Scilab Textbook Companion for Basic Mechanical Engineering by G. K. Pathak and D. K. Chavan[1]

Created by
Mutra Chanakya Reddy
M.TECH (INTEGRATED)
Mechanical Engineering
SASTRA UNIVERSITY
College Teacher
A. P. Mohan Raj
Cross-Checked by
Lavitha Pereira

December 20, 2013

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

Book Description

Title: Basic Mechanical Engineering

Author: G. K. Pathak and D. K. Chavan

Publisher: Rajsons Publications, New Delhi

Edition: 1

Year: 2009

ISBN: 9788189401313

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

fundamental concepts and defenitions

Scilab code Exa 1.1 To find the work done

```
clc
clear
//Input data
p=700;//pressure of fluid in kN/m^2
v1=0.28;//Initial volume of fluid in m^3
v2=1.68;//Final volume of fluid in m^3

//Calculations
W=p*(v2-v1);//Work done in kJ

//Output
printf('The Work done W= %3.2f kJ',W)
```

Scilab code Exa 1.2 New volume of the gas

```
clc
```

```
clear
//Input data
p1=138;//Initial pressure of gas in kN/m^2
p2=690;//Final pressure of gas in kN/m^2
v1=0.112;//Initial volume in m^3

//Calculations
P=p1/p2;//Pressure ratio
v2=v1*(P^(1/1.4));//Final volume of gas in m^3

//Output
printf('The new volume of the gas v2= %3.6f m^3',v2)
```

Scilab code Exa 1.3 The work done by the gas

```
clc
clear
//Input data
p1=2070;//Initial pressure of gas in kN/m^2
p2=207;//Final pressure of gas in kN/m^2
v1=0.014;//Initial volume of gas in m^3
n=1.35;//constant

//Calculations
P=p1/p2;//Pressure ratio
v2=v1*(P^(1/1.35));//Final volume of gas in m^3
W=(p1*v1-p2*v2)/(n-1);//Work done in kJ

//Output
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

```
clc
clear
//Input data
v1=0.056;//Initial volume of gas in m^3
v2=0.007;//Final volume of gas in m^3
p1=100;//Initial perssure compressed Isothermally in
    kN/m^2

//Calculations
p2=(p1*v1)/v2;//Final pressure in kN/m^2
W=p1*v1*(log(v2/v1));//Work done in kJ

//Output
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

```
clc
clear
//Input data
v1=1;//Initial volume in m^3
v2=3;//Final volume in m^3

//Calculations
W=10^5*(((v2^3-v1^3)/3)+8*(log(v2/v1)));//Work done
    in J

//Output
printf('The work done W= %3.1f J',W)
```

Scilab code Exa 1.6 The work done by the gas

```
clc
clear
//Input data
v1=0.2;//Initial volume in m^3
v2=0.5;//Final volume in m^3

//Calculations
W=1500*(((v2^2-v1^2)/200)+(v2-v1))/1000;//Work done
   in kJ

//Output
printf('The work done by the gas W= %3.4f kJ ',W)
```

Scilab code Exa 1.8 The net work done

```
clc
clear
//Input data
v1=1.5;//Initial volume in m^3
v2=2;//Final volume in m^3
w1=2;//Work receiving in Nm
p=6;//constsnt pressure of gas in N/m^2

//Calculations
w2=p*(v2-v1);//Work done in Nm
W=w2-w1;//Net work done by the system in Nm

//Output
printf('Net work done by the system W= %3.1f Nm',W)
```

Scilab code Exa 1.9 Readings of pressure

```
clc
clear
//Input data
d=13596;//Density of Hg in kg/m^3
g=9.806;//gravity in m/sec^2
z=760;//Barometer pressure in mm of Hg
Pv=40;//Vaccum pressure in cm
dw=1000;//Density of water in kg/m^3
Zw=1.5;//Level of water in m

//Calculations
p=(d*g*z)/10^6;//Pressure in kPa
p1=(80/76)*p;//Pressure in kPa
Pa=p-Pv;//Absolute pressure in kPa
p2=(36/76)*p;//Pressure in kPa
p3=(dw*g*Zw)/1000;//pressure in kPa
p4=(5.2*10^5)/1000;//pressure in kPa

//Output
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 5.2bar = %3.2f kPa',p1
    ,p2,p3,p4)
```

Scilab code Exa 1.10 Readings of pressure

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

```
d=13596;//Density of Hg in kg/m^3

//calculations
Pp=(d*g*z)/10^6;//Pressure in kPa
p1=(d*g*0.55)/1000;//Pressure in kPa
p2=Pp+(Pg*101.325);//Pressure in kPa
p3=Pp+((Pf*g*100))/1000;//Pressure in kPa
p4=4.6*100;//Pressure in kPa

//Output
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 4.6bar (Abs)= %3.2f kPa',p1,p2,p3,p4)
```

Scilab code Exa 1.11 Absolute pressure

```
clc
clear
//Input data
Zw=50;//Manometer reading of water in cm
Zo=763;//Atmospheric pressure in mm of Hg
d=13.6*10^3;//Density of Hg in kg/m^3
dw=1000;//Density of water in kg/m^3
g=9.81;//Gravity in m/sec^2

//Calculations
Pa=(d*g*Zo)/10^6;//Atmospheric pressure in kPa
Pg=(dw*g*Zw)/10^5;//Gauge pressure in kPa
Pab=Pa+Pg;//Absolute pressure in kPa

//Output
printf('Absolute pressure Pab = %3.3f kPa ',Pab)
```

Scilab code Exa 1.12 Absolute pressure

```
clc
clear
//Input data
Z=70;//Vaccum gauge reading in cm of Hg
Pa=101.325;//Atmospheric pressure in kPa
d=13.6*10^3;//Density of Hg in kg/m^3
g=9.81;//Gravity in m/sec^2

//Calculations
Pv=(d*g*Z)/10^5;//Vaccum pressure in kPa
Pab=Pa-Pv;//Absolute pressure in kPa

//Output
printf('Absolute pressure Pab = %3.4f kPa ',Pab)
```

Scilab code Exa 1.13 Absolute pressure

```
clc
clear
//Input data
Pv=30;//Vaccum pressure in kPa
Z=755;//Barometer reading in mm of Hg
d=13590;//Density of Hg in kg/m^3
g=9.81;//Gravity in m/sec^2

//calculations
Pa=(d*g*Z)/10^6;//Atmospheric perssure in kPa
Pab=Pa-Pv;//Absolute pressure in kPa

//Output
```

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

Scilab code Exa 1.14 The gas pressure

```
clc
clear
//Input data
Z=0.562;//Level of open limb in m
Z1=0.761;//Barometer reading in m of Hg
g=9.79;//Gravity in m/sec^2
d=13640;//Density of Hg in kg/m^2

//Calculations
Pa=(d*g*Z1)/1000;//Atmospheric pressure in kPa
Ph=(d*g*Z)/1000;//Pressure exercterd due to height
    in kPa
Pab=Pa+Ph;//Absolute pressure in kPa

//Output
printf('The gas pressure Pab = %3.3f kN/m^2',Pab)
```

Scilab code Exa 1.15 The absolute pressure

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

```

```
//Calculatins
Pg=(dl*g*Z)/10^7;//Gauge pressure in bar
Pa=(d*g*Z1)/10^5;//Atmospheric pressure in bar
Pab=Pa+Pg;//Absolute pressure in bar

//Output
printf('Absolute pressure of the gas Pab = %3.5f bar
    ',Pab)
```

Scilab code Exa 1.16 The absolute pressure of the gas

