)
Vg2=V2;//m^3/Kg(For dry saturated)
Tsup1=153.3;//degree C
Tsup2=154.8;//degree C
vg1=0.34844;//m^3/Kg
vg2=0.36106;//m^3/Kg
ts2=Tsup1+(Tsup2-Tsup1)/(vg2-vg1)*(V1-vg1);//degree
    C
disp(ts2,"Temperature at which steam begins to
    condense in degree C : ");
pg1=5.2;//bar
pg2=5.4;//bar
p2=pg1+(pg2-pg1)/(Tsup2-Tsup1)*(ts2-Tsup1);//bar
disp(p2,"Pressure in bar is :");
//Some data is taken from steam table.
```

Scilab code Exa 6.14 Work done Enthalpy and Heat Transfered

```
//Exa 6.14
clc;
clear;
close;
format('v',7);

//Given Data :
m=2;//Kg
p1=15;//bar
p2=15;//bar
Tsup1=250;//degree C
T1=Tsup1;//degree C
V1=0.152;//m^3/Kg(at 15 bar)
hf2=844.7;//KJ/Kg(at p=15 bar)
hg2=2789.9;//KJ/Kg(at p=15 bar)
hfg2=1945.2;//KJ/Kg(at p=15 bar)
h1=2923;//KJ/Kg
```

```
Vg2=0.1317;//m^3/Kg(at 15 bar)
x2=0.6;//dry
h2=hf2+x2*hfg2;//KJ/Kg
V2=x2*Vg2;//m^3/Kg
w=(p2*V2-p1*V1)*10^5/10^3;//KJ/Kg
W=m*w;//KJ
disp(W,"Total work done in KJ : ");
H2subH1=m*(h2-h1);//KJ/Kg
disp(H2subH1,"Change in enthalpy in KJ/Kg : ");
Q=H2subH1;//KJ
disp(Q,"Heat transfered in KJ : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.15 Rate of heat transfer and Density

```
//Exa 6.15
clc;
clear;
close;
format('v',7);

//Given Data :
p_gauge=15;//bar
p_at=750;//mm of Hg
p_at=p_at/760*1.01325;//bar
p=p_gauge+p_at;//bar
ms=200;//Kg/hr
Cpw=4.187;//KJ/KgK
t1=80;//degree C
hf1=Cpw*t1;//KJ/Kg
hf2=858.6;//KJ/Kg(at p=16 bar)
hg2=2791.8;//KJ/Kg(at p=16 bar)
hfg2=1933.2;//KJ/Kg(at p=16 bar)
ts=201.37;//degree C
x2=0.8;//dry
```

```
h2=hf2+x2*hfg2;//KJ/Kg
q=ms*(h2-hf1);//KJ/hr
q=q/3600;//KJ/s
disp(q,"Heat transfer in boiler in KJ/s : ");
tsup=ts+t1;//degree C
Cp=2.2;//KJ/KgK
hsup3=hg2+Cp*(tsup-ts);//KJ/Kg
qsup=ms*(hsup3-h2)/3600;//KJ/s
disp(qsup,"Heat transfered in superheated steam in
    KJ/s : ");
Vg=0.1237;//m^3/Kg(at 16 bar)
Ts=201.37+273;//K
Tsup=tsup+273;//K
Vsup=Tsup/Ts*Vg;//m^3/Kg
density=1/Vsup;//Kg/m^3
disp(density,"Density of steam in Kg/m^3 : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.16 Quantity of heat

```
//Exa 6.16
clc;
clear;
close;
format('v',7);

//Given Data :
m=1.5;//Kg
p1=5;//bar
x1=0.8;//dry
x2=0.4;//dry
Vg1=0.373;//m^3/Kg(at 5 bar)
hf1=640.1;//KJ/Kg(at p=5 bar)
hfg1=2107.4;//KJ/Kg(at p=5 bar)
Vg2=x1/x2*Vg1;//m^3/Kg
```

