

Scilab Textbook Companion for
Thermodynamics and Heat Power
by I. Granet and M. Bluestein¹

Created by
Macwan Genesis Samuel
B.tech
Others
Dharmasinh Desai University
College Teacher
Dr. Prarthan Mehta
Cross-Checked by
Chaitanya Potti

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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

Scilab code Exa 1.1 Temperature indicated on same on both Fahrenheit and Celsius thermometers

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.1\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.1 (page no. 8)
7 // Solution
8
9 //C=(5/9)*(F-32);
10 //F=32+(9*C/5);
11 //Letting C=F in equation;
12 //F=(5/9)*(F-32);
13 //Therefore
14 F=-160/4; //fahrenheit
15 disp(F,"F=");
16 printf("Both fahrenheit and celsius temperature
       scales indicate same temperature at %f",F);
```

Scilab code Exa 1.2 Force And Mass

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.2\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.2 (page no. 18)
7 // Solution
8
9 //Given
10 Mm=0.0123//Unit:lb //Mass of the moon;
11 Me=1 //Unit:lb //Mass of the earth;
12 Dm=0.273 //Unit:feet //Diameter of the moon;
13 De=1 //Unit:feet //Diameter of the earth;
14 Rm=Dm/2; //Radius of the moon; //Unit:feet
15 Re=De/2; //Radius of the earth; //Unit:feet
16
17 //F=(K*M1*M2)/d^2 //Law of universal gravitation;
18 //Fe=(K*Me*m)/Re^2; //Fe=Force exerted on the mass;
19 //Fm=(K*Mm*m)/Rm^2; //Fm=Force exerted on the moon;
20 F=(Me/Mm)*(Rm/Re)^2; //F=Fe/Fm;
21 printf("Relation of force exerted on earth to mass
        is")
22 disp(F,"Fe/Fm =");
```

Scilab code Exa 1.3 Calculating weight

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.3\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.3 (page no. 20)
7 // Solution
```

```

8
9 //Given
10 M=5; //Unit:kg //mass of body;
11 g=9.81; //Unit:m/s^2 //the local acceleration of
    gravity
12 W=M*g; //W=the weight of the body //Unit:Newton // 1
    N= 1 kg*m/s^2
13 printf("The weight of the body is %f N",W);

```

Scilab code Exa 1.4 Force and mass

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.4\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.4 (page no. 21)
7 // Solution
8
9 printf("Solution for (a)\n");
10 //given
11 M=10 //Unit:kg //mass of body;
12 g=9.5 //Unit:m/s^2 //the local acceleration of
    gravity
13 W=M*g; //W=the weight of the body; //Unit:Newton //
    1 N= 1 kg*m/s^2
14 printf("The weight of the body is %f N\n\n",W);
15
16 printf("Solution for (b)\n");
17 //Given
18 F=10; //Unit:Newton //Horizontal Force
19 a=F/M; //newton's second law of motion
20 printf("The horizontal acceleration of the body is
    %f m/s^2\n",a);

```

Scilab code Exa 1.5 The SI Unit

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.5\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.5 (page no. 25)
7 // Solution
8
9 //Conversion Problem
10 // 1 inch=0.0254 meter so, 1=0.0254 meter/inch //
    Eq.1
11 // 1 ft=12 inch so, 1=12 inch/ft .....// Eq.2
12 //Multiplying Eq.1 & Eq.2 // We get 1=0.0254*12
    meter/ft
13 //Taking Square both side
14 //1^2=(0.0254*12)^2 meter^2/ft^2
15 printf("1 ft^2=%f meter^2\n", (0.0254*12)^2);
```

Scilab code Exa 1.7 Pressure

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.7\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.7 (page no. 33)
7 // Solution
8
9 //The Specific gravity of mercury is 13.6 //Given
```

```

10 //Converting the unit of weight of grams per cubic
    centimeter to pounds per cubic foot
11 // 1 lbf=454 gram //1 inch= 2.54 cm
12 //So 1 gram=1/454 lbf and 1 ft=12*2.54 cm
13 //Gamma=(gram/cm^3)*(lb/gram)*(cm^3/ft^3)=lb/ft^3
14 //Gamma=(1 gram/cm^3)*(1 lbf/454 gram)*(2.54*12)^3 *
    cm^3/ft^3
15 Gamma=(1/454)*(2.54*12)^3; //lbf/ft^3 //conversion
    factor
16 disp(Gamma,"Conversion Factor=");
17 p=(1/12)*(Gamma*13.6); //lbf/ft^2 //gage pressure
18 p=(1/12)*Gamma*13.6*(1/144) //ft^2/inch^2 //gage
    pressure
19 printf("Guage Pressure is %f psi\n",p);
20 printf("Local atmospheric pressure is 14.7 psia\n");
21 P=p+14.7; //Pressure on the base of the column //
    Unit: psia
22 printf(" So Pressure on the base of the column is %f
    psia",P);

```

Scilab code Exa 1.8 Pressure

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.8\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.8 (page no. 34)
7 // Solution
8
9 //Given
10 Rho=13.595; //Unit: kg/m^3 //The density of mercury
11 h=25.4; //Unit: mm //Height of column of mercury
12 g=9.806; //Unit:m/s^2 //the local acceleration of
    gravity

```



```

13 //Solution
14 p=Rho*g*h; //P=Pressure at the base of a column of
    mercury //Unit:Pa
15 printf(" Pressure at the base of a column of mercury
    is %f Pa",p);

```

Scilab code Exa 1.9 Absolute pressure

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.9\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.9 (page no. 34)
7 // Solution
8
9 //Given
10 Patm=30.0; //in. //pressure of mercury at standard
    temperature
11 Vacuum=26.5; //in. //vaccum pressure
12 Pabs=Patm-Vacuum; //Absolute pressure of mercury //
    in.
13 // 1 inch mercury exerts a pressure of 0.491 psi
14 p=Pabs*0.491; //Absolute pressure in psia
15 printf("Absolute pressure of mercury in is %f psia",
    p);

```

Scilab code Exa 1.10 Pressure

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.10\n\n\n");

```

```

5 // Chapter 1: Fundamental Concepts
6 // Problem 1.10 (page no. 35)
7 // Solution
8
9 //Given
10 Rho=2000; //Unit: kg/m^3 //The density of fluid
11 h=-10; //Unit: mm //Height of column of fluid //the
    height is negative because it is measured up from
    the base
12 g=9.6 //Unit:m/s^2 //the local acceleration of
    gravity
13 //Solution
14 p=-Rho*g*h; //P=Pressure at the base of a column of
    fluid //Unit:Pa
15 printf("Pressure at the base of a column of fluid is
    %f Pa",p);

```

Scilab code Exa 1.11 Absolute pressure

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 1.11\n\n\n");
5 // Chapter 1: Fundamental Concepts
6 // Problem 1.11 (page no. 35)
7 // Solution
8
9 //Given
10 Patm=30.0 //in. //pressure of mercury at standard
    temperature
11 Vacuum=26.5 //in. //vaccum pressure
12 Pabs=Patm-Vacuum; //Absolute pressure of mercury //
    in.
13 // (3.5 inch* (ft/12 inch) * (13.6*62.4)LBf/ft^3 *
    kg/2.2 LBf * 9.806 N/kg)/((12 inch^2/ft^2) *

```

```
    (0.0254 m/inch) ^2)
14 p=(3.5*(1/12)*13.6*62.4*(1/2.2)*9.806)
    /(12^2*0.0254^2*1000); //kPa //Absolute pressure
    in psia
15 printf("Absolute pressure of mercury is %f kPa",p)
```

Chapter 2

Work energy and heat

Scilab code Exa 2.2 Work

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.2\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.2 (page no. 62)
6 // Solution
7
8 //Given
9 k=100; // Unit:lb/in. //k=spring constant
10 l=2; //Unit:inch //l= length of compression of
    string
11 work=(1/2)*k*l^2; //force-displacement relation //
    Unit:in*lb
12 printf("Workdone is %f inch*lb",work);
```

Scilab code Exa 2.3 Work

```
1 clear;
```

```

2  clc;
3  printf("\\t\\t\\tProblem Number 2.3\\n\\n\\n");
4  // Chapter 2: Work, Energy, and Heat
5  // Problem 2.3 (page no. 62)
6  // Solution
7
8  //Given
9  k=20*1000; // Unit:N/m //k=20kN //k=spring constant
10 l=0.075; //Unit:meter //l=75 mm //l= length of
    compression of string
11 work=(1/2)*k*l^2; //force-displacement relation //
    Unit:N*m
12 printf("Workdone is %f Jule",work);

```

Scilab code Exa 2.4 Potential Energy

```

1  clear;
2  clc;
3  printf("\\t\\t\\tProblem Number 2.4\\n\\n\\n");
4  // Chapter 2: Work, Energy, and Heat
5  // Problem 2.4 (page no. 66)
6  // Solution
7
8  //Given
9  Z=600; //Unit:ft //Z=The distance ,the body is raised
    from its initial position when the force is
    applied
10 gc=32.174; //Unit: (lbm*ft)/(lbf*s^2) //gc is
    constant of proportionality
11 g=gc; //Unit:ft/s^2 //g=The local gravity
12 m=1; //Unit:lbm //m=mass
13 PE=(m*g*Z)/gc; //potential energy //Unit:ft*lbf
14 printf("%f ft*lbf work is done lifting the water to
    elevation ",PE)

```

Scilab code Exa 2.5 Potential Energy

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.5\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.5 (page no. 66)
6 // Solution
7
8
9 m=1; //Unit:kg //m=mass
10 g= 9.81 //Unit:m/s^2 //g=The local gravity
11 Z=50 //Unit:m ////Z=The distance ,the body is raised
    from its initial position when the force is
    applied //In this case Z=delivered water from
    well to pump
12 PE=m*g*Z; //PE=Potential Energy //Unit:Joule
13 printf("Change in potential energy per kg of water
    is %f J ",PE); //J=Joule=N*m=kg*m^2/s^2
```

Scilab code Exa 2.6 power generated

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.6\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.6 (page no. 66)
6 // Solution
7
8 Rho=62.4; //Unit:lbm/ft^3 //Rho=The density of water
9 A=10000; //Flow=10000; gal/min
```

```

10 V=(231/1728); // 12 inch=1 ft //So,1 ft^3=1728 in^3
    // One Gallon is a volumetric measure equal to
    231 in^3
11 //A*V //Unit:ft^3/min
12
13 //In example, 2.4:
14 printf("From example 2.4\n");
15 Z=600; //Unit:ft //Z=The distance,the body is raised
    from its initial position when the force is
    applied
16 gc=32.174; //Unit: (lbm*ft)/(lbf*s^2) //gc is
    constant of proportionality
17 g=gc; //Unit:ft/s^2 //g=The local gravity
18 m=1; //Unit:lbm //m=mass
19 PE=(m*g*Z)/gc; //potential energy //Unit:ft*lbf
20 printf("%f ft*lbf work is done lifting the water to
    elevation\n ",PE);
21
22 //So,
23 printf("In example 2.5 \n")
24 M=Rho*A*V; //M=the mass flow
25 Power=M*PE; //Unit:ft*lbf/lbm
26 printf("Generated Power is %f ft*lbf/lbm \n",Power);
27 // 1 horsepower = 33,000 ft*lbf/min
28 printf("Power = %f hp\n",Power/33000);

```

Scilab code Exa 2.7 Power

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.7\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.7 (page no. 67)
6 // Solution
7

```

```

8 printf("In problem 2.5\n");
9 m=1; //Unit:kg //m=mass
10 g= 9.81 //Unit:m/s^2 //g=The local gravity
11 Z=50 //Unit:m ////Z=The distance,the body is raised
    from its initial position when the force is
    applied //In this case Z=delivered water from
    well to pump
12 PE=m*g*Z; //PE=Potential Energy //Unit:Joule
13 printf("Change in potential energy per kg of water
    is %f J \n",PE); //J=Joule=N*m=kg*m^2/s^2
14 //Given data in problem 2.7 is
15 M=1000; //Unit;kg/min//M=Water density
16 Power=PE*M*(1/60); //1 min=60 seconds //power //unit
    :Joule/s=W
17 printf("Power is %f Watt\n",Power); //Watt=N*m/s =
    Joule/s =Watt
18 //1 Hp=746 Watt
19 printf("Power is %f Horsepower",Power/745);

```

Scilab code Exa 2.8 Kinetic Energy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.8\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.8 (page no. 69)
6 // Solution
7
8 m=10; //Unit:lb //m=Mass
9 V1=88; //Unit:// ft/s V1=Velocity before it is slowed
    down
10 V2=10; //Unit;ft/s //V2=Velocity after it is slowed
    down
11 gc=32.174; //Unit: (lbm*ft)/(lbf*s^2) //gc is
    constant of proportionality

```



```

12
13 KE1=m*V1^2/(2*gc); //The kinetic energy of the body
    before it is slowed down //Unit:ft*lbf
14 printf("The kinetic energy of the body before it is
    slowed down is %f ft*lbf\n",KE1);
15
16 KE2=m*V2^2/(2*gc); //The kinetic energy of the body
    before it is slowed down //Unit:ft*lbf
17 printf("The kinetic energy of the body before it is
    slowed down is %f ft*lbf\n",KE2);
18
19 KE=KE1-KE2; //KE=Change in kinetic energy //Unit:ft*
    lbf
20 printf("Change in kinetic energy is %f ft*lbf",KE);

```

Scilab code Exa 2.9 Change in Kinetic Energy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.9\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.9 (page no. 70)
6 // Solution
7
8 m=1500; //Unit:kg //m=mass
9 V1=50; //Km/hour V1=Velocity before it is slowed
    down
10 //V1=(50*1000 m/hour)^2/(3600 s/hour)^2
11 KE1=(m*(V1*1000)^2/3600^2)/2; //KE1=Initial kinetic
    energy //Unit:Joule
12
13 //After slowing down
14 V2=30; //Unit:KM/hour //V2=Velocity after it is
    slowed down
15 //V2=(30*1000 m/hour)^2/(3600 s/hour)^2

```

```

16 KE2=(m*(V2*1000)^2/3600^2)/2; //KE2=After slowing
    down, the kinetic energy //Unit:Joule
17
18 KE=KE1-KE2; //KE=Change in kinetic energy //Unit:
    Joule
19 printf("Change in kinetic energy is %f kJ",KE/1000);

```

Scilab code Exa 2.10 Kinetic Energy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.10\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.10 (page no. 70)
6 // Solution
7
8 m=10 //Unit:kg //m=mass
9 Z=10 //Unit:m //Z=The distance, the body is raised
    from its initial position when the force is
    applied
10 g= 9.81 //Unit:m/s^2 //g=The local gravity
11 //There are no losses in the system
12 //So, initial potential energy plus initial kinetic
    energy equal to sum of final potential energy
    plus final kinetic energy
13 //So, PE1+KE1=PE2+KE2
14 //From the figure ,KE1=0; PE2=0;
15 //So, PE1=KE2;
16 PE1=m*g*Z; //PE=Potential Energy //Unit:Joule
17 //KE2=(m*v^2)/2
18 v=(PE1*2)/m;
19 V=sqrt(v); //Unit:m/s //velocity
20 printf("Velocity = %f m/s",V);
21 KE2=PE1; //kinetic energy //Unit:Joule
22 printf("\nKinetic energy is %f N*m",PE1);

```

Scilab code Exa 2.11 Flow work

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.11\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.11 (page no. 74)
6 // Solution
7
8 printf("At the entrance of device,\n");
9 p1=100; //pressure at the entance //Unit:psia ,lbf/in
      ^2
10 Rho1=62.4; //Unit:lbm/ft^3 //Rho=The density
11 v1=144*(1/Rho1) //Specific Volume at entrance or
      reciprocal of fluid density // 144 in^2=1 ft^2
12 //1 Btu = 778 ft*lbf
13 J=778; //Unit:ft*lbf/Btu //conversion factor
14 FW1=(p1*v1)/J; //Flow work //Btu/lbm
15 printf("Flow work = %f Btu/lbm\n",FW1);
16
17 printf("At the exit of device,\n");
18 p2=50; //pressure at the exit //Unit:psia ,lbf/in^2
19 Rho2=30; //Unit:lbm/ft^3 //Rho=The density
20 v2=144*(1/Rho2) //Specific Volume at exit or
      reciprocal of fluid density // 144 in^2=1 ft^2
21 //1 Btu = 778 ft*lbf
22 J=778; //Unit:ft*lbf/Btu //conversion factor
23 FW2=(p2*v2)/J; //Flow work //Btu/lbm
24 printf("Flow work = %f Btu/lbm\n",FW2);
```

Scilab code Exa 2.12 Flow work

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.12\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.12 (page no. 75)
6 // Solution
7
8 printf("At the entrance of device,\n");
9 p1=200*1000; //200kPa*1000 Pa/kPa //pressure at the
    entrance //Unit:N/m^2
10 Rho1=1000; //kg/m^3 //Fluid density at entrance
11 v1=1/Rho1; //Specific Volume at entrance or
    reciprocal of fluid density
12 FW1=p1*v1; //Flow work at entrance //Unit:N*m/kg
13 printf("Flow work = %fN*m/kg\n",FW1);
14
15 printf("At the exit of device,\n");
16 p2=100*1000; //200kPa*1000 Pa/kPa //pressure at the
    exit //Unit:N/m^2
17 Rho2=250; //kg/m^3 //Fluid density at exit
18 v2=1/Rho2; //Specific Volume at entrance or
    reciprocal of fluid density
19 FW2=p2*v2; //Flow work at exit//Unit:N*m/kg
20 printf("Flow work = %f N*m/kg\n",FW2);

```

Scilab code Exa 2.14 Work done

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.14\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.14 (page no. 78)
6 // Solution
7
8 //It is necessary that pressure be expressed as psfa

```

```

    when the volume is in cubic feet
9 //100 psia = 100*144 psfa
10 p1=100*144; //Unit:psfa //initial pressure
11 v1=2; //Unit:ft^3/lb //Initial Specific Volume
12 v2=1; //Unit:ft^3/lb //Final Specific Volume
13 w=p1*v1*log(v2/v1); //work done on fluid //Unit:ft*
    lbf/lbm
14 printf("Work done on fluid = %f ft*lbf/lb\n",w);
15 //1 Btu = 778 ft*lbf
16 printf("Work done on the fluid per pound of fluid is
    %f Btu/lbm",w/778);

```

Scilab code Exa 2.15 Work done

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 2.15\n\n\n");
4 // Chapter 2: Work, Energy, and Heat
5 // Problem 2.15 (page no. 79)
6 // Solution
7
8 //p1*v1=p2*v2
9 p1=200*1000; //p1=Initial Pressure //Unit:Pa
10 p2=800*1000; //p2=Final Pressure //Unit:Pa
11 v1=0.1; //v1=Initial Special Volume //Unit:m^3/kg
12 v2=(p1/p2)*v1; //v1=final Special Volume //Unit:m^3/
    kg
13 w=p1*v1*log(v2/v1); //workdone //Unit:kJ/kg
14 printf("Work done per kilogram of gas is %f kJ/kg (
    into the system)",w/1000);

```

Chapter 3

The First Law Of Thermodynamics

Scilab code Exa 3.1 Change in internal energy

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.1\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.1 (page no. 91)
6 // Solution
7
8 //For a constant volume process , 10 Btu/lbm heat is
   added to the system
9 //We can consider that a tank having a fixed volume
   has heat added to it
10 //Under these conditions ,the mechanical work done on
   or by the system must be 0
11 //u2-u1=q
12 printf("Heat has been converted to internal energy
   of the working fluid\n");
13 //So,
14 printf(" So,Change in internal energy u2-u1=10 Btu/
   Lbm");
```

Scilab code Exa 3.4 Change in internal energy

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.1\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.1 (page no. 91)
6 // Solution
7
8 printf("Solution For (a)\n");
9 m=10; //Unit:lbm //mass of water
10 //delataU=U2-U1
11 Heat=100; //Unit:Btu //heat added
12 deltaU=Heat/m; //Change in internal energy //unit:
    Btu/lbm
13 printf("Change in internal energy per pound of water
    is %f Btu/lbm\n",deltaU);
14
15 printf("Solution For (b)\n");
16 printf("In this process ,energy crosses the boundary
    of the system by means of fractional work\n");
17 printf("The contents of the tank will not
    distinguish between the energy if it is added as
    heat or the energy added as fraction work\n");
```

Scilab code Exa 3.5 The mass flow rate and exit velocity

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.5\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
```

```

5 // Problem 3.5 (page no. 96)
6 // Solution
7
8 P1=100 //Unit:psia //Pressure at the entrance to a
    steady-flow device
9 Rho1=62.4 //Unit:lbm/ft^3 //the density of the fluid
10 A1V1=10000 //Unit:ft^3/min //Entering fluid
11 A2=2 //Unit:ft^2 //Exit area
12 m=Rho1*A1V1; //Unit:lbm/min //mass rate of flow per
    unit time
13 printf("Mass flow rate is %f LBm/min\n",m);
14
15 Rho2=Rho1; //Unit:lbm/ft^3 //the density of the
    fluid
16 //m=Rho2*A2*V2
17 //So,
18 V2=m/(Rho2*A2); //velocity at exit //Unit:ft/min
19 printf("The exit velocity is %f ft/min",V2);

```

Scilab code Exa 3.6 The mass flow rate and the exit velocity

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.6\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.6 (page no. 97)
6 // Solution
7
8 Rho1=1000 //Unit:kg/m^3 //the density of the fluid
    at entrance
9 A1V1=2000 //Unit:m^3/min //Entering fluid
10 A2=0.5 //Unit:ft^2 //Exit area
11 m=Rho1*A1V1; //Unit:kg/min //mass rate of flow per
    unit time
12 printf("Mass flow rate is %f kg/min\n",m);

```



```

13
14 Rho2=Rho1; //Unit:kg/m^3 //the density of the fluid
    at exit
15 //m=Rho2*A2*V2
16 //So,
17 V2=m/(Rho2*A2); //The exit velocity //Unit:m/min
18 printf("The exit velocity is %f m/min",V2);

```

Scilab code Exa 3.7 The mass flow rate

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.7\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.7 (page no. 97)
6 // Solution
7
8 Rho=62.4 //Unit:lbm/ft^3 //the density of the fluid
9 V=100 //Unit:ft/s //Velocity of fluid
10 d=1 //Unit:in //Diameter
11 //1 ft^2=144 in^2 //A=(%pi/4)*d^2
12 A=(%pi*d^2)/(4*144) //Unit:ft^2 //area
13 m=Rho*A*V; //Unit:lbm/s //mass rate of flow per unit
    time
14 printf("Mass flow rate is %f lbm/s\n",m);

```

Scilab code Exa 3.8 Velocity at inlet and outlet

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.8\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.8 (page no. 98)

```

```

6 // Solution
7
8 m1=50000; //Unit:LBm/hr //An inlet steam flow
9 v1=0.831 //Unit:ft^3/LBm //Specific volume of inlet
    steam
10 d1=6 //Unit:in //Inlet diameter
11 A1=(%pi*d1^2)/(4*144) //1 ft^2=144 in^2 //Entering
    area
12 V1=(m1*v1)/(A1*60*60) //(60 min/hr * 60 s/min) //To
    convert hours into seconds //velocity at inlet
13 printf("The velocity at inlet is %f ft/s\n",V1);
14
15
16 m2=m1; //Unit:LBm/hr //m2=An outlet steam flow
17 v2=1.825 //Unit:ft^3/LBm //Specific volume of outlet
    steam
18 d2=8 //Unit:in //Outlet diameter
19 A2=(%pi*d2^2)/(4*144) //1 ft^2=144 in^2 //Exit area
20 V2=(m1*v2)/(A2*60*60) //(60 min/hr * 60 s/min) //To
    convert hours into seconds //velocity at outlet
21 printf("The velocity at outlet is %f ft/s",V2);

```

Scilab code Exa 3.9 Inlet and outlet velocities

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.9\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.9 (page no. 99)
6 // Solution
7
8 m1=10000; //Unit:kg/hr //An inlet steam flow
9 v1=0.05 //Unit:m^3/kg //Specific volume of inlet
    steam
10 d1=0.1 //Unit:m //Inlet diameter //100 mm =0.1 m

```

```

11 A1=(%pi/4)*d1^2 //Unit:m^2 //Entering area
12 V1=(m1*v1)/(A1*60*60) //(60 min/hr * 60 s/min) //To
    convert hours into seconds //velocity at inlet //
    Unit:m/s
13 printf("The velocity at inlet is %f m/s\n",V1);
14
15
16 m2=m1; //Unit:kg/hr //m2=An outlet steam flow
17 v2=0.10 //Unit:m^3/kg //Specific volume of outlet
    steam
18 d2=0.2 //Unit:m //Outlet diameter //200 mm = 0.2 m
19 A2=(%pi/4)*(d2^2) //Unit:m^2 //Exit area
20 V2=(m1*v2)/(A2*60*60) //(60 min/hr * 60 s/min) //To
    convert hours into seconds //velocity at outlet
    //Unit:m/s
21 printf("The velocity at outlet is %f m/s",V2);

```

Scilab code Exa 3.10 Workdone

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.10\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.10 (page no. 105)
6 // Solution
7
8 Cp=0.22; //Unit:Btu/(LBm*R) //Specific heat for
    constant pressure process
9 Cv=0.17; //Unit:Btu/(LBm*R) //Specific heat for
    constant volume process
10 q=800/10; //data given:800 Btu as heat is added to
    10 LBm //Unit:Btu/LBm
11 T1=100; //Unit:Fahrenheit //Initial temperature //T2
    =Final temperature
12 //For a non-flow ,constant pressure process

```

```

13 //q=deltah=h2-h1=Cp(T2-T1) //deltah=change in
    enthalpy
14 //deltaT=T2-T1;
15 deltaT=q/Cp; //Fahrenheit //change in temperature
16 T2=deltaT+T1; //Fahrenheit //final temperature
17 //For a constant volume pressure
18 //u2-u1=Change in internal energy //w=workdone
19 //q-w=u2-u1
20 //-w=(u2-u1)-q = Cv*(T2-T1)-q
21 w=- (Cv*(T2-T1)-q); //Unit: Btu/lbm //workdone
22 printf("%f Btu/lbm work is taken out of the system
    due to workdone by gas\n",w);
23 printf("As there is 10 lbm in the system\n")
24 printf("%f Btu work is taken out of the system due
    to workdone by gas\n",w*10);

```

Scilab code Exa 3.11 Determine the Power Produced

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.11\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.11 (page no. 111)
6 // Solution
7
8 //Given data
9 //
10 //Pressure (psia)      Inlet      Outlet
11 //Temperature (F)     1000      101.74
12 //Velocity (ft/s)     125       430
13 //Inlet position (ft) +10       0
14 //Enthalpy (Btu/LBm)  1505.4    940.0
15 //Steam flow rate of 150000 LBm/hr
16
17 //From the table ,

```

```

18 Z1=10; V1=125; h1=1505.4; Z2=0; V2=430; h2=940.0;
19
20 //Energy equation is given by
21 //((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + h1 + q = ((Z2/
    J)*(g/gc)) + (V2^2/(2*gc*J)) + h2 + w/J
22 printf("Solution for (a) \n");
23 q=0; //net heat
24 J=778; //Conversion factor
25 gc=32.174; //Unit: (LBm*ft)/(LBf*s^2) //gc is
    constant of proportionality
26 g=gc; //Unit:ft/s^2 //g=The local gravity
27 //W1=w/J;
28 //Energy equation is given by
29 W1=((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + h1 + q - ((Z2
    /J)*(g/gc)) - (V2^2/(2*gc*J)) - h2; //Unit:Btu/
    LBm
30 printf("If heat losses are negligible,\n");
31 printf("Total work of the turbine is %f Btu/LBm\n",
    W1);
32 printf("Total work of the turbine is %f Btu/hr\n",W1
    *150000);
33 //(W*150000*778)/(60*33000) //in terms of horsepower
    //1 hr=60 min //1 hp=33000 (ft*LBf)
34 printf("Total work of the turbine is %f hp \n", (W1
    *150000*778)/(60*33000));
35 //1 hp =0.746 kW
36 printf("Total work of the turbine is %f kW \n\n",((
    W1*150000*778)/(60*33000))*0.746);
37
38
39 printf("\nSolution for (b) \n");
40 //Heat losses equal 50,000 Btu/hr
41 q=50000/150000; //Unit:Btu/LBm //Heat loss
42 W2=((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + h1 - q - ((Z2
    /J)*(g/gc)) - (V2^2/(2*gc*J)) - h2; //Unit:Btu/
    LBm
43 printf("If heat losses equal 50,000 Btu/hr , Total
    work of the turbine is %f Btu/LBm\n",W2);

```

Scilab code Exa 3.12 Work output per kg

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.12\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.12 (page no. 112)
6 // Solution
7
8 Z1=2; //Unit:m //Inlet position
9 g=9.81 //Unit:m/s^2 //g=The local gravity
10 V1=40; //Unit:m/s //Inlet velocity
11 h1=3433.8; //Unit:kJ/kg //Inlet enthalpy
12 q=1 //Unit:kJ/kg //Heat losses
13 Z2=0; //Outlet position //unit:m
14 V2=162; //Unit:m/s //Outlet velocity
15 h2=2675.5; //Unit:kJ/kg //Outlet enthalpy
16
17 //Energy equation is given by
18 //((Z1*g)) + (V1^2/2) + h1 + q = ((Z2*g) + (V2^2/2)
    + h2 + w
19
20 w= ((Z1*g)/1000) + ((V1^2/2)/1000) + h1 - q - ((Z2*g
    )/1000) - ((V2^2/2)/1000) - h2 ; //Unit:kJ/kg //
    Conersation: 1 kJ=1000 J
21 printf("The work output per kilogram is %f kJ/kg\n",
    w);
```

Scilab code Exa 3.13 The work output per pound

```
1 clear;
```

```

2  clc;
3  printf("\\t\\t\\tProblem Number 3.13\\n\\n\\n");
4  // Chapter 3 : The First Law Of Thermodynamics
5  // Problem 3.13 (page no. 113)
6  // Solution
7
8  p1=150; //Unit:psia //Initial pressure
9  T1=1000; //Unit:R //Temperature at pressure p1
10 p2=15; //Unit:psia //Final pressure
11 T2=600; //Unit:R //Temperature at pressure p2
12 Cp=0.24; //Unit:Btu/(LBm*R) //Specific heat for
    constant pressure process
13 v1=2.47; //Unit:ft^3/LBm //Specific volume at inlet
    conditions
14 v2=14.8; //Unit:ft^3/LBm //Specific volume at outlet
    conditions
15
16 //For a non-flow ,constant pressure process
17 //w/J=deltah=h2-h1=Cp(T2-T1) //deltah=change in
    enthalpy
18 //W=w/J
19 W=Cp*(T1-T2); //W=Work output //Unit:Btu/LBm
20 printf("The work output of the turbine per pound of
    working fluid is %f Btu/LBm",W);

```

Scilab code Exa 3.14 The work output per pound

```

1  clear;
2  clc;
3  printf("\\t\\t\\tProblem Number 3.14\\n\\n\\n");
4  // Chapter 3 : The First Law Of Thermodynamics
5  // Problem 3.14 (page no. 114)
6  // Solution
7
8  //In problem 3.13 ,

```

```

 9 p1=150; //Unit:psia //Initial pressure
10 T1=1000; //Unit:R //Temperature at pressure p1
11 p2=15; //Unit:psia //Final pressure
12 T2=600; //Unit:R //Temperature at pressure p2
13 Cp=0.24; //Unit:Btu/(LBm*R) //Specific heat for
    constant pressure process
14 v1=2.47; //Unit:ft^3/LBm //Specific volume at inlet
    conditions
15 v2=14.8; //Unit:ft^3/LBm //Specific volume at outlet
    conditions
16
17 //For a non-flow ,constant pressure process
18 //w/J=deltah=h2-h1=Cp(T2-T1) //deltah=change in
    enthalpy
19 //W=w/J
20 W=Cp*(T1-T2); //W=Work output //Unit:Btu/LBm //h2-h1
21 printf("In problem 3.13 ,The work output of the
    turbine per pound of working fluid is %f Btu/LBm
    \n \n",W);
22
23 //Now,In problem 3.14 ,
24 q=1.1; //Unit:Btu/LBm //Heat losses
25 //For a non-flow ,constant pressure process
26 //q-w/J=deltah=h2-h1=Cp(T2-T1) //deltah=change in
    enthalpy
27 //W1=w/J
28 W1=-q+W; //W=Work output //Unit:Btu/LBm //W=h2-h1 //
    Because q is out of the system ,it is a negative
    quantity
29 printf("In problem 3.14 ,heat loss equal to 1.1 Btu/
    LBm,\n");
30 printf("The work output of the turbine per pound of
    working fluid is %f Btu/LBm \n",W1);

```

Scilab code Exa 3.15 Determine the heat transfer


```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.15\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.15 (page no. 115)
6 // Solution
7
8 p1=100; //Unit:psia //Initial pressure
9 t1=950; //Unit:Fahrenheit //Temperature at pressure
    p1
10 p2=76; //Unit:psia //Final pressure
11 t2=580; //Unit:Fahrenheit //Temperature at pressure
    p2
12 v1=4; //Unit:ft^3/LBm //Specific volume at inlet
    conditions
13 v2=3.86; //Unit:ft^3/LBm //Specific volume at outlet
    conditions
14 Cv=0.32; //Unit:Btu/(LBm*R) //Specific heat for
    constant volume process
15
16 T1=t1+460; //Unit:R //Temperature at pressure p1
17 T2=t2+460; //Unit:R //Temperature at pressure p2
18 J=778; //J=Conversion factor
19
20 //Z1=Inlet position //Unit:m
21 //V1=Inlet velocity //Unit:m/s
22 //Z2=Outlet position //Unit:m
23 //V2=Outlet velocity Unit:m/s
24 //u1=internal energy //energy in
25 //u2=internal energy //energy out
26
27 //Energy equation is given by
28 //(((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + u1 + ((p1*v1)/
    J) + q = ((Z2/J)*(g/gc)) + (V2^2/(2*gc*J)) + u2 +
    ((p2*v2)/J) + w/J; //Unit:Btu/LBm
29 //Because pipe is horizontal and velocity terms are
    to be neglected ,
30 // Also no work crosses the boundaries of the system

```

```

    , the energy equation is reduced to
31 //u1 + ((p1*v1)/J) + q = u2 + ((p2*v2)/J)
32 //u2-u1=Cv*(T2-T1) //For a constant volume process
    //u2-u1=Chnage in internal energy
33 //So,
34 q=Cv*(T2-T1) + (p2*v2*144)/J - (p1*v1*144)/J; //q=
    heat transfer //1 ft^2=144 in^2 //Unit:Btu/LBm
35 printf("%f Btu/LBm heat is transferred from the gas
    \n",q);

```

Scilab code Exa 3.16 Determine the heat transfer

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.16\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.16 (page no. 116)
6 // Solution
7
8 //In problem 3.15,
9 p1=100; //Unit:psia //Initial pressure
10 t1=950; //Unit:Fahrenheit //Temperature at pressure
    p1
11 p2=76; //Unit:psia //Final pressure
12 t2=580; //Unit:Fahrenheit //Temperature at pressure
    p2
13 v1=4; //Unit:ft^3/LBm //Specific volume at inlet
    conditions
14 v2=3.86; //Unit:ft^3/LBm //Specific volume at outlet
    conditions
15 Cv=0.32; //Unit:Btu/(LBm*R) //Specific heat for
    constant volume process
16
17 T1=t1+460; //Unit:R //Temperature at pressure p1
18 T2=t2+460; //Unit:R //Temperature at pressure p2