```
clc
clear
//Input data
Z1=0.17;//Level of liquid in m
Z=0.76;//Barometer readings in m
d=13596;//Density of Hg in kg/m^3
g=9.806;//Gravity in m/sec^2
s=0.8;//Specific gravity
d1=1000;//Density of water in kg/m^3

//Calculations
dl=s*d1;//Density of given liquid in kg/m^3
Pa=d*g*Z;//Atmospheric pressure in N/m^2
p=dl*g*Z1;//Pressure in N/m^2
Pab=(Pa-p)/10^5;//Absolute pressure in bar

//Output
printf('Absolute pressure of the gas Pab = %3.6f bar
    ',Pab)
```

Scilab code Exa 1.17 The absolute pressure of steam

```
clc
clear
//Input data
g=9.806;//Gravity in m/sec^2
d=13596;//Density of Hg in kg/m^3
Z=9.75;//Level of Hg in cm
dw=1000;//Density of water in kg/m^3
Zw=0.034;//Coloumn of condensate in m
Zo=0.76;//Atmospheric pressure in m of Hg

//Calculations
P=dw*g*Zw;//Pressure in N/m^2
Pa=d*g*Zo;//Atmospheric pressure in N/m^2
Pg=(d*g*Z)/100;//Gauge pressure in N/m^2
Pab=(Pa+Pg-P)/10^5;//Absolute pressure in bar

//Output
printf('Absolute pressure of steam Pab = %3.6f bar ',Pab)
```

Scilab code Exa 1.18 The absolute pressure of steam

```
clc
clear
//Input data
g=9.7;//Gravity in m/sec^2
d=13.69*10^3;//Density of Hg in kg/m^3
dw=1000;//Density of water in kg/m^3
Pa=98;//Atmospheric pressure in kPa
Z=0.6;//Manometer level difference in m of Hg
Zw=0.04;//Water coloumn level in m

//Calculations
Pw=(dw*g*Zw)/1000;//Pressure due to water in kPa
Pg=(d*g*Z)/1000;//Pressure in kPa
```

```
Pab1=Pa+Pg-Pw;//Absolute pressure in kPa
Pab=Pab1/100;//Absolute pressure in bar

//Output
printf('The absolute pressure of steam Pab = %3.5f bar ',Pab)
```

Scilab code Exa 1.19 The absolute pressure of steam

```
clc
clear
//Input data
Z=0.76;//Actual height of mercury coloumn in m
g=9.806;//Gravity in m/sec^2
d=13596;//Density of Hg in kg/m^3
dw=1000;//Density of water in kg/m^3
Zw=0.035;//Height of condensate coloumn in m
Zh=0.10;//Height of mercury coloumn in m

//Calculations
Pa=d*g*Z;//Atmospheric pressure in N/m^2
Pw=dw*g*Zw;//Pressure due to water in N/m^2
Ph=d*g*Zh;//Pressure due to Hg in N/m^2
Pab=(Pa+Ph-Pw)/10^5;//Absolute pressure in bar

//Output
printf('Absolute pressure of steam in the pipe Pab = %3.2f bar',Pab)
```

Scilab code Exa 1.20 The absolute pressure of vapour

```
clc
clear
```

```
//Input data
dk=800;//Density of kerosene in kg/m^3
g=9.81;//gravity in m/sec^2
Zk=0.051;//Kerosene vapour on Hg coloumn in m
d=13600;//Density of Hg in kg/m^3
Zh=0.1;//Hg level in m
Z=0.755;//Atmospheric pressure in m of Hg

//Calculations
Pk=dk*g*Zk;//Pressure of kerosene in N/m^2
Pa=d*g*Z;//Atmospheric pressure in N/m^2
Ph=d*g*Zh;//Pressure due to Hg in N/m^2
Pab=(Pa+Ph-Pk)/1000;//Absolute pressure in kPa

//Output
printf('Absolute pressure of vapour Pab = %3.5f kPa',Pab)
```

Scilab code Exa 1.21 The absolute pressure of the gas

```
clc
clear
//Input data
d=13596;//Density of Hg in kg/m^3
g=9.806;//Gravity in m/sec^2
df=0.8*1000;//Density of fluid in kg/m^3
Z=0.76;//Atmospheric pressure in m of Hg
Zf=0.3;//Height of fluid coloumn in m

//Calculations
Pa=d*g*Z;//Atmospheric perssure in N/m^2
P=df*g*Zf;//Pressure due to fluid in N/m^2
Pab=(Pa+P)/10^5;//Absolute pressure in bar
Zh=((Pab*10^5-Pa)/(d*g))*100;//Difference between the height of Hg coloumn in 2 arms in m
```

```

//Output
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

```

clc
clear
//Input data
Pa=1;//Atmospheric pressure in bar
g=9.81;//Gravity in m/sec^2
do=0.8*1000;//Density of oil in kg/m^3
Zo=0.8;//Level of oil in m
dw=1000;//Density of water in kg/m^3
Zw=0.65;//Level of water in m
d=13.6*10^3;//Density of Hg in kg/m^3
Z=0.45;//Level of Hg in m

//Calculations
Po=(do*g*Zo)/10^5;//Pressure of oil in bar
Pw=(dw*g*Zw)/10^5;//Pressure of water in bar
P=(d*g*Z)/10^5;//Pressure of Hg in bar
Pab=Pa+Po+Pw+P;//Pressure at the bottom of the coloumn in bar
Pow=Pa+Po;//Pressure at the interface of oil and water in bar
Poh=Pa+Po+Pw;//Pressure at the interface of water and Hg

//Output
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

```
clc
clear
//Input data
Z=0.76;//Barometer reading in m
g=9.81;//Gravity in m/sec^2
d=13.6*10^3;//Density of Hg in kg/m^3
Pab=1.2*10^5;//Absolute pressure in N/m^2
do=0.8*1000;//Density of oil in kg/m^3
dw=1000;//Density of water in kg/m^3
dh=13.6*10^3;//Density of Hg in kg/m^3

//calculations
Pa=dh*g*Z;//Atmospheric pressure in N/m^2
Pg=Pab-Pa;//Gauge pressure in N/m^2
Zo=Pg/(do*g);//Height of oil in manometer in m
Pw=Pab-Pa;//Pressure exercted by water in N/m^2
Zw=Pw/(dw*g);//Height of water in manometer in m
P=Pab-Pa;//Pressure of Hg in N/m^2
Zh=P/(d*g);//Height of Hg in manometer in m

//Output
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

```
clc
clear
//Input data
Zg=0.753;//Barometer reading at ground level in m
Zp=0.690;//Pilots barometer reading in the plane in m
d=13600;//Density of Hg in kg/m^3
g=9.81;//Gravity in m/sec^2
da=1.25;//Density of air in kg/m^3

//Calculations
Pg=d*g*Zg;//Pressure at ground level in N/m^2
Pp=d*g*Zp;//Pressure at plane level in N/m^2
P=Pg-Pp;//Change of pressure at ground level and that of plane level in N/m^2
Za=P/(da*g);//Altitude of plane from ground in m

//Output
printf('The altitude of the plane from ground level Za = %3.2f m ',Za)
```

Scilab code Exa 1.25 The pressure

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

```

//Calculations
Pw1=dw*g*Zw1;//First level of water pressure in N/m
    ^2
Pw2=dw*g*Zw2;//Second level of water pressure in n/m
    ^2
Ph=dh*g*Zh;//Pressure of Hg in N/m^2
Pb=((Pa*1000)+Pw1+Pw2-Ph)/1000;//Pressure exercted
    at B in kPa

//Output
printf('Pressure exercted at B Pb = %3.4f kPa',Pb)
```

