Scilab Textbook Companion for Engineering Thermodynamics by S. S. Khandare[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Introduction

Scilab code Exa 1.1 Absolute pressure

```
// Exa 1.1
clc;
clear;
close;
// Given data
P_m = 760;// pressure of mercury in mm
P_m_bar = P_m/750;// in bar
P_W = 0.006867;// pressure of water in bar
P = P_m_bar+P_W;// in bar
disp(P,"The absolute pressure of gas in bar is");
```

Scilab code Exa 1.2 Absolute pressure

```
// Exa 1.2
clc;
clear;
close;
// Given data
```

```
Rho = 13.6;
g = 9.81;
a = 760;// in mm
b = 480;// in mm
h = a-b;// in mm
P = (1000*Rho*g*h)/(1000);// in N/m^2
disp(P,"The absolute pressure in N/m^2 is");
P = P /100;// in mbar
disp(P,"The absolute pressure in mbar is");
```

Scilab code Exa 1.3 Absolute pressure

```
// Exa 1.3
clc;
clear;
close;
// Given data
G_P = 30;// guage pressure of steam in bar
P1 = 745;// in mm
P1= P1/750;//  in bar
PressureInBoiler = G_P+P1;// in bar
disp("The absolute pressure in the bioler in bar is
    "+string(PressureInBoiler)+" bar or "+string(
    PressureInBoiler*10^5)+" N/m^2");
P2 = 708.2;// in mm
P2= P2/750;// in
PressureInCond = P1-P2;// in bar
disp(PressureInCond,"The absolute pressure in the
    Condenser in bar is");
disp(PressureInCond*10^5,"The absolute pressure in
    the Condenser in N/m^2 is");
```

Scilab code Exa 1.4 Guage pressure

```
// Exa 1.4
clc;
clear;
close;
// Given data
Rho = 0.78;// in kg/m^3
g = 9.81;
h = 3;// in m
b = g*Rho*h*1000;// in N/m^2
b = b * 10^-3;// in kN/m^2
disp(b,"The gauge pressure in kN/m^2 is");
```

Scilab code Exa 1.5 Absolute pressure

```
// Exa 1.5
clc;
clear;
close;
// Given data
B_h = 755;// Barometric height in mm
M_h= 240;// Manometer height in mm
P = B_h+M_h;// in mm
P = P/750;// absolute pressure in bar
P= P*10^5;// in N/m^2
disp(P*10^-6,"The absolute pressure in the vessel in
    MN/m^2 is");
disp(P*10^-5,"The absolute pressure in the vessel in
    bar is");
```

Scilab code Exa 1.6 Temperature on absolute scale

```
// Exa 1.6
clc;
```

```
clear;
close;
// Given data
T = 287;// in degree C
T = T + 273;// in K
disp(T,"The temperature on absolute scale in K is");
```

Scilab code Exa 1.7 Temperature in degree C

```
// Exa 1.7
clc;
clear;
close;
// Given data
a = 0.26;
b = 5*10^-4;
E = 10;// in mV
T = (a/(2*b))*( sqrt(1+(4*E*b/a^2)) - 1 );// in degree C
disp("The unit of a will be mV/ C and the unit of b will be mV/ C ^2")
disp(T,"The Temperature in degree C is");
```

Scilab code Exa 1.8 Quantity of heat supplied to water

```
// Exa 1.8
clc;
clear;
close;
// Given data
Q_w = 500;// quantity of water flowing in kg/minute
T1 = 80;// in  C
T2 = 20;// in  C
```

```
del_T = T1-T2;// in  C
Spe_heat = 4.182;// in kJ/kg
Q_h = Q_w*del_T*Spe_heat;// in kJ/minute
disp("Quantity of heat supplied to water in the
    economizer is "+string(Q_h)+" kJ/minute or "+
    string(Q_h*10^-3)+" MJ/minute");
```

Scilab code Exa 1.9 Heat supplied to vessel and water

```
// Exa 1.9
clc;
clear;
close;
// Given data
CopperMass = 3;// in kg
WaterMass= 6;// in kg
Spe_heat_copper= 0.394;// in kJ/kg-K
T1 = 90;// in degree C
T2 = 20;// in degree C
del_T = T1-T2;// in degree C
H_C = CopperMass*Spe_heat_copper*del_T;// heat
    required by copper in kJ
Spe_heat_water= 4.193;// in kJ/kg-K
H_W = WaterMass*Spe_heat_water*del_T;// heat
    required by water in kJ
H = H_C+H_W;//heat required by vessel and water  in
    kJ
H = H * 10^-3;// in MJ
disp(H,"Heat required by vessel and water in MJ is")
    ;
```

Scilab code Exa 1.10 Quantity of heat supplied per kg of coal

```
// Exa 1.10
clc;
clear;
close;
// Given data
m = 18.2;//quantity of air supplied of coal in kg
T1 = 200;// in degree C
T2 = 18;// in degree C
del_T = T1-T2;// in degree C
Spe_heat = 1;// in kJ/kg-K
Q_C = m*Spe_heat*del_T;// in kJ
disp(Q_C,"The Quantity of heat supplied per kg of
    coal in kJ is");
```

Chapter 2

Gas Laws Ideal and Real Gases

Scilab code Exa 2.1 Pressure of air

```
// Example 2.1
clc;
clear;
close;
// Given data
P1= 250;// in kN/m^2
V1= 6.2;// in m^3
V2= 1.82;// in m^3
// Formula P1*V1 = P2*V2
P2= P1*V1/V2;// in kN/m^2
disp(P2,"Pressure of air after compression in kN/m^2
    is : ")
```

Scilab code Exa 2.2 New guage pressure

```
// Example 2.2
clc;
clear;
```

```
close;
// Given data
guagePressure= 1500;// in kN/m^2
atmPressure= 100;// in kN/m^2
P1= guagePressure+atmPressure;// in kN/m^2
V1= 0.1;// in m^3
V2= 0.4;// in m^3
// Formula P1*V1 = P2*V2
P2= P1*V1/V2;// in kN/m^2
NewGuagePressure= P2-atmPressure;// in kN/m^2
disp(NewGuagePressure,"New guage pressure in kN/m^2
   is : ")
```

Scilab code Exa 2.3 Temperature at the end of compression stroke

```
// Example 2.3
clc;
clear;
close;
// Given data
P1= -4+101.3;// in kN/m^2
V1= 96+475;// in cm^3
V2= 96;// in cm^3
// Formula P1*V1 = P2*V2
P2= P1*V1/V2;// in kN/m^2
disp(P2,"Pressure at the end of the compression
   stroke in kN/m^2 is : ")
disp(P2*10^-2,"and in bar : ")
```

Scilab code Exa 2.4 Volume occupied

```
// Example 2.4
clc;
```

```
clear;
close;
// Given data
V0= 1;// in m^3
t= 300;// in  C
V= V0*(1+t/273);// in m^3
disp(V,"The volume occupied in m^3 is : ")
```

Scilab code Exa 2.5 Final volume

```
// Example 2.5
clc;
clear;
close;
// Given data
V1= 2;// in m^3
T1= 30+273;// in K
T2= 230+273;// in K
// V1/T1 = V0/T0 = V2/T2
V2= V1*T2/T1;// in m^3
disp(V2,"The final volume in m^3 is : ")
```

Scilab code Exa 2.6 Pressure of the gas

```
// Example 2.6
clc;
clear;
close;
// Given data
P1= 7*10^5;// in N/m^2
V1= 3;// in m^3
V2= 9;// in m^3
T1= 150+273;// in K
```

```
T2= 10+273;// in K
// Formula P1*V1/T1 = P2*V2/T2
P2= P1*V1*T2/(T1*V2);// in N/m^2
disp(P2*10^-5,"Pressure of the gas in bar is : ")
```

Scilab code Exa 2.7 Pressure at the end of compression stroke

```
// Example 2.7
clc;
clear;
close;
// Given data
P1= 100;// in kN/m^2
V1byV2= 12;// in
T1= 115+273;// in K
T2= 180+273;// in K
// Formula P1*V1/T1 = P2*V2/T2
P2= P1*V1byV2*T2/T1;// in N/m^2
disp(P2*10^-2,"Absolute pressure at the end of
   compression stroke in bar is : ")
```

Scilab code Exa 2.8 Molecular volume of the gas

```
// Example 2.8
clc;
clear;
close;
// Given data
mR= 8314.3;// in J/kg-mole-K
P= 200*10^3;// in N/m^2
T= 30+273;// in K
// Formula P*V = mR*T
V= mR*T/P;// in m^3
```

```
disp(V,"The molecular volume of all the gases in m^3
    is : ")
```

Scilab code Exa 2.9 Temperature at the end compression

```
// Example 2.9
clc;
clear;
close;
// Given data
P1= 96;// in kN/m^2
P2= 725;// in kN/m^2
V1= 600;// in cm^3
V2= 100;// in cm^3
T1= 100+273;// in K
// Formula P1*V1/T1 = P2*V2/T2
T2= P2*V2*T1/(P1*V1);// in K
disp(T2-273,"Temperature at the end of compression
   in C is : ");
// Note:- In the book, There is an error to
   calculate the value of T2.
```

Scilab code Exa 2.10 Mass density and volume of the gas

```
// Example 2.10
clc;
clear;
close;
// Given data
MR= 8314.2;// in J/kg-mole-K
mass= 44;// Molecular mass of carbon dioxide in kg
R= MR/mass;// in J/kg-K
P= 11;// in MPa
```

```
P=P*10^6;// in Pa
V= 50*10^-3;// in m^3
T= 18+273;// in K
// Formula P*V= m*R*T
m= P*V/(R*T);// in kg
m=round(m);// in kg
MolecularVolume= MR*T/P;// in m^3
D= m/V;// density of the gas in kg/m^3
SpecificVolume= 1/D;// in m^3/kg
disp(m,"The mass of the gas in kg is : ")
disp(MolecularVolume,"The Molecular volume in m^3 is
    : ")
disp(D,"The density of the gas in kg/m^3 is : ")
disp(SpecificVolume,"The specific volume of the gas
    in m^3/kg is : ")
```

Scilab code Exa 2.11 New temperature of the gas

```
// Example 2.11
clc;
clear;
close;
// Given data
P1= 350;// in kN/m^2
P1=P1*10^3;// in N/m^2
P2= 1.05;// in kN/m^2
P2=P2*10^6;// in N/m^2
V= 0.3;// in m^3
R= 0.29;// in kJ/kg-K
R= R*10^3;// in j/kgK
T1= 35+273;// in K
// Formula P*V= m*R*T
m= P1*V/(R*T1);// in kg
// Formula P1*V1/T1 = P2*V2/T2 and since V1= V2
T2= P2*T1/P1;// in K
```

```
disp(T2-273,"Temperature at constant volume
   compression in  C is : ")
```

Scilab code Exa 2.12 Tyre guage reading

```
// Example 2.12
clc;
clear;
close;
// Given data
g1= 1.75;// gauge reading in bar
atm= 1.013;// in atmospheric pressure in bar
P1= g1+atm;// in bar
T1= 12+273;// in K
T2= 45+273;// in K
// Formula P1*V1/T1 = P2*V2/T2 and since V1= V2
P2= P1*T2/T1;// in bar
g2=P2-atm;// tyre gauge reading in bar
disp(g2,"Tyre guage reading at 45 C in bar is : ")
```

Scilab code Exa 2.13 Change in internal energy

```
// Example 2.13
clc;
clear;
close;
// Given data
Q= 120;// in kJ
W= 150;// in kJ
E= Q-W;// change in internal energy in kJ
disp(abs(E),"The internal energy of the system
   decreases by (in kJ)")
```

Scilab code Exa 2.14 Change in internal energy

```
// Example 2.14
clc;
clear;
close;
// Given data
Q= -40;// in kJ/kg
W= -80;// in kJ/kg
E= Q-W;// change in internal energy in kJ/kg
disp(E,"Change in internal energy in kJ/kg is : ")
disp("Thus internal energy of the working substance
    increases ")
```

Scilab code Exa 2.15 Mass of the fluid in the system

```
// Example 2.15
clc;
clear;
close;
// Given data
Int_energy_changes= 20;// in kJ/kg
Q= 0;// in kJ
W= -90;// in kJ
E= Q-W;// change in internal energy in kJ/kg
m= E/Int_energy_changes;// in kg
disp(m,"The mass of the fluid in the system in kg is
    : ")
```

Scilab code Exa 2.16 Specific enthalpy of steam

```
// Example 2.16
clc;
clear;
close;
// Given data
U= 2800;// in kJ/kg
P= 20;// in bar
P= P*10^5;// in N/m^2
V= 0.23/1000;// in m^3
SP= U+P*V;// specific enthalpy in kJ/kg
disp(SP,"The specific enthalpy in kJ/kg is : ")
```

Scilab code Exa 2.17 Fourth work transfer

```
// Example 2.17
clc;
clear;
close;
// Given data
h1= 210;//first heat transfer in kJ
h2= -20;// second heat transfer in kJ
h3= -190;// third heat transfer in kJ
h4= 60;// fourth heat transfer in kJ
W1= -180;// first work transfer in kJ
W2= 200;// second  work transfer in kJ
W3= -300;// third  work transfer in kJ
// Total Heat transfer = Total work transfer
W4= h1+h2+h3+h4-W1-W2-W3;// forth  work transfer in kJ
disp(W4,"Fourth work transfer in kJ is :")
disp("Thus the system delivers "+string(W4)+" kJ of work")
```

Scilab code Exa 2.18 Heat transfered to the gas

```
// Example 2.18
clc;
clear;
close;
// Given data
Cv= 0.718;// in kJ/kgK
R= 0.278;// in kJ/kgK
T1= 15+273;// in K
T2= 135+273;// in K
m= 2;// mass in kg
V1= 0.7;// in m^3
Q= m*Cv*(T2-T1);// in kJ
disp(Q,"Heat supplied to gas in kJ is : ")
// Formula P1*V1= m*R*T1
P1= m*R*T1/V1;// in kN/m^2 absolute
// From P1/T1= P2/T2
P2= P1*T2/T1;// in kN/m^2
disp(P2,"The final pressure in kN/m^2 is : ")
```

Scilab code Exa 2.19 Amount of heat extracted from the gas

```
// Example 2.19
clc;
clear;
close;
// Given data
Cv= 1.005;// in kJ/kgK
T1= 200+273;// in K
T2= 15+273;// in K
V1= 0.12;// in m^3
```

```
m= 0.25;// mass in kg
Q= m*Cv*(T1-T2);// in kJ
disp(Q,"Heat extracted from the gas in kJ is : ")
// From V1/T1= V2/T2
V2= V1*T2/T1;// in m^3
disp(V2,"The final volume of the gas in m^3 is : ")
```