```
p2=4;//bar(at Vg2=0.746)
hf2=529.6;//KJ/Kg(at p=4 bar)
hfg2=2184.9;//KJ/Kg(at p=4 bar)
V1=x1*Vg1;//m^3/Kg
V2=V1;//m^3/Kg
h1=hf1+x1*hfg1;//KJ/Kg
h2=hf2+x2*hfg2;//KJ/Kg
Q=m*[(h2-h1)-100*(p2*V2-p1*V1)];//KJ
disp(Q,"Quantity of heat in KJ : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.17 Heat transfered per Kg of steam

```
//Exa 6.17
clc;
clear;
close;
format('v',7);

//Given Data :
p1=1;//bar
x1=0.523;//dry
Vg1=1.694;//m^3/Kg(at 1 bar)
hf1=417.5;//KJ/Kg(at p=1 bar)
hfg1=2258;//KJ/Kg(at p=1 bar)
h1=hf1+x1*hfg1;//KJ/Kg
V1=x1*Vg1;//m^3/Kg
V2=V1;//m^3/Kg(Constant volume process)
Vg2=V2;//m^3/Kg
p2=2;//bar;//at Vg2 from steam table
hg2=2706.3;//KJ/Kg(at 2 bar)
h2=hg2;//KJ/Kg
W=0;//KJ/Kg of steam
q=W+(h2-h1)-100*(p2*V2-p1*V1);//KJ/Kg
disp(q,"Heat transfered in KJ/Kg : ");
```

```
//Steam table is used to get some data.
```

Scilab code Exa 6.18 Dryness fraction and Mass of steam

```
//Exa 6.18
clc;
clear;
close;
format('v',7);

//Given Data :
V1=0.9;//m^3
p1=8;//bar
x1=0.9;//dry
p2=4;//bar
Vg1=0.24;//m^3/Kg(at 8 bar)
hf1=720.9;//KJ/Kg(at p=8 bar)
hfg1=2046.5;//KJ/Kg(at p=8 bar)
Vg2=0.462;//m^3/Kg(at 4 bar)
hf2=604.7;//KJ/Kg(at p=4 bar)
hfg2=2132.9;//KJ/Kg(at p=4 bar)
//h1=h2 : hf1+x1*hfg1=hf2+x2*hfg2
x2=((hf1+x1*hfg1)-hf2)/hfg2;//dry
disp(x2,"Dryness fraction of steam : ");
m1=V1/x1/Vg1;//Kg
V2=V1;//m^3
m2=V2/x2/Vg2;//Kg
m=m1-m2;//Kg
disp(m,"Mass of steam blown off in Kg : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.19 Condition of steam

```
//Exa 6.19
clc;
clear;
close;
format('v',7);

//Given Data :
m=5;//Kg
p1=10;//bar
x1=0.9;//dry
p2=4;//bar
ts1=179.88;//degree C(at 10 bar)
disp(ts1,"Final condition of steam,(Temperature in
   degree C) : ");
Vg1=0.1943;//m^3/Kg(at 8 bar)
hf1=762.6;//KJ/Kg(at p=10 bar)
hfg1=2013.6;//KJ/Kg(at p=10 bar)
h1=hf1+x1*hfg1;//KJ/Kg
V1=x1*Vg1;//KJ/kg
u1=h1-p1*V1*10^5/1000;//KJ/Kg
U1=m*u1;//KJ
Tsup2=179.88;//degree C
t11=150;//degree C
h11=2752;//KJ/Kg(at 4bar,150 degree C)
v11=0.471;//m^3/Kg(at 4bar,150 degree C)
s11=6.929;//KJ/KgK(at 4bar,150 degree C)
t22=200;//degree C
h22=2860.4;//KJ/Kg(at 4bar,200 degree C)
v22=0.534;//m^3/Kg(at 4bar,200 degree C)
s22=7.171;//KJ/KgK(at 4bar,200 degree C)
h2=h11+(h22-h11)/(t22-t11)*(ts1-t11);//KJ/Kg
v2=v11+(v22-v11)/(t22-t11)*(ts1-t11);//m^3/Kg
s2=s11+(s22-s11)/(t22-t11)*(ts1-t11);//m^3
u2=h2-p2*10^5*v2/1000;//KJ/Kg
U2=m*u2;//KJ
deltaU=U2-U1;//KJ
disp(deltaU,"Change in internal energy in KJ ; ");
sf1=2.138;//KJ/KgK
```

```
sfg1=4.445;//KJ/Kg
s1=(sf1+x1*sfg1);//KJ/KgK
deltaS=m*(s2-s1);//KJ/K
Q=(ts1+273)*(deltaS);//KJ
disp(Q,"Heat transfer in KJ : ");
W=Q-deltaU;//KJ
disp(W,"Workdone in KJ : ");
//Steam table is used to get some data.
//Answer is not accurate in the book.
```

Scilab code Exa 6.20 Work done and condition of steam