Scilab code Exa 1.26 Weight of piston and slab

```
clc
clear
//Input data
do=0.902*10^3;//Density of oil in kg/m^3
Pg=2*10^5;//Gauge pressure in N/m^2
g=9.81;//Gravity in m/sec^2
ho=2;//Level of oil in m
d=2;//Diameter of cylinder in m
pi=3.141595;//Constant value of pi

//Calculations
A=(pi/4)*d^2;//Area of cylinder
Po=do*g*ho;//Pressure due to oil in N/m^2
W=(Pg+Po)*A;//Weight of the piston in N

//Output
printf('The total weight of piston and slab W = %3.2
    f N ',W)
```

Scilab code Exa 1.27 The pressure in the gas

```
clc
clear
//Input data
m=21;//Mass of piston in kg
P1=600;//Pressure in the pipe 1 in kPa
P2=170;//Pressure in the pipe 2 in kPa
d1=0.10;//Diameter of the piston 1 in m
d2=0.20;//Diameter of the piston 2 in m
pi=3.14155;//Constant value of pi

//Calculations
F=(m*9.81)/1000;//Force due to mass in kN
F1=(pi/4)*d1^2*P1;//Force 1 acting on 10 cm diameter
    piston in kN
F2=(pi/4)*(d2^2-d1^2)*P2;//Force 2 acting on 20 cm
    diameter piston in kN
F3=F+F1+F2;//Total downward force in kN
P3=F3/((pi/4)*d2^2);//Pressure 3 in the gas in kPa

//Output
printf('The pressure in the gas P3 = %3.4f kPa ',P3)
```

Scilab code Exa 1.28 The height of building

```

clc
clear
//Input data
P1=0.755;//Barometric reading at the bottom of the
    building in m
```

```
P2=0.73;//Barometric reading at the top of the building in m
da=1.18;//Density of air in kg/m^3
g=9.81;//Gravitalional constant in m/sec^2
d=13600;//Density of Hg in kg/m^3

//Calculations
h=((P1-P2)*d*g)/(da*g);//The height of the building in m

//Output
printf('The height of the building h = %3.2f m',h)
```

Scilab code Exa 1.29 The absolute pressure

```
clc
clear
PA=200;//Gauge pressure reading for A in kPa
PB=120;//Gauge pressure reading for B in kPa
hb=750;//Barometer reading in mm of Hg
g=9.806;//Gravitational constant in m/sec^2
d=13597;//Density of Hg in barometer in kg/m^3

//Calculations
Pa=d*g*hb/10^6;//Atmospheric pressure in kPa
Pab1=PA+Pa;//Absolute pressure in container A in kPa
Pab2=PB+Pab1;//Absolute pressure in container B in kPa

//Output
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

```
clc
clear
//Input data
C1=40;//Temperature 1 in degree centigrade
C2=-20;//Temperature 2 in degree centigrade

//calculations
F1=((C1/100)*180)+32;//Temperature 1 in Fahrenheit
F2=((C2/100)*180)+32;//Temperature 2 in Fahrenheit

//Output
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

```
//Given that the temperature has the same value on
   both the centrigrade and fahrenheit scales
//(C/100)=((F-32)/180)

//Putting C=F
C=(-32/180)/((1/100)-(1/180));//Centrigade
   temperature in degree C
F=C;//Fahrenheit temperature in degree Fahrenheit

printf('The temperature which has the same value on
   both the centrigrade and fahrenheit scales is %i
   degree C = %i degree F',C,F)
```

Scilab code Exa 1.32 The temperature

```
clc
clear
//Input data
P1=1.5;//Thermometric properties at ice point
P2=7.5;//Thermometric properties at steam point
P3=3.5;//Thermometric property

//Calculations
A=[log(P2) 1
   log(P1) 1] //Coefficient matrix
B=[100
   0]       //Constant matrix
X=inv(A)*B //Inverse matrix
t=(X(1)*log(P3)+X(2));//Required temperature in
    degree C

//Output
printf('The required temperature is %3.6f degree C',
    t)
```

Scilab code Exa 1.33 The temperature

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

```
//Calculations
A=[log(P(2)) 1
   log(P(1)) 1] //Coefficient matrix
B=[T(2)
   T(1)]  //Constant matrix
X=inv(A)*B;//Variable matrix
t=(X(1)*log(P1)+X(2));//Required temperature in degree C

//Output
printf('Temperature corresponding to the thermometric property is %3.1f degree C',t)
```

Scilab code Exa 1.34 The temperature

```
clc
clear
//Input data
p1=32;//Pressure in mm of Hg at triple point of water
p2=76;//Pressure in mm of Hg above atmospheric pressure
p3=752;//Barometric pressure in mm of Hg
T=273.16;//Triple point of water in K

//Calculations
P1=p3+p1;//Total pressure in mm of Hg
P2=p2+p3;//Total pressure in mm of Hg
T2=((T*P2)/P1)-273.16;//Temperture in degree C

//Output
printf('Temperature is %3.2f degree C',T2)
```

Scilab code Exa 1.35 The temperature

```
clc
clear
T=[32,212];//Temperatures of ice point and steam
    point respectively
P=[1.86,6.81];//P values at ice point and steam
    point respectively
P1=2.5;//Reading on the thermometer

//Calculations
A=[log(P(2)) 1
   log(P(1)) 1] //Coefficient matrix
B=[T(2)
   T(1)]  //Constant matrix
X=inv(A)*B;//Variable matrix
t=(X(1)*log(P1)+X(2));//Required temperature in
    degree C

//Output
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

```
clc
clear
//Input data
h1=60;//The heat transfer in the process in kJ
h2=-8;//The heat transfer in the process in kJ
h3=-34;//The heat transfer in the process in kJ
h4=6;//The heat transfer in the process in kJ

//Calculations
Q=h1+h2+h3+h4;//Net work transfer in a cycle in kJ

//Output
printf('Net work transfer in a cycle Q = %3.0f kJ ',
   Q)
```

Scilab code Exa 2.2 The work done

```
clc
```

```
clear
//Input data
Q=-300;//Heat transfer in the system consisting of the gas in kJ
u=0;//Internal energy is constant

//Calculations
W=Q-u;//Work done of the system in kJ

//Output
printf('The work done of the system W = %3.0f kJ ',W)
```

Scilab code Exa 2.3 Internal energy

```
clc
clear
//Input data
v1=1.5;//Initial volume of the process in m^3
v2=4.5;//Final volume of the process in m^3
Q=2000;//Amount of heat added in kJ

//Calculations
W=100*((3.5*log(v2/v1))+(3*(v2-v1)));//Amount of work done in kJ
U=Q-W;//The change in internal energy in kJ

//Output
printf('The change in internal energy is %3.4f kJ ',U)
```

Scilab code Exa 2.4 The change in KE and PE

```
clc
clear
//Input data
h1=35;//Enthalpy of water entering the boiler in kJ/kg
h2=705;//Enthalpy of steam leaving the boiler in kJ/kg
C=0;//Change in kinetic energy is neglected
Z=0;//Change in potential energy is neglected

//Calculations
q=h2-h1;//The heat transfer per kg of steam in kJ/kg

//Output
printf('The heat transfer per kg of steam q = %3.0f kJ/kg ',q)
```

Scilab code Exa 2.5 The net rate of work output

```
clc
clear
//Input data
Q=-170;//Sum of all heat transfers per cycle in kJ
N=100;//Total number of cycles per min in cycles/min
Q1=0;//Heat developed in a-b process in kJ/min
Q2=21000;//Heat developed in b-c process in kJ/min
Q3=-2100;//Heat developed in c-d process in kJ/min
W1=2170;//Work done in the process a-b in kJ/min
W2=0;//Work done in the b-c process in kJ/min
E3=-36600;//Change in energy in the process in kJ/min