Scilab code Exa 2.20 Value of Cv gamma and R

```
// Example 2.20
clc;
clear;
close;
// Given data
m=2;// molecular mass
UGC= 8.3143;// universal gas constant in kJ/kg-mole-
   K
Cp= 14.41;// in kJ/kg-K
R= UGC/m;// in kJ/kgK
Cv= Cp-R;// in kJ/kgK
gama= Cp/Cv;
disp(R,"The value of R in kJ/kgK is :")
disp(Cv,"The value of Cv in kJ/kgK is : ")
disp(gama,"The value of gama is : ")
```

Scilab code Exa 2.21 Temperature rise

```
// Example 2.21
clc;
clear;
close;
// Given data
Cp = 0.796;// in kJ/kg-K
```

```
Cv = 0.67;// in kJ/kg-K
P1=1;// in bar
P1= P1*10^5;// in N/m^2
P2=3.5;// in bar
P2= P2*10^5;// in N/m^2
V1= 0.12;// in m^3
V2= 0.05;// in m^3
m=1;// in kg
R= Cp-Cv;// in kJ/kg-K
R= R*10^3;// in J/kg-K
// Formula P*V= m*R*T
T1= P1*V1/(m*R);// in K
// Formula P1*V1/T1 = P2*V2/T2
T2= P2*V2*T1/(P1*V1);// in K
T= T2-T1;// Temperature rise in K
disp(T,"Temperature rise in K is : ")
E= m*Cv*(T2-T1);// change in internal energy kJ
disp(E,"Change in internal energy in kJ is : ");
```

Scilab code Exa 2.22 Average gas density

```
// Example 2.22
clc;
clear;
close;
// Given data
CO2= 0.12;//volume of CO2 in m^3
CO= 0.25;// in m^3
H2= 0.06;// in m^3
CH4= 0.02;// in m^3
N2= 0.55;// in m^3
R= 8.3143;// Universal gas constant in kJ/kg-mol-K
mm_CO2= 44;// molecular mass of CO2
mm_CO= 28;
mm_H2= 2;
```

```
mm_CH4= 16;
mm_N2= 28;
Gm_CO2= 5.28;// gravimetric mass of CO2
Gm_CO= 7.00;
Gm_H2= 0.12;
Gm_CH4= 0.32;
Gm_N2= 15.40;
total_Gm= Gm_CO2+Gm_CO+Gm_H2+Gm_CH4+Gm_N2;
Per_relative_CO2= Gm_CO2/total_Gm*100;// in %
Per_relative_CO= Gm_CO/total_Gm*100;// in %
Per_relative_H2= Gm_H2/total_Gm*100;// in %
Per_relative_CH4= Gm_CH4/total_Gm*100;// in %
Per_relative_N2= Gm_N2/total_Gm*100;// in %
disp("Analysis % Relative : ")
disp("CO2    :    "+string(Per_relative_CO2))
disp("CO      :    "+string(Per_relative_CO))
disp("H2       :    "+string(Per_relative_H2))
disp("CH4    :    "+string(Per_relative_CH4))
disp("N2      :    "+string(Per_relative_N2))
App_Gas_Constant= R/total_Gm;// in kJ/kg-K
mol_Vol= 22.4;//mole volume at NTP in m^3
Average_Density= total_Gm/mol_Vol;// in kg/m^3 at
    NTP
disp(App_Gas_Constant,"The Apparent gas constant in
    kJ/kg-K is : ")
disp(Average_Density,"The average density in kg/m^3
    at NTP. is : ")
```

Scilab code Exa 2.23 Internal energy of the gas

```
// Example 2.23
clc;
clear;
close;
// Given data
```

```
Cv = 652;// in J/kg-K
R= 287;// in J/kg-K
Cp= Cv+R;// in J/kg-K
m=0.3;// in kg
P= 1.5*10^5;// in N/m^2
V= 0.283;// in m^3
// Formula P*V= m*R*T
T= P*V/(m*R);// in K
T= T-273;// in  C
T1= -40;// in  C
delta_U= m*Cv*(T-T1);// in J
disp(delta_U*10^-3,"Internal energy in kJ is : ")
```

Scilab code Exa 2.24 Apparent molecular mass

```
// Example 2.24
clc;
clear;
close;
// Given data
H2= 0.50;//volume of H2 in m^3
CH4= 0.19;// in m^3
CO= 0.18;// in m^3
C2H4= 0.02;// in m^3
CO2= 0.05;// in m^3
N2= 0.06;// in m^3
P= 100;// pressure of mixture in kN/m^2
mm_CO2= 44;// molecular mass of CO2
mm_CO= 28;
mm_H2= 2;
mm_CH4= 16;
mm_C2H4= 28;
mm_N2= 28;
R= 8.3143;// Universal gas constant in kJ/kg-mol-K
R_H2= R/mm_H2;// gas constant for H2
```

```
R_CO2= R/mm_CO2;
R_CO= R/mm_CO;
R_C2H4= R/mm_C2H4;
R_CH4= R/mm_CH4;
R_N2= R/mm_N2;
M= mm_CO2*CO2+mm_H2*H2+mm_CH4*CH4+mm_CO*CO+mm_C2H4*
    C2H4+mm_N2*N2;// in kg
disp(M,"Apparent molecular mass of the gas in kg is
    : ")
mol_Vol= 22.4;//mole volume at NTP in m^3
density= M/mol_Vol;// in kg/m^3
disp(density,"Density of the mixture in kg/m^3 is :
    ")
mixture_G_constant= R/M;// in kJ/kg-K
disp(mixture_G_constant,"The mixture gas constant in
     kJ/kg-K is : ")
P_H2= P*H2;//partial pressure of H2 in kN/m^2
P_CH4= P*CH4;// in kN/m^2
P_CO= P*CO;// in kN/m^2
P_C2H4= P*C2H4;// in kN/m^2
P_CO2= P*CO2;// in kN/m^2
P_N2= P*N2;// in kN/m^2
disp(P_H2,"The partial pressure of H2 in kN/m^2")
disp(P_CH4,"The partial pressure of CH4 in kN/m^2")
disp(P_CO,"The partial pressure of CO in kN/m^2")
disp(P_C2H4,"The partial pressure of C2H4 in kN/m^2"
    )
disp(P_CO2,"The partial pressure of CO2 in kN/m^2")
disp(P_N2,"The partial pressure of N2 in kN/m^2")
```

Chapter 3

Thermodynamic Processes

Scilab code Exa 3.1 New pressure and temperature

```
// Exa 3.1
clc;
clear;
close;
// Given data
P = 2.15 * 10^5;// in N/m^2
T = 20;// in degree C
T = T + 273;// in K
V = 0.20;// in m^3
R = 0.2927;// in kJ/kg-K
R = R * 10^3;// in J/kg-K
m = (P*V)/(T*R);//in kg
Q = 20*10^3;// in J
C_v = 0.706*10^3;// in J/kg-K
theta = Q/(m*C_v);// in degree C
T = T - 273;// in degree C
T1 = theta + T;// new temp. in degree C
disp(T1,"New temperature in degree C is");
T1 = T1 + 273;// in K
T = T + 273;// in K
P2 = P * (T1/T);// in N/m^2
```

```
P2 = P2 * 10^-3;// in kN/m^2
disp(P2,"New pressure in kN/m^2 is");
```

Scilab code Exa 3.2 Initial temperature of air

```
// Exa 3.2
clc;
clear;
close;
// Given data
P = 350;// in kN/m^2
P = P * 10^3;// in N/m^2
m = 1;// in kg
m = m * 10^3;// in gram
V = 0.35;// in m^3
C_p = 1.005;// in kJ/kg-K
C_v = 0.710;// in kJ/kg-K
R = C_p - C_v;// in kJ/kg-K
T = (P*V)/(m*R);// in K
T = T - 273;// in degree C
disp(T,"The intial temperature in degree C is");
T = T + 273;// in K
T1 = 316;// in degree C
T1 = T1 + 273;// in K
P2 = P * (T1/T);// in N/m^2
P2 = P2 * 10^-3;// in kN/m^2
disp(P2,"The final pressure of air in kN/m^2 is");
T = T - 273;// in degree C
T1 = T1 - 273;// in degree C
m = m * 10^-3;// in kg
Q = m * C_v * (T1-T);// in kJ
disp(Q,"Heat added in kJ is");
G = m*C_v * (T1-T);// Gain of internal energy in kJ
disp(G,"Gain of internal energy in kJ is");
G_enthalpy = m*C_p*(T1-T);// Gain of enthalpy in kJ
```

```
disp(G_enthalpy,"Gain of enthalpy in kJ is");
```

Scilab code Exa 3.3 Heat added

```
// Exa 3.3
clc;
clear;
close;
// Given data
P = 3.2;// in bar
P = P * 10^5;// in N/m^2
R = 292.7;// in kJ/kg-K
C_p = 1.003;// in kJ/kg-K
m = 1;
V1 = 0.3;// in m^3
V2 = 2*V1;// in m^3
W = P*(V2-V1);// in J
W =  W * 10^-3;// in kJ
disp(W,"The work done in kJ is");
T1 = (P*V1)/(m*R);// in K
disp(T1-273,"The intail Temperature in  C is");
T2 = T1*(V2/V1);// in K
disp(T2-273,"The final temperature in  C is");
Q = m*C_p*(T2-T1);// in kJ
disp(Q,"The Heat added in kJ is");

// Note: To evaluate the value of Heat added, wrong
   value of T1 is putted (i.e 273 k  at place of 328
   K), so the answer of Heat added is wrong in the
   book.
```

Scilab code Exa 3.4 Heat transferred from the gas

```
// Exa 3.4
clc;
clear;
close;
// Given data
R = 0.29;// in kJ/kg-K
R = R * 10^3;// in J/kg-K
C_p = 1.005;// in kJ/kg-K
T = 185;// in degree C
T = T + 273;// in K
T2 = 70+273;// in K
V1 = 0.23;// in m^3
P = 500;// in kN/m^2
P = P * 10^3;// in N/m^2
m = (P*V1)/(R*T);// in kg
Q = m*C_p*(T2-T);// in kJ
disp(Q,"Heat transferred in kJ is");
disp("i.e. "+string(abs(Q))+" kJ heat has been
   abstracted from the gas")
V2 = V1*(T2/T);// in m^3
W = P * (V2-V1);// in J
W= W*10^-3;//in kJ
disp(W,"The work done in kJ is");
disp("i.e. "+string(abs(W))+" kJ work has been done
   on the gas ")
R= R*10^-3;// in kJ/kg-K
C_v = C_p - R;// in kJ/kg-K
I_E = m*C_v*(T2-T);// Change in internal energy in
   kJ
disp(I_E,"Change in internal energy in kJ is");
disp("i.e. "+string(abs(I_E))+" kJ energy is
   decrease in internal energy")
```

Scilab code Exa 3.5 Final pressure

```
// Exa 3.5
clc;
clear;
close;
// Given data
P1 = 1.1;// in MN/m^2
P1 = P1 * 10^6;// in N/m^2
V1 = 1.5;// in m^3
V2 = 7.5;// in m^3
P2 = (P1*V1)/V2;// in kN/m^2
P2 = P2 * 10^-6;// in MN/m^2
P2 = P2 * 10^3;// in kN/m^2
disp(P2,"The final pressure in kN/m^2 is");
W = P1*V1*log(V2/V1);// in J
W = W * 10^-3;// in kJ
disp(W,"The work done in kJ is");

// Note : There is an error in calculation to find
   the value of Work Done. So the answer in the book
    is wrong
```

Scilab code Exa 3.6 Final pressure and temperature

```
// Exa 3.6
clc;
clear;
close;
// Given data
P1 = 2800000;// in N/m^2
P1 = P1 * 10^-6;// in MN/m^2
C_p = 1.024;// in kJ/kg-K
C_v = 0.7135;// in kJ/kg-K
V1 = 1;// in m^3. (asuumed )
V2 = 5*V1;// in m^3
T1 = 220;// in degree C
```

```
T1 = T1 + 273;// in K
Gamma = C_p/C_v;
P2 = (P1*(V1)^Gamma)/((V2)^Gamma);// in MN/m^2
disp(P2,"The final pressure in MN/m^2 is");
T2 = (P2/P1)*V2*T1;// in K
disp(T2-273,"The final temperature in degree C is");
R = C_p-C_v;// in kJ/kg-K
W = (R*(T1-T2))/(Gamma - 1);// in kJ
disp(W,"Work done in kJ is");
```

Scilab code Exa 3.7 Value of Cp and Cv

```
// Exa 3.7
clc;
clear;
close;
// Given data
W = 89.947;// in kJ
T1 = 240;// in degree C
T1=T1+273;// in K
T2 = 115;// in degree C
T2=T2+273;// in K
C_v = W/(T1-T2);// in kJ/kg-K
disp(C_v,"The value of Cv in kJ/kg-K is");
V1 = 1;// in m^3 (assumed)
V2 = 2*V1;// in m^3
// (T1/T2) = (V2/V1)^(Gamma - 1)
Gamma=log10(T1/T2)/log10(V2/V1)+1;
Gamma = 1.4;
C_p = Gamma * C_v;// in kJ/kg-K
disp(C_p,"The value Cp in kJ/kg-K is");
```

Scilab code Exa 3.8 Pressure temperature and internal energy

```
// Exa 3.8
clc;
clear;
close;
// Given data
P = 7;// in bar
P = P *10^5;// in N/m^2
R = 0.287;// in kJ/kg-K
R=R*10^3;// in J/kg-K
Gamma = 1.4;
T = 100;// in degree C
T = T + 273;// in K
V = (R*T)/P;// in m^3
disp(V,"The volume of one kg of air in m^3 is : ")
C_v = 0.718;// in kJ/kg
T=T-273;// in degree C
InternalEnergy= C_v*T;// in kJ/kg
disp(InternalEnergy,"Internal energy of 1 kg air in
    kJ/kg is : ")
P1= P;// in bar
V1 = 1;// in m^3 (assumed)
V2 = 4 * V1;// in m^3
T1= T;// in degree C
T1=T1+273;// in K
P2 = (P * (V1)^Gamma)/((V2)^Gamma);// in N/m^2
disp(P2*10^-5,"The final pressure in bar is");
T2 = (P2*V2)/(P1*V1)*T1// in K
T2 = T2 - 273;// in degree
disp(T2,"The final temperature in degree C is");
I_E = C_v * T2;// in kJ/kg
disp(I_E,"Internal energy in kJ/kg is");
```

Scilab code Exa 3.9 Final pressure temperature and internal energy

```
// Exa 3.9
```

```
clc;
clear;
close;
// Given data
Gamma = 1.41;
C_v = 0.703;// in kJ/kg-K
P1 = 105;// in kN/m^2
P2 = 2835;// in kN/m^2
T1 = 15;// in degree C
T1 = T1 + 273;// in K
m = 0.2;// in kg
// Formula T2/T1 = (P2/P1)^((Gamma-1)/Gamma)
T2 = T1*(P2/P1)^((Gamma-1)/Gamma);// in K
T2 = T2 - 273;// in degree C
disp(T2,"The final temperature in degree C is");
T2 = T2+273;// in K
I_E = m*C_v*(T2-T1);// in kJ
disp(I_E,"Change in internal energy in kJ is");
W = I_E;// in kJ
disp(W,"Work done in kJ is");

// Note: There is an error to calculate the value of
    T2, and this wrong value is putted to evaluate
   the value of Change in internal energy but the
   value of Change in internal energy is calculated
   correc.
```

