Scilab Textbook Companion for Thermodynamics by K. M. Gupta[1]

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December 17, 2014

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Thermodynamics

Author: K. M. Gupta

Publisher: Umesh Publications, Daryaganj, Delhi

Edition: 1

Year: 2010

ISBN: 978-93-80176-07-9

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

Fundamentals Concepts and Definitions of Thermodynamics

Scilab code Exa 1.2 Absolute pressure

```
// Exa 1.2
clc;
clear;
close;
// Given data
Pvacc = 700;// mm of hg
Patm = 760;// mm of hg
Pabs = Patm - Pvacc;// mm of hg
disp(Pabs/760,"Absolute pressure in in kg/cm^2 is :");// as 1kg/cm^2= 760 mm of Hg
disp(Pabs*1.01325/760,"Absolute pressure in bar is :");// as 1.01325 bar = 760 mm of Hg
disp(Pabs*1.01325/760*10^2,"Absolute pressure in in kPa");// as 1 bar = 10^2 kPa
```

Scilab code Exa 1.3 Tank pressure

```
//Exa 1.3
clc;
clear;
close;
// Given data
Patm = 101;// kpa
Rho = 13.6 * 10^3;// in kg per m^3
h = 250;// in cm
h = h*10^-2;// in m
g = 9.806;
p = Rho * g * h;// in N/m^2
p= p*10^-3;// in kPa
// Total pressure in tank
p = p + Patm;// in kpa
p = p*10^-3;// in Mpa
disp(p,"Total pressure in tank in Mpa");
```

Scilab code Exa 1.4 Work done by the piston

```
// Exa 1.4
clc;
clear;
close;
// Given data
m = 1.5;// in kg
pi = 0.1;// in MPa
pi= pi*10^6;// in Pa
pf = 0.7;// in MPa
pf= pf*10^6;// in Pa
rho_i = 1.16;// kg per m^3
vi = m/rho_i;// in m^3
WorkDone= pi*vi*log(pi/pf);// in J
disp(WorkDone*10^-3,"Work done in kJ is : ")
if WorkDone<0 then
disp("The -ve sign indicates work is done on the
```

```
system, hence");
disp((WorkDone*10^-3),"The work done by the piston in kJ is : ")
end
```

Scilab code Exa 1.5 Work done

```
// Exav1.5
clc;
clear;
close;
// Given data
p = 1.0;// in Mpa
p = p*10^6;// in N per m^2
del_v = 1.5;//m^3 per min
del_v = del_v*60;// m^3 per h
W = p * del_v;// W stands for work done in J
W = W*10^-6;// in MJ
disp(W,"Work done by the pump upon the water in an hour in MJ is : ");
```

Scilab code Exa 1.6 Height from which the mass should fall

```
// Exa 1.6
clc;
clear;
close;
// Given data
// W = 2*g*h
// due to stirring of water
g = 9.81;
J = 4.1868*10^3;
m = (0.2+10*10^-3)*10^3;// in gm
```

```
s= 1;// in cal per gm C
del_T = 2;// in    C
H = m * s * del_T;// in cal
H = H*10^-3;// in kcal
// W = JH and W= 2*g*h
h = J*H/(2 * g);// in m
disp(h,"The height from the mass should be fall in
   meter is :");
```

Scilab code Exa 1.7 Power of feed pump

```
// Exa 1.7
clc;
clear;
close;
// Given data
// mass of 1 litr of water is 1 kg. so
m = 5000;// in kg
h = 10-1;// in m
g= 9.81;//
PE = m * g * h;// in N m
PE = PE*10^-3;// in kj
Eta = 0.85;
// Eta = energy output/energy input
E_input = PE/Eta;// in Kj
E_input = E_input*10^3;// in J
t = 45;// time in min
t = t*60;// in sec
P = E_input/t;// in J/s
P = P*10^-3;// in kW
disp(P,"Power required for the feed pump in kW is :"
   );
```

Scilab code Exa 1.11 Power of the engine

```
// Exa 1.11
clc;
clear;
close;
// Given data
V =  50;// km per hr
V = V * (1000/3600);// in m per sec
F = 900;// in N
P = F * V;// in watt
P = P *10^-3;// in kW
disp(P,"Power of the engine of a car in kW is : ");
H = P * 60;// in kJ
disp(H,"Heat equivalent of work per minute in kJ is");
```

Scilab code Exa 1.12 Power required

```
// Exa 1.12
clc;
clear;
close;
// Given data
E_air = 200-100;// in kJ/kg
E_lost = 40;// in kJ/kg
E_total = E_air + E_lost;// in kJ per kg
M = 0.5;// mass flow rate in kg per s
P = M * E_total;// in kJ/s
disp(P,"Power required for an air mass flowin kJ/s is :");
```

Scilab code Exa 1.13 Specific heat

```
// Exa 1.13
clc;
clear;
close;
// Given data
m_b = 1;// in kg
t_ib = 80;//in degree c
m_w = 10;// in kg
t_iw = 25;// in degree c
del_t = 5;// in degree c
S_w = 4.18;//  in kJ/kg
t_equ = (t_iw + del_t);// in degree c
// Heat loss by metal = Heat gained by water
S_b = m_w * S_w * (t_equ - t_iw)/(m_b * (t_ib -
    t_equ));// in kJ/kg-K
disp(S_b,"Specific heat of metal block in kJ/kg-K is
    ");
```

Scilab code Exa 1.15 Convert reading in kPa

```
// Exa 1.15
clc;
clear;
close;
// Given data
P_gauge = 90;// in cm of hg
P_atm = 760;// in mm of hg
P_atm = 76;// in cm of hg
P_abs = P_gauge + P_atm;// in cm of hg
P_abs = P_abs * (101.32/76);// in kPa
disp(P_abs,"Reading of pressure in kPa");
// Part (b)
P_vacuum = 40;// in cm of hg
P_abs = P_atm - P_vacuum;// in cm of hg
P_abs = P_abs * (101.32/76);// in kpa
```

```
disp(P_abs,"Reading of pressure to kpa");
// Part (c)
Rho = 1000;// in kg per m^3
g = 9.81;//
h = 1.2;// in m
P_gauge = Rho * g * h;// in N m^2
P_gauge= P_gauge*10^-3;// in kPa
P_atm = 101.32;// in kPa
P_abs = P_gauge + P_atm;// in kpa
disp(P_abs,"Reading of pressure in kPa");
```

Scilab code Exa 1.16 Depth of atmosphere

```
// Exa 1.16
clc;
clear;
close;
// Given data
g=9.81;// in m/s^2
P=1.0332*10^5;// in kN/m^2
v='(2.3*10^4/p)^1/1.4';// given expression
H= 1/g*(2.3*10^4)^(1/1.4)*integrate('(1/p)^(1/1.4)','p',0,P);// in m
disp(H*10^-3,"The value of H in km is : ")

// Note: There is the calculation error in the book in this question, so the answer in the book is wrong.
```

Chapter 2

Gas Laws Ideal and Real Gases

Scilab code Exa 2.1 Air pressure in the tyre

```
// Exa 2.1
clc;
clear;
close;
// Given data
p1= 2;// in bar
v1= 30;// in litre
T1= 27+273;// in K
T2= -3+273;// in K
v2= v1;// in litre
// Gas law  p1*v1/T1= p2*v2/T2
p2= p1*v1*T2/(T1*v2);// in bar
disp(p2,"The air pressure in the tyre in bar is :")
```

Scilab code Exa 2.2 Molar volume of the gas mixture

```
// Exa 2.2
clc;
```

```
clear;
close;
// Given data
p= 12;// in bar
p=p*10^5;// in N/m^2
v= 25;// in m^3
T= 30+273;// in K
// Part (a) Mass of each gas
//Formula p*v=m*R*T
R_U= 8314;// in J/kg-mole K
M_N2= 28.016;// in mole
M_O2= 32;// in mole
M_CO2= 44;// in mole
R_N2= R_U/M_N2;// in J/kg K
R_O2= R_U/M_O2;// in J/kg K
R_CO2= R_U/M_CO2;// in J/kg K
m_of_N2= p*v/(R_N2*T);// in kg
m_of_O2= p*v/(R_O2*T);// in kg
m_of_CO2= p*v/(R_CO2*T);// in kg
disp(m_of_N2,"The mass of Nitrogen gas stored in the vessel in kg is : ")
disp(m_of_O2,"The mass of Oxygen gas stored in the vessel in kg is : ")
disp(round(m_of_CO2),"The mass of Carbon dioxide gas stored in the vessel in kg is : ")

// Part (b) Molar Volume
// Formula v_molar= M*R*T/p= R_U*T/p
v_molar= R_U*T/p;// in m^3
disp(v_molar,"Molar volume of the gas mixture in m^3 is : ")

// Part (c) Average density
// rho_avg= total mass/total volume
rho_avg= (m_of_N2+m_of_O2+m_of_CO2)/v;// in kg/m^3
disp(rho_avg,"Average density of the gas mixture in kg/m^3 is : ")
```

Scilab code Exa 2.3 Value of Cp Cv and R

```
// Exa 2.3
clc;
clear;
close;
// Given data
Qp= 1230; // kJ/kg
Qv= 795; // kJ/kg
t1= 16;// in  C
t2= 96;// in  C
R_U= 8.314;
delta_T= t2-t1;// in  C
Cp= Qp/delta_T;// in kJ/kg  C
disp(Cp,"The value of Cp in kJ/kg C")
Cv= Qv/delta_T;// in kJ/kg  C
disp(Cv,"The value of Cv in kJ/kg C")
R= Cp-Cv;// in kJ/kg  C
disp(R,"The value of R in kJ/kg C")
molecular_weight= R_U/R;
disp(molecular_weight,"Molecular weight of the gas
   is : ")
```