//Calculations
E1=Q1-W1;//Change in energy in process a-b in kJ/min
E2=Q2-W2;//Change in energy in b-c process in kJ/min
```

```
W3=Q3-E3;//Work done in the c-d process in kJ/min
Qt=Q*N;//Total heat transfer per min in kJ/min
Q4=Qt-Q1-Q2-Q3;//Heat developed in the process d-a in kJ/min
Et=0;//Total change in energy of the cycle
E4=Et-E1-E2-E3;//Energy in the process d-a in kJ/min
W4=Q4-E4;//Work done in the d-a process in kJ/min
Wn=Qt/60;//Net rate of work output in kW

//Output
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

```
clc
clear
//Input data
Q1=50;//Heat developed in the 1-2 process in kJ/kg
U1=20;//Change in energy in the 1-2 process in kJ/kg
Q2=-30;//Heat developed in the 2-3 process in kJ/kg
W2=-40;//Work done in the 2-3 process in kj/kg
U3=-30;//Change in energy in the 3-1 process in kJ/kg
Wt=30;//Net work done per kg of fluid in kJ/kg
m=0.1;//Mass of fluid in the cycle in kg
N=10;//Number of cycles per sec in cycles/sec

//Calculations
```

```
W1=Q1-U1;//Work done in the 1-2 process in kJ/kg
U2=Q2-W2;//Change in energy in the 2-3 process in kJ/kg
W3=Wt-W1-W2;//Work done in the 3-1 process in kJ/kg
Q3=W3+U3;//Heat developed in the process in kJ/kg
m1=m*N;//mass flow rate per sec in kg/sec
P=Wt*m1;//Rate of power in kW

//Output
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

```
clc
clear
//Input data
m=3;//Mass of substance in the system in kg
P1=500;//Initial pressure of the system in kPa
P2=100;//Final pressure of the system in kPa
V1=0.22;//Initial volume of the system in m^3
n=1.2;//Polytropic index
Q1=30;//Heat transfer for the another process

//Calculations
V2=V1*(P1/P2)^(1/1.2);//Final volume of the system in m^3
U=3.56*(P2*V2-P1*V1);//Total change in internal energy in kJ
W1=(P2*V2-P1*V1)/(1-n);//Work done for the 1-2
```

```
process in kJ
Q=U+W1;//Heat developed in the process in kJ
W2=Q1-U;//Work done for the another process in kJ

//Output
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

```
clc
clear
m=5;//Mass of the substance in the system in kg
P1=500;//Initial pressure of the system in kPa
P2=100;//Final pressure of the system in kPa
V1=0.22;//Initial volume of the system in m^3
n=1.2;//Polytropic index

//Calculations
V2=V1*(P1/P2)^(1/1.2);//Final volume of the system in m^3
U=3.5*(P2*V2-P1*V1);//Change in the internal energy of the system in kJ
W=(P1*V1-P2*V2)/(n-1);//Work developed in the process in kJ
Q=U+W;//Heat transfer in the process in kJ

//Output
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

```
clc
clear
//Input data
p1=170;//Initial pressure of the fluid in kPa
p2=400;//Final pressure of the fluid in kPa
v1=0.03;//Initial volume in m^3
v2=0.06;//Final volume in m^3

//Calculations
U=3.15*[(p2*v2)-(p1*v1)];//The change in internal
    energy of the fluid in kJ
A=[1 v1
   1 v2] //Coefficient matrix
B=[p1
   p2]  //Constant matrix
X=inv(A)*B;//Variable matrix
W=[X(1)*(v2-v1)]+[X(2)*((v2^2-v1^2)/2)];//The work
    done during the process in kJ
Q=U+W;//The heat transfer in kJ

//Output
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

```
clc
clear
```

```
//Input data
E1=4000;//Enthalpy at entrance in kJ/Kg
E2=4100;//Enthalpy at exit in kJ/kg
V1=50;//Velocity at entrance in m/s
V2=20;//Velocity at exit in m/s
h1=50;//Height at the entrance
h2=10;//Height at the exit
m=1;//mass flow rate to the system in kJ/s
Q=200;//Heat transfer rate to the system in kJ/s
g=9.8;//Gravitational constant in m/s^2

//Calculations
P=m*(((V1^2-V2^2)/(2000))+(g*(h2-h1)/1000)+(E1-E2))+Q;//Power capacity of the system in kW
printf('Power capacity of the system P = %3.4f kW ',P)
```

Scilab code Exa 2.12 The specific intenal energy

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

```
g=9.81;//Gravitational constant in m/s^2

//Calculations
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

//Output
printf('Specific Internal Energy decreases by %3.3f kJ/kg ',U)
```

Scilab code Exa 2.13 The power capacity

```
clc
clear
//Input data
m=5;//Rate of fluid flow in the system in kg/s
P1=620;//Pressure at the entrance in kPa
P2=130;//Pressure at the exit in kPa
C1=300;//Velocity at the entrance in m/s
C2=150;//Velocity at the exit in m/s
U1=2100;//Internal energy at the entrance in kJ/kg
U2=1500;//Internal energy at the exit in kJ/kg
V1=0.37;//Specific volume at entrance in m^3/kg
V2=1.2;//Specific volume at exit in m^3/kg
Q=-30;//Heat loss in the system during flow in kJ/kg
Z=0;//Change in potential energy is neglected in m
g=9.81;//Gravitational constant in m/s^2

//Calculations
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
P=W*m;//Power capacity of the system in kW

//Output
```

```
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

```
clc
clear
P1=100;//Pressure at Inlet in kPa
P2=500;//Pressure at Exit in kPa
V1=0.6;//Specific volume at Inlet in m^3/kg
V2=0.15;//Specific volume at Exit in m^3/kg
U1=50;//Specific internal energy at inlet in kJ/kg
U2=125;//Specific internal energy at Exit in kJ/kg
C1=8;//Velocity of air at Inlet in m/s
C2=4;//Velocity of air at Exit in m/s
m=5;//Mass flow rate of air in kg/s
Q=-45;//Heat rejected to cooling water in kW
Z=0;//Change in potential energy is neglected in m
g=9.81;//Gravitational constant in m/s^2

//Calculations
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
P1=-P;//Power required to drive the compressor in kW

//Output
printf('The power required to drive the compressor P
    = %3.2f kW ',P1)
```

Scilab code Exa 2.15 The power developed

```
clc
clear
//Input data
m1=5000;//Steam flow rate in kg/hr
Q1=-250;//Heat loss from the turbine insulation to surroundings in kj/min
C1=40;//Velocity of steam at entrance in m/s
h1=2500;//Enthalpy of the steam at entrance in kJ/kg
C2=90;//Velocity of the steam at the Exit in m/s
h2=2030;//Enthalpy of the steam at exit in kj/kg
Z=0;//Change in potential energy is neglected in m
g=9.81;//Gravitational constant in m/s^2

//Calculations
m=m1/3600;//Steam flow rate in kg/s
Q=Q1/60;//Heat loss from the turbine to the surroundings
P=m*(((C1^2-C2^2)/(2*1000))+(g*Z)+(h1-h2))+Q;//Power developed by the turbine in kW

//Output
printf('The power developed by the turbine P = %3.3f kW ',P)
```

Scilab code Exa 2.16 The work output