```

```

19 J=778; //J=Conversion factor
20 gc=32.174; //Unit: (LBm*ft)/(LBf*s^2) //gc is
    constant of proportionality
21 g=gc; //Unit:ft/s^2 //g=The local gravity
22
23 //Z1=Inlet position //Unit:m
24 //V1=Inlet velocity //Unit:m/s
25 //Z2=Outlet position //Unit:m
26 //V2=Outlet velocity Unit:m/s
27 //u1=internal energy //energy in
28 //u2=internal energy //energy out
29
30 //Energy equation is given by
31 //((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + u1 + ((p1*v1)/
    J) + q = ((Z2/J)*(g/gc)) + (V2^2/(2*gc*J)) + u2 +
    ((p2*v2)/J) + w/J; //Unit:Btu/LBm
32 //In 3.15, the elevation of the pipe at section 1
    makes Z1 = 0
33 // Also no work crosses the boundaries of the system
    , the energy equation is reduced to
34 //u1 + ((p1*v1)/J) + q = u2 + ((p2*v2)/J) + ((Z2/J)
    *(g/gc))
35 //In problrm 3.16,
36 Z2=100; //Given //Unit:ft //Outlet position
37 //u2-u1=Cv*(T2-T1) //For a constant volume process
    //u2-u1=Chnage in internal energy
38 //So,
39 q=Cv*(T2-T1) + (p2*v2*144)/J - (p1*v1*144)/J + ((Z2/
    J)*(g/gc)) ; //q=heat transfer //1 ft^2=144 in^2
    //Unit:Btu/LBm
40 printf("%f Btu/LBm heat is transferred from the gas
    \n",q);
41 //For this problem , neglecting the elevation term
    leads to an insignificant error

```

Scilab code Exa 3.17 The boiler example

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.17\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.17 (page no. 117)
6 // Solution
7
8 p1=1000; //Unit:psia //Initial pressure
9 t1=100; //Unit:Fahrenheit //Temperature at pressure
   p1
10 p2=1000; //Unit:psia //Final pressure
11 t2=1000; //Unit:Fahrenheit //Temperature at pressure
   p2
12 // feed in 10,000 LBm/hr
13 h1=70.68 //Unit:Btu/LBm //Inlet enthalpy
14 h2=1505.9 //Unit:Btu/LBm //Outlet enthalpy
15
16 T1=t1+460; //Unit:R //Temperature at pressure p1
17 T2=t2+460; //Unit:R //Temperature at pressure p2
18 //Energy equation is given by
19 J=778; //J=Conversion factor
20
21 //Z1=Inlet position //Unit:m
22 //V1=Inlet velocity //Unit:m/s
23 //Z2=Outlet position //Unit:m
24 //V2=Outlet velocity Unit:m/s
25 //u1=internal energy //energy in
26 //u2=internal energy //energy out
27 //h=enthalpy
28
29 //Energy equation is given by
30 //((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + u1 + ((p1*v1)/
   J) + q = ((Z2/J)*(g/gc)) + (V2^2/(2*gc*J)) + u2 +
   ((p2*v2)/J) + w/J; //Unit:Btu/LBm
31
32 //we can consider this system as a single unit with
```

```

    feed water entering and steam leaving.
33 //It well designed, this unit will be thoroughly
    insulated, and heat losses will be reduced to a
    negligible amount
34 //Also, no work will be added to the fluid during the
    time it is passing through the unit, and kinetic
    energy differences will be assumed to be
    negligibly small
35 //Differences in elevation also be considered
    negligible
36 //So, the energy equation is reduced to
37 //u1 + ((p1*v1)/J) + q = u2 + ((p2*v2)/J)
38 //Because h=u+(p*v/J)
39 q=h2-h1; //q=net heat losses //Unit: Btu/LBm
40 printf("Net heat losses is %f Btu/LBm \n", q);
41 printf("For 10000 LBm/hr, \n");
42 printf("%f Btu/hr energy has been added to the water
    to convert it to steam", q*10000)

```

Scilab code Exa 3.18 The final velocity of the nozzle

```

1 clear;
2 clc;
3 printf("\t\t\t\t\tProblem Number 3.18\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.18 (page no. 119)
6 // Solution
7
8 h1=1220 //Unit: Btu/LBm //Inlet enthalpy
9 h2=1100 //Unit: Btu/LBm //Outlet enthalpy
10
11 //Z1=Inlet position //Unit: m
12 //V1=Inlet velocity //Unit: m/s
13 //Z2=Outlet position //Unit: m
14 //V2=Outlet velocity Unit: m/s

```

```

15 //u1=internal energy //energy in
16 //u2=internal energy //energy out
17 J=778; //J=Conversion factor
18 gc=32.174; //Unit: (LBm*ft)/(LBf*s^2) //gc is
    constant of proportionality
19
20 //Energy equation is given by
21 //((Z1/J)*(g/gc)) + (V1^2/(2*gc*J)) + u1 + ((p1*v1)/
    J) + q = ((Z2/J)*(g/gc)) + (V2^2/(2*gc*J)) + u2 +
    ((p2*v2)/J) + w/J; //Unit:Btu/LBm
22
23 //For this device ,differences in elevation are
    negligible.No work is done on or by the fluid ,
    friction is negligible
24 //And due to the speed of the fluid flowing and the
    short length of the nozzle ,heat transfer to or
    from the surroundings is also negligible.
25 //So ,the energy equation is reduced to
26 //u1 + ((p1*v1)/J) +(V1^2/(2*gc*J) = u2 + ((p2*v2)/
    J) + (V2^2/(2*gc*J)
27 // h1-h2 = ((V2^2-V1^2)/(2*gc*J))
28
29 printf(" Solution for (a)\n");
30 //For negligible entering velocity , V1=0
31 //So,
32 V2=sqrt((2*gc*J)*(h1-h2)); //the final velocity //
    ft/s
33 printf("It the initial velocity of the system is
    negligible ,the final velocity is %f ft/s \n \n",
    V2);
34
35 printf(" Solution for (b)\n");
36 //If the initial velocity is appreciable ,
37 V1=1000; //Unit:ft/s //the initial velocity
38 V2=sqrt(((h1-h2)*(2*gc*J)) + V1^2 ) ;
39 printf("It the initial velocity of the system is
    appreciable ,the final velocity is %f ft/s \n \n",
    V2);

```

Scilab code Exa 3.19 Nozzle

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.19\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.19 (page no. 120)
6 // Solution
7
8 h1=3450*1000 //Unit:J/kg //Enthalpy of steam when it
   enters a nozzle
9 h2=2800*1000 //Unit:J/kg //Enthalpy of steam when it
   leaves a nozzle
10
11 //V2^2/2=h1-h2;
12 V2=sqrt(2*(h1-h2)); //V2=Final velocity //Unit:m/s
13 printf("Final velocity = %f m/s\n",V2);
```

Scilab code Exa 3.21 The heat exchanger

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 3.21\n\n\n");
4 // Chapter 3 : The First Law Of Thermodynamics
5 // Problem 3.21 (page no. 125)
6 // Solution
7
8 m=400; //Unit:LBm/min //mass of lubricating oil
9 Cp=0.85; //Unit:Btu/LBm*R //Specific heat of the oil
10 T1=215; //Temperature when hot oil is entering //
   Unit:Fahrenheit
```

```

11 T2=125; //Temperature when hot oil is leaving //Unit
    :Fahrenheit
12 DeltaT=T2-T1; //Unit:Fahrenheit //change in
    temperature
13 Qoil=m*Cp*DeltaT; //Heat out of oil //Btu/min
14 printf("Heat out of oil is %f Btu/min (Out of oil)\n
    ",Qoil);
15 //Heat out of oil is the heat into the water
16 //Mw=Water flow rate
17 //M*Cpw*DeltaTw=Qoil
18 Cpw=1.0; //Unit:Btu/LBm*R //Specific heat of the
    water
19 T3=60; //Temperature when water is entering //Unit:
    Fahrenheit
20 T4=90; //Temperature when water is leaving //Unit:
    Fahrenheit
21 DeltaTw=T4-T3; //Unit:Fahrenheit //change in
    temperature
22 Mw=Qoil/(Cpw*DeltaTw); //The Required water flow
    rate //Unit;lbm/Min
23 printf("The Required water flow rate is %f lbm/Min\n
    ",abs(Mw));

```

Chapter 4

The Second Law Of Thermodynamics

Scilab code Exa 4.1 Efficiency

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.1\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.1 (page no. 148)
7 // Solution
8
9 //given data
10 t1=1000; //(unit:fahrenheit) //Source temperature
11 t2=80; //(unit:fahrenheit) //Sink temperature
12 //solution
13 //converting temperatures to absolute temperatures;
14 T1=t1+460; //Source temperature //Unit:R
15 T2=t2+460; //Sink temperature //Unit:R
16
17 printf("Solution for (a)\n");
18 ans=((T1-T2)/T1)*100; //(ans in %) //Efficiency of
    the engine
```

```

19 printf("Efficiency of the engine is %f percentage\n\n",ans);
20
21 printf("Solution for (b)\n");
22 T1=2000+460; //Source temperature //Unit:R
23 T2=t2+460; //Sink temperature //Unit:R
24 ans=((T1-T2)/T1)*100; //(ans in %) //Efficiency of
    the engine
25 printf("When the upper tempretrature is increased
    upto certain ,Efficiency of the engine is %f
    percentage \n\n",ans);
26
27 printf("Solution for (c)\n");
28 T1=t1+460; //Source temperature //Unit:R
29 T2=160+460; //Sink temperature //Unit:R
30 ans=((T1-T2)/T1)*100; //(ans in %) //Efficiency of
    the engine
31 printf("When the lower tempretrature is increased
    upto certain ,Efficiency of the engine is %f
    percentage \n\n",ans);

```

Scilab code Exa 4.2 Work and the heat removed from reservoir

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.2\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.2 (page no. 149)
7 // Solution
8
9 //given data
10 Qin=100; //heat added to the cycle
11
12 printf("In problem 4.1,\n")

```

```

13 //given data
14 t1=1000; //(unit:fahrenheit) //Source temperature
15 t2=80; //(unit:fahrenheit) //Sink temperature
16 //solution
17 //converting temperatures to absolute temperatures;
18 T1=t1+460; //Source temperature //Unit:R
19 T2=t2+460; //Sink temperature //Unit:R
20 printf("Solution for (a)\n");
21 printf("Efficiency of the engine is %f percentage\n\n",((T1-T2)/T1)*100);
22
23 printf("Now in problem 4.2,\n")
24 W=0.63*Qin; //W=W/J; //Efficiency in problem 4.1
25 W=Qin*(W/Qin); //amount of work
26 Qr=Qin-W; //Qin-Qr=W/J //Qr=heat rejected by the
    cycle
27 printf("The heat removed from the reservoir %f units
    ",Qr);

```

Scilab code Exa 4.3 Minimum input required

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.3\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.3 (page no. 149)
7 // Solution
8
9 //given data
10 t1=70; //(unit:fahrenheit) //Source temperature
11 t2=15; //(unit:fahrenheit) //Sink temperature
12 Qin=125000; //(unit=Btu/hr) //Qin=heat added to the
    cycle
13 //converting temperatures to absolute temperatures;

```

```

14 T1=t1+460; //Source temperature //Unit:R
15 T2=t2+460; //Sink temperature //Unit:R
16 Qr=Qin*(T2/T1); //Qr=heat rejected by the cycle
17 printf("Qr is %f in Btu/hr\n",Qr);
18 work=Qin-Qr; //reversed cycle requires atleast input
    //work //btu/hr
19 printf("Work is %f in Btu/hr\n",work);
20 // 1 hp = 33000 ft*LBf/min
21 // 1 Btu = 778 ft*LBf //1 hr = 60 min
22 printf("Minimum horsepower input required is %f hp",
    work*778/(60*33000));

```

Scilab code Exa 4.4 A Carnot engine

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.4\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.4 (page no. 150)
7 // Solution
8
9 W=(50*33000)/778; //output //W=W/J
10 // 1 hp = 33000 ft*LBf/min
11 // 1 Btu = 778 ft*LBf
12 printf("Output is %f in Btu/min\n",W);
13 t1=1000; //Source temperature //(unit:fahrenheit)
14 t2=100; //Sink temperature //(unit:fahrenheit)
15 //converting temperatures to absolute temperatures;
16 T1=t1+460; //Source temperature //Unit:R
17 T2=t2+460; //Sink temperature //Unit:R
18 n=(1-(T2/T1))*100; //efficiency
19 printf("Efficiency is %f percentage\n",n); //(in %)
20 //n=(W/J)/Qin
21 Qin=W/(n/100); //(unit Btu/hr) //Qin=heat added to

```

```

    the cycle
22 printf("Heat added to the cycle is %f in Btu/min\n"
    ,Qin);
23 Qr=Qin*(1-(n/100));//(unit Btu/hr) //Qr=heat
    rejected by the cycle
24 printf("Heat rejected by the cycle is %f in Btu/min
    \n",Qr);

```

Scilab code Exa 4.5 The Carnot engine

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.5\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.5 (page no. 151)
7 // Solution
8
9 t1=700; //Source temperature //Unit: Celcius
10 t2=20; //Sink temperature //Unit: Celcius
11 //converting in F
12 T1=t1+273; //Source temperature //Unit:R
13 T2=t2+273; //Sink temperature //Unit:R
14 n=(T1-T2)/T1*100; //Efficiency
15 printf("Efficiency is %f percentage\n",n);//(in %)
16 output=65;//in hp //Given
17 work=output*0.746;//(unit kJ/s) // 1 hp = 746 W
18 printf("Work is %f kJ/s\n",work);
19 Qin=work/(n/100);//(unit kJ/s) //Qin=heat added to
    the cycle
20 printf("Heat added to the cycle is %f kJ/s \n",Qin);
21 Qr=Qin*(1-(n/100));//(unit kJ/s) //Qr=heat rejected
    by the cycle
22 printf("Heat rejected by the cycle is %f kJ/s \n",
    Qr);

```

Scilab code Exa 4.7 Two Carnot engines

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.7\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.7 (page no. 152)
7 // Solution
8
9 t1=700; //(unit:fahrenheit) //Source temperature
10 t2=200; //(unit:fahrenheit) //Sink temperature
11 //converting temperatures to absolute temperatures;
12 T1=t1+460; //Source temperature //Unit:R
13 T2=t2+460; //Sink temperature //Unit:R
14 //n1=(T1-Ti)/T1 and n2=(Ti-T2)/Ti //n1 & n2 are
    efficiency
15 //(T1-Ti)/T1=(Ti-T2)/Ti;
16 Ti=sqrt(T1*T2); //Exhaust temperature //Unit:R
17 printf("Exhaust temperature of first engine is %f in
    R\n",Ti);
18 //converting absolute temperature to normal F
    temperature
19 //Ti(fahrenheit)=Ti(R)-460;
20 printf("Exhaust temperature of first engine is %f
    fahrenheit\n",Ti-460);
```

Scilab code Exa 4.8 Change in entropy

```
1 //scilab 5.4.1
2 clear;
```

```

3  clc;
4  printf("\t\t\tProblem Number 4.8\n\n\n");
5  // Chapter 4 : The Second Law Of Thermodynamics
6  // Problem 4.8 (page no. 157)
7  // Solution
8
9  //For reversible isothermal process ,
10 q=843.7; //Heat //Unit:Btu //at 200 psia
11 t=381.86; //(unit:fahrenheit) //temperature
12 ////converting temperatures to absolute temperatures
    ;
13 T=t+460; //temperature //unit:R
14 deltaS=(q/T); //Change in entropy //Unit:Btu/lbm*R
15 printf("Change in entropy is %f Btu/lbm*R\n",deltaS
    ); //1 LBm of saturated water

```

Scilab code Exa 4.9 work done per pound and energy rejected

```

1  //scilab 5.4.1
2  clear;
3  clc;
4  printf("\t\t\tProblem Number 4.9\n\n\n");
5  // Chapter 4 : The Second Law Of Thermodynamics
6  // Problem 4.9 (page no. 158)
7  // Solution
8
9  //For reversible isothermal process ,
10 //In problem 4.8,
11 q=843.7; //Heat //Unit:Btu //at 200 psia
12 t=381.86; //(unit:fahrenheit)
13 //converting temperatures to absolute temperatures;
14 T=t+460; //Unit:R"
15 deltaS=(q/T); //Change in entropy //Btu/lbm
16 printf("Change in entropy is %f Btu/lbm*R\n",deltaS
    ); //1 LBm of saturated water

```

```

17
18 //In problem 4.9
19 t1=381.86; //(unit:fahrenheit) //Source temperature
20 t2=50; //(unit:fahrenheit) //Sink temperature
21 //converting temperatures to absolute temperatures;
22 T1=t1+460; //Source temperature //Unit:R
23 T2=t2+460; //Sink temperature //Unit:R
24 qin=q; //heat added to the cycle
25 n=(1-(T2/T1))*100; //Efficiency
26 printf("Efficiency is %f percentage\n",n);
27 wbyJ=qin*n*0.01; //work output
28 printf("Work output is %f Btu/lbm\n",wbyJ);
29 Qr=qin-wbyJ; //heat rejected
30 printf("Heat rejected is %f Btu/lbm\n\n",Qr);
31 printf("As an alternative solution and referring to
    figure 4.12,\n")
32 qin=T1*deltaS; //heat added //btu/lbm
33 Qr=T2*deltaS; //Heat rejected //btu/lbm
34 printf("Heat rejected is %f Btu/lbm\n",Qr);
35 wbyJ=qin-Qr; //Work output //Btu/lbm
36 printf("Work output is %f Btu/lbm\n",wbyJ);
37 n=(wbyJ/qin)*100; //Efficiency
38 printf("Efficiency is %f percentage\n",n);

```

Scilab code Exa 4.10 Determine the change in entropy

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.10\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.10 (page no. 159)
7 // Solution
8
9 hfg=1959.7; //Unit:kJ/kg //Evaporative enthalpy

```



```

10 T=195.07+273; //Converted into Kelvin //Temperature
11 deltaS=hfg/T; //Change in entropy //kJ/kg*K
12 printf("Change in entropy at 1.4MPa for the
    vaporization of 1 kg is %f kJ/kg*K",deltaS); //
    Values compares very closely to the Steam Tables
    value

```

Scilab code Exa 4.11 Heat rejected

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.11\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.11 (page no. 159)
7 // Solution
8
9 //Let is assume that a Carnot engine cycle operates
    between two temperatures in each case.
10 t=1000; //(unit:fahrenheit)
11 //converting temperatures to absolute temperatures;
12 T1=t+460;
13 //T1*deltaS=Qin;
14 Qin=100; //Unit:Btu //heat added to the cycle
15 deltaS=Qin/T1; //Change in entropy //Btu/R
16 T2=50+460; //converting 50 F temperature to absolute
    temperature;
17 Qr=T2*deltaS; //Heat rejected //Unit:Btu
18 printf("%f Btu energy is unavailable with respect to
    a receiver at 50 fahrenheit \n",Qr);
19 T2=0+460; //converting 0 F temperature to absolute
    temperature;
20 Qr=T2*deltaS; //Heat rejected //unit:Btu
21 printf("%f Btu energy is unavailable with respect to
    a receiver at 0 fahrenheit \n",Qr);

```

Scilab code Exa 4.12 energy unavailable at receiver

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.12\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.12 (page no. 160)
7 // Solution
8
9 Qin=1000; //Unit:Joule //heat entered to the system
10 t=500; //(unit: Celcius) //temperature
11 //converting temperature
12 T1=t+273; //Unit:Kelvin
13 deltaS=Qin/T1; //Change in entropy //Unit:J/K
14 printf("Solution for (a),\n");
15 T2=20+273; //converted 20 Celcius temperature to
    Kelvin;
16 Qr=T2*deltaS; //Heat rejected at 20 celcius //Joule
17 printf("%f Joule energy is unavailable with respect
    to a receiver at 20 Celcius\n\n",Qr);
18
19 printf("Solution for (b),\n")
20 T2=0+273; //converted 0 Celcius temperature to
    Kelvin
21 Qr=T2*deltaS; //heat rejected at 0 celcius //Joule
22 printf("%f Joule energy is unavailable with respect
    to a receiver at 0 Celcius\n",Qr);
```

Scilab code Exa 4.13 The final temperature

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.13\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.13 (page no. 161)
7 // Solution
8
9 //deltas=Cp*ln(T2/T1)
10 //Multiplying both the sides of equation by the mass
    m,
11 //DeltaS=m*Cp*ln(T2/T1)
12 m=6; //mass //Unit:lbm
13 Cp=0.361; //Btu/lbm*R //Specific heat constant
14 DeltaS=-0.7062; //Unit:Btu/R //change in entropy
15 t=1440; //(unit:fahrenheit)
16 //converting temperatures to absolute temperatures;
17 T1=t+460; //Unit:R
18 //Rearranging the equation,
19 T2=T1*exp(DeltaS/(m*Cp)); //final temperature //Unit
    :R
20 printf("Final temperature is %f R",T2);
21 printf("or %f fahrenheit",T2-460);

```

Scilab code Exa 4.14 Net Change in entropy

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.14\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.14 (page no. 162)
7 // Solution
8
9 //1 lbm of water at 500F is mixed with 1 lbm of

```

```

    water at 100F
10 m1=1; //Unit:lbm //mass
11 m2=1; //Unit:lbm //mass
12 c1=1; //Specific heat constant
13 c2=1; //Specific heat constant
14 t1=500; //(unit:fahrenheit)
15 t2=100; //(unit:fahrenheit)
16 cmix=1; //Specific heat constant of mixture
17 //now, m1*c1*t1 +m2*c2*t2 = (m1+m2)*cmix*t
18 //So,
19 t=((m1*c1*t1)+(m2*c2*t2))/((m1+m2)*cmix) //resulting
    temperature of the mixture
20 printf("The resulting temperature of the mixture is
    %f fahrenheit\n",t);
21 //For this problem,the hot steam is cooled
22 deltas=cmix*log((t+460)/(t1+460)); //temperatures
    converted to absolute temperatures; //deltas=
    change in entropy //Unit:Btu/(lbm*R)
23 //The cold steam is heated
24 deltaS=cmix*log((t+460)/(t2+460)); //temperatures
    converted to absolute temperatures; //deltaS=
    change in entropy //Unit:Btu/(lbm*R)
25 printf("The net change in entropy is %f Btu/(lbm*R)\
    n",deltaS+deltas);

```

Scilab code Exa 4.15 Change in entropy

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 4.15\n\n\n");
5 // Chapter 4 : The Second Law Of Thermodynamics
6 // Problem 4.15 (page no. 163)
7 // Solution
8

```

```

9 //In problem 4.15,
10 //1 lbm of water at 500F is mixed with 1 lbm of
    water at 100F
11 m1=1; //Unit:lbm //mass
12 m2=1; //Unit:lbm //mass
13 c1=1; //Specific heat constant
14 c2=1; //Specific heat constant
15 t1=500; //(unit:fahrenheit)
16 t2=100; //(unit:fahrenheit)
17 cmix=1; //Specific heat constant of mixture
18 //now, m1*c1*t1 +m2*c2*t2 = (m1+m2)*cmix*t //So,
19 t=((m1*c1*t1)+(m2*c2*t2))/((m1+m2)*cmix) //resulting
    temperature of the mixture
20 printf("In problem 4.14,The resulting temperature of
    the mixture is %f fahrenheit\n",t);
21
22 //Now,in problem 4.15,taking 0F as a reference
    temperature,
23 //For hot fluid,
24 deltas=cmix*log((t1+460)/(0+460)); //temperatures
    converted to absolute temperatures; //deltas=
    change in entropy //Unit:Btu/(lbm*R)
25 //For cold fluid,
26 s=cmix*log((t2+460)/(0+460)); //temperatures
    converted to absolute temperatures; //s=change in
    entropy //Unit:Btu/(lbm*R)
27 //At final mixture temperature of t F,the entropy of
    each system above 0F is ,for the hot fluid
28 s1=cmix*log((t+460)/(0+460)); //temperatures
    converted to absolute temperatures; //s1=change
    in entropy //Unit:Btu/(lbm*R)
29 //and for the cold fluid,
30 s2=cmix*log((t+460)/(0+460)); //temperatures
    converted to absolute temperatures; //s2=change
    in entropy //Unit:Btu/(lbm*R)
31 printf("The change in the entropy for hot fluid is
    %f Btu/(lbm*R)\n",s1-deltas);
32 printf("The change in the entropy for cold fluid is

```

```
    %f Btu/(lbm*R)\n",s2-s);  
33 printf("The total change in entropy is %f Btu/(lbm*R  
    ",s1-deltas+s2-s);
```

Chapter 5

Properties Of Liquids And Gases

Scilab code Exa 5.1 The enthalpy

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.1\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.1 (page no. 182)
7 // Solution
8
9 p=0.6988; //Unit:psia //absolute pressure
10 vg=467.7; //Unit:ft^3/lbm //Saturated vapour
    specific volume
11 ug=1040.2; //Unit:Btu/lbm //Saturated vapour
    internal energy
12 J=778; //J=Conversion factor
13 // 1 Btu = 778 ft*LBf
14 //h=u+(p*v)/J
15 hg=ug+((p*vg*144)/J); //The enthalpy of saturated
    steam //1 ft^2=144 in^2 //Btu/lbm
16 printf("The enthalpy of saturated steam at 90 F is
```

```
%f Btu/lbm",hg); //The value is matched with the
value in table 1
```

Scilab code Exa 5.2 Determine the enthalpy of saturated steam

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.2\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.2 (page no. 187)
7 // Solution
8
9 p=4.246; //Unit:kPa //absolute pressure
10 vg=32.894; //Unit:m^3/kg //specific volume
11 ug=2416.6; //Unit:kJ/kg //internal energy
12 J=778; //J=Conversion factor
13 // 1 Btu = 778 ft*LBf
14 //h=u+(p*v)
15 hg=ug+(p*vg); //The enthalpy of saturated steam //1
    ft^2=144 in^2 //unit:kJ/kg
16 printf("The enthalpy of saturated steam at 30 C is
    %f kJ/kg",hg); //The value is matched with the
    value in table 1
```

Scilab code Exa 5.3 Determine hg vg sg and ug

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.3\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.3 (page no. 188)
```



```

7 // Solution
8
9 //The necessary interpolations are best done in
  tabular forms as shown:
10 // p    hg
11 // 115  1190.4  table 2
12 // 118  1190.8  (hg)118=1190.8
13 // 120  1191.1
14 hg=1190.4+(3/5)*(1191.1-1190.4); //Btu/lbm //
  enthaply
15 printf("The enthalpy of saturated steam at 118 psia
  is %f Btu/lbm\n",hg);
16
17 // p    vg
18 // 115  3.884  table 2
19 // 118  3.792  (vg)118=3.790
20 // 120  3.730
21 vg=3.884-(3/5)*(3.884-3.730); //ft^3/lbm //specific
  volume
22 printf("The specific volume of saturated steam at
  118 psia is %f ft^3/lbm\n",vg);
23
24 // p    sg
25 // 115  1.5921  table 2
26 // 118  1.5900  (sg)118=1.5900
27 // 120  1.5886
28 sg=1.5921-(3/5)*(1.5921-1.5886); //entropy
29 printf("The entropy of saturated steam at 118 psia
  is %f\n",sg);
30
31 // p    ug
32 // 115  1107.7  table 2
33 // 118  1108.06  (ug)118=1180.1
34 // 120  1108.3
35 ug=1107.7-(3/5)*(1108.3-1107.7); //internal energy
36 printf("The internal energy of saturated steam at
  118 psia is %f\n",ug);
37 //The interpolation process that was done in tabular

```

form for this problem can also be demonstrated by referring to figure 5.8 for the specific volume. It will be

38 //seen that the results of this problem and the tabulated values are essentially in exact agreement and that linear interpolation is satisfactory in these tables.

Scilab code Exa 5.4 hfg for saturated steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.4\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.4 (page no. 189)
7 // Solution
8
9 //By defination ,
10 //hg=ug+(p*vg)/J
11 //hf=uf+(p*vf)/J
12 //hfg = hg-hf = (ug-uf) + p*(vg-vf)/J = ufg + p*(vg-
    vf)/J
13 //From table 2 at 115 psia ,
14 p=115; //Unit:psia //absolute pressure
15 ufg=798.8; //Unit:Btu/lbm //Evap. internal energy
16 ug=3.884; //Unit:ft^3/lbm //Saturated vapour
    internal energy
17 vf=0.017850; //Unit:ft^3/lbm //Saturated liquid
    specific volume
18 J=778; //J=Conversion factor //Unit:ft*lbf/Btu
19 //1 ft^2=144 in^2
20 hfg=ufg+(p*144*(ug-vf))/J; //Evap. Enthalpy //Unit:
    Btu/lbm
21 printf("hfg for saturated steam at 115 psia is %f

```

```
Btu/lbm",hfg); //The tabulated values are matched
```

Scilab code Exa 5.5 find hfg

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.5\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.5 (page no. 190)
7 // Solution
8
9 //From table 2 at 1.0 MPa,
10 p=1000; //Unit:kN/m^2 //absolute pressure
11 ufg=1822.0; //Unit:kJ/kg //Evap. internal energy
12 vf=0.0011273; //Unit:m^3/kg //Saturated liquid
    specific volume
13 vg=0.19444; //Unit:m^3/kg //Saturated vapour
    specific volume
14 vfg=vg-vf; //Evap. specific volume //m^3/kg
15 hfg=ufg+(p*vfg); //Evap. Enthalpy //Unit:kJ/kg
16 printf("hfg for saturated steam at 1.0 MPa is %f kJ/
    kg",hfg); //The tabulated values are matched
```

Scilab code Exa 5.6 Determine hfg

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.6\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.6 (page no. 190)
7 // Solution
```

```

8
9 //For constant-temperature, reversible vaporization,
    hfg=deltah=T*deltas=T*sfg
10 hfg=(388.12+460)*(1.1042); //Evap. Enthalpy //Unit:
    Btu/lbm
11 printf("By considering the process to be a
    reversible, constant-temperature, hfg for saturated
    steam at 115 psia is %f Btu/lbm", hfg); //ans is
    wrong in the book
12 //Values are matched with tabulated values. Use of
    -459.67 F for absolute zero, which is the value
    used in table, gives almost exact agreement.

```

Scilab code Exa 5.7 Determine s_x h_x u_x and v_x

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.7\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.7 (page no. 192)
7 // Solution
8
9 //Using Table 2 ans a quality of 80%(x=0.8), we have
10 //at 120 psia
11 x=0.8;
12 sf=0.49201; //saturated liquid entropy //Unit:Btu/
    lbm*R
13 sfg=1.0966; //Evap. Entropy //Unit:Btu/lbm*R
14 hf=312.67; //saturated liquid enthalpy //Unit:Btu/
    lbm
15 hfg=878.5; //Evap. Enthalpy //Unit:Btu/lbm
16 uf=312.27; //saturated liquid internal energy //Unit
    :Btu/lbm
17 ufg=796.0; //Unit:Btu/lbm //Evap. internal energy

```

```

18 vf=0.017886; //Saturated liquid specific volume //
    Unit: ft ^3/lbm
19 vfg=(3.730-0.017886); //evap. specific volume //Unit
    : ft ^3/lbm
20 sx=sf+(x*sfg); //entropy //Btu/lbm*R
21 printf("Entropy of a wet steam mixture at 120 psia
    is %f Btu/lbm*R\n",sx);
22 hx=hf+(x*hfg); //enthalpy //Btu/lbm*R
23 printf("Enthalpy of a wet steam mixture at 120 psia
    is %f Btu/lbm\n",hx);
24 ux=uf+(x*ufg); //internal energy //Btu/lbm*R
25 printf("Internal energy of a wet steam mixture at
    120 psia is %f Btu/lbm\n",ux);
26 vx=vf+(x*vfg); ///specific volume //ft ^3/lbm
27 printf("Specific Volume of a wet steam mixture at
    120 psia is %f ft ^3/lbm\n",vx);
28 //As a check ,
29 J=778; //ft*lb/Btu //Conversion factor
30 px=120; //psia //pressure
31 ux=hx-((px*vx*144)/J); //1 ft ^2=144 in ^2 //internal
    energy
32 printf("As a check ,\n")
33 printf("Internal energy of a wet steam mixture at
    120 psia is %f Btu/lbm\n",ux);
34 printf("Which agrees with the values obtained above"
    );

```

Scilab code Exa 5.8 Determine s_x h_x u_x and v_x when quality is given

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.8\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.8 (page no. 193)

```

```

7 // Solution
8
9 //Using Table 2 ans a quality of 85%(x=0.85),we have
10 //at 1.0 MPa
11 x=0.85;
12 sf=2.1387; //saturated liquid entropy //Unit:kJ/kg*K
13 sfg=4.4487; //Evap. Entropy //Unit:kJ/kg*K
14 hf=762.81; //saturated liquid enthalpy //Unit:kJ/kg
15 hfg=2015.3; //Evap. Enthalpy //Unit:kJ/kg
16 uf=761.68; //saturated liquid internal energy //Unit
   :kJ/kg
17 ufg=1822.0; //Unit:kJ/kg //Evap. internal energy
18 vf=1.1273; //Saturated liquid specific volume //Unit
   :m^3/kg
19 vfg=(194.44-1.1273); //evap. specific volume //Unit:
   m^3/kg
20 sx=sf+(x*sfg); //entropy //kJ/kg*K
21 printf("Entropy of a wet steam mixture at 1.0 MPa
   is %f kJ/kg*K\n",sx);
22 hx=hf+(x*hfg); //enthalpy //kJ/kg*K
23 printf("Enthalpy of a wet steam mixture at 1.0 MPa
   is %f kJ/kg\n",hx);
24 ux=uf+(x*ufg); //internal energy //kJ/kg*K
25 printf("Internal energy of a wet steam mixture at
   1.0 MPa is %f kJ/kg\n",ux);
26 vx=(vf+(x*vfg))*(0.001); //specific volume //m^3/kg
27 printf("Specific Volume of a wet steam mixture at
   1.0 MPa is %f m^3/kg\n",vx);
28 //As a check,
29 px=10^6; //psia //pressure
30 ux=ux-((px*vx)/10^3); //1 ft^2=144 in^2 //internal
   energy
31 printf("As a check,\n")
32 printf("Internal energy of a wet steam mixture at
   120 psia is %f kJ/kg\n",ux);
33 printf("Which agrees with the values obtained above"
   );

```

Scilab code Exa 5.9 Quality of the steam

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.9\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.9 (page no. 193)
7 // Solution
8
9 //For the wet mixture , $h_x=h_f+(x*h_{fg})$ , solving for x
   gives us
10 //Using table 1,we have ,
11  $h_x=900$ ; //Btu/lbm //Enthalpy of wet mixture at 90F
12  $h_f=58.07$ ; //Btu/lbm //saturated liquid enthalpy
13  $h_{fg}=1042.7$ ; //Btu/lbm //Evap. Enthalpy
14  $x=(h_x-h_f)/h_{fg}$ ; //quality
15 printf("The quality is %f percentage of a wet steam
   at 90F\n",x*100);
```

