

Scilab Textbook Companion for  
Basic Mechanical Engineering  
by G. K. Pathak and D. K. Chavan<sup>1</sup>

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# Book Description

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

**Exa** Example (Solved example)

**Eqn** Equation (Particular equation of the above book)

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

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

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# Chapter 1

## fundamental concepts and definitions

Scilab code Exa 1.1 To find the work done

```
1  clc
2  clear
3  //Input data
4  p=700; //pressure of fluid in kN/m^2
5  v1=0.28; //Initial volume of fluid in m^3
6  v2=1.68; //Final volume of fluid in m^3
7
8  //Calculations
9  W=p*(v2-v1); //Work done in kJ
10
11 //Output
12 printf('The Work done W= %3.2 f kJ',W)
```

---

Scilab code Exa 1.2 New volume of the gas

```
1  clc
```



```

2 clear
3 //Input data
4 p1=138; //Initial pressure of gas in kN/m^2
5 p2=690; //Final pressure of gas in kN/m^2
6 v1=0.112; //Initial volume in m^3
7
8 //Calculations
9 P=p1/p2; //Pressure ratio
10 v2=v1*(P^(1/1.4)); //Final volume of gas in m^3
11
12 //Output
13 printf('The new volume of the gas v2= %3.6f m^3 ',v2)

```

---

**Scilab code Exa 1.3** The work done by the gas

```

1 clc
2 clear
3 //Input data
4 p1=2070; //Initial pressure of gas in kN/m^2
5 p2=207; //Final pressure of gas in kN/m^2
6 v1=0.014; //Initial volume of gas in m^3
7 n=1.35; //constant
8
9 //Calculations
10 P=p1/p2; //Pressure ratio
11 v2=v1*(P^(1/1.35)); //Final volume of gas in m^3
12 W=(p1*v1-p2*v2)/(n-1); //Work done in kJ
13
14 //Output
15 printf('(a)Final volume of gas v2= %3.5f m^3 \n (b)
      Work done by the gas during the expansion W= %3.2
      f kJ ',v2,W)

```

---

### Scilab code Exa 1.4 Final pressure and work done

```
1 clc
2 clear
3 //Input data
4 v1=0.056; //Initial volume of gas in m^3
5 v2=0.007; //Final volume of gas in m^3
6 p1=100; //Initial perssure compressed Isothermally in
    kN/m^2
7
8 //Calculations
9 p2=(p1*v1)/v2; //Final pressure in kN/m^2
10 W=p1*v1*(log(v2/v1)); //Work done in kJ
11
12 //Output
13 printf(' (a)Final pressure p2= %3.2f kN/m^2 \n (b)The
    work done on gas W= %3.2f kJ ',p2,W)
```

---

### Scilab code Exa 1.5 The work done

```
1 clc
2 clear
3 //Input data
4 v1=1; //Initial volume in m^3
5 v2=3; //Final volume in m^3
6
7 //Calculations
8 W=10^5*(((v2^3-v1^3)/3)+8*(log(v2/v1))); //Work done
    in J
9
10 //Output
11 printf('The work done W= %3.1f J ',W)
```

---

**Scilab code Exa 1.6** The work done by the gas

```
1 clc
2 clear
3 //Input data
4 v1=0.2; //Initial volume in m^3
5 v2=0.5; //Final volume in m^3
6
7 //Calculations
8 W=1500*((v2^2-v1^2)/200)+(v2-v1)/1000; //Work done
   in kJ
9
10 //Output
11 printf('The work done by the gas W= %3.4f kJ ',W)
```

---

**Scilab code Exa 1.8** The net work done

```
1 clc
2 clear
3 //Input data
4 v1=1.5; //Initial volume in m^3
5 v2=2; //Final volume in m^3
6 w1=2; //Work receiving in Nm
7 p=6; //constnt pressure of gas in N/m^2
8
9 //Calculations
10 w2=p*(v2-v1); //Work done in Nm
11 W=w2-w1; //Net work done by the system in Nm
12
13 //Output
14 printf('Net work done by the system W= %3.1f Nm',W)
```

---

**Scilab code Exa 1.9** Readings of pressure

```

1  clc
2  clear
3  //Input data
4  d=13596; //Density of Hg in kg/m^3
5  g=9.806; //gravity in m/sec^2
6  z=760; //Barometer pressure in mm of Hg
7  Pv=40; //Vaccum pressure in cm
8  dw=1000; //Density of water in kg/m^3
9  Zw=1.5; //Level of water in m
10
11 //Calculations
12 p=(d*g*z)/10^6; //Pressure in kPa
13 p1=(80/76)*p; //Pressure in kPa
14 Pa=p-Pv; //Absolute pressure in kPa
15 p2=(36/76)*p; //Pressure in kPa
16 p3=(dw*g*Zw)/1000; //pressure in kPa
17 p4=(5.2*10^5)/1000; //pressure in kPa
18
19 //Output
20 printf('(a)Pressure of 80cm of Hg = %3.3f kPa \n (b)
    Pressure of 40cm of Hg vaccum = %3.3f kPa \n (c)
    Pressure due to 1.5m of water coloumn = %3.2f kPa
    \n (d)Pressure in kPa for 5.2 bar = %3.2f kPa',p1
    ,p2,p3,p4)

```

---

#### Scilab code Exa 1.10 Readings of pressure

```

1  clc
2  clear
3  //Input data
4  z=750; //Barometric pressure in mm of Hg
5  g=9.81; //Gravity in m/sec^2
6  Pa=101.325; //one atm pressure in kN/m^2
7  Pg=3.3; //Pressure in atm
8  Pf=3.2; //Pressure in m of water

```

```

9 d=13596; //Density of Hg in kg/m^3
10
11 //calculations
12 Pp=(d*g*z)/10^6; //Pressure in kPa
13 p1=(d*g*0.55)/1000; //Pressure in kPa
14 p2=Pp+(Pg*101.325); //Pressure in kPa
15 p3=Pp+((Pf*g*100))/1000; //Pressure in kPa
16 p4=4.6*100; //Pressure in kPa
17
18 //Output
19 printf('(a)Pressure of 55cm of Hg (Abs) = %3.2f kPa
    \n (b)Pressure at 3.3 atm (Gauge)= %3.3f kPa \n (
    c)Pressure of 3.2m of water (Gauge)= %3.2f kPa \n
    (d)Pressure of 4.6 bar (Abs)= %3.2f kPa ',p1,p2,p3
    ,p4)

```

---

#### Scilab code Exa 1.11 Absolute pressure

```

1 clc
2 clear
3 //Input data
4 Zw=50; //Manometer reading of water in cm
5 Zo=763; //Atmospheric pressure in mm of Hg
6 d=13.6*10^3; //Density of Hg in kg/m^3
7 dw=1000; //Density of water in kg/m^3
8 g=9.81; //Gravity in m/sec^2
9
10 //Calculations
11 Pa=(d*g*Zo)/10^6; //Atmospheric pressure in kPa
12 Pg=(dw*g*Zw)/10^5; //Gauge pressure in kPa
13 Pab=Pa+Pg; //Absolute pressure in kPa
14
15 //Output
16 printf('Absolute pressure Pab = %3.3f kPa ',Pab)

```

---

### Scilab code Exa 1.12 Absolute pressure

```
1  clc
2  clear
3  //Input data
4  Z=70; //Vaccum gauge reading in cm of Hg
5  Pa=101.325; //Atmospheric pressure in kPa
6  d=13.6*103; //Density of Hg in kg/m3
7  g=9.81; //Gravity in m/sec2
8
9  //Calculations
10 Pv=(d*g*Z)/105; //Vaccum pressure in kPa
11 Pab=Pa-Pv; //Absolute pressure in kPa
12
13 //Output
14 printf('Absolute pressure Pab = %3.4f kPa ',Pab)
```

---

### Scilab code Exa 1.13 Absolute pressure

```
1  clc
2  clear
3  //Input data
4  Pv=30; //Vaccum pressure in kPa
5  Z=755; //Barometer reading in mm of Hg
6  d=13590; //Density of Hg in kg/m3
7  g=9.81; //Gravity in m/sec2
8
9  //calculations
10 Pa=(d*g*Z)/106; //Atmospheric perssure in kPa
11 Pab=Pa-Pv; //Absolute pressure in kPa
12
13 //Output
```

```
14 printf('Absolute pressure in the tank Pab = %3.3 f kPa
        ',Pab)
```

---

**Scilab code Exa 1.14** The gas pressure

```
1 clc
2 clear
3 //Input data
4 Z=0.562; //Level of open limb in m
5 Z1=0.761; //Barometer reading in m of Hg
6 g=9.79; //Gravity in m/sec^2
7 d=13640; //Density of Hg in kg/m^2
8
9 //Calculations
10 Pa=(d*g*Z1)/1000; //Atmospheric pressure in kPa
11 Ph=(d*g*Z)/1000; //Pressure exercterd due to height
    in kPa
12 Pab=Pa+Ph; //Absolute pressure in kPa
13
14 //Output
15 printf('The gas pressure Pab = %3.3 f kN/m^2 ',Pab)
```

---

**Scilab code Exa 1.15** The absolute pressure

```
1 clc
2 clear
3 //Input data
4 d=13.596*10^3; //Density of Hg in kg/m^3
5 d1=800; //Density of liquid in kg/m^3
6 Z=30; //Level of the liquid in the arm in cm
7 Z1=0.75; //Barometric pressure in m
8 g=9.81; //Gravity in m/sec^2
9
```

```

10 //Calculatins
11 Pg=(d1*g*Z)/10^7;//Gauge pressure in bar
12 Pa=(d*g*Z1)/10^5;//Atmospheric pressure in bar
13 Pab=Pa+Pg;//Absolute pressure in bar
14
15 //Output
16 printf('Absolute pressure of the gas Pab = %3.5f bar
        ',Pab)

```

---

**Scilab code Exa 1.16** The absolute pressure of the gas

```

1  clc
2  clear
3  //Input data
4  Z1=0.17;//Level of liquid in m
5  Z=0.76;//Barometer readings in m
6  d=13596;//Density of Hg in kg/m^3
7  g=9.806;//Gravity in m/sec^2
8  s=0.8;//Specific gravity
9  d1=1000;//Density of water in kg/m^3
10
11 //Calculations
12 d1=s*d1;//Density of given liquid in kg/m^3
13 Pa=d*g*Z;//Atmospheric pressure in N/m^2
14 p=d1*g*Z1;//Pressure in N/m^2
15 Pab=(Pa-p)/10^5;//Absolute pressure in bar
16
17 //Output
18 printf('Absolute pressure of the gas Pab = %3.6f bar
        ',Pab)