Scilab code Exa 2.4 Change in internal energy

```
// Exa 2.4
clc;
clear;
close;
// Given data
a= 0.85;
b= 0.00004;
```

```
c= 5*10^-5;
T1= 300;// in K
T2= 2300;// in K
gama= 1.5;// the ratio of specific heats
m=1;// in kg
delta_H= m*integrate('a+b*T+c*T^2','T',T1,T2);// in kJ
disp(delta_H*10^-3,"Change in enthalpy in MJ is : ")
// Formula delta_U= integration of m*Cv = integration of m*Cp/gama= delta_H/gama
delta_U= delta_H/gama;// in kJ
disp(delta_U*10^-3,"The change in internal energy in MJ is : ")
```

Scilab code Exa 2.5 Pressure exerted by unit mass of the gas

```
// Exa 2.5
clc;
clear;
close;
// Given data
v= 0.9/3;// in m^3/kg
v= 2*v;// in m^3/kg mole (as M_hydrogen = 2)
T=120+273;// in K
R=8314;// in J/kg mole K
a=2.51*10^4;// in Nm^4/(kg mole)^2
b= 0.0262;
// Part (a)
p= R*T/v;// in N/m^2
p= p*10^-5;// in bar
disp(p,"Using perfect gas law the pressure for unit mass of hydrogen in bar is : ")

// Part (b)
p= R*T/(v-b)-a/v^2;// N/m^2
```

```
p= p*10^-5;// in bar
disp(p,"Using Van der waals equation , the pressure
    in bar is : ")
```

Scilab code Exa 2.6 Density of gas

```
// Exa 2.6
clc;
clear;
close;
// Given data
p1= 0.98;// in bar
p2= 0.6;// in bar
v1= 0.45;// in m^3/kg
// Applying Boyle's law
v2= p1*v1/p2;// in m^3/kg
rho2= 1/v2;// in kg/m^3
disp(rho2,"The density of the gas under the changed
    condition in kg/m^3 is : ")
```

Scilab code Exa 2.7 Payload

```
// Exa 2.7
clc;
clear;
close;
// Given data
r=5;// in cm
R_U= 8314
T= 27+273;// in K
V= 4/3*%pi*r^3;// volume of balloon in cm^3
// atmPressure= 75 cm off mercury = 75/76*1.01325
atmPressure= round(75/76*1.01325) ;// in bar
```

```
p= atmPressure;// pressure of hydrogen in balloon in
    bar
p=p*10^5;// in N/m^2
R= R_U/2;// in J/kg K
m1= p*V/(R*T);// in kg
// The volume of air displaced = the volume of
   balloon , so
R=287;
T=20+273;// in K
m2= p*V/(R*T);// in kg
payload= m2-m1;// in kg
disp(payload,"Payload that can be lifted along with
   the balloon in kg is : ")
```

Scilab code Exa 2.12 Pressure of the gas

```
// Exa 2.12
clc;
clear;
close;
// Given data
AvogadroNo= 6.023*10^23;
n= 5/AvogadroNo;// number of moles
v=10^-6;// in m^3
T= -270+273;// in K
R= 0.287;
p= n*R*T/v;// in kPa
p= p*10^18;// in aPa
disp("The pressure in the space is "+string(p)+" aPa
   ");
```

Scilab code Exa 2.13 Change in enthalpy

```
// Exa 2.13
clc;
clear;
close;
// Given data
T1= 300;// in K
T2= 900;// in K
m=2;// in kg
Cp= '40+600/sqrt(T)+7000/T';// in kJ/kg mole K
delta_H=m* integrate('40-600/sqrt(T)+7000/T','T',T1,
    T2);// in kJ/kg mole
delta_H= delta_H/17.03;// in kJ/kg
disp(delta_H,"Change in enthalpy in kJ/kg is : ")
```

Scilab code Exa 2.14 Molecular weight

```
// Exa 2.14
clc;
clear;
close;
// Given data
m=12;// in kg mol
v=723.7;// in m^3
T=140;// in  C
T=T+273;// in K
rho= 0.644;// in kg/m^3
Ro= 8314;// in J/kg-mole K
// rho= m/v, where m in Kg , so rho= m*M/v
M= rho*v/m;
m= m*M;// in kg
disp(M,"Molecular weight is : ")

// Part (b)
R= Ro/M;// in J/kg K
disp(R*10^-3,"Gas constant in kJ/kg K")
```

```

// Part(c)
p= m*R*T/v;// in N/m^2
p=p*10^-5;// in bar
disp(p,"The pressure of the gas in bar is : ")
```

Scilab code Exa 2.15 Load that can be lifted with the air of aerostat

```
// Exa 2.15
clc;
clear;
close;
// Given data
p= 0.98;// in bar
p= p*10^5;// in N/m^2
v=1000;// in m^3
T= 27+273;// in K
g= 9.8;
M=2;
Ro= 8314;// in J/kg-mole K
R=Ro/M;// in kg K
m= p*v/(R*T);// in kg
W= m*g;// in N
disp(W,"The load that can be lifted with the air of
    aerostat in N is : ")
```

Scilab code Exa 2.16 Change in enthalpy

```
// Exa 2.16
clc;
clear;
close;
// Given data
```

```
T1= 500;// in K
T2= 2000;// in K
m=1;// in kg
Cp= '11.515-172/sqrt(T)-1530/T';// in kcal/kg mole K
delta_H=m* integrate('11.515-172/sqrt(T)-1530/T','T'
    ,T1,T2);// in kcal/kg mole
disp(delta_H,"Change in enthalpy in kcal/kg mole is
    : ")
```

Scilab code Exa 2.17 Value of Cv and Cp

```
// Exa 2.17
clc;
clear;
close;
// Given data
u='196+0.718*t';
pv= '0.278*(t+273)';
duBydt= 0.718;
Cv= duBydt;// in kJ/kg-K
h= u+pv;
h='273.351+1.005*t';
dhBydt= 1.005;// in kJ/kg-K
Cp= dhBydt;// in kJ/kg-K
disp(Cv,"The value of Cv in kJ/kg-K is : ")
disp(Cp,"The value of Cp in kJ/kg-K is : ")
```

Chapter 3

Zeroth Law of Thermodynamics and Temperature Scales

Scilab code Exa 3.1 Reading

```
// Exa 3.1
clc;
clear;
close;
// Given data
t_c = 303-273;// in  C
t_f = 9/5* t_c+32;// in  F
disp(t_f,"When the temperature is 303 K then the thermometer reading in  F is : ");
T_R = 460 + t_f;//  R
disp(T_R,"The absolute value of the temperature in Rankine scale in  R is :");
```

Scilab code Exa 3.2 Temperature of fluid

```
// Exa 3.2
clc;
clear;
close;
// Given data
T_K= '273.15+t_C';
T_R= '459.67+t_F';
// t_C= t_F or T_K-T_R= -186.52      (i)
// T_R/T_K = 1.68                              (ii)
// From eq (i) and (ii)
T_K= -186.52/(1-1.68);// temp. in kelvin in K
T_R= 1.68*T_K;// in temp. in rankine in  R
t_C= T_K-273.15;// in  C
t_F= T_R-459.67;// in  F
disp(T_K,"Temperature in kelvin is : ")
disp(T_R,"Temperature in  R is ")
disp(t_C,"Temperature in  C is ")
disp(t_F,"Temperature in  F is ")
```

Scilab code Exa 3.9 Temperature

```
// Exa 3.9
clc;
clear;
close;
// Given data
p0 = 1.86;
p100 = 6.81;
T1=32;
T2= 212;
// Relation of T in terms of p for ice point      T1
   = a*log(p0)+b          (i)
// Relation of T in terms of p for steam point  T2=
   a*log(p100)+b     (ii)
```

```
// From eq(i) and (ii)
a= (T2-T1)/log(p100/p0);
b= T1-a*log(p0);
// The temp at
p=2.5;
T= a*log(p)+b;// in  unit
disp(T,"The temperature at p=2.5 in  unit is :")
```

Scilab code Exa 3.10 Reading of thermometer

```
// Exa 3.10
clc;
clear;
close;
// Given data
Tp= 'a+b*Tq+lamda*Tq^2';// relation between Tp and Tq
Tp0=0;//in  C (at ice point)
Tq0=0;//in  C (at ice point)
// Putting these values in relation , we get
a=0;
Tp100=100;//in  C ( at steam point)
Tq100=100;//in  C ( at steam point)
// Tp100= b*Tq100+lamda*Tq100^2          (i)
Tp=45;// in  C (in oil path)
Tq=43;// in  C (in oil path)
// Tp= b*Tq+lamda*Tq^2                    (ii)
b= (Tp100-Tp*Tq100^2/Tq^2)/(Tq100-Tq100^2/Tq);// From eq (i) and (ii)
lamda= (Tp-b*Tq)/Tq^2;
Tp=20;
//lamda*Tq^2+b*Tq-Tp=0
P= [lamda b -Tp];
Tq= roots(P);// in  C
disp(Tq,"When P reads 20 C , then the readings of  Q
```

```
    in   C  are")
disp(Tq(2),"The realistic value of Tq in  C is : ")
```

