Scilab Textbook Companion for Basic Engineering Thermodynamics by A. Venkatesh[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.

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Chapter 1

Fundamental Concepts and Definitions

Scilab code Exa 1.1 Find velocity of a body

```
clc
clear
printf("Example 1.1 | Page number 5 \n\n");
//find velocity of a body.

//Given Data
distanceTravelled = 80 * 1000 //in meters
timeOfTravel = 2 * 3600 //in seconds
printf("Distance of travel = %.2f m \n",distanceTravelled);
printf("Time of travel = %.2f s \n\n",timeOfTravel);

//Solution
Velocity = distanceTravelled / timeOfTravel  //in meter/second
printf("Velocity = %.2f m/s \n",Velocity);
```

Scilab code Exa 1.2 Find the force acting on the body

```
clc
clear
printf("Example 1.2 | Page number 6 \n\n");
//find the force.

//Given Data
mass = 120 //in kg
acceleration = 10 //in m/s^2
printf("Mass = %.2f kg \n",mass);
printf("Acceleration = %.2f m/s^2 \n\n",acceleration);

//Solution
force = mass * acceleration * 0.001  //in kN
printf("Force = %.2f kN \n",force);
```

Scilab code Exa 1.3 Find the weight of body

```
clc
clear
printf("Example 1.3 | Page number 6 \n\n");
//find the weight of a body.

//Given Data
mass = 60 //in kg
accelerationDueToGravity = 9.8 //in m/s^2
printf("Mass = %.2f kg \n",mass);
printf("Acceleration due to gravity = %.2f m/s^2 \n\n",accelerationDueToGravity);

//Solution
weight = mass * accelerationDueToGravity  //in N
printf("Weight = %.2f N \n",weight);
```

Scilab code Exa 1.4 Find the steam pressures in kPa

```
clc
clear
printf("Example 1.4 | Page number 10 \n\n");
//find the steam pressure.

//Given Data
Pg = 12E5 //in N/m^2 //inlet gauge pressure
Pvac = 75 / 1000 //in m Hg //exit gauge pressure
atmosphericPressure = 760 / 1000 //in m Hg //atmospheric pressure
density = 13.6 * 10^3 //kg/m^3 //density of mercury
g = 9.805 //in m/s^2 //acceleration due to gravity

printf("At inlet to the turbine, Pg = %.3f N/m^2 \n",Pg);
printf("At the exit, Pvac = %.3f m Hg \n",Pvac);
printf("Atmospheric pressure = %.3f m Hg \n",atmosphericPressure);
printf("Density of mercury = %.3f kg/m^3 \n",density);
printf("Acceleration due to gravity = %.3f m/s^2 \n\n",g);

//Solution
Pvac = density*g*Pvac //Pvac in N/m^2
atmosphericPressure = density*g*atmosphericPressure //atmospheric pressure in N/m^2
PabsInlet = atmosphericPressure + Pg //in N/m^2 //absolute inlet pressure
PabsExit = atmosphericPressure - Pvac //in N/m^2 //absolute exit pressure
printf("At the inlet, absolute pressure = %.3f kPa \
```

```
    n",PabsInlet*.001);
printf("At the exit, absolute pressure = %.3f kPa \n
    ",PabsExit*.001);
```

Scilab code Exa 1.5 Find specific volume and density

```
clc
clear
printf("Example 1.5 | Page number 12 \n\n");
//find the specific volume and density.

//Given Data
mass = 50 * .001 //in kg
volume = 0.04 //in m^3
printf("Mass = %.2f kg \n",mass);
printf("Volume = %.2f m^3 \n\n",volume);

//Solution
specificVolume = volume / mass //in m^3/kg
density = 1/specificVolume //in kg/m^3
printf("Specific density = %.2f m^3/kg \n",
    specificVolume);
printf("Density = %.2f kg/m^3 \n",density);
```

Scilab code Exa 1.6 Find equivalent temperature in Kelvin scale

```
clc
clear
printf("Example 1.6 | Page number 12 \n\n");
//find the equivalent temperature in Kelvin scale.

//Given Data
temp = 100; //in degree Celsius
```

```
printf("Temperature in degree Celsius = %.2f degree
   C \n\n",temp);

//Solution
TEMP = temp + 273.15;
printf("Temperature in Kelvin = %.2f K",TEMP);
```

Scilab code Exa 1.7 Find corresponding temperature in degree Celsius

```
clc
clear
printf("Example 1.7 | Page number 12 \n\n");
//find the equivalent temperature in Celsius scale.

//Given Data
TEMP = 263.15; //in Kelvin
printf("Temperature in Kelvin = %.2f K \n\n",TEMP);

//Solution
temp = TEMP - 273.15;
printf("Temperature in degree Celsius = %.2f degree
   C",temp);
```

Chapter 2

Work

Scilab code Exa 2.1 Find the work done by the force

```
clc
clear
printf("Example 2.1 | Page number 28 \n\n");
//find work done.

//Given Data
Force = 180 //in N //horizontal force
theta = 30 //in degrees //angle of inclination
distance = 12 //in m //distance moved by block along inclined plane.

printf("Horizontal force acting on block = %.2f N \n",Force);
printf("Angle of inclination = %.2f degrees \n",theta);
printf("Distance moved by block = %.2f m \n\n",distance);


//Solution
Work = Force * (distance * cosd(theta)) //in J //
```

```
Work done
Work = 0.001 * Work // Work done in KJ
printf("Work done by block = %.4f KJ",Work);
```

Scilab code Exa 2.2 Find magnitude and direction of work

```
clc
clear
printf("Example 2.2 | Page number 31 \n\n");
//find the magnitude and direction of work for systems agent and body.

//Given Data
mass_body = 2 //in kg //mass of body
L = 5 //in m //vertical distance
g = 9.8 //in m/s^2 //acceleration due to gravity

printf("Mass of body = %.2f kg \n",mass_body);
printf("Vertical distance = %.2f m \n",L);
printf("Acceleration due to gravity = %.2f m/s^2 \n\n",g);


//Solution
Work_done_by_agent = mass_body * g * L //in Nm // work done by agent
Work_done_by_body = -1*Work_done_by_agent
printf("Work done by agent = %.2f Nm\n",Work_done_by_agent);
printf("Work done by body = %.2f Nm",Work_done_by_body);
```

Scilab code Exa 2.3 Identify interaction between battery and resistor

```
clc
clear
printf("Example 2.3 | Page number 32 \n\n");
//Indentify interaction between battery and resistor

//This example has a theoritical solution please refer to the textbook.
printf("This example has a theoritical solution please refer to the textbook.");
```

Scilab code Exa 2.4 Calculate magnitude and direction of work

```
clc
clear
printf("Example 2.4 | Page number 39 \n\n");
//(a)Calculate the magnitude and direction of work for air inside the balloon
//(b)Find the magnitide and direction of work for the atmosphere and the balloon

//Given Data
p1 = 1.5 * 10^(5) //N/m^2 //initial pressure in ballon
d1 = 0.25 //m //initial diameter of balloon
d2 = 0.3 //m //final diameter of balloon
p_atm = 10^(5) //N/m^2 //atmospheric pressure
printf("Initial pressure in ballon = %.2f N/m^2\n",p1);
printf("Initial diameter of ballon = %.2f m\n",d1);
printf("Final diameter of ballon = %.2f m\n",d2);
printf("Atmospheric pressure = %.2f N/m^2\n\n",p_atm);

//Solution

```

```
//Part (a)
printf("Part (a)\n");
printf("As p is proportional to d, p = k*d, where k
    is proportionality constant\n");
printf("Therefore,\n");

k = p1/d1;
printf("p1 = k*d1 => k = (p1/d1) = (%.2f/%.2f) = %.2
    f N/m^3\n",p1,d1,k);

p2 = k*d2; //N/m^2 //final pressure in balloon
printf("p2 = k*d2 = (%.2f*%.2f) = %.2f N/m^2\n\n",k,
    d2,p2);

W_air = integrate('k*(%pi/2)*(d^3)','d',d1,d2) //Nm
    //Work done by air on the balloon
printf("Work done by balloon on air = %.2f Nm\n\n",
    W_air);

//Part (b)
printf("Part (b)\n");
W_atm = integrate('p_atm*(0.5*%pi*(d^2))','d',d2,d1)
    ; //Nm //Work done by atmosphere on ballon
printf("Work done by atmosphere on balloon = %.2f Nm
    \n",W_atm);
W_balloon = -1*(W_air+W_atm);
printf("Work done by balloon = -(Work done by air +
    Work done by atmosphere) = -(%.2f%.2f) = %.2f Nm\
    n",W_air,W_atm,W_balloon);
```

Scilab code Exa 2.5 Find the work interaction

```
clc
clear
printf("Example 2.5 | Page number 40 \n\n");
```

```
//Find the work interaction for pure substance.
//Given Data
p1 = 10 //bar //initial pressure
V1 = 0.1 //m^3 //initial volume
p2 = 2 //bar //final pressure
V2 = 0.35 //m^3 //final volume

printf("Initial pressure = %.2f bar\n",p1);
printf("inital volume = %.2f m^3\n",V1);
printf("Final pressure = %.2f bar\n",p2);
printf("Final volume = %.2f m^3\n",V2);

//Solution
printf("\nLet the expansion process follow the path pV^(n) = constant\n");
printf("Therefore,\n");
n = (log(p1/p2))/(log(V2/V1));
printf("n = (ln(p1/p2))/(ln(V2/V1)) = (ln(%.2f/%.2f))/(ln(%.2f/%.2f)) = %.4f\n",p1,p2,V2,V1,n);
W_d = (p1*V1 - p2*V2)*10^5/(n-1) //J //Work interaction for pure substance
printf("Work interaction for pure substance = (p1V1 - p2V2)/(n-1) = %.2f kJ",W_d*.001)
```

Scilab code Exa 2.6 Find the work of compression for air

```
clc
clear
printf("Example 2.6 | Page number 41 \n\n");
//(a)Find the work of compression of air.
//(b)What would be the work done on air.

//Given Data
p1 = 1.0 //bar //initial pressure
V1 = 0.1 //m^3 //initial volume
```

```
p2 = 6    //bar //final pressure
          //and p1*(V1^1.4) = p2*(V2^1.4)

printf("Initial pressure = %.2f bar\n",p1);
printf("inital volume = %.2f m^3\n",V1);
printf("Final pressure = %.2f bar\n\n",p2);


//Solution
//Part (a)
printf("Part (a)\n");
V2 = V1*(p1/p2)^(1/1.4) //m^3 //final volume
printf("Final Volume = %.4f m^3\n",V2);

W_d = (10^5)*(p1*V1 - p2*V2)/(1.4-1); //J //Work of compression for air
printf("Work of compression for air = %.1f KJ\n\n",W_d*.001);

//Part (b)
printf("Part (b)\n");
V2 = (p1/p2)*V1; //m^3 //final volume
printf("Final Volume = %.4f m^3\n",V2);

W_d = (10^5)*p1*V1*log(V2/V1); //J //Work done on air
printf("Work done on air = %.1f KJ\n\n",W_d*.001);
```

Scilab code Exa 2.7 Find the mep and indicated power

```
clc
clear
printf("Example 2.7 | Page number 41 \n\n");
//Find the mep, in kPa, and the indicated power in kW.
```

```
//Given Data
//four-stroke engine
x = 3 //number of cylinders
y = 1 //engine is single-acting
n = 500 //rev/min
N = n/2 //cycles/min
D = 0.075 //m //bore length
L = 0.1 //m //stroke length
a = 6*10^(-4) //m^2 //area
l = 0.05 //m //length
S = 2*10^8 //N/m^3 //spring constant

//Solution
p_m = (a/l)*S //Pa //mep

printf("Mean effective pressure, mep{Pm} = %.2f kPa\n",p_m*.001)
A = (%pi/4)*D^2 //m^2

printf("Indicated power{P_ind} = %.2f kW",(x*y)*(p_m*L*A*N)/60000)
```

Scilab code Exa 2.8 Find the mechanical efficiency of engine

```
clc
clear
printf("Example 2.8 | Page number 45 \n\n");
//Find the mechanical efficiency of the engine

//Given Data
N = poly([0 .5],'n','c') //n is engine speed
x = 6 //six cylinders
y = 1 //assumed
d = 0.1 //m //bore length
```

```
A = %pi*(0.1)^2/4 //m^2 //Area
L = 0.15 //m //stroke length
P_shaft = 24.78 //KW //Power of shaft
T = 474.9 //Nm //Torque in the crank shaft
l = 0.05 //m //length of indicator diagram
a = 9.37*10^(-4) //cm^2 //area of indicator diagram
S = 0.5*(10^8) //N/m^3 //spring constant

//Solution
p_m = a*S/l //mean pressure difference
printf("Mean pressure difference = %.2f N/m^2\n",p_m);

P_ind = (x*y)*p_m*(L*A*N/60000) //indicated power
C = coeff(P_ind)
printf("Indicated Power = %.6f n kW\n",C(2));

P_shaft = 2*%pi*poly([0 1],'n','c')*T/60000 //shaft power output
C = coeff(P_shaft)
printf("Shaft power output (in KW)= %.5f n kW\n",C(2));

Mechanical_efficiency = coeff(P_shaft,1)/coeff(P_ind,1)*100
printf("Mechanical Efficiency = %.0f %%",Mechanical_efficiency(1));
```