```

---

**Scilab code Exa 1.17** The absolute pressure of steam



```

1  clc
2  clear
3  //Input data
4  g=9.806; //Gravity in m/sec^2
5  d=13596; //Density of Hg in kg/m^3
6  Z=9.75; //Level of Hg in cm
7  dw=1000; //Density of water in kg/m^3
8  Zw=0.034; //Coloumn of condensate in m
9  Zo=0.76; //Atmospheric pressure in m of Hg
10
11 //Calculations
12 P=dw*g*Zw; //Pressure in N/m^2
13 Pa=d*g*Zo; //Atmospheric pressure in N/m^2
14 Pg=(d*g*Z)/100; //Gauge pressure in N/m^2
15 Pab=(Pa+Pg-P)/10^5; //Absolute pressure in bar
16
17 //Output
18 printf('Absolute pressure of steam Pab = %3.6f bar ',
        ,Pab)

```

---

**Scilab code Exa 1.18** The absolute pressure of steam

```

1  clc
2  clear
3  //Input data
4  g=9.7; //Gravity in m/sec^2
5  d=13.69*10^3; //Density of Hg in kg/m^3
6  dw=1000; //Density of water in kg/m^3
7  Pa=98; //Atmospheric pressure in kPa
8  Z=0.6; //Manometer level difference in m of Hg
9  Zw=0.04; //Water coloumn level in m
10
11 //Calculations
12 Pw=(dw*g*Zw)/1000; //Pressure due to water in kPa
13 Pg=(d*g*Z)/1000; //Pressure in kPa

```

```

14 Pab1=Pa+Pg-Pw; //Absolute pressure in kPa
15 Pab=Pab1/100; //Absolute pressure in bar
16
17 //Output
18 printf('The absolute pressure of steam Pab = %3.5 f
        bar ',Pab)

```

---

**Scilab code Exa 1.19** The absolute pressure of steam

```

1  clc
2  clear
3  //Input data
4  Z=0.76; //Actual height of mercury coloumn in m
5  g=9.806; //Gravity in m/sec^2
6  d=13596; //Density of Hg in kg/m^3
7  dw=1000; //Density of water in kg/m^3
8  Zw=0.035; //Height of condensate coloumn in m
9  Zh=0.10; //Height of mercury coloumn in m
10
11 //Calculations
12 Pa=d*g*Z; //Atmospheric pressure in N/m^2
13 Pw=dw*g*Zw; //Pressure due to water in N/m^2
14 Ph=d*g*Zh; //Pressure due to Hg in N/m^2
15 Pab=(Pa+Ph-Pw)/10^5; //Absolute pressure in bar
16
17 //Output
18 printf('Absolute pressure of steam in the pipe Pab =
        %3.2 f bar ',Pab)

```

---

**Scilab code Exa 1.20** The absolute pressure of vapour

```

1  clc
2  clear

```

```

3 //Input data
4 dk=800; //Density of kerosene in kg/m^3
5 g=9.81; //gravity in m/sec^2
6 Zk=0.051; //Kerosene vapour on Hg coloumn in m
7 d=13600; //Density of Hg in kg/m^3
8 Zh=0.1; //Hg level in m
9 Z=0.755; //Atmospheric pressure in m of Hg
10
11 //Calculations
12 Pk=dk*g*Zk; //Pressure of kerosene in N/m^2
13 Pa=d*g*Z; //Atmospheric pressure in N/m^2
14 Ph=d*g*Zh; //Pressure due to Hg in N/m^2
15 Pab=(Pa+Ph-Pk)/1000; //Absolute pressure in kPa
16
17 //Output
18 printf('Absolute pressure of vapour Pab = %3.5f kPa
        ',Pab)

```

---

**Scilab code Exa 1.21** The absolute pressure of the gas

```

1 clc
2 clear
3 //Input data
4 d=13596; //Density of Hg in kg/m^3
5 g=9.806; //Gravity in m/sec^2
6 df=0.8*1000; //Density of fluid in kg/m^3
7 Z=0.76; //Atmospheric pressure in m of Hg
8 Zf=0.3; //Height of fluid coloumn in m
9
10 //Calculations
11 Pa=d*g*Z; //Atmospheric perssure in N/m^2
12 P=df*g*Zf; //Pressure due to fluid in N/m^2
13 Pab=(Pa+P)/10^5; //Absolute pressure in bar
14 Zh=((Pab*10^5-Pa)/(d*g))*100; //Difference between
        the height of Hg coloumn in 2 arms in m

```

```

15
16 //Output
17 printf('(a)The Absolute pressure of the gas in pipe
    line Pab = %3.7f bar \n (b)If the fluid used is
    Hg then the difference of height of Hg coloumn in
    the 2 arms Zh = %3.3f cm of Hg ',Pab,Zh)

```

---

**Scilab code Exa 1.22** The pressure in bar

```

1
2 clc
3 clear
4 //Input data
5 Pa=1; //Atmospheric pressure in bar
6 g=9.81; //Gravity in m/sec^2
7 do=0.8*1000; //Density of oil in kg/m^3
8 Zo=0.8; //Level of oil in m
9 dw=1000; //Density of water in kg/m^3
10 Zw=0.65; //Level of water in m
11 d=13.6*10^3; //Density of Hg in kg/m^3
12 Z=0.45; //Level of Hg in m
13
14 //Calculations
15 Po=(do*g*Zo)/10^5; //Pressure of oil in bar
16 Pw=(dw*g*Zw)/10^5; //Pressure of water in bar
17 P=(d*g*Z)/10^5; //Pressure of Hg in bar
18 Pab=Pa+Po+Pw+P; //Pressure at the bottom of the
    coloumn in bar
19 Pow=Pa+Po; //Pressure at the interface of oil and
    water in bar
20 Poh=Pa+Po+Pw; //Pressure at the interface of water
    and Hg
21
22 //Output
23 printf('(a)Pressure at the bottom of the coloumn Pab

```

= %3.5f bar \n (b) Pressure at the inter surface  
of oil and water Pow = %3.6f bar \n (c) Pressure  
at the inter surface of water and Hg Poh = %3.6f  
bar ', Pab, Pow, Poh)

---

### Scilab code Exa 1.23 The height of fluid

```

1  clc
2  clear
3  //Input data
4  Z=0.76; //Barometer reading in m
5  g=9.81; //Gravity in m/sec^2
6  d=13.6*10^3; //Density of Hg in kg/m^3
7  Pab=1.2*10^5; //Absolute pressure in N/m^2
8  do=0.8*1000; //Density of oil in kg/m^3
9  dw=1000; //Density of water in kg/m^3
10 dh=13.6*10^3; //Density of Hg in kg/m^3
11
12 //calculations
13 Pa=dh*g*Z; //Atmospheric pressure in N/m^2
14 Pg=Pab-Pa; //Gauge pressure in N/m^2
15 Zo=Pg/(do*g); //Height of oil in manometer in m
16 Pw=Pab-Pa; //Pressure exercted by water in N/m^2
17 Zw=Pw/(dw*g); //Height of water in manometer in m
18 P=Pab-Pa; //Pressure of Hg in N/m^2
19 Zh=P/(d*g); //Height of Hg in manometer in m
20
21 //Output
22 printf('(a)The height of fluid for oil Manometer Zo
= %3.2f m \n (b)The height of fluid for water
Manometer Zw = %3.2f m \n (c)The height of fluid
for Hg Manometer Zh = %3.2f m ', Zo, Zw, Zh)

```

---

**Scilab code Exa 1.24** The altitude of the plane

```
1  clc
2  clear
3  //Input data
4  Zg=0.753; //Barometer reading at ground level in m
5  Zp=0.690; //Pilots barometer reading in the plane in
      m
6  d=13600; //Density of Hg in kg/m^3
7  g=9.81; //Gravity in m/sec^2
8  da=1.25; //Density of air in kg/m^3
9
10 //Calculations
11 Pg=d*g*Zg; //Pressure at ground level in N/m^2
12 Pp=d*g*Zp; //Pressure at plane level in N/m^2
13 P=Pg-Pp; //Change of pressure at ground level and
      that of plane level in N/m^2
14 Za=P/(da*g); //Altitude of plane from ground in m
15
16 //Output
17 printf('The altitude of the plane from ground level
      Za = %3.2f m ',Za)
```

---

**Scilab code Exa 1.25** The pressure

```
1  clc
2  clear
3  //Input data
4  dw=1000; //Density of water in kg/m^3
5  dh=13590; //Density of Hg in kg/m^3
6  Pa=400; //Pressure at A in kPa
7  g=9.81; //Gravity in N/m^2
8  Zw1=2.5; //First level of water in m
9  Zw2=0.4; //Second level of water in m
10 Zh=0.6; //Level of Hg in m
```

```

11
12 // Calculations
13 Pw1=dw*g*Zw1;//First level of water pressure in N/m
    ^2
14 Pw2=dw*g*Zw2;//Second level of water pressure in n/m
    ^2
15 Ph=dh*g*Zh;//Pressure of Hg in N/m^2
16 Pb=((Pa*1000)+Pw1+Pw2-Ph)/1000;//Pressure exercted
    at B in kPa
17
18 //Output
19 printf('Pressure exercted at B Pb = %3.4f kPa',Pb)

```

---

#### Scilab code Exa 1.26 Weight of piston and slab

```

1 clc
2 clear
3 //Input data
4 do=0.902*10^3;//Density of oil in kg/m^3
5 Pg=2*10^5;//Gauge pressure in N/m^2
6 g=9.81;//Gravity in m/sec^2
7 ho=2;//Level of oil in m
8 d=2;//Diameter of cylinder in m
9 pi=3.141595;//Constant value of pi
10
11 // Calculations
12 A=(pi/4)*d^2;//Area of cylinder
13 Po=do*g*ho;//Pressure due to oil in N/m^2
14 W=(Pg+Po)*A;//Weight of the piston in N
15
16 //Output
17 printf('The total weight of piston and slab W = %3.2
    f N ',W)

```

---

**Scilab code Exa 1.27** The pressure in the gas

```
1  clc
2  clear
3  //Input data
4  m=21; //Mass of piston in kg
5  P1=600; //Pressure in the pipe 1 in kPa
6  P2=170; //Pressure in the pipe 2 in kPa
7  d1=0.10; //Diameter of the piston 1 in m
8  d2=0.20; //Diameter of the piston 2 in m
9  pi=3.14155; //Constant value of pi
10
11 //Calculations
12 F=(m*9.81)/1000; //Force due to mass in kN
13 F1=(pi/4)*d1^2*P1; //Force 1 acting on 10 cm diameter
    piston in kN
14 F2=(pi/4)*(d2^2-d1^2)*P2; //Force 2 acting on 20 cm
    diameter piston in kN
15 F3=F+F1+F2; //Total downward force in kN
16 P3=F3/((pi/4)*d2^2); //Pressure 3 in the gas in kPa
17
18 //Output
19 printf('The pressure in the gas P3 = %3.4f kPa ',P3)
```