Chapter 4

First Law of Thermodynamics

Scilab code Exa 4.1 Work done

```
// Exa 4.1
clc;
clear;
close;
// Given data
p = 1.0;// in MPa
p = p * 10^6;// in N per m^2
del_v = 1.5;// in m^3 per min
del_v = del_v * 60;// in m^3 per h
W = p * del_v;// in J
W = W * 10^-6;// in MJ
disp(W,"Work done by the pump upon the water in MJ")
    ;
```

Scilab code Exa 4.2 Height from which the mass should fall

```
// Exa 4.2
clc;
```

```
clear;
close;
// Given data
// w = 2*g*h
g = 9.81;
m =(0.2+10/1000)*10^3 ;// in gm
s = 1;// in cal/gm C
del_T = 2;// in  C
H = m * s * del_T;// in cal
H = H * 10^-3;// kcal
J = 4.1868 * 1000;
// W= 2*g*h= J*H
h = J*H/(2 * g);// in m
disp(h,"Height from which the mass should fall in
    meter is : ");
```

Scilab code Exa 4.3 Magnitude and direction of third heat transfer

```
// Exa 4.3
clc;
clear;
close;
// Given data
W1 = -25;// in kJ
W2 = 45;// in kJ
Q1 = 65;// in kJ
Q2 = -40;// in kJ
// del_U = Q - W and but for a cycle del_U = 0, So
// Q = W
// Q1 + Q2 +Q3 = W1 +W2
Q3 = W1 + W2 - Q1 - Q2;// in kJ
disp(Q3,"Third Heat transfer in kJ is ");
disp("That is Third Heat transfer is of "+string(abs
    (Q3))+" kJ from the fluid");
```

Scilab code Exa 4.5 External work done

```
// Exa 4.5
clc;
clear;
close;
// Given data
m = 1.5;// in kg
T1 = 90;// in C
T1 = T1 + 273;//in K
T2 = 225;// in C
T2 = T2 + 273;// in K
C_p = 0.24;
C_v = 0.17;
Q = (m * C_p * (T2-T1));// in kcal
del_U = (m * C_v * (T2-T1));// in kcal
W = Q - del_U;// in kcal
disp(W,"The external work done in kcal is");
```

Scilab code Exa 4.7 Mass of the gas

```
//Exa 4.7
clc;
clear;
close;
// Given data
v1 = 0.5;// in m^3
v2 = 0.125;// in m^3
p1 = 1.5;// in bar
p1 = p1 * 10^5;// in N per m^2
p2 = 9;//in bar
p2 = p2 * 10^5;// in N per m^2
```

```
T1 = 100;// in  C
T1 = T1 + 273;// in K
R = 8.31;
// Formula p1*v1= n*R*T1
n= p1*v1/(R*T1);// in mole
disp(n,"Mass of gas in mole is :");
// Part (b)
// 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 :");
// Part (c)
// Formula p1*v1^n = p2*v2^n
n1= log(p2/p1)/log(v1/v2)
disp(n1,"Value of index n of compression is :");
// Part (d)
F = 3;
C_v =1/2*R*F;
del_U = (n * C_v * (T2-T1));// in J
disp(del_U*10^-3,"Increase in internal energy of gas in kJ is : ");
// Part(e)
Gamma = 1.67;
Q_12 = n*(Gamma-n1)/(1-n1)*R*(T2-T1)/(Gamma-1);// in J
Q_12 = Q_12 * 10^-3;// in kJ
disp(Q_12,"Heat interaction in kJ is : ");
if Q_12<0 then
    disp("The -ve sign indicates heat rejection during the process")
end

// Note: There is some difference between the answer of book and coding . Both the answer is right but accurate answer is of coding.
//          Because in the book, the taken values are appox. and in the coding the values are accurate
```

Scilab code Exa 4.8 Law of the process

```
//Exa 4.8
clc;
clear;
close;
// Given data
p1 = 0.01;// in N/mm^2
p1 = p1 * 10^3;// in kN/m^2
p2 = 50;// in kN/m^2
v1 = 5;// in m^3
v2 = 1.5;// in m^3
Gamma = 1.4;
// Formula p1*v1^n = p2*v2^n
n= log(p2/p1)/log(v1/v2);
disp(n,"Part (a)   The value of n is : ")
disp("The process followed during air compression is
    POLYTROPIC");
// Part (b)
disp("Part (b)   The law of the process is p*v^"+
   string(n)+" = constant");
// Part (c)
W= (p1*v1-p2*v2)/(n-1);// in kNm or (kJ)
disp(W,"Part (c)   Work done during the process in
   kJ is : ");
disp("The -ve sign indicates that the work has been
   done on the system")
// Part (d)
Q = ((Gamma - n)/(Gamma - 1) * W);// in kJ
disp(Q,"Part (d)   Heat transfer during the process
    in kJ is :");
disp("The -ve sign indicates that the heat is
   rejected from the system")
```

Scilab code Exa 4.9 Change in internal energy

```
// Exa 4.9
clc;
clear;
close;
// Given data
// Relation of specific internal energy of the gas
// U= 1.5*p*v-85 kJ/kg
p1 = 1000;// in kpa
p2 = 200;// in pa
v1 = 0.20;// in m^3
v2 = 1.20;// in m^3
m = 1.5;// in kg
U1= 1.5*p1*v1-85;//  kJ/kg
U2= 1.5*p2*v2-85;//  kJ/kg
delU= U2-U1;// in kJ
disp(delU,"Change in internal energy in kJ is");
// p1= a+b*v1            (i)
// p2= a+b*v2            (ii)
// From eq(i) and (ii)
b= (p1-p2)/(v1-v2);// in kN/m^2
a= p1-b*v1;// in kN/m^2
disp(a,"The value of a in kN/m^2 is ")
disp(b,"The value of b in kN/m^2 is ")
// Part (c)
// Work done = integration of p w.r.t. v and p = a+b
   *v1
W= integrate('a+b*v','v',v1,v2);// in kJ
disp(W,"Work done in kJ is :")
// Part (d)
Q= delU+W;// in kJ
disp(Q,"The net heat transfer in kJ is : ")
```

Scilab code Exa 4.10 Maximum internal energy

```
// Exa 4.10
clc;
clear;
close;
// Given data
a= 1160;// in kN/m^2
b= -800;// in kN/m^2
v= -a/(2*b)
Umax= 1.5*(a*v+b*v^2)-85;// in kJ/kg
// For 1.5 kg mass of gas it is
Umax= Umax*1.5;// in kJ/kg
disp(Umax,"The maximum internal energy of the gas in
    kJ/kg is : ")
```

Scilab code Exa 4.11 Exit velocity of air

```
// Exa 4.11
clc;
clear;
close;
// Given data
T1 = 127;// in  C
T1 = T1 + 273;// in K
R = 287;
V1 = 300;// in m/s
p1 = 2;// in MPa
p2 = 0.5;// in MPa
p1 = p1 * 10^6;// in Pa
p2 = p2 * 10^6;// in Pa
C_P = 1.005*10^3;// in J/ kg-K
```

```
Gamma = 1.4;
V2 = sqrt(2 * C_P *T1 *{1-(p2/p1)^((Gamma-1)/Gamma)}
    + V1^2);// in m/s
disp(V2,"The exit velocity of air in m/s is : ");
m = 600;// in kg/hr
m = m / 3600;// in kg/sec
v1 = (R * T1)/p1;// in m^3 per kg
// m = (A1*V1)/v1 = (A2* V2)/v2
A1 = (m * v1)/V1;// in m^2
A1 = A1 * 10^6;// in mm^2
disp(A1,"Inlet area of the nozzle in square
    milimeter is : ");
T2 = T1*(p2/p1)^((Gamma-1)/Gamma);// in K
v2 = (R * T2)/(p2);// in m^3/kg
A2 = (m * v2)/V2;// in m^2
A2 = A2 * 10^6;// in mm^2
disp(A2,"Exit area of nozzel in square milimeter is
    : ");
```

Scilab code Exa 4.17 Net heat transfer

```
// Exa 4.17
clc;
clear;
close;
// Given data
W = -1;// in kWh
W = W * 10^3 * 3600;// in J
del_U = -5000;// in kj
del_U = del_U * 10^3;// in J
Q = del_U + W;// in J
Q = Q * 10^-6;// in MJ
disp(Q,"Net heat transfer for the system in MJ is :
    ");
```

Scilab code Exa 4.20 Heat flows into the system

```
//Exa 4.20
clc;
clear;
close;
// Given data
Q_acb = 84;//in kJ
W_acb = 32;// in kJ
//Formula Q_acb = del_U+W_acb where del_U = U_b -
    U_a;
del_U = Q_acb - W_acb;// in kJ
// Part (a) Path a b d
W_abd = 10.5;// in kJ
Q_abd = del_U + W_abd;// in kJ
disp(Q_abd,"Heat flows into the system along the
    path a b d in kJ is : ");
// Part (b) curved path b a
W_ba = -(21);// in kJ
Q_ba = -(del_U) + W_ba;// in kJ
disp(abs(Q_ba),"Heat liberated by the system in kJ
    is : ");
// Part (c) process a b and d b
W_ad = 10.5;// in kJ
del_U1 = 42;// in kJ
Q_ad = del_U1 + W_ad;// in kJ
disp(Q_ad,"Heat absorbed in processes a d  in kJ is
    : ");
W_db = -(42);// in kJ
del_U2 = 52;// in kJ
Q_bd = del_U2 + W_db;// in kJ
disp(Q_bd,"Heat absorbed in processes b d in kJ is :
     ");
W_db = 0;
```

```
W_abd = W_ad + W_db;// in kJ
disp(W_abd,"Heat absorbed in processes in a d and d
    b in kJ is : ");
```