Scilab code Exa 3.10 Pressure and temperature at the end of compression

```
// Exa 3.10
clc;
clear;
close;
// Given data
P1= 100;// in N/m^2
```

```
T1 = 30;// in degree C
T1 = T1 + 273;// in K
C_v = 0.718;// in kJ/kg-K
//C_v= C_v*10^3;// in J/kg-K
R = 287.1;// in J/kg-K
d = 15;// in cm
l = 20;// in cm
V = (%pi/4)*(d)^2*l;// in cm^3
V = V * 10^-3;// in litre
Clear_V = 1.147;// clearance volume
Vol = V+Clear_V;//volume of air at beginning of compression in litre
ROC = Vol/Clear_V;// Ratio of compression
P2 = P1*(Vol/Clear_V)^1.2;// in kN/m^2
disp(P2,"The pressure at the end of compression in kN/m^2 is");
T2 = (P2*Clear_V*T1)/(P1*Vol);// in K
T2 = T2 - 273;// in degree C
T1 = T1 - 273;// in degree C
T = T2-T1;// in degree C
disp(T,"The temperature at the end of compression in degree C is");
T1 = T1 + 273;// in K
m = (P1*Vol)/(R*T1);// in kg
I_E = m*C_v*T;// in kJ
disp(I_E,"The change in internal energy in kJ is");
```

Scilab code Exa 3.11 Final volume temperature and work done

```
// Exa 3.11
clc;
clear;
close;
// Given data
V1 = 2.5;// in litre
```

```
P1  = 1400;// kN/m^2
P2 = 280;//in kN/m^2
T1 = 1100;// in  C
T1 = T1 + 273;// in K
n = 1.28;
V2 = V1 * (P1/P2)^(1/1.28);// in litres
disp(V2,"Final volume in litres is");
T2 = T1  * ((P2*V2)/(P1*V1));// in K
T2 = T2  - 273;// in degree C
disp(T2,"Final temperature in degree C is");
W = (P1* V1 - P2*V2)/(n-1);// in Joules
disp(W*10^-3,"Work done in kJ is");
```

Scilab code Exa 3.12 The value of index

```
// Exa 3.12
clc;
clear;
close;
// Given data
Gamma = 1.4;
P1 = 780;// in kN/m^2
P2 = 100;// in kN/m^2
V1 = 750;// in cm^3
V1= V1*10^-6;// in m^3
V2 = (1/5)*V1;// in m^3
n = (log(P1/P2))/(log(V1/V2));
disp(n,"The value of index is");
W = (P1*V2-P2*V1)/(1-n);// in kJ
disp(W,"Work done in kJ is");
Q = ((Gamma - n)/(Gamma-1)) * (-W);// in kJ
disp("Heat rejected during Compression in kJ is "+
    string(Q)+" kJ or "+string(Q*10^3)+" joules");
```

Scilab code Exa 3.13 Change in entropy of air

```
// Exa 3.13
clc;
clear;
close;
// Given data
T1 = 40;// in degree C
T1 = T1  +273;// in K
P2 = 50;// in bar
P1 = 1;// in bar
Gamma = 1.4;
C_v = 0.718;// in kJ/kg-K
SpeHeat = 1.005;// in kJ/kg-K
HeatSupply= 125.6;// in kJ/kg
T2 = T1 * (P2/P1)^((Gamma-1)/Gamma);// in K
C_p = C_v * (T2-T1);// in kJ/kg
del_T = HeatSupply/SpeHeat;// in degree C
del_U = C_v * del_T;// in kJ/kg
disp(del_U,"Change in internal energy in kJ/kg is");
T3 = T2  + del_T;// in K
del_Phi = SpeHeat * log(T3/T2);// in kJ/kg-K
disp(del_Phi,"Change in entropy during constant
    pressure in kJ/kg-K is");
```

Scilab code Exa 3.14 Gain of entropy

```
// Exa 3.14
clc;
clear;
close;
// Given data
```

```
P1 = 30;// in bar
P1= P1*10^5;// in N/m^2
V1 = 0.85;// in m^3
V2 = 4.25;// in m^3
W = P1 *V1 * log(V2/V1);// in Joules
W = W * 10^-3;// in kJ
T = 400;// in K
del_U = W/T;// in kJ/K
disp(del_U,"Change in entropy in kJ/K is");
```

Scilab code Exa 3.15 Change of entropy

```
// Exa 3.15
clc;
clear;
close;
// Given data
C_P = 1.041;// in kJ/kg-K
C_V = 0.743;// in kJ/kg-K
R = C_P - C_V;// in kJ/kg-K
P1 = 140;// in kN/m^2
P2 = 1400;// in kN/m^2
V1 = 0.14;// in m^3
T1 = 25;// in degree C
T1 = T1 + 273;// in K
Gamma = 1.4;
n = 1.25;
m = (P1 *  10^3 *V1)/(R * 10^3 * T1);// in kg
V2 = V1 * (P1/P2)^(1/n);// in m^3
del_U = C_P * (log(V2/V1))  + C_V * (log(P2/P1));//
   in kJ/kg-K
del_U = m * del_U;// in kJ/K
disp("Part (i)")
disp(del_U,"Change in entropy in kJ/K is");
T2 = T1 * (V1/V2)^(n-1);// in K
```

```
del_U1 = C_P * (log(T2/T1)) - R*(log(P2/P1));// in
    kJ/kg-K
disp("Part (ii)")
disp(del_U1,"Change in entropy in kJ/kg-K is");
del_U2 = C_V * (log(T2/T1)) + R*(log(V2/V1));// in
    kJ/kg-K
disp("Part (iii)")
disp(del_U2,"Change in entropy in kJ/kg-K is");
del_U3 = C_V * (Gamma-n) * (log(V2/V1));// in kJ/kg-
    K
disp("Part (iv)")
disp(del_U3,"Change in entropy in kJ/kg-K is");
del_U4 = C_V * ((Gamma-n)/(n-1)) * (log(T1/T2));//
    in kJ/kg-K
disp("Part (v)")
disp(del_U4,"change in entropy in kJ/kg is");
del_U5 = C_V * ((Gamma-n)/n) * (log(P1/P2));// in kJ
    /kg-K
disp("Part (vi)")
disp(del_U5,"Change in entropy in kJ/kg-k is");
```

Scilab code Exa 3.16 Entropy

```
// Exa 3.16
clc;
clear;
close;
// Given data
P1 = 1;// in bar
P2 = 15;// in bar
T1 = 0;// in degree C
T1 = T1 + 273;// in K
T2 = 200;// in degree C
T2 = T2 + 273;// in K
C_P = 1.005;// in kJ/kg-K
```

```
C_V = 0.718;// in kJ/kg-K
R = C_P-C_V;// in kJ/kg-K
del_U = C_P * (log(T2/T1)) - R*(log(P2/P1));// in kJ
    /kg-K
disp(del_U,"Change in entropy in kJ/kg-K is");
```

Scilab code Exa 3.17 Change of entropy

```
// Exa 3.17
clc;
clear;
close;
// Given data
C_V = 2.174;// in kJ/kg-K
R = 0.5196;// in kJ/kg-K
C_P = C_V+R;// in kJ/kg-K
V2 = 1;// in m^3
V1 = 8;// in m^3
P1 = 0.7;// in bar
P2 = 7;// in bar
del_U = C_P * (log(V2/V1)) + C_V * (log(P2/P1));//
    in kJ/kg-K
m = 0.9;// in kg
del_U = m * del_U;// in kJ/K
disp(del_U,"Change in entropy in kJ/K is");
disp("It is a loss of entropy")
```

Scilab code Exa 3.18 Total enthalpy

```
// Exa 3.18
clc;
clear;
close;
```

```
// Given data
C_P = 1.005;// in kJ/kg-K
C_V = 0.718;// in kJ/kg-K
R = C_P - C_V;// in kJ/kg-K
R= R*10^3;//in J/kg-K
P1 = 3*10^5;//in N/m^2
V1 = 1.5;// m^3
T1 = 15;// in degree C
T1 = T1  +273;// in K
m1 = (P1*V1)/(R* T1);// in kg
m2 = m1+2;//final mass of air in kg
P2 = P1 * (m2/m1);// in kN/m^2
T1 = T1 - 273;// in degree C
T2 = 0;// in degree C
m = 1;// in kg
del_U = m * C_P * (T1-T2);// kJ
disp(del_U,"Total enthapy of air in kJ is");
```

Scilab code Exa 3.19 Temperature molecular mass and specific volume

```
// Exa 3.19
clc;
clear;
close;
// Given data
R = 0.287;// in kJ/kg-K
P1 = 30;// in bar
V1 = 0.12;// in m^3
m = 1.8;// in kg
U= 8.3143;// in kJ/kg-mol-K
T1 = (P1 * 10^5 * V1)/(m*R*10^3);// in K
T1 = T1 - 273;// in degree C
disp(T1,"The temperature in degree C is");
m_m = U/R;// in kg
disp(m_m,"The molecular mass in kg is");
```

```
V_s = V1/m;// in m^3
disp(V_s,"The Specific volume in m^3 is');
V_m = V_s * m_m;// in m^3
disp(V_m,"Molecular volume in m^3 is");
```

Scilab code Exa 3.20 Composition of the mixture by mass

```
// Exa 3.20
clc;
clear;
close;
// Given data
T=15+273;//in K
U= 8.3143;// in kJ/kg-mol-K
GasConstant = 0.618;// in kJ/kg-K
GasVolume= 1;// in m^3 (assume)
AirVolume= 1.5*GasVolume;// in m^3
P=760;// in mm
P= P/750;// in bar
P= P*10^5;//in N/m^2
MixtureVolume= GasVolume+AirVolume;//in m^3
disp("Percentage of gas by volume in the mixture in
    % is : ")
PGM= GasVolume/MixtureVolume*100;// in %
disp(PGM);
disp("Percentage of air by volume in the mixture in
    % is : ")
PAM= AirVolume/MixtureVolume*100;// in %
disp(PAM);
M1= U/0.287;// in mol
M2= U/0.618;// in mol
M= PAM/100*M1+PGM/100*M2;// mass of mixture in mol
R= U/M;// gas constant in kJ/kg-K
R= R*10^3;//in J/kg-K
disp(R*10^-3,"The gas constant in kJ/kg-K is : ");
```

```
disp("Percentage of air by mass in the mixture in %
    is ")
PAM1= PAM*M1/M;// in %
disp(PAM1);
disp("Percentage of gas by mass in the mixture in %
    is ")
PGM1= PGM*M2/M;// in %
disp(PGM1);
Rho= P/(R*T);// kg/m^3
disp(Rho,"The density of the gas in kg/m^3 is : ")
```

Scilab code Exa 3.21 Difference between work done by air

```
// Exa 3.21
clc;
clear;
close;
// Given data
Gamma = 1.4;
P1 = 7;// in bar
P1= P1*10^5;// in N/m^2
V1 = 1.6;// in m^3
V2 = 8;// in m^3
P2 = (P1 * (V1)^(Gamma))/((V2)^(Gamma));// in bar
W1 = (P1*V1-P2*V2)/(Gamma-1);//work done by the gas
    during isentropic expansion in J
Rho = V2/V1;
W2 = P1*V1*(log(Rho));//work done by the gas during
    isothermal expansion in J
del_W = W2-W1;// in J
disp(del_W*10^-3,"Difference between the work done
    during isentropic and isothemal expansion in kJ
    is");
```

Scilab code Exa 3.22 Temperature of the gas

```
// Exa 3.22
clc;
clear;
close;
// Given data
P1 = 1;// in  bar
V1 = 400;// in  cm^3
V2 = 80;// in Cm^3
T1 = 110;// in degree C
T1  = T1 + 273;// in K
Gamma = 1.3;
P2 = P1*((V1/V2)^(Gamma));// in bar
disp(P2,"The pressure in bar is");
T2 = T1 * ((P2*V2)/(P1*V1));// in K
T2 = T2-273;//in degree C
disp(T2,"The temperature in degree C is");
T2 = T2 + 273;// in K
m = 1;
C_V = 0.75;
del_U = m*C_V*(T2-T1);// in kJ
disp(del_U,"Change in internal energy in kJ is");
P1= P1*10^5;// in N/m^2
P2= P2*10^5;// in N/m^2
V1= V1*10^-3;// in litre
V2= V2*10^-3;// in litre
W = (P1*V1-P2*V2)/(Gamma-1);// in J
W = abs(W * 10^-3);// in kJ
disp(W,"Work done in kJ is");
P3 = 40*10^5;// in N/m^2
T3 = (P3/P2) * T2;// in K
T3 = T3 - 273;// in degree C
disp(T3,"Temperature of gas in degree C is");
```

Scilab code Exa 3.23 Total work done during the whole process

```
// Exa 3.23
clc;
clear;
close;
// Given data
C_P = 1.068;// in kJ/kg-K
C_V = 0.775;//in kJ/kg-K
R = C_P-C_V;// in kJ/kg-K
R= R*10^3;// in J/kg-K
P1 = 12;// in bar
P1= P1*10^5;// in N/m^2
V1 = 0.15;//in m^3
V2= 0.28;// in m^3
m = 1;// in kg
T1 = (P1*V1)/(R* m);// in K
T2 = T1 * (V2/V1);// in K
disp(T2-273,"Temperature at the end of Constant
    pressure in  C is");
W = P1* (V2-V1);// in J
W = W * 10^-3;// in kJ
Gamma = 1.38;
V3 = 1.5;// in m^3
T3 = T2/((V3/V2)^(Gamma-1));// in K
T3 = T3 - 273;// in degree C
disp(T3,"Temperature at the end of Isentropic in  C
     is");
T3 = T3 + 273;// in K
W1 = m *C_V*(T2-T3);//work done during isentropic
    expansion in kJ
W2 = W+W1;// in kJ
disp(W2,"Total Work done on in kJ is");
```