```
//Exa 6.20
clc;
clear;
close;
format('v',7);

//Given Data :
m=2;//Kg
p1=15;//bar
V1=0.3;//m^3
p2=1.5;//bar
v1=V1/m;//m^3/Kg
//p1*v1^(1.3)=p2*v2^(1.3)
v2=exp((log(p1)+1.3*log(v1)-log(p2))/1.3);//m^3/Kg
Vg2=1.1635;//m^3/Kg(at 1.5 bar)
x2=v2/Vg2;//dry
disp(x2,"Dryness of steam : ");
n=1.3;
W=m*(p1*v1-p2*v2)*10^5/(n-1);//J
W=W/1000;//KJ
disp(W,"Workdone in KJ : ");
//Steam table is used to get some data.
//Answer is wrong in the book.
```

Scilab code Exa 6.21 Amount of work done

```
//Exa 6.21
clc;
clear;
close;
format('v',7);

//Given Data :
m1=5;//Kg
p1=5;//bar
Tsup1=200;//degree C
p2=0.1;//bar
h1=2855;//KJ/Kg(from molliers diagram)
h2=2235;//KJ/Kg(from molliers diagram)
W=m1*(h1-h2);//KJ
disp(W,"Workdone in KJ : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.22 Specific work of expansion

```
//Exa 6.22
clc;
clear;
close;
format('v',7);

//Given Data :
p1=160;//bar
Tsup1=550;//degree C(from steam table)
q=0;//adiabatic process
```

```
deltaS=0.1;//KJ/KgK
p2=0.2;//bar
t11=500;//degree C
t22=600;//degree C
h11=3297.1;//KJ/Kg(at 4bar,500 degree C)
h22=3571;//KJ/Kg(at 4bar,600 degree C)
h1=h11+(h22-h11)/(t22-t11)*(Tsup1-t11);//KJ/Kg
s11=6.305;//KJ/KgK(at 4bar,500 degree C)
s22=6.639;//KJ/KgK(at 4bar,600 degree C)
s1=s11+(s22-s11)/(t22-t11)*(Tsup1-t11);//KJ/KgK
s2=deltaS+s1;//KJ/KgK
hf2=251.4;//KJ/Kg(at 0.2 bar)
hfg2=2358.2;//KJ/Kg(at 0.2 bar)
sf2=0.832;//KJ/KgK(at 0.2 bar)
sfg2=7.077;//KJ/KgK(at 0.2 bar)
//s2=sf2+x2*sfg2
x2=(s2-sf2)/sfg2;//dryness
h2=hf2+x2*hfg2;//KJ
Wsf_a=h1-h2;//KJ/Kg
disp(Wsf_a,"Actual Work of expansion in KJ : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.23 Final Specific volume temperature and entropy

```
//Exa 6.23
clc;
clear;
close;
format('v',7);

//Given Data :
mdot=2;//Kg/s
p1=10;//bar
Tsup1=200;//degree C(from steam table)
p2=1;//bar
```

```
h1=2826.8;//KJ/Kg(at 10bar,200 degree C)
S1=6.692;//KJ/KgK(at 10bar,200 degree C)
ts2=99.63;//degree C(at 1bar)
Vg2=1.694;//m^3/Kg(at 1bar)
hf2=417.5;//KJ/Kg(at 1bar)
hfg2=2258;//KJ/Kg(at 1bar)
sf2=1.303;//KJ/KgK(at 1bar)
sfg2=6.057;//KJ/KgK(at 1bar)
//S1=sf2+x2*sfg2
x2=(S1-sf2)/sfg2;//dryness
V3=x2*Vg2;//m^3/Kg
t2=ts2;//degree C
S2=S1;//KJ/KgK
Qdot=0;//KJ
h2=hf2+x2*hfg2;//KJ/Kg
Wsf_dot=Qdot-mdot*((h2-h1));//KJ/Kg
disp(Wsf_dot,"Work output of turbine in KJ/s or W :
   ");
//Steam table is used to get some data.
```

Scilab code Exa 6.24 Condition of steam and change in entropy

```
//Exa 6.24
clc;
clear;
close;
format('v',7);