Scilab code Exa 4.21 Net work

```
//Exa 4.21
clc;
clear;
close;
// Given data
v1 = 5;// in m^3
p1 = 2;// in bar
p2 = 6;// in bar
p3 = 2;// in bar
p1 = p1 * 10^5;// in N/m^2
p2 = p2 * 10^5;// in N/m^2
p3 = p3 * 10^5;// in N/m^2
n = 1.3;
v2 = v1 * ((p1/p2)^(1/1.3));// in m^3
W1_2 = ((p2 * v2)-(p1 * v1))/(1-n);// in J
Gamma = 1.4;
v3 = v2 * ((p2/p3)^(1/Gamma));// in m^3
W2_3 = ((p3 * v3) - (p2 * v2))/(1-Gamma);// in J
W_net = W1_2 + W2_3;// in J
W_net = W_net * 10^-3;// in kJ
disp(W_net,"net work done in kJ is : ");
```

Chapter 5

First Law of Thermodynamics

Scilab code Exa 5.1 Mass flow rate of air

```
// Exa 5.1
clc;
clear;
close;
// Given data
v1_total = 7;// in m^3/min
v_s1 = 0.35;// in m^3/kg
v_s2 = 0.12;// in m^3/kg
p1 = 1;// in bar
p1 = p1 * 10^5;// in N/m^2
p2 = 6;// in bar
p2 = p2 * 10^5;// in N/m^2
D1 = 110;// in mm
D1 = D1 * 10^-3;// in m
D2 = 65;// in mm
D2 = D2 * 10^-3;// in m
Af1 = %pi/4*D1^2;// in m^2
Af2 = %pi/4*D2^2;// in m^2
// v1_total = m1 * v_s1
m1 = v1_total / v_s1;//in kg/min
disp(m1,"The mass flow rate of air in kg/min is :");
```

```
m2 = m1;// in kg/min
v2_total = m2 * v_s2;// in m^3/min
del_W_flow = (p2 * v2_total) - (p1 * v1_total);// in
    J/min
disp(del_W_flow*10^-3,"The change in the work flow
   in kJ/min is : ");
v_f1 = v1_total/Af1;// in m/min
v_f2 = v2_total /Af2;//in m/min
del_v = v_f2 - v_f1;// in m/min
disp(del_v,"Change in velocity of the air flow in m/
   min is :");
```

Scilab code Exa 5.2 Rate of heat transfer

```
//Exa 5.2
clc;
clear;
close;
// Given data
m = 2;// in kg per min
m = m / 60;// in kg per sec
W = 20;// in kW
h1 = 1400;// in kJ/kg
h2 = 1300;// in kJ/kg
Q = (m * (h2 - h1)) + W;// in kJ/s
disp(Q,"Rate of heat transfer to the water jacket in
    kJ/sec");
```

Scilab code Exa 5.3 Power output of the turbine

```
// Exa 5.3
clc;
clear;
```

```
close;
// Given data
g= 9.81;
p1 = 3;// in Mpa
p2 = 10;// in kPa
T1 = 350;// in  C
T1 = T1 + 273;// in K
m = 1;// in kg per sec
v1 = 50;// in m per sec
v2 = 120;// in m per sec
z1 = 2;// in m
z2 = 5;// in m
C_p = 1.005;// in kJ per sec
Q = 5;// in kJ per sec
Q = -(Q) * 10^3;// in J per sec
T2 = (p2 * T1)/p1;// in K
del_h = C_p * (T2-T1);// in kJ
del_h = del_h * 10^3;// in J
t = m * ( del_h +(v2^2-v1^2)/2 + (g * (z2 - z1)));// t is variable taken for calculation
W_s = Q - t;// in J per sec
W_s = W_s * 10^-6;// in MW
disp(W_s,"The power output of the turbine in MW");
// If kinetic and potential energy are ignored then
W_s2 = Q -(m * del_h);// in J per sec
W_s2 = W_s2 * 10^-6;// in MW
errorIntroduced= (abs(W_s)-abs(W_s2))/abs(W_s)*100; // in %
disp(errorIntroduced,"Total error introduced in % is :");
```

Scilab code Exa 5.4 Quantity of water circulated

```
//Exa 5.4
clc;
```

```
clear;
close;
//Given data
h1 = 246.6;// in kJ/kg
h2 = 198.55;// in kJ/kg
W = 0;
g= 9.8;
Q= -(105000);// in kJ per hr
// m * (h1 + ((v1*^2)/(2*1000)) + ((g * z1)/1000)) + Q = m * (h2 + ((v2^2)/(2*1000)) + ((g * z2)/1000)) + W
// v1 and v2 is change in velocity is neglected and z2 = z1 + 10
m = Q/( (h2-h1) + ((g * 10)/1000) );// kg per hr
disp(m,"Quantity of  water circulated through the pipe in kg/hr is");
```

Scilab code Exa 5.5 Power of motor required

```
//Exa 5.5
clc;
clear;
close;
//Given data
m=15;// in kg/min
m= m/60;// in kg/sec
H1= 5;// in kJ/kg
H1= H1*10^3;// in J/kg
H2= 173;// in kJ/kg
H2= H2*10^3;// in J/kg
V1= 5;// in m/s
V2= 7.5;// in m/s
Q= 760;// in kJ/min
Q= Q*10^3/60;// in J/s
// Formula (H1+V1^2/2)+(-Q)= (H2+V2^2/2)+W
```

```
W= (H1+V1^2/2)+(-Q)-(H2+V2^2/2);// in W/kg
W= W*10^-3;// in kW/kg
// The work done will be
W= m*W;// in kW
P= abs(W);// in kW
disp(P,"Power of the motor required to drive the
    compressor in kW is : ")
// Part (b)
v1= 0.5;// in m^3/kg
v2= 0.15;// in m^3/kg
// A1/A2= rho2*V2/(rho1*V1) = v1*V2/(v2*V1)
ratioOFA1andA2= v1*V2/(v2*V1);
radioOFd1andd2= sqrt(ratioOFA1andA2);
disp(radioOFd1andd2,"Ratio of inlet pipe diameter to
    outlet pipe diameter is : ")
```

Chapter 6

Second Law of Thermodynamics

Scilab code Exa 6.1 Temperature of the source and the sink

```
//Exa 6.1
clc;
clear;
close;
//Given data
// In first case      (T1-T2)/T1=1/6              or
   T1= 1.2*T2                          (i)
// In seond case   (T1-(T2-62))/T1= 2/6   or    2*T1
   -3*(T2-62)=0        (ii)
// From eq (i) and (ii)
T2= 186/0.6;// in K
T1= 1.2*T2;// in K
disp(T2-273,"Temperature of the source in  C is : "
   )
disp(T1-273,"Temperature of the sink in  C is : ")
```

Scilab code Exa 6.2 Minimum power required

```
// Exa 6.2
clc;
clear;
close;
// Given data
T1 = 25;// in  C
T2 = 1;// in  C
T1 = T1 + 273;// in K
T2 = T2 + 273;// in K
HT= 2;// heat transfer across the wall and the roof in MJ/hr
HT= HT*10^6;// in J/hr
Q = HT* (T1-T2);// in J/hr
COP_heat = T1/(T1-T2);
W_net = Q/COP_heat;// in J/hr
disp(W_net*10^-3/3600,"Power rquired for operating the pump in kW");
// Part (b)
T2= 25;// in  C
T2=T2+273;// in K
// COP= T2/(T1-T2)             (i)
// COP= HT*(T1-T2)/W_net           (ii)
// From (i) and (ii)
T1= sqrt(W_net*T2/HT)+T2;// in K
T1= T1-273;// in  C
disp(T1,"The value of T1 in  C is : ")
```

Scilab code Exa 6.3 Ratio of heat transfer to circulating water to the engine

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

```
close;
//Given data
heatEngineEffi= 32/100;// heat engine efficiency
COP= 5;// COP of heat pump
// heat engine efficiency = Wnet/Q1 = (Q1-Q2)/Q1
Q1byWnet= 1/heatEngineEffi;
Q2byWnet= (1-heatEngineEffi)*Q1byWnet;
// COP = Q4/Wnet = Q4/(Q4-Q3)
Q4byWnet= COP;
ratio= (Q2byWnet+Q4byWnet)/Q1byWnet;// ratio of heat
    transferred to the circulating water to heat
   trasferred to the engine
disp(ratio,"Ratio of heat trasferred to the
   circulating water to heat trasferred to the
   engine is : ")
```

Scilab code Exa 6.4 Claim of inventor is true or not

```
//Exa 6.4
clc;
clear;
close;
//Given data
Q = 88;// in MJ
Q=Q*10^3;// in kJ
T1 = 190;// in  C
T1 = T1 + 273;// in K
T3 = -15;// in  C
T3 = T3 + 273;// in K
Eta_carnot = (T1 - T3)/T1;
Wnet= Eta_carnot * Q;// in kJ
CarnotPower= Wnet/3600;// in kWh
disp(CarnotPower,"The value of Carnot Power in kWh
   is : ")
disp("As the actual power produced by the invented
```

```
    engine is more than the Carnot Power, ");
disp("so inverter claim is ")
disp(" not true")
```