Scilab code Exa 5.10 Determine the quality

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.10\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.10 (page no. 194)
7 // Solution
8
9 //For the wet mixture , $h_x=h_f+(x*h_{fg})$ , solving for x
   gives us
```

```

10 //Using table 1,we have ,
11 hx=2000; //kJ/kg //Enthalpy of wet mixture at 30 C
12 hf=125.79; //kJ/kg //saturated liquid enthalpy
13 hfg=2430.5; // //Evap. Enthalpy //kJ/kg
14 x=(hx-hf)/hfg; //quality
15 printf("The quality is %f percentage of a wet steam
        at 30 C\n",x*100);

```

Scilab code Exa 5.11 Determine h v u and s of superheated steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.11\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.11 (page no. 197)
7 // Solution
8
9 //The values of temperature and pressure are listed
  in Table 3(Figure 5.10) and can be read directly.
10 printf("Specific volume of superheated steam at 330
        psia and 450F is v=1.4691 ft^3/lbm\n");
11 printf("Internal Energy of superheated steam at 330
        psia and 450F is u=1131.8 Btu/lbm\n");
12 printf("Enthalpy of superheated steam at 330 psia
        and 450F is h=1221.5 Btu/lbm\n");
13 printf("Entropy of superheated steam at 330 psia and
        450F is s=1.5219 Btu/lbm*R\n");

```

Scilab code Exa 5.12 Determine v u h and s of superheated steam

```

1 //scilab 5.4.1
2 clear;

```



```

3  clc;
4  printf("\t\t\tProblem Number 5.12\n\n\n");
5  // Chapter 5 : Properties Of Liquids And Gases
6  // Problem 5.12 (page no. 197)
7  // Solution
8
9  //The values of temperature and pressure are listed
   in Table 3(Figure 5.10) and can be read directly.
10 printf("Specific volume of superheated steam at 2.0
   MPa and 240 C is v=0.10845 m^3/lbm\n");
11 printf("Internal Energy of superheated steam at 2.0
   MPa and 240 C is u=2659.6 kJ/kg\n");
12 printf("Enthalpy of superheated steam at 2.0 MPa and
   240 C is h=2876.5 kJ/kg\n");
13 printf("Entropy of superheated steam at 2.0 MPa and
   240 C is s=6.4952 kJ/kg*K\n");

```

Scilab code Exa 5.13 Determine v h s and u of superheated steam

```

1  //scilab 5.4.1
2  clear;
3  clc;
4  printf("\t\t\tProblem Number 5.13\n\n\n");
5  // Chapter 5 : Properties Of Liquids And Gases
6  // Problem 5.13 (page no. 197)
7  // Solution
8
9
10 //The necessary interpolations(between 450F and 460F
   at 330 psia) are best done in tabular forms as
   shown:
11 //   t      v
12 // 460    1.4945
13 // 455    1.4818
14 // 450    1.4691

```

```

15 v=1.4691+(1/2)*(1.4945-1.4691); //ft^3/lbm //
    specific volume
16 printf("The specific volume of saturated steam at
    330 psia & 455F is %f ft^3/lbm\n",v);
17
18 // t    u
19 // 460  1137.0
20 // 455  1134.4
21 // 450  1131.8
22 u=1131.8+(1/2)*(1137.0-1131.8); //Btu/lbm //internal
    energy
23 printf("The internal energy of saturated steam at
    330 psia & 455F is %f Btu/lbm\n",u);
24
25 // t    h
26 // 460  1228.2
27 // 455  1224.9
28 // 450  1221.5
29 h=1221.5+(1/2)*(1228.2-1221.5); //enthaply //Btu/lbm
30 printf("The enthalpy of saturated steam at 330 psia
    & 455F is %f Btu/lbm\n",h);
31
32 // t    s
33 // 460  1.5293
34 // 455  1.5256
35 // 450  1.5219
36 s=1.5219+(1/2)*(1.5293-1.5219); //entropy //Btu/lbm*
    R
37 printf("The entropy of saturated steam at 330 psia &
    455F is %f Btu/lbm*R\n",s);

```

Scilab code Exa 5.14 Determine specific volume and enthalpy of superheated steam

```
1 //scilab 5.4.1
```

```

2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.14\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.14 (page no. 198)
7 // Solution
8
9 //From Table3, we first obtain the properties at 337
    psia and 460 F and then 340 psia and 470 F.
10 //The necessary interpolations are best done in
    tabular forms as shown:
11 //Proceeding with the calculation ,at 460 F,
12 // p      v                // p
    h
13 // 340   1.4448            //
    340   1226.7
14 // 337   1.4595            //
    337   1227.2
15 // 335   1.4693            //
    335   1227.5
16 v=1.4696-(2/5)*(1.4693-1.4448);           h
    =1227.5-(2/5)*(1227.5-1226.7);
17 //ft^3/lbm //specific volume           //Btu
    /lbm //enthaply
18
19 //And at 470 F,
20 // p      v                // p
    h
21 // 340   1.4693            //
    340   1233.4
22 // 337   1.4841            //
    337   1233.9
23 // 335   1.4940            //
    335   1234.2
24 v=1.4640-(2/5)*(1.4640-1.4693);           h
    =1234.2-(2/5)*(1234.2-1233.4);
25 //ft^3/lbm //specific volume           //Btu
    /lbm //enthaply

```

```

26
27 //Therefore ,at 337 psia and 465 F
28 // t      v      h      // t
29 // 470    1.4841  1233.9  // 470
30 // 465    1.4718  1230.7  // 465
31 // 460    1.4595  1227.5  // 460
32 v=1.4595+(1/2)*(1.4841-1.4595);      h
    =1227.5+(1/2)*(1233.9-1227.5);
33 //ft ^3/lbm //specific volume      //Btu/
    lbm //enthaply
34 printf("At 465 F and 337 psia ,specific volume=%f ft
    ^3/lbm and enthalpy=%f Btu/lbm\n",v,h);

```

Scilab code Exa 5.15 Determine h s v and u of subcooled water

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.15\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.15 (page no. 202)
7 // Solution
8
9 //The values of temperature and pressure are listed
    in Table 4(Figure 5.10) and can be read directly.
10 printf("Specific volume of subcooled water at 1000
    psia and 300F is v=0.017379 ft ^3/lbm\n");
11 printf("Internal Energy of subcooled water at 1000
    psia and 300F is u=268.24 Btu/lbm\n");
12 printf("Enthalpy of subcooled water at 1000 psia and
    300F is h=271.46 Btu/lbm\n");

```

```
13 printf("Entropy of subcooled water at 1000 psia and
    300F is s=0.43552 Btu/lbm*R\n");
```

Scilab code Exa 5.16 Determine enthalpy of subcooled water

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.16\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.16 (page no. 202)
7 // Solution
8
9 //It is necessary to obtain the saturation values
    corresponding to 300 F.This is done by reading
    Table A.1 in Appendix 3,which gives
10 pf=66.98; //psia //pressure
11 vf=0.017448; //ft^3/lbm //specific volume
12 hf=269.73; //Btu/lbm //enthalpy
13 //Now,
14 p=1000; //psia //pressure
15 J=778; //Conversion factor //ft*lb/Btu
16 //From eq.5.5 ,
17 h=hf+((p-pf)*vf*144)/J; //1ft^2=144 in^2 //The
    enthalpy of subcooled water //Btu/lbm
18 printf("The enthalpy of subcooled water is %f Btu/
    lbm\n",h);
19 //The difference between this value and the value
    found in problem 5.15,expressed as a percentage
    is
20 percentoferror=(h-271.46)/271.46;
21 printf("Percent of error is %f\n",percentoferror
    *100);
```

Scilab code Exa 5.25 the enthalpy of saturated steam

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.25\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.25 (page no. 211)
7 // Solution
8
9 //On a chart in Appendix 3,it is necessary to
   estimate the 90 F point on the saturation line .
   From the chart or the table in the upper left of
   the chart ,we note that 90 F is between 1.4 and
   1.5 in. of mercury.Estimating the intersection of
   this value with the saturation curve yields
10 printf("Enthalpy of saturated steam hg=1100 Btu/lbm\n
   n");
11 //This is a good agreement with results of problem
   5.1
```

Scilab code Exa 5.26 Enthalpy of a wet steam

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.26\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.26 (page no. 212)
7 // Solution
8
```

```

9 //The Mollier chart has lines of constant moisture
  in the wet region which correspond to (1-x).
  Therefore ,we read at 20% moisture (80% Quality)
  and 120 psia ,
10 printf("The enthalpy of a wet steam mixture at 120
  psia having quality 80 percent is 1015 Btu/lbm\n"
  );
11 //Which also agrees well with the calculated value
  in problem 5.7

```

Scilab code Exa 5.27 quality of a wet steam mixture

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.27\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.27 (page no. 213)
7 // Solution
8
9 //Entering the Mollier chart at 900 Btu/lbm and
  estimating 90 F(near the 1.5-in. Hg dashed line)
  yields a constant moisture percent of 19.2%.
10 printf("The quality is %f percent\n", (1-0.192)*100);
11 //We show good agreement with the calculated value.

```

Scilab code Exa 5.28 determine the enthalpy of steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.28\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases

```

```

6 // Problem 5.28 (page no. 214)
7 // Solution
8
9 //From the chart ,
10 printf("The enthalpy of steam at 330 psia is h=1220
    Btu/lbm\n");
11 //Compared to 1221.5 Btu/lbm found in problem 5.11

```

Scilab code Exa 5.29 Determine the enthalpy and entropy of steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.29\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.29 (page no. 214)
7 // Solution
8
9 //We note that the steam is superheated.From the
    Mollier chart in SI units ,
10 printf("The enthalpy h=2876.5 kJ/kg and entropy s
    =6.4952 kJ/kg*K\n");
11 //Values are matched with problem 5.12

```

Scilab code Exa 5.30 Determine the enthalpy of steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.30\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.30 (page no. 215)
7 // Solution

```



```

8
9 //Because neither pressure nor temperature is shown
  directly ,it is necessary to estimate to obtain
  the desired value.
10 printf("The enthalpy of steam is h=1231 Btu/lbm\n");
11 //In problem 5.14,h=1230.7 Btu/lbm,Which is matched
  here.

```

Scilab code Exa 5.31 determine hg

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.31\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.31 (page no. 215)
7 // Solution
8
9 //Reading the chart at 30 C and saturation gives us,
10 printf("The enthalpy of saturated steam is hg=2556
  kJ/kg\n");
11 //Which matches with value of problem 5.2

```

Scilab code Exa 5.32 Determine hx and sx

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.32\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.32 (page no. 215)
7 // Solution
8

```

```

9 //Reading the chart in wet region at 1.0 MPa and x
  =0.85(moisture of 15%) gives us
10 printf("hx=2476 kJ/kg and sx=5.92 kJ/kg*K\n");
11 //The chart does not give ux or vx directly

```

Scilab code Exa 5.33 Determine the quality of steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.33\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.33 (page no. 215)
7 // Solution
8
9 //Locate 30 C on the saturation line.Now follow a
  line of constant pressure ,which is also a line of
  constant temperature in wet region ,until an
  enthalpy of 2000kJ/kg is reached.
10 printf("The moisture content is 23 percent or x=77
  percent\n");

```

Scilab code Exa 5.34 Determine entropy and enthalpy

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.34\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.34 (page no. 216)
7 // Solution
8

```

```

9 //We enter the chart in the superheat region at 2.0
    MPa and 240 C to read the enthalpy and entropy.
    This procedure gives
10 printf("Enthalpy h=2877 kJ/kg and entropy s=6.495 kJ
    /kg*K\n");
11 //The other properties cant be obtained directly
    from the chart

```

Scilab code Exa 5.35 Determine the moisture in the steam flowing in the pipe

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.35\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.35 (page no. 218)
7 // Solution
8
9 //As already noted,h1=h2 for this process.On the
    Mollier chart,h2 is found to be 1170 Btu/lbm at
    14.7 psia and 250 F.Proceeding to the left on the
    chart,the constant-enthalpy value of 1170 Btu/
    lbm to 150 psia yields a moisture of 3% or a
    quality of 97%.
10 //If we use the tables to obtain the solution to
    this problem,we would first obtain h2 from the
    superheated vapor tables as 1168.8 Btu/lbm.
    Because  $h_x = h_f + (x \cdot h_{fg})$ ,we obtain x as
11 hx=1168.8; //Btu/lbm
12 hf=330.75; //Btu/lbm //values of 150 psia
13 hfg=864.2; //Btulbm //values of 150 psia
14 x=(hx-hf)/hfg; //Quality
15 printf("Moisture in the steam flowing in the pipe is
    %f percent\n", (1-x)*100);

```

```

16 printf("or quality of the steam is %f percent\n",x
    *100);
17 //very often ,it is necessary to perform multiple
    interpolations if the tables are used ,and the
    Mollier chart yields results within the rquired
    accuracy for most engineering problems and saves
    considerable time.
18 //We can also use the computerised programs to solve
    this program.We first enter the 250F and 14.7
    psia to obtain h of 1168.7 Btu/lbm.We then
    continue by entering h of 1168.7 Btu/lbm and p of
    150 psia.The printout gives us x of 0.9699 or 97
    %.While the computer solution is quick and easy
    to use ,you should still sketch out the problem
    on an h-s or T-s diagram to show the path of the
    process.

19
20 // Saturation Properties
21 //-----
22 // T=250.00 degF
23 // P=29.814 psia
24 //      z          z1          zg
25 // v(ft ^3/lbm)    0.01700    13.830
26 // h(Btu/lbm)      218.62     1164.1
27 // s(Btu/lbm*F)    0.3678     1.7001
28 // u(Btu/lbm)      218.52     1087.8
29
30 //Thermo Properties
31 //-----
32 // T= 250.00 degF
33 // P= 14.700 psia
34 // v= 28.417 ft ^3/lbm
35 // h= 1168.7 Btu/lbm
36 // s= 1.7831 Btu/lbm*F
37 // u= 1091.4 Btu/lbm
38
39 // Saturation Properties
40 //-----

```

```

41 // T=340.06 degF
42 // P=118.00 psia
43 //           z           z1           zg
44 // v(ft ^3/lbm)   0.01787   3.7891
45 // h(Btu/lbm)     311.39    1190.7
46 // s(Btu/lbm*F)   0.4904    1.5899
47 // u(Btu/lbm)     311.00    1108.0
48
49 //Thermo Properties
50 //-----
51 // T= 358.49 degF
52 // P= 150.00 psia
53 // v= 2.9248 ft ^3/lbm
54 // h= 1168.7 Btu/lbm
55 // s= 1.5384 Btu/lbm*F
56 // u= 1087.5 Btu/lbm
57 // x= 0.9699
58
59 //Region : Saturated

```

Scilab code Exa 5.36 The final pressure of the steam and the heat added

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.36\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.36 (page no. 219)
7 // Solution
8
9 //Because the tank volume is 10 ft ^3,the final
   specific volume of the steam is 10 ft ^3/lbm.
   Interpolations in Table A.2 yield a final
   pressure of 42 psia.The heat added is simply
   difference in internal energy between the two

```

```

    states.
10 u2=1093.0; //internal energy //Btu/lbm
11 u1=117.95; //internal energy //Btu/lbm
12 q=u2-u1; //heat added //Btu/lbm
13 printf("The final pressure is 42 psia and the heat
    added is %f Btu/lbm\n",q);

```

Scilab code Exa 5.37 Heat added per unit mass

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.37\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.37 (page no. 220)
7 // Solution
8
9 //The mass in the tank is constant ,and the heat
    added will be the change in internal energy of
    the contents of the tank between the two states.
    The initial mass in the tank is found as
    follows:
10 Vf=45; //volume of water //ft^2
11 vf=0.016715;
12 Vg=15; //Volume of steam //ft^2
13 vg=26.80;
14 mf=Vf/vf; //lbm
15 mg=Vg/vg; //lbm
16 total=mf+mg; //total mass
17 //The internal energy is the sum of the internal
    energy of the liquid plus vapor:
18 ug=1077.6;
19 uf=180.1;
20 Ug=mg*ug; //Btu
21 Uf=mf*uf; //Btu

```

```

22 Total=Ug+Uf; //total internal energy
23 printf("The total internal energy is %f Btu\n",Total
);
24 //Because the mass in the tank is constant,the final
specific volume must equal the initial specific
volume,or
25 vx=(Vf+Vg)/(mf+mg); //ft^3/lbm
26 //But vx=vf+(x*vfg).Therefore using table A.2 at 800
psia ,
27 vx=0.022282;
28 vf=0.02087;
29 vfg=0.5691-0.02087;
30 x=(vx-vf)/vfg;
31 printf("The final amount of vapor is %f lbm\n",x*
total); //x*total mass
32 mg=x*total;
33 printf("The final amount of liquid is %f lbm\n",
total-(x*total)); //total mass minus final amount
of vapor
34 mf=total-(x*total);
35 //The final internal energy is found as before:
36 ug=1115.0;
37 uf=506.6;
38 Ug=mg*ug; //Btu
39 Uf=mf*uf; //Btu
40 Total1=Ug+Uf;
41 difference=Total1-Total; //final internal energy-
initial internal energy
42 //per unit mass heat added is ,
43 printf("The heat added per unit is %f Btu/lbm\n",
difference/total); //the difference of internal
energy/total mass

```

Scilab code Exa 5.38 Determine the change in enthalpy

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.38\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.38 (page no. 222)
7 // Solution
8
9 //As shown in Fig. 5.21b,the process dscribed in
   this problem is a vertical line on the Mollier
   Chart.For 800 psia and 600F,the Mollier chart
   yeilds h1=1270 Btu/lbm and s1=1.485.Proceeding
   vertically down the chart at constant s to 200
   psia yields a final enthalpy h2=1148 Btu/lbm.The
   change in enthalpy using the process is
   1270-1148=122 Btu/lbm.
10 //We may also solve this problem using the steam
   tables in Appendix 3.Thus,the enthalpy at 800
   psia and 600 F is 1270.4 Btu/lbm,and its entropy
   is 1.4861 Btu/lbm*R.
11 //Because the process is isentropic ,the final
   entropy at 200psia must be 1.4861.From the
   saaturation table ,the entropy of saturated steam
   at 200 psia is 1.5464,which indicates the final
   steam condition must be wet because the entropy
   of the final steam is less than the entropy of
   saturation.Using the wet steam relation yields ,
12 //sx=sf+(x*sfg)
13 h1=1270.4; sx=1.4861; sf=0.5440; sfg=1.0025 ;hf
   =355.6; hfg=843.7;
14 x=(sx-sf)/sfg; //Quality
15 //Therefore ,the final enthalpy is
16 hx=hf+(x*hfg); //Btu/lbm
17 printf("The final enthalpy is %f Btu/lbm\n",hx);
18 printf("The change in enthalpy is %f Btu/lbm\n",h1-
   hx); //Note the agreement with the Mollier chart
   solution
19 //we can also use the computer program to solve this

```



```

    problem.For 600F and 800 psia , h=1270. Btu/lbm
    and s=1.4857 Btu/lbm*R.Now using p=200 psia and s
    =1.4857,we obtain
20 //h=1148.1 Btu/lbm.The change in enthalpy is
    1270.0-1148.1=121.9 Btu/lbm.Note the effort saved
    using either the Mollier chart or the computer
    program.

21
22 // Saturation Properties
23 //-----
24 // T=600.00 degF
25 // P=1541.7 psia
26 //          z          z1          zg
27 // v(ft ^3/lbm)    0.02362    0.2675
28 // h(Btu/lbm)      616.59     1166.2
29 // s(Btu/lbm*F)    0.8129     1.3316
30 // u(Btu/lbm)      609.85     1089.9
31
32 //Thermo Properties
33 //-----
34 // T= 600.00 degF
35 // P= 800.00 psia
36 // v= 0. ft ^3/lbm
37 // h= 1168.7 Btu/lbm
38 // s= 1.5384 Btu/lbm*F
39 // u= 1087.5 Btu/lbm
40 //Region: Superheated
41
42 // Saturation Properties
43 //-----
44 // T=381.87 degF
45 // P=200.00 psia
46 //          z          z1          zg
47 // v(ft ^3/lbm)    0.01839    2.2883
48 // h(Btu/lbm)      355.60     1199.0
49 // s(Btu/lbm*F)    0.5440     1.5462
50 // u(Btu/lbm)      354.92     1114.3
51

```

```

52 //Thermo Properties
53 //-----
54 // T= 381.87 degF
55 // P= 200.00 psia
56 // v= 2.1512 ft^3/lbm
57 // h= 1148.1 Btu/lbm
58 // s= 1.4857 Btu/lbm*R
59 // u= 1068.5 Btu/lbm
60 // x= 0.9396
61
62 //Region: Saturated

```

Scilab code Exa 5.39 Determine the final state of the steam

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.39\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.39 (page no. 226)
7 // Solution
8
9 //As referring to figure 5.21, it will be seen that
   the final temperature and enthalpy will both be
   higher than for the isentropic case.
10 //80% of the isentropic enthalpy difference
11 deltah=0.8*122; //change in enthalpy //Btu/lbm
12 h1=1270; //Btu/lbm //initial enthalpy
13 h2=h1-deltah; //the final enthalpy //Btu/lbm
14 printf("The final enthalpy is %f Btu/lbm\n",h2);
15 printf("and the final pressure is 200 psia\n");
16 printf("The Mollier chart indicates the final state
   to be in the wet region,\n");
17 printf("with 3.1 percent moisture content and an
   entropy of 1.514 Btu/lbm*R");

```

Scilab code Exa 5.40 Change in enthalpy

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.40\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.40 (page no. 226)
7 // Solution
8
9 //Using the Mollier chart ,
10 h1=2942; //kJ/kg //initial enthalpy
11 //Proceeding as shown in figure 5.21b,that is ,
    vertically at constant entropy to a pressure of
    0.1 MPa,gives us
12 h2=2512; //kJ/kg //final enthalpy
13 printf("Neglecting kinetic & potential energy ,The
    change in enthalpy of the steam is %f kJ/kg",h1-
    h2);
```

Scilab code Exa 5.41 Determine Final velocity of the steam

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.41\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.41 (page no. 226)
7 // Solution
8
9 //From the conditions given in problem 5.38,the
    isentropic change in enthalpy is 122 Btu/lbm
```

```

10 //So,
11 h1minush2=122; //Btu/lbm //change in enthalpy
12 J=778; //Conversion factor
13 gc=32.17; //lbm*ft/lbf*s^2 //constant of
    proportionality
14 V2=sqrt(2*gc*J*(h1minush2)); //final velocity //ft/s
15 printf("As the steam leaves the nozzle ,The final
    velocity is %f ft/s",V2);

```

Scilab code Exa 5.42 Determine the final velocity

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.42\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.42 (page no. 227)
7 // Solution
8
9 //Because the process is irreversible ,we cannot show
    it on the Mollier diagram.However,the analysis
    of problem 3.22 for the nozzle is still valid ,and
    all that is needed is the enthalpy at the
    beginning and the end of the expansion.From the
    problem 5.38,
10 h1=1270; //Btu/lbm //initial enthalpy
11 //For h2 we locate the state point on the Mollier
    diagram as being saturated vapor at 200 psia.This
    gives us
12 h2=1199; //Btu/lbm //final enthalpy
13 J=778; //Conversion factor
14 gc=32.17; //lbm*ft/lbf*s^2 //constant of
    proportionality
15 V2=sqrt(2*gc*J*(h1-h2)); //final velocity //Ft/s
16 printf("As the steam leaves the nozzle ,The final

```

```
velocity is %f ft/s",V2);
```

Scilab code Exa 5.43 Heat added per pound

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.43\n\n\n");
5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.43 (page no. 229)
7 // Solution
8
9 //From the saturation table ,500 psia corresponds to
   a temperature of 467.13F,and the saturated vapor
   has an enthalpy of 1205.3 Btu/lbm.At 500 psia and
   800 F,the saturated vapor has an enthalpy
   of 1412.1 Btu/lbm.Because this process is a
   steady-flow process at constant pressure ,the
   energy equation becomes  $q=h_2-h_1$ ,assuming that
   differences in the kinetic energy and potential
   energy terms are negligible.Therefore ,
10 h2=1412.1; //Btu/lbm //final enthalpy
11 h1=1205.3; //Btu/lbm //initial enthalpy
12 q=h2-h1; //heat added //Btu/lbm
13 printf("%f Btu/lbm heat per pound of steam was added
   \n",q);
```

Scilab code Exa 5.44 Heat removed

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 5.44\n\n\n");
```

```

5 // Chapter 5 : Properties Of Liquids And Gases
6 // Problem 5.44 (page no. 229)
7 // Solution
8
9 //From the saturation table at 1 psia ,
10 hf=69.74; //Btu/lbm //saturated liquid enthalpy
11 hfg=1036.0; //Btu/lbm //Evap. Enthalpy
12 hg=1105.8; //Btu/lbm //The enthalpy of saturated
    steam
13 x=0.97; //Quality
14 //Because the condensation process is carried out at
    constant pressure ,the energy equation is q=
    deltah.
15 hx=hf+(x*hfg); //the initial enthalpy //Btu/lbm
16 printf("The initial enthalpy is %f Btu/lbm\n",hx);
17 //The final enthalpy is hf=69.74.So,
18 deltah=hx-hf; //The enthalpy difference //Btu/lbm
19 printf("At 1 psia ,The enthalpy difference is %f Btu/
    lbm\n",deltah);
20 printf("By the computer solution ,the enthalpy
    difference is 1004.6 Btu/lbm");
21 // Saturation Properties
22 //-----
23 // T=101.71 degF
24 // P=1.0000 psia
25 //          z          z1          zg
26 // v(ft ^3/lbm)    0.01614    333.55
27 // h(Btu/lbm)     69.725     1105.4
28 // s(Btu/lbm*F)   0.1326     1.9774
29 // u(Btu/lbm)     69.722     1043.6
30
31 //Thermo Properties
32 //-----
33 // T= 101.71 degF
34 // P= 1.0000 psia
35 // v= 323.55 ft ^3/lbm
36 // h= 1074.3 Btu/lbm
37 // s= 1.9221 Btu/lbm*F

```

```
38 // u= 1014.4 Btu/lbm
39 // x= 0.9700
40
41 //Region : Saturated
```

Chapter 6

The Ideal Gas

Scilab code Exa 6.1 Boyles law

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.1\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.1 (page no. 241)
6 // Solution
7
8 P1=100; //Pressure at volume V1=100 ft^3 //Unit:psia
9 V1=100; //Unit:ft^3 //V1=Volume at 100 psia
10 P2=30 // Reduced Pressure //Unit:psia
11 //Boyle's law ,P1*V1=P2*V2
12 V2=(P1*V1)/P2; //Volume occupied by the gas //ft^3
13 printf("Volume occupied by the gas = %f ft^3",V2);
```

Scilab code Exa 6.2 Boyles law

```
1 clear;
2 clc;
```



```

3 printf("\t\t\tProblem Number 6.2\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.2 (page no. 241)
6 // Solution
7
8 P1=10^6; //Pressure at volume V1=2 m^3 //Unit:Pa
9 V1=2; //Unit:m^3 //V1=Volume at 10^6 Pa
10 P2=8*10^6 // Increased Pressure //Unit:Pa
11 //Boyle's law,P1*V1=P2*V2
12 V2=(P1*V1)/P2; //Volume occupied by gas //unit:m^3
13 printf("Volume occupied by gas = %f m^3",V2);

```

Scilab code Exa 6.3 Charles law

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.3\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.3 (page no. 242)
6 // Solution
7
8 T1=32+460; //Temperature at volume V1=150 ft^3 //
   Unit:R
9 V1=150; //Unit:ft^3 //V1=Volume at 32 F
10 T2=100+460 // Increased Temperature //Unit:R
11 //Charles's law,V1/V2 = T1/T2
12 V2=(T2*V1)/T1; //Volume occupied by gas //unit:m^3
13 printf("Volume occupied by gas = %f m^3",V2);

```

Scilab code Exa 6.4 Percent increase in ideal gas

```

1 clear;
2 clc;

```

```

3 printf("\t\t\tProblem Number 6.4\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.4 (page no. 242)
6 // Solution
7
8 //If for this process  $T_2=1.25*T_1$ ,
9 //  $T_2/T_1 = 1.25$ 
10 //Therefore ,
11 //  $p_2/p_1 = T_2/T_1$  //Charles 's law(volume constant)
12 //Thus,
13 printf("The absolute gas pressure increases by 25
    percent\n");

```

Scilab code Exa 6.5 Determine Final volume

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.5\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.5 (page no. 242)
6 // Solution
7
8 V1=4; //m^3 //initial volume
9 T2=0+273; //celsius converted to kelvin //gas is
    cooled to 0 C //final temperature
10 T1=100+273; //celsius converted to kelvin //initial
    temperature
11 V2=V1*(T2/T1); //final volume //Charles 's law(
    pressure constant) //unit:m^3
12 printf("The final volume is %f m^3",V2);

```

Scilab code Exa 6.6 The gas in the container

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.6\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.6 (page no. 245)
6 // Solution
7
8 //Let us first put each of the given variables into
   a consistent set of units:
9 p=(200+14.7)*(144); //Unit:psfa*(lbf/ft^2) //1 ft
   ^2=144 in^2 //pressure
10 T=(460+73); //Fahrenheit temperature converted to
   absolute temperature //unit:R
11 V=120/1728; //1 ft^3=1728 in^3 //total volume //
   unit:ft^3
12 R=1545/28; //Unit:ft*lbf/lbm*R //because the
   molecular weight of nitrogen is 28 //constant of
   proportionality
13 //Applying, p*v=R*T, //ideal gas law
14 v=(R*T)/p; //Unit:ft^3/lbm //specific volume
15 printf("The specific volume is %f ft^3/lbm\n",v);
16 //The mass of gas is the total volume divided by the
   specific volume
17 printf("The gas in the container is %f lbm\n",V/v);
18 //The same result is obtained by direct use of eq. p
   *V=m*R*T
19 m=(p*V)/(R*T); //The gas in the container //unit:lbm
   //ideal gas law
20 printf("The gas in the container is %f lbm\n",m);

```

Scilab code Exa 6.7 Determine final pressure

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.7\n\n\n");

```

```

4 // Chapter 6: The Ideal Gas
5 // Problem 6.7 (page no. 245)
6 // Solution
7
8 //Applying ,  $(p_1*V_1)/T_1 = (p_2*V_2)/T_2$ 
9 //and  $p_2=p_1*(T_2/T_1)$  because  $V_1=V_2$ 
10 p1=200+14.7; //Unit:psia //initial pressure
11 T2=460+200; //final temperature is 200 F //
    Fahrenheit temperature converted to absolute
    temperature //unit:R
12 T1=460+73; //Fahrenheit temperature converted to
    absolute temperature //unit:R
13 p2=p1*(T2/T1); //final pressure //Unit:psia //
    Charles 's law(volume constant)
14 printf("The final pressure is %f psia",p2);

```

Scilab code Exa 6.8 Determine the gas in the tank

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.8\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.8 (page no. 246)
6 // Solution
7
8 //For CO2,
9 R=8.314/44; //Unit:kJ/kg*K //constant of
    proportionality //Molecular weight of CO2=44
10 p=500; //Unit:kPa //pressure
11 V=0.5; //Unit:m^3 //volume
12 T=(100+273); //Unit:K //Celsius converted to kelvin
13 //Applying  $p*V=m*R*T$  ,
14 m=(p*V)/(R*T); //mass //kg //ideal gas law
15 printf("The mass of gas in the tank is %f kg\n",m);

```

Scilab code Exa 6.9 Determine the mean specific heat

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.9\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.9 (page no. 252)
6 // Solution
7
8 T2=500+460; //absolute final temperature //unit:R
9 T1=80+460; //absolute initial temperature //unit:R
10 //The equation  $c_{pbar} = 0.338 - (1.24 \cdot 10^2 / T) + (4.15 \cdot 10^4) / T^2$  has a form ,  $c_{pbar} = A_{dash} + (B_{dash} / T) + (D_{dash} / T^2)$ 
11 //So,
12 Adash=0.338; //constant
13 Bdash=-1.24*10^2; //constant
14 Ddash=4.15*10^4; //constant
15 //Therefore ,from equation , $c_{pbar} = A_{dash} + ((B_{dash} \cdot \log(T2 / T1)) / (T2 - T1)) + (D_{dash} / (T2 \cdot T1))$ 
16  $c_{pbar} = A_{dash} + ((B_{dash} \cdot \log(T2 / T1)) / (T2 - T1)) + (D_{dash} / (T2 \cdot T1))$ ; //The mean specific heat //Btu/lbm*R
17 printf("The mean specific heat at constant pressure
between 80F and 500F is %f Btu/lbm*R\n", cpbar);
```

Scilab code Exa 6.10 The mean specific heat at constant pressure

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.10\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.10 (page no. 252)
```

```

6 // Solution
7
8 //The table in Appendix 3 does not give us the
   enthalpy data at 960R and 540R that we need.
   Interpolating yields
9 // T      hbar      T      hbar
10 // 537   3729.5    900   6268.1
11 // 540   3750.4    960   6694.0
12 // 600   4167.9    1000  6977.9
13 //So,
14 hbar540=3729.5+(3/63)*(4167.9-3729.5); //enthalpy //
   unit:Btu/lbm
15 hbar960=6268.1+(60/100)*(6977.9-6268.1); //enthalpy
   //unit:Btu/lbm
16 //Note that hbar is given for a mass of 1 lb mole.To
   obtain the enthalpy per pound,it is necessary to
   divide the values og h by the molecular weight
   ,28.
17 h2=6694.0; //enthalpy //unit:Btu/lbm
18 h1=3750.4; //enthalpy //unit:Btu/lbm
19 T2=500+460; //absolute final temperature //unit:R
20 T1=80+460; //absolute initial temperature //unit:R
21 cbar=(h2-h1)/(28*(T2-T1)); //The mean specific heat
   at constant pressure //unit:Btu/lbm*R
22 printf("The mean specific heat at constant pressure
   is %f Btu/lbm*R\n",cbar);
23 //With the more extesive Gas tables ,these
   interpolations are avoided.The Gas Tables provide
   a relatively easy and accurate method of
   obtaining average specific heats.Also ,these
   tables have been computerized for ease of
   application.