Scilab code Exa 3.24 Internal energy change

```
// Exa 3.24
clc;
clear;
close;
// Given data
C_P = 1.005;// in kJ/kg-K
C_V = 0.718;// in kJ/kg-K
R = C_P-C_V;// in kJ/kg-K
P1 = 20;//in bar
P2 = 12;// in bar
T1 = 200;//in degree C
T1 = T1 + 273;// in K
T2 = 125;//in degree c
T2 = T2 + 273;// in K
V1 = (R*10^3*T1)/(P1*10^5);// in m^3
V2 = (R*10^3*T2)/(P2*10^5);// in m^3
W = 10^5 * integrate('-293*V + 40','V'
    ,0.0679,0.0952);//in Joules
W = round(W * 10^-3);// in kJ
disp(W,"Work done in kJ is");
m = 1;// in kg
del_U = m*C_V*(T2-T1);//change in internal energy in
     kJ
disp(del_U,"Change in internal energy in kJ is");
disp("Negative sign indicates that there is decrease
     in internal energy of the gas. ")
C_Enthalpy = m*C_P*(T2-T1);//change in enthalpy in
    kJ
disp(C_Enthalpy,"The change in enthalpy in kJ is :")
disp("Negative sign indicates that there is decrease
     in enthalpy of the gas")
Q = W+ del_U;// in kJ
```

```
disp(Q,"Heat transfer in kJ is");
disp("Negative sign indicates that the heat is
   rejected by the air")
```

Scilab code Exa 3.25 Change in internal energy

```
// Exa 3.25
clc;
clear;
close;
// Given data
P1 = 14;// in bar
P3 = 2.222;// in bar
V3byV1 = P1/P3;
P2 = 1.05;// in bar
Gamma = log(P1/P2)/log(V3byV1);
C_P = 1.005;// in kJ/kg-K
C_V = C_P/Gamma;// in kJ/kg-K
T3 = 343;// in degree C
T3 = T3 + 273;// in K
T2 = ceil(T3*P2)/P3;// in K
m = 0.5;// in kg
del_U = m*C_V*(T2-T3);// in kJ
disp(del_U,"Change in internal energy in kJ is");
disp("i.e. there is a loss of "+string(abs(del_U))+"
    kJ of internal energy")
```

Scilab code Exa 3.26 Mass of oxygen used

```
// Exa 3.26
clc;
clear;
close;
```

```
// Given data
R = 0.26;// in kJ/kg-K
R = R * 10^3;// in J/kg-K
Gamma = 1.4;
P1 = 3.1;// MN/m^2
P1 = P1 * 10^6;// N/m^2
P2 = 1.7;// in  MN/m^2
P2 = P2 * 10^6;// in N/m^2
V1 = 500;// in cm^3

T = 18;// in degree C
T = T + 273;// in K
T2 = 15;// in degree C
T2 = T2 + 273;// in K
m = (P1*V1)/(R*T)*10^-3;// in kg
m_desh = (P2*V1)/(R*T2)*10^-3;//in kg
M = m-m_desh;// in kg
disp(M,"The mass of oxygen in kg is");
R = R * 10^-3;// in kJ/kg-K
C_v = R/(Gamma-1);// in kJ/kg-K
Q = m_desh*C_v * (T-T2);// kJ
disp(Q,"Heat transfered in kJ is");
```

Scilab code Exa 3.27 The change in internal energy and in enthalpy

```
// Exa 3.27
clc;
clear;
close;
// Given data
P1 = 1 * 10^5;// in N/m^2
V1 = 0.1;// in m^3
V2 = 0.01;// in m^3
T1 = 90;// in degree C
T1 = T1  +273;// in K
```

```
R = 0.287;// in kJ/kg-K
R = R  *10^3;
C_v = 0.717;// in kJ/kg-K
C_P = 1.005;// in kJ/kg-K
m = (P1 * V1)/(R*T1);// in kg
Gamma = 1.4;
T2 = T1 * ((V1/V2)^(Gamma - 1));// in K
del_U = m*C_v*(T1-T2);// in kJ
disp(del_U,"The change in internal energy in kJ is : ")
del_E = m * C_P*(T2-T1);// in kJ
disp(del_E,"The change in enthalpy in kJ is : ")
U2 = m*C_v*T2;//Internal energy at 2 in kJ
T= 473;// temp. of entering air
E = V1*C_P*T;//Enthalpy of entering air in kJ
// U3= (m+V1)*C_v*T3 ; (internal energy at 3)
// U3= U2+E
T3 = (E+U2)/( (m+V1)*C_v );// in K
disp(T3,"Temperature in K is");
m=m+.1;
P3 =m* R*T3/V2;// in N/m^2
disp(P3*10^-6,"The pressure in MN/m^2 is");

// Note: There is a calculation error to evaluating the value of P3. So the answer in the book of P3 is wrong.
```

Scilab code Exa 3.28 temperature of gas in the cylinder

```
// Exa 3.28
clc;
clear;
close;
// Given data
T= 60+273;// in K
```

```
T2= 25+273;// in K
P1=3.5*10^6;// in Pa
P2=1.7*10^6;// in Pa
Gamma=0.4;// value of Cp-Cv
m1=1;// (assumed value)
// R= P1*V/(m*T)                (i)
// R= P2*V/((m-m1)*T2) (ii)
// From eq(i) and (ii)
m= m1*P1*T2/(P1*T2-P2*T);
// U= m*Cv*T and U1= (m-m1)*Cv*T2+m1*Cv*T1
// U-U1= P1*V1= m1*R*T1 or
// m1*R*T1= m*Cv*T-[(m-m1)*Cv*T2+m1*Cv*T1]
T1= (m*T-(m-m1)*T2)/(m1*Gamma+m1);// in K
disp(T1-273,"The temperature of gas in the cylinder
   in  C is : ")
```

Scilab code Exa 3.29 Work transfer

```
// Exa 3.29
clc;
clear;
close;
/// Given data
U=180;// energy received by system in kJ
RH= 200;// rejected heat by system in kJ
RcHeat= 50;// received heat by system in kJ
W= U-RH+RcHeat;// in kJ
U1 = 0;// in kJ
U2= U+U1;// in kJ
U3 = RcHeat-RH+U2;// in kJ
disp(U3,"Internal energy in kJ is");
```

Scilab code Exa 3.30 Initial value of entropy

```
// Exa 3.30
clc;
clear;
close;
// Given data
C_P = 1.045;// in kJ/kg-K
Q = 100;// in kJ
del_T = Q/C_P;// in degree C
T1 = 25;// in degree C
T1 = T1 + 273;// in K
T = 0;// in degree C
T = T + 273;// in K
T2 = T1 + del_T;// in K
del_Phi = C_P * (log(T2/T1));// in kJ/kg-K
disp(del_Phi,"The change in entropy in the process
    in kJ/kg-K is");
ini_entropy = C_P * (log(T1/T));// initial entropy
    in in kJ/kg-K
disp(ini_entropy,"The initial entropyin kJ/kg-K is")
    ;
```

Chapter 4

Availability

Scilab code Exa 4.1 Entropy production accompanying the heat transfer

```
// Example 4.1
clc;
clear;
close;
// Given data
Q= 1000;// in kJ
T1= 1000;// in K
T2= 400;// in K
delta_Qsource= -Q/T1;// in kJ/K
delta_Qsystem= Q/T2;// in kJ/K
delta_Qnet=delta_Qsystem+delta_Qsource;// in kJ/K
disp(delta_Qnet,"The entropy production accompanying
    the heat transfer in kJ/K is : ")
T0= 300;// in K
Q1= Q-T0*abs(delta_Qsource);// in kJ
Q2= Q-T0*abs(delta_Qsystem);// in kJ
LossOfEnergy= Q1-Q2;// in kJ
disp(LossOfEnergy,"The decrease in available energy
   after heat transfer in kJ is : ")
```

Scilab code Exa 4.2 The increase in unavailable energy

```
// Example 4.2
clc;
clear;
close;
// Given data
T1= 800+273;// in K
T2= 400+273;// in K
T3= 179+273;// in K
T0= 25+273;// in K
Q= 2018.4;// heat taken by water in kJ/kg
// Formula mCp*(T1-T2)= Q
mCp= Q/(T1-T2);
delta_Qgas= mCp*integrate('1/T','T',T1,T2);// in kJ/
    K
delta_Qwater= Q/T3;// in kJ/K
delta_Qnet= delta_Qwater+delta_Qgas;//  in kJ/K
disp(delta_Qnet,"Net entropy changes in kJ/K is : ")
E1= T0*abs(delta_Qgas);// Original unavailable
    energy in kJ
E2= T0*delta_Qwater;//unavailable energy after heat
    transfer in kJ
E= E2-E1;// in increase in unavailable energy in kJ
disp(E,"The increase in unavailable energy in kJ is
    : ")

// Note: There is some difference in the value of
    increase in unavailable energy because in the
    book the value of change of entropy of the gas is
     not correct.
```

Chapter 5

Air standard Cycles

Scilab code Exa 5.1 Efficiency of heat engine

```
// Exa 5.1
clc;
clear;
close;
// Given data
T1 = 550;// in degree C
T1 = T1 + 273;// in K
T2 = 27;// in degree C
T2 = T2 + 273;// in K
Eta = ((T1-T2)/T1)*100;// in %
disp(Eta,"Maximum possible efficiency for staem
   turbine plant in % is");
T1 = 2500;// in degree C
T1 = T1 + 273;// in K
T2 = 400;// in degree C
T2 = T2 + 273;// in K
Eta = ((T1-T2)/T1)*100;// in %
disp(Eta,"Maximum possible efficiency for internal
   combustion engine in % is");
T1 = 450;// in degree C
T1 = T1 + 273;// in K
```

```
T2 = 15;// in degree C
T2 = T2 + 273;// in K
Eta = ((T1-T2)/T1)*100;// in %
disp(Eta,"Maximum possible efficiency for nuclear
   power plant in % is");
```

Scilab code Exa 5.2 Efficiency of a four stroke cycle gas engine

```
// Exa 5.2
clc;
clear;
close;
// Given data
D = 0.3;// in m
L = 0.45;// in m
V_s = (%pi/4)*(D)^2*L;// in m^3
V_c = 0.0114;// in m^3
V = V_c+V_s;// in m^3
r = V/V_c;
Gamma = 1.4;
Eta = (1-((1/r)^(Gamma-1)))*100;// in %
disp(Eta,"Efficiency of engine in % is");
```

Scilab code Exa 5.3 Pressure and temperature

```
// Exa 5.3
clc;
clear;
close;
// Given data
P1 = 0.93;// in bar
T1 = 93;// in degree C
T1 = T1 + 273;// in K
```

```
V2 = 1;// assumed
V1 = 8.5*V2;
r = V1/V2;
Gamma = 1.4;
P2 = P1 * ((V1/V2)^(Gamma));// in bar
disp(P2,"Pressure at the beginning of compression stroke in bar is");
T2 = (P2*V2*T1)/(P1*V1);// in K
disp(T2-273,"Temperature at the beginning of compression stroke in  C")
P3 = 38;// in bar
T3 = T2 * (P3/P2);// in K
disp(P3,"Pressure at the beginning of expansion stroke in bar is : ")
disp(T3-273,"Temperature at the beginning of expansion stroke in  C is :")
V3 = V2;
V4 = V1;
P4 = P3 * ((V3/V4)^(Gamma));// in bar
T4 = T1 * (P4/P1);// in K
disp(P4,"Pressure at the end of expansion stroke in bar is :")
disp(T4-273,"Temperature at the end of expansion stroke in  C is :")
Eta = 1 - (1/((r)^(Gamma-1)));
Eta = Eta * 100;// in %
disp(Eta,"Standard air efficiency in % is");
```

Scilab code Exa 5.4 Consumption of gas

```
// Exa 5.4
clc;
clear;
close;
// Given data
```

```
CalorificValue= 14.887*10^3;// in kJ/m^3
Vs= 1;// in m^3 (assumed)
Vc= 0.25*Vs;// clearance volume in m^3
V= Vs+Vc;// in m^3
Ratio= V/Vc;// ratio of compression
Gamma= 1.4;
r= 5;
Eta=1-1/(r^(Gamma-1)) ;
Eta= Eta*100;// in %
disp(Eta,"Air standard efficiency in % is :")
Eta_Th= Eta*60/100;// thermal efficiency
disp(Eta_Th,"Thermal efficiency in % is : ")
Eta_br_th= Eta_Th*75/100;// break thermal efficiency
disp(Eta_br_th,"Brake thermal efficiency in % is :")
E= 3600;// energy equivalent of brake in kJ
GasConsumption= E/CalorificValue;// in m^3
disp(GasConsumption,"The consumption of gas in m^3
    is :")
```

Scilab code Exa 5.7 Efficiency of dual combustion engine

```
// Exa 5.7
clc;
clear;
close;
// Given data
Gamma = 1.4;
r = 8;
Eta = 1 - (1/((r)^(Gamma-1)));
Eta = Eta  * 100;// in %
disp(Eta,"Otto engine efficiency in % is");
r = 13;
x = 1;
Rho = 2.5;
Eta = 1-(1/r)^(Gamma-1)*[(Rho^Gamma-1)/(Gamma*(Rho
```

```
    -1))];
Eta = Eta * 100;// in %
disp(Eta,"Diesel engine efficiency in % is");
r = 13;
x = 3.5;
Rho = 2.5;
Eta = 1-(1/r)^(Gamma-1)*[(x*Rho^Gamma-1)/((x-1)+x*
    Gamma*(Rho-1))];
Eta = Eta * 100;// in %
disp(Eta,"Dual engine efficiency in % is");
```

Scilab code Exa 5.8 Efficiency of engine

```
// Exa 5.8
clc;
clear;
close;
// Given data
D = 15;
L = 25;
V_s = (%pi/4) * (D)^2 * L;// in cm^3
V_c = 400;// in cm^3
V = V_s+V_c;// in cm^3
r = V/V_c;
Rho = (V_c +( V_s*(5/100) ))/V_c;
Gamma = 1.4;
Eta = 1-((1/r)^(Gamma-1)) * ( (((Rho)^(Gamma))-1)/(
    Gamma*(Rho-1)) );
Eta = Eta * 100;// in %
disp(Eta,"Efficiency of diesel cycle in % is");

// Note: Calculation in the book is wrong, So the
    answer in the book is wrong
```

Scilab code Exa 5.9 Temperature at the end of compression stroke

```
// Exa 5.9
clc;
clear;
close;
// Given data
C_P = 0.966;// in kJ/kg-K
C_v = 0.712;// in kJ/kg-K
T1 = 83;// in  degree C
T1  =T1 + 273;// in K
T3 = 1800;// in degree C
T3 = T3+273;// in K
r = 13;
Gamma = 1.4;
T2 = T1 * (r)^(Gamma-1);// in K
disp(T2-273,"Temperature at the end of compression
   in  C is");
Rho = T3/T2;
T4 = ((Rho)^(Gamma)) * T1;// in K
disp(T4-273,"Temperature at the end of expansion in
    C is");
Q = C_P * (T3-T2);// in kJ
disp(Q,"Heat supplied at constant pressure in kJ is"
   );
Q1 = C_v * (T4-T1);// in kJ
disp(Q1,"Heat rejected at constant volume in kJ is")
   ;
Eta = ((Q-Q1)/Q) * 100;// in %
disp(Eta,"Thermal efficiency in % is");

// Note: The answer in the book is not accurate
```