Scilab code Exa 2.9 Compute net work for battery and motor

```
clc
clear
printf("Example 2.9 | Page number 46 \n\n");
//(a) Compute the torque in the driving shaft and shaft power output of the motor.
```

```
//(b) Compute the net work for battery and motor.

//Given Data
d = 0.4 //m //cylinder diameter
t = 10 //min //Time taken for stirring
L = 0.49 //m //distance moved by the piston
p_atm = 1 //bar //atmospheric pressure
W_net = -1965 //Nm //net work done
n = 750 //rev/min //rotational velocity of electric motor
I = 0.9 //A //current
V = 24 //V //voltage

//Solution
//Part(a)
printf("Part (a)\n");
W_d = 10^5*p_atm * (%pi/4) * d^2 * L; //Nm //work done by fluid on piston
printf("Work done by fluid on the piston = %.1f Nm\n",W_d);
W_str = W_net - W_d; //Nm //Work done by stirrer
printf("Work done by stirrer on the fluid = %.1f Nm\n",W_str);
P_shaft = abs(W_str)/(t*60); //W //shaft power output
printf("Shaft power output = %.2f W\n",P_shaft);
T = (P_shaft*60)/(2*%pi*n); //Nm //Torque in the driving shaft
printf("Torque in the driving shaft = %.3f Nm\n", T);

//Part(b)
printf("\nPart (b)\n");
W_bat = I*V*t*60; //Nm //work done by battery
printf("Work done by battery = %.1f Nm\n",W_bat);
W_motor = -1*(W_bat+W_str) //Nm //work done by motor
printf("Work done by motor = %.1f Nm",W_motor);
```

Chapter 3

Temperature and Heat

Scilab code Exa 3.1 Temperature in degree Celsius and Fahrenheit

```
clc
clear
printf("Example 3.1 | Page number 73 \n\n");
//(a) Average human temperature in  C
//(b) Annual average temperature in peninsular India in  F

//Solution
//Part(a)
printf("Part (a)\n")
tf = 98.6 //  F //average temperature Human Body in  C
tc = (tf - 32)/1.8 //  C
printf("Average human temperature in  C = %.1f  C\n\n",tc);


//Part(b)
printf("Part (b)\n")
tc = 27 //  C //Annual average temperature in peninsular India in  C
```

```
tf = 1.8*tc+32 //Annual average temperature in peninsular India in  F
printf("Annual average temperature in peninsular India in  F = %.1f  F \n\n",tf);
```

Scilab code Exa 3.2 Find temperature in Kelvin

```
clc
clear
printf("Example 3.2 | Page number 73 \n\n");
//find temperature in kelvin

t = 27 //  C
T = t + 273.15 //K
printf("Temperature in Kelvin = %.2f K",T)
```

Scilab code Exa 3.3 Find temperature in degree Celsius

```
clc
clear
printf("Example 3.3 | Page number 74 \n\n");
//find temperature in  C

T = 250 //K
t = T - 273.15 //  C
printf("Temperature in  C = %.2f  C ",t)
```

Scilab code Exa 3.4 Determine what A reads when B reads 30

```
clc
```

```
clear
printf("Example 3.4 | Page number 77 \n\n");
//Part(a) Determine what A reads when B reads 30
printf("Part (a)\n");
//t_A and t_B are readings two Celsius thermometers A and B
//t_A = p + q*t_B + r*(t_B)^2
//p, q and are are constants.
X = [1, 0, 0; 1, 100, 100^2; 1, 50, 50^2]\[0; 100; 51]
p = X(1);
q = X(2);
r = X(3);

deff('y = t_A(t_B)',['y = q*t_B + r*(t_B^2)'])
t_B = 30;

printf("When thermometer B reads %0.1f C then thermometer A reads, t_B = %.02f C\n",t_B,t_A(t_B));
//Part(b)
printf("\nPart (b)\n");
printf("This part is theoritical quesition, book shall be referred for solution.");
```

Scilab code Exa 3.5 Find the temperature attained by the coil

```
clc
clear
printf("Example 3.5 | Page number 79 \n\n");
//Find the temperature attained by the coil during full load.
Rt = 80
t = 25
//Substituting Rt and t in Rt = Ro(1+0.00395t)
```

```
Ro = 80/(1+0.00395*25)
printf("Ro {Resistance at 0 C} = %.2f ohm\n",Ro)
//Full load condition
Rt = 95
//temperature at full load condition
printf("t {Temperature at full load condition} = %.2f C",((Rt/Ro)-1)/0.00395);
```

Scilab code Exa 3.6 Find thermometer reading when gas thermometer reads 50 degree C

```
clc
clear
printf("Example 3.6 | Page number 80 \n\n");
//What will be thermometer read in place where gas thermometer reads 50 C
deff('y = e(t)',['y = 0.0367*t + 1.33 * 10^(-4)*t^2'])

printf("Thermometer read in place where gas thermometer reads 50 C = %.2f C",e(50)/(e(100)/100))
```

Chapter 4

The First Law of Thermodynamics for Systems Pure Substances

Scilab code Exa 4.1 Find the magnitude and direction of the fourth work interaction

```
clc
clear
printf("Example 4.1 | Page number 93 \n\n");
//Find magnitude and direction of W_4
//Given Data
//four heat transfer
Q_1 = 900 //J
Q_2 = 80 //J
Q_3 = -800 //J
Q_4 = 150 //J
//four work interactions
W_1 = 200 //J
W_2 = 150 //J
W_3 = 300 //J
//W_4
//Solution
```

```
W_4 = Q_1 +Q_2 +Q_3 +Q_4 -W_1 -W_2 -W_3
printf("Magnitude and Direction of the fourth work
    interaction , W4 = %.2f J",W_4)
```

Scilab code Exa 4.2 Find the change in energy of the system and find the magnitude and direction of work done during B

```
clc
clear
printf("Example 4.2 | Page number 94 \n\n");
//Part (a) Find change in energy of the system
//Part (b) Find the magnitude and direction of work
    during B
//Given Data
Q_a = -50 //KJ //heat transferred from the system
    along path A
W_a = -65 //KJ //work done along path A
Q_b = 0 //KJ //heat transferred from the system
    along path B
//W_b work done along path B

//Solution

//Part(a)
printf("Part (a)\n");
delE_a = Q_a - W_a //KJ //Change in energy along
    path A
printf("Change in energy of the system = %.2f KJ\n\n
    ",delE_a);

//Part(b)
printf("Part (b)\n");
delE_b = -1*delE_a //KJ //Change in energy along
    path B
W_b = delE_b - Q_b //KJ //work done along path B
```

```
printf("Magnitude and direction of work done during B, W_b = %.2f KJ",W_b)
```

Scilab code Exa 4.3 Evaluate total energy of the system

```
clc
clear
printf("Example 4.3 | Page number 99 \n\n");
//Find the total energy of the system with respect to an observer at rest at sea level.
//Given data
m = 2.3 //kg //mass of substance
u = 21 * 10^3 //J/kg //internal energy
V = 110 //m/s //velocity
z = 1500 //m //elevation above sea level
g = 9.81 //m/s^2 //acceleration due to gravity


//Solution
E = m*(g*z + V^2/2 + u) //J/kg //Total energy of the system
printf("The total energy of the system with respect to an observer at rest at sea level, E = %.4f KJ",0.001*E);
```

Scilab code Exa 4.4 Find Cv and Cp

```
clc
clear
printf("Example 4.4 | Page number 103 \n\n");
//find Cv and Cp
//Given data
t = poly(0,'t'); // C //Temperature in C
```

```
u = 196 + .718*t; //KJ/kg //specific internal energy
pv = 287*(t+273); //Nm/kg //p is pressure and v =
    specific volume

//Solution
Cv = coeff(derivat(u));
printf("Specific heat at constant volume,Cv = %.3f
    kJ/kgK\n",Cv(1));

h = u + pv*.001 //KJ/kg //enthalpy
Cp = coeff(derivat(h));
printf("Specific heat at constant pressure,Cp = %.3f
     kJ/kgK",Cp(1));
```

Scilab code Exa 4.5 Show that work done on system is equal to increase in enthalpy

```
clc
clear
printf("Example 4.5 | Page number 103 \n\n");
//This question is theoritical. Refer textbook for
    solution
printf("This is a theoritical question. Refer
    textbook for solution.")
```

Chapter 5

First Law of Thermodynamics for Control Volumes

Scilab code Exa 5.1 Find work output

```
clc
clear
printf("Example 5.1 | Page number 119 \n\n");
//Find the work output in KJ/kg
//Given data
Q = -24; //KJ/kg

p1 = 5e5; //N/m^2
t1 = 227; //  C
V1 = 50; //m/s
v1 = 0.78; //m^3/kg

p2 = 1e5; //N/m^2
t2 = 57; //  C
V2 = 100; //m/s
v2 = 0.97; //m^3/kg

g = 9.81; //m/s^2 //acceleration due to gravity

```

```
delta_z = -5; //m
Cv = 0.7; //KJ/kg
delta_u = Cv*(t2 - t1); //KJ/kg //change in internal energy //u2-u1

//Solution
delta_h = delta_u + (p2*v2 - p1*v1)*.001; //KJ/kg // change in enthalpy //h2-h1

W_x = Q - (delta_h + (V2^2 - V1^2)/2*.001 + g*delta_z*.001); //kJ/kg //Work Output

printf("Work output = %.2f KJ/kg",W_x);
```

Scilab code Exa 5.2 Find the change in enthalpy across the turbine

```
clc
clear
printf("Example 5.2 | Page number 120 \n\n");
//Part (a) Find the change in enthalpy across turbine, if inlet velocity is negligible
//Part (b) Find the change in enthalpy across turbine, if inlet velocity is 60m/s

//Given Data
m = 5000/3600 // kg/s // flow rate
W_x = 550 // KJ/s //power developed by turbine
Q = 0 //Heat loss is negligible

//Solution
//Part (a)
printf("Part(a)\n\n")
V1 = 0 // m/s //inlet velocity
V2 = 360 // m/s //exit velocity
g = 9.81 // m/s^2
```

```
delta_z = 0 //m //z2−z1

delta_h = ((Q-W_x)/m)-g*delta_z*.001-((V2^2-V1^2)
    /2000) //KJ/Kg //change in enthalpy
printf("Change in enthalpy = %.2f KJ/kg\n",delta_h)

//Part (a)
printf("\nPart(b)\n\n")
V1 = 60 // m/s //inlet velocity
V2 = 360 // m/s //exit velocity
g = 9.81 // m/s^2
delta_z = 0 //m //z2−z1

delta_h = ((Q-W_x)/m)-g*delta_z*.001-((V2^2-V1^2)
    /2000) //KJ/Kg //change in enthalpy
printf("Change in enthalpy = %.2f KJ/kg\n",delta_h)
```

Scilab code Exa 5.3 Determine the temperature at the inlet and power developed

```
clc
clear
printf("Example 5.3 | Page number 122 \n\n");
//Part(a) Determine the temperature of air at inlet
    to the turbine
//PArt(b) Determine power developed by turbine

//Given Data
mA = 0.8 // kg/s //flow rate of stream A
pA = 15e5 // N/m^2 //Pressure of stream A
tA = 250 // C //temperature of stream A


mB = 0.5 // kg/s //flow rate of stream B
pB = 15e5 // N/m^2 //Pressure of stream B
```

```
tB = 200 //  C  //temperature of stream B

Q = 0 //No heat loss

p1 = 10e5 // N/m^2 //pressure supply of chamber
t2 = 30 //  C  //exhaust air temperature from turbine

Cv = 0.718 // KJ/kgK //heat capacity at constant volume
Cp = 1 // KJ/kgK //heat capacity at constant pressure

//solution
//Part(a)
printf("Part (a)\n")
t1 = ((mA*Cp*tA)+(mB*Cp*tB))/((mA*Cp)+(mB*Cp)) //  C  //the temperature of air at inlet to the turbine
printf("The temperature of air at inlet to the turbine = %.2f  C\n",t1);
//Part(b)
printf("\nPart (b)\n")
WT = -1*(mA+mB)*Cp*(t2-t1) //  kW //power developed by turbine
printf("Power developed by turbine = %.2f kW",WT);
```

Scilab code Exa 5.4 Find the inlet and exit velocities

```
clc
clear
printf("Example 5.4 | Page number 123 \n\n");
//Find inlet and exit velocities

//Given Data
d1 = 0.15 //m //inlet diameter
```

```
m = 4000/3600 // kg/s //flow rate
v1 = 0.285 //m^3/kg //specific volume at entry
d2 = 0.25 //m //exit diameter
v2 = 15 // m^3/kg //specific volume at exit

//Solution

A1 = %pi*d1^2/4 //m^2 //inlet cross sectional area
A2 = %pi*d2^2/4 // m^2 // exit cross sectional area
printf("Inlet cross sectional area (A1)= %.5f m^2\n"
    ,A1);
printf("Exit cross sectional area (A2)= %.5f m^2\n",
    A2);

V1 = m*v1/A1 //m/s //inlet velocity
V2 = m*v2/A2 //m/s //exit velocity

printf("\nInlet velocity = %.1f m/s",V1);
printf("\nExit velocity = %.1f m/s",V2);
```