```

Scilab code Exa 6.11 Determine the mean specific heat

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.11\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.11 (page no. 253)
6 // Solution
7
8 T2=500+460; //absolute final temperature //unit:R
9 T1=80+460; //absolute initial temperature //unit:R
10 //cp=0.219 + (3.42*10^-5*T) - (2.93*10^-9*T^2); //
    Unit:Btu/lbm*R
11 //Comparing with c=A+(B*T)+(D*T^2)
12 A=0.219; //constant
13 B=3.42*10^-5; //constant
14 D=2.93*10^-9; //constant
15 //Using these values and equation cbar=A+((B/2)*(T2+
    T1))+((D/3)*(T2^2+(T2*T1)+T1^2))
16 cpbar=A+((B/2)*(T2+T1))+((D/3)*(T2^2+(T2*T1)+T1^2));
    //The mean specific heat //Btu/lbm*R
17 printf("The mean specific heat at constant pressure
    for air between 80F and 500F is %f Btu/lbm*R\n",
    cpbar);

```

Scilab code Exa 6.12 Determine cv

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.12\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.12 (page no. 255)
6 // Solution
7
8 //The molecular weight of oxygen is 32. Therefore ,
9 R=1545/32; //Unit:ft*lbF/lbm*R //constant of
    proportionality

```

```

10 J=778; //conversion factor
11 cp=0.24; //Unit:Btu/lbm*R //specific heat at
    constant pressure
12 //cp-cv=R/J
13 cv=cp-(R/J); //specific heat at constant volume //
    unit:Btu/lbm*R
14 printf(" Specific heat at constant volume is %f Btu/
    lbm*R\n",cv);

```

Scilab code Exa 6.13 Determine cv and cp in SI units

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.13\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.13 (page no. 255)
6 // Solution
7
8 //From equation ,cv=R/(k-1) ,
9 R=8.314/32; //constant of proportionality //kJ/kg*K
    //The molecular weight of oxygen is 32
10 k=1.4 //for oxygen //given //k=cp/cv
11 cv=R/(k-1); //Specific heat at constant volume //
    unit:kJ/kg*K
12 printf(" Specific heat at constant volume is %f kJ/kg
    *K\n",cv);
13 cp=k*cv; //specific heat at constant pressure //Unit
    :kJ/kg*K
14 printf(" Specific heat at constant pressure is %f kJ/
    kg*K\n",cp);

```

Scilab code Exa 6.14 Determine k cp and cv for the gas


```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.14\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.14 (page no. 255)
6 // Solution
7
8 R=60; //Unit:ft*lb_f/lbm*R //constant of
      proportionality
9 deltah=500; //Btu/lbm //change in enthalpy
10 deltau=350; //Btu/lbm //change in internal energy
11 J=778; //conversion factor
12 //Because deltah=(cp*deltaT) and deltau=cv*deltaT
13 // deltah/deltaT=(cp*deltaT)/(cv*deltaT)=cp/cv=k
14 k=deltah/deltaT; //Ratio of specific heats
15 printf("Ratio of specific heats k is %f\n",k);
16 //From equation cv=R/(J*(k-1))
17 cv=R/(J*(k-1)); //specific heat at constant volume
      //Btu/lbm*R
18 printf("Specific heat at constant volume is %f Btu/
      lbm*R\n",cv);
19 cp=k*cv; //Specific heat at constant pressure //Btu/
      lbm*R
20 printf("Specific heat at constant pressure is %f Btu
      /lbm*R\n",cp);

```

Scilab code Exa 6.15 Find the specific heat at constant pressure

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.15\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.15 (page no. 256)
6 // Solution
7

```

```

8 //When solving this type of problem ,it is necessary
  to note carefully the information given and to
  write the correct energy equation for this
  process.Because the process is carried out at
  constant volume,the heat added equals the change
  in inernal energy.Because the change in internal
  energy per pound for the ideal gas is  $cv*(T2$ 
   $-T1)$ ,the total change in internal energy for m
  pounds must equals the heat added.Thus,
9 //data given
10 Q=0.33; //heat
11 //Initial conditions
12 V=60; //in^3 //volume
13 m=0.0116; //lbs //mass
14 p1=90; //psia //pressure
15 T1=460+40; //Fahrenheit temperature converted to
  absolute temperature
16 //Final condition=Initial condition + heat
17 V=60; //in^3 //volume
18 m=0.0116; //lbs //mass
19 p2=108; //psia //pressure
20 T2=460+140; //Fahrenheit temperature converted to
  absolute temperature //unit:R
21 //Q=m*(u2-u1)=m*cv*(T2-T1)
22 cv=Q/(m*(T2-T1)); //specific heat at constant volume
  //Btu/lbm*R
23 printf(" Specific heat at constant volume is %f Btu/
  lbm*R\n",cv);
24 //To obtain cp,it is first necessary to obtain R.
  Enough information was given in the initial
  conditions of the problem to apply eqn.  $p*V=m*R*T$ 
25 R=(144*p1*(V/1728))/(m*T1); //1 ft^2=144 in^2 //1 ft
  ^3=1728 in^3 //Unit:ft*lbf/lbm*R //constant of
  proportionality
26 printf(" Constant of proportionality R is %f ft*lbf/
  lbm*R\n",R);
27 //cp-cv=(R/J)
28 J=778; //conversion factor

```

```

29 cp=cv+(R/J); //Specific heat at constant pressure //
    Btu/lbm*R
30 printf(" Specific heat at constant pressure is %f Btu
    /lbm*R\n",cp);

```

Scilab code Exa 6.16 Determine the change in entropy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.16\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.16 (page no. 260)
6 // Solution
7
8 //data
9 cp=0.24; //Specific heat at constant pressure //Btu/
    lbm*R
10 p2=15; //psia //final pressure
11 p1=100; //psia //initial pressure
12 T2=460+0; //absolute final temperature //unit:R
13 T1=460+100; //absolute initial temperature //unit:R
14 J=778; //conversion factor
15 R=1545/29; //molecular weight=29 //Unit:ft*lbf/lbm*R
    //constant of proportionality
16 //On the basis of the data given,
17 deltas=(cp*(log(T2/T1)))-((R/J)*(log(p2/p1))); //
    change in entropy //Btu/lbm*R
18 printf("The change in enthalpy is %f Btu/lbm*R\n",
    deltas);

```

Scilab code Exa 6.17 Determine change in entropy

```

1 clear;

```

```

2  clc;
3  printf("\t\t\tProblem Number 6.17\n\n");
4  // Chapter 6: The Ideal Gas
5  // Problem 6.17 (page no. 261)
6  // Solution
7
8  //data of problem6.16
9  cp=0.24; //Specific heat at constant pressure //Btu/
    lbm*R
10 p2=15; //psia //final pressure
11 p1=100; //psia //initial pressure
12 T2=460+0; //absolute final temperature //unit:R
13 T1=460+100; //absolute initial temperature //unit:R
14 J=778; //conversion factor
15 R=1545/29; //moleculer weight=29 //Unit:ft*lb/ft^3*R
    //constant of proportionality
16 //Because cp and R are given, let us first solve for
    cv,
17 //cp=(R*k)/(J*(k-1))
18 k=(cp*J)/((cp*J)-R); //k=cp/cv //ratio of specific
    heats
19 printf("Ratio of specific heats k is %f\n",k);
20 //k=cp/cv
21 cv=cp/k; //Specific heat at constant volume //Btu/
    lbm*R
22 printf("Specific heat at constant volume is %f Btu/
    lbm*R\n",cv);
23 //Now, deltas=(cv*log(p2/p1))+(cp*log(v2/v1));
24 //But, v2/v1=(T2*p1)/(T1*p2)
25 v2byv1=(T2*p1)/(T1*p2); // v2/v1 //unitless
26 deltas=(cv*log(p2/p1))+(cp*log(v2byv1)); //The
    change in enthalpy //unit:Btu/lbm*R
27 printf("The change in enthalpy is %f Btu/lbm*R\n",
    deltas);
28 //The agreement is very good.

```

Scilab code Exa 6.18 Determine the change in entropy

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.18\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.18 (page no. 261)
6 // Solution
7
8 //data,
9 cp=0.9093; //Specific heat at constant pressure //kJ
    /kg*R
10 p2=150; //kPa //final pressure
11 p1=500; //kPa //initial pressure
12 T2=273+0; //final temperature //Celsius converted
    to kelvin
13 T1=273+100; //initial temperature //Celsius
    converted to kelvin
14 //J=778; //conversion factor
15 R=8.314/32; //moleculer weight of oxygen=32 //Unit:
    ft*lbF/lbm*R //constant of proportionality
16 //Using equation, and dropping J gives,
17 deltas=(cp*(log(T2/T1)))-((R)*(log(p2/p1))); //
    change in entropy //kJ/kg*K
18 //For 2 kg,
19 deltaS=2*deltas; //The change in enthalpy in kJ/K
20 printf("For 2 kg oxygen,The change in enthalpy is %f
    kJ/K\n",deltaS);
```

Scilab code Exa 6.19 Determine the increase in pressure

```
1 clear;
```

```

2  clc;
3  printf(" \t\t\tProblem Number 6.19\n\n\n");
4  // Chapter 6: The Ideal Gas
5  // Problem 6.19 (page no. 262)
6  // Solution
7
8  //from the equation ,  $\Delta s/c_v = (k \cdot \log(v_2/v_1)) + \log(p_2/p_1)$  //change in entropy
9  k=1.4; // $k=c_p/c_v$  //ratio of specific heats
10 //  $\Delta s = (1/4) \cdot c_v$  //so ,
11 //  $1/4 = (k \cdot \log(v_2/v_1)) + \log(p_2/p_1)$ 
12 v2=1/2; //Because ,  $v_2 = (1/2) \cdot v_1$  //initial specific
    volume
13 v1=1; //final specific volume
14 p2byp1=exp((1/4) - (k * log(v2/v1))); //increase in
    pressure
15 printf(" p2/p1=%f\n" ,p2byp1);
16 printf("So, increase in pressure is %f " ,p2byp1);

```

Scilab code Exa 6.20 Determine change in entropy

```

1  clear;
2  clc;
3  printf(" \t\t\tProblem Number 6.20\n\n\n");
4  // Chapter 6: The Ideal Gas
5  // Problem 6.20 (page no. 264)
6  // Solution
7
8  //data
9  T2=460+270; //Fahrenheit temperature converted to
    absolute final temperature //unit:R
10 T1=460+70; //Fahrenheit temperature converted to
    absolute initial temperature //unit:R
11 cv=0.17; //specific heat at constant volume //Btu/
    lbm*R

```

```

12 //Now,
13 deltas=cv*log(T2/T1); //change in entropy //Unit:Btu
    /lbm*R
14 //For 1/2 lb ,
15 deltaS=(1/2)*deltas; //The change in enthalpy in Btu
    /R
16 printf("For 1/2 lb of gas ,The change in enthalpy is
    %f Btu/R\n",deltaS);

```

Scilab code Exa 6.21 Determine the change in entropy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.21\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.21 (page no. 264)
6 // Solution
7
8 //data
9 T2=100+273; //Celsius temperature converted to
    Kelvin //final temperature
10 T1=20+273; //Celsius temperature converted to Kelvin
    //initial temperature
11 cv=0.7186; //specific heat at constant volume //kJ/
    kg*K
12 //Now,
13 deltas=cv*log(T2/T1); //change in entropy //Unit:kJ/
    kg*K
14 //For 0.2 kg ,
15 deltaS=(0.2)*deltas; //The change in enthalpy in kJ/
    K
16 printf("For 0.2 kg of air ,The change in enthalpy is
    %f kJ/K\n",deltaS);

```

Scilab code Exa 6.22 Determine the higher temperature

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.22\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.22 (page no. 264)
6 // Solution
7
8 //data
9 deltas=0.0743; //change in entropy //Unit:Btu/lbm*R
10 T1=460+100; //Fahrenheit temperature converted to
    absolute initial temperature
11 cv=0.219; //specific heat at constant volume //Btu/
    lbm*R
12 //Now,
13 //deltas=cv*log(T2/T1);
14 T2=T1*exp(deltas/cv); //higher temperature //
    absolute temperature //unit:R
15 printf("The higher temperature is %f R\n",T2)
```

Scilab code Exa 6.23 Determine the initial temperature

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.23\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.23 (page no. 265)
6 // Solution
7
8 //data
9 deltaS=0.4386; //change in entropy //Unit:kJ/K
```



```

10 T2=273+425; //Celsius temperature converted to
    kelvin //initial temperature
11 cv=0.8216; //specific heat at constant volume //kJ/
    kg*K
12 m=1.5; //mass //kg
13 //Now,
14 //deltas=m*cv*log(T2/T1);
15 T1=T2/(exp(deltas/(m*cv))) //initial temperature //
    unit:K
16 printf("The initial temperature of the process is %f
    K or %f C\n",T1,T1-273)

```

Scilab code Exa 6.24 Determine deltas deltas and flow work

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.24\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.24 (page no. 267)
6 // Solution
7
8 //data given
9 T2=460+400; //Fahrenheit temperature converted to
    absolute final temperature //unit:R
10 T1=460+70; //Fahrenheit temperature converted to
    absolute initial temperature //unit:R
11 cp=0.24; //specific heat at constant pressure //Btu/
    lbm*R
12 J=778; //conversion factor
13 R=1545/29; //moleculer weight=29 //Unit: ft*lbf/lbm*R
    //constant of proportionality
14 //From the energy equation for the constant-pressure
    process ,the heat transferred is deltax. Therefore
15 //q=deltax=cp*(T2-T1)

```

```

16 deltah=cp*(T2-T1); //heat transferred //Btu/lb //
    into system
17 printf("The heat transferred is %f Btu/lb(into
    system)\n",deltah);
18 deltas=cp*log(T2/T1); //increase in entropy //Btu/
    lbm*R
19 printf("The increase in entropy is %f Btu/lbm*R\n",
    deltas);
20 //The flow work change is (p2*v2)/J - (p1*v1)/J = (R
    /J)*(T2-T1)
21 flowworkchange=(R/J)*(T2-T1); //Btu/lbm //The flow
    work change per pound of air
22 printf("The flow work change per pound of air is %f
    Btu/lbm\n",flowworkchange);
23 //In addition to each of the assumptions made in all
    the process being considered,it has further been
    tacitly assumed that these processes are carried
    out quasi-          statically and without friction.

```

Scilab code Exa 6.25 Determine the heat transferred and the increase in entropy per kg of air

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.25\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.25 (page no. 268)
6 // Solution
7
8 //data given
9 T2=500+273; //Celsius temperature converted to
    Kelvin //final temperature
10 T1=20+273; //Celsius temperature converted to Kelvin
    //initial temperature
11 cp=1.0062; //specific heat at constant pressure //kJ

```

```

    /kg*K
12 //From the energy equation for the constant-pressure
    process ,the heat transferred is deltah. Therefore
    ,
13 //q=deltah=cp*(T2-T1)
14 deltah=cp*(T2-T1); //heat transferred //kJ/kg //into
    system
15 printf("The heat transferred is per kilogram of air
    %f kJ/kg\n",deltah);
16 deltas=cp*log(T2/T1); //increase in entropy //kJ/kg*
    K
17 printf("The increase in entropy per kilogram of air
    is %f kJ/kg*K\n",deltas);

```

Scilab code Exa 6.26 Determine the heat added and work out of the system

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.26\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.26 (page no. 270)
6 // Solution
7
8 //data given
9 v2=2; //Because ,v2=(2)*v1 //volume increases to its
    twice its final volume
10 v1=1; //initial volume
11 T=460+200; //Fahrenheit temperature converted to
    absolute temperature
12 J=778; //conversion factor
13 R=1545/28; //molecular weight of nitrogen=28 //Unit:
    ft*lbm/lbm*R //constant of proportionality
14 //From the equation , w/J=q=T*deltas=((R*T)/J)*log(v2
    /v1)

```

```

15 q=((R*T)/J)*log(v2/v1); //Btu/lbm //the heat added
    to system
16 //For 0.1 lb ,
17 Q=0.1*q; //Btu //the heat added to system
18 printf("The heat added to system is %f Btu\n",Q);
19 //The work out of the system is equal to the heat
    added;thus ,
20 WbyJ=Q; //The work out of the system(out of the
    system) //unit:Btu
21 printf("The work out of the system is %f Btu(out of
    the system)\n",WbyJ);

```

Scilab code Exa 6.27 Determine the heat added and workout of the system

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.27\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.27 (page no. 270)
6 // Solution
7
8 //data given
9 T=50+273; //Celsius temperature converted to Kelvin
    //final temperature //unit:K
10 v2=1/2; //Because ,v2=(1/2)*v1 //volume increases to
    its half its final volume
11 v1=1;
12 R=8.314/32; //moleculer weight of oxygen=32 //Unit:
    kJ/kg*K //constant of proportionality
13 //From the equation , q=((R*T))*log(v2/v1)
14 q=R*T*log(v2/v1); //heat added //kJ/kg
15 printf("The heat added to system is %f kJ/kg(heat
    out of system)\n",q);
16 //The work out of the system is equal to the heat

```

```

    added;thus ,
17 W=q; //The work out of the system //unit:kJ/kg
18 printf("The work out of the system is %f kJ/kg(into
    system)\n",W);

```

Scilab code Exa 6.28 Determine the change in entropy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.28\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.28 (page no. 271)
6 // Solution
7
8 //data given in problem 6.27
9 T=50+273; //Celsius temperature converted to Kelvin
    //final temperature
10 v2=1/2; //Because ,v2=(1/2)*v1 //volume increases to
    its half its final volume
11 v1=1;
12 R=8.314/32; //molecular weight of oxygen=32 //Unit:
    kJ/kg*K //constant of proportionality
13 //From the equation , q=((R*T))*log(v2/v1)
14 q=R*T*log(v2/v1); //heat added //kJ/kg
15 printf("The heat added to system is %f kJ/kg(heat
    out of system)\n",q);
16 //For a constant temperature ,
17 deltas=q/T; //Change in entropy //unit:kJ/kg*K
18 printf("The change in entropy is %f kJ/kg*K\n",
    deltas);

```

Scilab code Exa 6.29 Determine the final state and work done by the air

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.29\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.29 (page no. 274)
6 // Solution
7
8 //data given
9 T1=1000; //absolute initial temperature //unit:R
10 p2=1; //unit:atm //absolute final pressure
11 p1=5; //unit:atm //absolute initial pressure
12 J=778; //conversion factor
13 R=1545/29; //molecular weight=29 //Unit:ft*lbm/lbm*R
    //constant of proportionality
14 k=1.4; //k=cp/cv //ratio of specific heats
15 //From the equation ,
16 T2=T1*((p2/p1)^((k-1)/k)); //Unit:R //The absolute
    final temperature
17 printf("The absolute final temperature is %f R\n",T2
    );
18 work=(R*(T2-T1))/(J*(1-k)); //Btu/lbm //The work
    done by air(out)
19 printf("The work done by air is %f Btu/lbm(out)\n",
    work)

```

Scilab code Exa 6.30 Determine the final state and work done

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.30\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.30 (page no. 274)
6 // Solution
7
8 //data given

```

```

 9 //mass of 1 kg
10 T1=500+273; //Celsius temperature converted to
    Kelvin //final temperature
11 p2=1; //atm //absolute final pressure
12 p1=5; //atm //absolute initial pressure
13 J=778; //conversion factor
14 R=8.314/29; //molecular weight=29 //Unit:kJ/kg*K //
    constant of proportionality
15 k=1.4; //k=cp/cv //ratio of specific heat
16 //From the equation ,
17 T2=T1*((p2/p1)^((k-1)/k)); //Unit:Kelvin //The
    absolute final temperature
18 printf("The absolute final temperature is %f K or %f
    C\n",T2,T2-273);
19 work=(R*(T2-T1))/((1-k)); //kJ/kg //The work done by
    air(out)
20 printf("The work done by air is %f kJ/kg(out)\n",
    work)

```

Scilab code Exa 6.31 Determine value of k

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.31\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.31 (page no. 275)
6 // Solution
7
8 //data given
9 T1=800+273; //Celsius temperature converted to
    Kelvin //initial temperature
10 T2=500+273; //Celsius temperature converted to
    Kelvin //final temperature
11 p2=1; //atm //absolute final pressure
12 p1=5; //atm //absolute initial pressure

```

```

13 //A gas expands isentropically
14 //From the equation ,
15 //T2/T1=((p2/p1) ^((k-1)/k));
16 //rearranging ,
17 k=inv(1-((log(T2/T1)/log(p2/p1)))); //k=cp/cv //
    Ratio of specific heats
18 printf("Ratio of specific heats (k) is %f\n",k);

```

Scilab code Exa 6.32 Determine q work and change in entropy

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.32\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.32 (page no. 279)
6 // Solution
7
8 //data given
9 n=1.3; //p*v^1.3=constant
10 k=1.4; //k=cp/cv Ratio of specific heats
11 cp=0.24; //specific heat at constant pressure //Btu/
    lbm*R
12 T2=600; //absolute final temperature //unit:R
13 T1=1500; //absolute initial temperature //unit:R
14 R=53.3; //Unit:ft*lbf/lbm*R //constant of
    proportionality
15 J=778; //conversion factor
16 cv=cp/k; //specific heat at constant volume //Btu/
    lbm*R
17 //Therefore ,
18 cn=cv*((k-n)/(1-n)); //Polytropic specific heat //
    Btu/lbm*R
19 printf("Polytropic specific heat(cn) is %f Btu/lbm*R
    \n",cn);
20 //The negative sign of cn indicates that either the

```



```

    heat transfer for the process comes from the
    system or there is a negative temperature change
    while heat is transferred to the system.
21 //The heat transferred is cn*(T2-T1).Therefore ,
22 q=cn*(T2-T1); //heat transferred //Btu/lbm(to the
    system)
23 printf("The heat transferred is %f Btu/lbm(to the
    system)\n",q);
24 //The work done can be found using equation ,
25 w=(R*(T2-T1))/(J*(1-n)); //Btu/lbm //the workdone(
    from the system)
26 printf("The work done is %f Btu/lbm(from the system)
    \n",w);
27 deltas=cn*log(T2/T1)' //change in entropy //Btu/lbm*
    R
28 printf("The change in enthalpy is %f Btu/lbm*R\n",
    deltas);

```

Scilab code Exa 6.33 Ratio of inlet pressure to outlet pressure

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.33\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.33 (page no. 279)
6 // Solution
7
8 //data given in problem 6.32,
9 n=1.3; //p*v^1.3=constant
10 k=1.4; //k=cp/cv //ratio of specific heats
11 cp=0.24; //specific heat at constant pressure //Btu/
    lbm*R
12 T2=600; //absolute final temperature //unit:R
13 T1=1500; //absolute initial temperature //unir:R
14 R=53.3; //Unit:ft*lbm/lbm*R //constant of

```

```

    proportionality
15 J=778; //conversion factor
16 //Equation ,
17 //  $T1/T2=((p1/p2)^{((n-1)/n)})$ ;
18 //rearranging ,
19  $p1byp2=\exp(\log(T1/T2)/((n-1)/n))$ ; //The ratio of
    inlet to outlet pressure
20 printf("The ratio of inlet to outlet pressure is %f\
    n",p1byp2);

```

Scilab code Exa 6.34 Change in enthalpy internal energy and entropy

```

1 clear;
2 clc;
3 printf("\\t\\t\\tProblem Number 6.34\\n\\n\\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.34 (page no. 284)
6 // Solution
7
8 //From the table at 1000 R: //
    From the table at 500 R:
9 h2=240.98; // h1
    =119.48;
10 //Btu/lbm //enthalpy //
    Btu/lbm //enthalpy
11 u2=172.43; // u1
    =85.20;
12 //Btu/lbm //internal energy //
    Btu/lbm //internal energy
13 fy2=0.75042; // fy1
    =0.58233;
14 //Btu/lbm*R //
    Btu/lbm*R
15
16 //The change in enthalpy is

```

```

17 deltax=h2-h1; //Btu/lbm
18 //The change in internal energy is
19 deltau=u2-u1; //Btu/lbm
20 printf("The change in enthalpy is %f Btu/lbm & the
        change in internal energy is %f Btu/lbm\n",deltah
        ,deltau);
21 //Because in the constant-pressure process  $-R\log(p2
        /p1)$  is zero ,
22 deltax=fy2-fy1; //Btu/lbm*R //The entropy when air
        is heated at constant pressure
23 printf("The entropy when air is heated at constant
        pressure is %f Btu/lbm/R\n",deltax);

```

Scilab code Exa 6.35 Determine final temperature and workdone

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.35\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.35 (page no. 285)
6 // Solution
7
8 //In this problem,the air expands from 5 atm
        absolute to 1 atm absolute from an initial
        temperature of 1000R,
9 pr=12.298; //relative pressure //unit:atm
10 h=240.98; //Btu/lbm //enthalpy
11 pr=12.298/5; //The value of the final relative
        pressure //unit:atm
12 //Interpolation in the air table yields the
        following:
13 //   T       pr
14 //   620     2.249
15 //           2.4596
16 //   640     2.514

```

```

17 T=620+(((2.4596-2.249)/(2.514-2.249))*20); //the
    final temperature //unit:R
18 printf("The absolute final temperature is %f R\n",T)
    ;
19 u1=172.43; //initial internal energy //Btu/lbm
20 u2=108.51; //final internal energy //Btu/lbm
21 work=u1-u2; //Btu/lbm The work done by air in an
    isentropic nonflow expansion //where the value of
    u2 is obtained by interpolation at T
    temperature and the value of u1 is read from the
    air table at 1000 R.
22 printf("The work done by air in an isentropic
    nonflow expansion is %f Btu/lbm(out)\n",work)

```

Scilab code Exa 6.36 Determine the velocity of sound air and hydrogen

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.36\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.36 (page no. 288)
6 // Solution
7
8 T=1000+460; //Fahrenheit temperature converted to
    absolute temperature
9 //The velocity of sound in air at 1000 F is
10 Va=49.0*sqrt(T); //velocity //ft/s
11 printf("The velocity of sound air at 1000 F is %f ft
    /s\n",Va);
12 //Hydrogen has a specific heat ratio of 1.41 and R
    =766.53. Therefore ,
13 khydrogen=1.41; //specific heats ratio for air
14 kair=1.40; //specific heats ratio for air
15 Rhydrogen=766.53; //gas constant //ft*lbf/lbm*R
16 Rair=53.36; //gas constant //ft*lbf/lbm*R

```

```

17 // Vahydrogen/Vaair = sqrt((Rhydrogen*khydrogen)/(
    Rair*kair))
18 //rearranging ,
19 Vahydrogen=Va*sqrt((Rhydrogen*khydrogen)/(Rair*kair)
    ); //The velocity of sound in hydrogen at 1000 F
    //unit:ft/s
20 printf("The velocity of sound in hydrogen at 1000 F
    is %f ft/s\n",Vahydrogen);

```

Scilab code Exa 6.37 Determine the mach number

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.37\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.37 (page no. 288)
6 // Solution
7
8 T=200+460; //Fahrenheit temperature converted to
    absolute temperature //unit:R
9 V=1500; //ft/s //the local velocity
10 Va=49.0*sqrt(T); //velocity of sound air at 200 F
    //unit:ft/s
11 printf("The velocity of sound air at 200 F is %f ft/
    s\n",Va);
12 M=V/Va; //The Mach number=the local velocity/
    velocity of sound //unitless
13 printf("The Mach number is %f\n",M);

```

Scilab code Exa 6.38 Determine the total enthalpy

```

1 clear;
2 clc;

```

```

3 printf("\t\t\tProblem Number 6.38\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.38 (page no. 290)
6 // Solution
7
8 //data given
9 V=1000; //ft/s //the fluid velocity
10 gc=32.17; //Unit:(Lbm*ft)/(Lbf*s^2) //gc is constant
    of proportionality
11 J=778; //conversion factor
12 h=1204.4; //Btu/lbm //enthalpy of saturated steam
13 //h0-h=V^2/(2*gc*J)
14 h0=h+((V^2)/(2*gc*J)); //Btu/lbm //h0=stagnation
    enthalpy
15 printf("The total enthalpy is %f Btu/lbm\n",h0);
16 //It will be noted for this problem that if the
    initial velocity had been 100ft/s,deltah would
    have been 0.2 Btu/lbm,and for most practical
    purposes,the total properties and those of
    the flowing fluid would have been essentially the
    same.Thus,for low-velocity fluids,the difference
    in total and steam properties can be
    neglected.

```

Scilab code Exa 6.39 Converging and Diverging Nozzles

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.39\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.39 (page no. 297)
6 // Solution
7
8 k=1.4; //the specific heats ratio //k=cp/cv
9 M=1; //(table 6.5) //The Mach number=the local

```

```

    velocity/velocity of sound
10 T0=800; //absolute temperature //unit:R
11 gc=32.17; //Unit:(Lbm*ft)/(Lbf*s^2) //gc is constant
    of proportionality
12 R=53.35; //gas constant //ft*lbf/lbm*R
13 p0=300; //psia //pressure
14
15 // * or "star" subscripts to conditions in which M
    =1;
16 // "0" subscript refers to isentropic stagnation
17 //Refer to figure 6.26,
18 //Tstar/T0=0.8333
19 Tstar=T0*0.8333; //temperature when M=1 //unit:R
20 printf("If the mach number at the outlet is unity,
    temperature is %f R\n",Tstar);
21 Vat=sqrt(gc*R*Tstar*k); //ft/s //Vat=V2 //local
    velocity of sound
22 printf("If the mach number at the outlet is unity,
    velocity is %f ft/s\n\n",Vat)
23
24 //For A/Astar=2.035
25 //The table yields
26 M1=0.3; //mach number at inlet
27 printf("At inlet ,The mach number is %f\n",M1)
28 //pstar/p0=0.52828
29 pstar=p0*0.52828; //pressure when M=1 //psia
30 //also ,
31 //T1/T0=0.98232 and p1/p0=0.93947
32 //Therefore ,
33 T1=T0*0.982332; //unit:R //T1=temperature at inlet
34 printf("At inlet ,The temperature is %f R\n",T1);
35 p1=p0*0.93947; //psia //p1=pressure at inlet
36 printf("At inlet ,The pressure is %f psia\n",p1);
37 //From the inlet conditions derived ,
38 Va1=sqrt(gc*k*R*T1); //ft/s //V1=velocity at inlet
39 V1=M1*Va1; //ft/s //velocity
40 printf("At inlet ,The velocity is %f ft/s\n",V1);
41 //The specific volume at inlet is found from the

```

```

    equation of state for an ideal gas:
42 v=(R*T1)/(p1*144); //ft^3/lbm //1 ft^2=144 in^2(for
    conversion of unit) //specific volume
43 rho=inv(v); //inverse of specific volume //density
44 A=2.035; //area //ft^2
45 m=rho*A*V1; //mass flow //unit:lbm/s
46 printf("At inlet ,The mass flow is %f lbm/s\n",m);

```

Scilab code Exa 6.40 Converging and Diverging Nozzles

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.40\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.40 (page no. 299)
6 // Solution
7
8 // * or "star" subscripts to conditions in which M
   =1;
9 // "0" subscript refers to isentropic stagnation
10 //This problem will be solved by two methods(A and B
   )
11 printf("Method A\n"); //By equations:
12 k=1.4; //the specific heat ratio //k=cp/cv
13 R=53.3; //gas constant //ft*lbm/lbm*R
14 M=2.5; //mach number=the local velocity/velocity of
   sound
15 printf("Solution for (a)\n");
16 // T/Tstar = (k+1)/(2*(1+((1/2)*(k-1)*M^2)))
17 // Tstar/T0=2/(k+1)
18 //Therefore ,
19 // (Tstar/T0)*(T/Tstar) = (T/T0)=1/(1+((1/2)*(k-1)*M
   ^2))
20 T0=560; //absolute temperature or stagnation
   temperature //unit:R

```



```

21 T=T0/(1+((1/2)*(k-1)*M^2)); //temperature at M=2.5
22 printf("The temperature is %f R\n\n",T);
23 printf("Solution for (b)\n");
24 p=0.5; //static pressure //unit:psia
25 // p0/p = (T0/T)^(k/(k-1))
26 p0=p*14.7*((T0/T)^(k/(k-1))); //pressure at M=2.5 //
    unit:psia
27 printf("The pressure is %f psia\n\n",p0);
28 printf("Solution for (c)\n");
29 gc=32.17; //Unit:(Lbm*ft)/(Lbf*s^2) //gc is constant
    of proportionality
30 Va=sqrt(gc*k*R*T); //ft/s //local velocity of sound
31 V=M*Va; //valocity at M=2.5 //unit:ft/s
32 printf("The velocity is %f ft/s\n\n",V);
33 printf("Solution for (d)\n");
34 v=(R*T)/(p*14.7*144); //ft^3/lbm //1 ft^2=144 in^2
    //specific volume at M=2.5
35 printf("The specific volume is %f ft^3/lbm\n\n",v);
36 printf("Solution for (e)\n");
37 //Mass velocity is definrd as the mass flow per unit
    area
38 // m/A=(A*V)/(v*A)=V/v
39 printf("The mass velocity is %f lbm/(s*ft^2)\n\n\n",
    V/v); //mass velocity at M=2.5
40
41
42 printf("Method B\n"); //By the gas tables: //table
    6.5 gives
43 M=2.5; //mach number=the local velocity/velocity of
    sound
44 printf("Solution for (a)\n");
45 T0=560; //absolute temperature or stagnation
    temperature
46 //T/T0=0.44444
47 T=T0*0.44444; //temperature at M=2.5
48 printf("The temperature is %f R\n\n",T)
49 printf("Solution for (b)\n");
50 p=0.5; //static pressure

```

```

51 //p/p0=0.05853
52 p0=(p*14.7)/0.05853; //pressure at M=2.5
53 printf("The pressure is %f psia\n\n",p0);
54 printf("Solution for (c)\n");
55 printf("As before %f ft/s\n\n",V)
56 printf("Solution for (d)\n");
57 printf("As before %f ft^3/lbm\n\n",v)
58 printf("Solution for (e)\n");
59 printf("As before %f lbm/(s*ft ^1)\n",V/v)

```

Scilab code Exa 6.41 Real Gases

```

1 clear;
2 clc;
3 printf("\t\t\tProblem Number 6.41\n\n\n");
4 // Chapter 6: The Ideal Gas
5 // Problem 6.41 (page no. 304)
6 // Solution
7
8 //For Methane(CH4,MW=16)
9 p=500; //evaluate specific volume at p pressure //
   Unit:psia
10 pc=674; //critical temperature //Unit:psia
11 T=50+460; //evaluate specific volume at T
   temperature //Unit:R
12 Tc=343; //critical temperature //Unit:R
13 R=1545/16; //gas constant R = 1545/Molecular Weight
   //ft*lb/ft^2*lbm*R
14 pr=p/pc; //reduced pressure //unit:psia
15 Tr=T/Tc; //reduced temperature //unit:R
16 //Reading figure 6.28 at these values gives
17 Z=0.93; //compressibility factor
18 //Z=(p*v)/(R*T)
19 v=Z*((R*T)/(p*144)); //ft^3/lbm //1 ft^2=144 in^2(
   for conversion of unit) //specific volume

```

```
20 printf("Using the value of Z=0.93,the specific
    volume is %f ft^3/lbm\n",v);
21 //For ideal gas,
22 v=(R*T)/(p*144); //ft^3/lbm //1 ft^2=144 in^2(for
    conversion of unit) //specific volume
23 printf("For the ideal gas,the specific volume is %f
    ft^3/lbm\n",v);
```

Chapter 7

Mixtures Of Ideal Gases

Scilab code Exa 7.1 Dry air mixture of oxygen and nitrogen

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.1\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.1 (page no. 322)
7 // Solution
8
9 //As the basis of the calculation ,assume that we
   have 1 lbm of mixture.Also,take the molecular
   weight of oxygen to be 32.00 and nitrogen to be
   28.02.(from table7.1)
10 printf("Solution for (a)\n");
11 nO2=0.2315/32; //no of moles of oxygen=ratio of mass
   and molecular weight //0.2315 lb of oxygen per
   pound
12 printf("The moles of oxygen is %f mole/lbm of
   mixture\n",nO2);
13 nN2=0.7685/28.02; //no of moles of nitrogen=ratio of
   mass and molecular weight //0.7685 lb of
   nitrogen per pound
```