Scilab code Exa 5.11 Ratio of expansion

```
// Exa 5.11
clc;
clear;
close;
// Given data
r = 10;
Gamma = 1.4;
P1 = 1;// in bar
P2 = 1 * ((r)^(Gamma));// in bar
P3 = 40;// in bar
P4 = P3;// in bar
T1 = 80;// in degree C
T1 = T1+273;// in K
T2 = T1 * ((r)^(Gamma-1));// in K
T3 = (P3/P2)*T2;// in K
T4 = 1700;// in degree C
T4 = T4 + 273;// in K
Vc= 1;// in m^3(assumed)
V4= Vc*T4/T3;
V1= 10*Vc;// volume at beginning of compression in m
    ^3
Vs= V1-Vc;// in m^3
PercentageStroke= (V4-Vc)/Vs*100;// in %
disp(PercentageStroke,"Percentage of stroke at which
    heat reception must stop is : ")
r= V1/V4;
P5= P4/r^Gamma;// in bar
disp("Ratio of work done during expansion to that
    done during compression is ")
ratio= (P4*V4-P5*V1)/(P2*Vc-P1*V1);
disp(ratio)
```

Scilab code Exa 5.12 Mean effective pressure of the cycle

```
// Exa 5.12
clc;
clear;
close;
// Given data
P1 = 1;// in bar
T1 = 320;// in K
r= 11.6;
Vc= 1;// in m^3 (assumed)
Vs= 10.6*Vc;//in m^3
V1= r*Vc;// in m^3
Gamma= 1.4;
P2= P1*r^Gamma;// in bar
V2= Vc;// in m^3
V3= Vc;// in m^3
V4=1.38*Vc;// in m^3
P3= 1.53*P2;// in bar
P4= P3;// in bar
expansionRatio= V1/V4;
P5= P4/expansionRatio^Gamma;// in bar
V5= r*Vc;// in m^3
W= [P3*(V4-Vc)+(P4*V4-P5*V5)/(Gamma-1)-(P2*V2-P1*V1)
    /(Gamma-1)]*10^5;// in joule
Pm= W/(Vs*10^4);// in N/cm^2
disp(Pm,"The mean effective pressure of the cycle in
     N/cm^2")

// Note: The calculation in the book is wrong
```

Scilab code Exa 5.13 Ideal efficiency

```
// Exa 5.13
clc;
clear;
close;
// Given data
C_P = 0.998;// in kJ/kg-K
C_v = 0.707;//in kJ/kg-K
T1 = 15;// in degree C
T1 = T1  +273;// in K
T2 = 400;// in degree C
T2 = T2 + 273;// in K
Eta = (1 - (T1/T2))*100;// in %
disp(Eta,"The ideal efficiency when engine is fitted with a perfect regenerator in % is");
R = C_P-C_v;// in kJ/kg-K
r = 3;
Eta_r = 0.8;
Eta = ((R*(log(r)))*(T2-T1))/( (R*(log(r))*T2) + (1-Eta_r) * C_v * (T2-T1) )*100;// in %
disp(Eta,"The ideal efficicency when efficiency of the regenrator is 0.8 in % is");
```

Scilab code Exa 5.14 Power developed per kg of air supplied per second

```
// Exa 5.14
clc;
clear;
close;
// Given data
T1 = 15;// in degree C
T1 = T1 + 273;// in K
P1 = 1;// in bar
P2 = 5;// in bar
Gamma = 1.4;
T2 = T1 * ((P2/P1)^((Gamma-1)/Gamma));// in K
```

```
C_P = 1.003;// in kJ/kg-K
CompWork = C_P*(T2 - T1);// Compressure work in kJ/kg
T3 = 800;// in degree C
T3 = T3 + 273;// in K
T4 = T3/((P2/P1)^((Gamma-1)/Gamma));// in K
T4= round(T4);// in K
turbineWork = C_P * (T3-T4);// Turbine work in kJ/kg
Q = C_P * (T3-T2);// Heat input in kJ/kg
W = turbineWork-CompWork;// in kJ/kg
W= round(W);//in kJ/kg
Eta = (W/Q)* 100;// in %
disp(round(Eta),"the thermal efficiency of plant in % is");
disp("Output of gas turbine installation is "+string(W)+" kW per kg of flow per second")
```

Scilab code Exa 5.15 The efficiency of cycle

```
// Exa 5.15
clc;
clear;
close;
// Given data
C_v = 0.711;// in kJ/kg-K
T3 = 850;// in degree C
T3 = T3 + 273;// in K
T2 = 90;// in degree C
T2 = T2 + 273;// in K
E = C_v * (log(T3/T2));// Entropy change in kJ/kg-K
disp(E,"Entrophy change in kJ/kg-K is");
W = (E * (T3-T2))/2;//output work in kJ/kg
Q = T2+E;//rejected heat in kJ/kg
Q1 = W + Q;//heat supplied in kJ/kg
Eta = (W/Q1);// in %
```

```
disp(Eta,"The efficiency of cycle in % is");
```

Chapter 6

Properties of Steam and Steam Cycle

Scilab code Exa 6.1 Work done

```
// Exa 6.1
clc;
clear;
close;
// Given data
P = 10;// in bar
P = P  *10^5;// in N/m^2
V = 2;//volume of water in m^3
W = P * V;// in J
W = W * 10^-6;// in MJ
disp(W,"Work done in MJ is");
```

Scilab code Exa 6.2 External work done

```
// Exa 6.2
clc;
```

```
clear;
close;
// Given data
P = 1.013;// atm pressure in bar
P = P * 10^5;// in N/m^2
area= 1000*10^-4;// in m^2
L_w = 1000;// in N
P_L = L_w/area;// Pressure due to load in N/m^2
PressOnPiston = P_L+P;// absolute pressure to piston
    in N/m^2
a = 10^-3;// in m^2
disp("Energy required to pump 1 kg of water at 0 C
    into the cylinder in joules is:")
U = PressOnPiston*a;// in Joules
disp(U);
// Part (b)
absPressure= 111.3*10^3;// in N/m^2
increaseInVol= (1.02-1)*10^-3;// in m^3
disp("Energy required to effect the change in volume
    in joules is : ")
u_f= increaseInVol*absPressure;// in joules
disp(u_f);
// Part (c)
increaseInVol= (1.52-0.001);// in m^3
ExternalWorkDone= absPressure*increaseInVol;// in
    joules
disp(ExternalWorkDone*10^-3,"External work done in
    kJ is :")
```

Scilab code Exa 6.3 Dryness fraction of steam

```
// Exa 6.3
clc;
clear;
close;
```

```
// Given data
m_s = 92.3;// mass of steam in kg
m_w = 0.78;// mass of water in kg
m = m_s + m_w;// total mass in kg
D_s = 92.3;// Dry steam in kg
D_F = D_s/m;// Dryness fraction
disp(D_F,"Dryness fraction is");
```

Scilab code Exa 6.4 Heat necessary to raise the temperature

```
// Exa 6.4
clc;
clear;
close;
// Given data
L = 693.3;// Liquid heat in kJ/kg
L1 = 125.7;// Liquid heat of feed water in kJ/kg
m = 2;// mass of water in kg
Q = m * (L-L1);// in kJ
disp(Q,"Heat required to raise temperature in kJ is"
    );
disp("The water is still liquid at the end of the
    heat supply")
```

Scilab code Exa 6.5 Heat required

```
// Exa 6.5
clc;
clear;
close;
// Given data
x = 0.9;
h_f = 762.2;// in kJ/kg
```

```
h_fg = 2013.8;// in kJ/kg
H_wet = h_f + (x*h_fg);// in kJ/kg
En = 125.7;// Enthapy of liquid in kJ/kg
H_wet = H_wet - En;// in kJ
disp(H_wet,"When dry fraction is 0.9, Heat required,
    to convert in kJ is");
// Part (b) when dry fraction is saturated
H_sat = h_f + h_fg;// in kJ/kg
H_sat = H_sat-En;// in kJ
disp(H_sat,"Heat required when steam is dry and
    saturated in kJ is");
C_P = 2.093;// in kJ/kg-K
t_sup = 300;// in degree C
t_sat = 179.9;// in degree C
H_sup = h_f + h_fg + C_P*(t_sup-t_sat);// in kJ
H_sup1 = H_sup - En;// in kJ
disp(H_sup1,"Heat required when the steam is super
    heated in kJ is");
```

Scilab code Exa 6.6 Specific volume of steam

```
// Exa 6.6
clc;
clear;
close;
// Given data
x = 0.95;
v_f = 0.001;
v_g = 0.1238;// in m^3/kg
V_wet = ((1-x)*v_f)+(x*v_g);// in m^3 correction
    little diff in ans
disp(V_wet,"Specific volume of wet steam in m^3 is")
    ;
disp(v_g,"When the steam is dry saturated, the
    specific volume in m^3/kg is");
```

```
T_sat = 201.3;// in degree C
T_sat = T_sat + 273;// in K
T_sup = 300;// in degree C
T_sup = T_sup + 273;// in K
V_sup = v_g  * (T_sup/T_sat);// in m^3
disp(V_sup,"When the steam is superheated , the
   specific volume in m^3 is");
```

Scilab code Exa 6.7 Internal energy

```
// Exa 6.7
clc;
clear;
close;
// given data
h_f = 720.7;// in kJ
h_fg = 2046.6;// in kJ
v_g = 0.2405;// in m^3
x = 0.9;
P = 8*10^2;// in kN/m^2
U_sat = h_f+x*h_fg-x*v_g*P;// in kJ
disp(U_sat,"When the steam is wet, the internal
   energy in kJ is");
En = 2767.3;// Enthalpy of dry saturated stream
U_sat = En-(v_g*P);//in kJ/kg
disp(U_sat,"When the steam is dry and saturated , the
    internal energy in kJ/kg is");
C_P = 2.093;
del_s = 100;// in degree C
H_sup = h_f + h_fg + (C_P*del_s);// in kJ/kg
t_sat = 170.4+273;// in K
V_sup = (v_g*(t_sat+del_s))/t_sat;// in m^3
U_sup = H_sup - P*V_sup;// in kJ/kg
disp(U_sup,"When the steam is super heated , the
   internal energy in kJ/kg is");
```

Scilab code Exa 6.8 Heat units

```
// Exa 6.8
clc;
clear;
close;
// Given data
x = 0.88;// dryness fraction
h_fg = 2392.7;// in kJ/kg
H_wet = x * h_fg;// in kJ/kg
Vs = 14.67;// Specific volume in m^3/kg
V_wet = x * Vs;// in m^3/kg
Q = H_wet/V_wet;// in kJ/m^3
disp(Q,"Heat to be extracted in kJ/m^3 is");
```

Scilab code Exa 6.9 The enthalpy

```
// Exa 6.9
clc;
clear;
close;
// Given data
P = 12*10^2;// in kN/m^2
h_f = 798.1;// in kJ/kg
h_fg = 1984.5;// in kJ/kg
x = 0.8;
H_wet = h_f + (x*h_fg);// in kJ/kg
v_f = 0.001;// in m^3
v_g = 0.1684;// in m^3
V_wet = ((1-x)*v_f) + (x*v_g);// in m^3
En = H_wet/V_wet;// kJ/m^3
```

```
disp(En,"The enthalpy in kJ/m^3 is");
U_wet = H_wet - ( V_wet * P );// in kJ
U_wet1 = (U_wet/V_wet);// in kJ/m^3
disp(U_wet1,"Internal energy in kJ/m^3 is");

// Note: There is calculation error to find the value of V_wet.( the correct value of V_wet is 0.13492 not 0.1308), so there is some difference between the output of coding and the answer of the book
```

Scilab code Exa 6.10 Entropy of 1 kg of steam

```
// Exa 6.10
clc;
clear;
close;
// Given data
T = 0;// in degree C
T = T + 273;// in K
T_sat = 179.9;// in degree C
T_sat = T_sat + 273;// in K
x = 0.8;
h_fg = 2013.8;// in kJ/kg
c_f = 4.188;
Phi_wet = c_f*log(T_sat/T)+x*h_fg/T_sat;// in kJ/kg-K
disp(Phi_wet,"The entropy of wet steam in kJ/kg-K is");
Phi_g = (c_f*(log(T_sat/T))) + (h_fg/T_sat);// in kJ/kg-K
disp(Phi_g,"The entropy of dry saturated steam in kJ/kg-K is");
C_P = 2.3;
T_sup = 200+273;// in K
```

```
Phi = c_f *log(T_sat/T) + h_fg/T_sat+  C_P*log(T_sup
   /T_sat);// in kJ/kg-K
disp(Phi,"The entropy of superheated steam in kJ/kg-
   K is");
```

Scilab code Exa 6.11 Value of specific entropy

```
// Exa 6.11
clc;
clear;
close;
// Given data
T_sat = 198.3;// in degree C
T_sat = T_sat + 273;// in K
T_sup = 300;// in degree C
T_sup = T_sup + 273;// in K
c_f = 4.188;
h_fg = 1945;// in kJ/kg-K
T = 273;// in K
C_P = 2.093;// in kJ/kg-K
Phi_sup =c_f *log(T_sat/T)+h_fg/T_sat+C_P*log(T_sup/
   T_sat);// in kJ/kg-K
disp(Phi_sup,"The value of specific entropy in kJ/kg
   -K is");
```

Scilab code Exa 6.12 Dryness fraction of steam

```
// Exa 6.12
clc;
clear;
close;
//Given data
P = 16;// in bar
```

```
m_w = 73;// in gm
m_s = 980;// in gm
x = m_s/(m_s+m_w);
disp(x,"Dryness fraction of steam is");
```

Scilab code Exa 6.13 Dryness fraction of steam

```
// Exa 6.13
clc;
clear;
close;
// Given data
P1 = 7;// in bar
P2 = 1.2;// in bar
h_f1 = 696.9;// in kJ/kg
h_fg1 = 2065;// in kJ/kg
h_g2 = 2684.9;// in kJ/kg
T_sup = 112;// in degree C
T_sat = 104.77;// in degree C
C_P = 2.1;// in kJ/kg
x1 = (h_g2+(C_P*(T_sup-T_sat))-h_f1)/h_fg1;
disp(x1,"Dryness fraction of steam is");
```

Scilab code Exa 6.14 Minimum dryness fraction of steam

```
// Exa 6.14
clc;
clear;
close;
// Given data
P1 = 14;// in bar
P2 = 1.2;// in bar
h_f1 = 830;
```

```
h_fg1 = 1958;
h_g2 = 2684.9;
x = (h_g2-h_f1)/h_fg1;
disp(x,"Dryness fraction of steam is");
```

Scilab code Exa 6.15 Dryness fraction in the steam main

```
// Exa 6.15
clc;
clear;
close;
// Given data
m_s = 2.2;// in kg
m_w = 0.18;// in kg
x1 = m_s/(m_s+m_w);
h_f1 = 743;
h_fg1 = 2031;
h_g2 = 2685;
C_P = 2;
T_sup = 115;// in degree C
T_sat = 104.8;// in degree C
x2 = (h_g2 + (C_P*(T_sup-T_sat)) - h_f1)/h_fg1;
x = x1 *  x2;
disp(x,"The dryness fraction of steam is");
```