//Given Data :
p1=7;//bar
x1=0.8;//dryness
p2=1;//bar
hf1=697;//KJ/Kg(at 7bar)
hfg1=2064.9;//KJ/Kg(at 7bar)
hf2=417.5;//KJ/Kg(at 1bar)
```

```
hfg2=2258;//KJ/Kg(at 1bar)
//hf1+x1*hfg1=hf2+x2*hfg2
x2=(hf1+x1*hfg1-hf2)/hfg2;//dryness
disp(x2,"Final conditio of steam(dryness) : ");
sf2=1.303;//KJ/Kg(at 1bar)
sfg2=6.057;//KJ/Kg(at 1bar)
sf1=1.992;//KJ/Kg(at 7bar)
sfg1=4.713;//KJ/Kg(at 7bar)
deltaS=(sf2+x2*sfg2)-(sf1+x1*sfg1)
disp(deltaS,"Change in entropy in KJ/KgK : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.25 Pressure at exit of throttle valve

```
//Exa 6.25
clc;
clear;
close;
format('v',7);

//Given Data :
p1=10;//bar
x1=0.9;//dryness
p2=1;//bar
hf1=762.6;//KJ/Kg(at 10bar)
hfg1=2013.6;//KJ/Kg(at 10bar)
h1=hf1+x1*hfg1;//KJ/Kg
h2=h1;//KJ/Kg
hg2=h2;//KJ/Kg
p2=0.075;//bar(from steam table)
disp(p2,"Pressure at exit in bar : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.26 State of steam Exit area of nozzle

```
//Exa 6.26
clc;
clear;
close;
format('v',7);

//Given Data :
m1dot=3;//Kg/min
p1=10;//bar
Tsup1=250;//degree C
m2dot=5;//Kg/min
p2=10;//bar
x2=0.7;//dryness
p3=10;//bar
p4=5;//bar
p5=2;//bar
m3dot=m1dot+m2dot;//Kg/min
hsup1=2826.8;//KJ/Kg(at 10bar)
hf2=762.6;//KJ/Kg(at 10bar)
hf3=762.6;//KJ/Kg(at 10bar)
hfg2=2013.6;//KJ/Kg(at 10bar)
hfg3=2013.6;//KJ/Kg(at 10bar)
//m1dot*hsup1+m2dot*(hf2+x2*hfg2)=m3dot*(hf3+x3*hfg3
   )
x3=((m1dot*hsup1+m2dot*(hf2+x2*hfg2))/m3dot-hf3)/
   hfg3;//dryness
disp(x3,"State of steam after mixing(dryness) : ");
x4=0.838;//dryness(from molliers diagram)
disp(x4,"State of steam after throttling(dryness) :
   ");
sf3=2.138;//KJ/KgK(From steam table
sfg3=4.445;//KJ/KgK(From steam table
sf4=1.860;//KJ/KgK(From steam table)
sfg4=4.959;//KJ/KgK(From steam table
s4SUBs3=m3dot/60*[(sf4+x4*sfg4)-(sf3+x3*sfg3)];//KJ/
   Kg
```

```
disp(s4SUBs3,"Increase in entropy due to throttling
    in KJ/KgK : ");
h4=2405;//KJ/Kg(from Molliers diagram)
h5=2265;//KJ/Kg(from Molliers diagram)
x5=0.802;//dryness
C4=0;//m/s(from S.F.E.E)
//h4+C4^2/2/1000=h5+C5^2/2/1000
C5=sqrt((h4+C4^2/2/1000-h5)*2*1000);//m/s
p5=2;//bar(from steam table)
Vg5=0.885;//m^3/Kg(from steam table)
//mdot/60=A5*C5/x5/Vg5
A5=m3dot/60/C5*x5*Vg5;//m^2
disp(A5*10^4,"Exit area of nozzle in cm^2 : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.27 Dryness Fraction of steam

```
//Exa 6.27
clc;
clear;
close;
format('v',7);

//Given Data :
ms=5;//Kg
m2=140;//Kg
p=10;//bar
mc=20;//KJ/K
t1=20;//degree C
mwdot=20;//Kg
t2=40;//degree C
Cpw=4.19;//KJ/KgK
hfg=2021.4;//KJ/Kg(at 10bar)
ts=179.88;//degree C
//ms*(x*hfg)+ms*Cpw*(ts-t2)=m2*Cpw*(t2-t1)+mc*(t2-t1
```

```
    )
x=(m2*Cpw*(t2-t1)+mc*(t2-t1)-ms*Cpw*(ts-t2))/ms/hfg;
    //dryness
disp(x,"Dryness fraction of steam : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.28 Dryness Fraction of steam