```

14 printf("The moles of nitrogen is %f mole/lbm of
      mixture\n",nN2);
15 nm=nO2+nN2; //Unit:Mole/lbm //number of moles of gas
      mixture is sum of the moles of its constituent
      gases
16 printf("The total number of moles is %f mole/lbm\n",
      nm);
17 xO2=nO2/nm; //mole fraction of oxygen=ratio of no of
      moles of oxygen and total moles in mixture
18 xN2=nN2/nm; //mole fraction of nitrogen=ratio of no
      of moles of oxygen and total moles in mixture
19 printf("The mole fraction of oxygen is %f and the
      mole fraction of nitrogen is %f\n",xO2,xN2);
20 //(Check:xO2+xN2=1)
21 printf("xO2+xN2=%f\n\n",xO2+xN2);
22
23 printf("Solution for (b)\n");
24 // the air is at 14.7 psia
25 pO2=xO2*14.7; //the partial pressure of oxygen=
      pressure of air * the mole fraction of oxygen //
      psia
26 printf("The partial pressure of oxygen is %f psia\n"
      ,pO2);
27 pN2=xN2*14.7; //the partial pressure of nitrogen=
      pressure of air * the mole fraction of nitrogen
      //psia
28 printf("The partial pressure of nitrogen is %f psia\
      n\n",pN2);
29
30 printf("Solution for (c)\n");
31 MWm=(xO2*32) + (xN2*28.02); //the molecular weight
      of air=sum of products of mole fraction of each
      gas component
32 printf("The molecular weight of air is %f\n\n",MWm);
33
34 printf("Solution for (d)\n");
35 Rm=1545/MWm; //the gas constant of air
36 printf("The gas constant of air is %f\n\n",Rm);

```

Scilab code Exa 7.2 Determine molecular weight and partial pressure

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.2\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.2 (page no. 323)
7 // Solution
8
9 //For Gaseous Freon-12 (CCl2F2)
10 //MW of air=29 & MW of freon-12=120.9
11 //initial pressure in tank is atmospheric pressure
    that is 14.7 psia
12 //final pressure of tank is 1000 psia
13 //The partial pressure of the Freon-12 is 1000-14.7
14 printf("The partial pressure of the Freon-12 is %f\n
    ",1000-14.7)
15 //the mole fraction of air=the initial pressure /
    final pressure
16 printf("The mole fraction of air is %f\n",14.7/1000)
17 //the mole fraction of freon=the partial pressure of
    freon / the final pressure
18 printf("The mole fraction of Freon-12 is %f\n"
    ,(1000-14.7)/1000)
19 MWm=((14.7/1000)*29) + (((1000-14.7)/1000)*120.9);//
    the molecular weight of mixture=sum of products
    of mole fraction of each gas component
20 printf("The molecular weight of the mixture is %f",
    MWm);
```

Scilab code Exa 7.3 Determine moles moles fraction molecular weight and gas constant

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.3\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.3 (page no. 323)
7 // Solution
8
9 //Ten pounds of air ,1 lb of carbon dioxide ,and 5 lb
   of nitrogen are mixed at constant temperature
   until the mixture pressure is constant
10 nair=10/29; //no of moles of air=ratio of mass and
   molecular weight //10 lb of nitrogen per pound //
   molecular weight of air=29
11 printf("The moles of air is %f mole/lbm of mixture\n
   ",nair);
12 nCO2=1/44; //no of moles of carbon dioxide=ratio of
   mass and molecular weight //1 lb of per pound //
   molecular weight of CO2=44
13 printf("The moles of carbon dioxide is %f mole/lbm
   of mixture\n",nCO2);
14 nN2=5/28; //no of moles of nitrogen=ratio of mass
   and molecular weight //5 lb of nitrogen per pound
   //molecular weight of N2=28
15 printf("The moles of nitrogen is %f mole/lbm of
   mixture\n",nN2);
16 nm=nair+nCO2+nN2; //Unit:Mole/lbm //number of moles
   of gas mixture is sum of the moles of its
   constituent gases
17 printf("The total number of moles is %f mole/lbm\n\n
   ",nm);
18
19 xair=nair/nm //mole fraction of air=ratio of no of
   moles of air and total moles in mixture
20 xCO2=nCO2/nm; //mole fraction of carbon dioxide=
```

```

        ratio of no of moles of carbon dioxide and total
        moles in mixture
21  xN2=nN2/nm; //mole fraction of nitrogen=ratio of no
        of moles of oxygen and total moles in mixture
22  printf("The mole fraction of air is %f \n",xair);
23  printf("The mole fraction of carbon dioxide is %f\n"
        ,xC02)
24  printf("The mole fraction of nitrogen is %f\n\n",xN2
        );
25
26  //final pressure of is 100 psia
27  pair=xair*100; //the partial pressure of air= final
        pressure * the mole fraction of air //psia
28  printf("The partial pressure of air is %f psia\n",
        pair);
29  pC02=xC02*100; //the partial pressure of carbon
        dioxide= final pressure * the mole fraction of
        CO2 //psia
30  printf("The partial pressure of carbon dioxide is %f
        psia\n",pC02);
31  pN2=xN2*100; //the partial pressure of nitrogen=
        final pressure * the mole fraction of nitrogen //
        psia
32  printf("The partial pressure of nitrogen is %f psia\
        n\n",pN2);
33
34  //the molecular weight of mixture=sum of products of
        mole fraction of each gas component
35  MWm=(xair*29) + (xC02*44) + (xN2*28); //The
        molecular weight of air
36  printf("The molecular weight of air is %f\n\n",MWm);
37
38  Rm=1545/MWm; //the gas constant of air
39  printf("The gas constant of air is %f\n\n",Rm);

```

Scilab code Exa 7.4 Volume of a mixture

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.4\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.4 (page no. 325)
7 // Solution
8
9 //five moles of oxygen and 10 moles of hydrogen are
   mixed
10 //The total number of moles is 10+5=15. Therefore ,
   mole fraction of each constituent is
11 xO2=5/15; //The mole fraction of oxygen
12 xH2=10/15; //The mole fraction of hydrogen
13 printf("The mole fraction of oxygen is %f and of
   hydrogen is %f\n",xO2,xH2);
14 //the molecular weight of mixture=sum of products of
   mole fraction of each gas component(MW of O2=32
   and MW of H2=2.016)
15 printf("The molecular weight of the final mixture is
   %f\n",((5/15)*32)+((10/15)*2.016));
16 R=1545/32; //the gas constant of oxygen
17 T=460+70; //absolute temperature //Unit:R
18 p=14.7; //pressure //psia
19 //The partial volume of the oxygen can be found as
   follows:per pound of oxygen ,
20 //p*vO2=R*T;
21 vO2=(R*T)/(p*144); //ft^3/lbm //1 in^2=144 ft^2
22 //Because there are 5 moles of oxygen ,each
   containing 32 lbm ,
23 VO2=vO2*5*32; //ft^3 //partial volume of oxygen
24 printf("The partial volume of oxygen is %f ft^3\n",
   VO2);
25 //For the hydrogen ,we can simplify the procedure by
   noting that the fraction of the total volume
   occupied by the oxygen is the same as its mole
```

```

    fraction. Therefore ,
26 Vm=3*V02; //total volume occupied //ft^3
27 printf("The mixture volume is %f ft^3\n",Vm);
28 //and the hydrogen volume
29 VH2=Vm-V02; //Ft^2 //partial volume of hydrogen
30 printf("From simplified procedure,The partial volume
    of hydrogen is %f ft^3\n",VH2);
31
32 //We could obtain the partial volume of hydrogen by
    proceeding as we did for the oxygen.Thus,
33 //p*vH2=R*T;
34 R=1545/2.016; //the gas constant of hydrogen
35 vH2=(R*T)/(p*144); //ft^3/lbm //1 in^2=144 ft^2
36 //Because there are 10 moles of hydrogen,each
    containing 2.016 lbm,
37 VH2=vH2*10*2.016; //ft^3 //partial volume of
    hydrogen
38 printf("The partial volume of hydrogen is %f ft^3\n\
    n",VH2);
39 //Which checks our previous values.
40
41
42 printf("From another method,\n");
43 //As an alternative to the foregoing,we could also
    use the fact that at 14.7 psia and 32F a mole of
    any gas occupies a volume of 358 ft^3.
44 printf("At 70F and 14.7 psia ,a mole occupies %f ft
    ^3\n",358*((460+70)/(460+32)));
45 //Therefore , 5 moles of oxygen occupies
46 V02=5*358*((460+70)/(460+32)); //The partial volume
    of oxygen //ft^3
47 printf("The partial volume of oxygen is %f ft^3\n",
    V02);
48 //and 10 moles of hydrogen occupies
49 VH2=10*358*((460+70)/(460+32)); //The partial volume
    of hydrogen //ft^3
50 printf("The partial volume of hydrogen is %f ft^3\n"
    ,VH2);

```

51 //Both values are in good agreement with the
previous calculations.

Scilab code Exa 7.5 The volume of a mixture

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.5\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.5 (page no. 326)
7 // Solution
8
9 //Referring to figure 7.3,we have for CO2,
10 nCO2=10/44; //mole //no of moles of carbon dioxide=
    ratio of mass and molecular weight //10 lb of per
    pound //molecular weight of CO2=44
11 //and for N2,
12 nN2=5/28.02; //mole //no of moles of nitrogen=ratio
    of mass and molecular weight //5 lb of nitrogen
    per pound
13 printf("The total number of moles in the mixture is
    %f mole\n",nCO2+nN2);
14 //Therefore ,
15 xCO2=nCO2/(nCO2+nN2); //mole fraction of carbon
    dioxide=ratio of no of moles of carbon dioxide
    and total moles in mixture
16 xN2=nN2/(nCO2+nN2); //mole fraction of nitrogen=
    ratio of no of moles of oxygen and total moles in
    mixture
17 printf("The mole fraction of carbon dioxide is %f
    and the mole fraction of nitrogen is %f\n",xCO2,
    xN2);
18 //the molecular weight of mixture=sum of products of
    mole fraction of each gas component
```

```

19 MWm=(xC02*44) + (xN2*28.02); //the molecular weight
    of mixture
20 printf("The molecular weight of air is %f\n",MWm);
21 //Because the mixture is 15 lbm (10CO2 + 5N2),the
    volume of the mixture is found from  $p_m V_m = n R T_m$ 
    Tm
22 pm=100; //mixture pressure //psia
23 Tm=460+70; //mixture temperature //R(absolute
    temperature)
24 Rm=1545/37.0; //gas constant of mixture
25 mm=15; //mass of mixture //Unit:lb
26 //So, rearranging the equation ,gives
27 Vm=(mm*Rm*Tm)/(pm*144); //mixture volume //ft^3 //1
    in^2= 144 ft^2
28 printf("The mixture volume is %f ft^3\n",Vm);
29 //the partial volume of carbon dioxide is the total
    volume multiplied by the mole fraction.Thus,
30 VC02=Vm*xC02; //the partial volume of CO2 //ft^3
31 printf("The partial volume of carbon dioxide is %f
    ft^3\n",VC02);
32 VN2=Vm*xN2; //the partial volume of N2 //ft^3
33 printf("The partial volume of nitrogen is %f ft^3\n"
    ,VN2);
34 //The partial pressure of each constituent is
    proportional to its mole fraction ,for these
    conditions ,
35 pC02=pm*xC02; //the partial pressure of carbon
    dioxide= final pressure * the mole fraction of
    CO2 //psia
36 printf("The partial pressure of carbon dioxide is %f
    psia\n",pC02);
37 pN2=pm*xN2; //the partial pressure of nitrogen=final
    pressure * the mole fraction of nitrogen //psia
38 printf("The partial pressure of nitrogen is %f psia\
    n\n",pN2);

```

Scilab code Exa 7.6 Mixture composition

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.6\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.6 (page no. 327)
7 // Solution
8
9 //we will assume that we have 100 volumes of gas
  mixture and set up table 7.2.In first coloumn ,we
  tabulate the gas ,and in the second coloumn ,we
  tabulate the given volume fractions .Because the
  mole fraction equals to volume fraction ,the
  values in coloumn 3 are the same as those in
  coloumn 2.
10 //The molecular weight is obtained from table 7.1.
  Because the MW of the mixture is the sum of the
  individual mole fraction multiplied by the
  respective molecular weights ,the next
  coloumn tabulates the product of the mole
  fraction multiplied by molecular weight(3*4).The
  sum of these entries is the molecular weight of
  the mixture ,which for this case is 33.4.
11 printf("Basis:100 volumes of gas mixture\n\n")
12 printf("gas      Volume      Mole      Molecular
          mass      \n")
13 printf("          fraction    fraction x    weight MW
          (x)MW      fraction\n")
14 printf("CO2      0.40      0.40      44.0
          %f      %f\n" , (0.40*44.0)
          , (0.40*44.0)/33.4)
15 printf("N2      0.10      0.10      28.02
```

```

          %f          %f          \n"
      ,(28.02*0.10) ,(28.02*0.10)/33.4)
16 printf("H2      0.10      0.10      2.016
          %f          %f          \n"
      ,(0.10*2.016) ,(0.10*2.016)/33.4)
17 printf("O2      0.40      0.40      32.0
          %f          %f          \n"
      ,(0.40*32.0) ,(0.40*32.0)/33.4)
18 printf("
          1.00      1.00
          33.4=MWm          =
1.000          \n ")

```

Scilab code Exa 7.7 Mixture Composition

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.7\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.7 (page no. 328)
7 // Solution
8
9 //We will take as a basis 100 lbm of mixture.
10 //Dividing column 2 by 3 gives us mass/molecular
    weight or moles of each constituents.The total
    number of moles in the mixture is the sum of
    column 4,and the molecular weight of the
    mixture is the mass of the mixture(100 lbm)
    divided by the number of moles
11 //In coloumn 5,mole fraction is given by moles/total
    mole
12
13 printf("Basis:100 pounds of gas mixture\n\n")
14 printf("gas      Mass      Molecular      Moles
          Mole      Percent      \n")

```

```

15 printf("          lbm          weight MW
          fraction          Volume
          \n")
16 printf("CO2      52.7          44.0          1.2
          %f          %f          \n", (1.2/3)
          , (1.2/3)*100)
17 printf("N2       8.4          28.02         0.3
          %f          %f          \n", (0.3/3)
          , (0.3/3)*100)
18 printf("H2       0.6          2.016         0.3
          %f          %f          \n", (0.3/3)
          , (0.3/3)*100)
19 printf("O2       38.3         32.0          1.2
          %f          %f          \n", (1.2/3)
          , (1.2/3)*100)
20 printf("          =100.0          =3.0
          =1.00          = 100
          \n ")
21 printf("          MWm=100/3=33.3
          ")

```

Scilab code Exa 7.8 Mixture Composition

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.8\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.8 (page no. 329)
7 // Solution
8
9 //We will take as a basis 100 lbm of mixture.
10 //Dividing column 2 by 3 gives us mass/molecular
    weight or moles of each constituents.The total
    number of moles in the mixture is the sum of

```

```

        column 4,and the      molecular weight of the
        mixture is the mass of the mixture(100 lbm)
        divided by the number of moles
11 //In coloumn 5,mole fraction is given by moles/total
    mole
12
13 printf("Basis:100 pounds of gas mixture\n\n")
14 printf("gas      Mass      Molecular      Moles
15 printf("      lbm      weight MW      Volume
16 printf("O2      23.18      32.00      0.724
17 printf("N2      75.47      28.02      2.693
18 printf("A      1.30      39.90      0.033
19 printf("CO2     0.05      44.00      -
20 printf("      =100.00      -      =3.45
21 printf("      =1.00      = 100
21 printf("      MWm
    =100/3.45=28.99      ")

```

Scilab code Exa 7.9 Thermodynamic properties of a gas mixture

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.9\n\n\n");

```



```

5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.9 (page no. 331)
7 // Solution
8
9 //Given: cp of oxygen is 0.23 Btu/lbm*R. cp of
    nitrogen is 0.25 Btu/lbm*R. 160 lbm/hr of oxygen
    and 196 lbm/hr of nitrogen are mixed. oxygen is at
    500 F and nitrogen is at 200 F.
10
11 //The energy equation for the steady-flow, adiabatic
    mixing process gives us the requirement that the
    enthalpy of the mixture must equal to the
    enthalpies of the components, because  $\Delta h = q = 0$ . An alternative statement of this requirement
    is that the gain in enthalpy of the nitrogen must
    equal the decrease in enthalpy of the oxygen.
    Using the latter statement, that the change in
    enthalpy of nitrogen, yields
12 //  $(160 \cdot 0.23 \cdot (500 - t_m)) = (196 \cdot 0.25 \cdot (t_m - 200))$  where
     $t_m$  = mixture temperature
13 //where  $m \cdot c_p \cdot \Delta t$  has been used for  $\Delta h$ . //cp=
    specific heat at constant pressure //Unit for cp
    is Btu/lbm*R
14 //rearranging the above equation,
15  $t_m = ((500 \cdot 160 \cdot 0.23) + (196 \cdot 0.25 \cdot 200)) / ((196 \cdot 0.25)$ 
     $+ (160 \cdot 0.23))$ ; // $t_m$  = mixture temperature //Unit:
    fahrenheit
16 printf("The final temperature of the mixture is %f F
    \n", t_m);
17 //Using the requirement that the enthalpy of the
    mixture must equal to the sum of the enthalpies
    of the components yields an alternative solution
    to this problem. Let us assume that at 0 F, the
    enthalpy of each gas and of the mixture is zero.
    The enthalpy of the entering oxygen is
     $(160 \cdot 0.23 \cdot (500 - 0))$ , and the enthalpy of the
    entering nitrogen is  $(196 \cdot 0.25 \cdot (200 - 0))$ .
    The enthalpy of the mixture is  $((160 + 196) \cdot c_{pm} \cdot (t_m$ 

```

```

-0))
18 //Therefore , (160*0.23*500)+(196*0.25*200) =
    ((160+196)*cpm*tm)
19 cpm=((160/(160+196))*0.23)+((196/(160+196))*0.25);
    //specific heat at constant pressure for gas
    mixture //Btu/lbm*R
20 printf("For mixture ,Specific heat at constant
    pressure is %f Btu/lbm*R\n",cpm);
21 //therefore ,
22 tm=((160*0.23*500)+(196*0.25*200))/(cpm*(160+196));
    //tm=mixture temperature //Unit:fahrenheit
23 printf("By using value of cpm,The final temperature
    of the mixture is %f F\n",tm);
24 //The use of 0 F as a base was arbitrary but
    convenient.Any base would yield the same results.
25 //The answer of cpm is wrong in the book.

```

Scilab code Exa 7.10 The final temperature of the mixture

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.10\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.10 (page no. 332)
7 // Solution
8
9 //Problem 7.9 is carried out as a nonflow mixing
    process.
10 //Given in problem 7.9 ,: cp of oxygen is 0.23 Btu/
    lbm*R.cp of nitrogen is 0.25 Btu/lbm*R. 160 lbm/
    hr of oxygen and 196 lbm/hr of nitrogen are mixed
    .oxygen is at 500F and nitrogen is at 200 F. //
    cp=specific heat at constant pressure
11 //Given in problem 7.10 ,: cv of oxygen is 0.164 Btu/

```

```

    lbm*R.cv of nitrogen is 0.178 Btu/lbm*R. //cv=
    specific heat at constant volume
12
13 //Because this is a nonflow process ,the energy
    equation for this process requires the internal
    energy of the mixture to equal to the sum of the
    internal energy of its components.
14 //Alternatively ,the decrease in internal energy of
    the oxygen must equal the increase in internal
    energy of the nitrogen.Using latter statement
    gives us ,
15 // (160*0.164*(500-tm)) = (196*0.178*(tm-200))
16 //where m*cv*deltat has been used for deltau. //Unit
    for cp & cv is Btu/lbm*R
17 //rearranging the above equation ,
18 tm=((500*160*0.164)+(196*0.178*200))/((196*0.178)
    +(160*0.164)); //tm=mixture temperature //Unit:
    fahrenheit
19 printf("The final temperature of the mixture is %f F
    \n",tm);

```

Scilab code Exa 7.12 The change in entropy

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.12\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.12 (page no. 334)
7 // Solution
8
9 //The change in entropy of the mixture is the sum of
    the changes in entropy of each component.
10 //Given in problem 7.9 ,: cp of oxygen is 0.23 Btu/
    lbm*R.cp of nitrogen is 0.25 Btu/lbm*R. 160 lbm/

```

```

    hr of oxygen and 196 lbm/hr of nitrogen are mixed
    .oxygen is at 500F and nitrogen is at 200 F. //
    cp=specific heat at constant pressure
11 //In 7.9,for the oxygen,the temperature starts at
    500F(960 R) and decreases to 328.7 F.For the
    nitrogen ,the temperature starts at 200F(660 R)
    and increase to 328.7 F.
12 //deltas = (cp*log(T2/T1)); //Unit:Btu/lbm*R //
    change in entropy
13
14 //For the oxygen ,
15 cp=0.23; //specific heat at constant pressure //Unit
    :Btu/lbm*R
16 T2=328.7+460; //Unit:R //final temperature
17 T1=500+460; //Unit:R //starting temperature
18 deltas=(cp*log(T2/T1)); //Unit:Btu/lbm*R //change in
    entropy for oxygen
19 DeltaS=160*deltas; //Btu/R //The total change in
    entropy of the oxygen
20 printf("The total change in entropy of the oxygen is
    %f Btu/R\n",DeltaS);
21
22 //For the nitrogen ,
23 cp=0.25; //specific heat at constant pressure //Unit
    :Btu/lbm*R
24 T2=328.7+460; //Unit:R //final temperature
25 T1=200+460; //Unit:R //starting temperature
26 deltas=(cp*log(T2/T1)); //Unit:Btu/lbm*R //change in
    entropy for nitrogen
27 deltaS=196*deltas; //Btu/R //The total change in
    entropy of the nitrogen
28 printf("The total change in entropy of the nitrogen
    is %f Btu/R\n",deltaS);
29 deltaS=deltaS+DeltaS; //the total change in entropy
    for the mixture //Btu/lbm*R
30 printf("The total change in entropy for the mixture
    is %f Btu/R\n",deltaS);
31

```

```

32 //Per pound of mixture ,
33 deltam=deltaS/(196+160); //increase in entropy per
    pound mass of mixture
34 printf("Increase in entropy per pound mass of
    mixture is %f Btu/lbm*R\n\n",deltasm);
35
36
37 printf("An alternative solution:\n");
38 //As an alternative solution ,assume an arbitrary
    datum of 0 F(460 R).
39 cp=0.23; //specific heat at constant pressure //Unit
    :Btu/lbm*R
40 //For initial entropy of oxygen ,
41 T2=500+460; //Unit:R //final temperature
42 T1=0+460; //Unit:R //starting temperature
43 deltas=cp*log(T2/T1); //the initial change in
    entropy for oxygen // Btu/lbm*R
44 printf("The initial change in entropy for oxygen is
    %f Btu/lbm*R\n",deltas);
45 //For final entropy of oxygen ,
46 T2=328.7+460; //Unit:R //final temperature
47 T1=0+460; //Unit:R //starting temperature
48 Deltas=cp*log(T2/T1); //the final change in entropy
    for oxygen // Btu/lbm*R
49 printf("The final change in entropy for oxygen is %f
    Btu/lbm*R\n",Deltas);
50 deltaS=Deltas-deltas; //The entropy change of the
    oxygen //Btu/lbm*R
51 printf("The entropy change of the oxygen is %f Btu/
    lbm*R\n",deltaS);
52
53 //For nitrogen ,
54 cp=0.25; //specific heat at constant pressure //Unit
    :Btu/lbm*R
55 //For initial entropy of nitrogen ,
56 T2=200+460; //Unit:R //final temperature
57 T1=0+460; //Unit:R //starting temperature
58 deltas=cp*log(T2/T1); //the initial change in

```

```

    entropy for nitrogen // Btu/lbm*R
59 printf("The initial change in entropy for nitrogen
    is %f Btu/lbm*R\n",deltas);
60 //For final entropy of nitrogen ,
61 T2=328.7+460; //Unit:R //final temperature
62 T1=0+460; //Unit:R //starting temperature
63 Deltas=cp*log(T2/T1); //the final change in entropy
    for nitrogen // Btu/lbm*R
64 printf("The final change in entropy for nitrogen is
    %f Btu/lbm*R\n",Deltas);
65 deltaS=Deltas-deltas; //The entropy change of the
    nitrogen //Btu/lbm*R
66 printf("The entropy change of the nitrogen is %f Btu
    /lbm*R\n",deltaS);
67
68 //The remainder of the problem is as before.The
    advantage of using this alternative method is the
    negative logarithms are avoided by choosing a
    reference temperature lower than any
    other temperature in the system

```

Scilab code Exa 7.13 The dew point temperature

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.13\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.13 (page no. 338)
7 // Solution
8
9 //Referring to figure 7.6,it will be seen that the
    cooling of an air–water vapor mixture from B to A
    proceeds at constant pressure until the
    saturation curve is reached.

```

```

10 //At 80 F(the mixture temperature),the Steam Tables
    give us a saturation pressure of a 0.5073 psia ,
    and because the relative humidity is 50%,the
    vapor pressure of the water is 0.5*0.5073=0.2537
    psia .
11 //Using the steam tables ,the saturation temperature
    corresponding to 0.2537 psia is 60 F.
12 //So ,
13 printf("The dew point temperature of the air is 60 F
    \n")

```

Scilab code Exa 7.14 Air water vapor mixture

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.14\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.14 (page no. 338)
7 // Solution
8
9 //To solve this probelm ,it is necessary to determine
    the properties of the saturated mixture 90 F.If
    the air is saturated at 90 F,the partial pressure
    of the water vapor is found directly from the
    Steam Tables as 0.6988 psia ,and the specific
    volume of the water vapor is 467.7 ft3/lbm of
    vapor .
10 printf("The partial pressure of the dry air is %f
    psia\n" ,14.7-0.6988); //the mixture is at 14.7
    psia
11 R=1545/28.966; //gas constant of dry air=1545/
    Molecular weight
12 T=90+460; //temperature of dry air //Unit:R
13 pdryair=14.0; //psia //pressure of dry air

```

```

14 //Applying the ideal gas equation to the air ,
15 vdryair=(R*T)/(pdryair*144); //volume of dry air //
    ft^3/lbm //1 in^2=144 Ft^2
16 //the mass of dry air in the 467.7 ft^3 container
17 printf("The mass of dry air in the 467.7 ft^3
    container is %f lbm\n",467.7/vdryair);
18 //To obtain relative humidity(phy),it is necessary
    to determine the mole fraction of water vapor for
    both the saturated mixture and the mixture in
    question.
19 //The saturated mixture contains 1 lbm of water
    vapor or 1/18.016 moles =0.055 mole of water
    vapor and (467.7/vdryair)/28.966=1.109 moles of
    dry air.
20 //For the saturated mixture, the ratio of moles of
    water vapor to moles of mixture is
    0.055/(0.055+1.109)=0.0477
21 //For the actual mixture,the moles of water vapor
    per pound of dry air is 0.005/18.016=0.000278 and
    1 lbm of dry air is 1/28.966=0.0345 mole.So,the
    mole of water vapor per mole of mixture at the
    conditions of the mixture is
    0.000278/(0.0345+0.000278)=0.00799
22 //From the defination of relative humidity,
23 printf("The relative humidity of the mixture is %f \
    n", (0.00799/0.0477)*100);
24
25 //Because the mole ratio is also the ratio of the
    partial pressures for the ideal gas,phy can be
    expressed as the ratio of the partial pressure of
    the water vapor in the mixture to the partial
    pressure of the water vapor at saturation.
    Therefore ,
26 printf("The partial pressure of the vapor at
    saturation is %f psia\n", (0.00799/0.0477)*0.6988)
    ;
27 printf("And the partial pressure of the dry air in
    the mixture is %f psia\n",14.7-((0.00799/0.0477)

```



```

    *0.6988)); //14.7–The partial pressure of the
    vapor at saturation
28 //The dew point temperature is the saturation
    temperature corresponding to the partial pressure
    of the water vapor in the mixture. So,
29 printf("The dew point temperature corresponding to
    %f psia is 39F\n", (0.00799/0.0477)*0.6988);

```

Scilab code Exa 7.15 Determine partial pressure and relative humidity and dew point temperature

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.15\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.15 (page no. 343)
7 // Solution
8
9 //Problem 7.14 using equations ,  $R_m = ((m_a / (m_a + m_v)) * R_a)$ 
    +  $((m_v / (m_a + m_v)) * R_v)$  and  $p_{hy} * p_{vs} = p_v$ 
10 W=0.005; //Humidity ratio
11 pm=14.7; //mixture is at 14.7 psia
12 //W=0.622*(p_v/(p_m-p_v))
13 //Rearranging ,
14 p_v=(W*pm)/(0.622+W); //the partial pressure of the
    water vapor
15 printf("The partial pressure of the water vapor is
    %f psia\n", p_v);
16 p_a=p_m-p_v; //p_a=the partial pressure of the dry air
    in the mixture
17 printf("The partial pressure of dry air is %f psia\n
    ", p_a);
18 //It is necessary to obtain p_v_s from the Steam
    Tables at 90 F. This is 0.6988 psia.

```

```

19 pvs=0.6988; //saturation pressure of water vapor at
    the temperature of mixture
20 printf("The partial pressure of the water vapor at
    saturation is %f psia\n",pvs);
21 //Therefore ,
22 phy=pv/pvs; //relative humidity
23 printf("The relative humidity is %f percent\n",phy
    *100);
24 //The dew point temperature is the saturation
    temperature corresponding to 0.117 psia ,which is
    found from the Steam Tables to be 39 F.
25 printf("The dew point temperature of the mixture is
    39 F\n");
26 //The results of this problem and problem 7.14 are
    in good agreement

```

Scilab code Exa 7.16 Determine how much water was removed from the air

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.16\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.16 (page no. 343)
7 // Solution
8
9 pm=14.7; //the barometer is at 14.7 psia //mixture
    is at 14.7 psia
10 //The amount of water vapor removed (per pound of
    dry air) is the difference between the humidity
    ratio (specific humidity) at inlet and outlet of
    the conditioning unit.We shall therefore
    evaluate W for both specified conditions.Because
    phy=pv/pvs ,

```

```

11 //At 90F:
12 phy=0.7; //relative humidity
13 pvs=0.6988; //psia //saturation pressure of water
    vapor at the temperature of mixture
14 pv=phy*pvs; //psia //the partial pressure of the
    water vapor
15 pa=pm-pv; //psia //pa=the partial pressure of the
    dry air in the mixture
16 W=0.622*(pv/pa); //Humidity ratio
17
18 //At 80F:
19 phy=0.4; //relative humidity
20 pvs=0.5073; //psia //saturation pressure of water
    vapor at the temperature of mixture
21 pv=phy*pvs; //psia //the partial pressure of the
    water vapor
22 pa=pm-pv; //psia //pa=the partial pressure of the
    dry air in the mixture
23 w=0.622*(pv/pa); //Humidity ratio
24
25 printf("The amount of water removed per pound of dry
    air is %f\n",W-w);

```

Scilab code Exa 7.17 Determine dew point temperature using psychrometric chart

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.17\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.17 (page no. 347)
7 // Solution
8
9 //Problem 7.13 using the psychrometric chart

```

```

10 //Entering figure 7.11 at a dry-bulb temperature of
    80 F,we proceed vertically until we reach 50%
    humidity curve.At this intersection ,we proceed
    horizontally and read the dew-point
    temperature as approximately 60 F.
11 printf("The dew point temperature of air is 60 F\n")
    ;

```

Scilab code Exa 7.18 Determine partial pressure and relative humidity and dew point temperature using psychrometric chart

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.18\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.18 (page no. 347)
7 // Solution
8
9 //Problem 7.14 using the psychrometric chart
10 //In this problem,we are given the moisture content
    of the air to be 0.005 lb per pound of dry air.
11 //This corresponds to 0.005*7000=35 grains per pound
    of dry air.
12 //Entering the chart at 90F and proceeding vertically
    to 35 grains per pound of dry air,we find the
    dew point to be 39F by proceeding horizontally to
    the intersection with the saturation curve.
13 printf("The dew-point temperature of the mixture is
    39 F\n");
14 printf("The relative humidity is approximately 17
    percent\n");
15 //From the leftmost scale ,we read the pressure of
    water vapor to be 0.12 psia.
16 printf("The partial pressure of the air is %f psia\n

```

```
    ”,14.7-0.12);  
17 //Comparing these results to problem 7.14,indicated  
    good agreement between the results obtained by  
    chart and by calculation
```

Scilab code Exa 7.19 Determine water removed from the air using psychrometric chart

```
1 //scilab 5.4.1  
2 clear;  
3 clc;  
4 printf("\t\t\tProblem Number 7.19\n\n");  
5 // Chapter 7 : Mixtures Of Ideal Gases  
6 // Problem 7.19 (page no. 348)  
7 // Solution  
8  
9 //Problem 7.16 using the psychrometric chart  
10 //The initial conditions are 90 F and 70% relative  
    humidity  
11 //Entering the chart at 90 F dry bulb temperature  
    and proceeding vertically to 70% relative  
    humidity,we find the air to have 150 grains water  
    vapor per pound of dry air.At the final  
    condition of 80F and 40% relative humidity,we  
    read 61 grains of water/lb of dry air.  
12 //So,  
13 printf("The water removed is %f grains per pound of  
    dry air\n",150-61);  
14 printf("Or %f lb of water per pound of dry air is  
    removed\n", (150-61)/7000);
```

Scilab code Exa 7.20 Determine the heat required

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.22\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.22 (page no. 349)
7 // Solution
8
9 //dry bulb temperature is 50 F
10 //relative humidity is 50 percent
11 //We first locate 50 F and 50 percent relative
    humidity on figure 7.11.At this state ,we read 26
    grains of water per pound of dry air and a total
    heat of 16.1 Btu per pound of a dry air .
12 //We now proceed horizontally to 80 F at a constant
    value of 26 grains of water per pound of dry air
    and read a total heat of 23.4 Btu per pound of
    dry air .
13 printf("The heat required is %f Btu per pound of dry
    air" ,23.4-16.1)

```

Scilab code Exa 7.21 Determine relative humidity

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.21\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.21 (page no. 352)
7 // Solution
8
9 //An evaporative cooling process
10 //Because the exit air is saturated ,we find the exit
    condition on the curve corresponding to a wet-
    bulb temperature of 50 F.The process is carried

```

```

    out at constant      total enthalpy , which is along
    a line of constant wet-bulb temperature.
11 //Proceeding along the 50 F wet-bulb temperature
    line of figure 7.11 diagonally to the right until
    it intersects with the vertical 80 F dry-bulb
    temperature line yields a relative humidity of
    approximately 4 %
12 printf("For An evaporative cooling process ,The
    relative humidity of the entering air is 4
    percent");

```

Scilab code Exa 7.22 The final mixture composition

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.22\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.22 (page no. 356)
7 // Solution
8
9 //As noted from figure 7.27, 1 lb of mixture ,4/5 lb
    of indoor air ,and 1/5 lb of outdoor air are mixed
    per pound of mixture.
10 //We now locate the two end states on the
    psychrometric chart and connect them with a
    straight line.The line connecting the end states
    is divided into 5 equal parts. Using the results
    of equation ,  $(h_a-h_{a2})/(h_a-h_{a1}) = (W_2-W)/(W-W_1) =$ 
 $m_1/m_2 = 11/12$  ,we now proceed from the 75 F
    indoor air state 1 part toward the 90F outdoor
    air state.This Locates
11 printf("The final mixture ,which is found to be a dry
    -bulb temperature of approximately 78 F,a wet-
    bulb temperature of 66 F and relative humidity of