Scilab code Exa 6.16 Quantity of circulating water required

```
// Exa 6.16
clc;
clear;
close;
// Given data
h_f1 = 232;// in kJ/kg
```

```
h_fg = 2369;// in kJ/kg
x = 0.8;
h_f2 = 167.5;// in kJ/kg
H_wet1 = h_f1 + (x*h_fg);// in kJ/kg
H_wet = H_wet1 - h_f2;// in kJ/kg
T1 = 38;// in degree C
T2 = 25;// in degree C
T = T1-T2;// in degree C
SpeHeat = 4.188;// in kJ/kg-K
m = H_wet/(T*SpeHeat);// in kJ/kg
disp(round(m),"The quantity of circulating water
   required of condensed steam in kJ/kg is");
```

Scilab code Exa 6.17 Final condition of steam

```
// Exa 6.17
clc;
clear;
close;
// Given data
V1 = 0.4;// volume of dry saturated steam
P1 = 1.5;// in MN/m^2
disp("Part (i) :  For Isothermal operation :")
Vs = 0.1318;// specific volume of dry steam
m = V1/Vs;// quantity of steam present in the vessel
    in kg
h_f1= 844.6;// in kJ/kg
x1= 0.5;// dryness fraction
h_fg1= 1945.2;// in kJ/kg
Specific_Enth= h_f1+x1*h_fg1;// in kJ/kg
En= Specific_Enth*m;// kJ
disp(En,"Enthalpy of the fluid in kJ is : ")
HeatLost= m*(1-x1)*h_fg1;// in kJ
disp(HeatLost,"The loss of heat during the constant
   temperature process in kJ is : ");
```

```
disp("Part (ii) : For Hyperbolic operation :")
h_f2= 1008.3;// in kJ/kg
h_fg2= 1794;// in kJ/kg
Vs= 0.0659;// Specific volume after compression in m
    ^3/kg
Vs1= 0.0666;// Specific volume of dry saturated
    steam in m^3/kg
x2=Vs/Vs1;
H_wet= h_f2+x2*h_fg2;// in kJ/kg
H= m*H_wet;// in kJ
disp(H,"Enthalpy of the fluid in kJ is :")
```

Scilab code Exa 6.18 Velocity of steam

```
// Exa 6.18
clc;
clear;
close;
// Given data
P = 13.5;// power developed by engine in kW
P1 = 12;// Steam consumption of the engine in kg/kWh
S_C = P*P1;//steam consumed per hour  in kg
S_C = S_C/60;// in kg/min
x = 0.85;
V_g = 1.430;
Volume = x * V_g;// in m^3/kg
Volume = S_C * Volume;// in m^3
d = 15*10^-2;//diameter of exhaust pipe in meter
A = (%pi/4) * (d)^2;// in m^2
C = Volume/A;// in meter/minute
disp(C,"The velocity of steam in metre/minute is");
```

Scilab code Exa 6.19 Dryness fraction of steam

```
// Exa 6.19
clc;
clear;
close;
// Given data
P = 2;//pressure of steam in bar
m = 0.1;//mass of steam in kg
V = 0.080;//volume of steam in m^3
V1 = 0.8872;//volume of 1kg dry saturated steam in m
    ^3
x = V/(m*V1);
disp(x,"Dryness fraction of steam is");
```

Scilab code Exa 6.20 Condition of steam

```
// Exa 6.20
clc;
clear;
close;
// Given data
P1 = 7+ 1;// in bar
H = 2767;// Enthalpy in kJ/kg
P2 = 1.5+1;// in bar
H1 = 2717;// enthalpy of 1kg of dry steam in kJ/kg
H_sup = H - H1;// Superheated of 1kg of steam in kJ
S1 = 2.17;// super heated steam in kJ/kg-K
theta = H_sup/S1;// in degree C
T_sat = 127.4;// in degree C
T_sup = T_sat + theta;// in degree C
disp(T_sup,"The super heated temperature in degree C
     is");
```

Scilab code Exa 6.21 Temperature of feed water leaving the heating

```
// Exa 6.21
clc;
clear;
close;
// Given data
T_sat = 99.6;// in degree C
h_fg = 2258;// in kJ/kg
m = 1;// steam output of the boiler in (assumed)
m1 = 0.03;// exhaust steam
x = 0.9;
T1 = 21;// in degree C
Cp = 4.187;// kJ/kg-K
// Formula m1*(Cp*(T_sat-t)+x*h_fg)= m*Cp*(t-T1)
t= (m1*(Cp*T_sat+x*h_fg)+m*Cp*T1)/(Cp*(m+m1))
disp(t,"Temperature of the feed water leaving the
    heater in degree C is");
```

Scilab code Exa 6.22 Quantity of water sprayed

```
// Exa 6.22
clc;
clear;
close;
// Given data
T = 20;// in degree C
H1 = 3039;// Enthalpy in kJ/kg
H2 = 2725;// Enthalpy of 1kg dry saturated steam
H_sup = H1-H2;// superheat of 1kg of steam in kJ/kg
H= 2621.4;// heat required for 1kg or water in kJ
m = H_sup/H;// in kg
disp(m,"Quantity of water in kg is");
```

Scilab code Exa 6.23 Heat received by steam

```
// Exa 6.23
clc;
clear;
close;
// Given data
x = 0.9;
h_f1 = 1087.4;// in kJ/kg
h_fg1 = 1712.9;// in kJ/kg
H_wet1 = h_f1 + (x*h_fg1);// in kJ/kg
H_sup2 = 3095;// in kJ/kg
H = H_sup2 - H_wet1;// in kJ/kg
disp(H,"Heat recieved in kJ/kg is");
```

Scilab code Exa 6.24 Pressure and condition of steam

```
// Exa 6.24
clc;
clear;
close;
// Given data
V_fg =0.1632;// in m^3
T_sup = 200;// in degree C
T_sup = T_sup + 273;// in K
T_sat = 188;// in degree C
T_sat = T_sat + 273;// in K
V_sup = (V_fg*T_sup)/T_sat;// in m^3/kg
V = 0.24;// Capacity of the vessel in m^3
Q = V/V_sup;// in kg
V1 = 0.9774;//volume of 1kg dry saturated steam in m
    ^3
x = V_sup/V1;
disp(x,"Dryness fraction of steam is");
```

Scilab code Exa 6.25 Mass of steam in vessel

```
// Exa 6.25
clc;
clear;
close;
// Given data
V = 0.6;// in m^3
P2 = 2*10^2;// in kN/m^2
P1 = 10*10^2;// in kN/m^2
m = V/0.1946;// in kg
V_s = 0.8872;// Specific volume of dry saturated
    steam in m^3
x = 0.1946/V_s;
h_f1 = 505;// in kJ/kg
h_fg1 = 2202;// in kJ/kg
H2 = m*(h_f1 + (x*h_fg1));// in kJ
H1 = m*2776;// in kJ
Q = (H2-H1) - (V*(P2-P1));// in kJ
disp(m,"The mass of steam in the vessel in kg is : "
    )
disp(x,"The dryness fraction of steam in the vessel
    is : ")
disp(Q,"The amount o heat transferred in kJ is");
disp("Thus during cooling process there is loss of
    heat")
```

Scilab code Exa 6.26 Total energy and internal energy

```
// Exa 6.26
clc;
clear;
close;
// Given data
x1 = 0.95;
```

```
P1 = 9;// in bar
P1= P1*10^2;// in kN/m^2
h_f1 = 743;// in kJ/kg
h_fg1 = 2030;// in kJ/kg
V = 0.204;// in m^3
x2 = 0.544
P2 = 5;// in bar
P2= P2*10^2;// in kN/m^2
h_f2 = 640;// in kJ/kg
h_fg2 = 2108;// in kJ/kg
H_wet1 = h_f1 + (x1*h_fg1);// in kJ/kg
disp(H_wet1,"Total energy in kJ/kg is");
U1 = H_wet1 - P1*V;// in kJ/kg
disp(U1,"The internal energy in kJ/kg is : ")
V_g1 = 0.204;// in m^3
V1 = 0.3753;//volume of 1kg of dry stream in m^3
x2 = V_g1/V1;
H_wet2 = h_f2 + (x2*h_fg2);// in kJ
U2 = H_wet2 - P2*V;// in kJ
del_U = U1-U2;// in kJ
H = del_U/V;// in kJ
disp(H,"Heat removed from 1 m^3 of steam in kJ is");
```

Scilab code Exa 6.27 Mass of steam present

```
// Exa 6.27
clc;
clear;
close;
// Given data
P1 = 2.1;// in MN/m^2
P1= P1*10^3;//in kN/m^2
P2 = 0.7;// in MN/m^2
P2= P2*10^3;//in kN/m^2
V1 = 0.1281;// in m^3
```

```
x = 0.9;
n = 1.25;
h_f1= 920;// in kJ/kg
h_fg1= 1878.6;// in kJ/kg
h_f2= 697.0;// in kJ/kg
h_fg2= 2065.0;// in kJ/kg
V_wet1 = x * 0.0949;// in m^3/kg
m = V1/V_wet1;// in kg
disp(m,"Mass of steam in kg is");
V2 = V1*((P1/P2)^(1/n));//in m^3
del_W = (P1*V1-P2*V2)/(n-1);// in kJ
disp(del_W,"External work done in kJ is");
V_2 = V2/m;// in m^3/kg
x2 = V_2/0.273;
H1= h_f1+x*h_fg1;// in kJ/kg
U1= H1-P1*V_wet1;// in kJ/kg
H2= h_f2+x2*h_fg2;// in kJ/kg
U2= H2-P2*V_2;// in kJ/kg
del_E = m*(U2-U1);//in kJ
disp(del_E,"Change in internal energy in kJ is");
Q = del_W +del_E;// in kJ
disp(Q,"Heat exchange in kJ is");
disp("Heat is lost to the surroundings.")
```

Scilab code Exa 6.28 Amount of heat put into or extracted from the steam

```
// Exa 6.28
clc;
clear;
close;
// Given data
h_f1 = 670;// in kJ/kg
h_fg1 = 2085;// in kJ/kg
h_f2 = 475;// in kJ/kg
h_fg2 = 2221;// in kJ/kg
```

```
P2 = 6*10^2;// in kJ/kg
P1 = 1.6*10^2;// in kJ/kg
n = 1.1;
x1 = 0.9;
V1 = 0.3159;// in m^3
V2 = 1.092;// in m^3
H_wet = h_f1 + (x1*h_fg1);// in kJ/kg
V_wet1 = x1*V1;// in m^3
V_wet2 = V_wet1*(P2/P1)^(1/n);// in m^3
x2 = V_wet2/V2;
H_wet2 = h_f2 + (x2*h_fg2);// in kJ/kg
U2= H_wet2-H_wet+P2*V_wet1-P1*V_wet2;// in kJ/kg
W= (P2*V_wet1-P1*V_wet2)/(n-1);// in kJ/kg
Q= U2+W;// in kJ/kg
disp(Q,"Heat recieved by steam in kJ/kg is");
```

Scilab code Exa 6.29 Final dryness fraction

```
// Exa 6.29
clc;
clear;
close;
// Given data
P1 = 0.85*10^3;// in kN/m^2
P2 = 0.17*10^3;// in kN/m^2
n = 1.13;
x1 = 0.95;
V1 = x1*0.227;// in m^3/kg
V2 = V1 * ((P1/P2)^(1/n));// in m^3/kg
x2 = V2/1.032;
disp(x2,"Final dryness fraction of steam is");
W = (P1*V1-P2*V2)/(n-1);// in kJ/kg
disp(W,"Change in internal energy in kJ/kg is");
```

Scilab code Exa 6.30 Final temperature of steam

```
// Exa 6.30
clc;
clear;
close;
// Given data
Cp= 2.3;// in kJ/kg-K
T_sat= 179.9;// in  C
T_sat= T_sat+273;// in K
H= 3052;// enthalpy in kJ/kg
P= 10*10^2;// in kN/m^2
h_f= 763;// in kJ/kg
h_fg= 2015;// in kJ/kg
V= 0.1944;// in m^3
// Formula H= h_f+h_fg*Cp*(t_sup-T_sat)-P*V*(t_sup/
   T_sat)
t_sup= (h_f+h_fg-Cp*T_sat-H)/(P*V/T_sat-Cp);// in K
t_sup= t_sup-273;// in  C
disp(t_sup,"The final temperature of the steam in
    C is : ")
```

Scilab code Exa 6.31 Increase in entropy

```
// Exa 6.31
clc;
clear;
close;
// Given data
m1 = 3;// in kg
m2 = 2;// in kg
T1 = 10;// in degree C
```

```
T2 = 80;// In Degree C
T = ((m1*T1)+(m2*T2))/(m1+m2);// in degree C
T = T + 273;// in K
T1 = T1 + 273;// in K
T2 = T2 + 273;// in K
c_f = 4.188;
del_phi1 = m1 * c_f*log(T/T1);// in kJ/K
del_phi2 = m2 * c_f*log(T/T2);// in kJ/K
Phi = del_phi1 + del_phi2;// in kJ/K
disp(Phi,"Total change in entropy in kJ/K is")
```

Scilab code Exa 6.32 Rankine efficiency

```
// Exa 6.32
clc;
clear;
close;
// Given data
P1 = 15;// in bar
P2 = 0.15;// in bar
T_sat = 198.3;// in degree C
T_sat = T_sat + 273;// in K
h_fg1 = 1947;// in kJ/kg
h_fg2= 2369;// in kJ/kg
h_g1 = 845;// in kJ/kg
h_f2 = 232;// in kJ/kg
f_g2 = 7.985;// in kJ/kg-K
x1 = 0.8;
Phi_f1 = 2.315;// in kJ/kg-K
Phi_f2 = 0.772;// in kJ/kg-K
Phi1 = Phi_f1 + ((x1*h_fg1)/T_sat);// in kJ/kg-K
H1 = h_g1 + (x1*h_fg1);// in kJ/kg-K
Phi2 = Phi1;// in kJ/kg-K
x2 = (Phi1 - Phi_f2)/(f_g2 - Phi_f2);
H2 = h_f2 + (x2*h_fg2);// in kJ/kg
```

```
Eta = ((H1-H2)/(H1-h_f2))*100;// in %
disp("Part (i) When the steam supply is wet and dryness fraction is 0.8")
disp(Eta,"Rankine efficiency in % is");
delH = H1-H2;//theoretical work of steam in kJ/kg
W = delH*60/100;// in kJ/kg
Energy_Equivalent= 3600;// in kJ
Steam_C = Energy_Equivalent/W;// Steam consumption in kg
disp(Steam_C,"Steam consumption per kW-hr in kg is : ")
disp("Part (ii) When the steam supply is dry and saturated")
H_1 = 2792;// in kJ/kg
Phi_g1 = 6.445;// in kJ/kg-K
x_2 = (Phi_g1-Phi_f2)/(f_g2-Phi_f2);
H_2 = h_f2 + (x_2*h_fg2);// in kJ/kg
Eta1 = (H_1-H_2)/(H_1-h_f2);
disp("Rankine efficiency is "+string(Eta1)+" or "+string(Eta1*100)+" %");
W1 = (H_1-H_2)*60/100;// in kJ/kg
Steam_C= Energy_Equivalent/W1;// in kg
disp(Steam_C,"Steam consumption per kW-hr in kg is : ")
disp("Part (iii) When steam is superheated and temperature is 300 C")
H_1 = 3039;// in kJ/kg
Phi_1 = 6.919;// in kJ/kg-K
x_2 = (Phi_1 - Phi_f2)/(f_g2-Phi_f2);
H_2 = h_f2 + (x_2 * h_fg2);// in kJ/kg
Eta = (H_1 - H_2)/(H_1-h_f2);
disp("Rankine efficiency is "+string(Eta)+" or "+string(Eta*100)+" %");
W2 = (H_1-H_2)*60/100;// in kJ/kg
Steam_C= Energy_Equivalent/W2;// in kg
disp(Steam_C,"Steam consumption per kW-hr in kg is : ")
```