Scilab code Exa 5.5 Find the temperature of air after throttling

```
clc
clear
printf("Example 5.5 | Page number 125 \n\n");
//Find air temperature after throttling

//Given Data
p1 = 10//bar //inlet pressure
t1 = 300 // C //inlet temperature

p2 = 0.1 //bar //exit pressure
Cp = 1 //kJ/kgK // heat capacity at constant
    pressure
//Solution
```

```
//Adiabatic process
delta_h = 0 //change in enthalpy
t2 = delta_h/Cp + t1
printf("Temperature of air after throttling = %.1f
    C",t1)
```

Scilab code Exa 5.6 Calculate the work input to the compressor

```
clc
clear
printf("Example 5.6 | Page number 126 \n\n");
// Calculate work input to compressor

//Given Data
p1 = 1e5 // N/m^2 //inlet pressure
v1 = 0.08 //m^3/kg // specific volume at inlet
p2 = 7e5 // N/m^2 //exit pressure
v2 = 0.016 // m^3/kg //specific volume at exit
u1 = 48 // kJ/kg // internal energy at inlet
u2 = 200 // kJ/kg // internal energy at exit
Q = -120 // kJ/kg // heat loss
//Solution
Wc = ((u2 - u1) + (p2*v2 - p1*v1)*.001 - Q)*-1 // kJ
   /kg // work input to compressor
printf("Work input to compressor (Wc) = %.1f kJ/kg",
   Wc)
```

Scilab code Exa 5.7 Find the mass flow rate of cooling water

```
clc
clear
printf("Example 5.7 | Page number 128 \n\n");
//Find mass flow rate of cooling water
```

```
mh = 9.45 // kg/s // flow rate of steam
h_h2 = 140 // kJ/kg // enthalpy of condensate
h_h1 = 2570 // kJ/kg // inlet enthalpy of steam
t1 = 25 //  C //inlet temperature of cooling water
t2 = 36 //  C //exit temperature of cooling water
c = 4.189 // kJ/kg deg // specific heat of water
//Solution
mc = -1*(mh*(h_h2-h_h1))/(c*(t2-t1)) // kg/s //mass flow rate of cooling water
printf("Mass flow rate of cooling water = %.2f kg/s",mc)
```

Scilab code Exa 5.8 Find the mass flow rate of cooling water if the heat loss to surrounding is 10 percent of heat transferred from steam to cooling water

```
clc
clear
printf("Example 5.8 | Page number 129 \n\n");
//Redo example 5.7 for heat loss 10% of heat transferred
mh = 9.45 // kg/s // flow rate of steam
h_h2 = 140 // kJ/kg // enthalpy of condensate
h_h1 = 2570 // kJ/kg // inlet enthalpy of steam
t1 = 25 //  C //inlet temperature of cooling water
t2 = 36 //  C //exit temperature of cooling water
c = 4.189 // kJ/kg deg // specific heat of water
fractionalheatloss = 0.1 // fractional heat loss
//Solution
mc = -1*((1-fractionalheatloss)*mh*(h_h2-h_h1))/(c*(t2-t1)) // kg/s //mass flow rate of cooling water
printf("Mass flow rate of cooling water = %.1f kg/s",mc)
```

Scilab code Exa 5.9 Find the inlet air temperature

```
clc
clear
printf("Example 5.9 | Page number 130 \n\n");
//Find inlet air temperature
V1 = 300 //m/s //inlet air velocity
t2 = 100 // C //exit air temperature
V2 = 15 //m/s //exit air velocity
//Solution
t1 = t2 + .001*(V2^2 - V1^2)/2 // C //inlet air temperature
printf("Inlet air temperature = %.1f C",t1)
```

Scilab code Exa 5.10 Find the mass of air entering and the final temperature of the air in the vessel

```
clc
clear
printf("Example 5.10 | Page number 131 \n\n");
//Find the mass of air entering and temperature of air in vessel

//Given Data
m1 = 0.8 //kg //initial mass of air
p1 = 150 //kPa //initial pressure of air
T1 = 300 //K //initial temperature of air
p_p = 600 //kPa //pressure of air in pipe
T_p = 330 //K // temperature of air in pipe

//Solution
m2T2 = (p_p/p1)*T1*m1
```

```
m2 = ((0.718*(m2T2/m1-T1))/(331.65)*m1)+m1 //kg //
    final mass of air
printf("Mass of air entering in vessel = %.4f kg\n",
    m2-m1)
T2 = m2T2/m2 //K //Temperature of air in vessel
printf("Temperature of air in vessel = %.1f K",T2)
```

Scilab code Exa 5.11 Show relation between mass and pressure ratios

```
clc
clear
printf("Example 5.11 | Page number 133 \n\n");
//This is a theoritical question. Refer textbook for
    solution.
printf("This is a theoritical question. Refer
    textbook for solution.")
```

Chapter 6

Heat Engines The Second Law of Thermodynamics

Scilab code Exa 6.1 Find the heat rejected at the condenser and the thermal efficiency of the plant

```
clc
clear
printf("Example 6.1 | Page number 148 \n\n");
//Find the heat rejected at the condensor and thermal efficiency of the plant

//Given Data
Q1 = 300 //kJ //heat supplied at the boiler
Wt = 100 //kJ //work output of turbine
Wp = 0.5 //kJ //work input to pump

//Solution
Q2 = Q1 - (Wt - Wp) //kJ //heat rejected at the condensor
printf("Heat rejected at the condensor = %.1f kJ\n",Q2);
efficiency = 1 - (Q2/Q1)
printf("The thermal efficiency of plant = %.2f ",
```

```
efficiency)
```

Scilab code Exa 6.2 Find the rate of heat transfer power input and COP

```
clc
clear
printf("Example 6.2 | Page number 153 \n\n");
//Part(a)Find the rate of heat transfer in the evaporator and the power input to the compressor.
//Part(b)Calculate COP if refrigerator were to operate as heat pump

//Given Data
COP_ref = 4 //COP of refrigerator
Q1 = 0.5 //kJ/s //rate of heat transfer at the condensor

//Solution
//Part(a)
printf("Part(a)\n");
Wc = Q1/(COP_ref+1) //kJ/s //Power input to compressor
Q2 = COP_ref*Wc //kJ/s //Rate of heat transfer in evaporator
printf("Rate of heat transfer in evaporator = %.1f kJ/s\n",Q2)
printf("Power input to compressor = %.1f kJ/s\n\n",Wc)

//Part(b)
printf("Part(b)\n");
COP_hp = 1 + COP_ref //COP of heat pump
printf("COP of heat pump = %.1f",COP_hp)
```

Scilab code Exa 6.3 Find savings in the monthly electricity bill

```
clc
clear
printf("Example 6.3 | Page number 154 \n\n");
//Part(a)Find the additional monthly electricity
   bill
//Part(b)What would be the saving in monthly
   electricity bill

//Part(a)
printf("Part(a)\n");
I = 4.5 //Amp //Current drawn
V = 220 //V
Electricity_consumption = I*V //Watts
ElectricityUnitPerDay = Electricity_consumption
   /1000*8 //kWh
MonthlyBill_part_a = ElectricityUnitPerDay * 5 * 30
printf("The additional monthly electricity bill = Rs
   . %.2f\n\n",MonthlyBill_part_a);

//Part(b)
printf("Part(b)\n");
Q1 = Electricity_consumption*.001 //kW //Rate of
   heat transfer from heat pump
COP_hp = 4 //COP of heat pump
W = Q1/COP_hp //kW //rate at which energy is
   consumed
ElectricityUnitPerDay = W*8
MonthlyBill_part_b = ElectricityUnitPerDay * 5 * 30
printf("Saving in monthly electricity bill = Rs. %.2
   f",MonthlyBill_part_a - MonthlyBill_part_b)
```

Chapter 7

Reversibility and the Thermodynamics Temperature Scale

Scilab code Exa 7.1 Fiind the work output of the engine and the magnitude of heat interaction

```
clc
clear
printf("Example 7.1 | Page Number 174 \n\n");
//Part(a) Find the work output of the engine
//Part(b) Find the magnitude of heat interaction
    with the reservoir at t2 and work input to the
    heat pump.

//Part(a)
printf("Part (a)\n");
//Given Data
Q1 = 500 //kJ //Heat transfer from reservoir at t1
Q2 = 187.5 //kJ //Heat transfer from reservoir at t2

//Solution
nr = 1-(Q2/Q1) //Efficiency
```

```
W = nr*Q1 //kJ //Work output of the engine
printf("Work output of the engine = %.1f kJ\n\n",W);

//Part(b)
printf("Part (b)\n");
//Given Data
Q1 = 500 //kJ //Heat transfer from reservoir at t1
//Solution
COP_hp = 1/nr
W = Q1/COP_hp //kJ //Work input to heat pump
Q2 = Q1-W //kJ //heat ineraction with reservoir at
    t2
printf("Heat ineraction with reservoir at t2 = %.1f
    kJ\n",Q2);
printf("Work input to the heat pump = %.1f kJ\n",W);
```

Scilab code Exa 7.2 Evaluate validity of claim

```
clc
clear
printf("Example 7.2 | Page Number 178 \n\n");
//Evaluate validity of claim
//Given Data
nr = 0.7 //maximum efficiency
W = 80 //kJ //Work
Q1 = 100 //kJ //heat transfered
//Solution
nx = W/Q1 //claimed efficiency
if nx>nr then
    printf("Engine X is not a viable proposition
       because the claimed efficiency %.2f is
       greater than maximum efficiency %.2f",nx,nr)
else
    printf("Engine X is a viable proposition because
        the claimed efficiency %.2f is less than
```

```
        maximum efficiency %.2f",nx,nr)
end
```

Scilab code Exa 7.3 Comment on internal and external reversibility

```
clc
clear
printf("Example 7.3 | Page number 185 \n\n");
//This is a theoritical question. Refer textbook for
    solution
printf("This is a theoritical question. Refer
   textbook for solution.");
```

Scilab code Exa 7.4 Find efficiency

```
clc
clear
printf("Example 7.4 | Page number 191 \n\n");
//Part(a) Find efficiency if the engine is
   reversible.
//Part(b) Find efficiency if the engine is
   irreversible.

//Given Data
T1 = (527+273) //K
T2 = (27+273) //K
//Part (a)
printf("Part (a)\n");
nr = 1 - (T2/T1) //reversible efficiency
printf("Reversible efficiency = %.3f \n\n",nr);

//Part(b)
printf("Part (b)\n");
```

```
printf("As the values of at least any two from among Q1,Q2 and W are not given \nthe efficiency of the engine cannot be evaluated.However, according to \nCarnots statement, the efficiency will be less than %.3f",nr)
```

Scilab code Exa 7.5 Find COP

```
clc
clear
printf("Example 7.5 | Page number 192 \n\n");
//Part(a) Find the COP of reversible heat engine as refrigerator.
//Part(b) Find the COP of reversible heat engine as heat pump.

//Given Data
T1 = 273 + 37 //K
T2 = 273 - 13 //K

//Part(a)
printf("Part (a)\n");
COP_ref = T2/(T1-T2) //COP of reversible heat engine as refrigerator.
printf("COP of reversible heat engine as refrigerator = %.1f\n\n",COP_ref)
//Part(b)
printf("Part (b)\n");
COP_hp = T1/(T1-T2) //COP of reversible heat engine as heat pump.
printf("COP of reversible heat engine as heat pump = %.1f",COP_hp)
```

Chapter 8

Entropy Available and Unavailable Energy

Scilab code Exa 8.1 Clausius inequality

```
clc
clear
printf("Example 8.1 | Page number 211 \n\n");
//This is a theoritical question.Refer textbook for
   solution
printf("This is a theoritical question.Refer
   textbook for solution")
```

Scilab code Exa 8.2 Find change in entropy

```
clc
clear
printf("Example 8.2 | Page number 211 \n\n");
//Evaluate delta S for the reservoir
//Given Data
Q = 10 //kJ //heat transfered from reservoir
```

```
T = 100+273 //K //isothermal expansion temperature
T_res = 300+273 //K //reservoir temperature
//Solution
delta_S_sys = (Q/T) //kJ/K //delta S for the system
printf("Change in entropy(Delta S) for the system =
    %.5f kJ/K\n",delta_S_sys);

delta_S_res = -1*(Q/T_res) //kJ/K //delta S for the
    reservoir
printf("Change in entropy(Delta S) for the reservoir
    = %.5f kJ/K\n",delta_S_res);
```

Scilab code Exa 8.3 Find change in entropy if reservoir temperature is 100 degree Celsius

```
clc
clear
printf("Example 8.3 | Page number 212 \n\n");
//Evaluate delta S for the reservoir
//Given Data
Q = 10 //kJ //heat transfered from reservoir
T = 100+273 //K //isothermal expansion temperature
T_res = 100+273 //K //reservoir temperature
//Solution
delta_S_sys = (Q/T) //kJ/K //delta S for the system
printf("Change in entropy(Delta S) for the system =
    %.5f kJ/K\n",delta_S_sys);

delta_S_res = -1*(Q/T_res) //kJ/K //delta S for the
    reservoir
printf("Change in entropy(Delta S) for the reservoir
    = %.5f kJ/K\n",delta_S_res);
```