Scilab code Exa 6.5 Minimum power required

```
//Exa 6.5
clc;
clear;
close;
// Given data
T1 = 24;// in  C
T1 = T1 + 273;// in K
T2 = 2;// in  C
T2 = T2 + 273;// in K
Q = 100;//in MJ/h
Q = Q * 10^3;//in kJ/h
COP_heatPump = T1/(T1-T2);
W = Q/COP_heatPump;//in kJ/h
W = W/3600;// in kW
disp(W,"The theoretical minimum power required to
    drive the heat pump in kW is : ")
COP_refrigerator = T2/(T1-T2);
W = Q/COP_refrigerator;// in kJ/h
W = W/3600;// in kW
disp(W,"The theoretical power required to drive the
    heat pump when it is used as a refrigerator in kW
     is : ");
```

Scilab code Exa 6.6 Reversible or irreversible cycle

```
//Exa 6.6
clc;
```

```
clear;
close;
//Given data
Q1= 278;// in kJ/s
T1= 283+273;// in K
T2= 50+273;// in K
// Let integrate of delta Q by T is V
disp("Part (a)")
Q2= 208;// in kJ/s
// By Clausius inequality
V= Q1/T1-Q2/T2;
if V<0 then
    disp("The cycle is irreversible")
else
    if V>0 then
        disp("Reversible or irreversible cycle is
           not possible and the result is impossible
           ")
    else
        disp("The cycle is reversible")
    end
end
disp("Part (b)")
Q2= 139;// in kJ/s
V= Q1/T1-Q2/T2;
if V<0 then
    disp("The cycle is irreversible")
else
    if V>0 then
        disp("Reversible or irreversible cycle is
           not possible and the result is impossible
           ")
    else
        disp("The cycle is reversible")
    end
end
disp("Part (c)")
Q2= 161.5;// in kJ/s
```

```
V= Q1/T1-Q2/T2;
if V<0 then
    disp("The cycle is irreversible")
else
    if V>0 then
        disp("Reversible or irreversible cycle is
           not possible and the result is impossible
           ")
    else
        disp("The cycle is reversible")
    end
end
```

Scilab code Exa 6.16 Heat rejected

```
//Exa 6.16
clc;
clear;
close;
// Given data
Wnet_compresser= 3;// in kW
Wnet_compresser=Wnet_compresser*3600;// in kJ/h
Qabsorbed= 50;// in MJ/h
Qabsorbed=Qabsorbed*10^3;// in kJ/h
T1 = 46+273;// in K
T2 = 1+273;// in K
Qrejected= Wnet_compresser+Qabsorbed;// in kJ/h
disp(Qrejected*10^-3,"The heat rejected in MJ/h is :
   ")
I= -(-Qrejected/T1+Qabsorbed/T2);// in kJ/h
disp(I,"Irreversibility in kJ/h is : ")
```

Scilab code Exa 6.17 Entropy generated

```
//Exa 6.17
clc;
clear;
close;
// Given data
T1 = 12;// in  C
T2 = 92;// in  C
T1 = T1 + 273;// in K
T2 = T2 + 273;// in K
del_T = T2 - T1;// in K
m = 20;// in kg
C_v = 4.187;
s= 1;
Q = m * s * del_T;// in cal
Q = Q * 4.18;// in J
H = 2;// heat given by the heater in kw
H = H * 10^3;// in J/sec
t = Q/H;//time taken by the heater to raise the temp. in sec
disp(t,"Time taken by the heater to raise the temperature in sec is");
del_phi = m * C_v * log(T2/T1);// in kJ/K
disp(del_phi,"Entrophy generated during the process in kJ/K");
```

Scilab code Exa 6.18 Reversible irreversible or carnot cycle

```
// Exa 6.18
clc;
clear;
close;
// Given data
Q1 = 1000;// in kW
Q2 = 492;// in kW
T1 = 285;// in  C
```

```
T1 = T1 + 273;// in K
T2 = 5;// in  C
T2 = T2 + 273;// in K
Eta_carnot = (T1-T2)/T1*100;// in percentage
disp(Eta_carnot,"Carnot efficiency in % is : ")
Eta_heat = (Q1 - Q2)/Q1*100;// in percentage
disp(Eta_heat,"Efficiency of the heat engine in % is : ")
if Eta_heat>Eta_carnot then
    disp("As the efficiency of heat engine cannot be more than Carnot efficiency , Hence engine cannot execute irreversible cycle.So engine will execute Carnot Cycle which is a reversible cycle too")
end
```

Scilab code Exa 6.19 Output of the engine

```
// Exa 6.19
clc;
clear;
close;
// Given data
n = 1080;// in cycle/min
Q_s = 57;// in J/cycle
T1 = 12;// in  C
T1 = T1 + 273;// in K
T2 = 2;// in  C
T2 = T2 + 273;// in K
// 1-(Q_r/Q_s) = 1- (T2/T1)
Q_r = (T2/T1)*Q_s;// in J/cycle
W = Q_s - Q_r;// in J/cycle
P_o = W * n;// in J/min
P_o = P_o/60;// in W
disp(P_o,"The output of the engine in watt is");
```

Scilab code Exa 6.20 Minimum power required

```
// Exa 6.20
clc;
clear;
close;
// Given data
Q2 = 10^5;// in kJ/hr
T1 = -3;// in  C
T1 = T1 + 273;// in K
T2 = 22;// in  C
T2 = T2 + 273;// in K
COP_heat = 1/(1-T1/T2);
W = Q2/COP_heat;// in kJ/hr
W = W/3600;// in kW
disp(W,"Minimum power required in kW is");
```

Scilab code Exa 6.21 Engine efficiency

```
//Exa 6.21
clc;
clear;
close;
// Given data
T_A= 927+273;// in K
T_B= 127+273;// in K
T_C= T_B;// in K
// Q_A= Q_B+Q_C+W = 2*Q_B+W (since Q_B=Q_C)        (i)
// Q_A/T_A= Q_B/T_B+Q_C/T_C or
// Q_A= 2*Q_B*T_A/T_B                (ii)
// From eq (i) and (ii)W= 2*Q_B*(T_A/T_B-1)        (iii
    )
```

```
// Dividing (iii) by (ii)
WbyQ_A= (T_A/T_B-1)/(T_A/T_B);
disp(WbyQ_A*100,"The engine efficiency in % is : ")
```

Scilab code Exa 6.22 Heat rejected

```
//Exa 6.22
clc;
clear;
close;
// Given data
T_A= 700;// in K
T_B= 600;// in K
T_C= 500;// in K
Q_A= 1200;// in kJ
// Q_B+Q_C= Q_A-200                              (i)
// Q_A/T_A = Q_B/T_B+Q_C/T_C      (ii)
// From eq(i) and (ii)
Q_B= (Q_A*(1/T_B-1/T_A)-200/T_B)/(1/T_B-1/T_C);// in
    kJ
Q_C= Q_A-Q_B-200;// in kJ
disp(Q_B,"The heat rejected at B in kJ is : ")
disp(Q_C,"The heat rejected at C in kJ is : ")
```

Scilab code Exa 6.23 Intermediate temperature

```
//Exa 6.23
clc;
clear;
close;
// Given data
T1= 180+273;// in K
T2= 20+273;// in K
```

```
// W_A/Q1= 1-T3/T1         (i)
// W_B/QB= 1-T2/T3         (ii)
// W_A= W_B                     (iii)
// Q1= Q_B+W_A             (iv)
// From eq(i),(ii),(iii) and (iv)
T3= (T1+T2)/2;// in K
disp(T3-273,"The intermediate temperature in  C is
    : ")
```

Scilab code Exa 6.24 Least power necessary to pump

```
//Exa 6.24
clc;
clear;
close;
// Given data
Q2 = 1.75;// in kJ/sec
T1 = -15;// in  C
T1 = T1 + 273;// in K
T2 = 30;// in  C
T2 = T2 + 273;// in K
del_T = T2 - T1;// in K
// Q2/W_net = T2/(del_T)
W_net = Q2 * del_T/T1;// in kW
disp(W_net,"Least power required in kW is");
```

Chapter 7

Entropy

Scilab code Exa 7.2 Change in entropy of air

```
//Exa 7.2
clc;
clear;
close;
// Given data
v1 = 0.05;// in m^3
v2 = 8 * v1;// in m^3
T1 = 280;// in   C
T1 = T1 + 273;// in K
T2 = 25;// in   C
T2 = T2 + 273;// in K
p1 = 8;// in bar
C_p = 1.005;// in kJ/kgK
C_v = 0.712;// in kJ/kgK
R = C_p - C_v;// in kJ/kgK
del_phi = (R * ( log(v2/v1)) ) + (C_v * (log(T2/T1))
    );// in kJ/kgK
disp(del_phi,"The change in entrophy of air during
   the process in kJ/kgKis");
```

Scilab code Exa 7.3 Overall change in entropy

```
// Exa 7.3
clc;
clear;
close;
// Given data
m = 5;// in kg
T1 = 50;// in  C
T1 = T1 + 273;// in K
T2 = 250;// in  C
T2 = T2 + 273;// in K
C_p = 1.0;
C_v = 0.72;
T3 = 50;// in  C
T3 = T3 + 273;// in K
del_phi = m * C_p * (log(T2/T1));// in kJ/ K (this is increase in entrophy)
del_phi1 = m * C_v * (log(T3/T2));// in kJ/K (this is decrease in entrophy)
phi_net = del_phi - abs(del_phi1);// in kJ/K
disp(phi_net,"The net change in entrophy in kJ/K is");
```