```
//Exa 6.28
clc;
clear;
close;
format('v',7);

//Given Data :
p1=15;//bar
p2=15;//bar
p3=1;//bar
Tsup3=150;//degree C
mw=0.2;//Kg/min
ms=10;//Kg/min
x1=ms/(ms+mw);//dryness
disp(x1,"Dryness factor of steam : ");
hf2=844.7;//KJ/Kg(from steam table,at 15 bar)
hfg2=1945.2;//KJ/Kg(from steam table,at 15 bar)
hsup3=2776.3;//KJ/Kg(from steam table,at 15 bar)
//hsup3=hf2+x2*hfg2;//KJ/Kg
x2=(hsup3-hf2)/hfg2;//KJ/Kg
x=x1*x2;//dryness
disp(x,"Dryness fraction in the mains : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.29 Minimum value of dryness fraction

```
//Exa 6.29
clc;
clear;
close;
format('v',5);

//Given Data :
p1=1;//MPa
p2=100;//KPa
p1=p1*10^6/10^5;//bar
p2=p2*10^3/10^5;//bar
hf1=762.5;//KJ/Kg(from steam table)
hfg2=2013.6;//KJ/Kg(from steam table)
hg2=2675.5;//KJ/Kg(from steam table)
//hg2=hf1+x1*hfg2;//KJ/Kg
x1=(hg2-hf1)/hfg2;//
disp(x1,"Dryness fraction in the mains : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.30 Dryness fraction of steam

```
//Exa 6.30
clc;
clear;
close;
format('v',7);

//Given Data :
p1=900;//KN/m^2
p2=900;//KN/m^2
p3=0.1013;//MN/m^2
p1=p1/10^2;//bar
p3=p2/10^2;//bar
p3=p3*10^6/10^5;//bar
Tsup3=115;//degree C
```

```
ms=1.8;//Kg
mw=0.16;//Kg
x1=ms/(ms+mw);//dryness
hf2=742.6;//KJ/Kg(from steam table)
hfg2=2029.5;//KJ/Kg(from steam table)
hg3=2676;//KJ/Kg(from steam table)
Ts3=100;//degree C
Cp=2;//KJ/KgK
//hf2+x2*hfg2=hg3+Cp*(Tsup3-Ts3);//KJ/Kg
x2=(hg3+Cp*(Tsup3-Ts3)-hf2)/hfg2;//KJ/Kg
x=x1*x2;//dryness
disp(x,"Dryness fraction of steam in mains : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.31 Quality of steam

```
//Exa 6.31
clc;
clear;
close;
format('v',7);

//Given Data :
p1=1.5;//MPa
p1=p1*10^6/10^5;//bar
p2=p1;//bar
p3=0.1;//MPa
p3=p3*10^6/10^5;//bar
Tsup3=110;//degree C
Vw=0.15;//litres
Vw=0.15*10^-3;//m^3 at 70 degree C
ms=3.24;//Kg
Vf=0.001023;//m^3/Kg
mw=Vw/Vf;//Kg
x1=ms/(ms+mw);//dryness
```

```
hf2=844.7;//KJ/Kg(from steam table)
hfg2=1945.2;//KJ/Kg(from steam table)
hg3=2675;//KJ/Kg(from steam table)
Ts3=99.63;//degree C
Cp=2;//KJ/KgK
//hf2+x2*hfg2=hg3+Cp*(Tsup3-Ts3);//KJ/Kg
x2=(hg3+Cp*(Tsup3-Ts3)-hf2)/hfg2;//KJ/Kg
x=x1*x2;//dryness
disp(x,"Quality of steam in pipe line(Dryness
    fraction) : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.32 Dryness fraction of steam

```
//Exa 6.32
clc;
clear;
close;
format('v',7);