---

**Scilab code Exa 1.28** The height of building

```
1
2  clc
3  clear
4  //Input data
5  P1=0.755; //Barometric reading at the bottom of the
    building in m
```



```

6 P2=0.73; //Barometric reading at the top of the
   building in m
7 da=1.18; //Density of air in kg/m^3
8 g=9.81; //Gravitational constant in m/sec^2
9 d=13600; //Density of Hg in kg/m^3
10
11 //Calculations
12 h=((P1-P2)*d*g)/(da*g); //The height of the building
   in m
13
14 //Output
15 printf('The height of the building h = %3.2f m',h)

```

---

**Scilab code Exa 1.29** The absolute pressure

```

1 clc
2 clear
3 PA=200; //Gauge pressure reading for A in kPa
4 PB=120; //Gauge pressure reading for B in kPa
5 hb=750; //Barometer reading in mm of Hg
6 g=9.806; //Gravitational constant in m/sec^2
7 d=13597; //Density of Hg in barometer in kg/m^3
8
9 //Calculations
10 Pa=d*g*hb/10^6; //Atmospheric pressure in kPa
11 Pab1=PA+Pa; //Absolute pressure in container A in kPa
12 Pab2=PB+Pab1; //Absolute pressure in container B in
   kPa
13
14 //Output
15 printf('(a)The absolute pressure in the container A
   Pab1 = %3.2f kPa \n (b)The absolute pressure in
   the container B Pab2 = %3.2f kPa ',Pab1,Pab2)

```

---

**Scilab code Exa 1.30** The temperature

```
1  clc
2  clear
3  //Input data
4  C1=40; //Temperature 1 in degree centigrade
5  C2=-20; //Temperature 2 in degree centigrade
6
7  //calculations
8  F1=((C1/100)*180)+32; //Temperature 1 in Fahrenheit
9  F2=((C2/100)*180)+32; //Temperature 2 in Fahrenheit
10
11 //Output
12 printf('(a)Temperature 40 degree C =%3.0f F \n (b)
    Temperature -20 degree C=%3.0f F',F1,F2)
```

---

**Scilab code Exa 1.31** The temperature

```
1 //Given that the temperature has the same value on
    both the centigrade and fahrenheit scales
2 //((C/100)=(F-32)/180)
3
4 //Putting C=F
5 C=(-32/180)/((1/100)-(1/180)); //Centrigade
    temperature in degree C
6 F=C; //Fahrenheit temperature in degree Fahrenheit
7
8 printf('The temperature which has the same value on
    both the centigrade and fahrenheit scales is %i
    degree C = %i degree F',C,F)
```

---

**Scilab code Exa 1.32** The temperature

```
1  clc
2  clear
3  //Input data
4  P1=1.5; //Thermometric properties at ice point
5  P2=7.5; //Thermometric properties at steam point
6  P3=3.5; //Thermometric property
7
8  //Calculations
9  A=[log(P2) 1
10     log(P1) 1] //Coefficient matrix
11 B=[100
12     0] //Constant matrix
13 X=inv(A)*B //Inverse matrix
14 t=(X(1)*log(P3)+X(2)); //Required temperature in
    degree C
15
16 //Output
17 printf('The required temperature is %3.6f degree C',
    t)
```

---

**Scilab code Exa 1.33** The temperature

```
1  clc
2  clear
3  //Input data
4  T=[100,300]; //Temperature of ice and steam point in
    the scale
5  P=[1.86,6.8]; //Values of thermometric properties at
    ice point nad steam point respectively
6  P1=2.5; //Thermometric property
```

```

7
8 // Calculations
9 A=[log(P(2)) 1
10    log(P(1)) 1] // Coefficient matrix
11 B=[T(2)
12    T(1)] // Constant matrix
13 X=inv(A)*B; // Variable matrix
14 t=(X(1)*log(P1)+X(2)); // Required temperature in
    degree C
15
16 // Output
17 printf('Temperature corresponding to the
    thermometric property is %3.1f degree C',t)

```

---

**Scilab code Exa 1.34** The temperature

```

1 clc
2 clear
3 // Input data
4 p1=32; // Pressure in mm of Hg at triple point of
    water
5 p2=76; // Pressure in mm of Hg above atmospheric
    pressure
6 p3=752; // Barometric pressure in mm of Hg
7 T=273.16; // Triple point of water in K
8
9 // Calculations
10 P1=p3+p1; // Total pressure in mm of Hg
11 P2=p2+p3; // Total pressure in mm of Hg
12 T2=((T*P2)/P1)-273.16; // Temperature in degree C
13
14 // Output
15 printf('Temperature is %3.2f degree C',T2)

```

---

Scilab code Exa 1.35 The temperature

```
1  clc
2  clear
3  T=[32,212]; //Temperatures of ice point and steam
   point respectively
4  P=[1.86,6.81]; //P values at ice point and steam
   point respectively
5  P1=2.5; //Reading on the thermometer
6
7  // Calculations
8  A=[log(P(2)) 1
   log(P(1)) 1] //Coefficient matrix
10 B=[T(2)
   T(1)] //Constant matrix
12 X=inv(A)*B; //Variable matrix
13 t=(X(1)*log(P1)+X(2)); //Required temperature in
   degree C
14
15 //Output
16 printf('Temperature corresponding to the
   thermometric property is %3.0f degree C',t)
```

---

## Chapter 2

# First Law of Thermodynamics

Scilab code Exa 2.1 The net work

```
1  clc
2  clear
3  //Input data
4  h1=60; //The heat transfer in the process in kJ
5  h2=-8; //The heat transfer in the process in kJ
6  h3=-34; //The heat transfer in the process in kJ
7  h4=6; //The heat transfer in the process in kJ
8
9  //Calculations
10 Q=h1+h2+h3+h4; //Net work transfer in a cycle in kJ
11
12 //Output
13 printf('Net work transfer in a cycle Q = %3.0f kJ ',
        Q)
```

---

Scilab code Exa 2.2 The work done

```
1  clc
```

```

2 clear
3 //Input data
4 Q=-300;//Heat transfer in the system consisting of
   the gas in kJ
5 u=0;//Internal energy is constant
6
7 //Calculations
8 W=Q-u;//Work done of the system in kJ
9
10 //Output
11 printf('The work done of the system W = %3.0f kJ ',W
   )

```

---

### Scilab code Exa 2.3 Internal energy

```

1 clc
2 clear
3 //Input data
4 v1=1.5;//Initial volume of the process in m^3
5 v2=4.5;//Final volume of the process in m^3
6 Q=2000;//Amount of heat added in kJ
7
8 //Calculations
9 W=100*((3.5*log(v2/v1))+(3*(v2-v1)));//Amount of
   work done in kJ
10 U=Q-W;//The change in internal energy in kJ
11
12 //Output
13 printf('The change in internal energy is %3.4f kJ ',
   U)

```

---

### Scilab code Exa 2.4 The change in KE and PE

```

1  clc
2  clear
3  //Input data
4  h1=35; //Enthalpy of water entering the boiler in kJ/
      kg
5  h2=705; //Enthalpy of steam leaving the boiler in kJ/
      kg
6  C=0; //Change in kinetic energy is neglected
7  Z=0; //Change in potential energy is neglected
8
9  //Calculations
10 q=h2-h1; //The heat transfer per kg of steam in kJ/kg
11
12 //Output
13 printf('The heat transfer per kg of steam q = %3.0 f
      kJ/kg ',q)

```

---

**Scilab code Exa 2.5** The net rate of work output

```

1  clc
2  clear
3  //Input data
4  Q=-170; //Sum of all heat transfers per cycle in kJ
5  N=100; //Total number of cycles per min in cycles/min
6  Q1=0; //Heat developed in a-b process in kJ/min
7  Q2=21000; //Heat developed in b-c process in kJ/min
8  Q3=-2100; //Heat developed in c-d process in kJ/min
9  W1=2170; //Work done in the process a-b in kJ/min
10 W2=0; //Work done in the b-c process in kJ/min
11 E3=-36600; //Change in energy in the process in kJ/
      min
12
13 //Calculations
14 E1=Q1-W1; //Change in energy in process a-b in kJ/min
15 E2=Q2-W2; //Change in energy in b-c process in kJ/min

```



```

16 W3=Q3-E3; //Work done in the c-d process in kJ/min
17 Qt=Q*N; //Total heat transfer per min in kJ/min
18 Q4=Qt-Q1-Q2-Q3; //Heat developed in the process d-a
    in kJ/min
19 Et=0; //Total change in energy of the cycle
20 E4=Et-E1-E2-E3; //Energy in the process d-a in kJ/min
21 W4=Q4-E4; //Work done in the d-a process in kJ/min
22 Wn=Qt/60; //Net rate of work output in kW
23
24 //Output
25 printf('(a)Change in energy in a-b process E = %3.0f
    kJ/min \n (b)Change in energy in b-c process E =
    %3.0f kJ/min \n (c)Work done in the c-d process
    W = %3.0f kJ/min \n (d)Heat developed in the
    process d-a Q = %3.0f kJ/min \n (e)Energy in the
    process d-a E = %3.0f kJ/min \n (f)Work done in
    the d-a process W =%3.0f kJ/min \n (g)Net rate of
    work output W = %3.2f kW ',E1,E2,W3,Q4,E4,W4,Wn)

```

---

### Scilab code Exa 2.6 The power developed

```

1  clc
2  clear
3  //Input data
4  Q1=50; //Heat developed in the 1-2 process in kJ/kg
5  U1=20; //Change in energy in the 1-2 process in kJ/kg
6  Q2=-30; //Heat developed in the 2-3 process in kJ/kg
7  W2=-40; //Work done in the 2-3 process in kJ/kg
8  U3=-30; //Change in energy in the 3-1 process in kJ/
    kg
9  Wt=30; //Net work done per kg of fluid in kJ/kg
10 m=0.1; //Mass of fluid in the cycle in kg
11 N=10; //Number of cycles per sec in cycles/sec
12
13 //Calculations