```
clc
clear
//Input data
c1=16;//Velocity of steam at entrance in m/s
c2=37;//Velocity of steam at exit in m/s
h1=2990;//Specific enthalpy of steam at entrance in kJ/kg
h2=2530;//Specific enthalpy of steam at exit in kJ/kg
```

```
Q=-25;//Heat lost to the surroundings in kJ/kg
m1=360000;//The steam flow rate in kg/hr

//Calculations
m=m1/3600;//The steam flow rate in kg/s
W=(((c1^2-c2^2)/(2*1000))+(h1-h2))+Q;//Total work
    done in the system in kJ/kg
P=m*W;//Power developed by the turbine in kW
//Output
printf('The work output from the turbine P = %3.1f
   kW ',P)
```

Scilab code Exa 2.17 The external work output

```
clc
clear
//Input data
p1=720;//Pressure at the entrance in kPa
t1=850;//Temperature at the entrance in degree
    centigrade
c1=160;//Velocity of the gas at entrance in m/s
Q=0;//Insulation (adiabatic turbine)
P2=115;//Pressure at the exit in kPa
t2=450;//Temperature at the exit in degree
    centigrade
c2=250;//Velocity of the gas at exit in m/s
cp=1.04;//Specific heat of gas at constant pressure
    in kJ/kg-K

//Calculations
H=cp*(t1-t2);//Change in Enthalpy of the gas at
    entrance and exit in kJ/kg
W=((c1^2-c2^2)/(2*1000))+(H);//External work output
    of the turbine in kJ/kg

```

```
//Output
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

```
clc
clear
//Input data
p=5000;//Power output of an adiabatic steam turbine
    in kW
p1=2000;//Pressure at the inlet in kPa
p2=0.15;//Pressure at the exit in bar
t1=400;//temperature at the inlet in degree
    centigrade
x=0.9;//Dryness at the exit
c1=50;//Velocity at the inlet in m/s
c2=180;//Velocity at the exit in m/s
z1=10;//Elevation at inlet in m
z2=6;//Elevation at exit in m
h1=3248.7;//Enthalpy at the inlet from the steam
    table corresponding to and 20 bar in kJ/kg
hf=226;//Enthalpy at exit at 0.15 bar from steam
    tables in kJ/kg
hfg=2373.2;//Enthalpy at exit at 0.15 bar from steam
     tables in kJ/kg
g=9.81;//Gravitational constant in m/s^2

//Calculations
h2=hf+(x*hfg);//Enthalpy at the exit in kJ/kg
W=(h1-h2)+((c1^2-c2^2)/(2*1000))+((g*(z1-z2))/1000);
    //Work done in the system in kJ/kg
m=p/W;//Mass flow rate of the steam

//Output
```

```
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

```
clc
clear
p1=1000;//Pressure at the inlet in kPa
t1=750;//Temperature at the inlet in K
c1=200;//Velocity at the inlet in m/s
p2=125;//Pressure at the exit in kPa
c2=40;//Velocity at the exit in m/s
m1=1000;//Mass flow rate of air in kg/hr
cp=1.053;//Specific heat at constant pressure in kJ/
    kgK
k=1.375;//Adiabatic index
Q=0;//The turbine is adiabatic

//Calculations
m=m1/3600;//The mass flow rate of air in kg/s
P=p2/p1;//Ratio of the pressure
t2=t1*((p2/p1)^((k-1)/k));//Temperature of air at
    exit in K
h=cp*(t2-t1);//Change in enthalpy of the system in
    kJ
p=m*(((c2^2-c1^2)/(2*1000))+h);//Power output of the
     turbine in kW
p1=-p;//Power output of the turbine in kW

//Output
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

```
clc
clear
//Input data
c1=7;//Velocity of air at entrance in m/s
c2=5;//Velocity of air at exit in m/s
p1=100;//Pressure at the entrance in kPa
p2=700;//Pressure at the exit in kPa
v1=0.95;//Specific volume at entrance in m^3/kg
v2=0.19;//Specific volume at exit in m^3/kg
u=90;//Change in internal energy of the air entering and leaving in kJ/kg
z=0;//Potential energy is neglected
Q=-58;//Heat rejected to the surroundings in kW
m=0.5;//The rate at which air flow in kg/s
g=9.81;//Gravitational constant in m/s^2

//Calculations
P=m*([(c1^2-c2^2)/(2000)]+(p1*v1-p2*v2)-u)+(Q);//The rate of work input to the air in kW
A=(v1*c2)/(v2*c1);//From continuity equation the ratio of areas
D=A^(1/2);//The ratio of inlet pipe diameter to the outlet pipe diameter

//Output
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

```
clc
clear
//Input data
h1=3000;//Enthalpy of the fluid passing at inlet in
    kJ/kg
h2=2757;//Enthalpy of the fluid at the discharge in
    kJ/kg
c1=60;//Velocity of the fluid at inlet in m/s
A1=0.1;//Inlet area of the nozzle in m^2
v1=0.187;//Specific volume at inlet in m^3/kg
v2=0.498;//Specific volume at the outlet in m^3/kg
q=0;//Heat loss during the flow is negligable
z=0;//The nozzle is horizontal so change in PE is
    constant
w=0;//The work done is also negligable

//Calculations
c2=[2*1000*((h1-h2)+(c1^2/2000))]^(1/2);//Velocity
    at the exit in m/s
m=(A1*c1)/v1;//The mass flow rate in kg/s
A2=(m*v2)/c2;//Area at the exit of the nozzle in m^3

//Output
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

```
clc
clear
//Input data
h1=3000;//Specific enthalpy of steam at inlet in kJ/
    kg
h2=2762;//Specific enthalpy of steam at the outlet
```

```
in kJ/kg
v1=0.187;//Specific volume of steam at inlet in m^3/kg
v2=0.498;//Specific volume of steam at the outlet in m^3/kg
A1=0.1;//Area at the inlet in m^2
q=0;//There is no heat loss
z=0;//The nozzle is horizontal ,so no change in PE
c1=60;//Velocity of the steam at the inlet in m/s

//Calculations
c2=[(2*1000)*((h1-h2)+(c1^2/2000))]^(1/2);//Velocity of the steam at the outlet in m/s
m=(A1*c1)/v1;//Mass flow rate of steam in kg/s
m1=m*3600;//Mass flow rate of steam in kg/hr
A2=(m*v2)/c2;//Area at the nozzle exit in m^2

//Output
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

```
clc
clear
//Input data
c1=40;//Velocity of air at the inlet of nozzle in m/s
h=180;//The decrease in enthalpy in the nozzle in kJ/kg
w=0;//Since adiabatic
q=0;//Since adiabatic
z=0;//Since adiabatic
```

```

//Calculations
c2=[(2*1000)*((h)+(c1^2/(2*1000)))]^(1/2);//The exit velocity of air in m/s

//Output
printf('The exit velocity of the air C2 = %3.2f m/s ',c2)
```

Scilab code Exa 2.24 The shaft power

```
clc
clear
//Input data
p1=100;//Pressure at the inlet of the compressor in kPa
p2=500;//Pressure at the outlet of the compressor in kPa
v1=3;//Volume of the air at the inlet of the compressor in m^3/kg
v2=0.8;//Volume of the air at the outlet of the compressor in m^3/kg
c1=25;//The velocity of air at the inlet of the compressor in m/s
c2=130;//The velocity of air at the outlet of the compressor in m/s
z=12;//The height of delivery connection above the inlet in m
g=9.81;//Gravitational constant in m/s^2
n=1.3;//Polytropic index

//Calculations
W=[(n)*(p1*v1-p2*v2)]/(n-1);//Workdone for open system polytropic process in kJ/kg
K=[(c2^2-c1^2)/2000];//Change in kinetic energy of
```