Scilab code Exa 7.6 Entropy generated during the process

```
// Exa 7.6
clc;
clear;
close;
// Given data
Q1 = 1600;// in kJ
```

```
Q2 = 1600;// in kJ
T1 = 800;// in K
T2 = 127;// in  C
T2 = T2 + 273;// in K
d1_phi = Q1/T1;// in kJ per K
d2_phi = Q2/T2;// in kJ per K
net_phi = d2_phi - d1_phi;// in kJ per K
disp(net_phi,"Total entrophy generated during the
    process in kJ/K is : ");
```

Scilab code Exa 7.8 The flow of air

```
// Exa 7.8
clc;
clear;
close;
// Given data
T_A= 50+273;// in K
T_B= 13+273;// in K
P_A= 130;// in kPa
P_B= 100;// in kPa
Cp= 1.005;// in kJ/kg-K
pvByT= 0.287;// p in kPa, v in m^3/kg, T in K
del_S_system= Cp*log(T_B/T_A)-pvByT*log(P_B/P_A);//
    in kJ/kg-K
del_S_surrounding=0;
del_S_universe= del_S_system+del_S_surrounding;// in
     kJ/kg-K
disp(del_S_universe,"The change in entropy in kJ/kg-
    K is : ")
disp("But a negative change in entropy is not
    possible,");
disp("hence the flow of air must be from B to A")
```

Scilab code Exa 7.9 Change in entropy

```
// Exa 7.9
clc;
clear;
close;
// Given data
m = 5;// in kg
s= 4.18;
T1 = 0;// in  C
T2 = 20;// in  C
dt = T2 - T1;// in  C
Q = m * s * dt;// in kJ
L = 335;// in kJ/kg
// Q = m_i * l
m_i = Q/L;// in kg
T1 = T1 + 273;// in K
T2 = T2 + 273;// in K
del_S = ((m_i * L)/T1) - (m * s * (log(T1/T2)));// in kJ per K
disp(del_S,"Change in entrophy of the adiabatic in kJ/K is");
```

Scilab code Exa 7.11 Net heat transfer and overall change in entropy

```
//Exa 7.11
clc;
clear;
close;
// Given data
p1 = 1 * 10^5;// in N/m^2
C_p = 1.005;// in kJ/kg k
```

```
R = 287;// in j/kg k
T1 = 290;// in K
T2 = 580;// in K
v1 = 1;// in m^3
m = (p1 * v1)/(R * T1);// in kg
Q = m * R * (T2-T1);// in J
Q = Q * 10^-3;// in kJ
del_phi = m * C_p * (log(T2/T1));// in kJ per K
R = R * 10^-3;// in kJ/kg K
C_v = C_p - R;// in kJ/kg k
del1_phi = m * C_v * (log(T1/T2));// in kJ/K
net_phi = del_phi + del1_phi;// in kJ/K
disp(net_phi,"Over all change in entrophy in kJ/K");
```

Chapter 8

Availability and Irreversibility

Scilab code Exa 8.1 Availability and unavailability of heat

```
//Exa 8.1
clc;
clear;
close;
// Given data
Q = 16;// in MJ
Q = Q * 10^3;// in kJ
T_H = 227;// in  C
T_H = T_H + 273;// in K
T_L = 15;// in  C
T_L = T_L + 273;// in K
del_S = Q/T_H;// in kJ/K
A = Q - (T_L * del_S);// in kJ
disp(A,"The available part of heat in kJ is ");
U_P_ofHeat = T_L * del_S;// unavailable part of heat
    in kJ
disp(U_P_ofHeat,"The unavailable part of heat in kJ
   is :");
```

Scilab code Exa 8.2 Availability and unavailability of system

```
//Exa 8.2
clc;
clear;
close;
// Given data
Q = 12000;// in kJ
T_H = 600;// in K
T_L = 300;// in K
dS = Q / T_H;//in kJ/K
A = Q - (T_L * dS);//available work in kJ
disp(A,"Available work is in kJ");
UA = T_L * dS;//unavailable work in kJ
disp(UA,"Anavailable work is in kJ");
```

Scilab code Exa 8.3 Available and unavailable energy

```
// Exa 8.3
clc;
clear;
close;
// Given data
m = 800;// in kg
C_p = 0.5;// in kJ/kg K
T2 = 500;// in K
T1 = 1250;// in K
T_o = 300;// in K
del_t = T1 - T2;// in K
Q = m * C_p * del_t;// in kJ
dS = abs(m * C_p * log(T2/T1));// in kJ/K
availableEnergy = Q - (T_o * dS);//in kJ
disp(round(availableEnergy*10^-3),"Available energy in MJ is :");
unavailableEnergy = T_o * dS;// UA stands for
```

```
   unavailable energy in kJ
disp(round(unavailableEnergy*10^-3),"Unavailable
   energy in MJ is :");
```

Scilab code Exa 8.4 Availability per kg of steam entering and leaving the turbine

```
//Exa 8.4
clc;
clear;
close;
// Given data
h_i = 726.1;
h_o = 25.03;
T_o = 298;// in K
s_i = 1.582;
s_o = 0.087;
h2 = 669;
s2 = 1.677;
h3 = 52.17 + (0.9 * 567.7);
s3 = 0.1748 + (0.9 * 1.7448);
sai_i = (h_i - h_o) - (T_o * (s_i - s_o));// in kcl/
   kg
disp(sai_i,"The availablibity per kg of steam
   entering in kcl/kg is :");
sai_e = (0.25 * ((h2 - h_o) - (T_o * (s2 - s_o)))) +
    (0.75 * ((h3 - h_o) - (T_o * (s3 - s_o)))) ;//
   in kcl/kg
disp(sai_e,"The availablibity per kg of steam
   leaving in kcl/kg is :");
w_rev = sai_i - sai_e;// in kcl/kg
disp(w_rev,"reveseble work per kg of steam in kcl/kg
   ");

// Note: There is calculation error in evaluating
```

```
the value of availability per kg of steam leaving in kcl/kg . so the answer in the book is wrong and coding is right.
```

Scilab code Exa 8.5 Irreversibility

```
// Exa 8.5
clc;
clear;
close;
// Given data
T_o = 298;// in K
m2 = 25000;
s2 = 16775;
m3 = 75000;
s3 = 17448;
m1 = 1000000;
s1 = 1582;
Q = -16;// in MJ
Q = Q * 10^3;// in kJ
I = (T_o * ((m2 * s2) + (m3 * s3) - (m1 * s1))) - Q;// in cal/hr
I=I*10^-3;// in kcal/hr
disp(I,"The irreversiblity in kcal/hr");

// Note: There is calculation error in evaluating the value of the irreversibility in kcal/hr. so the answer in the book is wrong and coding is right.
```

Scilab code Exa 8.6 Availability per kg of steam

```
// Exa 8.6
```

```
clc;
clear;
close;
// Given data
h_i = 749.2;
h_o = 25.03;
T_o = 298;// in K
s_i = 1.6202;
s_o = 0.0877;
phi_i = (h_i - h_o)- (T_o * (s_i - s_o));// kcal/kg
disp(phi_i,"The availablibity before adiabatic
    throttling in kcal/kg is : ");
h_e = 749.2;
s_e = 1.6936;
phi_e = (h_e - h_o) - (T_o * (s_e - s_o));// in kcal
    /kg
disp(phi_e,"The availablibity before adiabatic
    throttling in kcal/kg is : ");
Wrev = phi_i - phi_e;// in kcal/kg
disp(Wrev,"Reversible work in kcal/kg is : ");
Wactual = 0;
i = Wrev-Wactual;// in kcal/kg
disp(i,"Irreversibility per kg of steam in kcal/kg
    is : ");
```

Scilab code Exa 8.7 Lost work

```
//Exa 8.7
clc;
clear;
close;
// Given data
// del_W = T * ds - del_Q
T = 600;// in K
p_i = 7;//kgf/cm^2
```

```
p_e = 1.5;//kgf/cm^2
T_o = 298;// in K
R = 29.27/427;
del_W_lost = T * ( R *log(p_i/p_e));// in kcal/kg
disp(del_W_lost,"Lost work in kcal/kg is");
i = T_o * (R * (log(p_i/p_e)));// in kcal/kg
disp(i,"Irreversebility per kg of air flow in kcal/
    kg is");
```

Chapter 9

Properties of Steam and Thermodynamic Cycles

Scilab code Exa 9.1 Specific volume enthalpy latent heat and entropy

```
// Exa 9.1
clc;
clear;
close;
// Given data
disp("Part (i) : For dry saturated steam at 17.8 bar
  ")
p= 17.8;// in bar
p1= 17.5;// in bar
p2= 18.0;// in bar
Vs1= 0.1135;// in litre/kg
Vs2= 0.1104;// in litre/kg
Hs1= 2796.1;// in kJ/kg
Hs2= 2796.4;// in kJ/kg
L1= 1918;// in kJ/kg
L2= 1912;// in kJ/kg
phi_s1= 6.389;// in kJ/kg K
phi_s2= 6.379;// in kJ/kg K
Vs= Vs1-(Vs2-Vs1)/(p2-p1)*(p-p1);// in litre/kg
```

```
Hs= Hs1+(Hs2-Hs1)/(p2-p1)*(p-p1);// in kJ/kg
L= L1- (L1-L2)/(p2-p1)*(p-p1);// in kJ/kg
phi_s= phi_s1- (phi_s1-phi_s2)/(p2-p1)*(p-p1);// in kJ/kg K
disp("Part (i) : For dry saturated steam at 17.8 bar ")
disp(Vs,"The specific volume in litre/kg is : ");
disp(Hs,"The enthalpy in kJ/kg is : ");
disp(L,"The latent heat in kJ/kg is : ");
disp(phi_s,"The entropy in kJ/kg K")
disp("Part (ii) : For superheated steam at 16 bar and 340 C")
T= 340;// in K
T1= 300;// in K
T2= 350;// in K
Vsup1= 0.1585;// in m^3/kg
Vsup2= 0.1743;// in m^3/kg
Hsup1= 3030;// in kJ/kg
Hsup2= 3142;// in kJ/kg
phi_sup1= 6.877;// in kJ/kg K
phi_sup2= 7.063;// in kJ/kg K
Vsup= Vsup1+(Vsup2-Vsup1)/(T2-T1)*(T-T1);// in m^3/kg
Hsup= Hsup1+(Hsup2-Hsup1)/(T2-T1)*(T-T1);// in kJ/kg
phi_sup= phi_sup1+(phi_sup2-phi_sup1)/(T2-T1)*(T-T1);// in kJ/kg
disp(Vsup,"The specific volume in m^3/kg is : ");
disp(Hsup,"The enthalpy in kJ/kg is : ");
disp(phi_sup,"The entropy in kJ/kg K is : ")
```