```

```

14 W1=Q1-U1; //Work done in the 1-2 process in kJ/kg
15 U2=Q2-W2; //Change in energy in the 2-3 process in kJ
    /kg
16 W3=Wt-W1-W2; //Work done in the 3-1 process in kJ/kg
17 Q3=W3+U3; //Heat developed in the process in kJ/kg
18 m1=m*N; //mass flow rate per sec in kg/sec
19 P=Wt*m1; //Rate of power in kW
20
21 //Output
22 printf('(a)Work done in the 1-2 process W=%3.0f kJ/
    kg \n (b)Change in energy in the 2-3 process U =
    %3.0f kJ/kg \n (c)Work done in the 3-1 process W
    = %3.0f kJ/kg \n (d)Heat developed in the process
    Q = %3.0f kJ/kg \n (e)mass flow rate per sec m =
    %3.0f kg/sec \n (f)Rate of power P = %3.0f kW',
    W1,U2,W3,Q3,m1,P)

```

---

#### Scilab code Exa 2.7 The work transfer

```

1 clc
2 clear
3 //Input data
4 m=3; //Mass of substance in the system in kg
5 P1=500; //Initial pressure of the system in kPa
6 P2=100; //Final pressure of the system in kPa
7 V1=0.22; //Initial volume of the system in m^3
8 n=1.2; //Polytropic index
9 Q1=30; //Heat transfer for the another process
10
11 //Calculations
12 V2=V1*(P1/P2)^(1/1.2); //Final volume of the system
    in m^3
13 U=3.56*(P2*V2-P1*V1); //Total change in internal
    energy in kJ
14 W1=(P2*V2-P1*V1)/(1-n); //Work done for the 1-2

```

```

    process in kJ
15 Q=U+W1; //Heat developed in the process in kJ
16 W2=Q1-U; //Work done for the another process in kJ
17
18 //Output
19 printf('(a)Total change in internal energy U = %3.0f
    kJ \n (b)Work done for the 1-2 process W = %3.0f
    kJ \n (c)Heat developed in the process Q = %3.0f
    kJ \n (d)Work done for the another process W =
    %3.0f kJ ',U,W1,Q,W2)

```

---

#### Scilab code Exa 2.8 Heat transfer work and IE

```

1  clc
2  clear
3  m=5; //Mass of the substance in the system in kg
4  P1=500; //Initial pressure of the system in kPa
5  P2=100; //Final pressure of the system in kPa
6  V1=0.22; //Initial volume of the system in m^3
7  n=1.2; //Polytropic index
8
9  //Calculations
10 V2=V1*(P1/P2)^(1/1.2); //Final volume of the system
    in m^3
11 U=3.5*(P2*V2-P1*V1); //Change in the internal energy
    of the system in kJ
12 W=(P1*V1-P2*V2)/(n-1); //Work developed in the
    process in kJ
13 Q=U+W; //Heat transfer in the process in kJ
14
15 //Output
16 printf('(1)Heat transfer of the process Q = %3.0f kJ
    \n (2)Total change in Internal Energy U = %3.0f
    kJ \n (3)Non flow work in the process W = %3.0f
    kJ ',Q,U,W)

```

---

**Scilab code Exa 2.9** Work and heat transfer

```
1  clc
2  clear
3  //Input data
4  p1=170; //Initial pressure of the fluid in kPa
5  p2=400; //Final pressure of the fluid in kPa
6  v1=0.03; //Initial volume in m^3
7  v2=0.06; //Final volume in m^3
8
9  //Calculations
10 U=3.15*[(p2*v2)-(p1*v1)]; //The change in internal
    energy of the fluid in kJ
11 A=[1 v1
12     1 v2] //Coefficient matrix
13 B=[p1
14     p2] //Constant matrix
15 X=inv(A)*B; //Variable matrix
16 W=[X(1)*(v2-v1)]+[X(2)*((v2^2-v1^2)/2)]; //The work
    done during the process in kJ
17 Q=U+W; //The heat transfer in kJ
18
19 //Output
20 printf('(a)The direction and magnitude of work W =
    %3.2f kJ \n (b)The direction and magnitude of
    heat transfer Q = %3.2f kJ ',W,Q)
```

---

**Scilab code Exa 2.11** The power capacity

```
1  clc
2  clear
```

```

3 //Input data
4 E1=4000; //Enthalpy at entrance in kJ/Kg
5 E2=4100; //Enthalpy at exit in kJ/kg
6 V1=50; //Velocity at entrance in m/s
7 V2=20; //Velocity at exit in m/s
8 h1=50; //Height at the entrance
9 h2=10; //Height at the exit
10 m=1; //mass flow rate to the system in kJ/s
11 Q=200; //Heat transfer rate to the system in kJ/s
12 g=9.8; //Gravitational constant in m/s^2
13
14 //Calculations
15 P=m*((V1^2-V2^2)/(2000))+(g*(h2-h1)/1000)+(E1-E2))+
    Q; //Power capacity of the system in kW
16 printf('Power capacity of the system P = %3.4f kW ',
    P)

```

---

**Scilab code Exa 2.12** The specific intenal energy

```

1 clc
2 clear
3 //Input data
4 W=135; //Work done by the system in kJ/kg
5 V1=0.37; //Specific volume of fluid at inlet in m^3/
    kg
6 V2=0.62; //Specific volume of fluid at outlet in m^3/
    kg
7 P1=600; //Pressure at the inlet in kPa
8 P2=100; //Pressure at the outlet in kPa
9 C1=16; //Velocity at the inlet in m/s
10 C2=270; //Velocity at the outlet in m/s
11 Z1=32; //Inlet height from floor level in m
12 Z2=0; //Outlet height from floor level in m
13 q=-9; //Heat loss between inlet and discharge in kJ/
    kg

```

```

14 g=9.81; //Gravitational constant in m/s^2
15
16 //Calculations
17 U=((C2^2-C1^2)/2000)+(g*(Z2-Z1))/1000+(P2*V2-P1*V1)+
    W-q; //Change in specific internal energy of the
    system in kJ/kg
18
19 //Output
20 printf('Specific Internal Energy decreases by %3.3f
    kJ/kg ',U)

```

---

**Scilab code Exa 2.13** The power capacity

```

1  clc
2  clear
3  //Input data
4  m=5; //Rate of fluid flow in the system in kg/s
5  P1=620; //Pressure at the entrance in kPa
6  P2=130; //Pressure at the exit in kPa
7  C1=300; //Velocity at the entrance in m/s
8  C2=150; //Velocity at the exit in m/s
9  U1=2100; //Internal energy at the entrance in kJ/kg
10 U2=1500; //Internal energy at the exit in kJ/kg
11 V1=0.37; //Specific volume at entrance in m^3/kg
12 V2=1.2; //Specific volume at exit in m^3/kg
13 Q=-30; //Heat loss in the system during flow in kJ/kg
14 Z=0; //Change in potential energy is neglected in m
15 g=9.81; //Gravitational constant in m/s^2
16
17 //Calculations
18 W=((C1^2-C2^2)/(2*1000))+(g*Z)+(U1-U2)+(P1*V1-P2*V2)
    +Q; //Total work done in the system in kJ/kg
19 P=W*m; //Power capacity of the system in kW
20
21 //Output

```

```

22 printf('(a) Total work done in the system W = %3.2f
    kJ/kg \n (b) Power capacity of the system P = %3.2
    f kW ',W,P)

```

---

**Scilab code Exa 2.14** The power required

```

1  clc
2  clear
3  P1=100; // Pressure at Inlet in kPa
4  P2=500; // Pressure at Exit in kPa
5  V1=0.6; // Specific volume at Inlet in m^3/kg
6  V2=0.15; // Specific volume at Exit in m^3/kg
7  U1=50; // Specific internal energy at inlet in kJ/kg
8  U2=125; // Specific internal energy at Exit in kJ/kg
9  C1=8; // Velocity of air at Inlet in m/s
10 C2=4; // Velocity of air at Exit in m/s
11 m=5; // Mass flow rate of air in kg/s
12 Q=-45; // Heat rejected to cooling water in kW
13 Z=0; // Change in potential energy is neglected in m
14 g=9.81; // Gravitational constant in m/s^2
15
16 // Calculations
17 P=m*(((C1^2-C2^2)/(2*1000))+(g*Z)+(U1-U2)+(P1*V1-P2*
    V2))+Q; // Power required to drive the compressor
    in kW
18 P1=-P; // Power required to drive the compressor in kW
19
20 // Output
21 printf('The power required to drive the compressor P
    = %3.2f kW ',P1)

```

---

**Scilab code Exa 2.15** The power developed

```

1  clc
2  clear
3  //Input data
4  m1=5000; //Steam flow rate in kg/hr
5  Q1=-250; //Heat loss from the turbine insulation to
           surroundings in kj/min
6  C1=40; //Velocity of steam at entrance in m/s
7  h1=2500; //Enthalpy of the steam at entrance in kJ/kg
8  C2=90; //Velocity of the steam at the Exit in m/s
9  h2=2030; //Enthalpy of the steam at exit in kJ/kg
10 Z=0; //Change in potential energy is neglected in m
11 g=9.81; //Gravitational constant in m/s^2
12
13 //Calculations
14 m=m1/3600; //Steam flow rate in kg/s
15 Q=Q1/60; //Heat loss from the turbine to the
           surroundings
16 P=m*(((C1^2-C2^2)/(2*1000))+(g*Z)+(h1-h2))+Q; //Power
           developed by the turbine in kW
17
18 //Output
19 printf('The power developed by the turbine P = %3.3 f
           kW ',P)

```

---

**Scilab code Exa 2.16** The work output

```

1  clc
2  clear
3  //Input data
4  c1=16; //Velocity of steam at entrance in m/s
5  c2=37; //Velocity of steam at exit in m/s
6  h1=2990; //Specific enthalpy of steam at entrance in
           kJ/kg
7  h2=2530; //Specific enthalpy of steam at exit in kJ/
           kg

```



```

8 Q=-25; //Heat lost to the surroundings in kJ/kg
9 m1=360000; //The steam flow rate in kg/hr
10
11 // Calculations
12 m=m1/3600; //The steam flow rate in kg/s
13 W=((c1^2-c2^2)/(2*1000))+(h1-h2))+Q; //Total work
    done in the system in kJ/kg
14 P=m*W; //Power developed by the turbine in kW
15 //Output
16 printf('The work output from the turbine P = %3.1f
    kW ',P)