//Given Data :
p1=1.5;//MPa
p1=p1*10^6/10^5;//bar
p_gauge=7;//bar
p_at=1;//bar
p2=p_gauge+p_at;//bar
p3=1;//bar
Tsup3=110;//degree C
mw=3.5;//Kg
ms=48;//Kg
Cp=2.1;//KJ/KgK
x1=ms/(ms+mw);//dryness
hf2=720.9;//KJ/Kg(from steam table)
hfg2=2059.3;//KJ/Kg(from steam table)
hg3=2675.5;//KJ/Kg(from steam table)
```

```
Ts3=99.63;//degree C
//hf2+x2*hfg2=hg3+Cp*(Tsup3-Ts3);//KJ/Kg
x2=(hg3+Cp*(Tsup3-Ts3)-hf2)/hfg2;//KJ/Kg
x=x1*x2;//dryness
disp(x,"Quality of steam in pipe line(Dryness
    fraction) : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.33 Net work done and Rankine Efficiency

```
//Exa 6.33
clc;
clear;
close;
format('v',7);

//Given Data :
p1=20;//bar
Tsup3=360;//degree C
pb=0.08;//bar
m=1;//Kg
hf1=173.9;//KJ/Kg(from steam table)
h1=hf1;//KJ/Kg
wp=(p1-pb)/10;//KJ/Kg
h2=h1+wp;//KJ/Kg
h3=3160.62;//KJ/Kg(from steam table)
S3=6.994;//KJ/Kg
Sf4=0.593;//KJ/Kg(from steam table)
Sfg4=7.637;//KJ/Kg(from steam table)
S3=6.994;//KJ/Kg
//S3=S4=Sf4+x4*Sfg4
x4=(S3-Sf4)/Sfg4;//dryness
hf4=173.9;//KJ/Kg(from steam table)
hfg4=2403.2;//KJ/Kg(from steam table)
h4=hf4+x4*hfg4;//KJ/Kg
```

```
Ws=h3-h4-wp;//KJ/Kg
disp(Ws,"Net work done in KJ/Kg : ");
EtaR=Ws/(h3-h2)*100;//%
disp(EtaR,"Rankine efficiency in % : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.34 Thermal Efficiency and Turbine work

```
//Exa 6.34
clc;
clear;
close;
format('v',7);

//Given Data :
p1=80;//bar
Tsup3=350;//degree C
pb=712.5/760*1.01325;//bar
mdot=2;//Kg/s
//mdot=1;//Kg
h3=2964;//KJ/Kg(Molliers diagram)
h4=2184;//KJ/Kg(Molliers diagram)
WT=h3-h4;//KJ/Kg
WTdot=mdot*WT;//KW
disp(WTdot,"Total turbine work in KW : ");
wp=(p1-pb)/10;//KJ/Kg
hf1=411.35;//KJ/Kg(from steam table)
h1=hf1;//KJ/Kg
h2=h1+wp;//KJ/Kg
qi=h3-h2;//KJ/Kg
EtaR=(WT-wp)/qi*100;//%
disp(EtaR,"Rankine efficiency in % : ");
//Steam table is used to get some data.
```

Scilab code Exa 6.35 Heat supplied Dryness Fraction Work done Efficiency

```
//Exa 6.35
clc;
clear;
close;
format('v',7);

//Given Data :
p1=30;//bar
Tsup3=350;//degree C
pb=0.5;//bar
h1=340.5;//KJ/Kg(from steam table, at 0.5 bar)
Vw=0.001;//m^3/Kg
wp=(p1-pb)*10^5*Vw/1000;//KJ/Kg
h2=h1+wp;//KJ/Kg
h3=2854.8;//KJ/Kg(from steam table, at 30 bar)
S3=6.286;//KJ/KgK
S4=S3;//KJ/KgK
Sf4=1.091;//KJ/KgK
Sfg4=6.503;//KJ/KgK
//S4=Sf4+x4*Sfg4
x4=(S4-Sf4)/Sfg4;//dryness
disp(x4,"Dryness fraction of steam entering in
    condenser : ");
hf4=340.5;//KJ/Kg(from steam table)
hfg4=2305.4;//KJ/Kg(from steam table)
h4=hf4+x4*hfg4;//KJ/Kg
q=h3-h2;//
disp(q,"Heat supplied to stem in boiler in KJ : ");
Ws=h3-h4-(h2-h1);//KJ/Kg
disp(Ws,"Work done in KJ/Kg : ");
steam_rate=3600/Ws;//KJ/KWh
```