Scilab code Exa 8.4 Find the change in entropy for paddle stirred gas

```
clc
clear
printf("Example 8.4 | Page number 212 \n\n");
//Evaluate delta S for the reservoir
//Given Data
Q = 1; //kJ //heat transfered from reservoir
T = 100+273; //K //isothermal expansion temperature
T_res = 100+273; //K //reservoir temperature
//Solution
delta_S_res = -1*(Q/T_res); //kJ/K //delta S for the
    reservoir
printf("Change in entropy(Delta S) for the reservoir
    = %.5f kJ/K\n",delta_S_res);
```

Scilab code Exa 8.5 Identify possible and impossible processes

```
clc
clear
printf("Example 8.5 | Page number 217 \n\n");
//This is a theoritical question.Refer textbook for
    solution
printf("This is a theoritical question.Refer
    textbook for solution")
```

Scilab code Exa 8.6 Identify processes as reversible irreversible or impossible

```
clc
clear
printf("Example 8.6 | Page number 217 \n\n");
```

```
//This is a theoritical question.Refer textbook for
    solution
printf("This is a theoritical question.Refer
    textbook for solution")
```

Scilab code Exa 8.7 State whether entropy change of the universe is positive negative or zero

```
clc
clear
printf("Example 8.7 | Page number 220 \n\n");
//This is a theoritical question.Refer textbook for
    solution
printf("This is a theoritical question.Refer
    textbook for solution")
```

Scilab code Exa 8.8 Determine the change in entropy

```
clc
clear
printf("Example 8.8 | Page number 222 \n\n");
//This is a theoritical question.Refer textbook for
    solution
printf("This is a theoritical question.Refer
    textbook for solution")
```

Scilab code Exa 8.9 Find the change in entropy

```
clc
clear
```

```
printf("Example 8.9 | Page number 223 \n\n");
//This is a theoritical question.Refer textbook for
   solution
printf("This is a theoritical question.Refer
   textbook for solution")
```

Scilab code Exa 8.10 Find the change in entropy during melting process

```
clc
clear
printf("Example 8.10 | Page number 224 \n\n");
//This is a theoritical question.Refer textbook for
   solution
printf("This is a theoritical question.Refer
   textbook for solution")
```

Scilab code Exa 8.11 Can system undergo isentropic process

```
clc
clear
printf("Example 8.11 | Page number 224 \n\n");
//This is a theoritical question.Refer textbook for
   solution
printf("This is a theoritical question.Refer
   textbook for solution")
```

Scilab code Exa 8.12 Find direction of flow of air

```
clc
clear
```

```
printf("Example 8.12 | Page number 225 \n\n");
//Find the direction fo air flow
//Given Data
pA = 120 //kPa //Pressure at location A
TA = 50+273 //K //Temperature at location A
VA = 150 //m/s //Velocity at location A

pB = 100 //kPa //Pressure at location B
TB = 30+273 //K //Temperature at location B
VB = 250 //m/s //Velocity at location B

Cp = 1.005 //kJ/kg
R = 0.287 //kJ/kgK
//Solution
delta_S_sys = (Cp*log(TB/TA))-(R*log(pB/pA)) //kJ/
    kgK //Entropy of system
if delta_S_sys < 0 then
    printf("Flow is from B to A.");
else
    printf("Flow is from A to B.")
end
```

Scilab code Exa 8.13 Find the change in entropy

```
clc
clear
printf("Example 8.13 | Page number 226 \n\n");
//Part(a)Temperature of the mixture when ice-water
    equilibrium.
//Change in entropy during the process for:
//Part(b) ice
//Part(c) water
//Part(d) universe

//Given Data
```

```
mi = 5 //kg //mass of ice
Ti = 273 - 10 //K //Temperature of ice
ci = 2.1 //kJ/kgK //specific heat of ice
L = 330 //kJ/kg //Latent heat
mw = 20 //kg //mass of water
Tw = 273+80 //K //Temperatur of water
cw = 4.2 //kJ/kgK //specific heat of water
//Part(a)
printf("Part (a)\n");
Tmix = ((mi*ci*(Ti-273))-(L*mi)+(mw*cw*Tw)+(mi*cw
    *273))/(mw*cw+mi*cw)
printf("Temperature of the mixture when equilibrium
    is established between ice and water = %.1f K\n\n
    ",Tmix)
//Part (b)
printf("Part (b)\n");
delta_S_ice = mi*(ci*log(273/Ti)+L/273+cw*log(Tmix
    /273))//kJ/K //Entropy of ice
printf("Entropy of ice = %.2f kJ/K\n\n",delta_S_ice)
//Part (c)
printf("Part (c)\n");
delta_S_water = mw*(cw*log(Tmix/Tw))//kJ/K //Entropy
     of water
printf("Entropy of water = %.2f kJ/K\n\n",
    delta_S_water)
//Part (d)
printf("Part (d)\n");
delta_S_uni = delta_S_water+delta_S_ice//kJ/K //
    Entropy of universe
printf("Entropy of universe = %.2f kJ/K\n\n",
    delta_S_uni)
```

Scilab code Exa 8.14 Find the available and unavailable parts of 100 kJ heat

```
clc
clear
printf("Example 8.14 | Page number 230 \n\n");
//Find the available and unavailable parts of 100kJ
    of heat from
//Part(a) a reservoir at 1000K
//Part(b) a reservoir at 600K

//Given Data
Q1 = 100 //kJ //Heat input
T0 = 300 //K //Surrounding temperature

//Part(a)
printf("Part (a)\n");
T1 = 1000 //K //reservoir temperature
printf("Avalable enery of 100 kJ of heat from a
    reservoir at 1000K = %.1f kJ\n",Q1*(1-(T0/T1)));
printf("Unvalable enery of 100 kJ of heat from a
    reservoir at 1000K = %.1f kJ\n\n",Q1-Q1*(1-(T0/T1
    )))
//Part(b)
printf("Part (b)\n");
T1 = 600 //K //reservoir temperature
printf("Avalable enery of 100 kJ of heat from a
    reservoir at 1000K = %.1f kJ\n",Q1*(1-(T0/T1)));
printf("Unvalable enery of 100 kJ of heat from a
    reservoir at 1000K = %.1f kJ\n\n",Q1-Q1*(1-(T0/T1
    )))
```

Scilab code Exa 8.15 Evaluate the increase in unavailable energy

```
clc
clear
printf("Example 8.15 | Page number 231 \n\n");
//Evaluate the increse in unavailable energy due to
```

```
   irreversible heat transfer
//Given Data
T0 = 300 //K //Surrounding temperature
T1 = 1000 //K //Temperature of final reservoir
T2 = 600 //K //Temperature of intermediate reservoir
Q1 = 100 //kJ //Heat input
//Solution
printf("Increase in unavaliable energy due to
   irreversible heat transfer = %.1f kJ",Q1*(1-T0/T1
   )-Q1*(1-T0/T2))
```

Scilab code Exa 8.16 What are the available and unavailable energies

```
clc
clear
printf("Example 8.16 | Page number 234 \n\n");
//What are available and unavailable energies of Q1
//Given data
T1 = 500 //K
T0 = 300 //K
T2 = 350 //K
W = 250 //kJ
Q1 = 1000 //kJ
printf("Available energy = %.1f kJ\n",(1-(T0/T1))*Q1
   );
printf("Unavailable energy = %.1f kJ\n",Q1 - (1-(T0/
   T1))*Q1);
```

Chapter 9

Ideal Gas and Ideal Gas Mixtures

Scilab code Exa 9.1 What is the volume occupied by Nitrogen

```
clc
clear
printf("Example 9.1 | Page number 253 \n\n");
//Find the volume occupied
//Given Data
m = 6 //kg //mass of nitrogen
M = 28 //kg/kmol //molar mass of nitrogen
R = 8314.3 //kg/kmol
p = 1e5 //Pa //pressure
T = 27+273 //K //temperature
//Solution
V = m*R*T/(p*M)
printf("Volume occupied by nitrogen = %.3f m^3",V)
```

Scilab code Exa 9.2 Find the final volume

```
clc
clear
printf("Example 9.2 | Page number 253 \n\n");
//Find the final volume
//Given data
p1 = 10 //bar //inital pressure
T1 = 273+227 //K //inital temperature
v1 = 0.01 //m^3 //initial volume
p2 = 1 //bar //final pressure
T2 = 273+27 //K //final temperature
//Solution
v2 = (p1/p2)*(T2/T1)*v1 //m^3 //final volume
printf("Final volume = %.2f m^3",v2)
```

Scilab code Exa 9.3 Find internal energy and enthalpy

```
clc
clear
printf("Example 9.3 | Page number 255 \n\n");
//Part(a) Find internal energy
//Part(b) Find enthalpy and internal energy at (i)10
    bar,50 C and,(ii)0.085 m^3/kg and 50 C

//Given Data
p = 1 //bar //pressure
T = 50+273 // C //temperature
h = 324.6 //kJ/kg //enthalpy
R = 8.3143 //kJ/kmolK
M = 28.97 //kg/kmol
//Part (a)
printf("Part (a)\n");
u = h - (R/M)*T //kJ/kg //internal energy
printf("Internal energy = %.1f kJ/kg\n",u)
//Part (b)
printf("\nPart (b):(i)\n");
```

```
u = h - (R/M)*T //kJ/kg //internal energy
printf("Enthalpy = %.1f kJ/kg\n",h)
printf("Internal energy = %.1f kJ/kg\n",u)
printf("Part (b):(ii)\n");
u = h - (R/M)*T //kJ/kg //internal energy
printf("Enthalpy = %.1f kJ/kg\n",h)
printf("Internal energy = %.1f kJ/kg",u)
```

Scilab code Exa 9.4 Calculate the value of Cp for air

```
clc
clear
printf("Example 9.4 | Page number 256 \n\n");
//Calculate Cp of air
//Given Data
Cv = 718 //J/kgK //specific at constant volume
M = 28.97 //kg/kmol //molar mass of air
R = 8314.3 //J/kmolK
//Solution
Cp = (R/M)+Cv //J/kgK //specific heat at constant
    pressure
printf("Specific heat at constant pressure = %.1f J/
    kg K",Cp)
```

Scilab code Exa 9.5 Calculate the increase in specific enthalpy and change in enthalpy

```
clc
clear
printf("Example 9.5 | Page number 258 \n\n");
//Part(a) Calculate increase in specific enthalpy
//Part(b) Calculate change in enthalpy

```

```
//Given data
p1 = 1 //bar //initial pressure
T1 = 27+273 //K //initial temperature
p2 = 10 //bar //final pressure
T2 = 327+273 //K //final temperature
//Solution
//Part(a)
printf("Part(a)\n");
delta_h = integrate('1.4-18.3*(T/100)^(-1.5)+38.3*(T/100)^(-2)-29.3*(T/100)^(-3)','T',T1,T2) //kJ/kg //Increase in specific enthalpy
printf("Increase in specific enthalpy = %.2f kJ/kg\n",delta_h)
//Part(b)
printf("\nPart(b)\n");
delta_h = integrate('1.042','T',T1,T2) //kJ/kg //Increase in specific enthalpy
printf("Increase in specific enthalpy at (Cp = 1.042 kJ/kgK) = %.2f kJ/kg",delta_h)
```

Scilab code Exa 9.6 Find the final temperature of air

```
clc
clear
printf("Example 9.6 | Page number 268 \n\n");
//Find the final temperature when:
//Part(a) V = constant
//Part(b) pV = constant
//Part(c) pV^y = constant
//And P-V diagram

//Given Data
Cp = 1005 //J/kgK //specific heat at constant
```