```

---

**Scilab code Exa 2.17** The external work output

```

1 clc
2 clear
3 //Input data
4 p1=720; //Pressure at the entrance in kPa
5 t1=850; //Temperature at the entrance in degree
    centigrade
6 c1=160; //Velocity of the gas at entrance in m/s
7 Q=0; //Insulation (adiabatic turbine)
8 P2=115; //Pressure at the exit in kPa
9 t2=450; //Temperature at the exit in degree
    centigrade
10 c2=250; //Velocity of the gas at exit in m/s
11 cp=1.04; //Specific heat of gas at constant pressure
    in kJ/kg-K
12
13 // Calculations
14 H=cp*(t1-t2); //Change in Enthalpy of the gas at
    entrance and exit in kJ/kg
15 W=((c1^2-c2^2)/(2*1000))+(H); //External work output
    of the turbine in kJ/kg
16

```

```

17 //Output
18 printf('The external work output of the turbine W =
    %3.2f kJ/kg ',W)

```

---

**Scilab code Exa 2.18** The work done and mass flow rate

```

1  clc
2  clear
3  //Input data
4  p=5000;//Power output of an adiabatic steam turbine
    in kW
5  p1=2000;//Pressure at the inlet in kPa
6  p2=0.15;//Pressure at the exit in bar
7  t1=400;//temperature at the inlet in degree
    centigrade
8  x=0.9;//Dryness at the exit
9  c1=50;//Velocity at the inlet in m/s
10 c2=180;//Velocity at the exit in m/s
11 z1=10;//Elevation at inlet in m
12 z2=6;//Elevation at exit in m
13 h1=3248.7;//Enthalpy at the inlet from the steam
    table corresponding to and 20 bar in kJ/kg
14 hf=226;//Enthalpy at exit at 0.15 bar from steam
    tables in kJ/kg
15 hfg=2373.2;//Enthalpy at exit at 0.15 bar from steam
    tables in kJ/kg
16 g=9.81;//Gravitational constant in m/s^2
17
18 //Calculations
19 h2=hf+(x*hfg);//Enthalpy at the exit in kJ/kg
20 W=(h1-h2)+((c1^2-c2^2)/(2*1000))+((g*(z1-z2))/1000);
    //Work done in the system in kJ/kg
21 m=p/W;//Mass flow rate of the steam
22
23 //Output

```

```

24 printf('(a)The work done per unit mass of the steam
    flowing through turbine W = %3.2f kJ/kg \n (b)The
    mass flow rate of the steam m = %3.3f kg/s ',W,m
    )

```

---

**Scilab code Exa 2.19** The power output

```

1  clc
2  clear
3  p1=1000; //Pressure at the inlet in kPa
4  t1=750; //Temperature at the inlet in K
5  c1=200; //Velocity at the inlet in m/s
6  p2=125; //Pressure at the exit in kPa
7  c2=40; //Velocity at the exit in m/s
8  m1=1000; //Mass flow rate of air in kg/hr
9  cp=1.053; //Specific heat at constant pressure in kJ/
    kgK
10 k=1.375; //Adiabatic index
11 Q=0; //The turbine is adiabatic
12
13 //Calculations
14 m=m1/3600; //The mass flow rate of air in kg/s
15 P=p2/p1; //Ratio of the pressure
16 t2=t1*((p2/p1)^((k-1)/k)); //Temperature of air at
    exit in K
17 h=cp*(t2-t1); //Change in enthalpy of the system in
    kJ
18 p=m*(((c2^2-c1^2)/(2*1000))+h); //Power output of the
    turbine in kW
19 p1=-p; //Power output of the turbine in kW
20
21 //Output
22 printf('(a)Temperature of air at exit t2 = %3.3f K \
    n (b)The power output of the turbine P = %3.3f kW
    ',t2,p1)

```

---

**Scilab code Exa 2.20** The ratio of pipe diameter

```
1  clc
2  clear
3  //Input data
4  c1=7; //Velocity of air at entrance in m/s
5  c2=5; //Velocity of air at exit in m/s
6  p1=100; //Pressure at the entrance in kPa
7  p2=700; //Pressure at the exit in kPa
8  v1=0.95; //Specific volume at entrance in m3/kg
9  v2=0.19; //Specific volume at exit in m3/kg
10 u=90; //Change in internal energy of the air entering
    and leaving in kJ/kg
11 z=0; //Potential energy is neglected
12 Q=-58; //Heat rejected to the surroundings in kW
13 m=0.5; //The rate at which air flow in kg/s
14 g=9.81; //Gravitational constant in m/s2
15
16 //Calculations
17 P=m*([(c12-c22)/(2000)]+(p1*v1-p2*v2)-u)+(Q); //The
    rate of work input to the air in kW
18 A=(v1*c2)/(v2*c1); //From continuity equation the
    ratio of areas
19 D=A(1/2); //The ratio of inlet pipe diameter to the
    outlet pipe diameter
20
21 //Output
22 printf('(a)The rate of work input to the air P = %3
    .3f kW \n (b)The ratio of inlet pipe diameter to
    the outlet pipe diameter D = %3.2f ',P,D)
```

---

**Scilab code Exa 2.21** The nozzle

```

1  clc
2  clear
3  //Input data
4  h1=3000; //Enthalpy of the fluid passing at inlet in
      kJ/kg
5  h2=2757; //Enthalpy of the fluid at the discharge in
      kJ/kg
6  c1=60; //Velocity of the fluid at inlet in m/s
7  A1=0.1; //Inlet area of the nozzle in m^2
8  v1=0.187; //Specific volume at inlet in m^3/kg
9  v2=0.498; //Specific volume at the outlet in m^3/kg
10 q=0; //Heat loss during the flow is negligible
11 z=0; //The nozzle is horizontal so change in PE is
      constant
12 w=0; //The work done is also negligible
13
14 //Calculations
15 c2=[2*1000*((h1-h2)+(c1^2/2000))]^(1/2); //Velocity
      at the exit in m/s
16 m=(A1*c1)/v1; //The mass flow rate in kg/s
17 A2=(m*v2)/c2; //Area at the exit of the nozzle in m^3
18
19 //Output
20 printf('(a)The velocity at the exit c2 = %3.2f m/s \
      \n (b)The mass flow rate m = %3.2f kg/s \n (c)Area
      at the exit A2 = %3.4f m^2 ',c2,m,A2)

```

---

**Scilab code Exa 2.22** Velocity and Exit area

```

1  clc
2  clear
3  //Input data
4  h1=3000; //Specific enthalpy of steam at inlet in kJ/
      kg
5  h2=2762; //Specific enthalpy of steam at the outlet

```

```

        in kJ/kg
6  v1=0.187; // Specific volume of steam at inlet in m^3/
    kg
7  v2=0.498; // Specific volume of steam at the outlet in
    m^3/kg
8  A1=0.1; // Area at the inlet in m^2
9  q=0; // There is no heat loss
10 z=0; // The nozzle is horizontal ,so no change in PE
11 c1=60; // Velocity of the steam at the inlet in m/s
12
13 // Calculations
14 c2=[(2*1000)*((h1-h2)+(c1^2/2000))]^(1/2); // Velocity
    of the steam at the outlet in m/s
15 m=(A1*c1)/v1; // Mass flow rate of steam in kg/s
16 m1=m*3600; // Mass flow rate of steam in kg/hr
17 A2=(m*v2)/c2; // Area at the nozzle exit in m^2
18
19 // Output
20 printf('(a) Velocity of the steam at the outlet c2 =
    %3.2f m/s \n (b) Mass flow rate of steam m = %3.3f
    kg/s (or) %3.2f kg/hr \n (c) Area at the nozzle
    exit A2 = %3.4f m^2 ',c2,m,m1,A2)

```

---

**Scilab code Exa 2.23** The exit velocity

```

1  clc
2  clear
3  //Input data
4  c1=40; // Velocity of air at the inlet of nozzle in m/
    s
5  h=180; // The decrease in enthalpy in the nozzle in kJ
    /kg
6  w=0; // Since adiabatic
7  q=0; // Since adiabatic
8  z=0; // Since adiabatic

```

```

9
10 // Calculations
11 c2=[(2*1000)*((h)+(c1^2/(2*1000)))]^(1/2); //The exit
    velocity of air in m/s
12
13 //Output
14 printf('The exit velocity of the air C2 = %3.2f m/s
    ',c2)

```

---

**Scilab code Exa 2.24** The shaft power

```

1  clc
2  clear
3  //Input data
4  p1=100; //Pressure at the inlet of the compressor in
    kPa
5  p2=500; //Pressure at the outlet of the compressor in
    kPa
6  v1=3; //Volume of the air at the inlet of the
    compressor in m^3/kg
7  v2=0.8; //Volume of the air at the outlet of the
    compressor in m^3/kg
8  c1=25; //The velocity of air at the inlet of the
    compressor in m/s
9  c2=130; //The velocity of air at the outlet of the
    compressor in m/s
10 z=12; //The height of delivery connection above the
    inlet in m
11 g=9.81; //Gravitational constant in m/s^2
12 n=1.3; //Polytropic index
13
14 // Calculations
15 W=[(n)*(p1*v1-p2*v2)]/(n-1); //Workdone for open
    system polytropic process in kJ/kg
16 K=[(c2^2-c1^2)/2000]; //Change in kinetic energy of

```

```

    the system in kJ/kg
17 P=g*(z)/1000;//Change in potential energy of the
    system in kJ/kg
18 w=W-K-P;//The shaft work of the compressor in kJ/kg
19
20 //Output
21 printf('The Shaft work of the compressor w = %3.3 f
    kJ/kg \n It is the power absorbing system ',w)

```

---

**Scilab code Exa 2.25** The power required

```

1 clc
2 clear
3 //Input data
4 m=10;//The rate of fluid compressed adiabatically in
    kg/s
5 p1=500;//Initial pressure of the process in kPa
6 p2=5000;//Final pressure of the process in kPa
7 v=0.001;//The specific volume of the fluid in m^3/kg
8
9 //Calculations
10 P=m*v*(p2-p1);//The power required in kW
11
12 //Output
13 printf('The power required P = %3.0 f kW ',P)

```

---

**Scilab code Exa 2.26** The exit air temperature

```

1 clc
2 clear
3 //Input data
4 m=2;//Mass flow rate of air in kg/s

```



```

5 t1=20; //Initial temperature of the air in degree
   centigrade
6 P=-30; //The amount of power consumed in kW
7 c1=100; //The inlet velocity of air in m/s
8 c2=150; //The outlet velocity of air in m/s
9 R=0.287; //The gas constant for air in kJ/kg-K
10 g=1.4; //It is the adiabatic index
11 cp=1.005; //Specific heat at constant pressure in kJ/
   kg-K
12 q=0; //Heat developed as it is adiabatic condition
13 z=0; //The change in potential energy is neglected
14
15 // Calculations
16 h=(P/m)+((c2^2-c1^2)/(2*1000)); //The change in
   enthalpy of the system in kJ/kg
17 t=h/cp; //The change in temperature of the system in
   degree centigrade
18 t2=t1-t; //The exit air temperature in degree
   centigrade
19
20 //Output
21 printf('The exit air temperature is t2 = %3.2f
   degree centigrade ',t2)