```

54 percent\n");

Scilab code Exa 7.23 The cooling tower

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 7.23\n\n\n");
5 // Chapter 7 : Mixtures Of Ideal Gases
6 // Problem 7.23 (page no. 358)
7 // Solution
8
9 //The cooling tower
10 //From the Steam tables ,
11 //For water:
12 h100F=68.05; //Btu/lbm //enthalpy at 100 F
13 h70F=38.09; //Btu/lbm //enthalpy at 70 F
14 //For air:
15 h=20.4; //Unit:Btu/lb //at inlet ,total heat/lb dry
    air
16 w=38.2; //Unit:grains/lb //at inlet ,moisture pickup
    /lb dry air (at 60F D.B. and 50% R.H.)
17 H=52.1; //Unit:Btu/lb //at outlet ,total heat/lb dry
    air
18 W=194.0; //Unit:grains/lb //at outlet ,moisture
    pickup/lb dry air (at 90F D.B. and 90% R.H.)
19
20 //Per pound of dry air ,the heat interchange is H-h
    Btu per pound of dry air .
21 //Per pound of dry air ,the moisture increase is (W-w
    )/7000 lb per pound of dry air .
22 //From the equation , ma*(H-h) = 200000*h100F - mwout
    *h70F //ma=mass of air mwout=mass of
    cooled water
23 //and ma*((W-w)/7000) = 200000 - mwout
```



```

24 //Solving the latter equation for mwout,we have
    mwout=200000-(ma*((W-w)/7000))
25 //Substituting this into the heat balance yields ,
26 // ma*(H-h) = 200000*h100F - 200000*h70F + ma*h70F
    *((W-w)/7000)
27 //Solving gives us ,
28 ma=(200000*(h100F-h70F))/((H-h)-(h70F*((W-w)/7000)))
    ; //The amount of air required per hour //Unit:
    lbm/hr of dry air
29 printf("The amount of air required per hour is %f
    lbm/hr of dry air\n",ma);
30 printf("The amount of water lost per hour due to
    evaporation is %f lbm/hr\n",ma*((W-w)/7000));
31 //note that the water evaporated is slightly over 2%
    of the incoming water ,and this is the makeup
    that has to be furnished to the tower.
32 //answer are slightly differ because of value of (W-
    w)/7000 is given 0.0233 instead of 0.0225

```

Chapter 8

Vapor Power Cycles

Scilab code Exa 8.1 Thermal efficiency neglecting pump work and including pump work

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.1\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.1 (page no. 380)
7 // Solution
8
9 //From the Steam Tables or Mollier chart in Appendix
   3,we find that
10 hf=340.49; //Unit:kJ/kg //at 50kPa //enthalpy
11 h1=hf; //at 50kPa //hf=enthalpy of saturated liquid
   //Unit:kJ/kg
12 h4=3230.9; //Unit:kJ/kg //enthalpy
13 h5=2407.4; //Unit:kJ/kg ////enthalpy
14 //Here,point 5 is in the wet steam region.
15 printf("Solution for (a)\n");
16 //Neglecting pump work (h2=h1) gives
17 nR=(h4-h5)/(h4-h1); //Thermal efficiency of the
   cycle
```

```

18 printf("The thermal efficiency of the cycle is %f
    percentage\n\n",nR*100);
19
20 printf("Solution for (b)\n");
21 p2=3000; //Unit:kPa //Upper pressure
22 p1=50; //Unit:kPa //Lower pressure
23 vf=0.001030; //Specific volume of saturated liquid
    //m^3/kg
24 Pumpwork=(p2-p1)*vf; //Unit:kJ/kg //pump work
25 //The efficiency of the cycle including pump work is
26 nR=((h4-h5)-Pumpwork)/((h4-h1)-Pumpwork); //Thermal
    efficiency of the cycle
27 printf("The thermal efficiency of the cycle
    including pump work is %f percentage\n\n",nR*100)
    ;

```

Scilab code Exa 8.2 Thermal efficiency using computer disk property values

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.2\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.2 (page no. 381)
7 // Solution
8
9 //Using the computer disk to obtain the necessary
    properties
10 printf("Solution for (a)\n");
11 //For the conditions given in problem8.1,the
    properties are found to be
12 hf=340.49; //Unit:kJ/kg //at 50kPa //enthalpy
13 h1=hf; //at 50kPa //hf=enthalpy of saturated liquid
14 h2=h1; //Enthalpy //Unit:kJ/kg

```

```

15 h4=3230.9; //Unit:kJ/kg //enthalpy
16 h5=2407.4; //Unit:kJ/kg //enthalpy
17 //Neglecting pump work
18 nR=(h4-h5)/(h4-h2); //Thermal efficiency of the
    cycle
19 printf("The thermal efficiency of the cycle is %f
    percentage\n\n",nR*100);
20
21 printf("Solution for (b)\n");
22 //For the pump work,we do not need the approximation
    ,because the computerized tables give us the
    necessary values directly.
23 //Assuming that the condensate leaving the condenser
    is saturated liquid gives us an enthalpy of
    340.54 kJ/kg and an entropy of 1.0912 kJ/kg*K for
    an isentropic compression , the final cond-ition
    is the boiler pressure of 3Mpa and an entropy of
    1.0912 kJ/kg*K. For these values ,the program
    yields an enthalpy of 343.59 kJ/kg*K.The
    isentropic pump work is equal to
24 Pumpwork=343.59-340.54; //Unit:kJ/kg //pumpwork
25 //The efficiency of the cycle including pump work is
26 nR=((h4-h5)-Pumpwork)/((h4-h1)-Pumpwork); //Thermal
    efficiency of the cycle
27 printf("The thermal efficiency of the cycle
    including pump work is %f percentage\n\n",nR*100)
    ;
28 //Final results in this problem agree with the
    result in problem8.1

```

Scilab code Exa 8.3 Thermal efficiency

```

1 //scilab 5.4.1
2 clear;
3 clc;

```

```

4 printf("\t\t\tProblem Number 8.3\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.3 (page no. 382)
7 // Solution
8
9 //Solution for (a)
10 //Figure 8.3 with the cycle extending into the
    superheat region and expanding along 4->5 is the
    appropriate diagram for this process.
11
12 printf("Solution for (b)\n");
13 //This problem can be solved either by use of the
    Mollier chart or the Steam Tables.If the chart is
    used,14.696 psia is first located on the
    saturated vapor line.Because the expansion,4->5,
    is isentropic ,a vertical line on the chart is the
    path of the process.The point corresponding to 4
    in figure 8.3 is found where this vertical line
    intersects 400 psia.At this point ,the ent-halpy
    is 1515 Btu/lbm ,and the corresponding temperature
    is approximatelty 980F.Saturated vapor at 14.696
    psia has an enthalpy of 1150.5 Btu/lbm(from the
    Mollier chart).The Steam Tables sh-ow that
    saturated liquid at 14.696 psia has an enthalpy
    of 180.15 Btu/lbm.In terms of figure 8.3 ,and
    neglecting pump work ,we have
14 h1=180.15; //Unit:Btu/lbm //enthalpy
15 h2=h1; //Enthalpy //Unit:Btu/lbm
16 h4=1515; //Unit:Btu/lbm //enthalpy
17 h5=1150.5; //Unit:kJ/kg //enthalpy
18 //Neglecting pump work yields
19 nR=(h4-h5)/(h4-h2); //Thermal efficiency of the
    cycle
20 printf("Neglecting the pump work ,The thermal
    efficiency of the cycle is %f percentage\n\n",nR
    *100);
21 p2=400; //Unit:Psia //Upper pressure
22 p1=14.696; //Unit:Psia //Lower pressure

```

```

23 vf=0.01167; //Specific volume of saturated liquid
    //ft^3/lbm
24 J=778; //Conversion factor
25 Pumpwork=((p2-p1)*vf*144)/J; //Unit:Btu/lbm //1ft
    ^2=144 in^2 //pumpwork
26 //The efficiency of the cycle including pump work is
27 nR=((h4-h5)-Pumpwork)/((h4-h1)-Pumpwork); //Thermal
    efficiency of the cycle
28 printf("The thermal efficiency of the cycle
    including pump work is %f percentage\n\n",nR*100)
    ;
29 //where the denominator is h4-h2=h4-h1-(h2-h1).
    Neglecting pump work is obviously justified in
    this case.An alternative solution is obtained by
    using the Steam Tables:at 14.696 psia ans sat-
    uration ,sg=1.7567 ; at 400 psia ,s= 1.7567.From
    Table 3(at 400 psia)
30 //      s      h      t
31 //1.7632  1523.6  1000
32 //1.7567  1514.2  982.4
33 //1.7558  1512.9  980

```

Scilab code Exa 8.4 Thermal efficiency using computer generated property values

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.4\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.4 (page no. 383)
7 // Solution
8
9 //Refer to figure8.3.The desired quantities are
    obtained as follows:

```

```

10 //at 14.696 psia ,saturated vapor (x=1),s=1.7566 Btu/
    lbm*R
11 h5=1150.4; //Unit:Btu/lbm //enthaply
12 //at 14.696 psia ,saturated liquid (x=0),s=0.3122 Btu
    /lbm*R
13 h2=180.17; //Unit:Btu/lbm //enthaply
14 h1=h2;
15 //at 400 psia ,s=1.7566 Btu/lbm*R,
16 h4=1514.0; //Unit:Btu/lbm //Enthalpy
17 t=982.07; //Unit:F //tempearature
18 //at 400 psia ,s=0.3122 Btu/lbm*R, //s=entropy
19 h=181.39; //Unit:Btu/lbm //Enthalpy
20 //Note the agreement of these values with the ones
    obtained for problem8.4.Alos ,note the temperature
    of 982.07F compared to 982.4F.Continuing ,
21 //Neglecting pump work
22 nR=(h4-h5)/(h4-h2); //Thermal efficiency of the
    cycle
23 printf("Neglecting the pump work ,The thermal
    efficiency of the cycle is %f percentage\n\n",nR
    *100);
24 Pumpwork=h-h2; //Unit:kJ/kg ///pumpwork
25 //The efficiency of the cycle including pump work is
26 nR=((h4-h5)-Pumpwork)/((h4-h2)-Pumpwork); //Thermal
    efficiency of the cycle
27 printf("The thermal efficiency of the cycle
    including pump work is %f percentage\n\n",nR*100)
    ;

```

Scilab code Exa 8.5 Carnot cycle efficiency and type efficiency

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.5\n\n\n");

```

```

5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.5 (page no. 385)
7 // Solution
8
9 //The Carnot cycle would operate between 982.4F and
  212F.
10 T1=982.4+460; //temperature converted to absolute
    temperature //Unit:R
11 T2=212+460; //temperature converted to absolute
    temperature //Unit:R
12 nc=((T1-T2)/T1)*100; //Efficiency of carnot cycle
13 printf("The efficiency is %f percentage\n",nc);
14 //In problem 8.3,
15 nR=27.3; //Thermal efficiency of the cycle
    neglecting the pump work
16 typen=(nR/nc)*100; //Type efficiency=ideal thermal
    efficiency/efficiency of carnot cycle operating
    between min and max temperature limits
17 printf("The type efficiency of the ideal Rankine
    cycle is %f percentage\n",typen);

```

Scilab code Exa 8.6 Efficiency of Rankine cycle

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.6\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.6 (page no. 385)
7 // Solution
8
9 //For the upper temperature of the cycle ,we have 400
  C,and for 50kPa,the steam tables give us a
  saturation temperature of 81.33C.The efficiency
  of a Carnot cycle operating between the limits

```



```

    would be
10 T1=400+273; //Celcius temperature converted to
    fahrenheit temperature
11 T2=81.33+273; //temperature converted to fahrenheit
    temperature
12 nc=((T1-T2)/T1)*100; //Efficiency of carnot cycle
13 printf("The efficiency is %f percentage\n",nc);
14 //In problem 8.1,
15 nR=28.5; //Thermal efficiency of the cycle
    neglecting the pump work
16 typen=(nR/nc)*100; //Type efficiency=ideal thermal
    efficiency/efficiency of carnot cycle operating
    between min and max temperature limits
17 printf("The type efficiency of the ideal Rankine
    cycle is %f percentage\n",typen);

```

Scilab code Exa 8.7 Thermal efficiency

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.7\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.7 (page no. 386)
7 // Solution
8
9 //From problem 8.3,
10 work=1515-1150.5; //Unit:Btu/lbm of steam //pump
    work is neglected //Useful ideal work
11 //Because of the heat losses , 50 Btu/lbm of the
    364.5 Btu/lbm becomes unavailable.
12 available=364.5-50; //Unit:Btu/lbm
13 n=available/(1515-180.15); //Thermal efficiency of
    the cycle neglecting pump work h4=1515; //Unit:
    Btu/lbm //enthalpy & h1=180.15; //Unit:Btu/lbm //

```

```

enthalpy
14 printf("The thermal efficiency of the cycle
neglecting pump work is %f percentage\n\n",n*100)
;

```

Scilab code Exa 8.8 Heat rate and steam rate per kilowatt hour

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.8\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.8 (page no. 387)
7 // Solution
8
9 //Neglecting the pump work,we have
10 heatrate=3413/0.273; //Unit:Btu/kWh //0.273=
efficiency //1 kWh=3413 //heat rate
11 printf("The heat rate is %f Btu/kWh\n",heatrate);
12 //Per pound of steam,1515-1150.5=364.5 Btu is
delivered.
13 //Because 1 kWh=3413
14 printf("The steam rate is %f lbm of steam per
kilowatt-hour\n",3413/(1515-1150.5));

```

Scilab code Exa 8.9 Efficiency of reheat cycle

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.9\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.9 (page no. 388)

```

```

7 // Solution
8
9 //The Mollier chart provides a convenient way of
    solving this problem.Expanding from 980F,400 psia
    ,s=1.7567 to 200 psia yields a final enthalpy of
    1413 Btu/lbm.Expanding from 200 psia ans an
    enthalpy of 1515 Btu/lbm to 14.696 psia yields a
    final enthaply of 1205 Btu/lbm.
10 h4=1515; //Unit:Btu/lbm //enthalpy
11 h5=1205; //Unit:Btu/lbm //enthalpy
12 h7=1413; //Unit:Btu/lbm //enthalpy
13 h1=180.15; //Unit:Btu/lbm //enthalpy
14 nreheat=((h4-h5)+(h4-h7))/((h4-h1)+(h4-h7)); //The
    efficiency of the reheat cycle
15 printf("The efficiency of the reheat cycle is %f
    percentage",nreheat*100);
16 //It is apparent that for the conditions of this
    problem,the increase in efficiency is not very
    large.The final condition of the fluid after the
    second expansion is superheated steam at
17 //14.696 psia.By condensing at this relatively high
    pressure condition ,a large amount of heat is
    rejected to the condenser cooling water.7

```

Scilab code Exa 8.10 efficiency of reheat cycle by computerized properties

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.10\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.10 (page no. 389)
7 // Solution
8
9 //Some of the property data required was found in

```

```

        problem8.4.In addition we have ,
10 //at 200 psia ,s=1.7566 Btu/lbm*R,
11 h7=1413.6; //Unit:Btu/lbm //Enthalpy
12 //at 200 psia ,s=1.8320 Btu/lbm*R,
13 h4=1514.0; //Unit:Btu/lbm //Enthalpy
14 //at 14.696 psia ,s=1.8320 Btu/lbm*R,
15 h5=1205.2; //Unit:Btu/lbm //Enthalpy
16 h1=180.17; //Unit:Btu/lbm //enthalpy
17 //Using these data ,
18 nreheat=((h4-h5)+(h4-h7))/((h4-h1)+(h4-h7)); //The
        efficiency of the reheat cycle
19 printf("The efficiency of the reheat cycle is %f
        percentage",nreheat*100);

```

Scilab code Exa 8.11 Efficiency of Rankine and regenerative cycle

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.11\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.11 (page no. 394)
7 // Solution
8
9 printf("Solution for (a)\n");
10 //For the rankine cycle ,the Mollier chart gives
11 h4=1505; //Enthalpy //Unit:Btu/lbm
12 h5=922; //Enthalpy //Unit:Btu/lbm
13 h6=h5; //Enthalpy //Unit:Btu/lbm
14 //and at the condenser ,
15 h1=69.74; //enthalpy //Unit:Btu/lbm
16 nR=(h4-h5)/(h4-h1); //efficiency of rankine cycle
17 printf("The efficiency of rankine cycle is %f
        percentage\n\n",nR*100);
18

```

```

19 printf("Solution for (b)\n");
20 //Figure 8.16 shows the regenerative cycle.After
    doing work(isentropically),W lbs of steam are
    bled from the turbine at 50 psia for each lbm of
    steam leaving the steam generator ,and (1-W)
    pound goes through the turbine and is condensed
    in the condenser to saturated liquid at 1 psia.
    This condensate is pumped to the heater ,where it
    mixes with the extraced steam and leaves as
    saturated liquid at 50 psia.The required
    enthalpies are:
21 //Leaving turbine:
22 h5=1168; //Btu/lbm at 50 psia
23 //Leaving condenser:
24 h7=69.74; //Btu/lbm at 1 psia // is equal to h8 if
    pump work is neglected
25 //Leaving heater:
26 h1=250.24; //Btu/lbm at 50 psia //is equal to h2 if
    pump work is neglected(saturated liquid)
27 //A Heat balance around the heater gives
28 //W*h5 + (1-W)*h7 = 1*h1
29 W=((1*h1)-h7)/(h5-h7); //Unit:lbm //W lb of steam
30 printf("W=%f lbm\n",W);
31 work=(1-W)*(h4-922) + W*(h4-h5); //h5=922 from the
    mollier chart //Unit:Btu/lbm //The work output
32 printf("The work output is %f Btu/lbm\n",work);
33 //Heat into steam generator equals the enthalpy
    leaving minus the enthalpy of the saturated
    liquid entering at 50 psia:
34 qin=h4-h1; //Unit:Btu/lbm //Heat in
35 n=work/qin; //Efficiency of regenerative cycle
36 printf("The efficiency of regenerative cycle is %f
    percentage\n",n*100);
37 //The efficiency of a regenerative cycle with one
    open heater is given by
38 n=1-(((h5-h1)*(h6-h7))/((h4-h1)*(h5-h7))); //
    efficiency of a regenerative cycle
39 W=(h1-h7)/(h5-h7); //Unit:lbm //W lb of steam

```

```

40 printf("When the rankine cycle is compared with
    regenerative cycle ,\n");
41 printf("W=%f lbm and the efficiency of a
    regenerative cycle with one open heater is given
    by %f percentage\n",W,n*100);

```

Scilab code Exa 8.12 The efficiency of the cycle

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.12\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.12 (page no. 396)
7 // Solution
8
9 //Figure 8.16(a) shows the cycle.For this cycle ,W2
    pounds are extracted at 100 psia ,and W1 pounds
    are extracted at 50 psia for each pound produced
    by the steam generator.The enthalpies that are
    required are:
10 //Leaving turbine: 922 //Btu/lbm at 1 psia
11 //Leaving condenser: 69.74 //Btu/lbm at 1 psia (
    saturated liquid)
12 //Leaving low pressure heater: 250.24 //Btu/lbm at
    50 psia (saturated liquid)
13 //Leaving high pressure heater: 298.61 //Btu/lbm at
    100 psia
14 //At low pressure extraction: 1168 //Btu/lbm at 50
    psia
15 //At high pressure extraction: 1228.6 //Btulbm at
    100 psia
16 //Entering turbine: 1505 //Btu/lbm
17 //The heat balance around the high pressure heater
    gives us

```

```

18 //W2*1228.6 + (1-W2)*250.24 = 1*298.61
19 W2=((1*298.61)-250.24)/(1228.6-250.24); //lbm //W2
    pounds are extracted at 100 psia
20 printf("W2=%f lbm\n",W2);
21 //A heat balance around the low pressure heater
    yields
22 //W1*1168 + (1-W1-W2)*69.74 = (1-W2)*250.24
23 W1=(((1-W2)*250.24)-69.74+(W2*69.74))/(1168-69.74);
    //lbm //W1 pounds are extracted at 50 psia
24 printf("W1=%f lbm\n",W1);
25 work=((1505-1228.6)*1)+((1-W2)*(1228.6-1168))+((1-W1
    -W2)*(1168-922)); //The work output //Btu/lbm
26 printf("The work output is %f Btu/lbm\n",work);
27 //Heat into the steam generator equals the enthalpy
    leaving minus the enthalpy of saturated liquid at
    100 psia:
28 Qin=1505-298.61; //Btu/lbm //Heat in
29 printf("Heat in = %f Btu/lbm\n",Qin);
30 n=work/Qin; //The efficiency
31 printf("The efficiency is %f percentage\n",n*100);
32 //In terms of figure 8.16a,
33 //W2=(h1-h11)/(h5-h11)
34 //W1=(h5-h1/h6-h9)*(h10-h9/h5-h10) neglecting the
    pump work
35 //n=1-(h7-h8/h4-h1)*(h5-h1/h5-h10)*(h6-h10/h6-h8)
36 //For this problem , h8=h9 , h10=h11 and h1=h2.Thus
37 W2=(298.61-250.24)/(1228.6-250.24); //lbm //W2
    pounds are extracted at 100 psia
38 printf("Comparing the results ,\n");
39 printf("W2=%f lbm\n",W2);
40 W1=((1228.6-298.61)*(250.24-69.74))/((1168-69.74)
    *(1228.6-250.24)); //lbm //W1 pounds are
    extracted at 50 psia
41 printf("W1=%f lbm\n",W1);
42 n=1-(((922-69.74)*(1228.6-298.61)*(1168-250.24))
    /(((1505-298.61)*(1228.6-250.24)*(1168-69.74))));
    //Efficiency
43 printf("The efficiency is %f percentage\n",n*100);

```

Scilab code Exa 8.13 efficiency of cycle and comparision

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 8.13\n\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.13 (page no. 398)
7 // Solution
8
9 //Regenerative cycle
10 //Assume that 1 lbm of steam leaves the steam
    generator and that W1 lbm is bled off to the
    closed heater at 100 psia and that W2 lbm is bled
    off to the open heater at 50 psia. Alos, assume
    that the feedwater leaving the closed heater at
    310F, 18F less than the saturation temperature
    corresponding to 100 psia. For calculation
    purposes, we will use hf at 310 F for this
    enthalpy. Using the Mollier diagram and the steam
    tables, we find the following values of enthalpy:
11
12 //h to turbine=1505 Btu/lbm(at 1000 psia and 1000F)
13 //h at first extraction=1228 Btu/lbm(isentropically
    to 100 psia)
14 //h at second extraction=1168 Btu/lbm(isentropically
    to 100 psia)
15 //h at turbine exit=922 Btu/lbm (isentropically to 1
    psia)
16 //hf=298.61 Btu/lbm(at 100 psia)
17 //hf=250.24 Btu/lbm(at 50 psia)
18 //hf=280.06 Btu/lbm(at 310 F)
19 //hf=69.74 Btu/lbm (at 1 psia)
20 //A heat balance around the high pressure heater
```



```

    gives us
21 //W1*(1228-298.61) = 1*(280.06-250.24)
22 W1=((1*(280.06-250.24))/(1228-298.61)); //lbm //W1
    lbm is extracted at 100 psia
23 printf("W1=%f lbm\n",W1);
24 //A heat balance around the open heater gives us
25 //W2*1168 +(1-W1-W2)*69.74 + W1*268.61 = 1*250.24
26 W2=((1*250.24)-(W1*268.61)-69.74+(W1*69.74))
    /(1168-69.74); //lbm //W2 lbm is extracted at 50
    psia
27 printf("W2=%f lbm\n",W2);
28 //The work output of the cycle consists of the work
    that 1 lbm does in expanding isentropically to
    100 psia, plus the work done by (1-W1)lbm
    expanding isentropically from 100 to 50 psia, plus
    the work done by (1-W1-W2)lbm expanding
    isentropically from 50 to 1 psia.
29 //Numerically, the work is
30 workout=(1*(1505-1228))+((1-W1)*(1228-1168))+((1-
    W1-W2)*(1168-922)); //Btu/lbm //the work output
31 printf("The work output is %f Btu/lbm\n",workoutput)
    ;
32 heatinput=1505-280.06; //Btu/lbm //the heat input
33 printf("The heat input is %f Btu/lbm\n",heatinput);
34 n=workoutput/heatinput; //Efficiency
35 printf("The efficiency is %f percentage\n",n*100);
36 //When compared to 8.11, we conclude that the
    addition of additional closed heater raises the
    efficiency.

```

Scilab code Exa 8.14 efficiency of energy utilization and thermal efficiency

```

1 //scilab 5.4.1
2 clear;
3 clc;

```

```

4 printf("\t\t\tProblem Number 8.14\n\n");
5 // Chapter 8 : Vapor Power Cycles
6 // Problem 8.14 (page no. 426)
7 // Solution
8
9 //From problem 8.11,
10 //Leaving turbine:
11 h5=1168; //Btu/lbm at 50 psia
12 //For the rankine cycle ,the Mollier chart gives
13 h4=1505; //Enthalpy //Unit:Btu/lbm
14 h6=922; //Enthalpy //Unit:Btu/lbm //h6=h5;
15 //and at the condenser ,
16 h1=69.74; //enthalpy //Unit:Btu/lbm
17 //Leaving condenser:
18 h7=69.74; //Btu/lbm at 1 psia // is equal to h8 if
    pump work is neglected
19 //Leaving heater:
20 h2=250.24; //Btu/lbm at 50 psia //is equal to h1 if
    pump work is neglected(saturated liquid)
21 //A Heat balance around the heater gives
22 //W*h5 + (1-W)*h7 = 1*h1
23 W=((1*h2)-h7)/(h5-h7); //Unit:lbm
24 liquidleaving=(W*h2)+(1-W)*h1; //Btu/lbm //liquid
    leaving the heatexchange
25
26 //Using these data,,
27 heatin=h4-liquidleaving; //Btu/lbm //heat in the
    boiler
28 printf("Heat in at boiler is %f Btu/lbm\n",heatin);
29 workout=((1-W)*(h4-h6))+(W*(h4-h5)); //Btu/lbm //The
    work out of turbine
30 printf("The work out of turbine is %f Btu/lbm\n",
    workout);
31 n=workout/heatin; //efficiency //The conventional
    thermal efficiency
32 printf("The conventional thermal efficiency is %f
    percentage\n",n*100);
33 //If at this time we have define the efficiency of

```

```

    energy utilization to be the ratio of the work
    out plus the useful heat out divided by the heat
    input to the cycle, nenergyutilization=((w+
    qoutuseful)/qin)*100
34 qout=W*(h5-h2); //heat out //Btu/lbm
35 n=(workout+qout)/heatin; //efficiency of energy
    utilization
36 printf("Efficiency of energy utilization is %f
    percentage\n",n*100);
37 //Comparing with 8.11, we see that conventional
    thermal efficiency is decreased and efficiency of
    energy utilization is increased

```

Chapter 9

Gas Power Cycles

Scilab code Exa 9.1 The efficiency of Otto cycle and Carnot cycle

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.1\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.1 (page no. 462)
7 // Solution
8
9 Rc=7; //Compression Ratio Rc=v2/v3
10 k=1.4; //It is apparent increase in compression
    ratio yields an increased cycle efficiency
11 notto=(1-(1/Rc)^(k-1))*100; //Efficiency of an otto
    engine
12 printf("The efficiency of the otto cycle is %f
    percentage\n",notto);
13 //For the carnot cycle,
14 //Nc=1-(T2/T4) //efficiency for the carnot cycle //
    T2=lowest temperature //T4=Highest temperature
15
16 T2=70+460; //for converting to R //Conversion of
    unit
```

```

17 //At 700 F
18 T4=700+460; //temperatures converted to absolute
    temperatures;
19 nc=(1-(T2/T4))*100; //efficiency of the carnot cycle
20 printf("When peak temperature is 700 fahrenheit ,
    efficiency of the carnot cycle is %f percentage\n
    ",nc);
21
22 //At 1000 F
23 T4=1000+460; //temperatures converted to absolute
    temperatures;
24 nc=(1-(T2/T4))*100; //efficiency of the carnot cycle
25 printf("When peak temperature is 1000 fahrenheit ,
    efficiency of the carnot cycle is %f percentage\n
    ",nc);
26
27 //At 3000 F
28 T4=3000+460; //temperatures converted to absolute
    temperatures;
29 nc=(1-(T2/T4))*100; //efficiency of the carnot cycle
30 printf("When peak temperature is 3000 fahrenheit ,
    efficiency of the carnot cycle is %f percentage\n
    ",nc);

```

Scilab code Exa 9.2 Efficiency and net work out

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.2\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.2 (page no. 463)
7 // Solution
8
9 cv=0.172; //Unit:Btu/(lbm*R) //Specific heat

```

```

    constant
10 Rc=7; //Compression Ratio Rc=v2/v3
11 k=1.4; //It is apparent increase in compression
    ratio yields an increased cycle efficiency
12 T2=70+460; //for converting to R //Conversion of
    unit
13 //For 1000 F
14 T4=1000+460; //temperatures converted to absolute
    temperatures;
15 T3byT2=Rc^(k-1); //Unit less
16 T3=T3byT2*T2;
17 Qin=cv*(T4-T3); //Unit:Btu/lbm //Heat added
18 //Qr=cv*(T5-T2)*(T5/T4)=(v2/v3)^(k-1)
19 Qr=(inv(Rc))^(k-1); //Unit:Btu/lbm //Heat rejected
20 T5=T4*Qr;
21 Qr=cv*(T5-T2); //Unit:Btu/lbm //Heat rejected
22 printf("The net work out is %f Btu/lbm\n",Qin-Qr);
23 notto=((Qin-Qr)/Qin)*100; //The efficiency of otto
    cycle
24 printf("The efficiency of otto cycle is %f
    percentage",notto);
25 //The value agrees with the results of problem 9.1

```

Scilab code Exa 9.3 Determine the Peak temperature

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.3\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.3 (page no. 464)
7 // Solution
8
9 cv=0.7186; //Unit:kJ/(kg*K) //Specific heat constant
    for constant volume process

```

```

10 Rc=8; //Compression Ratio Rc=v2/v3
11 k=1.4; //It is apparent increase in compression
    ratio yields an increased cycle efficiency
12 T2=20+273; //20 C converted to its kelvin value
13 qin=50; //Heat added //Unit:kJ
14 T3byT2=Rc^(k-1);
15 T3=T3byT2*T2; //Unit:K
16 //qin=cv*(T4-T3) //heat added //Unit:kJ
17 T4=(qin/cv)+T3; //The peak temperature of the cycle
    //Unit:K
18 printf("The peak temperature of the cycle is %f
    Kelvin i.e. %f Celcius",T4,T4-273);

```

Scilab code Exa 9.4 Determine temperature pressure and specific volume at each point

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.4\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.4 (page no. 465)
7 // Solution
8
9 //For an Otto cycle ,
10 rc=7; //Compression Ratio Rc=v2/v3
11 q=50; //Unit:Btu/lbm //Heat added
12 p2=14.7; //Unit:psia //pressure at point 2
13 T2=60+460; //temperatures converted to absolute
    temperatures; //Unit:R
14 cp=0.24; //Unit:Btu/(lbm*R) //Specific heat constant
    for constant pressure process
15 cv=0.171; //Unit:Btu/(lbm*R) //Specific heat
    constant for constant volume process
16 R=53.3; //Unit:ft*lbm/lbm*R //constant of

```

```

    proportionality
17 k=1.4; //It is apparent increase in compression
    ratio yields an increased cycle efficiency
18 //Referring to figure 9.9,
19 //At (2),we need v2.
20 //p2*v2=R*T2
21 v2=(R*T2)/(p2*144); //Unit:ft^3/lbm //1ft^2=144 in^2
    //specific volume at point 2
22 printf("At point (2),\nspecific volume v2=%f ft^3/
    lbm\n\n",v2);
23 //For The isentropic path (2)&(3),p3*v3^k=p2*v2^k,so
24 //So,p3=p2*(v2/v3)^k;
25 p3=p2*rc^k; //Unit:psia //pressure at point 3
26 printf("At path(2)&(3)\n");
27 printf("pressure p3=%f psia\n",p3);
28 v3=v2/rc; //Unit:ft^3/lbm //specific volume at point
    3
29 printf("specific volume v3=%f ft^3/lbm\n",v3);
30 T3=(p3*v3*144)/R; //Unit:R //1ft^2=144 in^2 //
    temperature at point 3
31 printf("temperature T3=%f R\n\n",T3);
32 printf("At point(4),\n");
33 //To obtain the values at (4),we note
34 v4=v3; //Unit:ft^3/lbm //specific volume at point 4
35 printf("specific volume v4=%f ft^3/lbm\n",v4);
36 //qin=cv*(T4-T3)
37 T4=T3+(q/cv); //Unit:R //temperature at point 4
38 printf("temperature T4=%f R\n",T4);
39 //For p4,
40 p4=(R*T4)/(144*v4); //Unit:psia //1ft^2=144 in^2 //
    pressure at point 4
41 printf("pressure p4=%f psia\n\n",p4);
42 //The last point has the same specific volume as (2)
    ,giving
43 printf("At last point,\n");
44 v5=v2; //Unit:ft^3/lbm //specific volume at point 5
45 printf("specific volume v5=%f ft^3/lbm\n",v5);
46 //The isentropic path equation ,p5*v5^k=p4*v4^k,so

```



```

47 p5=p4*(v4/v5)^k; //Unit:psia //pressure at point 5
48 printf(" pressure p5=%f psia\n",p5);
49 T5=(p5*v5*144)/(R); //Unit:R //1ft^2=144 in^2
    temperature at point 5
50 printf(" temperature T5=%f R\n\n",T5);
51 n=((T4-T3)-(T5-T2))/(T4-T3)*100; //The efficiency
    of the cycle
52 printf("The efficiency of the cycle is %f percentage
    ",n);

```

Scilab code Exa 9.7 Determine the horsepower

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.7\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.7 (page no. 468)
7 // Solution
8
9 //For four cycle engine ,
10 //Using the results of problem 9.6 ,
11 pm=1000; //Unit:kPa //mean effective pressure //Unit
    :psia
12 N=4000/2; //Power strokes per minute //2L engine //
    Unit:rpm
13 LA=2 //Mean //Unit:liters
14 hp=(pm*LA*N)/44760; //The horsepower //Unit:hp
15 printf("The horsepower is %f hp",hp);

```

Scilab code Exa 9.9 Compression ratio

```

1 //scilab 5.4.1

```

```

2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.9\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.9 (page no. 469)
7 // Solution
8
9 //An otto engine
10 c=0.2; //clearance equal to 20% of its displacement
11 //Using results of problem 9.8,
12 rc=(1+c)/c; //The compression ratio
13 printf("The compression ratio is %f",rc);