```
disp(steam_rate,"Steam rate per in KJ/Kwh :  ");
EtaR=Ws/(h3-h2)*100;//%
disp(EtaR,"Rankine efficiency in  % : ");
//Steam table is used to get some data.
```

Chapter 7

IC Engines

Scilab code Exa 7.1 Friction Power

```
//Ex 7.1
clc;
clear;
close;
format('v',5);

//Given data :
T=10;//N-m
N=1500;//rpm
IP=1.85;//KW
//Calculation
BP=T*2*%pi*N/60/1000;//KW
FP=IP-BP;//KW
disp(FP,"Friction power(KW) : ");
```

Scilab code Exa 7.2 BP of the engine

```
//Ex 7.2
```

```
clc;
clear;
close;
format('v',7);

//Given data :
d=18/100;//m
L=26/100;//m
N=400;//rpm
positive_mep=6;//bar
negative_mep=-0.3;//bar
n=180;//strokes/min
Etta_m=0.75;

//Calculation
Pm=positive_mep+negative_mep;//bar
A=%pi/4*d^2;//m^2
IP=Pm*10^5*A*L*n/60/1000;//KW
BP=IP*Etta_m;//KW
disp(BP,"B.P. of engine in KW : ");
```

Scilab code Exa 7.3 Power and Efficiencies

```
//Ex 7.3
clc;
clear;
close;
format('v',6);

//Given data :
r=6;//cm
d=10/100;//m
L=12.5/100;//m
Pmi=2.6;//bar
W=60;//N
```

```
S=19; //N
R=40/100; //m
mf=1; //Kg/hr
mf=mf/60/60; //Kg/sec
CV=42000; //KJ/Kg
N=2000; //rpm

//Calculation
A=%pi/4*d^2; //m^2
n=N/2; //no. of strokes/min
IP=Pmi*10^5*A*L*n/60/1000; //KW
disp(IP,"Indicated Power in KW : ");
BP=(W-S)*R*2*%pi*N/60/1000; //KW
disp(BP,"Brake Power in KW : ");
Etta_m=BP/IP*100; //%
disp(Etta_m,"Mechanical efficiency in % : ");
Etta_o=BP/mf/CV*100; //%
disp(Etta_o,"Overall efficiency in % : ");
Gamma=1.4; //constant
Etta_a=(1-1/(r^(Gamma-1)))*100 ; //%
disp(Etta_a,"Air standard efficiency in % : ");
Etta_r=Etta_o/Etta_a*100; //%
disp(Etta_r,"Relative efficiency in % : ");
```

Scilab code Exa 7.4 Bore and length of stroke

```
//Ex 7.4
clc;
clear;
close;
format('v',7);

//Given data :
IP=50; //KW
Vf=16; //litre/hr
```

```
Sp_gravity_fuel=0.755;
CV=44500;//KJ/Kg
N=3000;//rpm
Pmi=5.2;//bar

//Calculation
mf=Vf*10^-3*Sp_gravity_fuel*1000;//Kg/hr
mf=mf/3600;//Kg/s
Etta_i=IP/mf/CV*100;//%
disp(Etta_i,"Indicated thermal efficiency in % :");
//IP=Pmi*10^5*%pi/4*d^2*L*N/2/60/1000;//KW
d=(IP*60*1000/Pmi/10^5/(%pi/4)/1.1/(N/2))^(1/3);//meter(L=1.1*d)
disp(d*100,"Bore in cm : ");
L=1.1*d;//meter
disp(L*100,"Length of stroke in cm : ");
```

Scilab code Exa 7.5 Indicated Power of Engine

```
//Ex 7.5
clc;
clear;
close;
format('v',7);

//Given data :
Vs=5.7;//litre
Vs=Vs/1000;//m^3
Pm=600;//KN/m^2
N=800;//rpm

//Calculation
n=N/2;//No. of strokes/min
IP=Pm*Vs*n/60;//KW
disp(IP,"Indicated power of Engine in KW :  ");
```

Scilab code Exa 7.6 Diameter and stroke of engine

```
//Ex 7.6
clc;
clear;
close;
format('v',7);

//Given data :
n1=6;//cylinders
IP=100;//KW
N=800;//rpm
Lbyd=1.25;//stroke to bore ratio
Etta_m=80/100;
bmep=5;//bar