```
the system in kJ/kg
P=g*(z)/1000;//Change in potential energy of the system in kJ/kg
w=W-K-P;//The shaft work of the compressor in kJ/kg

//Output
printf('The Shaft work of the compressor w = %3.3f kJ/kg \n It is the power absorbing system',w)
```

Scilab code Exa 2.25 The power required

```
clc
clear
//Input data
m=10;//The rate of fluid compressed adiabatically in kg/s
p1=500;//Initial pressure of the process in kPa
p2=5000;//Final pressure of the process in kPa
v=0.001;//The specific volume of the fluid in m^3/kg

//Calculations
P=m*v*(p2-p1);//The power required in kW

//Output
printf('The power required P = %3.0f kW ',P)
```

Scilab code Exa 2.26 The exit air temperature

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

```
t1=20;//Initial temperature of the air in degree centigrade
P=-30;//The amount of power consumed in kW
c1=100;//The inlet velocity of air in m/s
c2=150;//The outlet velocity of air in m/s
R=0.287;//The gas constant for air in kJ/kg-K
g=1.4;//It is the adiabatic index
cp=1.005;//Specific heat at constant pressure in kJ/kg-K
q=0;//Heat developed as it is adiabatic condition
z=0;//The change in potential energy is neglected

//Calculations
h=(P/m)+((c2^2-c1^2)/(2*1000));//The change in enthalpy of the system in kJ/kg
t=h/cp;//The change in temperature of the system in degree centigrade
t2=t1-t;//The exit air temperature in degree centigrade

//Output
printf('The exit air temperature is t2 = %3.2f degree centigrade ',t2)
```

Scilab code Exa 2.27 The exit air temperature

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

```
z=0;//Change in potential energy is neglected
c=0;//Change in kinetic energy is neglected
q=0.4;//Heat lost to the cooling water ,bearings and frictional effects is 40% of input
cp=1.005;//Specific heat at constant pressure in kJ/kg-K

//Calculations
Q=q*W;//Net heat losses from the system in kW
H=W-Q;//Change in total enthalpy of the system in kW
t2=(H/(m*cp))+t1;//The exit air temperature in degree centigrade

//Output
printf('The exit air temperature T2 = %3.0f degree centigrade ',t2)
```

Scilab code Exa 2.28 The rate of heat transfer

```
clc
clear
//Input data
m1=100;//Air flow rate in kg/hr
q1=600;//The heat generated by each person in kJ/hr
h1=85;//The enthalpy of air entering the room in kJ/kg
h2=60;//The enthalpy of air leaving the room in kJ/kg
Q1=0.2;//The heat added by each lamp in the room in kW
P1=0.2;//The power consumed by each fan in kW

//Calculations
q=(5*q1)/3600;//The heat generated by 5 persons in the room in kW
```

```
Q=3*Q1;//The heat added by three lamps in the room in kW
P=2*P1;//The power consumed by two fans in the room in kW
m=m1/3600;//Mass flow rate of air in kg/s
H=[q+Q+P]+[m*(h1-h2)];//Heat to be removed by the cooler in kW

//Output
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

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

```

```
//Calculations
Q=m*[((c2^2-c1^2)/(2*1000))+((g*(z2-z1)/(1000)))+(h2-h1)]+W;//The heat loss/gain by the system in kW

//Output
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

```
clc
clear
//Input data
t1=15;//The inlet temperature of the air passing through the heat exchanger in degree centigrade
c1=30;//The inlet velocity of air in m/s
t2=800;//The outlet temperature of the air from heat exchanger in degree centigrade
t2'==800;//The inlet temperature of the air to the turbine in degree centigrade
c2=30;//The inlet velocity of air to the turbine in m/s
t3=650;//The outlet temperature of the air from the turbine in degree centigrade
t3'==650;//the inlet temperature of the air to the nozzle in degree centigrade
c3=60;//The outlet velocity of the air from turbine in m/s
c3'==60;//Velocity at the inlet of the nozzle in m/s
t4=500;//The temperature at the outlet of the nozzle in degree centigrade
m=2;//Air flow rate in kg/s
cp=1.005;//Specific heat at constant pressure in kJ/kgK

```

```
//Calculations
Qh=m*cp*(t2-t1);//Rate of heat transfer to the air in the heat exchanger in kJ/s
P=m*[(cp*(t2'-t3))+((c2^2-c3^2)/2000)];//Power output from the turbine in kW
c4=[(2*1000)*[cp*(t3'-t4)]+c3^2]^(1/2);//Velocity of air at exit from nozzle in m/s

//Output
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

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

//Calculations
```

```
R=G/M;//Characteristic gas constant in kNm/kgK
v1=(R*t1)/p1;//Specific volume at the inlet in m^3/kg
v2=V*v1;//Specific volume at the outlet in m^3/kg
n=log(p2/p1)/log(v1/v2);//Polytropic index
t2=[(t1)*((p2/p1)^((n-1)/n))];//Final temperature of the gas in a turbine in K
w=(n/(n-1))*(R*(t1))*[1-((p2*v2)/(p1*v1))];//Specific work in kJ/kg
K=c2^2/(2*1000);//Change in kinetic energy in kJ/kg
Ws=w-K;//Work done by the shaft in kJ/kg
q=Ws+(cp*(t2-t1))+K;//The heat transfer during the process in kJ/kg
m=P/Ws;//Mass flow rate of gas required in kg/s
A2=(m*v2)/c2;//Exit area of the turbine in m^2

//Output
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

```
clc
clear
//Input data
t1=270;//Temperature inside surface of the furnace
    wall in degree centigrade
t3=20;//Temperature outside surface is dissipating
    heat by convection into air in degree centigrade
L=0.04;//Thickness of the wall in m
K=1.2;//Thermal conductivity of wall in W/m-K
t2=70;//Temperature of outside surface should not
    exceed in degree centigrade
A=1;//Assuming area in m^2

//Calculations
Q1=(K*A*(t1-t2))/(L);//Heat transfer through the
    furnace wall in W
hc=(Q1)/(A*(t2-t3));//Heat transfer coefficient in W
    /m^2K

//Output
printf('The minimum value of heat transfer
```

```
    coefficient at the outer surface hc = %3.1f W/m^2
    K',hc)
```

Scilab code Exa 6.2 Emissive power

```
clc
clear
//Input data
t1=30;//Normal temperature of black body in degree
    centigrade
t2=100;//Heated temperature of black body in degree
    centigrade
s=20.52*10^-8;//Stefan Boltzmann constant in kJ/hrK
    ^4
A=1;//Assume area in m^2

//Calculations
T1=273+t1;//Black body temperatures in kelvin K
T2=273+t2;//Heated temperature of black body in
    kelvin K
E=s*(T2^4-T1^4);//Increase of emissive power in kJ/
    hr

//Output
printf('The change in its emissive power E= %3.4f kJ
    /hr',E)
```

Scilab code Exa 6.3 Temperature and Heat transfer coefficient

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

```
t1=100;//Temperature of water in tank in degree centigrade
t4=20;//Atmospheric temperature of air in degree centigrade
K=50;//Thermal conductivity of mild steel in W/m-K
hi=2850;//Convection heat transfer coefficient on water side in W/m^2-K
ho=10;//Convection heat transfer coefficient on air side in W/m^2-K
Q1=60;//Heat trasfer from the incandicent lamp in W
s=5.67*10^-8;//Stefan boltzmann constant in W/m^2/K^4
T1=2500;//Lamp surface temperature in K
T2=300;//Room temperature in K
A=1;//Assuming area in m^2