```

Scilab code Exa 9.10 Determine the mean effective pressure

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.10\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.10 (page no. 470)
7 // Solution
8
9 //For four cycle ,six cylinder engine ,
10 //Using the results of problem 9.5,
11 hp=100; //Horsepower //Unit:hp
12 L=4/12; //Unit:ft //stroke is 4 in.
13 A=(%pi/4)*(3)^2*6; //Cylinder bore is 3 in.
14 N=4000/2; //Power strokes per minute //2L engine //
    Unit:rpm
15 //hp=(pm*LA*N)/33000;
16 pm=(hp*33000)/(L*A*N); //The mean effective pressure
    //psia
17 printf("The mean effective pressure is %f psia",pm);

```

Scilab code Exa 9.11 The mean effective pressure

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.11\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.11 (page no. 470)
7 // Solution
8
9 //six cylinder engine ,with displacement 3.3L
10 //Using the results of problem 9.5 ,
11 hp=230; //Horsepower //Unit:hp
12 //3.3L*1000 cm^3/L*(in/2.54 cm)^3
13 LA=3.3*1000*(1/2.54)^3; //mean //in^3
14 N=5500/2; //Power strokes per minute //2L engine //
    Unit:rpm
15 //hp=(pm*LA*N)/33000;
16 pm=(hp*33000*12)/(LA*N); //1ft=12inch //The mean
    effective pressure //psia
17 printf("The mean effective pressure is %f psia",pm);
```

Scilab code Exa 9.12 Efficiency and temperature of the exhaust

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.12\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.12 (page no. 478)
7 // Solution
8
```

```

 9 //An air-standard Diesel engine
10 rc=16; //Compression Ratio Rc=v2/v3
11 v4byv3=2; //Cutoff ratio=v4/v3
12 k=1.4; //with the cycle starting at 14 psia and 100
    F //It is apparent increase in compression
    ratio yields an increased cycle efficiency
13 T2=100+460; //temperatures converted to absolute
    temperatures;
14 ndiesel=1-((inv(rc))^(k-1)*(((v4byv3)^k-1)/(k*(
    v4byv3-1))))); //The efficiency of the diesel
    engine
15 printf("The efficiency of the diesel engine is %f
    percentage\n",ndiesel*100);
16 // T3/T2=rc^k-1 and T5/T4=(1/re^k-1) //re=expansion
    ratio=v5/v4
17 //But T4/T3=v4/v3=rc/re
18 //So,
19 T5=T2*(v4byv3)^k; //The temperature of the exhaust
    of the cycle //Unit:R
20 printf("The temperature of the exhaust of the cycle
    is %f R i.e. %f F",T5,T5-460);

```

Scilab code Exa 9.13 Determine net work and mean effective pressure

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 9.13\n\n\n");
5 // Chapter 9 : Gas Power Cycles
6 // Problem 9.13 (page no. 479)
7 // Solution
8
9 //Now, in problem 9.12,
10 //An air-standard Diesel engine
11 rc=16; //Compression Ratio Rc=v2/v3

```

```

12 v4byv3=2; //Cutoff ratio=v4/v3
13 k=1.4; //with the cycle starting at 14 psia and 100
    F //It is apparent increase in compression
    ratio yields an increased cycle efficiency
14 T2=100; //Unit:F //temperature
15 T5=1018; //Unit:F //Found in 9.12 //The temperature
    of the exhaust of the cycle //Unit:R
16 ndiesel=0.614 //Efficiency of the diesel engine //
    Found in 9.12
17 //Now, in problem 9.13,
18 cp=0.24; //Unit:Btu/(lbm*R) //Specific heat constant
    for constant pressure process
19 cv=0.172; //Unit:Btu/(lbm*R) //Specific heat
    constant for constant volume process
20
21 Qr=cv*(T5-T2); //Heat rejected //Unit:Btu/lbm
22 //ndiesel=1-(Qr/qin); //Efficiency=ndiesel //qin=
    heat added
23 qin=Qr/(1-ndiesel); //Unit:Btu/lbm
24 J=778; //J=Conversion factor
25 networkout=J*(qin-Qr); //(ft*lbf)/lbm //Net work out
    per pound of gas
26 printf("Net work out per pound of gas is %f (ft*lbf)
    /lbm\n",networkout);
27 //The mean effective pressure is net work divided by
    (v2-v3):
28 mep=networkout/((16-1)*144); //1ft^2=144 in^2 //Unit
    :psia //The mean effective pressure
29 printf("The mean effective pressure is %f psia",mep)
    ;

```

Scilab code Exa 9.14 Determine Heat in and heat rejected

```

1 //scilab 5.4.1
2 clear;

```

```

3  clc;
4  printf("\\t\\t\\tProblem Number 9.14\\n\\n\\n");
5  // Chapter 9 : Gas Power Cycles
6  // Problem 9.14 (page no. 489)
7  // Solution
8
9  //A Brayton cycle
10 rc=7; //Compression Ratio Rc=v2/v3
11 k=1.4; //It is apparent increase in compression
        ratio yields an increased cycle efficiency
12 cp=0.24; //Unit:Btu/(lbm*R) //Specific heat constant
        for constant pressure process
13 T3=1500; //(unit:fahrenheit) //peak teperature
14 p1=14.7; //Unit:psia //Initial condition
15 T1=70+460; //temperatures converted to absolute
        temperatures; //Initial condition
16 R=53.3; //Unit:ft*lbm/lbm*R //constant of
        proportionality
17 nBrayton=1-((inv(rc))^(k-1)); //A Brayton cycle
        efficiency
18 printf("A Brayton cycle efficiency is %f percentage\\
        n",nBrayton*100);
19 //If we base our calculation on 1 lbm of gas and use
        subscripts that corresponds to points (1),(2)
        ,(3) and (4) of fig.9.22,we have
20 v1=(R*T1)/p1; //Unit:ft^3/lbm //specific volume at
        point 1
21 //Because rc=7 then ,
22 v2=v1/rc; //Unit:ft^3/lbm //specific volume at point
        2
23 //After the isentropic compression , T2*v2^k-1 = T1*
        v1^k-1
24 T2=T1*(v1/v2)^(k-1); //Unit:R //temperature at point
        2
25 T2=T2-460; //Unit:fahrenheit //temperature at point
        2
26 qin=cp*(T3-T2); //Heat in //Unit:Btu/lbm
27 printf("The heat in is %f Btu/lbm\\n",qin);

```

```
28 //Because efficiency can be stated to be work out
    divided by heat in ,
29 wbyJ=nBrayton*qin; //The work out //Unit:Btu/lbm
30 printf("The work out is %f Btu/lbm\n",wbyJ); //
    Answer is wrong in the book.cause they have taken
    efficiency value wrong
31 printf("The heat rejected is %f Btu/lbm\n",qin-wbyJ)
    ; //Anser is affected because of value of wbyJ
```

Chapter 10

Refrigeration

Scilab code Exa 10.1 A Carnot Refrigeration Cycle

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.1\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.1 (page no. 503)
7 // Solution
8
9 T1=70+460; //70F=70+460 R //Energy flows into the
    system at reservoir at constant temperature T1(
    unit:R)
10 T2=32+460; //32F=32+460 R //Heat is rejected to the
    constant temperature T2(Unit:R)
11 printf("Solution for (a),\n");
12 COP=T2/(T1-T2); //Coefficient of performance
13 printf("Coefficient of performance(COP) of the cycle
    is %f\n\n",COP);
14 printf("Solution for (b),\n");
15 Qremoved=1000; //Unit:Btu/min //heat removal
16 WbyJ=Qremoved/COP; //The power required //Unit:Btu/
    min
```



```

17 printf("The power required is %f Btu/min\n\n",WbyJ);
18 printf("Solution for (c),\n");
19 Qrej=Qremoved+WbyJ; //The rate of heat rejected to
    the room //Unit:Btu/min
20 printf("The rate of heat rejected to the room is %f
    Btu/min",Qrej);

```

Scilab code Exa 10.2 A carnot refrigeration cycle

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.2\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.2 (page no. 504)
7 // Solution
8
9 T1=20+273; //20C=20+273 R //Energy flows into the
    system at reservoir at constant temperature T1(
    unit:R)
10 T2=-5+273; //-5C=-5+273 R //Heat is rejected to the
    constant temperature T2(Unit:R)
11 printf("Solution for (a),\n");
12 COP=T2/(T1-T2); //Coefficient of performance
13 printf("Coefficient of performance(COP) of the cycle
    is %f\n\n",COP);
14 printf("Solution for (b),\n");
15 Qremoved=30; //Unit:kW //heat removal
16 W=Qremoved/COP; //power required //unit:kW
17 printf("The power required is %f kW \n\n",W);
18 printf("Solution for (c),\n");
19 Qrej=Qremoved+W; //The rate of heat rejected to the
    room //Unit:kW
20 printf("The rate of heat rejected to the room is %f
    kW",Qrej);

```

Scilab code Exa 10.3 Defined Ratings

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.3\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.3 (page no. 505)
7 // Solution
8
9 T1=70+460; //70F=70+460 R //Energy flows into the
    system at reservoir at constant temperature T1(
    unit:R)
10 T2=20+460; //20F=20+460 R //Heat is rejected to the
    constant temperature T2(Unit:R)
11 printf("Solution for (a),\n");
12 COP=T2/(T1-T2); //Coefficient of performance
13 printf("Coefficient of performance(COP) of the cycle
    is %f\n\n",COP);
14 printf("Solution for (b),\n");
15 HPperTOR=4.717/COP; //Horsepower per ton of
    refrigeration //Unit:hp/ton
16 COPactual=2; //Actual Coefficient of performance(COP
    ) is stated to be 2
17 HPperTORactual=4.717/COPactual; //Horsepower per ton
    of refrigeration(actual) //Unit:hp/ton
18 printf("The horsepower required by the actual cycle
    over the minimum is %f hp/ton",HPperTORactual-
    HPperTOR);
```

Scilab code Exa 10.4 Defined Ratings

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.4\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.4 (page no. 506)
7 // Solution
8
9 COP=4.5; //Coefficient of performance //From problem
10      10.1
11 HPperTOR=4.717/COP; //Horsepower per ton of
12      refrigeration //Unit:hp/ton
13 Qremoved=1000; //Unit:Btu/min //From problem 10.1
14 //1000 Btu/min /200 Btu/min ton = 5 tons of
15      refrigeration
16 HPrequired=HPperTOR*5; //The horsepower required //
17      unit:hp
18 printf("The horsepower required is %f hp\n",
19      HPrequired);
20 //In problem 10.1, 77.2 Btu/min was required
21 printf("The power required is %f hp\n",77.2*778*inv
22      (33000)); //1 Btu=778 ft*lbf //1 min*hp = 33000
23      ft*lbf
24 //The ratio of the power required in each problem is
25      the same as the inverse ratio of the COP value
26 //Therefore ,
27 printf("The power required is %f hp\n",(COP/12.95)*
28      HPrequired); //COP(in problem 10.1)=12.95
29 printf("This checks our results")

```

Scilab code Exa 10.5 Defined Ratings

```

1 //scilab 5.4.1
2 clear;
3 clc;

```

```

4 printf("\t\t\tProblem Number 10.5\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.5 (page no. 506)
7 // Solution
8
9 COP=10.72; //In the problem 10.2 //Coefficient of
    performance
10 P=2.8; //In the problem 10.2 //The power was 2.8 kW
11 COPactual=3.8; //Actual Coefficient of performance(
    COP)
12 power=P*COP/COPactual; //The power required //unit:
    kW
13 printf("The power required is %f kW",power)

```

Scilab code Exa 10.6 Refrigeration cycles

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.6\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.6 (page no. 509)
7 // Solution
8
9 //From Appendix 3,at 120psia ,the corresponding
    saturation temperature is 66 F, enthalpies are
10 h1=116.0; //Unit:Btu/lbm //enthalpy
11 h2=116.0; //Unit:Btu/lbm //Throttling gives h1=h2 //
    enthalpy
12 h3=602.4; //Unit:Btu/lbm //enthalpy
13 //From the consideration that s3=s4,h4 is found at
    15 psia ,
14 s3=1.3938; //s=entropy //Unit:Btu/(lbm*F)
15 //Therefore by interpolation in the superheat tables
    at 120 psia ,

```

```

16 t4=237.4; //Unit:fahrenheit //temperature
17 h4=733.4; //Unit:Btu/lbm //enthalpy
18 printf("Solution for (a),\n");
19 COP=(h3-h1)/(h4-h3); //Coefficient of performance
20 printf("Coefficient of performance is %f\n\n",COP);
21 printf("Solution for (b),\n");
22 printf("The work of compression is %f Btu/lbm\n\n",
        h4-h3);
23 printf("Solution for (c),\n");
24 printf("The refrigerating effect is %f Btu/lbm\n\n",
        h3-h1);
25 printf("Solution for (d),\n");
26 tons=30; //capacity of 30 tons is desired
27 printf("The pounds per minute of ammonia required
        for circulation is %f lbm/min\n\n", (200*tons)/(h3-
        h1));
28 printf("Solution for (e),\n");
29 printf("The ideal horsepower per ton of
        refrigeration is %f hp/ton\n\n", 4.717*((h4-h3)/(
        h3-h1)));

```

Scilab code Exa 10.7 Refrigeration cycles

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.7\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.7 (page no. 510)
7 // Solution
8
9 //From Appendix 3,110 psig corresponds to 96 F,
    enthalpies are
10 h1=30.14; //Unit:Btu/lbm //enthalpy
11 h2=30.14; //Unit:Btu/lbm //Throttling gives h1=h2 //

```

```

    enthalpy
12 h3=75.110; //Unit:Btu/lbm //enthalpy
13 //From the consideration that s3=s4, at -20F,
14 s3=0.17102; //Unit:Btu/(lbm*F) //s=entropy
15 //Therefore by interpolation in the Freon-12
    superheat table at these values,
16 h4=89.293; //Unit:Btu/lbm //enthalpy
17 printf("Solution for (a),\n");
18 COP=(h3-h1)/(h4-h3); //Coefficient of performance
19 printf("Coefficient of performance is %f\n\n", COP);
20 printf("Solution for (b),\n");
21 printf("The work of compression is %f Btu/lbm\n\n",
    h4-h3);
22 printf("Solution for (c),\n");
23 printf("The refrigerating effect is %f Btu/lbm\n\n",
    h3-h1);
24 printf("Solution for (d),\n");
25 tons=30; //capacity of 30 tons is desired
26 printf("The pounds per minute of ammonia required
    for circulation is %f lbm/min\n\n", (200*tons)/(h3-
    h1));
27 printf("Solution for (e),\n");
28 printf("The ideal horsepower per ton of
    refrigeration is %f hp/ton\n\n", 4.717*((h4-h3)/(
    h3-h1)));

```

Scilab code Exa 10.8 An ideal Refrigeration cycle

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.8\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.8 (page no. 517)
7 // Solution

```

```

8
9 //From Appendix 3,using the Freon-12 tables ,
   enthalpies are
10 h1=28.713; //Unit:Btu/lbm //enthalpy
11 h2=28.713; //Unit:Btu/lbm //Throttling gives h1=h2
   //enthalpy
12 h3=78.335; //Unit:Btu/lbm //enthalpy
13 //From the consideration that s3=s4 ,
14 s3=0.16798; //Unit:Btu/(lbm*F) //s=entropy
15 //Therefore by interpolation in the superheat tables
   at 90 F,
16 s=0.16798; //entropy at 90F //Btu/lbm*F
17 h4=87.192; //Unit:Btu/lbm //enthalpy
18 printf("The heat extracted is %f Btu/lbm\n\n",h3-h1)
   ;
19 printf("The work required is %f Btu/lbm\n\n",h4-h3);
20 COP=(h3-h1)/(h4-h3); //Coefficient of performance
21 printf("The Coefficient of performance(COP) of this
   ideal cycle is %f",COP);

```

Scilab code Exa 10.9 Coefficient of performance

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.9\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.9 (page no. 518)
7 // Solution
8
9 //From Appendix 3,using the HFC-134a tables ,
   enthalpies are
10 h1=41.6; //Unit:Btu/lbm //enthalpy
11 h2=41.6; //Unit:Btu/lbm //Throttling gives h1=h2 //
   enthalpy

```

```

12 h3=104.6; //Unit:Btu/lbm //enthalpy
13 //From the consideration that s3=s4,
14 s3=0.2244; //Unit:Btu/(lbm*F) //s=entropy
15 h4=116.0; //Unit:Btu/lbm //enthalpy
16 printf("The heat extracted is %f Btu/lbm\n\n",h3-h1)
    ;
17 printf("The work required is %f Btu/lbm\n\n",h4-h3);
18 COP=(h3-h1)/(h4-h3); //Coefficient of performance
19 printf("The Coefficient of performance(COP) of this
    ideal cycle is %f",COP);

```

Scilab code Exa 10.10 total work and mass

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.10\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.10 (page no. 518)
7 // Solution
8
9 printf("Solution for (a)\n");
10 //By definition ,the efficiency of the compressor is
    the ratio of the ideal compression work to actual
    compression work.
11 //Based on the points on fig.10.12, //n=(h4-h3)/(h4
    '-h3);
12 //There is close correspondence between 5.3 psia and
    -60F for saturated conditions. Therefore ,state 3
    is a superheated vapour at 5.3 psia and
    approximately -20F, because the problem states
13 //that state 3 has a 40F superheat. Interpolation in
    the Freon tables in Appendix 3 yields
14 T=-20; //Unit:F //temperature
15 // p h s

```



```

16 //7.5 75.719 0.18371
17 //5.3 76.885 0.18985 h3=75.886 Btu/lbm
18 //5.0 75.990 0.19069
19
20 //At 100 psia and s=0.18985,
21 // t s h
22 // 170F 0.18996 100.571
23 // 169.6F 0.18985 100.5 h4=100.5 Btu/lbm
24 // 160F 0.18726 98.884
25
26 //The weight of refrigerant is given by
27 // 200(tons)/(h3-h1) = (200*5)/(75.886-h1)
28 //In the saturated tables ,h1 is
29 // p h
30 // 101.86 26.832
31 // 100psia 26.542
32 // 98.87 26.365
33
34 //m=mass flow/min
35 h1=26.542; //enthalpy //Unit:Btu/lbm
36 n=0.8; //Efficiency
37 h4=100.5; //enthalpy //Unit:Btu/lbm
38 h3=75.886; //enthalpy //Unit:Btu/lbm
39 m=(200*5)/(75.886-h1); //mass
40 h4dashminush3=(h4-h3)/n;
41 //Total work of compression=m*(h4minush3)
42 J=778; //J=Conversion factor
43 work=(h4dashminush3*m*J)/33000; //1 horsepower =
44 // 33,000 ft*Lbf/min //Unit:hp //work
45 printf("%f horsepower is required to drive the
46 // compressor if it has a mechanical efficiency 100
47 // percentage\n\n",work);
48
49 printf("Solution for (b)\n");
50 //Assuming a specific heat of the water as unity ,we
51 // obtain
52 //From part (a),
53 //h4'-h3=h4minush3

```

```

50 h4dash=h4dashminush3+h3; //Unit:Btu/lbm
51 mdot=(m*(h4dash-h1))/(70-60); //water enters at 60F
    and leaves at 70F //the required capacity in lbm/
    min
52 printf("%f lbm/min of cooling water i.e. %f gal/min
    is the required capacity of cooling water to pump
    ",mdot,mdot/8.3);

```

Scilab code Exa 10.11 Work and mass

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.11\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.11 (page no. 521)
7 // Solution
8
9 printf("Solution for (a)\n");
10 //From appendix3,reading the p-h diagram directly ,we
    have
11 h3=76.2; //Unit:Btu/lbm //Enthalpy
12 h4=100.5; //Unit:Btu/lbm //Enthalpy
13 n=0.8; //Efficiency //From 10.10
14 work=(h4-h3)/n; //Work of compression //Unit:Btu/lbm
15 //The enthalpy of saturated liquid at 100 psia is
    given at 26.1 Btu/lbm.Proceeding as before yields
16 m=(200*5)/(h3-26.1); //Unit:lbm/min //m=massflow/min
17 J=778; //J=Conversion factor
18 totalwork=(m*work*J)/33000; //1 horsepower = 33,000
    ft*LBf/min //total ideal work //unit:hp
19 printf("Total ideal work of compression is %f hp\n\n
    ",totalwork);
20
21 printf("Solution for (b)\n");

```

```

22 h4dash=h3+work; //Btu/lbm
23 mdot=(m*(h4dash-26.5))/(70-60); //water enters at 60
    F and leaves at 70F //the required capacity in
    lbm/min
24 printf("%f lbm/min of cooling water i.e. %f gal/min
    is the required capacity of cooling water to pump
    ",mdot,mdot/8.3);

```

Scilab code Exa 10.12 Determine the airflow required per ton of refrigeration

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.12\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.12 (page no. 526)
7 // Solution
8
9 COP=2.5; //Coefficient of performance
10 cp=0.24; //Unit:Btu/(lbm*R) //Specific heat constant
    for constant pressure process
11 T1=-100+460; //temperatures converted to absolute
    temperatures; //Unit:R //lowest temperature of
    the cycle
12 T3=150+460; //temperatures converted to absolute
    temperatures; //Unit:R //Upper temperature of the
    cycle
13 //T1/T4-T1 = COP
14 T4=(3.5*T1)/COP; //Unit:R //temperature at point 4
15 //T2/T3-T2 =COP
16 T2=(COP*T3)/3.5; //Unit:R //temperature at point 2
17 printf("The work of the expander is %f Btu/lbm of
    air\n",cp*(T4-T1));
18 printf("The work of the compressor is %f Btu/lbm of

```

```

    air\n",cp*(T3-T2));
19 printf("The net work required by the cycle is %f Btu
    /lbm\n", (cp*(T3-T2))-(cp*(T4-T1)));
20 printf("Per ton of refrigeration ,the required
    airflow is %f lbm/min per ton\n",200/(cp*(T2-T1))
    );

```

Scilab code Exa 10.13 A vacuum Refrigeration system

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.13\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.13 (page no. 536)
7 // Solution
8
9 //A VACUUM REFRIGERATION SYSTEM
10 //A vacuum refrigeration system is used to cool
    water from 90F to 45F
11 h1=58.07; //Unit:Btu/lbm //enthalpy
12 h2=13.04; //Unit:Btu/lbm //enthalpy
13 h3=1081.1; //Unit:Btu/lbm //enthalpy
14 m1=1; //mass //unit:lbm
15 //m2=1-m3 //unit:lbm
16 //Now, m1*h1 = m2*h2 + m3*h3
17 //Putting the values and arranging the equation ,
18 m3=(m1*h1-h2)/(h3+h2); //The mass of vapour that
    must be removed per pound //unit:lbm
19 printf("The mass of vapour that must be removed per
    pound of entering water is %f lbm",m3);

```

Scilab code Exa 10.14 A vacuum Refrigeration system

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.14\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.14 (page no. 536)
7 // Solution
8
9 //In problem 10.13,
10 //A VACUUM REFRIGERATION SYSTEM
11 //A vacuum refrigeration system is used to cool
    water from 90F to 45F
12 h1=58.07; //Unit:Btu/lbm //enthalpy
13 h2=13.04; //Unit:Btu/lbm //enthalpy
14 h3=1081.1; //Unit:Btu/lbm //enthalpy
15 m1=1; //mass //lbm
16 //m2=1-m3 //unit:lbm
17 //Now, m1*h1 = m2*h2 + m3*h3
18 //Putting the values and arranging the equation,
19 m3=(m1*h1-h2)/(h3+h2); //The mass of vapour that
    must be removed per pound //unit:lbm
20 m2=1-m3; //mass //unit:lbm
21 printf("The mass of vapour that must be removed per
    pound of entering water is %f lbm\n",m3);
22 //Now, in problem 10.14,
23 //The refrigeration effect can be determined as m3*(
    h3-h1) or m2*(h1-h2)
24 printf("The refrigeration effect using eqn m3*(h3-h1
    ) is %f Btu/lbm\n",m3*(h3-h1));
25 printf("The refrigeration effect using eqn m2*(h1-h2
    ) is %f Btu/lbm\n",m2*(h1-h2));

```

Scilab code Exa 10.15 The heat pump

```

1 //scilab 5.4.1

```

```

2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.15\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.15 (page no. 539)
7 // Solution
8
9 //THE HEAT PUMP
10 T1=70+460; //70F=70+460 R //Energy flows into the
    system at reservoir at constant temperature T1(
    unit:R) //from problem 10.1
11 T2=32+460; //32F=32+460 R //Heat is rejected to the
    constant temperature T2(Unit:R) //from problem
    10.1
12 COP=T1/(T1-T2); //Coefficient of performance for
    carnot heat pump
13 printf("Coefficient of performance(COP) of the
    carnot cycle is %f\n",COP);
14 printf("The COP can also be obtained from the energy
    items solved for in problem 10.1\n")
15 //In problem 10.1, The power was found to be 77.2
    Btu/min and the total tare of heat rejection was
    1077.2 Btu/min
16 //Therefore ,
17 printf("Coefficient of performance(COP) of the cycle
    is %f\n",1077.2/77.2);

```

Scilab code Exa 10.16 The heat pump

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 10.16\n\n\n");
5 // Chapter 10 : Refrigeration
6 // Problem 10.16 (page no. 539)

```

```

7 // Solution
8
9 //Let us first consider the cycle as a refrigeration
  cycle
10 //In problem 10.1
11 T1=70+460; //70F=70+460 R //Energy flows into the
  system at reservoir at constant temperature T1(
  unit:R)
12 T2=0+460; //0F=32+460 R //Heat is rejected to the
  constant temperature T2(Unit:R)
13 COP=T2/(T1-T2); //Coefficient of performance
14 printf("Coefficient of performance(COP) of the cycle
  is %f\n\n",COP);
15 Qremoved=1000; //Unit:Btu/min //heat removal
16 WbyJ=Qremoved/COP; //the power input //unit:Btu/min
17 printf("The power input is %f Btu/min\n\n",WbyJ);
18 Qrej=Qremoved+WbyJ; //The rate of heat rejected to
  the room //Unit:Btu/min
19 printf("The rate of heat rejected to the room is %f
  Btu/min\n",Qrej);
20 printf("The COP as a heat pump is %f\n",Qrej/WbyJ);
21 printf("As a check ,COP of heat pump is %f = 1 + COP
  of carnot cycle %f",Qrej/WbyJ,COP);

```

Chapter 11

Heat Transfer

Scilab code Exa 11.1 Heat transfer per square foot of wall

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 11.1\n\n\n");
4 // Chapter 11: Heat Transfer
5 // Problem 11.1 (page no. 553)
6 // Solution
7
8
9 deltaX=6/12; //6 inch = 6/12 feet //deltaX=length //
   unit:feet
10 k=0.40; //Unit:Btu/(hr*ft*F) //k=proportionality
   constant //k=thermal conductivity //From the
   table
11 T1=150; //temperature maintained at one face //
   fahrenheit
12 T2=80; //tempereture maintained at other face //
   fahrenheit
13 deltaT=T2-T1; //fahrenheit //Change in temperature
14 Q=(-k*deltaT)/deltaX; //Heat transfer per square
   foot of wall //Unit:Btu/hr*ft^2
15 printf("Heat transfer per square foot of wall is %f
```



```
Btu/hr*ft^2",Q);
```

Scilab code Exa 11.2 Heat transfer per unit wall area

```
1 clear;
2 clc;
3 printf("\t\t\tProblem Number 11.2\n\n\n");
4 // Chapter 11: Heat Transfer
5 // Problem 11.2 (page no. 553)
6 // Solution
7
8 deltaX=0.150; //Given,150 mm =0.150 meter // //
   deltaX=length //Unit:meter
9 k=0.692; //Unit:W/(m*celcius) //k=proportionality
   constant //k=thermal conductivity
10 T1=70; //temperature maintained at one face //
   celcius
11 T2=30; //tempereture maintained at other face //
   celcius
12 deltaT=T2-T1; //celcius //change in temperature
13 Q=(-k*deltaT)/deltaX; //Heat transfer per square
   foot of wall //unit:W/m^2
14 printf("Heat transfer per square foot of wall is %f
   W/m^2",Q);
```

Scilab code Exa 11.3 determine the resistance needed

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.3\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.3 (page no. 556)
```

```

7 // Solution
8
9 //From example 11.1,
10 deltaX=6/12; //6 inch = 6/12 feet //deltaX=length //
    unit:feet
11 A=1; //area //ft^2
12 k=0.40; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
13
14 Rt=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
15
16 //Q=deltaT/Rt //Q=heat transfer //ohm's law (fourier
    's equation)
17 //i=deltaE/Re //i=current in amperes //deltaE=The
    potential difference //Re=the electrical
    resistance //ohm's law
18 // Q/i = (deltaT/Rt)*(deltaE/Re)
19 //Q/i=100; //Given // 1 A correspond to 100 Btu/(hr*
    ft^2)
20 deltaE=9; //Unit:Volt //potential difference
21 T1=150; //temperature maintained at one face //
    fahrenheit
22 T2=80; //tempetature maintained at other face //
    fahrenheit
23 deltaT=T2-T1; //fahrenheit //Change in temperature
24 Re=(100*deltaE*Rt)/deltaT; //Unit:Ohms //The
    electrical resistance needed
25 printf("The electrical resistance needed is %f ohms\
    n",abs(Re));
26 i=deltaE/Re; //current //Unit:amperes
27 Q=100*i; //Heat transfer per square foot of wall //
    Unit:Btu/hr*ft^2
28 printf("Heat transfer per square foot of wall is %f
    Btu/hr*ft^2",abs(Q));

```

Scilab code Exa 11.4 Heat transfer per sqr foot of wall

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.4\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.4 (page no. 558)
7 // Solution
8
9 //For Brick ,
10 deltaX=6/12; //6 inch = 6/12 feet //deltaX=length //
    unit:ft
11 A=1; //area //unit:ft^2
12 k=0.40; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
13 R=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
14 printf("For brick ,\n");
15 printf("The resistance is %f (hr*F)/Btu\n\n",R);
16 R1=R;
17
18 //For Concrete ,
19 deltaX=(1/2)/12; //(1/2) inch = (1/2)/12 feet //
    deltaX=length //unit:ft
20 A=1; //area //ft^2
21 k=0.80; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
22 R=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
23 printf("For Concrete ,\n");
24 printf("The resistance is %f (hr*F)/Btu\n\n",R);
```

```

25 R2=R;
26
27 //For plaster ,
28 deltaX=(1/2)/12; // (1/2) inch = 6/12 feet //deltaX=
    length //unit:ft
29 A=1; //area //ft^2
30 k=0.30; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
31 R=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
32 printf("For plaster ,\n");
33 printf("The resistance is %f (hr*F)/Btu\n\n",R);
34 R3=R;
35
36 Rot=R1+R2+R3; //Rot=The overall resistance //unit:(
    hr*F)/Btu
37 printf("The overall resistance is %f (hr*F)/Btu\n\n"
    ,Rot);
38 T1=70; //temperature maintained at one face //
    fahrenheit
39 T2=30; //tempetature maintained at other face //
    fahrenheit
40 deltaT=T2-T1; //fahrenheit //Change in temperature
41 Q=deltaT/Rot; //Q=Heat transfer //Unit:Btu/(hr*ft^2)
    ; //ohm's law (fourier's equation)
42 printf("Heat transfer per square foot of wall is %f
    Btu/hr*ft^2",abs(Q));

```

Scilab code Exa 11.5 The interface temperatures

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.5\n\n\n");

```

```

5 // Chapter 11 : Heat Transfer
6 // Problem 11.5 (page no. 558)
7 // Solution
8
9 printf("In problem 11.4,\n");
10 //From example 11.4,,,
11 //For Brick ,
12 deltaX=6/12; //6 inch = 6/12 feet //deltaX=length //
    unit:ft
13 A=1; //area //unit:ft^2
14 k=0.40; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
15 R=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
16 printf("For brick,\n");
17 printf("The resistance is %f (hr*F)/Btu\n\n",R);
18 R1=R;
19
20 //For Concrete ,
21 deltaX=(1/2)/12; //(1/2) inch = (1/2)/12 feet //
    deltaX=length //unit:ft
22 A=1; //area //ft^2
23 k=0.80; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
24 R=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
25 printf("For Concrete,\n");
26 printf("The resistance is %f (hr*F)/Btu\n\n",R);
27 R2=R;
28
29 //For plaster ,
30 deltaX=(1/2)/12; // (1/2) inch = 6/12 feet //deltaX=
    length //unit:ft
31 A=1; //area //ft^2
32 k=0.30; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the

```

```

        table
33 R=deltaX/(k*A); //Thermal resistance //Unit:(hr*f)/
    Btu
34 printf("For plaster ,\n");
35 printf("The resistance is %f (hr*F)/Btu\n\n",R);
36 R3=R;
37
38 Rot=R1+R2+R3; //Rot=The overall resistance //unit:(
    hr*F)/Btu
39 printf("The overall resistance is %f (hr*F)/Btu\n\n"
    ,Rot);
40 T1=70; //temperature maintained at one face //
    fahrenheit
41 T2=30; //tempereture maintained at other face //
    fahrenheit
42 deltaT=T2-T1; //fahrenheit //Change in temperature
43 Q=deltaT/Rot; //Q=Heat transfer //Unit:Btu/(hr*ft^2)
    ;
44 printf("Heat transfer per square foot of wall is %f
    Btu/hr*ft^2",abs(Q));
45
46 printf("Now in problem 11.5,\n");
47 deltaT=R*Q //ohm's law (fourier's equation) //Change
    in temperature //fahrenheit
48 //For Brick ,
49 deltaT=Q*R1; //Unit:fahrenheit //ohm's law (fourier'
    s equation) //Change in temperature
50 t1=deltaT;
51 //For Concrete ,
52 deltaT=Q*R2; //Unit:fahrenheit //ohm's law (fourier'
    s equation) //Change in temperature
53 t2=deltaT;
54 //For plaster ,
55 deltaT=Q*R3; //Unit:fahrenheit //ohm's law (fourier'
    s equation) //Change in temperature
56 t3=deltaT;
57
58 deltaTo=t1+t2+t3; //Overall Change in temperature //

```

```

    fahrenheit
59 printf("The overall change in temperature is %f F\n"
    ,abs(deltaTo));
60 //The interface temperature are:
61 printf("The interface temperature are:\n");
62 printf("For brick-concrete : %f fahrenheit\n",abs(T2
    )+abs(t1));
63 printf("For concrete-plaster : %f fahrenheit\n",abs(
    T2)+abs(t1)+abs(t2));

```

Scilab code Exa 11.6 Heat transfer per square meter of wall

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.6\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.6 (page no. 559)
7 // Solution
8
9 //For Brick ,
10 deltaX=0.150; //Unit:m //150 mm = 0.150 m //deltaX=
    length //unit:meter
11 A=1; //area //unit:m^2
12 k=0.692; //Unit:W/(m*C) //k=proportionality constant
    //k=thermal conductivity //From the table
13 R=deltaX/(k*A); //Thermal resistance //Unit:C/W
14 printf("For brick ,\n");
15 printf("The resistance is %f Celcius/W\n\n",R);
16 R1=R;
17
18 //For Concrete ,
19 deltaX=0.012; //Unit:m //12 mm = 0.0120 m //deltaX=
    length //unit:meter
20 A=1; //area //unit:m^2

```