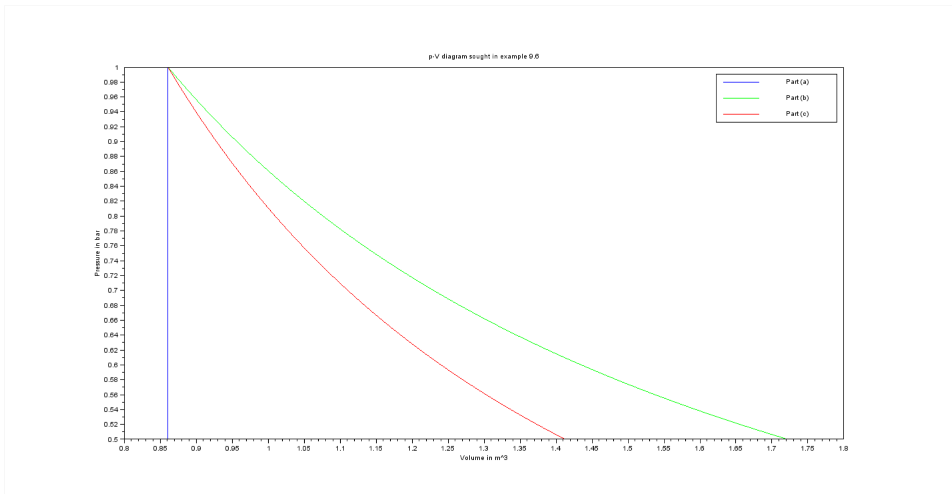

Figure 9.1: Find the final temperature of air

```
    pressure
Cv = 718 //J/kgK //specific heat at constant volume
m = 1 //kg //mass of air
T1 = (27+273) //K //initial temperature
p1 = 1e5 //Pa //initial pressure
p2 = p1/2 //Pa //final pressure

//Solution
//Part(a)
printf("Part(a)\n");
R = Cp-Cv //J/kgK
V1_a = m*R*T1/p1 //m^3 //initial volume
V2_a = V1_a //m^3 //final volume
T2 = p2*V2_a/(m*R) //K //final temperature
printf("Final temperature,T2 = %.1f K\n\n",T2)

//Part(b)
printf("Part(b)\n");
V1_b = m*R*T1/p1 //m^3 //initial volume
V2_b = V1_b*(p1/p2) //m^3 //final volume
//Isothermal process => T1 = T2
```

```
printf("Final temperature,T2 = %.1f K\n\n",T1)

//Part(c)
printf("Part(c)\n");
R = Cp-Cv //J/kgK
y = Cp/Cv
V1_c = m*R*T1/p1 //m^3 //initial volume
V2_c = V1_c*(p1/p2)^(1/y) //m^3 //final volume
T2 = p2*V2_c/(m*R) //K //final temperature
printf("Final temperature,T2 = %.1f K\n\n",T2)

//P-V diagram
P = [p1*1e-5 p2*1e-5]
V = [V1_a V1_a]
plot(V,P,'b')        //plot for part(a)

V = linspace(V1_b,V2_b,100)
P = (p1*1e-5*V1_b)./V
plot(V,P,'g')       //plot for part(b)

V = linspace(V1_c,V2_c,100)
P = (p1*1e-5*V1_c^y)./V.^y
plot(V,P,'r')      //plot for part(c)
xlabel('Volume in m^3')
ylabel('Pressure in bar')
title('p-V diagram sought in example 9.6')
legends(['Part (a)';'Part (b)';'Part (c)'],[2 3 5],
    opt=1)
```

Scilab code Exa 9.7 Find the enthalpy entropy and internal energy of Nitrogen

```
clc
clear
printf("Example 9.7 | Page number 270 \n\n");
```

```
//Part(a) How many kilograms of nitrogen are stored
   in the bottle
//Part(b) (i) Find temperature of nitrogen at
   maximum pressure,(ii)increase in internal energy
   (iii)increase in enthalpy (iv)increase in entropy
    of nitrogen
//Given Data
p1 = 10e6 //N/m^2 //initial pressure
T1 = 273+27 //K //inital temperature
V1 = 50e-3 //m^3 //inital volume
M = 28 //g/mol //molecular mass
R = 8314.3/M //J/kgK
y = 1.4 //gamma

//Solution
//Part(a)
printf('Part(a)\n');
m = (p1*V1)/(R*T1)
printf("Mass of nitrogen stored in bottle = %.3f kg\
   n\n",m)

//Part(b):(i)
printf('Part(b):(i)\n');
p2 = 15e6 //N/m^2 //final pressure
V2 = V1 //m^3 //final volume
T2 = (p2*V2)/(m*R)
printf("Temperature of nitrogen at maximum permitted
    temperature = %.1f K\n\n",T2)

//Part(b):(ii)
printf('Part(b):(ii)\n');
C = [1, -1.4;1, -1]\[0;R] //J/kgK //C = [Cp;Cv]
delta_U = m*C(2)*(T2-T1)*.001 //kJ //Change in
   internal energy
printf("Change in internal energy = %.1f kJ\n\n",
   delta_U)

//Part(b):(iii)
```

```
printf('Part(b):(iii)\n');
delta_H = m*C(1)*(T2-T1)*.001 //kJ //Change in
    enthalpy
printf("Change in enthalpy = %.1f kJ\n\n",delta_H)

//Part(b):(iv)
printf('Part(b):(iv)\n');
delta_S = m*(C(2)*log(T2/T1)+R*log(V2/V1))*.001 //kJ
    /K //Change in entropy
printf("Change in entropy = %.4f kJ/K",delta_S)
```

Scilab code Exa 9.8 Calculate work per kilogram of air and change in entropy

```
clc
clear
printf("Example 9.8 | Page number 271 \n\n");
//Calculate work per kilogram of air and change in
    entropy
//Given Data
T1 = 800 //K //initial temperature
p1 = 1.5e6 //N/m^2 //initial pressure
T2 = 540 //K //final temperature
T2s = 485 //K //final temperature for reversible
    process
Q = 0 //adiabatic process
y = 1.4
Cv = 718 //J/kgK //specific heat at constant volume

//Solution
delta_U = Cv*(T2-T1) //kJ/kg //change in internal
    energy
W = (Q-delta_U)*.001 //kJ/kg //work done per
    kilogram
printf("Work done per kilogram = %.1f kJ/kg\n",W);
```

```
p2 = p1*(T2s/T1)^(y/(y-1)) //N/m^2 //final pressure
delta_S = (y*Cv)*log(T2/T1)-(y*Cv-Cv)*log(p2/p1)
printf("Change in entropy = %.3f kJ/kgK",delta_S
    *.001)
```

Scilab code Exa 9.9 Find the molar mass and the gas constant of the mixture

```
clc
clear
printf("Example 9.9 | Page number 279 \n\n");
//Find molar mass and gas constant and find mass
    fractions of the constituents.
//Given Data
xCO2 = 0.1 //mole fraction of CO2
xO2 = .09 //mole fraction of O2
xCO = 0.01 //mole fraction of CO
xN2 = 0.8 //mole fraction of N2

//Solution
M = xCO2*44 + xO2*32 + xCO*28 + xN2*28 //kg/kmol //
    avg. molar mass
R = 8314.3/M //J/kgK //gas constant
yCO2 = xCO2*(44/M) //mass fraction of CO2
yO2 = xO2*(32/M) //mass fraction of O2
yCO = xCO*(28/M) //mass fraction of CO
yN2 = xN2*(28/M) //mass fraction of N2

printf("Molar Mass = %.2f kg/kmol\n",M);
printf("Gas constant = %.1f J/kgK\n",R);
printf("Mass fraction of CO2 = %.4f \n",yCO2);
printf("Mass fraction of O2 = %.4f \n",yO2);
printf("Mass fraction of CO = %.4f \n",yCO);
printf("Mass fraction of N2 = %.4f \n",yN2);
```

Scilab code Exa 9.10 Find the molar mass and gas constant for the mixture and mole fractions partial pressures and partial volumes of the constituents

```
clc
clear
printf("Example 9.10 | Page number 280 \n\n");
//Part(a) Find molar mass and gas constant
//Part(b) Find mole fractions , partial fractions and
    partial volumes
//Given
m = 1.9 //kg
T = 273+20 //K
p = 150e3 //Pa
yO2 = 0.1 //mass fraction of O2
yN2 = 0.75 //mass fraction of N2
yCO2 = 0.12 //mass fraction of CO2
yCO = 0.03 //mass fraction of CO

//Solution
//Part(a)
printf("Part(a)\n\n");
M = 1/((yO2/32)+(yN2/28)+(yCO/28)+(yCO2/44)) //kg/
   kmol //molar mass
printf("Molar mass = %.2f kg/kmol \n",M)
R = 8314.3/M //J/kgK //Gas constant
printf("Gas Constant = %.2f J/kgK \n",R)
V = m*R*T/p //m^3 //Volume

//Part(b)
printf("\nPart(b)\n")
xO2 = yO2*(M/32) //mole fraction O2
printf("\nMole fraction of O2 = %.3f",xO2)
pO2 = xO2*p //partial pressure O2
```

```
printf("\nPartial pressure of O2 = %.2f kPa",pO2*.001)
VO2 = xO2*V //partial volume of O2
printf("\nPartial volume of O2 = %.4f m^3\n",VO2)


xN2 = yN2*(M/28) //mole fraction N2
printf("\nMole fraction of N2 = %.3f",xN2)
pN2 = xN2*p //partial pressure N2
printf("\nPartial pressure of N2 = %.2f kPa",pN2*.001)
VN2 = xN2*V //partial volume of N2
printf("\nPartial volume of N2 = %.4f m^3\n",VN2)


xCO2 = yCO2*(M/44) //mole fraction CO2
printf("\nMole fraction of CO2 = %.3f",xCO2)
pCO2 = xCO2*p //partial pressure CO2
printf("\nPartial pressure of CO2 = %.2f kPa",pCO2*.001)
VCO2 = xCO2*V //partial volume of CO2
printf("\nPartial volume of CO2 = %.4f m^3\n",VCO2)


xCO = yCO*(M/28) //mole fraction CO
printf("\nMole fraction of CO = %.3f",xCO)
pCO = xCO*p //partial pressure CO
printf("\nPartial pressure of CO = %.2f kPa",pCO*.001)
VCO = xCO*V //partial volume of CO
printf("\nPartial volume of CO = %.4f m^3\n",VCO)
```

Scilab code Exa 9.11 Evaluate the mass fraction and volume fractions of nitrogen and hydrogen in the mixture

```
clc
clear
printf("Example 9.11 | Page number 283 \n\n");
//Evaluate the mass fraction and volumes fractions
    of N2 and H2 in mixture
//Given data
R = 1841 //J/kgK //Gas constant
Cp = 6310 //J/kgK //specific heat at constant
    pressure
MN = 28 //kg/kmol //molar mass N2
MH = 2 //kg/kmol //molar mass H2
CpN = 1042 //J/kgK //specific heat of N2
CpH = 14210 //J/kgK //specific heat of H2

//Solution
Y = [8314.3/MN, 8314.3/MH;CpN, CpH]\[R; Cp]
YN = Y(1) //mass fraction of N2
YH = Y(2) //mass fraction of H2
XN = YN*(8314.3/(R*MN)) //volume fraction of N2
XH = YH*(8314.3/(R*MH)) //volume fraction of H2
printf("Mass fraction of N2 = %.1f \n",YN)
printf("Mass fraction of H2 = %.1f \n",YH)
printf("Volume fraction of N2 = %.4f \n",XN)
printf("Volume fraction of H2 = %.4f \n",XH)
```

Scilab code Exa 9.12 Determine specific heat internal energy enthalpy and entropy change

```
clc
clear
printf("Example 9.12 | Page number 284 \n\n");
//Part(a) Find specific heats
//Part(b) Find internal energy
//Part(c) Find enthalpy
//Part(d) Find entropy
```

```
//Given Data
m = 1.9 //kg
T = 273+20 //K
p = 150 //kPa
pdat = 100 //kPa //datum pressure
Tdat = 273 //K //datum temperature
yO2 = 0.1 //mass fraction of O2
yN2 = 0.75 //mass fraction of N2
yCO2 = 0.12 //mass fraction of CO2
yCO = 0.03 //mass fraction of CO
xO2 = 0.093 //mole fraction of O2
xN2 = 0.795 //mole fraction of N2
xCO2 = 0.081 //mole fraction of CO2
xCO = 0.031 //mole fraction of CO
R = 280.22 //J/kgK
M = 29.67 //kg/kmol //mixture molar mass
CpO2=0.922 //kJ/kgK
CpN2=1.042 //kJ/kgK
CpCO2=0.842 //kJ/kgK
CpCO=1.041 //kJ/kgK
//Part(a)
printf("Part(a)\n");
Cp = yN2*CpN2 + yO2*CpO2 + yCO2*CpCO2 + yCO*CpCO //kJ/kgK // specific heat of mixture at constant pressure
Cv = Cp - R*.001 //specific heat of mixture at constant volume
printf("Cp = %.3f kJ/kgK\n",Cp)
printf("Cv = %.4f kJ/kgK\n",Cv)

//Part(b)
printf("\nPart(b)\n");
U = m*(Cv*(T-Tdat)) //kJ //internal energy
printf("Internal energy = %.2f kJ\n",U)

//Part(c)
printf("\nPart(c)\n")
H = U + m*R*T*.001 //kJ //enthalpy
```

```
printf("Enthalpy = %.1f kJ\n",H)

//Part(d)
printf("\nPart(d)\n")
SO2 = CpO2*log(T/Tdat)-(8.3143/32)*log(xO2*(p/pdat)) //kJ/kgK //entropy of O2
SN2 = CpN2*log(T/Tdat)-(8.3143/28)*log(xN2*(p/pdat)) //kJ/kgK //entropy of N2
SCO2 = CpCO2*log(T/Tdat)-(8.3143/44)*log(xCO2*(p/pdat)) //kJ/kgK //entropy of CO2
SCO = CpCO*log(T/Tdat)-(8.3143/28)*log(xCO*(p/pdat)) //kJ/kgK //entropy of CO

S = m*(yO2*SO2+yN2*SN2+yCO2*SCO2+yCO*SCO) //kJ/K //entropy
printf("Entropy = %.4f kJ/K",S)
```