Scilab code Exa 6.33 Rankine efficiency

```
// Exa 6.33
clc;
clear;
close;
// Given data
T1 = 400;// in degree C
T1 = T1 + 273;// in K
T2 = 72.7;// in degree C
T2 = T2 + 273;// in K
Eta = ((T1-T2)/T1)*100;// in %
disp("For carnot cycle : ")
disp(Eta,"Rankine efficiency in % is : ")
H1 = 3248;// in kJ/kg
h_f2 = 304.5;// in kJ/kg
del_H = 809.2;// in kJ/kg
Eta = (del_H/(H1-h_f2))*100;// in %
disp("For Rankine cycle : ")
disp(Eta,"Rankine efficiency in % is");
```

Scilab code Exa 6.34 Efficiency of cycle

```
// Exa 6.34
clc;
clear;
close;
// Given data
P1 = 15;// in bar
H1 = 3039;// in kJ/kg
V_g1 = 0.1697;// in m^3/kg
Phi1 = 6.919;// in kJ/kg-K
```

```
P2_desh = 3.5*10^2;// in kN/m^2
Phi_g2 = 6.941;// in kJ/kg-K
Phi_f2 = 1.727;// in kJ/kg-K
P2 = 0.15*10^2;// in kN/m^2
h_f2 = 232;// in kJ/kg
x = (Phi1-Phi_f2)/(Phi_g2 - Phi_f2);
h_f = 584;// in kJ/kg
h_fg = 2148;// in kJ/kg
H2 = h_f + (x*h_fg);// in kJ/kg
V = 0.5241;// in m^3
V2=x*V;// in m^3/kg
W = (H1-H2) + (P2_desh-P2)*V2;//work output of the
    cycle in kJ/kg
Eta = W/(H1-h_f2)*100;// in %
disp(Eta,"The efficiency of the cycle in % is");
Energy_equivalent= 3600;// in kJ
S_consumption = Energy_equivalent/W;// in kg
V = S_consumption* V_g1;// in m^3
disp(V,"Total volume of steam in m^3 is");
```

Chapter 7

Flow Process

Scilab code Exa 7.1 Work tranfer

```
// Exa 7.1
clc;
clear;
close;
// Given data
H1 = 2600;// in kJ/kg
H2 = 1850;// in kJ/kg
g = 9.81;
C1 = 10;// in meter/second
C2 = 20;// in meter/secon
Q = 120;// in kJ/kg
Z1 = 30;// in meter
Z2 = 10;// in meter
W = g*(Z1-Z2)/1000+H1-H2+(C1^2-C2^2)/(2*1000)+Q
disp(W,"The work done in kJ/kg is");
```

Scilab code Exa 7.2 Power output of the turbine

```
// Exa 7.2
clc;
clear;
close;
// Given data
H1 = 3100;// in kJ/kg
H2 = 1950;// in kJ/kg
C1 = 20;// in meter/second
C2 = 30;// in meter/secon
Q = 0;// in kJ/kg
Q_desh= 20;// in kJ/kg
Vs= 1.1;// in m^3/kg
W = H1-H2+(C1^2-C2^2)/(2*1000)+Q-Q_desh;// in kJ/kg
m= 2;//mass flow rate in kg/sec
Power= m*W;// in kW
disp(Power,"Power output of the turbine in kW is : "
    )
Area= m*Vs/C2;// in m^2
disp(Area,"Area of exhaust pipe in m^2 is : ")
```

Scilab code Exa 7.3 Velocity of steam

```
// Exa 7.3
clc;
clear;
close;
// Given data
H1 = 2940;// in kJ/kg
H2 = 2630;// in kJ/kg
C = sqrt((H1-H2)*1000*2);// in m/sec
disp(C,"Velocity of the steam leaving the nozzle in
    m/sec is");
```

Scilab code Exa 7.4 Exit velocity and total exit area

```
// Exa 7.4
clc;
clear;
close;
// Given data
H1 = 2800;// in kJ/kg
H2 = 2600;// in kJ/kg
C2 = sqrt(2*(H1-H2)*1000);// in m/s
disp(C2,"Exit velocity in m/s is ");
m_f = 25;// mass flow rate in kg/sec
V = 0.154;// in m^3/kg
A = (m_f*V)/C2;// in m^2
disp(A,"Total exit area in m^2 is");
```

Scilab code Exa 7.5 Mass flow rate

```
// Exa 7.5
clc;
clear;
close;
// Given data
Q = 20;// in kJ/kg
P = 10;// in MW
P = P * 10^3;// in kW
H1 = 3248;// in kJ/kg
H2 = 2552;// in kJ/kg
C1 = 20;// m/s
C2 = 40;// m/s
m = P/((H1-H2+(C1^2-C2^2)/(2*1000))-Q);// in kg/s
disp(m,"Mass in kg is");
```

Scilab code Exa 7.6 Rate of heat transfer

```
// Exa 7.6
clc;
clear;
close;
// Given data
h_f1 = 2584;// in kJ/kg
h_fg1 = 2392;// in kJ/kg
H2 = 192;// in kJ/kg
x = 0.2;
H1 = round(h_f1- (x*h_fg1));// in kJ/kg
x1 = 0.8;
Vs = 14.67;// in m^3
V1 = x1*Vs;// in m^3/kg
A = 0.45;// in m^2
C1 = V1/A;// in m/s
Q = 5;// kJ/s
C2 = 0;
W = 0;
Q_desh = W-H1 - C1^2/(2*1000)-Q+H2+C2^2/2;// in kJ/s
disp(Q_desh,"Rate of heat transfer in kJ/s is");
```

Chapter 8

Fuels and Combustion

Scilab code Exa 8.1 Higher calorific value

```
// Exa 8.1
clc;
clear;
close;
// Given data
C= 85;// in %
H= 12.5;// in %
H1 = 35000;// heat liberated by carbon in kJ
H2 = 143000;// heat liberated by hydrogen in kJ
HCV = (C*H1+H*H2)/100;// Higher calorific value in
    kJ/kg
disp(HCV,"Higher calorific value in kJ/kg is");
ms = 9;
LCV= HCV -(ms*H*2442)/100 ;// Lower calorific value
    in kJ/kg
disp(LCV,"Lower calorific value in kJ/kg is");

// Note: The calculated value in the book is not
    accurate
```

Scilab code Exa 8.2 HCV and LCV

```
// Exa 8.2
clc;
clear;
close;
// Given data
CH4 = 77;// in %
C2H6 = 22.5;//in %
H1 = 40.08;// heat liberated by CH4 in MJ/nm^3
H2 = 69.52;// heat liberated by C2H6 in MJ/nm^3
HCV = (CH4*H1+C2H6*H2)/100;// Higher calorific value
    in kJ/kg
disp(HCV,"The higher calorific value in MJ/nm^3")
V1= CH4*2/100;// volume of water due to combustion
    of CH4 in m^3
V2= C2H6*3/100;// volume of water due to combustion
    of C2H6 in m^3
V= V1+V2;// total volume in m^3
ms= 18/22.41;// in kg
LCV= HCV-ms*V*2.242;// in MJ/nm^3
disp(LCV,"The lower calorific value in MJ/nm^3")
disp("The word nm^3 means that cubic metre at normal
    temperature and pressure")

// Note: The calculated value in the book is not
    accurate
```

Scilab code Exa 8.3 Calorific value of a sample of coal

```
// Exa 8.3
clc;
```

```
clear;
close;
// Given data
mw = 2.5;//mass of water in kg
mc= 0.744;//water equivalen of apparatus in kg
CoalMass = 1.01*10^-3;// in kg
T_r = 2.59;//temp. rise in degree C
C_c = 0.016;// Cooling correction in degree C
theta = T_r +C_c;//corrected temp. rise in degree C
Cp = 4.1868;// in kJ/kg-K
m = mw+mc;// in kg
Qw = m * Cp*theta;//heat received by water in kJ
C = (Qw/CoalMass);// in kJ/kg
disp(C,"Calorific value of the fuel in kJ/kg is");
```

Scilab code Exa 8.4 HCV and LCV

```
// Exa 8.4
clc;
clear;
close;
// Given data
T_r = 2.912;// temp. rise in degree C
C_c = 0.058;//cooling correction in degree C
theta = T_r + C_c;// in degree C
HyCon= 14/100;// Hydrogen content
C_P = 4.1868;// in J/gm-K
Cc = 16750;//calorific value of cotton in J/gm
m_w = 1400;// in gm
m_c = 500;// in gm
m = m_w+m_c;// in gm
m1 = 0.005;//mass of cotton in gm
m2 = 0.579;//mass of oil in gm
Qw = m*C_P*theta ;// in J
H1= m1*Cc;// heat given out by combustion of cotton
```

```
    in J
Qin= Qw-H1;// in J
C= Qin/m2;// J/gm or kJ/kg
LCV= C-2442*9*HyCon;// in J/gm or kJ/kg
disp(C,"Higher Calorific value of the fuel in J/gm
    or kJ/kg is :")
disp(LCV,"Lower Calorific value of the fuel in J/gm
    or kJ/kg is :")
```

Scilab code Exa 8.5 Calorific value

```
// Exa 8.5
clc;
clear;
close;
// Given data
W_c = 500*10^-3;//water collected in kg
C_P = 4.1868;// in kJ/kg-K
T_o = 28.3;//outlet temp. in  C
T_i = 14;//inlet temp. in  C
P_bero= 785;// barometric pressure in mm
P_gas= P_bero+90/13.6;// in mm
T1=17+273;// gas temp. in K
T2= 15+273;// in K
theta = T_o-T_i;//temp. rise in  C
Qw = W_c * C_P*theta;// in kJ
Vgs= 2.8*10^-3;//volume of gas consumed  in m^3
E = Qw/Vgs;// in kJ
V1= P_gas/760*(T2/T1);// in m^3
CalorificValue= E/V1;// in kJ/standard m^3
disp(CalorificValue,"Calorific value in kJ/m^3 is :
    ")
```

Scilab code Exa 8.6 Theoretical mass of air

```
// Exa 8.6
clc;
clear;
close;
// Given data
C = 0.83;// in kg
H = 0.05;// in kg
O = 0.02;// in kg
S = 0.002;// in kg
AbyF_min = (11.6 * C) + +(34.8*(H-(O/8))) + (4.35 *
    S);// in kg
disp(AbyF_min,"The therotical mass of air in kg is")
    ;
```

Scilab code Exa 8.7 Theoretical mass of air

```
// Exa 8.7
clc;
clear;
close;
// Given data
C = 0.86;// in kg
H = 0.14;// in kg
S = 0;// in kg
O = 0;// in kg
Vair = 0.77;//volume of 1kg of air in m^3
Spe_Gravity = 0.8;// specific gravity of petrol
maBYmf = (11.6*C)+(34.8*(H-O/8)) + (4.35*S);// in kg
disp(maBYmf,"The therotical mass of air in kg is");
V = maBYmf *Spe_Gravity*Vair ;// in m^3/litre
disp(V,"Volume of air required in m^3/litre is");
```

Scilab code Exa 8.8 Mass of air

```
// Exa 8.8
clc;
clear;
close;
// Given data
C = 0.75;// in kg
H = 0.08;// in kg
O = 0.03;// in kg
S = 0;// in kg
P = 1.1;// in bar
P = P*10^5;// in N/m^2
maBYmf = (11.6*C) + (34.8 * (H-(O/8))) + (4.35 *S);
    // in kg
disp(maBYmf ,"The mass of air in kg is");
m = 1.5*(maBYmf );// in kg
T = 20+273;// in K
R = 29.27;
V = (m*R*T)/P;// in m^3
disp(V,"Volume in m^3 is");

// Note: The calculated value of V in the book is
    wrong.
```

Scilab code Exa 8.9 Minimum quantity of air

```
// Exa 8.9
clc;
clear;
close;
// Given data
```

```
C = 0.82;// in kg
H2 = .12;// in kg
O2 = 0.02;// in kg
a = C/12;
b = H2/2;
y = (32*(a+(0.5*b))-O2)/0.23;
disp(y,"Minimum quantity of air in kg is");
```

Scilab code Exa 8.10 Percentage analysis of dry flue gas

```
// Exa 8.10
clc;
clear;
close;
// Given data
mC= 0.88;//mass of carbon in kg
mH2= 0.03;//mass of H2 in kg
mS= 0.005;//mass of S in kg
O2_mass= 2.66*mC + 8*mH2 + 2*mS;// in kg
Air_mass= O2_mass/0.23;// in kg
Air_mass= 1.5*Air_mass;// in kg (as 50% excess air
    is supplied)
disp(Air_mass,"Actula mass of air required per kg of
    fuel for complete combustion in kg is : ")
// The flue gases per kg of fuel will be:
CO2= 3.226;// in kg
N2= 13.04;// in kg
O2= 1.298;// in kg
total_mass= CO2+N2+O2;// in kg
CO2_per_by_mass= CO2/total_mass*100;// in %
O2_per_by_mass= O2/total_mass*100;// in %
N2_per_by_mass= N2/total_mass*100;// in %
disp(CO2_per_by_mass,"Percentage of CO2 by mass is :
    ")
disp(O2_per_by_mass,"Percentage of O2 by mass is : "
```

```
)
disp(N2_per_by_mass,"Percentage of N2 by mass is : ")
M_wt_CO2= 44;
CO2_Per_M_com_M_wt= CO2_per_by_mass/M_wt_CO2;// % Mass composition molecular weight
M_wt_O2= 32;
O2_Per_M_com_M_wt= O2_per_by_mass/M_wt_O2;// % Mass composition molecular weight
M_wt_N2= 28;
N2_Per_M_com_M_wt= N2_per_by_mass/M_wt_N2;// % Mass composition molecular weight
total= CO2_Per_M_com_M_wt + O2_Per_M_com_M_wt + N2_Per_M_com_M_wt;
CO2_per_by_vol= CO2_Per_M_com_M_wt/total*100;// in %
O2_per_by_vol= O2_Per_M_com_M_wt/total*100;// in %
N2_per_by_vol= N2_Per_M_com_M_wt/total*100;// in %
disp(CO2_per_by_vol,"Percentage of CO2 by volume is : ")
disp(O2_per_by_vol,"Percentage of O2 by volume is : ")
disp(N2_per_by_vol,"Percentage of N2 by volume is : ")
```