//Calculation
n=N/2;//No. of strokes/min
//IP=Pm*%pi/4*d^2*d*Lbyd*n/60000
d=(IP/(bmep*%pi/4*Lbyd*n/60000))^(1/3);//m
L=Lbyd*d;//m
disp(d,"Diameter in meter : ");
disp(L,"Length ofstroke in meter :  ");
//Solution is not complete in the book.
```

Scilab code Exa 7.7 Indicated Power of Engine

```
//Ex 7.7
clc;
clear;
close;
```

```
format('v',7);

//Given data :
d=110/1000;//m
L=140/1000;//m
Pmi=600;//KN/m^2
N=1000;//rpm
n=N;//strokes/min(for 2 stroke)
A=%pi/4*d^2;//m^2
IP=Pmi*A*L*n/60;//KW
disp(IP,"Indicated power of the engine in KW : ");
```

Scilab code Exa 7.8 Engine Crank Shaft Speed

```
//Ex 7.8
clc;
clear;
close;
format('v',7);

//Given data :
n1=6;//cylinders
IP=150;//KW
N=800;//rpm
TwoLN=320;//m/s
Lbyd=1.2;//stroke to bore ratio
Pmi=650;//Kn/m^2

//Calculation
//IP=n1*Pmi*(%pi/4*d^2)*L*n/60;//KW
d=sqrt(IP/n1/Pmi/(%pi/4)*2/TwoLN*2*60);//meter(L*N replaced by TwoLN/2)
L=Lbyd*d;//in meter
N=TwoLN/2/L;//rpm
disp(N,"Engine crank shaft speed in rpm : ");
```

Scilab code Exa 7.9 Power and Efficiency

```
//Ex 7.9
clc;
clear;
close;
format('v',7);

//Given data :
d=250/1000;//meter
L=400/1000;//meter
Pmi=6.50;//bar
N=250;//rpm
NetBrakeLoad=1080;//N
Db=1.5;//meter
mf=10;//Kg/hr
mf=mf/60/60;//Kg/sec
CV=44300;//KJ/Kg

//Calculation
n=N/2;//stroke/min
IP=Pmi*10^5*(%pi/4*d^2)*L*n/60/1000;//KW
disp(IP,"Indicated Power in KW : ");
Rb=Db/2;//meter
BP=NetBrakeLoad*Rb*2*%pi*N/60/1000;//KW
disp(BP,"Brake Power in KW : ");
Etta_m=BP/IP*100;//%
disp(Etta_m,"Mechanical Efficiency in % : ");
Etta_i=IP/mf/CV*100;//%
disp(Etta_i,"Indicated Thermal Efficiency in % : ");
```

Scilab code Exa 7.10 Fuel Consumption and Efficiency

```
//Ex 7.10
clc;
clear;
close;
format('v',7);

//Given data :
mf=20;//Kg/hr
BP=80;//KW
Etta_m=80/100;
CV=45000;//KJ/Kg
bsfc=mf/BP;//break specified fuel consumption in Kg/
    KWh
disp(bsfc,"Break specified fuel consumption in Kg/
    KWh : ");
IP=BP/Etta_m;//KW
mf=mf/60/60;//Kg/s
n=mf/100;//Kg/KWh
Etta_b=BP/mf/CV*100;//%
disp(Etta_b,"Break Efficiency in % : ");
Etta_I=Etta_b/Etta_m;//
disp(Etta_I,"Indicated thermal Efficiency in % : ");
```

Scilab code Exa 7.11 IP BP and Efficiency

```
//Ex 7.11
clc;
clear;
close;
format('v',7);

//Given data :
d=270/1000;//meter
L=380/1000;//meter
Pmi=6;//bar
```

```
N=350; //rpm
WsubS=1000; //N
Db=1.5; //meter
mf=10; //Kg/hr
CV=44400; //KJ/Kg

IP=Pmi*10^5*(%pi/4*d^2)*L*N/2/60/1000; //KW
disp(IP,"Indicated Power in KW : ");
BP=(WsubS)*%pi*Db*N/60/1000; //KW
disp(BP,"Brake Power in KW : ");
Etta_m=BP/IP*100; //%
disp(Etta_m,"Mechanical Efficiency in % : ");
mf=mf/60/60; //Kg/s
Etta_b=BP/mf/CV*100; //
disp(Etta_b,"Indicated thermal Efficiency in % : ");
```