Scilab code Exa 9.13 Calculate magnitude and direction of heat transfer and pressure of the mixture

```
clc
clear
printf("Example 9.13 | Page number 288 \n\n");
//Find magnitude and direction of heat transfer

//Given data
V_He = 0.3 //m^3 //volume of Helium
p_He = 20e5 //Pa //pressure of Helium
T_He = 273+30 //K //Temperature of Helium
V_O2 = 0.7 //m^3 //volume of O2
p_O2 = 6e5 //Pa //pressure of O2
T_O2 = 273+2 //K Temperature of O2
R_He = 2077 //J/kgK
R_O2 = 260 //J/kgK
Cv_He = 3116 //J/kgK
```

```
Cv_02 = 662 //J/kgK
//Solution
m_He = (p_He*V_He)/(R_He*T_He) //kg //mass of Helium
m_02 = (p_02*V_02)/(R_02*T_02) //kg //mass of O2
T_ad = (m_He*Cv_He*T_He+m_02*Cv_02*T_02)/(m_He*Cv_He
    +m_02*Cv_02) //K //Temperature after mixing
T_final = 300 //K //final temperature
Q = (Cv_He*m_He+Cv_02*m_02)*(T_final-T_ad) //J //
    Magnitude of heat transfer
printf("Magnitude of heat transfer = %.2f kJ",Q
    *.001)
```

Scilab code Exa 9.14 Determine mixture temperature and rate of entropy generation

```
clc
clear
printf("Example 9.14 | Page number 289 \n\n");
//Part(a) Find mixture temperature
//Part(b) Find rate of entropy generation

//Given Data
T_E = (273+20) //K //temperature of ethane
p_E = 200 //kPa //pressure of ethane
T_M = 273+45 //K //temperature of methane
p_M = 200 //kPa //pressure of methane
m_E = 9 //kg/s //mass rate of ethane
m_M = 4.5 //kg/s //mass rate of methane
Cp_E = 1766 //J/kgK //specific heat of ethane
Cp_M = 2254 //J/kgK //specific heat of methane

//Solution
//Part(a)
printf("Part(a)\n");
T = (m_E*Cp_E*T_E+m_M*Cp_M*T_M)/(m_E*Cp_E+m_M*Cp_M)
```

```
//K //mixture temperature
printf("Mixture temperature = %.1f K\n\n",T)

//Part(b)
printf("Part(b)\n");
R_E = 8314.3/30 //J/kgK //gas constant for ethane
R_M = 8314.3/16 //J/kgK //gas constant for methane
R = (m_E/(m_E+m_M))*R_E+(m_M/(m_E+m_M))*R_M //J/kgK //gas constant of mixture
M = 8314.3/R //kg/kmol //mixture molar mass
x_E = (m_E/(m_E+m_M))*(M/30) //mole fraction of ethane
x_M = (m_M/(m_E+m_M))*(M/16) //mole fraction of methane

delta_S_E = Cp_E*log(T/T_E) - R_E*log(x_E) //J/kgK //change in entropy of ethane
delta_S_M = Cp_M*log(T/T_M) - R_M*log(x_M) //J/kgK //change in entropy of methane

printf("Rate of entropy production = %.4f kJ/sK",(m_E*delta_S_E+m_M*delta_S_M)*.001)
```

Chapter 10

Properties of Pure Substance Water

Scilab code Exa 10.1 Find dryness fraction of mixture

```
clc
clear
printf("Example 10.1 | Page number 333 \n\n");
//Find dryness fraction of mixture
//Given data
m = 1.5 //kg //mass of wet steam
mf = 0.08*m //kg //mass of liquid in wet steam
//Solution
x = (m-mf)/m //dryness fraction of mixture
printf("Dryness fraction of mixture = %.2f",x)
```

Scilab code Exa 10.2 Find ratio of mass of saturated liquid to saturated steam

```
clc
clear
```

```
printf("Example 10.2 | Page number 333 \n\n");
//Find the ratio of mass of saturated liquid to saturated steam
//Given Data
x = 0.85 //quality of steam
printf("The ratio of mass of saturated liquid to saturated steam = %.5f",(1-x)/x)
```

Scilab code Exa 10.3 Find volume enthalpy internal energy and entropy per kg water

```
clc
clear
printf("Example 10.3 | Page number 350 \n\n");
//Find volume, enthalpy, internal energy and entropy per kilogram of water
//Given Data
p1 = 200 //kPa //initial pressure
t1 = 100 // C //initial temperature
ts = 120.23 // C //saturated steam temperature

//Solution
//From steam table
v1 = 0.001044 //m^3/kg //volume per kilogram of water
h1 = 419 //kJ/kg //enthalpy per kilogram of water
s1 = 1.3068 //kJ/kg //entropy per kilogram of water
u1 = h1-p1*v1 //kJ/kg //internal energy per kilogram of water
printf("Volume per kilogram of water = %.6f m^3/kg\n",v1)
printf("Enthalpy per kilogram of water = %.1f kJ/kg\n",h1)
printf("Entropy per kilogram of water = %.4f kJ/kgK\n",s1)
```

```
printf("Internal energy per kilogram of water = %.1f kJ/kg\n",u1)
```

Scilab code Exa 10.4 Find temperature and all other specific properties

```
clc
clear
printf("Example 10.4 | Page number 350 \n\n");
//Find temperature and all other specific properties
//Given data
p1 = 500 //kPa //initial pressure
s1 = 1.3625 //initial entropy

//Solution
//Using Method 2:
Ts = 424.28 //K //temperature at 500kPa
sf = 1.8606 //kJ/kgK //entropy at 500kPa
Cwat = 4.189 //kJ/kgK //specific heat of water
T1 = (exp((sf-s1)/Cwat)/Ts)^-1 //K
printf("Temperature = %.2f  C \n",T1-273)
v1 = 0.001 //m^3/kg //volume per kg water
h1 = (640.21 - Cwat*(151.86-T1+273)) // kJ/kg // Enthalpy per kg water
u1 = h1 - p1*v1 //kJ/kg //internal energy per kg water
printf("Volume per kg water = %.3f m^3/kg\n",v1)
printf("Enthalpy per kg water = %.1f kJ/kg\n",h1)
printf("Internal energy per kg water = %.1f kJ/kg\n",u1)
```

Scilab code Exa 10.5 Find other properties of water

```
clc
```

```
clear
printf("Example 10.5 | Page number 352 \n\n");
//Find properties of water
//Given data
t = 50 // C //temperature of water
h = 209.31 //kJ/kg
//Solution
//From saturated property table
p = 12.35 //kPa
v = 0.001012 //m^3/kg
u = h - p*v //kJ/kg
s = 0.7037 //kJ/kg
printf("Pressure = %.2f kPa\n",p)
printf("Volume per kg water = %.6f m^3/kg\n",v)
printf("Internal energy per kg water = %.1f kJ/kg\n"
    ,u)
printf("Entropy per kg water = %.4f kJ/kgK",s)
```

Scilab code Exa 10.6 Find all other properties of steam

```
clc
clear
printf("Example 10.6 | Page number 353 \n\n");
//Find all properties of steam
//Given Data
p = 12 //bar //pressure of steam leaving boiler
h = 2705 //kJ/kg //Enthalpy of steam
//Solution
//From pressure based saturated property table, at p
     = 12bar
hf = 798.64 //kJ/kg
hg = 2784.8 //kJ/kg
x = (h-hf)/(hg-hf) //Dryness fraction
v = (1-x)*0.001139 + (x)*0.1633 //m^3/kg
s = (1-x)*2.2165 + (x)*6.5233 //m^3/kgK
```

```
u = h - p*v*100 //kJ/kg
printf("Volume per kg water = %.6f m^3/kg\n",v)
printf("Internal energy per kg water = %.1f kJ/kg\n"
    ,u)
printf("Entropy per kg water = %.4f kJ/kgK",s)
```

Scilab code Exa 10.7 Find all other thermodynamic properties

```
clc
clear
printf("Example 10.7 | Page number 354 \n\n");
//Find all thermodynamic properties
//Given data
p = 15 //bar
u = 2594.5 //kJ/kg
//Solution
//From saturated steam table based on pressure at p
    = 15 bar
hf = 844.87 //kJ/kg
hg = 2792.1 //kJ/kg
vf = 0.001154 //m^3/kg
vg = 0.13177 //m^3/kg
uf = hf-100*p*vf //kJ/kg
ug = hg-100*p*vg //kJ/kg
if u-ug<0.1 then
    printf("Temperature = %.2f  C\n",198.32)
    printf("Volume per kg water = %.3f m^3/kg\n",vg)
    printf("Enthalpy per kg water = %.1f kJ/kg\n",hg
       )
    printf("Internal energy per kg water = %.1f kJ/
       kg\n",ug)
    printf("Entropy per kg water = %.4f kJ/kgK"
       ,6.4448)

end
```

Scilab code Exa 10.8 Find all other thermodynamic properties of steam

```
clc
clear
printf("Example 10.8 | Page number 355 \n\n");
//Find all thermodynamic property of steam
//Given data
p = 10e6 //Pa
t = 550 // C
//Solution
//From superheated property table
v_500 = 0.03279 //m^3/kg
v_600 = 0.03837 //m^3/kg
v_550 = v_500 + (v_500-v_600)/(500-600)*(550-500) //m^3/kg
h_500 = 3373.6 //kJ/kg
h_600 = 3625.3 //kJ/kg
h_550 = h_500 + (h_500-h_600)/(500-600)*(550-500) //kJ/kg
s_500 = 6.5965 //kJ/kgK
s_600 = 6.9028 //kJ/kgK
s_550 = s_500 + (s_500-s_600)/(500-600)*(550-500) //kJ/kgK
printf("Volume per kg water = %.6f m^3/kg\n",v_550)
printf("Enthalpy per kg water = %.1f kJ/kg\n",h_550)
printf("Entropy per kg water = %.4f kJ/kgK",s_550)
```

Scilab code Exa 10.9 Find the all other thermodynamic properties of steam

```
clc
clear
```

```
printf("Example 10.9 | Page number 355 \n\n");
//Find thermodynamic properties
//Given data
t = 250 // C
h = 2855.8 //kJ/kg
//From superheated property table
p = 3e6 //Pa
v = 0.07058 //m^3/kg
s = 6.2871 //kJ/kgK
u = h - p*v*.001 //kJ/kg
printf("Pressure = %.1f MPa\n",p*1e-6)
printf("Volume per kilogram of water = %.6f m^3/kg\n
    ",v)
printf("Enthalpy per kilogram of water = %.1f kJ/kg\
    n",h)
printf("Entropy per kilogram of water = %.4f kJ/kgK\
    n",s)
printf("Internal energy per kilogram of water = %.1f
     kJ/kg\n",u)
```

Scilab code Exa 10.10 Find the temperature of steam

```
clc
clear
printf("Example 10.10 | Page number 359 \n\n");
//Find the temperature of steam
p = 2 //bar
m = 0.16 //kg
V = 0.1 //m^3
//Solution
//refereing to the saturation temperature
    corresponding to 2bar
v = V/m //m^3/kg
vf = 0.001061 //m^3/kg
vg = 0.8857 //m^3/kg
```

```
printf('Specific volume at saturated liquid phase (vf) = %.6f m^3/kg \n',vf)
printf('Specific volume at saturated vapor phase (vg) = %.6f m^3/kg \n',vg)

if v<vg & v>vf then
    printf('\nThe temperature of the steam must be equal to saturation temperature corresponding to 2 bar\n')
    printf("Temperature of steam = %.2f  C",120.23)
end
```

Scilab code Exa 10.11 Find the heat rejected from steam

```
clc
clear
printf("Example 10.11 | Page number 360 \n\n");
//Find the heat rejected from steam
//Given data
p1 = 2 //bar
v1 = 0.624 //m^3/kg
t = 120.23 //  C
m = 0.16 //kg
//Solution
vf = 0.001061 //m^3/kg
vg = 0.8857 //m^3/kg
x1 = (v1-vf)/(vg-vf) //Dryness fraction
hf = 504.68 //kJ/kg
hg = 2706.6 //kJ/kg
h1 = (1-x1)*hf + x1*hg //kJ/kg
u1 = h1 - p1*v1*100//kJ/kg

v2 = v1 //m^3/kg
vf = 0.001044 //m^3/kg
vg = 1.673 //m^3/kg
```

```
x2 = (v1-vf)/(vg-vf) //Dryness fraction
hf = 419 //kJ/kg
hg = 2676 //kJ/kg
h2 = (1-x2)*hf + x2*hg //kJ/kg
p2 = 1.010325 //bar
u2 = h2 - p2*v2*100 //kJ/kg

printf("Heat rejected from steam = %.1f kJ",m*(u2-u1))
```

Scilab code Exa 10.12 Find work and heat interaction during expansion process

```
clc
clear
printf("Example 10.12 | Page number 361 \n\n");
//Find the work and heat interactions during the expansion process
//Given data
m =0.1 //kg
p1 = 10 //bar
p2 = 1 //bar
//Solution
//From saturated steam table
v1 = 0.1944 //m^3/kg
v2 = (p1/p2)^(1/1.3)*v1 //m^3/kg
W = m*(p1*v1-p2*v2)*100/(1.3-1) //kJ
printf("Work during expansion process = %.2f kJ\n",W)
h1 = 2778.1 //kJ/kg
u1 = (h1 - p1*v1*100) //kJ/kg

vf = 0.001043 //m^3/kg
vg = 1.694 //m^3/kg
x2 = (v2-vf)/(vg-vf) //Dryness fraction
```

```
hf = 417.33 //kJ/kg
hg = 2675.5 //kJ/kg
h2 = (1-x2)*hf + x2*hg //kJ/kg
u2 = h2 - p2*v2*100 //kJ/kg
printf("Heat rejected from steam = %.2f kJ",W+m*(u2-
    u1))
```