//Calculations
T=t1-t4;//Temperature difference in degree centigrade
Q=(T)/((1/hi)+(L/K)+(1/ho));//Rate of heat loss per m^2 area of surface of tank in W
t3=(Q/(ho*A))+(t4);//Temperature of the outside surface in degree centigrade
U=(Q)/(A*T);//Overall Heat transfer coefficient in W/m^2/K
a=(Q1)/(s*(T1^4-T2^4));//surface area of the coil in m^2
a1=a*10^6;//Surface area of the coil in mm^2

//Output
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

```
clc
clear
//Input data
A1=3.5;//Area of the boiler plate in m^2
X2=0.02;//Thickness of the plate in m
K2=50;//Thermal conductivity of plate in W/m-K
X1=0.002;//Thickness of layer inside boiler in m
K1=1;//Thermal conductivity of layer in W/m-K
t1=250;//The hot gas temperature of the plate in
    degree centigrade
t3=200;//Temperature of cold air in degree
    centigrade

//Calculations
T=t1-t3;//Temperature difference in degree
    centigrade
Q=(T*A1)/((X1/K1)+(X2/K2));//Rate of heat loss in W
Q1=Q/1000;//Rate of heat loss in kJ/s
Q2=Q1*3600;//Rate of heat loss in kJ/hr

//Output
printf('(a)Rate of heat loss in kJ/s = %3.2f kJ/s \n
     (b)Rate of heat loss per hour Q = %3.2f kJ/hr ',
    Q1,Q2)
```

Scilab code Exa 6.5 Rate of heat loss and Temperature

```
clc
clear
//Input data
```

```
L1=0.225;//Thickness of the brick in m
K1=4.984;//Thermal conductivity of brick in kJ/hr m C/m
L2=0.125;//Thickness of insulating brick in m
K2=0.623;//Thermal conductivity of insulating brick in kJ/hr m C /m
Ti=1650;//Temperature inside the furnace in degree centigrade
hl=245.28;//Conductance at inside wall in kJ/hr m^2 C
ho=40.88;//Conductance at outside wall in kJ/hr m^2 C
To=27;//Temperature of surrounding atmosphere in degree centigrade

//Calculations
R=((1/hl)+(L1/K1)+(L2/K2)+(1/ho));//Total resistance of the wall in C hr/kJ
q=(Ti-To)/R;//Rate of heat loss per m^2 of the wall in kJ/hr m^2
T1=Ti-(q*(1/hl));//Inner surface temperature in degree centigrade
T3=Ti-(q*((1/hl)+(L1/K1)+(L2/K2)));//Outer surface temperature in degree centigrade

//Output
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

```
clc
```

```
clear
//Input data
x=0.3;//Thickness of the wall in degree centigrade
t1=24;//Inside surface temperature of the wall in degree centigrade
t2=-6;//Outside temperature of wall in degree centigrade
h=2.75;//Height of the wall in m
L=6.1;//Length of the wall in m
K=2.6;//Coefficient of conductivity of brick in kJ/hr m C

//Calculations
A=h*L;//Area of the wall in m^2
T=t2-t1;//Temperature difference in degree centigrade
q=(K*A*(-T))/(x);//Heat transfer by conduction in kJ/hr
R=(t1-t2)/q;//Resistance of the wall in C hr/kJ
C=1/R;//Conductance of the wall in kJ/m C

//Output
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

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

```
   ^2 T^4

//Calculations
Q=s*T^4;//Heat received by unit area on the earths
   surface perpendicular to solar rays in kJ/hr

//Output
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

```
clc
clear
//Input data
D=0.07;//Diameter of the steel tube in m
L=3;//Length of the steel tube
t1=227;//Temperature of the steel tube in m
t2=27;//Temperature of the room in degree centigrade
s=20.52*10^-8;//Stefan Boltzmann constant in kJ/hr m
   ^2 T^4
pi=3.1428;//Constant value of pi

//Calculations
A=2*pi*D*L;//Surface area of the tube in m^2
Q=(A)*(s)*((t1+273)^4-(t2+273)^4);//Loss of heat by
   radiation in kJ/hr
Q1=Q/3600;//Loss of heat by radiation in kW

//Output
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

```
clc
clear
//Input data
T1=7;//Inside temperature of refrigerator in degree centigrade
T0=28;//Temperature in the kitchen in degree centigrade
K1=40;//Thermal conductivity of mild steel in W/mC
x1=0.03;//Thickness of mild sheets in m
K3=40;//Thermal conductivity of the mild steel in W/mC
x3=0.03;//Thickness of another side mild sheet in m
x2=0.05;//Thickness of glass wool insulated in m
hi=10;//Heat transfer coefficient in the inner surface of refrigerator in W/m^2 C
ho=12.5;//Heat transfer coefficient in the outer surface of refrigerator in W/m^2 C
K2=0.04;//Thermal conductivity of glass in W/mC

//Calculations
Q=(T1-T0)/((1/hi)+(x1/K1)+(x2/K2)+(x3/K3)+(1/ho));//Heat transfer per unit area in W/m^2

//Output
printf('The rate of heat removed from the refrigirator Q = %3.3f W/m^2 ',Q)
```

Scilab code Exa 6.11 Heat loss and maximum temperature

```
clc
clear
//Input data
x1=0.2;//Thickness of the fire brick
```

```
x2=0.2;//Thickness of the common brick
Ti=1400;//Temperature of hot gases in the inner surface of the brick in degree centigrade
To=50;//Temperature of gases in the outer surface of the brick in degree centigrade
h1=16.5;//Convection heat transfer coefficient on gas side in W/mC
h2=17.5;//radiation heat transfer coefficient on gas side in W/mC
h3=12.5;//Convection heat transfer coefficient on outer side in W/mC
h4=6.5;//Radiation heat transfer coeeficient on outer side in W/mC
K1=4;//Thermal conductivity of fire brick in W/mC
K2=0.65;//Thermal conductivity of common brick in W/mC

//Calculations
hi=h1+h2;//Total heat transfer coefficient in inner in W/mC
ho=h3+h4;//Total heat transfer coefficient in outer in W/mC
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
Q1=Q/1000;//Heat flow through the furnace composite wall per unit area in kW/m^2
T1=Ti-(Q/hi);//Temperature at the inside of the fire brick in degree centigrade
T2=T1-(Q*(x1/K1));//Maximum temperature to which common brick is subjected in degree centigrade

//Output
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

```
clc
clear
//Input data
K1=0.93;//Thermal conductivity of fire clay in W/mC
K2=0.13;//Thermal conductivity of diatomite brick in W/mC
K3=0.7;//Thermal conductivity of red brick in W/mC
x1=0.12;//Thickness of fire clay in m
x2=0.05;//Thickness of diatomite in m
x3=0.25;//Thickness of brick in m
T=1;//Assume the difference between temperature in degree centigrade

//Calculations
Q=(T)/((x1/K1)+(x2/K2)+(x3/K3));//The heat flow per unit area in W/m^2
X3=K3*((T/Q)-(x1/K1));//Thickness of the red brick layer in m
X=X3*100;//Thickness of the red brick layer in cm

//Output
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

```
clc
clear
```

```
//Input data
R1=0.06;//Thickness of material layer in m
R2=0.12;//Thickness of the two insulating materials in m
R3=0.16;//Thickness of material layers with pipe in m
K1=0.24;//Thermal conductivity of one layer in W/mC
K2=0.4;//Thermal conductivity of another layer in W/mC
L=60;//Length of the pipe in m
hi=60;//Heat transfer coefficient inside in W/m^2C
ho=12;//Heat transfer coefficient outside in W/m^2C
ti=65;//Temperature of hot air flowing in pipe in degree centigrade
to=20;//Atmospheric temperature in degree centigrade
pi=3.1428;//Constant value of pi

//Calculations
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
Q1=Q/1000;//Rate of heat loss in kW

//Output
printf('The rate of heat loss Q = %3.5f kW ',Q1)
```