Scilab code Exa 9.2 Condition of steam

```
// Exa 9.2
clc;
clear;
```

```
close;
// Given data
h_sen = 798.43;// in kJ/kg
L = 1984.3;// in kJ/kg
H_total_wet = 2665.7;
// H_total_wet= h_sen+x*L
x = (H_total_wet - h_sen)/L;
disp(x,"The value of x is :");
// Part (b)
h_total_sup= 2961;// in kJ/kg
Cps= 2.112;// in kJ/kg
H_total_dry= 2782.7;// in kJ/kg
// Let deltaT= T_sup-T_sat
// h_total_sup = h_sen+L+h_sup = H_total_dry +Cps*deltaT
deltaT= (h_total_sup-H_total_dry)/Cps;// in  C
disp(deltaT,"Degree of superheat in  C is :")
```

Scilab code Exa 9.3 Change in enthalpy and entropy

```
// Exa 9.3
clc;
clear;
close;
// Given data
H2 = 3055;// in kj per kg
H3 = 2550;// in kj per kg
fie_1 = 7.15;// kj per kg k
fie_2 = 7.57;// kj per kg k
d_fie= fie_2 - fie_1;// in kj per kg k
disp(d_fie,"Change in entropy during throttling process in kJ/kg-K is :");
dH = H2 - H3;// in kj per kg
disp(dH,"Change in enthalpy during isentropic process in kJ/kg is : ");
```

Scilab code Exa 9.4 Quantity of heat

```
// Exa 9.4
clc;
clear;
close;
// Given data
H_w = 670.4;// in kJ/kg
L = 2085;// kJ per kg
T_sat = 158.8;// in degree c
m = 4;// in kg
x = 0.5;
h_sen = 670.4;// in kJ/kg
H_totalwet = m * ( h_sen + (x *L));// in kJ
x1 = 0.95
H_totalwet1 = m *( h_sen + (x1 *L));// in kJ
Q1 =  H_totalwet1 - H_totalwet;// in kJ
disp(Q1,"Part (i) The quantity of heat in case first
    in kJ is : ");
// Part (b)
x2 = 1;
H_totaldry = m *( h_sen + (x2 *L));// in kJ
Q2 = H_totaldry - H_totalwet;// in kJ
disp(Q2,"Part (ii) The quantity of heat in case
   second in kJ is : ");
// Part (c)
H_totalsup = 3062.3;// in kJ per kg
H_totalsup = m * H_totalsup;// in kJ
Q3 = H_totalsup - H_totalwet;// in kJ
disp(Q3,"Part (iii) The quantity of heat in case
   third in kJ is : ");
// Part (d)
H_totalsup = 2950.4;// in kj per kg
H_totalsup = m * H_totalsup;// in kj
```

```
Q4 = H_totalsup - H_totalwet;// in kj
disp(Q4,"Part (iv) The quantity of heat in case
    forth in kJ is : ");
```

Scilab code Exa 9.5 Isentropic efficiency of turbine

```
// Exa 9.5
clc;
clear;
close;
// Given data
p1 = 2.5;// Mpa
p1 = p1 * 10^6;// in pa
p1 = p1 * 10^-5;// in bar
p2 = 10;// in kpa
p2 = p2 * 10^3;// in pa
p2 = p2 * 10^-5;// in bar
H1 = 2878;// in kJ/kg at 25 bar and 250 C
H2 = 2583.9;// in kJ/kg at 0.1 bar for dry saturated
    steam
AHD= H1-H2;// actual heat drop in kJ/kg
H2_desh = 2110;// in kj per kg
IHD = H1 - H2_desh;// Isentropic heat drop in kJ/ kg
Eta_Isentropic = (AHD/IHD) * 100;// in %
disp(Eta_Isentropic,"Isentropic efficiency in % is")
    ;
// H1 + v1^2/2 + g*z1 + Q = H2 + v2^2/2 + g*z2 + W
W = H1 - H2;// in kJ/kg (as v1=v2, z1= z2 and Q=0)
disp(W,"Turbine work is in kJ/kg is :");
```

Scilab code Exa 9.6 Dryness fraction of steam

```
//Exa 9.6
```

```
clc;
clear;
close;
// Given data
p1 = 11;// in bar
p2 = 1.2;// in bar
H_w1 = 781.1;//in kJ/kg
L1 = 2000;// in kJ/kg
t1 = 120;// in degree c
t1 = t1 + 273;// in K
t2 = 104.81;// in degree c
t2 = t2 + 273;// in K
H_dry2 = 2683.4;// in kJ/kg
C_p = 2.607;// in kJ/kgK
// From Hw1+x*L1 = H_dry2+Cp*(t1-t2)
x = (H_dry2 + (C_p * (t1 - t2)) - H_w1) / L1;
disp(x,"Dryness fraction of steam is :");
x1 = (H_dry2 - H_w1)/L1;
disp(x1,"Maximum dryness fraction of steam is :");
```

Scilab code Exa 9.7 Dryness fraction of sample steam

```
//Exa 9.7
clc;
clear;
close;
// Given data
W = 21;// in kg
w_wp = 2;// in kg
h1 = 781.15;// in kJ/kg
L1 = 1998.5;// in kJ/kg
m = 2;// in kg
h2 = 420.5;// in kJ/kg
L = 2255.9;// in kJ/kg
t_sat = 100.4;// in degree c
```

```
t1 = 110;// in degree c
C_ps = 2;// in kJ/kgK
x1 = W / (W + w_wp);
x2 = (h2 + L + m * (t1-t_sat) - h1)/ L1;
x = x1 * x2;
disp(x,"The dryness fraction for sample steam is");
```

Scilab code Exa 9.8 Heat transfer during the process

```
//Exa 9.8
clc;
clear;
close;
// Given data
h_sen = 417.4;// in kJ/kg
h_totaldry = 2675.4;// in kJ/kg
L = 2258;// in kJ/kg
v = 5;// in m^3
v_v = 4.95;// in m^3
x = v_v/v;
Q = h_totaldry -(h_sen +x*L);// in kJ/kg
disp(Q,"Heat transfered per kg in kJ/kg is : ");
```

Scilab code Exa 9.9 Work done during evaporation

```
// Exa 9.9
clc;
clear;
close;
// Given data
m = 1;// in kg
p = 10;// in bar
p = p * 10^2;// in kpa
```

```
x = 0.94;
h_sen = 762.61;// in kJ/kg
L = 2013.6;// in kJ/kg
v_s = 0.1942;// in m^3 per kg
w_ext = p * x * v_s * m;// in kJ/kg
disp(w_ext,"The work done during evaporation in kJ/
   kg is");
// Part (b)
L_internal = (x * L) - w_ext;// in kJ/kg
disp(L_internal,"Internal latent heat in kJ/kg is");
// Part (c)
U_wet = h_sen+x*L-p*x*v_s;// in kJ/kg
disp(U_wet,"Internal energy in kJ/kg is");
```

Scilab code Exa 9.10 Entropy

```
// Exa 9.10
clc;
clear;
close;
// Given data
T_sat = 179.88;// in degree c
T_sat = T_sat + 273;// in k
T_sup = 200;// in degree c
T_sup = T_sup + 273;// in k
L = 2013.6;// in kJ/kg
C_ps = 2.326;
C_pw = 1;
x = 0.8;
phi_wet = C_pw *log(T_sat/273) + ( (x * L)/T_sat);//
    in kJ/kg-K
disp(phi_wet,"Entropy of wet steam in kJ/kg-K is");
// Part (b)
phi_dry =C_pw * log(T_sat/273)+L/T_sat;// in kJ/kg
disp(phi_dry,"Entropy of dry and saturated steam in
```

```
kJ/kg-K is");
// Part (c)
phi_sup = phi_dry+C_ps *log(T_sup/T_sat);// in kJ/kg
disp(phi_sup,"Entropy at 200  C in kJ/kg-K is :");
```