Scilab code Exa 10.13 Find the exit area of the nozzle

```
clc
clear
printf("Example 10.13 | Page number 361 \n\n");
//Find the exit area of the nozzle
//Given data
p1 = 10 //bar
t1 = 300 // C
V1 = 50 //m/s
p2 = 1 //bar
m = 1.2 //kg/s

//Solution
//From superheated steam table
h1 = 3051.2 //kJ/kg
s1 = 7.1228 //kJ/kgK
p2 = 1 //bar
s2 = s1 //kJ/kgK

sf = 1.3025 //kJ/kgK
sg = 7.3593 //kJ/kgK
x2 = (s2-sf)/(sg-sf) //Dryness fraction
hf = 417.44 //kJ/kg
hg = 2675.5 //kJ/kg
h2 = (1-x2)*hf + x2*hg //kJ/kg
vf = 0.001043 //m^3/kg
vg = 1.694 //m^3/kg
```

```
v2 = (1-x2)*vf + x2*vg //m^3/kg
V2 = (2*(1000*(h1-h2))+V1^2)^0.5 //m/s
A2 = m*v2/V2*10000//cm^3
printf("The exit area of the nozzle = %.1f cm^2",A2)
```

Scilab code Exa 10.14 Find the flow rate of feed water

```
clc
clear
printf("Example 10.14 | Page number 363 \n\n");
//Find the flow rate of feed water into the heater.
//Given data
m1 = 0.2 //kg/s
p = 4 //bar
//Solution
//From superheated steam table
h1 = 2752.8 //kJ/kg
h2 = 209.31 //kJ/kg
h3 = 604.73 //kJ/kg

m2 = (m1*h1-m1*h3)/(h3-h2) //kg/s
printf("The flow rate of feed water into the heater
    = %.3f kg/s",m2)
```

Chapter 11

Real Gas

Scilab code Exa 11.1 Calculate the specific volume of propane

```
clc
clear
printf("Example 11.1 | Page number 394 \n\n");
//Calculate specific volume of propane and ideal gas
//Given data
P = 70e5 //Pa
T = 150 + 273 //K
Z = 0.55 //Compressibility factor
R = 8314.3/44 //J/kgK
//Solution
//For propane
v = Z*R*T/P //m^3/kg
printf("Specific volume for propane = %.6f m^3/kg\n",v)
//ideal gas
v = R*T/P //m^3/kg
printf("Specific volume for ideal gas = %.6f m^3/kg",v)
```

Scilab code Exa 11.2 Find the reduced properties of air

```
clc
clear
printf("Example 11.2 | Page number 396 \n\n");
//Find reduced properties for air at 10 bar, 27 C
//Given data
Z = 1.04 //Compressiblity factor
pc = 3.77e6 //Pa //crticial pressure
Tc = 132.5 //K
vc = 0.0883 //m^3/kmol
p = 10e5 //Pa
T = 300 //K
//Solution
R = 287 //J/kgK
pR = p/pc //reduced pressure
TR = T/Tc //reduced temperature
v = Z*R*T/p //m^3/kg
vR = v/vc //reduced volume

printf("Reduced pressure = %.5f \n",pR)
printf("Reduced temperature = %.5f \n",TR)
printf("Reduced volume = %.5f \n",vR)
```

Scilab code Exa 11.3 At what temperature and pressure steam be similar to air

```
clc
clear
printf("Example 11.3 | Page number 397 \n\n");
//Find temperature and pressure at which steam will
   beahve similar to air
//Given Data
pR = 0.26525 //reduced pressure
TR = 2.26415 //reduced temperature
```

```
pc = 22.09 //bar //critical pressure of water
Tc = 647.3 //K //critical temperature of water
//Solution
p = pR*pc //bar
T = TR*Tc //K
printf("Temperature at which steam would beahve
    similar to air at 10 bar and 27 C = %.1f K\n",T)
printf("Pressure at which steam would beahve similar
    to air at 10 bar and 27 C = %.2f bar\n",p)
```

Scilab code Exa 11.4 Find Z for air

```
clc
clear
printf("Example 11.4 | Page number 399 \n\n");
//Find Z for air at 5.65 MPa and 27 C
//Given data
pc = 3.77e6 //Pa //critical pressure
p = 5.65e6 //Pa
Tc = 132.5 //K //critical temperature
T = 300 //K
//Solution
pR = p/pc //reduced pressure
TR = T/Tc //reduced temperature
//from generalized compressibilty chart
Z =0.97
printf("From the generalized compressiblity chart,
    at reduced pressure of %.1f and reduced
    temperature of %.2f, Z = %.2f",pR,TR,Z)
```

Scilab code Exa 11.5 Calculate specific volume of gaseous propane

```
clc
clear
printf("Example 11.5 | Page number 399 \n\n");
//Calculate specific volume for gaseous propane using:
//(i) ideal gas equation
//(ii) generalized compressiblity chart
//Given data
T =150+273 //K
p = 7e6 //Pa

//Part (i)
printf("Part(i)\n")
v = (8314.3/44)*T/p //m^3/kg
printf("Specific volume for gaseous propane using ideal gas equation = %.4f m^3/kg\n\n",v)

//Part(ii)
printf("Part(ii)\n")
pc = 4.26e6 //Pa //critical pressure
Tc = 370 //K //critical temperature

pR = p/pc //reduced pressure
TR = T/Tc //reduced temperature
Z = 0.56 //compressibility factor
printf("From the generalized compressiblity chart, at reduced pressure of %.1f and reduced temperature of %.2f, Z = %.2f\n",pR,TR,Z)
v = Z*v
printf("Specific volume for gaseous propane using generalized compressiblity chart = %.5f m^3/kg\n\n",v)
```

Scilab code Exa 11.6 Determine the pressure exerted by Carbon dioxide

```
clc
clear
printf("Example 11.6 | Page number 404 \n\n");
//Find pressure exerted using (i) ideal gas equation
    of state (ii) van der Waals equation of state
//Given data
m = 5//kg //mass of CO2
T = 300 //K
R = 8314.3/44 //J/kgK
V = 1.5 //m^3

//Part(i)
printf("Part(i)\n")
p = m*R*T/V
printf("Pressure exerted by CO2(using ideal gas
    equation) = %.2f kPa\n\n",p*.001)

//Part(ii)
printf("Part(ii)\n")
R = 8.3143 //J/kmolK
a = 0.3658e3 //kPam^6/kmol^2
b = 0.0428 //m^3.kmol
v = 44*V/m //m^3/kmol
p = T*R/(v-b) - a/v^2
printf("Pressure exerted by CO2(using van der Waals
    equation) = %.1f kPa\n\n",p)
```

Scilab code Exa 11.7 Determine the pressure in rigid vessel

```
clc
clear
printf("Example 11.7 | Page number 406 \n\n");
//Determine the pressure using:
//(i) ideal gas equation of state
//(ii) generalised compressibility chart
```

```
//(iii) van der Waals equation
//(iv) Redlich-Kwong equation of state
//(v) Bettie-Bridgeman equation

//Given Data
M = 28 //g/mol
m = 3.5//kg
V = 0.015 //m^3
v = V/m //m^3/kg
T = 473 //K
R = 8314.3/M //J/kgK
//Solution

//Part(i)
printf("Part(i)\n")
p = m*R*T/V //Pa
printf("Pressure (using ideal gas equation of state)
    = %.2f MPa\n\n",p*(1e-6))

//Part(ii)
printf("Part(ii)\n")
pc = 3.39e6 //Pa //critical pressure
Tc = 126.2 //K //critical temperature
vc = 0.0899 //m^3/kmol //critical volume

TR = T/Tc //reduced temperature
vR = v/(R*Tc/pc) //reduced volume
Z = 1.1 //Compressibility factor
printf("From the generalized compressiblity chart,
   at reduced volume of %.4f and reduced temperature
    of %.2f, Z = %.2f\n",vR,TR,Z)
p = Z*R*T/v //Pa
printf("Pressure (using generalised compressibility
   chart) = %.3f MPa\n\n",p*(1e-6))

//Part(iii)
printf("Part(iii)\n")
a = 0.1366e6 //Pam^5/kmol^2
```

```
b = 0.0386 //m^3/kmol
p = (8314.3*T/(v*M - b)) - a/(v*M)^2
printf("Pressure (using van der Waals equation) = %.2f MPa\n\n",p*(1e-6))

//Part(iv)
printf("Part(iv)\n")
a = (0.427*(R*M)^2*Tc^2.5/pc)
b = 0.0866*(R*M*Tc/pc)

p = (R*M*T/(v*M-b))-(a/(((v*M)^2 + v*M*b)*(T^0.5)))
printf("Pressure (using Redlich-Kwong equation of state) = %.2f MPa\n\n",p*(1e-6))

//---Note--- //Solution to Part(iv) in the textbook is 40.58 MPa which is wrong. The correct solution (38.13 MPa) is computed here.

//Part(v)
printf("Part(v)\n")
A0 = 136.2315
a = 0.02617
B0 = 0.05046
b = -0.00691
c = 42000

A = A0*(1 - a/(v*M))
B = B0*(1 - b/(v*M))
eps = c/(T^3 * v*M)
p = ((8314.3)*T*(1-eps)*(v*M+B))/(v*M)^2 - 1e3*A/(v*M)^2
printf("Pressure (using ideal gas equation of state) = %.2f MPa\n\n",p*(1e-6))
```

Chapter 12

Fuels and Combustion

Scilab code Exa 12.1 Find the gravimetric and ultimate analysis

```
clc
clear
printf("Example 12.1 | Page number 412 \n\n");
//Part(a) Find gravimetric analysis
//Part(b) Find ultimate analysis
//Given solution
xCO2 = 0.03 //mole fraction of CO2
xCO = 0.19 //mole fraction of CO
xH2 = 0.41 //mole fraction of H2
xCH4 = 0.25 //mole fraction of CH4
xC2H4 = 0.09 //mole fraction of C2H4
xN2 = 0.03 //mole fraction of N2

//Solution
//Part(a)
printf("Part(a)\n");
M = xCO2*44 + xCO*28 + xH2*2 + xC2H4*28 +xCH4*16 +
   xN2*28 //kg/mol //average molar mass
yCO2 = xCO2*(44/M)
yCO = xCO*(28/M)
yH2 = xH2*(2/M)
```

```
yCH4 = xCH4*(16/M)
yC2H4 = xC2H4*(28/M)
yN2 = xN2*(28/M)
printf("yCO2 = %.2f%%\n",yCO2*100)
printf("yCO = %.2f%%\n",yCO*100)
printf("yH2 = %.2f%%\n",yH2*100)
printf("yCH4 = %.2f%%\n",yCH4*100)
printf("yC2H4 = %.2f%%\n",yC2H4*100)
printf("yN2 = %.2f%%\n\n",yN2*100)

//Part(b)
printf("Part(b)\n");
nC = xCO2 + xCO + xCH4 + xC2H4*2 //number of moles
    of C
nH2 = xH2 + xCH4*2 + xC2H4*2 //number of moles of H2
nO2 = xCO2 + 0.5*xCO //number of moles of O2
nN2 = xN2 //number of moles of N2

mC = nC*12/M
mH2 = nH2*2/M
mO2 = nO2*32/M
mN2 = nN2*28/M
printf("mC = %.2f%%\n",mC*100)
printf("mH2 = %.2f%%\n",mH2*100)
printf("mO2 = %.2f%%\n",mO2*100)
printf("mN2 = %.2f%%\n",mN2*100)
```

Scilab code Exa 12.2 Find the stoichiometric air

```
clc
clear
printf("Example 12.2 | Page number 416 \n\n");
//Find the stoichiometric air for combustion of (a)
    Carbon (b)Hydrogen (c)Sulphur
//Given data
```

```
//Molar masses of O2,H2,N2,C and S respectively
MO2 = 32 //g/mol
MH2 = 2 //g/mol
MN2 = 28 //g/mol
MC = 12 //g/mol
MS = 32 //g/mol
//Part(a)
printf("Part(a)\n")
printf("Stoichiometric air(Carbon) = %.2f kg/kg
    carbon\n\n",(MO2 + 3.76*MN2)/MC)
//Part(b)
printf("Part(b)\n")
printf("Stoichiometric air(Hydrogen) = %.2f kg/kg
    hydrogen\n\n",0.5*(MO2 + 3.76*MN2)/MH2)
//Part(c)
printf("Part(c)\n")
printf("Stoichiometric air(Sulphur) = %.2f kg/kg
    sulphur\n",(MO2 + 3.76*MN2)/MS)
```