Scilab code Exa 8.11 Maximum quantity of heat

```
// Exa 8.11
clc;
clear;
close;
// Given data
Cp= 1;// in kJ/kg
H= 2.7*10^3;// total heat of vaport in flue gas in kJ/kg
CoalCalorific= 32.82*10^3;// in kJ/kg
```

```
T1= 310;// final gas flue temp. in  C
T2= 25;// boiler house temp. in  C
mC= 0.84;//mass of carbon in kg
mH2= 0.05;//mass of H2 in kg
O2_mass= 2.66*mC + 9*mH2;// in kg
Air_mass= O2_mass/0.23;// in kg
Air_mass= 1.5*Air_mass;// in kg (as 50% excess air is supplied)
disp(Air_mass,"Actual mass of air required per kg of fuel for complete combustion in kg is : ")
// Analysis of dry flue gas by weight
CO2= 3.08;// in kg
N2= 13.24;// in kg
O2= 1.32;// in kg
total_mass= CO2+N2+O2;// in kg
CO2_per_by_mass= CO2/total_mass*100;// in %
O2_per_by_mass= O2/total_mass*100;// in %
N2_per_by_mass= N2/total_mass*100;// in %
disp(CO2_per_by_mass,"Percentage of CO2 by mass is : ")
disp(O2_per_by_mass,"Percentage of O2 by mass is : ")
disp(N2_per_by_mass,"Percentage of N2 by mass is : ")
M_wt_CO2= 44;
CO2_Per_M_com_M_wt= CO2_per_by_mass/M_wt_CO2;// % Mass composition molecular weight
M_wt_O2= 32;
O2_Per_M_com_M_wt= O2_per_by_mass/M_wt_O2;// % Mass composition molecular weight
M_wt_N2= 28;
N2_Per_M_com_M_wt= N2_per_by_mass/M_wt_N2;// % Mass composition molecular weight
total= CO2_Per_M_com_M_wt + O2_Per_M_com_M_wt + N2_Per_M_com_M_wt;
CO2_per_by_vol= CO2_Per_M_com_M_wt/total*100;// in %
O2_per_by_vol= O2_Per_M_com_M_wt/total*100;// in %
N2_per_by_vol= N2_Per_M_com_M_wt/total*100;// in %
```

```
disp(CO2_per_by_vol,"Percentage of CO2 by volume is
   : ")
disp(O2_per_by_vol,"Percentage of O2 by volume is :
   ")
disp(N2_per_by_vol,"Percentage of N2 by volume is :
   ")
H_w_v= 9*mH2*H;//heat carried away by water vapour
   in kJ
H_dry_flue= total_mass*Cp*(T1-T2);// in kJ
H_total= H_w_v+H_dry_flue;// in kJ
H_available= CoalCalorific-H_total;// in kJ
disp(H_available,"Heat available for steam
   generation in kJ is : ")
```

Scilab code Exa 8.12 Percentage analysis of dry exhaust gases by volume

```
// Exa 8.12
clc;
clear;
close;
// Given data
mC= 0.86;//mass of carbon in kg
mH2= 0.14;//mass of H2 in kg
maBYmf= (2.66*mC + 8*mH2)/0.23;// in kg/kg of fuel
Air_supp_deficiency= maBYmf/10;// in kg/kg of fuel
Air_saved= 16/(12*0.23);// in kg/kg of carbon
m1= Air_supp_deficiency/Air_saved;// mass of coal
   burns to carbon monoxide
m2= mC-m1;// mass of coal burns to carbon diooxide
CO2_formed= m2*3.66;// in kg
CO_formed= m1*28/12;// in kg
N2_formed= Air_supp_deficiency*0.77*9;// in kg
M_wt_CO2= 44;// molecular weight
M_wt_CO= 28;
M_wt_N2= 28;
```

```
CO2_rel_vol= CO2_formed/M_wt_CO2;
CO_rel_vol= CO_formed/M_wt_CO;
N2_rel_vol= N2_formed/M_wt_N2;
total_rel_vol=CO2_rel_vol+CO_rel_vol+N2_rel_vol;
CO2_vol= CO2_rel_vol/total_rel_vol*100;// in %
CO_vol= CO_rel_vol/total_rel_vol*100;// in %
N2_vol= N2_rel_vol/total_rel_vol*100;// in %
disp(CO2_vol,"Volumetric analysis of CO2 in % is : "
    )
disp(CO_vol,"Volumetric analysis of CO in % is : ")
disp(N2_vol,"Volumetric analysis of N2 in % is : ")
```

Scilab code Exa 8.13 Quantity of air passing to the furnace

```
// Exa 8.13
clc;
clear;
close;
// Given data
N = 83;//compositon of nitrogen in %
C = 81;//carbon mass in the fuel in %
C1 = 11;//compositon of CO2 in %
C2 = 2;// compositon of CO in %
O = 4;// composition of O2 in %
AirSupplied =N*C/(33*(C1+C2));// in kg/kg
disp(AirSupplied,"The amount of air supplied in kg
    per kg of fuel is : ")
ExcessAir =79*O*C/(21*33*(C1+C2));// in kg/kg
disp(ExcessAir,"Weight of excess air in kg per kg of
     fuel is : ")
```

Scilab code Exa 8.14 Gravimetric analysis of the fuel

```
// Exa 8.14
clc;
clear;
close;
// Given data
CO2= 10;// in %
O2= 6;// in %
N2= 84;// in %
// a= x/12 and b= (1-x)/2
// 0.23*y/32= a+b/2+c
abyc= CO2/O2;
// a/(0.77*y/28)= CO2/N2
x=0.835;
carbon_per= x*100;// in %
hydrogen_per= 100-carbon_per;// in %
disp("The fuel consists of "+string(carbon_per)+" % carbon and "+string(hydrogen_per)+" % hydrogen.")
```

Scilab code Exa 8.15 Minimum quantity of air

```
// Exa 8.15
clc;
clear;
close;
// Given data
H2 = 50;// in %
CO = 5;// in %
CH4 = 35;// in %
disp("Quantity of air required for complete combustion of 1m^3 of gas in m^3 is:")
V = ((0.5*(H2+CO))+(2*CH4))/21;// in m^3
disp(V)
```

Scilab code Exa 8.16 Volume of air required

```
// Exa 8.16
clc;
clear;
close;
// Given data
H2= 0.4;// in m^3
CH= 0.425;// in m^3
C2H4= 0.0253;// in m^3
C4H8= 0.0127;// in m^3
CO= 0.075;// in m^3
O2_vol= 0.5*H2 + 2*CH + 3*C2H4 + 6*C4H8 + 0.5*CO;//
    in m^3
Air_vol= O2_vol/0.21;// in m^3
disp(Air_vol,"The volume of air required for
    complete combustion in m^3 is");
actualAirSupplied= 1.3*Air_vol;// in m^3
disp(actualAirSupplied,"The actual quantity of air
    supplied in m^3 is : ")
```

Scilab code Exa 8.17 Volume of air supplied

```
// Exa 8.17
clc;
clear;
close;
// Given data
V_H2= 0.15;// in m^3
V_CH4= 0.02;// in m^3
V_CO= 0.20;// in m^3
V_CO2= 0.06;// in m^3
```

```
V_O2= 0.03;// in m^3
V_N2= 0.54;// in m^3
V1= 0.5*V_H2;// quantity of O2 required for complete
    combustion of H2
V2= 2*V_CH4;// in m^3
V3= 0.5*V_CO;// in m^3
V= V1+V2+V3;// total oxygen required in m^3
O2_supp= V-V_O2;// O2 to be supplied by air in m^3
Air_req_min= O2_supp/0.21;// minimum quantity of air
    required in m^3
Actual_Air_Supp= 1.5*Air_req_min;// m^3 of air
disp(Actual_Air_Supp,"The volume of air supplied  in
    m^3")
Vol_Carbondioxide_inFlue= V_CO2+V_CH4+V_CO;//total
    volume of carbon dioxide
Vol_O2_inFlue= (Actual_Air_Supp-Air_req_min)*0.21;//
    in m^3
N2_from_air_Supp= 0.79*Actual_Air_Supp;// in m^3
Vol_N2_inFlue= N2_from_air_Supp+V_N2;// in m^3
total= Vol_Carbondioxide_inFlue+Vol_O2_inFlue+
    Vol_N2_inFlue;// in m^3
Per_CarbonDioxide= Vol_Carbondioxide_inFlue/total
    *100;// in %
Per_Oxygen= Vol_O2_inFlue/total*100;// in %
Per_Nitrogen= Vol_N2_inFlue/total*100;// in %
disp(Per_CarbonDioxide,"% Carbon dioxide is : ")
disp(Per_Oxygen,"% Carbon dioxide is : ")
disp(Per_Nitrogen,"% Carbon dioxide is : ")
```

Scilab code Exa 8.18 Percentage composition by volume and mass

```
// Exa 8.18
clc;
clear;
close;
```

```
// Given data
V_CH4= 0.14;// in m^3
V_CO= 0.35;// in m^3
V_CO2= 0.06;// in m^3
V_N2= 0.03;// in m^3
V_H2= 0.42;// in m^3
a= V_CH4+V_CO2+V_CO;
b= 2*V_CH4+V_H2;
// a+0.5*b+c= V_CO2+V_CO/2+0.21*5
c= V_CO2+V_CO/2+0.21*5-a-0.5*b;
d=V_N2+5*0.79;
total= a+c+d;
Vol_per_CO2= a/total*100;// in %
Vol_per_O2= c/total*100;// in %
Vol_per_N2= d/total*100;// in %
disp(Vol_per_CO2,"Volume percentage of CO2 is : ")
disp(Vol_per_O2,"Volume percentage of O2 is : ")
disp(Vol_per_N2,"Volume percentage of N2 is : ")
m_CO2= 44;// molecular mass
m_O2= 32;// molecular mass
m_N2=28;// molecular mass
mass_ratio_CO2= Vol_per_CO2/m_CO2;
mass_ratio_O2= Vol_per_O2/m_O2;
mass_ratio_N2= Vol_per_N2/m_N2;
total_mass_ratio= mass_ratio_CO2+mass_ratio_O2+
    mass_ratio_N2;
mass_per_CO2= mass_ratio_CO2/total_mass_ratio*100;
mass_per_O2= mass_ratio_O2/total_mass_ratio*100;
mass_per_N2= mass_ratio_N2/total_mass_ratio*100;
disp(mass_per_CO2,"Mass percentage of CO2 is : ")
disp(mass_per_O2,"Mass percentage of O2 is : ")
disp(mass_per_N2,"Mass percentage of N2 is : ")
```

Scilab code Exa 8.19 Air fuel ratio by volume

```
// Exa 8.19
clc;
clear;
close;
// Given data
GCR= 110;// gas consumption rate in m^3/hour
rpm= 300;// round per minute
Vs= 0.1;// swept volume of engine in m^3
V_H2=0.50;// in m^3
V_CO= 0.05;// in m^3
V_CH4=0.25;// in m^3
V_CO2= 0.10;// in m^3
V_N2= 0.10;// in m^3
V_O2= 5.8;// in m^3
AirRequired= (0.5*(V_H2+V_CO)+2*V_CH4)/0.21;// in m
    ^3
CO2_formed= V_CO+V_CH4;// in m^3
total_CO2= CO2_formed+V_CO2;// in m^3
N2_of_air= 0.79*AirRequired;// in m^3
total_N2= N2_of_air+V_N2;// in m^3
TotalVolume= total_N2+total_CO2;// in m^3
V= TotalVolume;// in m^3
ExcessAirSupplied= (V_O2*V)/(21-V_O2);// in m^3
TotalAirSupplied= ExcessAirSupplied+AirRequired;//
    in m^3
AirFuel_ratio= round(TotalAirSupplied)/1;
disp(AirFuel_ratio,"Air fuel ratio by volume is : ")
// Let V1= Volume of air + gas aspirated per hour
V1= GCR*6;// in m^3
Vs_out= Vs*rpm/2*60;// in m^3
Ratio= V1/Vs_out;
disp("The value of Ratio i.e.")
disp(Ratio,"(Volume of air + gas aspirted per hour)/
    Volume swept out by piston per hour")
```

Scilab code Exa 8.20 Air fuel ratio by different methods

```
// Exa 8.20
clc;
clear;
close;
// Given data
CO2= 9.9;// in %
CO= 7.2;// in %
H2= 3.3;// in %
CH4= 0.3;// in %
N2= 79.3;// in %
O2= N2*21/79;// in %
disp("Method 1 : By Carbon balance : ")
Z= (CO2+CO+CH4)/8;
x= 8*Z;
measured_air_fuel_ratio= 11.3;
mm1= 29;// molecular mass of air
mm2= 12*8+17;// molecular mass of C8H17
massOf_air= (O2+N2)*mm1;
massOf_fuel= Z*mm2;
air_fuel_ratio= massOf_air/massOf_fuel;
disp(air_fuel_ratio,"The air fuel ratio by mass is : ")
Per_error= (air_fuel_ratio - measured_air_fuel_ratio)/measured_air_fuel_ratio*100;
disp(Per_error,"Percentage error is : ")
disp("Method 2 : By Hydrogen balance : ")
X= (O2-CO2-CO/2)*2;
Z= (4*CH4+2*H2+X*2)/17;
massOf_air= (O2+N2)*mm1;
massOf_fuel= Z*mm2;
air_fuel_ratio= massOf_air/massOf_fuel;
disp(air_fuel_ratio,"The air fuel ratio by mass is : ")
Per_error= (air_fuel_ratio - measured_air_fuel_ratio)/measured_air_fuel_ratio*100;
disp(Per_error,"Percentage error is : ")
```

```
disp("Method 3 : By Carbon−Hydrogen balance : ")
y= (4*CH4+2*H2+X*2);
massOf_air= (O2+N2)*mm1;
massOf_fuel= x*12+y;
air_fuel_ratio= massOf_air/massOf_fuel;
disp(air_fuel_ratio,"The air fuel ratio by mass is :
    ")
Per_error= (air_fuel_ratio - measured_air_fuel_ratio
   )/measured_air_fuel_ratio*100;
disp(Per_error,"Percentage error is : ")
```