Scilab code Exa 9.11 Volume of steam

```
// Exa 9.11
clc;
clear;
close;
// Given data
m = 1;// in kg
x = 0.9;
p = 1;// N/mm^2
p = p * 10^1;// in bar
p = p * 10^2;// in kPa
h_sen  = 762.61;// in kJ/kg
L = 2013.6;// in kJ/kg
v_s = 0.1944;// in m^3 per kg
H_totalwet = h_sen + x*L;// in kJ/kg
U_wet = H_totalwet - (p * x * v_s);// in kJ/kg
I = U_wet / H_totalwet;// internal energy as a
    fraction of total heat
I = I * 10^2;// in %
disp(I,"The internal energy in % is");
// Part (b)
v_s = 0.1542;// in m^3/kg
h_sen = 815;// in kJ/kg
L = 1972;// in kJ/kg
H_totaldry = 2787;// in kJ/kg
C_ps = 2.199;
t_sup = 250;// in  C
t_sup = t_sup + 273;// in K
t_sat = 190.74;// in  C
```

```
t_sat = t_sat + 273;// in K
p1 = 13 * 10^2;// in kPa
v_ssup = v_s*t_sup/t_sat;// in m^3/kg
disp(v_ssup,"The volume of superheated steam in m^3/
    kg is");
// Part (c)
t_sat = t_sat - 273;// in  C
t_sup = t_sup - 273;// in  C
U_sup =h_sen+L+C_ps*(t_sup-t_sat)-p1*v_ssup;// in kJ
del_U =  U_sup -  U_wet;// in kJ
disp(del_U,"Change in internal energy in kJ is :");
```

Scilab code Exa 9.12 Condition of steam

```
// Exa 9.12
clc;
clear;
close;
// Given data
m = 0.5;// in kg
M = 6.6;// in kg
x1 = M / (M+m);
h_dry = 2683;//in kJ/kg
C_p = 2.1;
h_sen = 814.5;//in kJ/kg
L = 1973;// in kJ/kg
t_sup = 120;// in  C
t_sat = 104.8;// in  C
x2 =(h_dry+C_p*(t_sup - t_sat)-h_sen)/ L;
x = x2 * x1;
disp(x,"the dryness fraction of steam is");
```

Chapter 10

Steam Power Plant and Rankine Cycle

Scilab code Exa 10.1 Carnot efficiency

```
//Exa 10.1
clc;
clear;
close;
// Given data
p1 = 10;// in bar
p2 = 0.5;// in bar
T1 = 179.9;// in  C
T1 = T1 +273;// in K
T2 = 81.4;// in  C
T2 = T2 + 273;// in K
Eta_carnot = (T1 - T2)/T1*100;// in %
disp(Eta_carnot,"Carnot efficiency of an engine when
    the steam is 0.87 dry in % is");
disp(Eta_carnot,"Carnot efficiency of an engine when
    the steam is dry saturated in % is");
T1 = T1 + 50;// in K
Eta_carnot1 = (T1 - T2) / T1*100;// in %
disp(Eta_carnot1,"Carnot efficiency of an engine
```

```
when the steam is superheated in % is");
```

Scilab code Exa 10.2 Heat supplied to the boiler

```
// Exa 10.2
clc;
clear;
close;
// Given data
h1 = 3015;// in kJ/kg
h2 = 2326;// in kJ/kg
h3 = 113;// in kJ/kg
h4 = 114.95;// in kJ/kg
Q = h1 - h4;// in kJ/kg
disp(Q,"Heat supplied to the boiler in kJ/kg is");
W_T = h1 - h2;/// in kJ/kg
disp(W_T,"Work developed by turbine in kJ/kg is : ")
    ;
W_P = ( h1 - h3) - Q;// in kJ/kg
disp(W_P,"Work absorbed by pump in kJ/kg is : ");
Eta = (W_T - W_P)/Q*100;// in %
disp(Eta,"Efficiency of flow system in % is : ");
```

Scilab code Exa 10.3 Percentage increse in Rankine efficiency

```
// Exa 10.3
clc;
clear;
close;
// Given data
phi_s = 6.583;
phi_w = 1.091;
phi_s1 = 6.504;
```

```
C_p = 2.25;
T_sat =179.9;// in  C
T_sat = T_sat + 273;// in K
T_sup = T_sat + 50;// in K
x2 = (phi_s - phi_w)/phi_s1;
H1 = 2776.2; // in kJ/kg
H_w2 = 340.6;// in kJ/kg
L2 = 2305;
H2 = H_w2 + (x2 * L2);// in kJ/kg
Eta_rankine = (H1 - H2)/(H1 - H_w2)*100;// in %
disp(Eta_rankine,"Rankine efficiency in % is");
phi_w1 = 2.138;
x1 = 0.87;
phi_s1 = 4.445;
phi_w2 = 1.091;
phi_s2 = 6.504;
x2 = (phi_w1 + (x1 * phi_s1) - phi_w2) / phi_s2;
H1 = 762.6 + (x1 * 2013.6);// in kJ/kg
H2 = 340.6 + (x2 * 2305);// in kJ/kg
Eta_rankine1 = (H1 - H2) / (H1 - H_w2)*100;// in %
PerDropInRankine= (Eta_rankine - Eta_rankine1)/
   Eta_rankine * 100;// in %
disp(PerDropInRankine,"Percentage drop in Rankine
   efficiency in % is : ");
phi_s1 = 6.583;
phi_w1 = 1.091;
phi_s2 = 6.504;
x2 = (phi_s1 + C_p * log(T_sup/T_sat) - phi_w1)/
   phi_s2;
H_s1 = 2776.2;
H1 = H_s1 + C_p * (T_sup - T_sat);// in kJ/kg
H2 = 340.6 + (0.88 * 2305);// in kJ/kg
H_w2 = 340.6;
Eta_rankine2 = (H1 - H2) / (H1 - H_w2);
Eta_rankine2 = Eta_rankine2 * 10^2;// in percentage
PerIncInRank = ((Eta_rankine2 - Eta_rankine)/
   Eta_rankine2) * 100;// in percentage
disp(PerIncInRank,"Percentage increase in rankine
```

```
efficiency in % is :");
```

Scilab code Exa 10.4 Thermal efficiency of the cycle

```
//Exa 10.4
clc;
clear;
close;
// Given data
H2 = 2776.2;// in kJ/kg
p1 = 10;// in bar
p_2 = 1;// in bar
p_3 = 0.25;// in bar
p_4 = p_3;// in bar
// w = (H2 - H_2) + ((p_2 - p_3) * v_2);// work done in kJ/kg
phi_2 = 6.583;
phi_d2 = 1.303;
L = 6.057;
x_2 = (phi_2 - phi_d2) / L;
H2_desh = 417.5 + (x_2* 2257.9);// in kJ/kg
v_s = 1.694;
v_2 = x_2 * v_s;// in m^3 per kg
w = (H2 - H2_desh) + ((p_2 - p_3) * v_2);// in kJ/kg
H4 = 282.7;// in kJ/kg
H_w4 =H4;// in kJ/kg
HeatSupplied = H2 - H4;// kJ/kg
Eta_modifiedRankine = w / HeatSupplied*100;// in %
disp(Eta_modifiedRankine,"Thermal effienciency of the cycle in % is : ");
HeatRemoved = HeatSupplied - w;// in kJ/kg
disp(HeatRemoved,"Heat removed in condenser in kJ/kg is : ");
```

Scilab code Exa 10.13 Work output per kg

```
// Exa 10.13
clc;
clear;
close;
// Given data
Q = 1100;// in kW
m=1;// in kg
p1 = 15;// in bar
p1 = p1 * 10^5;// in Pa
p1 = p1 * 10^-3;// in kPa
p2 = 0.05 * 10^2;// in kPa
v1 = 0.16;// m^3 per kg
v2 = 26;// in m^3 per kg
V1 = 110;// in m per s
V2 = 120;// in m per s
u1 = 2935;// in kJ per kg
u2 = 1885;// in kJ per kg
g = 9.8;
z1 = 0;
z2 = 0;
// Formula Q-W= m*{(u2 - u1) + (p2*v2-p1*v1)+1/2*(V2^2-V1^2)+g*(z2 - z1)}
W =Q-m*{(u2 - u1) + (p2*v2-p1*v1)+1/2*(V2^2-V1^2)+g*(z2 - z1)};// in kW
disp(W,"Work output per kg in kW is");
SteamFlowRate = Q / W;// in kg/sec
SteamFlowRate = SteamFlowRate * 3600;// in kg per hr
disp(SteamFlowRate,"Steam flow rate in kg/hr is");
```

Scilab code Exa 10.14 Ratio of mass flow rate of cooling water to condensing steam

```
// Exa 10.14
clc;
clear;
close;
// Given data
h_sen = 191.9;// in kJ/kg
L = 2392;// in kJ/kg
x = 0.95;
t_o = 35;// in  C
t_i = 20;// in  C
C = 4.18;
H_totalwet =  h_sen + (x * L);//in kJ/kg
// m_steam * (H_totalwet - h_sen) = m_water * C * (t_o - t_i)
msBYmw = (H_totalwet - h_sen) / ( C * (t_o - t_i)); //
disp(msBYmw,"The Ratio of mass flow rate of cooling water to condensing steam is : ");
```

Chapter 11

Introduction to Working of IC Engines

Scilab code Exa 11.1 Capacity of the engine

```
// Exa 11.1
clc;
clear;
close;
// Given data
n = 3;
l = 80;// in mm
d = 76;// in mm
r = 8.5;
V_s = (%pi/4) * d * d * l;// in mm^3
V_s = V_s * 10^-3;// in cm^3
// r = 1+ (V_s/V_c)
V_c = (1/(r - 1)) * V_s;// in cm^3
disp(V_c*10^3,"Clearance volume of cylinder in mm^3
    is : ");
C = V_s * n;// C stands for capacity of engine in cm
    ^3
C = C * 10^-3;// in litre
disp(C,"Capacity of the engine in litre is :");
```