Scilab code Exa 12.3 Find the stoichiometric air

```
clc
clear
printf("Example 12.3 | Page number 417 \n\n");
//Find the stoichiometric air
//Given data
xC3H8 = 0.2 //mole fraction of propane
xC4H10 = 0.8 //mole fraction of butane
//Molar masses of O2,H2,N2 & C respectively
MO2 = 32 //g/mol
MH2 = 2 //g/mol
MN2 = 28 //g/mol
MC = 12 //g/mol

//Solution
```

```
//C balance
b = xC3H8*3+xC4H10*4
//H2 balance
d = xC3H8*4 + xC4H10*5
//O2 balance
a = b + d/2
//N2 balance
c = 3.76*a

Stoichiometric_air =  a*(MO2 + 3.76*MN2)/(xC3H8*(MC+
    MO2)+xC4H10*(MC*4+MH2*5))
printf("Stoichiometric air = %.2f kg/kg cooking gas"
    ,Stoichiometric_air)
```

Scilab code Exa 12.4 Find the excess air and percent theoretical air

```
clc
clear
printf("Example 12.4 | Page number 418 \n\n");
//Find excess air and % theoretical air
//Given data
xC3H8 = 0.2 //mole fraction of propane
xC4H10 = 0.8 //mole fraction of butane

xO2 = 0.21 //mole fraction of O2
xN2 = 0.79 //mole fraction of N2
//Molar masses of O2,H2,N2 & C respectively
MO2 = 32 //g/mol
MH2 = 2 //g/mol
MN2 = 28 //g/mol
MC = 12 //g/mol
Stoichiometric_air = 15.42 //kg/kg

//Solution
//C balance
```

```
b = xC3H8*3+xC4H10*4
//H2 balance
e = xC3H8*4 + xC4H10*5
//O2 balance
d = 40*xO2-b -0.5*e
//N2 balance
c = 40*xN2

actual_air = 40*(xO2*MO2 + xN2*MN2)/(xC3H8*(MC*3+MH2*4)+xC4H10*(MC*4+MH2*5)) //kg/kg gas

excess_air = (actual_air - Stoichiometric_air)/Stoichiometric_air*100
printf("Excess air = %.1f%%\n",excess_air)

theoritical_air = 100+excess_air
printf("Theoritical air = %.1f%%\n",theoritical_air)
```

Scilab code Exa 12.5 Find the Orsat analysis

```
clc
clear
printf("Example 12.5 | Page number 420 \n\n");
//Find the Orsat analysis of the combustion products
//Given Data
nCO2 = 3.8 //Number of moles of CO2
nN2 = 31.6 //Number of moles of N2
nO2 = 2.2 //Number of moles of O2

//Solution
n = nCO2 + nN2 + nO2
xCO2 = nCO2/n //mole fraction of CO2
xN2 = nN2/n //mole fraction of N2
xO2 = nO2/n //mole fraction of O2

```

```
printf("xCO2 = %.1f %% \n",xCO2*100)
printf("xN2 = %.1f %% \n",xN2*100)
printf("xO2 = %.1f %% \n",xO2*100)
```

Scilab code Exa 12.6 Find the volume fraction and mass fraction of the products of combustion

```
clc
clear
printf("Example 12.6 | Page number 421 \n\n");
//Find the volume fraction and mass fraction
//Given Data
nCO2 = 3.8 //Number of moles of CO2
nN2 = 31.6 //Number of moles of N2
nO2 = 2.2 //Number of moles of O2
nH2O = 4.8 //Number of moles of H2O

//Solution
//Solution
n = nCO2 + nN2 + nO2 + nH2O
xCO2 = nCO2/n //mole fraction of CO2
xN2 = nN2/n //mole fraction of N2
xO2 = nO2/n //mole fraction of O2
xH2O = nH2O/n //mole fraction of H2O

printf("Volume fraction of CO2 = %.1f%%\n",xCO2*100)
printf("Volume fraction of N2 = %.1f%%\n",xN2*100)
printf("Volume fraction of O2 = %.1f%%\n",xO2*100)
printf("Volume fraction of H2O = %.1f%%\n\n",xH2O
    *100)

M = xCO2*44 + xN2*28 + xO2*32 + xH2O*18 //Mass of
    combustion product

yCO2 = xCO2*(44/M)
```

```
yH2O = xH2O*(18/M)
yN2 = xN2*(28/M)
yO2 = xO2*(32/M)

printf("Mass fraction of CO2 = %.1f%%\n",yCO2*100)
printf("Mass fraction of N2 = %.1f%%\n",yN2*100)
printf("Mass fraction of O2 = %.1f%%\n",yO2*100)
printf("Mass fraction of H2O = %.1f%%\n\n",yH2O*100)
```

Scilab code Exa 12.7 Find the actual air excess air theoretical air mass fraction and dew point temperature

```
clc
clear
printf("Example 12.7 | Page number 422 \n\n");
//Find
//(a) Actual air
//(b) Excess air
//(c) Percentage theoritical air
//(d) Mass fractions
//(e) Dew point

//Part(a)
printf("Part(a)\n")
mC = 0.65 //kg //mass of C per kg coal
mA = 0.15 //kg //mass of Ash per kg coal
CR = 0.05 //kg //mass of carbon in solid refuse per
   kg coal
mR = 0.2 //kg //mass of refuse per kg coal
m = mC- CR //kg //mass of carbon burnt per kg coal

//By C balance
x = (14 + 1)*(12/0.6) //kg //mass of burnt coal
//By H2 balance
b = x*(0.06/2)
```

```
//By O2 Balance
a = (14 + 0.5 + 3.5 + 4.5)-(x*0.1/32)
actual_air = a*(32+3.76*28)/x //kg/kg coal
printf("Actual air = %.3f kg/kg coal\n\n",actual_air
    )

//Part(b)
printf("Part(b)\n")
Stoichiometric_air = (0.6*11.45+0.06*34.3)
    -(0.1/0.232) //kg
excess_air = (actual_air - Stoichiometric_air)/
    Stoichiometric_air*100
printf("Excess air = %.1f%%\n\n",excess_air)

//Part(c)
printf("Part(c)\n");
printf("Percentage theoritical air = %.1f%%\n\n"
    ,100+excess_air)

//Part(d)
printf("Part(d)\n")
m = 14*44 + 1*28 +3.5*32 +81.5*28 +9*18 //kg //mass
    of combustion product
printf("Mass fraction of CO2 = %.2f%%\n",14*44/m
    *100)
printf("Mass fraction of CO = %.2f%%\n",1*28/m*100)
printf("Mass fraction of O2 = %.2f%%\n",3.5*32/m
    *100)
printf("Mass fraction of N2 = %.2f%%\n",81.5*28/m
    *100)
printf("Mass fraction of H2O = %.2f%%\n\n",9*18/m
    *100)

//Part(e)
printf("Part(e)\n")
xH2O = 9/(14+1+3.5+81.5+9) //molfraction of H2O
pH2O = xH2O*1e5 //Pa //partial pressure
//From steam table
```

```
tdp = 42.5 // C
printf("Dew point temperature = %.1f  C",tdp)
```

Scilab code Exa 12.8 Find the actual air and excess air

```
clc
clear
printf("Example 12.8 | Page number 425 \n\n");
//Find actual air and excess air
//Given Data
xCO2 = 9.7 //mole percent CO2
xCO = 1.1 //mole percent CO
xO2 = 4 //mole percent O2
xN2 = 85.2 //mole percent N2

//Solution
//by C balance
b = 2
//by H2 balance
d = 2
//by O2 balance
a = b+d*.5
//by N2 balance
c = 3.76*a

Stoichiometric_air = a*(32+3.76*28)/28 //kg/kg ethylene

//by C balance
x = (xCO2+xCO)/2 //kmol of ehtylene be burnt
//by H2 balance
q = 2*x
//by O2 balance
p = xCO2 + xCO/2 + xO2 + q/2

```

```
actual_air = p*(32+3.76*28)/(x*28) //kg/kg ethylene
excess_air = (actual_air - Stoichiometric_air)/
    Stoichiometric_air*100
printf("Actual air = %.1f kg/kg ethylene \n",
    actual_air)
printf("Excess air = %.1f%%",excess_air)
```

Scilab code Exa 12.9 Find the heat transfer from the combustor

```
clc
clear
printf("Example 12.9 | Page number 433 \n\n");
//Find the heat transfer from the combustor
excess_air = 10 //%
tR = 30 // C //temperature of reactant
tP = 120 // C //temperature of product
delta_H = -802.3*1000 //kJ/kmol CH4
Cp_CH4 = 36 //kJ/lmolK
Cp_O2 = 29.5 //kJ/lmolK
Cp_N2 = 29.2 //kJ/lmolK
Cp_CO2 = 37 //kJ/lmolK
Cp_H2O = 33.7 //kJ/lmolK
tA = 30 // C
tX = 25 // C
tY = tX // C
tB = 120 // C
//Solution
Q_AB = (1*Cp_CO2 + 0.2*Cp_O2 + 8.272*Cp_N2 + 2*
    Cp_H2O)*(tB-tX)+ delta_H + (1*Cp_CH4 + 2.2*Cp_O2
    +8.272*Cp_N2)*(tY-tA)
printf("The heat transfer from the combustor = %.1f
    kJ/kg CH4 ",Q_AB/16)
```

Scilab code Exa 12.10 Find the enthalpy of reaction

```
clc
clear
printf("Example 12.10 | Page number 435 \n\n");
//Find enthalpy of reaction
//Given Data
deltaH_gasgas = -2651.4e3 //kJ/kmol butane
hfg_butane = 370 //kJ/kg //enthalpies of
   vaporisation of butance
hfg_water = 2442 //kJ/kg //enthalpies of
   vaporisation of water
M_butane = 58 //g/mol
M_water = 18 //g/mol

//Solution
deltaH_liqliq = deltaH_gasgas + M_butane*hfg_butane
   - 5*M_water*hfg_water
printf("Enthalpy of reaction = %.1f kJ/kg",
   deltaH_liqliq/M_butane)
```

Scilab code Exa 12.11 Find the standard change in enthalpy for the reaction

```
clc
clear
printf("Example 12.11 | Page number 437 \n\n");
//Find standard delta_H for reaction
//Given Data
//Formation Enthalpies
hf_CO2 = -393510 //kJ/kmol
hf_H2O = -285838 //kJ/kmol
hf_C3H8 = -104680 //kJ/kmol
hf_O2 = 0 //kJ/kmol

```

```
//Solution
Hp = 3*hf_CO2 + 4*hf_H2O
Hr = hf_C3H8 + 5*hf_O2
deltaH_std = Hp-Hr
printf("Standard change in enthalpy for the reaction = %.1f kJ/kg",deltaH_std/44)
```

Scilab code Exa 12.12 Find the heat transferred from the combustor

```
clc
clear
printf("Example 12.12 | Page number 438 \n\n");
//Find the heat transferred from the combustor per kg ethylene
//Given Data
Cp_C2H4 = 28*1.548 //kJ/lmolK
Cp_O2 = 32*0.922 //kJ/lmolK
Cp_N2 = 28*1.042 //kJ/lmolK
Cp_CO2 = 44*0.842 //kJ/lmolK
Cp_H2O = 18*1.86 //kJ/lmolK

//Solution
deltaH_BX = (2*Cp_CO2 + 2*Cp_H2O + 0.3*Cp_O2 + 12.408*Cp_N2)*(120-25)
deltaH_YA = (Cp_C2H4 + 3.3*Cp_O2 + 12.408*Cp_N2)*(25-50)
hf_CO2 = -393510 //kJ/kmol
hf_H2O = -241820 //kJ/kmol
hf_C2H4 = 52283 //kJ/kmol
deltaH_XY = 2*hf_CO2 + 2*hf_H2O - hf_C2H4 //kJ/kmol
deltaH_BA = deltaH_BX + deltaH_YA + deltaH_XY //kJ/kmol

printf("The heat transferred from the combustor per kg ethylene = %.1f kJ/kg ethane",deltaH_BA/28)
```

Scilab code Exa 12.13 Find the adiabatic combustion temperature

```
clc
clear
printf("Example 12.13 | Page number 441 \n\n");
//Find adiabatic combustion temperature when methane
    is burnt
//Part(a) using average Cp values
//Part(b) using ideal gas enthalpy

//Part(a)
printf("Part(a)\n")
//Picking up various Cp values from Table 12.1
tB = (16*50010)
   /(44*0.842+2*18*1.86+3*32*0.922+22.56*28*1.042)
   +25
printf("Adiabatic combustion temperature (using
   average Cp values)= %.1f K\n\n",tB+273)

//Part(b)
printf("Part(b)\n")
tb1 = 1000 //K //first guess temperature
tb2 = 1200 //K second guess temperature
tb = (tb1 - tb2)/(637617-836847)*(800160-836847) +
   tb2
printf("Adiabatic combustion temperature (using
   ideal gas enthalpy)= %.1f K",tb)
```

Scilab code Exa 12.14 Find the LCV and HCV of gaseous hexane

```
clc
```

```
clear
printf("Example 12.14 | Page number 443 \n\n");
//Find LCV and HCV of gaseous hexane
//Given data
delta_H_std = -45101 //kJ/kg
hfg = 2442 //kJ/kg //enthalpy of vaporisation

//Solution
LCV = -1*delta_H_std // kJ/kg hexane
printf("LCV of gaseous hexane = %.1f kJ/kg hexane\n"
    ,LCV)

m = 7*18/86 //mass of H2O per kg hexane
HCV = LCV+m*hfg //kJ/kg hexane
printf("HCV of gaseous hexane = %.1f kJ/kg hexane",
    HCV)
```