```

---

**Scilab code Exa 2.27** The exit air temperature

```

1 clc
2 clear
3 //Input data
4 m=0.6; //Mass flow rate of air in kg/s
5 W=40; //Power required to run the compressor in kW
6 p1=100; //Initial pressure at the inlet of the
   compressor in kPa
7 t1=30; //Initial temperature at the inlet of the
   compressor in degree centigrade

```

```

8 z=0; //Change in potential energy is neglected
9 c=0; //Change in kinetic energy is neglected
10 q=0.4; //Heat lost to the cooling water ,bearings and
    frictional effects is 40% of input
11 cp=1.005; //Specific heat at constant pressure in kJ/
    kg-K
12
13 // Calculations
14 Q=q*W; //Net heat losses from the system in kW
15 H=W-Q; //Change in total enthalpy of the system in kW
16 t2=(H/(m*cp))+t1; //The exit air temperature in
    degree centigrade
17
18 //Output
19 printf('The exit air temperature T2 = %3.0f degree
    centigrade ',t2)

```

---

**Scilab code Exa 2.28** The rate of heat transfer

```

1 clc
2 clear
3 //Input data
4 m1=100; //Air flow rate in kg/hr
5 q1=600; //The heat generated by each person in kJ/hr
6 h1=85; //The enthalpy of air entering the room in kJ/
    kg
7 h2=60; //The enthalpy of air leaving the room in kJ/
    kg
8 Q1=0.2; //The heat added by each lamp in the room in
    kW
9 P1=0.2; //The power consumed by each fan in kW
10
11 // Calculations
12 q=(5*q1)/3600; //The heat generated by 5 persons in
    the room in kW

```

```

13 Q=3*Q1; //The heat added by three lamps in the room
    in kW
14 P=2*P1; //The power consumed by two fans in the room
    in kW
15 m=m1/3600; //Mass flow rate of air in kg/s
16 H=[q+Q+P]+[m*(h1-h2)]; //Heat to be removed by the
    cooler in kW
17
18 //Output
19 printf('The rate at which the heat is to be removed
    by cooler X = %3.3f kJ/sec ',H)

```

---

**Scilab code Exa 2.29** The heat loss or gain

```

1 clc
2 clear
3 //Input data
4 p1=1000; //Pressure at the inlet of the system in kPa
5 p2=15; //Pressure at the outlet of the system in kPa
6 v1=0.206; //Specific volume at the inlet of the
    system in m^3/kg
7 v2=8.93; //Specific volume at the outlet of the
    system in m^3/kg
8 h1=2827; //Specific enthalpy at the inlet of the
    system in kJ/kg
9 h2=2341; //Specific enthalpy at the outlet of the
    system in kJ/kg
10 c1=20; //Velocity at the inlet of the system in m/s
11 c2=120; //Velocity at the outlet of the system in m/s
12 z1=3.2; //Elevation at the inlet of the system in m
13 z2=0.5; //Elevation at the outlet of the system in m
14 m=2.1; //The fluid flow rate in kg/s
15 W=750; //The work output of the device in kW
16 g=9.81; //Gravitational constant in m/s^2
17

```

```

18 // Calculations
19 Q=m*[((c2^2-c1^2)/(2*1000))+((g*(z2-z1)/(1000)))+(h2
    -h1)]+W; //The heat loss/gain by the system in kW
20
21 //Output
22 printf('The Heat loss by the system Q = %3.4f kW ',Q
    )

```

---

**Scilab code Exa 2.30** Rate of heat transfer and power and velocity

```

1 clc
2 clear
3 //Input data
4 t1=15; //The inlet temperature of the air passing
    through the heat exchanger in degree centigrade
5 c1=30; //The inlet velocity of air in m/s
6 t2=800; //The outlet temperature of the air from heat
    exchanger in degree centigrade
7 t2'==800; //The inlet temperature of the air to the
    turbine in degree centigrade
8 c2=30; //The inlet velocity of air to the turbine in
    m/s
9 t3=650; //The outlet temperature of the air from the
    turbine in degree centigrade
10 t3'==650; //the inlet temperature of the air to the
    nozzle in degree centigrade
11 c3=60; //The outlet velocity of the air from turbine
    in m/s
12 c3'==60; //Velocity at the inlet of the nozzle in m/s
13 t4=500; //The temperature at the outlet of the nozzle
    in degree centigrade
14 m=2; //Air flow rate in kg/s
15 cp=1.005; //Specific heat at constant pressure in kJ/
    kgK
16

```

```

17 // Calculations
18 Qh=m*cp*(t2-t1); //Rate of heat transfer to the air
    in the heat exchanger in kJ/s
19 P=m*[(cp*(t2'-t3))+((c2^2-c3^2)/2000)]; //Power
    output from the turbine in kW
20 c4=[(2*1000)*[cp*(t3'-t4)]+c3^2]^(1/2); //Velocity of
    air at exit from nozzle in m/s
21
22 //Output
23 printf('(a)Rate of heat transfer to the air in the
    heat exchanger q = %3.2f kJ/s \n (b)Power output
    from the turbine W = %3.1f kW \n (c)Velocity of
    air at exit from nozzle C = %3.2f m/s ',Qh,P,c4)

```

---

**Scilab code Exa 2.31** The heat transfer and exit area

```

1 clc
2 clear
3 //Input data
4 p1=400; //Initial pressure of the gas in a turbine in
    kPa
5 t1=573; //Initial temperature of the gas in a turbine
    in K
6 p2=100; //Final pressure of the gas in a turbine in
    kPa
7 V=2.5; //It is the ratio of final volume to the inlet
    volume
8 c2=50; //Velocity of the gas at exit in m/s
9 P=1000; //Power developed by the turbine in kW
10 cp=5.193; //Specific heat of the helium at constant
    pressure in kJ/kg K
11 G=8.314; //Gas constant in kNm/kgK
12 M=4; //Molecular weight of the helium
13
14 // Calculations

```

```

15 R=G/M; // Characteristic gas constant in kNm/kgK
16 v1=(R*t1)/p1; // Specific volume at the inlet in m^3/
    kg
17 v2=V*v1; // Specific volume at the outlet in m^3/kg
18 n=log(p2/p1)/log(v1/v2); // Polytropic index
19 t2=[(t1)*((p2/p1)^((n-1)/n))]; // Final temperature of
    the gas in a turbine in K
20 w=(n/(n-1))*(R*(t1))*[1-((p2*v2)/(p1*v1))]; //
    Specific work in kJ/kg
21 K=c2^2/(2*1000); // Change in kinetic energy in kJ/kg
22 Ws=w-K; // Work done by the shaft in kJ/kg
23 q=Ws+(cp*(t2-t1))+K; // The heat transfer during the
    process in kJ/kg
24 m=P/Ws; // Mass flow rate of gas required in kg/s
25 A2=(m*v2)/c2; // Exit area of the turbine in m^2
26
27 // Output
28 printf('(a)The mass flow rate of the gas required m
    = %3.4f kg/s \n (b)The heat transfer during the
    process q = %3.2f kJ/kg \n (c)Exit area of the
    turbine A2 = %3.4f m^2 ',m,q,A2)

```

---

# Chapter 6

## Introduction to heat transfer

Scilab code Exa 6.1 Heat transfer coefficient

```
1  clc
2  clear
3  //Input data
4  t1=270; //Temperature inside surface of the furnace
        wall in degree centigrade
5  t3=20; //Temperature outside surface is dissipating
        heat by convection into air in degree centigrade
6  L=0.04; //Thickness of the wall in m
7  K=1.2; //Thermal conductivity of wall in W/m-K
8  t2=70; //Temperature of outside surface should not
        exceed in degree centigrade
9  A=1; //Assuming area in m^2
10
11 //Calculations
12 Q1=(K*A*(t1-t2))/(L); //Heat transfer through the
        furnace wall in W
13 hc=(Q1)/(A*(t2-t3)); //Heat transfer coefficient in W
        /m^2K
14
15 //Output
16 printf('The minimum value of heat transfer
```

coefficient at the outer surface  $hc = \%3.1f \text{ W/m}^2 \text{ K}$ ,hc)

---

### Scilab code Exa 6.2 Emissive power

```
1  clc
2  clear
3  //Input data
4  t1=30; //Normal temperature of black body in degree
    centigrade
5  t2=100; //Heated temperature of black body in degree
    centigrade
6  s=20.52*10^-8; //Stefan Boltzmann constant in kJ/hrK
    ^4
7  A=1; //Assume area in m^2
8
9  //Calculations
10 T1=273+t1; //Black body temperatures in kelvin K
11 T2=273+t2; //Heated temperature of black body in
    kelvin K
12 E=s*(T2^4-T1^4); //Increase of emissive power in kJ/
    hr
13
14 //Output
15 printf('The change in its emissive power E= %3.4f kJ
    /hr ',E)
```

---

### Scilab code Exa 6.3 Temperature and Heat transfer coefficient

```
1  clc
2  clear
3  //Input data
4  L=0.012; //Wall thickness of a mild steel tank in m
```



```

5 t1=100; //Temperature of water in tank in degree
   centigrade
6 t4=20; //Atmospheric temperature of air in degree
   centigrade
7 K=50; //Thermal conductivity of mild steel in W/m-K
8 hi=2850; //Convection heat transfer coefficient on
   water side in W/m^2-K
9 ho=10; //Convection heat transfer coefficient on air
   side in W/m^2-K
10 Q1=60; //Heat trasfer from the incandicent lamp in W
11 s=5.67*10^-8; //Stefan boltzmann constant in W/m^2/K
   ^4
12 T1=2500; //Lamp surface temperature in K
13 T2=300; //Room temperature in K
14 A=1; //Assuming area in m^2
15
16 // Calculations
17 T=t1-t4; //Temperature difference in degree
   centigrade
18 Q=(T)/((1/hi)+(L/K)+(1/ho)); //Rate of heat loss per
   m^2 area of surface of tank in W
19 t3=(Q/(ho*A))+(t4); //Temperature of the outside
   surface in degree centigrade
20 U=(Q)/(A*T); //Overall Heat transfer coefficient in W
   /m^2/K
21 a=(Q1)/(s*(T1^4-T2^4)); //surface area of the coil in
   m^2
22 a1=a*10^6; //Surface area of the coil in mm^2
23
24 //Output
25 printf('(a) The rate of heat loss per sq m area of
   the tank Q = %3.2f W \n (b) Overall heat transfer
   coefficient U = %3.2f W/m^2/K \n (c) Temperature
   of the outside surface of tank t3 = %3.2f degree
   centigrade \n (d)The surface area of the coil is
   %3.3f mm^2 ',Q,U,t3,a1)