Scilab code Exa 6.14 Heat loss

```
clc
clear
//Input data
R1=8;//Inner radius of the pipe in cm
R2=8.5;//Outter radius of the pipe in cm
x1=3;//Thickness of first layer in cm
x2=5;//Thickness of second layer in cm
```

```
T1=300;//Inner surface temperature of the steam pipe in degree centigrade
pi=3.1428;//Constant value of pi
T4=50;//Temperature at outer surface of insulation in degree centigrade
L=1;//Length of the pipe in m
K1=50;//Thermal conductivity of pipe in W/mC
K2=0.15;//Thermal conductivity of first layer in W/mC
K3=0.08;//Thermal conductivity of second layer in W/mC
h=2751;//Enthalpy of dry and saturated steam at 300 degree centigrade in kJ/kg
q=40;//Quantity of steam flow in gm/hr
hf=1345;//Enthalpy of fluid at 300 degree centigrade in kJ/kg
hfg=1406;//enthalpy at 300 degree centigrade in kJ/kg

//Calculations
R3=R2+x1;//Radius of pipe with first layer
R4=R3+x2;//Radius of pipe with two layers
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
Q1=Q/1000;//Quantity of heat loss per meter length of pipe in kW
Q2=Q1*3600;//Quantity of heat loss per meter length of pipe in kJ/hr
hg=((h)-(Q2/q));//Enthalpy of steam in kJ/kg
x=(hg-hf)/(hfg);//Dryness fraction of steam

//Output
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

```
clc
clear
//Input data
x=0.3;//Thickness of brick wall in m
ti=24;//Inside surface temperature of wall in degree
     centigrade
to=-6;//Outside surface temperature of wall in
    degree centigrade
h=2.75;//Height of the wall in m
L=6.1;//Length of the wall in m
K=2.6;//Thermal conductivity of brick material in kJ
    /m hr C

//Calculations
T=ti-to;//Temperature difference across the wall in
    degree centigrade
A=h*L;//Area of the wall in m^2
Q=(K*A*T)/(x);//Heat transfer through conduction by
    the wall per hour in kJ/hr
R=T/Q;//Resistance of the wall in hr C/kJ
C=1/R;//Conductance of the wall in kJ/hr C

//Output
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

```
clc
clear
//Input data
x1=0.3;//Thickness of refractory bricks in m
K1=5.66;//Thermal conductivity of refractory bricks in kJ/hr mC
t1=1650;//Inner surface temperature of the wall in degree centigrade
t2=320;//Outside surface temperature of the wall in degree centigrade
x2=0.3;//Thickness of insulating brick in m
K2=1.26;//Thermal conductivity of insulating brick in kJ/hr mC
A=1;//unit surface area in m^2
t3=27;//Outside surface temperature of the brick in degree centigrade

//Calculations
T1=t1-t2;//Temperature difference in degree centigrade
Q1=(K1*A*T1)/(x1);//Heat loss without insulation in kJ/hr/m^2
R1=(K1*A)/(x1);//Heat loss for the change in temperature for refractory brick wall material in kJ/hrC
R2=(K2*A)/(x2);//Heat loss for the change in temperature for insulated brick wall material kJ/hrC
Q2=(t1-t3)/((1/R1)+(1/R2));//Heat loss with insulation in kJ/hr/m^2
Q3=Q1-Q2;//Reduction in heat loss through the wall in kJ/hr/m^2

//Output
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

```
clc
clear
//Input data
L=4.6;//Length of the wall in m
b=2.3;//Breadth of the wall in m
x1=0.025;//Thickness of the wood in m
x2=0.075;//Thickness of the cork slabbing in m
x3=0.115;//Thickness of the brick in m
t1=18;//Exterior temperature of the wall in degree centigrade
t4=-20;//Interior temperature of the wall in degree centigrade
K1=7.5;//Thermal conductivity of the wood in kJ/hr mC
K2=1.9;//Thermal conductivity of the wood in kJ/hr.mC
K3=41;//Thermal conductivity of the brick in kJ/hr mC

//Calculations
A=L*b;//Area of the wall in m^2
R1=(K1*A)/(x1);//Heat loss for the change in temperature for insulated wood material in kJ/hrC
R2=(K2*A)/(x2);//Heat loss for the change in temperature for cork material in kJ/hrC
R3=(K3*A)/(x3);//Heat loss for the change in temperature for brick in kJ/hrC
Q=(t1-t4)/(1/R1+1/R2+1/R3);//Heat loss with insulation in kJ/hr
Q1=Q*24;//Heat loss with insulation in kJ/24hr
t2=t1-(Q/R1);//Interface temperature t2 in degree centigrade
```

```
t3=t2-(Q/R2);//Interface temperature t3 in degree centigrade

//Output
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

```
clc
clear
//Input data
L=0.3;//Thickness of the wall in m
ti=320;//Inner surface temperature in degree centigrade
to=38;//Outer surface temperature in degree centigrade
A=1;//Assume unit area in m^2

//Calculations
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

//Output
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

```
clc
clear
//Input data
d=11.5;//Outer diameter of steam pipe line in cm
t1=5;//Thickness of first layer in cm
K1=0.222;//Thermal conductivity of first layer in kJ
    /hr mC
t2=3;//Thickness of second layer in cm
pi=3.1428;//Constant value of pi
K2=3.14;//Thermal conductivity of second layer in kJ
    /hr mC
T1=235;//Outside surface temperature of steam pipe
    in degree centigrade
T3=38;//Outer surface of lagging in degree
    centigrade
L=1;//Length of the pipe in m

//Calculations
I=log((d+(2*t1))/d);//For inner layer calculation
O=log((d+(2*t1)+(2*t2))/(d+(2*t1)));//For outer
    layer calculations
R1=(2*pi*L*K1)/I;//Heat loss for change in
    temperature for first insulated material in kJ/hC
R2=(2*pi*L*K2)/O;//Heat loss for the change in
    temperature for second insulated material in kJ/
    hC
Q=(T1-T3)/(1/R1+1/R2);//Heat loss per metre length
    of pipe per hr in kJ/hr
T2=T1-(Q/R1);//Temperature between the two layers of
     insulation in degree centigrade

//Output
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

```
clc
clear
//Input data
t1=24;//Temperature at the outside surface in degree
    centigrade
t4=-15;//Temperature at the inner surface in degree
    centigrade
A=1;//Assuming unit area in m^2
K1=23.2;//Thermal conductivity of steel in W/mC
K2=0.014;//Thermal conductivity of glasswood in W/mC
K3=0.052;//Thermal conductivity of plywood in W/mC
x1=0.0015;//Thickness of steel sheet at outer
    surface in m
x2=0.02;//Thickness of glasswood in between in m
x3=0.01;//Thickness of plywood at a inner surface in
    m

//Calculations
R1=(K1*A)/x1;//Heat loss for the change in
    temperature for first insulated material
R2=(K2*A)/x2;//Heat loss for the change in
    temperature for second insulated material
R3=(K3*A)/x3;//Heat loss for the change in
    temperature for third insulated material
Q=(t1-t4)/(1/R1+1/R2+1/R3);//The rate of heat flow
    in W/m^2

//Output
printf('The rate of heat flow Q = %3.2f W/m^2 ',Q)
```