```

21 k=1.385; //Unit:W/(m*C) //k=proportionality constant
    //k=thermal conductivity //From the table
22 R=deltaX/(k*A); //Thermal resistance //Unit:C/W
23 printf("For Concrete ,\n");
24 printf("The resistance is %f Celcius/W\n\n",R);
25 R2=R;
26
27 //For plaster ,
28 deltaX=0.0120; //Unit:m //12 mm = 0.0120 m //deltaX=
    length //unit:meter
29 A=1; //area //unit:m^2
30 k=0.519; //Unit:W/(m*C) //k=proportionality constant
    //k=thermal conductivity //From the table
31 R=deltaX/(k*A); //Thermal resistance //Unit:C/W
32 printf("For plaster ,\n");
33 printf("The resistance is %f Celcius/W\n\n",R);
34 R3=R;
35
36 Ro=R1+R2+R3; //Rot=The overall resistance //unit:C/W
37 printf("The overall resistance is %f Celcius/W\n",Ro
    );
38 T1=0; //temperature maintained at one face //Celcius
39 T2=20; //tempereture maintained at other face //
    Celcius
40 deltaT=T2-T1; //Change in temperature //Celcius
41 Q=deltaT/Ro; //Q=Heat transfer //Unit:W/m^2; //ohm's
    law (fourier's equation)
42 printf("Heat transfer per square meter of wall is %f
    W/m^2",abs(Q));

```

Scilab code Exa 11.7 The temperature at the interfaces

```

1 //scilab 5.4.1
2 clear;
3 clc;

```



```

4 printf("\t\t\tProblem Number 11.7\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.7 (page no. 560)
7 // Solution
8
9 printf("In problem 11.6,\n");
10 //For Brick ,
11 deltaX=0.150; //Unit:m //150 mm = 0.150 m //deltaX=
    length //unit:meter
12 A=1; //area //unit:meter^2
13 k=0.692; //Unit:W/(m*C) //k=proportionality constant
    //k=thermal conductivity //From the table
14 R=deltaX/(k*A); //Thermal resistance //Unit:Celcius/
    W
15 printf("For brick,\n");
16 printf("The resistance is %f Celcius/W\n\n",R);
17 R1=R;
18
19 //For Concrete ,
20 deltaX=0.012; //Unit:m //12 mm = 0.0120 m //deltaX=
    length //unit:meter
21 A=1; //area //unit:meter^2
22 k=1.385; //Unit:W/(m*C) //k=proportionality constant
    //k=thermal conductivity //From the table
23 R=deltaX/(k*A); //Thermal resistance //Unit:Celcius/
    W
24 printf("For Concrete,\n");
25 printf("The resistance is %f Celcius/W\n\n",R);
26 R2=R;
27
28 //For plaster ,
29 deltaX=0.0120; //Unit:m //12 mm = 0.0120 m //deltaX=
    length //unit:meter
30 A=1; //area //unit:meter^2
31 k=0.519; //Unit:W/(m*C) //k=proportionality constant
    //k=thermal conductivity //From the table
32 R=deltaX/(k*A); //Thermal resistance //Unit:Celcius/
    W

```

```

33 printf("For plaster ,\n");
34 printf("The resistance is %f Celcius/W\n\n",R);
35 R3=R;
36
37 Ro=R1+R2+R3; //Rot=The overall resistance Celcius/W
38 printf("The overall resistance is %f Celcius/W\n",Ro
);
39 T1=0; //temperature maintained at one face //Celcius
40 T2=20; //tempereture maintained at other face //
Celcius
41 deltaT=T2-T1; //Change in temperature //Celcius
42 Q=deltaT/Ro; //Q=Heat transfer //Unit:W/m^2;
43 printf("Heat transfer per square meter of wall is %f
W/m^2\n\n",abs(Q));
44
45 printf("Now in problem 11.5,\n");
46 //deltaT=R*Q //ohm's law (fourier's equation)
47 //For Brick ,
48 deltaT=Q*R1; //Unit:Celcius //Change in temperature
49 t1=deltaT;
50 //For Concrete ,
51 deltaT=Q*R2; //Unit:Celcius //Change in temperature
52 t2=deltaT;
53 //For plaster ,
54 deltaT=Q*R3; //Unit:Celcius //Change in temperature
55 t3=deltaT;
56
57 deltaTo=t1+t2+t3; //The overall Change in
temperature //Celcius
58 printf("The overall change in temperature is %f
celcius\n",abs(deltaTo));
59 //The interface temperature are:
60 printf("The interface temperature are:\n");
61 printf("%f Celcius\n",abs(deltaTo)-abs(t1));
62 printf("%f Celcius\n",abs(deltaTo)-abs(t1)-abs(t2));
63 printf("%f Celcius\n",abs(deltaTo)-abs(t1)-abs(t2)-
abs(t3));

```

Scilab code Exa 11.8 total heat loss

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.8\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.8 (page no. 561)
7 // Solution
8
9 deltaX=4/12; //4 inch = 6/12 feet //deltaX=length //
    unit:ft
10 A=7*2; //area //area=hight*width //unit:ft^2
11 k=0.090; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity for fir //From
    the table
12 Rfir=deltaX/(k*A); //Resistance of fir //Unit:(hr*F)
    /Btu
13 printf("For fir ,\n");
14 printf("The resistance is %f (hr*F)/Btu\n\n",Rfir);
15
16 deltaX=4/12; //4 inch = 6/12 feet //deltaX=length //
    unit:ft
17 A=7*2; //area //area=hight*width //unit:ft^2
18 k=0.065; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity for pine //From
    the table
19 Rpine=deltaX/(k*A); //Resistance of pine //Unit:(hr*
    F)/Btu
20 printf("For pine ,\n");
21 printf("The resistance is %f (hr*F)/Btu\n\n",Rpine);
22
23 deltaX=4/12; //4 inch = 6/12 feet //deltaX=length //
    unit:ft
```

```

24 A=7*2; //area //area=height*width //unit:ft^2
25 k=0.025; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity for corkboard
    //From the table
26 Rcorkboard=deltaX/(k*A); //Resistance of corkboard
    //Unit:(hr*F)/Btu
27 printf("For corkboard,\n");
28 printf("The resistance is %f (hr*F)/Btu\n\n",
    Rcorkboard);
29
30 Roverall=inv(inv(Rfir)+inv(Rpine)+inv(Rcorkboard));
31 printf("The overall resistance is %f (hr*F)/Btu\n\n"
    ,Roverall);
32
33 T1=60; //temperature maintained at one face //unit:
    fahrenheit
34 T2=80; //tempetature maintained at other face //unit
    :fahrenheit
35 deltaT=T2-T1; //Change in temperature //unit:
    fahrenheit
36 Qtotal=deltaT/Roverall; //Q=Total Heat loss //Unit:
    Btu/hr; //ohm's law (fourier's equation)
37 printf("Total Heat loss from the wall is %f Btu/hr\n
    ",abs(Qtotal));
38
39 //As a check,
40 Qfir=deltaT/Rfir; //Q=Fir Heat loss //Unit:Btu/hr;
    //ohm's law (fourier's equation)
41 printf("Heat loss from the wall made of fir is %f
    Btu/hr\n",abs(Qfir));
42 Qpine=deltaT/Rpine; //Q=Pine Heat loss //Unit:Btu/hr
    ; //ohm's law (fourier's equation)
43 printf("Heat loss from the wall made of pine is %f
    Btu/hr\n",abs(Qpine));
44 Qcorkboard=deltaT/Rcorkboard; //Q=corkboard Heat
    loss //Unit:Btu/hr; //ohm's law (fourier's
    equation)
45 printf("Heat loss from the wall made of corkboard is

```

```

    %f Btu/hr\n",abs(Qcorkboard));
46 Qtotal=Qfir+Qpine+Qcorkboard; //Total Heat loss from
    the wall //unit:Btu/hr
47 printf("Total Heat loss from the wall is %f Btu/hr\n
    ",abs(Qtotal));

```

Scilab code Exa 11.9 The heat loss from the pipe

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.9\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.9 (page no. 565)
7 // Solution
8
9 //A bare steel pipe
10 ro=3.50; //Outside diameter //Unit:in.
11 ri=3.00; //inside diameter //Unit:in.
12 Ti=240; //Inside temperature //unit:fahrenheit
13 To=120; //Outside temperature //unit:fahrenheit
14 L=5; //Length //Unit:ft
15 deltaT=Ti-To; //Change in temperature //unit:
    fahrenheit
16 k=26 //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity
17 Q=(2*pi*k*L*deltaT)/log(ro/ri); //The heat loss
    from the pipe //unit:Btu/hr
18 printf("The heat loss from the pipe is %f Btu/hr",Q)
    ;

```

Scilab code Exa 11.10 heat loss from the pipe

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.10\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.10 (page no. 566)
7 // Solution
8
9 //A bare steel pipe
10 ro=90; //Outside diameter //Unit:mm
11 ri=75; //inside diameter //Unit:mm
12 Ti=110; //Inside temperature //Unit: Celcius
13 To=40; //Outside temperature //Unit: Celcius
14 L=2; //Length //Unit:m
15 deltaT=Ti-To; //Change in temperature //Unit: Celcius
16 k=45 //Unit:W/(m*C) //k=proportionality constant //k
    =thermal conductivity
17 Q=(2*pi*k*L*deltaT)/log(ro/ri); //The heat loss
    from the pipe //unit:W
18 printf("The heat loss from the pipe is %f W",Q);

```

Scilab code Exa 11.11 heat loss from mineral of wool

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.11\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.11 (page no. 567)
7 // Solution
8
9 //From problem 11.9,
10 //A bare steel pipe
11 r2=3.50; //Outside diameter //Unit:in.
12 r1=3.00; //inside diameter //Unit:in.

```

```

13 Ti=240; //Inside temperature //unit:fahrenheit
14 L=5; //Length //Unit:ft
15 k1=26; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity
16 ans1=(inv(k1)*log(r2/r1));
17
18 //Now,in problem 11.11,
19 //Mineral wool
20 r3=5.50; //inside diameter //Unit:in.
21 r2=3.50; //outside diameter //Unit:in.
22 To=85; //Outside temperature //unit:fahrenheit
23 deltaT=Ti-To; //Change in temperature //unit:
    fahrenheit
24 k2=0.026 //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity
25 ans2=(inv(k2)*log(r3/r2));
26
27 Q=(2*pi*L*deltaT)/(ans1+ans2); //The heat loss from
    the pipe //unit:Btu/hr
28 printf("The heat loss from the pipe is %f Btu/hr",Q)
    ;

```

Scilab code Exa 11.12 Convection

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.12\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.12 (page no. 569)
7 // Solution
8
9 //From problem 11.9,
10 //The bare pipe
11 r2=3.50; //Outside diameter //Unit:in.

```

```

12 r1=3.00; //inside diameter //Unit:in.
13 Ti=240; //Inside temperature //unit:fahrenheit
14 L=5; //Length //Unit:ft
15 k=26; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity
16 Rpipe=log(r2/r1)/(2*pi*k*L); //the resistance of
    pipe //Unit:(hr*F)/Btu
17 printf("The resistance of pipe is %f (hr*F)/Btu\n",
    Rpipe);
18
19 //Now,in problem 11.12,
20 To=70; //Outside temperature //unit:fahrenheit
21 deltaT=Ti-To; //Change in temperature //unit:
    fahrenheit
22 h=0.9; //Coefficient of heat transfer //Unit:Btu/(hr
    *ft^2*F)
23 A=(pi*r2)/12*L; //Area //Unit:ft^2 //1 inch = 1/12
    feet //unit:ft^2
24 Rconvection=inv(h*A); //The resistance due to
    natural convection to the surrounding air //Unit
    :(hr*F)/Btu
25 printf("The resistance due to natural convection to
    the surrounding air is %f (hr*F)/Btu\n",
    Rconvection);
26
27 Rtotal=Rpipe+Rconvection; //The total resistance
    //unit:(hr*F)/Btu
28 printf("The total resistance is %f (hr*F)/Btu\n\n",
    Rtotal);
29 Q=deltaT/Rtotal; //ohm's law (fourier's equation) //
    The heat transfer from the pipe to the
    surrounding air //unit:Btu/hr
30 printf("The heat transfer from the pipe to the
    surrounding air is %f Btu/hr\n",Q);

```

Scilab code Exa 11.15 Convection

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.15\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.15 (page no. 574)
7 // Solution
8
9 D=3.5/12; //3.5 inch = 3.5/12 feet//Unit:ft //
    Outside diameter
10 Ti=120; //Inside temperature //unit:fahrenheit
11 To=70; //Outside temperature //unit:fahrenheit
12 deltaT=Ti-To; //unit:fahrenheit //Change in
    temperature
13 h=0.9; //Coefficient of heat transfer //Unit:Btu/(hr
    *ft^2*F)
14 L=5; //Length //Unit:ft //From problem 11.10
15 A=(%pi*D)*L; //Area //Unit:ft^2
16 Q=h*A*deltaT; //The heat loss due to convection //
    Unit:Btu/hr //Newton's law of cooling
17 printf("The heat loss due to convection is %f Btu/hr
    ",Q);
```

Scilab code Exa 11.16 Determine the heat transfer through the wall and wall temperature

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.16\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.16 (page no. 575)
7 // Solution
```

```

8
9 //This problem can not be solved directly ,because
    the individual film resistances are functions of
    unknown temperature differences .Therefore ,
10 //From the first approximation ,
11 h=1/2; //Coefficient of heat transfer //unit:Btu/(hr
    *ft ^2*F)
12 //For area 1 ft ^2,
13 R=(3/12)/0.07; //The wall resistance is  $\Delta x/(kA)$ 
    //k=0.07 //Unit:Btu/(hr*ft*F) //k=
    proportionality constant //k=thermal conductivity
14 Roverall=inv(1/2)+inv(1/2)+R; //the overall series
    resistance //Unit:Btu/(hr*ft*F)
15 printf("For h=0.5,the overall series resistance is
    %f Btu/(hr*ft*F)\n",Roverall);
16 //Using the value of Roverall,we can now obtain Q
    and individual temperature differences ,
17 Ti=80; //warm air temperature //unit:fahrenheit
18 To=50; //cold air temperature //unit:fahrenheit
19 deltaT=Ti-To; //unit:fahrenheit //Change in
    temperature
20 Q=deltaT/Roverall; //Unit:Btu/(hr*ft ^2) //heat
    transfer //ohm's law (fourier's equation)
21 printf("For h=0.5,heat transfer is %f Btu/(hr*ft ^2)\
    n",Q);
22 printf("For h=0.5,\n");
23 //deltaT through the hot air film is Q/(1/2)
24 printf("Temperature difference through the hot air
    film is %f F\n",Q/(1/2));
25 //Through the wall deltaT is R*Q
26 printf("Temperature difference through the wall is %f
    F\n",Q*R);
27 //deltaT through the cold air film is Q/(1/2)
28 printf("Temperature difference through the cold air
    film is %f F\n\n",Q/(1/2));
29
30 //With these temperature differences ,we can now
    enter figures 11.12 and 11.14 to verify our

```

```

    approximation.From figure 11.14,we find h=0.42
    Btu/(hr*ft*2*F)
31 //Using h=0.42,we have for the overall resistance
    (1/0.42)+(1/0.42)+R
32 h=0.42; //Coefficient of heat transfer //unit:Btu/(
    hr*ft^2*F)
33 Roverall=inv(h)+inv(h)+R; //the overall series
    resistance //Unit:Btu/(hr*ft*F)
34 printf("For h=0.42,the overall series resistance is
    %f Btu/(hr*ft*F)\n",Roverall);
35 Q=deltaT/Roverall; //Unit:Btu/(hr*ft^2) //heat
    transfer //ohm's law (fourier's equation)
36 printf("For h=0.42,heat transfer is %f Btu/(hr*ft^2)
    \n",Q);
37 printf("For h=0.42,\n");
38 //deltat through both air films is Q/h
39 printf("Temperaure difference through the hot and
    cold air film is %f F\n",Q/h);
40 //and through the wall,deltat is Q*R
41 printf("Temperaure difference through the wall is %f
    F\n\n",Q*R);
42
43 //Entering figure 11.14,we find that h stays
    essentially 0.42,and our solution is that the
    heat flow is Q,the "hot" side of the wall is at
    Ti-(Q/h),the "cold" side is at To+(Q/h),and
    temperature drop in the wall is Ti-(Q/h)-(To+(Q/h
    )).
44 printf("The temperature drop on the hot side of the
    wall is %f F\n",Ti-(Q/h));
45 printf("The temperature drop on the cold side of the
    wall is %f F\n",To+(Q/h));
46 printf("The temperature drop in the wall is %f F\n",
    Ti-(Q/h)-(To+(Q/h)));
47 //Which checks our wall deltat calculation.

```

Scilab code Exa 11.17 Determine the heat transfer coefficient

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.17\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.17 (page no. 578)
7 // Solution
8
9 //The first step is to check Reynolds number.It will
   be recalled that the Reynolds number is given by
    $(D*V*\rho)/\mu$  and is dimensionless. Therefore, we
   can use D, diameter in feet; V velocity in ft
   /hr;  $\rho$  density in  $\text{lbm}/\text{ft}^3$  and  $\mu$  viscosity in
    $\text{lbm}/(\text{ft}*\text{hr})$ .
10 //Alternatively ,the Reynolds number is given by  $(D*G$ 
    $)/\mu$ , where G is the mass flow rate per unit area
    $(\text{lbm}/(\text{hr}*\text{ft}^2))$ .
11  $G=((20*60)*(4*144)/(\%pi*0.87^2))$ ; //Unit:  $\text{lbm}/(\text{hr}*\text{ft}$ 
    $^2)$  //Inside diameter=0.87 inch //1 in. $^2=144$ 
    $\text{ft}^2$  //20 lbm/min of water(min converted to
   second)
12 //the viscosity of air at these conditions is
   obtained from figure 11.17 as  $0.062 \text{ lbm}/(\text{ft}*\text{hr})$ .
   So,
13  $\mu=0.33$ ; //the viscosity of air //unit:  $\text{lbm}/(\text{ft}*\text{hr})$ 
14  $D=0.87/12$ ; //Inside diameter //1 in. $^2=144 \text{ ft}^2$ 
15 //Therefore Reynolds number is
16  $Re=(D*G)/\mu$ ; //Reynolds number
17 //which is well into the turbulent flow regime.
18 printf("The Reynolds number is %f\n",Re);
19 //The next step is to enter Figure 11.18 at  $W/1000$ 
   of  $20*(60/1000)=1.2$  and 400F to obtain  $h_1=630$ .
```

```

20 //From the figure 11.20,we obtain F=1.25 for an
    inside diameter of 0.87 inch.So,
21 h1=630; //basic heat transfer coefficient //unit:Btu
    /(hr*ft^2*F)
22 F=1.25; //correction factor
23 h=h1*F; //heat transfer coefficient //the inside
    film coefficient //unit:Btu/(hr*ft^2*F)
24 printf("The heat-transfer coefficient is %f Btu/(hr*
    ft^2*F)\n",h);

```

Scilab code Exa 11.18 Determine the inside film coefficient

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.18\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.18 (page no. 579)
7 // Solution
8
9 //We first check the Reynolds number and note that G
    is same as for problem 11.17.So,
10 //G is the mass flow rate per unit area (lbm/(hr*ft
    ^2)).
11 G=((20*60)*(4*144))/(%pi*(0.87^2)); //Unit:lbm/(hr*
    ft^2) //Inside diameter=0.87 inch ////1 in
    ^2=144 ft^2 //20 lbm/min of water(min converted
    to second)
12 //the viscosity of air at these conditions is
    obtained from figure 11.17 as 0.062 lbm/(ft*hr).
    So,
13 mu=0.062; //the viscosity of air //unit:lbm/(ft*hr)
14 D=0.87/12; //Inside diameter //1 in^2=144 ft^2
15 //Reynolds number is DG/mu, therefore
16 Re=(D*G)/mu; //Reynolds number

```

```

17 printf("The Reynolds number is %f\n",Re);
18 //which places the flow in the turbulent regime.
    Because W/1000(W=weight flow) is same as for
    problem 11.17 and equals 1.2,we now enter figure
    11.19 at 1.2 and 400F to obtain h1=135.Because
    the inside tube diameter is same as before ,F
    =1.25.Therefore ,
19 h1=135; //basic heat transfer coefficient //unit:Btu
    /(hr*ft^2*F)
20 F=1.25; //correction factor
21 h=h1*F; //heat transfer coefficient //the inside
    film coefficient //unit:Btu/(hr*ft^2*F)
22 printf("The inside film coefficient is %f Btu/(hr*ft
    ^2*F)\n",h);
23 //It is interesting that for equal mass flow rates ,
    water yields a heat-transfer coefficient almost
    five times greater than air

```

Scilab code Exa 11.19 Determine the heat loss by radiation

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.19\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.19 (page no. 586)
7 // Solution
8
9 //A bare steel pipe
10 //From the Table 11.5,case 2,
11 Fe=0.79; //Emissivity factor to allow for the
    departure of the surfaces interchanging heat from
    complete blackness;Fe is a function of the
    surface emissivities and configurations
12 FA=1; //geometric factor to allow for the average

```

```

        solid angle through which one surface "sees" the
        other
13  sigma=0.173*10^-8; //Stefan-Boltzmann constant //
    Unit:Btu/(hr*ft^2*R^4)
14  T1=120+460; //outside temperature //Unit:R //
    fahrenheit converted to absolute temperature
15  T2=70+460; //inside temperature //Unit:R //
    fahrenheit converted to absolute temperature
16  D=3.5/12; //3.5 inch = 3.5/12 feet//Unit:ft //
    Outside diameter
17  L=5; //Length //Unit:ft //From problem 11.10
18  A=(%pi*D)*L; //Area //Unit:ft^2
19  Q=sigma*Fe*FA*A*(T1^4-T2^4); //The net interchange
    of heat by radiation between two bodies at
    different temperatures //Unit:Btu/hr ////Stefan-
    Boltzmann law
20  printf("The heat loss by radiation is %f Btu/hr\n",Q
    );

```

Scilab code Exa 11.20 Determine the heat transfer coefficient

```

1  //scilab 5.4.1
2  clear;
3  clc;
4  printf("\t\t\tProblem Number 11.20\n\n\n");
5  // Chapter 11 : Heat Transfer
6  // Problem 11.20 (page no. 588)
7  // Solution
8
9  //The upper temperature is given as 120 F and the
    temperature difference is
10  Ti=120; //Inside temperature //unit:fahrenheit
11  To=70; //Outside temperature //unit:fahrenheit
12  deltaT=120-70; //unit:fahrenheit //Change in
    temperature

```

```

13 //Using figure 11.28,
14 hrdash=1.18; //factor for radiation coefficient //
    Unit:Btu/(hr*ft^2*F)
15 Fe=1; //Emissivity factor to allow for the departure
    of the surfaces interchanging heat from complete
    blackness;Fe is a function of the surface
    emissivities and configurations
16 FA=0.79; //geometric factor to allow for the average
    solid angle through which one surface "sees" the
    other
17 hr=Fe*FA*hrdash; //The radiation heat-transfer
    coefficient for the pipe //Unit:Btu/(hr*ft^2*F)
18 printf("The radiation heat-transfer coefficient for
    the pipe is %f Btu/(hr*ft^2*F)\n",hr);
19
20 //As a check,Using the results of problem 11.17,
21 printf("As a check,using the results of problem
    11.17,\n");
22 D=3.5/12; //3.5 inch = 3.5/12 feet//Unit:ft //
    Outside diameter
23 L=5; //Length //Unit:ft //From problem 11.10
24 A=(%pi*D)*L; //Area //Unit:ft^2
25 Q=214.5; //heat loss //Unit:Btu/hr
26 hr=Q/(A*deltaT); //The radiation heat-transfer
    coefficient for the pipe //Unit:Btu/(hr*ft^2*F)
    //Newton's law of cooling
27 printf("The radiation heat-transfer coefficient for
    the pipe is %f Btu/(hr*ft^2*F)\n",hr);

```

Scilab code Exa 11.21 Determine the heat loss due to convection

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.21\n\n");

```



```

5 // Chapter 11 : Heat Transfer
6 // Problem 11.21 (page no. 589)
7 // Solution
8
9 //Because the conditions of illustrative problem
   11.15 are the same as for problem 11.19 and
   11.20,we can solve this problem in two ways to
   obtain a check.
10 //Thus,adding the results of these problems yields ,
11 printf("Adding the results of the problems yields ,\n
   ")
12 Qtotal=206.2+214.5; //Unit:Btu/hr //total heat loss
13 printf("The heat loss due to convection is %f Btu/hr
   \n",Qtotal);
14
15 //We can also approach this solution by obtaining
   radiation and convection heat-transfer co-
   efficient.Thus,
16 hcombined=0.9+0.94; //Coefficient of heat transfer
   //Unit:Btu/(hr*ft^2*F)
17 D=3.5/12; //3.5 inch = 3.5/12 feet //Unit:ft //
   Outside diameter
18 Ti=120; //Inside temperature //unit:fahrenheit
19 To=70; //Outside temperature //unit:fahrenheit
20 deltaT=Ti-To; //unit:fahrenheit //Change in
   temperature
21 L=5; //Length //Unit:ft //From problem 11.10
22 A=(%pi*D)*L; //Area //Unit:ft^2
23 Qtotal=hcombined*A*deltaT; //Unit:Btu/hr //total
   heat loss due to convection //Newton's law of
   cooling
24 printf("By obtaining radiation and convection heat-
   transfer co-efficient ,\n")
25 printf("The heat loss due to convection is %f Btu/hr
   ",Qtotal);

```

Scilab code Exa 11.22 Determine the overall heat transfer coefficient

```
1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.22\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.22 (page no. 595)
7 // Solution
8
9 //For brick ,concrete ,plaster ,hot film and cold film ,
10 A=1; //area //Unit:ft^2
11 //For a plane wall ,the areas are all the same ,and if
    we use 1 ft^2 of wall surface as the reference
    area ,
12 //For Brick ,
13 deltax=6/12; //6 inch = 6/12 feet //deltax=length //
    unit:ft
14 k=0.40; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
15 brickResistance=deltax/(k*A); //Thermal resistance
    //Unit:(hr*f)/Btu
16 printf("For brick ,");
17 printf("The resistance is %f (hr*F)/Btu\n",
    brickResistance);
18
19 //For Concrete ,
20 deltax=(1/2)/12; //(1/2) inch = (1/2)/12 feet //
    deltax=length //unit:ft
21 k=0.80; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
22 concreteResistance=deltax/(k*A); //Thermal
```

```

    resistance //Unit:(hr*f)/Btu
23 printf("For Concrete,");
24 printf("The resistance is %f (hr*F)/Btu\n",
    concreteResistance);
25
26 //For plaster,
27 deltax=(1/2)/12; // (1/2) inch = 6/12 feet //deltax=
    length //unit:ft
28 k=0.30; //Unit:Btu/(hr*ft*F) //k=proportionality
    constant //k=thermal conductivity //From the
    table
29 plasterResistance=deltax/(k*A); //Thermal resistance
    //Unit:(hr*f)/Btu
30 printf("For plaster,");
31 printf("The resistance is %f (hr*F)/Btu\n",
    plasterResistance);
32
33 //For "hot film",
34 h=0.9; //Coefficient of heat transfer //Unit:Btu/(hr
    *ft^2*F)
35 hotfilmResistance=inv(h*A); //Thermal resistance //
    Unit:(hr*f)/Btu
36 printf("For hot film,");
37 printf("The resistance is %f (hr*F)/Btu\n",
    hotfilmResistance);
38
39 //For "cold film",
40 h=1.5; //Coefficient of heat transfer //Unit:Btu/(hr
    *ft^2*F)
41 coldfilmResistance=inv(h*A); //Thermal resistance //
    Unit:(hr*f)/Btu
42 printf("For cold film,");
43 printf("The resistance is %f (hr*F)/Btu\n\n",
    coldfilmResistance);
44
45 totalResistance=brickResistance+concreteResistance+
    plasterResistance+hotfilmResistance+
    coldfilmResistance; //the overall resistance //

```

```

Unit:(hr*f)/Btu
46 printf("The overall resistance is %f (hr*F)/Btu\n",
totalResistance);
47
48 U=inv(totalResistance); //Unit:Btu/(hr*ft^2) //The
overall conductance(or overall heat-transfer
coefficient)
49 printf("The overall conductance(or overall heat-
transfer coefficient) is %f Btu/(hr/ft^2)\n",U);
50 //In problem 11.21,the solution is straightforward,
because the heat-transfer area is constant for
all series resistances.

```

Scilab code Exa 11.23 Determine the overall heat transfer coefficient of outside and inside area

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.23\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.23 (page no. 596)
7 // Solution
8
9 hi=45; //Film coefficient on the inside of the pipe
//Unit:Btu/(hr*ft^2*F)
10 r1=3.0/2; //Inside radius //Unit:inch
11 k1=26; //Unit:Btu/(hr*ft^2*F) //k=proportionality
constant for steel pipe //k=thermal conductivity
for fir //From the table
12 r2=3.5/2; //outside radius //Unit:inch
13 k2=0.026; //Unit:Btu/(hr*ft^2*F) //k=proportionality
constant for mineral wool //k=thermal
conductivity for fir //From the table
14 r3=5.50/2; //radius //Unit:inch

```

```

15 ho=0.9; //Film coefficient on the outside of the
    pipe //Unit:Btu/(hr*ft^2*F)
16 //Results of problem 11.23,
17 Ui=1/(((1/hi)+((r1/(k1*12))*log(r2/r1))+((r1/(k2*12))
    *log(r3/r2))+1/(ho*(r3/r1))))); //Unit:Btu/(hr*ft
    ^2*F) //1 in.=12 ft //Heat transfer coefficient
    based on inside surface
18 printf("Heat transfer coefficient based on inside
    surface is %f Btu/(hr*ft^2*F)\n",Ui);
19 //Because Uo*Ao=Ui*Ai
20 Uo=Ui*(r1/r3); //Heat transfer coefficient based on
    outside surface //Unit:Btu/(hr*ft^2*F)
21 printf("Heat transfer coefficient based on outside
    surface is %f Btu/(hr*ft^2*F)\n",Uo);

```

Scilab code Exa 11.24 Determine the outside tube surface required

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.24\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.24 (page no. 601)
7 // Solution
8
9 //A COUNTERFLOW HEAT EXCHANGER
10 //Hot oil enters at 215 F and leaves at 125 F
11 //Water enters the unit at 60 F and leaves at 90 F
12 //Therefore,From figure 11.34,
13 thetaA=215-90; //the greatest temperature difference
    between the fluids(at either inlet or outlet) //
    Unit:fahrenheit
14 thetaB=125-60; //the least temperature difference
    between the fluids(at either inlet or outlet) //
    Unit:fahrenheit

```

```

15 deltaTm=(thetaA-thetaB)/log(thetaA/thetaB); //
    logarithmic mean temperature difference //Unit:
    fahrenheit
16 //From the oil data,
17 m=400*60; //mass //Unit:lb/sec //1 min=60 sec
18 Cp=0.85; //Specific heat of the oil //Unit:Btu/(lb*F
    )
19 deltaT=215-125; //Change in temperature //Unit:
    fahrenheit
20 Q=m*Cp*deltaT //The heat transfer //Unit:Btu/hr
21 //Q=U*A*deltaTm
22 U=40; //The overall coefficient of heat transfer of
    the unit //Unit:Btu/(hr*ft^2*F)
23 A=Q/(U*deltaTm); //Unit:ft^2 //The outside surface
    area
24 printf("The outside surface area required is %f ft^2
    ",A);

```

Scilab code Exa 11.25 Determine the outside surface area required

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.25\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.25 (page no. 602)
7 // Solution
8
9 //In problem 11.24, A COUNTERFLOW HEAT EXCHANGER is
    operated in the parallel flow
10 //Hot oil enters at 215 F and leaves at 125 F
11 //Water enters the unit at 60 F and leaves at 90 F
12 //Therefore,From figure 11.35,
13 thetaA=215-60; //the greatest temperature difference
    between the fluids(at either inlet or outlet) //

```

```

Unit:fahrenheit
14 thetaB=125-90; //the least temperature difference
    between the fluids(at either inlet or outlet) //
    Unit:fahrenheit
15 deltaTm=(thetaA-thetaB)/log(thetaA/thetaB); //
    logarithmic mean temperature difference //Unit:
    fahrenheit
16 //From the oil data,
17 m=400*60; //mass //Unit:lb/sec //1 min=60 sec
18 Cp=0.85; //Specific heat of the oil //Unit:Btu/(lb*F
    )
19 deltaT=215-125; //Change in temperature //Unit:
    fahrenheit
20 Q=m*Cp*deltaT //The heat transfer //Unit:Btu/hr
21 //Q=U*A*deltaTm
22 U=40; //The overall coefficient of heat transfer of
    the unit //Unit:Btu/(hr*ft^2*F)
23 A=Q/(U*deltaTm); //Umit:ft^2 //The outside surface
    area
24 printf("The outside surface area required is %f ft^2
    ",A);

```

Scilab code Exa 11.26 the outside surface area required

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.26\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.26 (page no. 603)
7 // Solution
8
9 //From the table 11.7,
10 //For the oil side,a resistance(fouling factor) of
    0.005 (hr*F*ft^2)/Btu can be used

```

```

11 //and for the water side ,a fouling factor of 0.001 (
    hr*F*ft^2)/Btu can be used
12 //From problem 11.25,
13 U=40;//The coefficient of heat transfer of the unit
    //Unit:Btu/(hr*ft^2*F)
14 //therefore ,
15 Roil=0.005; //unit:(hr*ft^2*F)/Btu //resistance at
    oil side
16 Rwater=0.001; //unit:(hr*ft^2*F)/Btu //resistance
    for water side
17 Rcleanunit=inv(U); //unit:(hr*ft^2*F)/Btu //
    resistance at clean unit
18 Roverall=Roil+Rwater+Rcleanunit; //unit:(hr*ft^2*F)/
    Btu //overall resistance
19 Uoverall=inv(Roverall); //Unit:Btu/(hr*ft^2*F) //The
    overall coefficient of heat transfer of the unit
20 //Because all the parameters are the same,the
    surface area required will vary inversely as U
21 A=569*(U/Uoverall); //A=569 ft^2 in the problem
    11.25 //unit:ft^2 //The outside surface area
22 printf("The outside surface area required is %f ft^2
    ",A);

```

Scilab code Exa 11.27 True mean temperature difference

```

1 //scilab 5.4.1
2 clear;
3 clc;
4 printf("\t\t\tProblem Number 11.27\n\n\n");
5 // Chapter 11 : Heat Transfer
6 // Problem 11.27 (page no. 605)
7 // Solution
8
9 //HEAT EXCHANGER
10 //Oil flows in the tube side and is cooled from 280

```



```

        F to 140 F
11 //Therefore ,
12 t2=140; //Unit:fahrenheit
13 t1=280; //Unit:fahrenheit
14 //On the shell side ,water is heated from 85 F to 115
    F
15 T1=85; //Unit:fahrenheit
16 T2=115; //Unit:fahrenheit
17 P=(t2-t1)/(T1-t1);
18 R=(T1-T2)/(t2-t1);
19 //From the figure ,
20 F=0.91; //Correction factor
21 LMTD=((t1-T2)-(t2-T1))/log((t1-T2)/(t2-T1)); //LMTD=
    Log mean temperature difference //Unit:fahrenheit
22 TMTD=F*LMTD; //TMTD=True mean temperature difference
    //Unit:fahrenheit
23 printf("The true mean temperature is %f fahrenheit",
    TMTD);

```