```

---

### Scilab code Exa 6.4 Heat loss rate and Temperature

```
1  clc
2  clear
3  //Input data
4  A1=3.5; //Area of the boiler plate in m^2
5  X2=0.02; //Thickness of the plate in m
6  K2=50; //Thermal conductivity of plate in W/m-K
7  X1=0.002; //Thickness of layer inside boiler in m
8  K1=1; //Thermal conductivity of layer in W/m-K
9  t1=250; //The hot gas temperature of the plate in
    degree centigrade
10 t3=200; //Temperature of cold air in degree
    centigrade
11
12 //Calculations
13 T=t1-t3; //Temperature difference in degree
    centigrade
14 Q=(T*A1)/((X1/K1)+(X2/K2)); //Rate of heat loss in W
15 Q1=Q/1000; //Rate of heat loss in kJ/s
16 Q2=Q1*3600; //Rate of heat loss in kJ/hr
17
18 //Output
19 printf('(a)Rate of heat loss in kJ/s = %3.2 f kJ/s \n
    (b)Rate of heat loss per hour Q = %3.2 f kJ/hr ',
    Q1,Q2)
```

---

### Scilab code Exa 6.5 Rate of heat loss and Temperature

```
1  clc
2  clear
3  //Input data
```

```

4 L1=0.225; //Thickness of the brick in m
5 K1=4.984; //Thermal conductivity of brick in kJ/hr m
    C/m
6 L2=0.125; //Thickness of insulating brick in m
7 K2=0.623; //Thermal conductivity of insulating brick
    in kJ/hr m C /m
8 Ti=1650; //Temperature inside the furnace in degree
    centigrade
9 h1=245.28; //Conductance at inside wall in kJ/hr m^2
    C
10 ho=40.88; //Conductance at outside wall in kJ/hr m^2
    C
11 To=27; //Temperature of surrounding atmosphere in
    degree centigrade
12
13 //Calculations
14 R=((1/h1)+(L1/K1)+(L2/K2)+(1/ho)); //Total resistance
    of the wall in C hr/kJ
15 q=(Ti-To)/R; //Rate of heat loss per m^2 of the wall
    in kJ/hr m^2
16 T1=Ti-(q*(1/h1)); //Inner surface temperature in
    degree centigrade
17 T3=Ti-(q*((1/h1)+(L1/K1)+(L2/K2))); //Outer surface
    temperature in degree centigrade
18
19 //Output
20 printf('(a)The rate of heat loss per sq m of the
    wall q = %3.2f kJ/hr m^2 \n (b)The temperature at
    the inner surface T1 = %3.2f degree centigrade \
n (c)The temperature at the outer surface T3 = %3
    .2f degree centigrade ',q,T1,T3)

```

---

### Scilab code Exa 6.6 The heat transfer and conductance

```
1 clc
```

```

2 clear
3 //Input data
4 x=0.3; //Thickness of the wall in degree centigrade
5 t1=24; //Inside surface temperature of the wall in
    degree centigrade
6 t2=-6; //Outside temperature of wall in degree
    centigrade
7 h=2.75; //Height of the wall in m
8 L=6.1; //Length of the wall in m
9 K=2.6; //Coefficient of conductivity of brick in kJ/
    hr m C
10
11 //Calculations
12 A=h*L; //Area of the wall in m^2
13 T=t2-t1; //Temperature difference in degree
    centigrade
14 q=(K*A*(-T))/(x); //Heat transfer by conduction in kJ
    /hr
15 R=(t1-t2)/q; //Resistance of the wall in C hr/kJ
16 C=1/R; //Conductance of the wall in kJ/m C
17
18 //Output
19 printf('(a)The heat transfer by conduction through
    the wall q = %3.2f kJ/hr \n (b)Resistance of the
    wall R = %3.5f C hr/kJ \n Conductance of the wall
    C= %3.2f kJ/m C',q,R,C)

```

---

**Scilab code Exa 6.8** The energy received

```

1 clc
2 clear
3 //Input data
4 T=300; //Temperature of the earth as a black body in
    K
5 s=20.52*10^-8; //Stefan Boltzmann constant in kJ/hr m

```

```

        ^2 T^4
6
7 //Calculations
8 Q=s*T^4;//Heat received by unit area on the earths
    surface perpendicular to solar rays in kJ/hr
9
10 //Output
11 printf('Heat received by the unit area of earths
    surface Q = %3.2f kJ/hr ',Q)

```

---

**Scilab code Exa 6.9** The loss of heat

```

1 clc
2 clear
3 //Input data
4 D=0.07;//Diameter of the steel tube in m
5 L=3;//Length of the steel tube
6 t1=227;//Temperature of the steel tube in m
7 t2=27;//Temperature of the room in degree centigrade
8 s=20.52*10^-8;//Stefan Boltzmann constant in kJ/hr m
    ^2 T^4
9 pi=3.1428;//Constant value of pi
10
11 //Calculations
12 A=2*pi*D*L;//Surface area of the tube in m^2
13 Q=(A)*(s)*((t1+273)^4-(t2+273)^4);//Loss of heat by
    radiation in kJ/hr
14 Q1=Q/3600;//Loss of heat by radiation in kW
15
16 //Output
17 printf('The loss of heat by radiation from steel
    tube Q = %3.4f kW ',Q1)

```

---

**Scilab code Exa 6.10** The rate of heat removed

```
1  clc
2  clear
3  //Input data
4  T1=7; //Inside temperature of refrigerator in degree
      centigrade
5  T0=28; //Temperature in the kitchen in degree
      centigrade
6  K1=40; //Thermal conductivity of mild steel in W/mC
7  x1=0.03; //Thickness of mild sheets in m
8  K3=40; //Thermal conductivity of the mild steel in W/
      mC
9  x3=0.03; //Thickness of another side mild sheet in m
10 x2=0.05; //Thickness of glass wool insulated in m
11 hi=10; //Heat transfer coefficient in the inner
      surface of refrigerator in W/m^2 C
12 ho=12.5; //Heat transfer coefficient in the outer
      surface of refrigerator in W/m^2 C
13 K2=0.04; //Thermal conductivity of glass in W/mC
14
15 //Calculations
16 Q=(T1-T0)/((1/hi)+(x1/K1)+(x2/K2)+(x3/K3)+(1/ho)); //
      Heat transfer per unit area in W/m^2
17
18 //Output
19 printf('The rate of heat removed from the
      refrigerator Q = %3.3f W/m^2 ',Q)
```

---

**Scilab code Exa 6.11** Heat loss and maximum temperature

```
1  clc
2  clear
3  //Input data
4  x1=0.2; //Thickness of the fire brick
```

```

5 x2=0.2; //Thickness of the common brick
6 Ti=1400; //Temperature of hot gases in the inner
   surface of the brick in degree centigrade
7 To=50; //Temperature of gases in the outer surface of
   the brick in degree centigrade
8 h1=16.5; //Convection heat transfer coefficient on
   gas side in W/mC
9 h2=17.5; //radiation heat transfer coefficient on gas
   side in W/mC
10 h3=12.5; //Convection heat transfer coefficient on
   outer side in W/mC
11 h4=6.5; //Radiation heat transfer coefficient on
   outer side in W/mC
12 K1=4; //Thermal conductivity of fire brick in W/mC
13 K2=0.65; //Thermal conductivity of common brick in W/
   mC
14
15 // Calculations
16 hi=h1+h2; //Total heat transfer coefficient in inner
   in W/mC
17 ho=h3+h4; //Total heat transfer coefficient in outer
   in W/mC
18 Q=(Ti-To)/((1/hi)+(x1/K1)+(x2/K2)+(1/ho)); //Heat
   flow through the furnace composite wall per unit
   area in W/m^2
19 Q1=Q/1000; //Heat flow through the furnace composite
   wall per unit area in kW/m^2
20 T1=Ti-(Q/hi); //Temperature at the inside of the fire
   brick in degree centigrade
21 T2=T1-(Q*(x1/K1)); //Maximum temperature to which
   common brick is subjected in degree centigrade
22
23 //Output
24 printf('(a)Heat loss per m^2 area of the furnace
   wall Q = %3.2f kW/m^2 \n (b)Maximum temperature
   to which common brick is subjected T1 = %3.3f
   degree centigrade \n          similarly on other side
   T2 = %3.3f degree centigrade ',Q1,T1,T2)

```

---

**Scilab code Exa 6.12** The thickness of brick

```
1  clc
2  clear
3  //Input data
4  K1=0.93; //Thermal conductivity of fire clay in W/mC
5  K2=0.13; //Thermal conductivity of diatomite brick in
      W/mC
6  K3=0.7; //Thermal conductivity of red brick in W/mC
7  x1=0.12; //Thickness of fire clay in m
8  x2=0.05; //Thickness of diatomite in m
9  x3=0.25; //Thickness of brick in m
10 T=1; //Assume the difference between temperature in
      degree centigrade
11
12 //Calculations
13 Q=(T)/((x1/K1)+(x2/K2)+(x3/K3)); //The heat flow per
      unit area in W/m^2
14 X3=K3*((T/Q)-(x1/K1)); //Thickness of the red brick
      layer in m
15 X=X3*100; //Thickness of the red brick layer in cm
16
17 //Output
18 printf('The thickness of the red brick layer, \n if
      the brick work is to be laid with out diatomic is
      %3.3f cm ',X)
```

---

**Scilab code Exa 6.13** The rate of heat loss

```
1  clc
2  clear
```



```

3 //Input data
4 R1=0.06; //Thickness of material layer in m
5 R2=0.12; //Thickness of the two insulating materials
   in m
6 R3=0.16; //Thickness of material layers with pipe in
   m
7 K1=0.24; //Thermal conductivity of one layer in W/mC
8 K2=0.4; //Thermal conductivity of another layer in W/
   mC
9 L=60; //Length of the pipe in m
10 hi=60; //Heat transfer coefficient inside in W/m^2C
11 ho=12; //Heat transfer coefficient outside in W/m^2C
12 ti=65; //Temperature of hot air flowing in pipe in
   degree centigrade
13 to=20; //Atmospheric temperature in degree centigrade
14 pi=3.1428; //Constant value of pi
15
16 //Calculations
17 Q=(ti-to)*(2*pi*L)/((1/(hi*R1))+(log(R2/R1)/(K1))+
   log(R3/R2)/(K2))+1/(ho*R3)); //Rate of heat loss
   in W
18 Q1=Q/1000; //Rate of heat loss in kW
19
20 //Output
21 printf('The rate of heat loss Q = %3.5 f kW ',Q1)

```

---

#### Scilab code Exa 6.14 Heat loss

```

1 clc
2 clear
3 //Input data
4 R1=8; //Inner radius of the pipe in cm
5 R2=8.5; //Outer radius of the pipe in cm
6 x1=3; //Thickness of first layer in cm
7 x2=5; //Thickness of second layer in cm

```

```

8 T1=300; //Inner surface temperature of the steam pipe
   in degree centigrade
9 pi=3.1428; //Constant value of pi
10 T4=50; //Temperature at outer surface of insulation
   in degree centigrade
11 L=1; //Length of the pipe in m
12 K1=50; //Thermal conductivity of pipe in W/mC
13 K2=0.15; //Thermal conductivity of first layer in W/
   mC
14 K3=0.08; //Thermal conductivity of second layer in W/
   mC
15 h=2751; //Enthalpy of dry and saturated steam at 300
   degree centigrade in kJ/kg
16 q=40; //Quantity of steam flow in gm/hr
17 hf=1345; //Enthalpy of fluid at 300 degree centigrade
   in kJ/kg
18 hfg=1406; //enthalpy at 300 degree centigrade in kJ/
   kg
19
20 // Calculations
21 R3=R2+x1; //Radius of pipe with first layer
22 R4=R3+x2; //Radius of pipe with two layers
23 Q=(2*pi*L*(T1-T4))/((log(R2/R1)/(K1))+log(R3/R2)/(
   K2))+log(R4/R3)/(K3)); //Quantity of heat loss
   per meter length of pipe in W/m
24 Q1=Q/1000; //Quantity of heat loss per meter length
   of pipe in kW
25 Q2=Q1*3600; //Quantity of heat loss per meter length
   of pipe in kJ/hr
26 hg=((h)-(Q2/q)); //Enthalpy of steam in kJ/kg
27 x=(hg-hf)/(hfg); //Dryness fraction of steam
28
29 //Output
30 printf('(a)The quantity of heat lost per meter
   length of steam pipe Q = %3.1f kJ/hr \n (b)The
   quantity of steam coming out of one meter length
   pipe x = %3.5f gm/hr ',Q2,x)

```

---

**Scilab code Exa 6.15** Heat transfer and conductance and resistance

```
1  clc
2  clear
3  //Input data
4  x=0.3; //Thickness of brick wall in m
5  ti=24; //Inside surface temperature of wall in degree
        centigrade
6  to=-6; //Outside surface temperature of wall in
        degree centigrade
7  h=2.75; //Height of the wall in m
8  L=6.1; //Length of the wall in m
9  K=2.6; //Thermal conductivity of brick material in kJ
        /m hr C
10
11 //Calculations
12 T=ti-to; //Temperature difference across the wall in
        degree centigrade
13 A=h*L; //Area of the wall in m^2
14 Q=(K*A*T)/(x); //Heat transfer through conduction by
        the wall per hour in kJ/hr
15 R=T/Q; //Resistance of the wall in hr C/kJ
16 C=1/R; //Conductance of the wall in kJ/hr C
17
18 //Output
19 printf('(a)The heat transfer by conduction through
        the wall per hr Q = %3.1f kJ/hr \n (b)The
        resistance of the wall R = %3.4f hr C/kJ \n
        The conductance of the wall C = %3.2f kJ/hr C ',Q
        ,R,C)
```

---

**Scilab code Exa 6.16** Reduction in heat loss

```

1  clc
2  clear
3  //Input data
4  x1=0.3; //Thickness of refractory bricks in m
5  K1=5.66; //Thermal conductivity of refractory bricks
    in kJ/hr mC
6  t1=1650; //Inner surface temperature of the wall in
    degree centigrade
7  t2=320; //Outside surface temperature of the wall in
    degree centigrade
8  x2=0.3; //Thickness of insulating brick in m
9  K2=1.26; //Thermal conductivity of insulating brick
    in kJ/hr mC
10 A=1; //unit surface area in m^2
11 t3=27; //Outside surface temperature of the brick in
    degree centigrade
12
13 //Calculations
14 T1=t1-t2; //Temperature difference in degree
    centigrade
15 Q1=(K1*A*T1)/(x1); //Heat loss without insulation in
    kJ/hr/m^2
16 R1=(K1*A)/(x1); //Heat loss for the change in
    temperature for refractory brick wall material in
    kJ/hrC
17 R2=(K2*A)/(x2); //Heat loss for the change in
    temperature for insulated brick wall material kJ/
    hrC
18 Q2=(t1-t3)/((1/R1)+(1/R2)); //Heat loss with
    insulation in kJ/hr/m^2
19 Q3=Q1-Q2; //Reduction in heat loss through the wall
    in kJ/hr/m^2
20
21 //Output
22 printf('The reduction in heat loss through the wall
    is %3.2f kJ/hr/m^2 ',Q3)

```

---

Scilab code Exa 6.17 Leakage and temperature

```
1  clc
2  clear
3  //Input data
4  L=4.6; //Length of the wall in m
5  b=2.3; //Breadth of the wall in m
6  x1=0.025; //Thickness of the wood in m
7  x2=0.075; //Thickness of the cork slabbing in m
8  x3=0.115; //Thickness of the brick in m
9  t1=18; //Exterior temperature of the wall in degree
    centigrade
10 t4=-20; //Interior temperature of the wall in degree
    centigrade
11 K1=7.5; //Thermal conductivity of the wood in kJ/hr
    mC
12 K2=1.9; //Thermal conductivity of the wood in kJ/hr.
    mC
13 K3=41; //Thermal conductivity of the brick in kJ/hr
    mC
14
15 //Calculations
16 A=L*b; //Area of the wall in m^2
17 R1=(K1*A)/(x1); //Heat loss for the change in
    temperature for insulated wood material in kJ/hrC
18 R2=(K2*A)/(x2); //Heat loss for the change in
    temperature for cork material in kJ/hrC
19 R3=(K3*A)/(x3); //Heat loss for the change in
    temperature for brick in kJ/hrC
20 Q=(t1-t4)/(1/R1+1/R2+1/R3); //Heat loss with
    insulation in kJ/hr
21 Q1=Q*24; //Heat loss with insulation in kJ/24hr
22 t2=t1-(Q/R1); //Interface temperature t2 in degree
    centigrade
```

```

23 t3=t2-(Q/R2); //Interface temperature t3 in degree
    centigrade
24
25 //Output
26 printf('(a)The leakage through the wall per 24 hours
    Q = %3.2f kJ/24hr \n (b)Temperature at the
    interface t2 = %3.4f degree centigrade \n
    Temperature at interface t3 = %3.4f degree
    centigrade ',Q1,t2,t3)

```

---

**Scilab code Exa 6.18** The heat loss

```

1  clc
2  clear
3  //Input data
4  L=0.3; //Thickness of the wall in m
5  ti=320; //Inner surface temperature in degree
    centigrade
6  to=38; //Outer surface temperature in degree
    centigrade
7  A=1; //Assume unit area in m^2
8
9  //Calculations
10 Q=(A/L)*((0.01256/2)*(ti^2-to^2)-(4.2/3)*10^-6*(ti
    ^3-to^3)); //Heat loss per sq metre of surface
    area for a furnace wall in kJ/hr/m^2
11
12 //Output
13 printf('The heat loss per sq metre of surface area
    for a furnace wall Q = %3.1f kJ/hr/m^2 ',Q)

```

---

**Scilab code Exa 6.19** The heat loss and the temperature

```

1  clc
2  clear
3  //Input data
4  d=11.5;//Outer diameter of steam pipe line in cm
5  t1=5;//Thickness of first layer in cm
6  K1=0.222;//Thermal conductivity of first layer in kJ
    /hr mC
7  t2=3;//Thickness of second layer in cm
8  pi=3.1428;//Constant value of pi
9  K2=3.14;//Thermal conductivity of second layer in kJ
    /hr mC
10 T1=235;//Outside surface temperature of steam pipe
    in degree centigrade
11 T3=38;//Outer surface of lagging in degree
    centigrade
12 L=1;//Length of the pipe in m
13
14 //Calculations
15 I=log((d+(2*t1))/d);//For inner layer calculation
16 O=log((d+(2*t1)+(2*t2))/(d+(2*t1)));//For outer
    layer calculations
17 R1=(2*pi*L*K1)/I;//Heat loss for change in
    temperature for first insulated material in kJ/hC
18 R2=(2*pi*L*K2)/O;//Heat loss for the change in
    temperature for second insulated material in kJ/
    hC
19 Q=(T1-T3)/(1/R1+1/R2);//Heat loss per metre length
    of pipe per hr in kJ/hr
20 T2=T1-(Q/R1);//Temperature between the two layers of
    insulation in degree centigrade
21
22 //Output
23 printf('(a)The heat loss per metre length of pipe
    per hr Q = %3.2f kJ/hr \n (b)Temperature between
    the two layers of insulation T= %3.2f degree
    centigrade ',Q,T2)

```

---

Scilab code Exa 6.20 The rate of heat flow

```
1  clc
2  clear
3  //Input data
4  t1=24; //Temperature at the outside surface in degree
      centigrade
5  t4=-15; //Temperature at the inner surface in degree
      centigrade
6  A=1; //Assuming unit area in m^2
7  K1=23.2; //Thermal conductivity of steel in W/mC
8  K2=0.014; //Thermal conductivity of glasswood in W/mC
9  K3=0.052; //Thermal conductivity of plywood in W/mC
10 x1=0.0015; //Thickness of steel sheet at outer
      surface in m
11 x2=0.02; //Thickness of glasswood in between in m
12 x3=0.01; //Thickness of plywood at a inner surface in
      m
13
14 //Calculations
15 R1=(K1*A)/x1; //Heat loss for the change in
      temperature for first insulated material
16 R2=(K2*A)/x2; //Heat loss for the change in
      temperature for second insulated material
17 R3=(K3*A)/x3; //Heat loss for the change in
      temperature for third insulated material
18 Q=(t1-t4)/(1/R1+1/R2+1/R3); //The rate of heat flow
      in W/m^2
19
20 //Output
21 printf('The rate of heat flow Q = %3.2 f W/m^2 ',Q)
```

---