

Scilab Textbook Companion for
Fundamentals Of Engineering Heat And Mass
Transfer
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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

Basic Concepts

Scilab code Exa 1.1 Rate of heat transfer

```
1 //Chapter -1, Example 1.1, Page 9
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L=0.02; //Thicness of stainless steel plate in m
8 T=[550,50]; //Temperatures at both the faces in
   degree C
9 k=19.1; //Thermal Conductivity of stainless steel at
   300 degree C in W/m.K
10
11 //CALC9ULATIONS
12 q=((k*(T(1)-T(2)))/(L*1000)); //Heat transfered per
   uni area in kW/m^2
13
14 //OUTPUT
15 mprintf('The heat transfered through the material
   per unit area is %3.1f kW/m^2',q)
```

```
16
17 //=====END OF PROGRAM
    =====
```

Scilab code Exa 1.2 Rate of heat transfer

```
1 //Chapter -1, Example 1.2, Page 11
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 L=1;//Length of the flat plate in m
8 w=0.5;//Width of the flat plate in m
9 T=30;//Air stream temperature in degree C
10 h=30;//Convective heat transfer coefficient in W/m
    ^2.K
11 Ts=300;//Temperature of the plate in degree C
12
13 //CALCULATIONS
14 A=(L*w);//Area of the plate in m^2
15 Q=(h*A*(Ts-T)/(1000));//Heat transfer in kW
16
17 //OUTPUT
18 mprintf('Heat transfer rate is %3.2f kW',Q)
19
20 //=====END OF PROGRAM
    =====
```

Scilab code Exa 1.3 Rate of radiant heat

```

1 //Chapter -1, Example 1.3, Page 11
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 T=55; //Surface temperature in degree C
8
9 //CALCULATIONS
10 q=(5.6697*10^-8*(273+T)^4)/1000; //The rate at which
    the radiator emits radiant heat per unit area if
    it behaves as a black body in kW/m^2
11
12 //OUTPUT
13 mprintf('The rate at which the radiator emits
    radiant heat per unit area is %3.2f kW/m^2',q)
14
15 //=====END OF PROGRAM
    =====


---



```

Scilab code Exa 1.5 Overall heat transfer coefficient

```

1 //Chapter -1, Example 1.5, Page 20
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 k=0.145; //Thermal conductivity of Firebrick in W/m.K
8 e=0.85; //Emissivity
9 L=0.145; //Thickness of the wall in m

```

```

10 Tg=800; //Gas temperature in degree C
11 Twg=798; //Wall temperature ion gas side in degree C
12 hg=40; //Film conductance on gas side in W/m^2.K
13 hc=10; //Film conductance on coolant side in W/m^2.K
14 F=1; //Radiation Shape factor between wall and gas
15
16 //CALCULATIONS
17 R1=(((e*5.67*10^-8*F*((Tg+273)^4-(Twg+273)^4))/(Tg-
    Twg)))+(1/hg)); //Thermal resistance inverse
18 R2=(L/k); //Thermal resistance
19 R3=(1/hc); //Thermal resistance
20 U=1/((1/R1)+R2+R3); //Overall heat transfer
    coefficient in W/m^2.K
21
22 //OUTPUT
23 mprintf('Overall heat transfer coefficient is %3.3f
    W/m^2.K',U)

```

Scilab code Exa 1.6 Heat loss per unit length

```

1 //Chapter -1, Example 1.6 , Page 21
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 D=0.05; //Outside diameter of the pipe in m
8 e=0.8; //Emmissivity
9 T=30; //Room Temperature in degree C
10 Ts=250; //Surface temperature in degree C
11 h=10; //Convective heat transfer coefficient in W/m
    ^2.K
12

```

```

13 //CALCULATIONS
14 q=((h*3.14*D*(Ts-T))+(e*3.14*D*5.67*10^-8*((Ts+473)
    ^4-(T+273)^4))); //Heat loss per unit length of
    pipe in W/m
15
16 //OUTPUT
17 mprintf('Heat loss per unit length of pipe is %3.1f
    W/m',q)
18
19 //=====END OF PROGRAM
    =====

```

Scilab code Exa 1.7 Surface temperature

```

1 //Chapter -1, Example 1.7, Page 21
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 A=0.1; //Surface area of water heater in m^2
8 Q=1000; //Heat transfer rate in W
9 Twater=40; //Temperature of water in degree C
10 h1=300; //Heat transfer coefficient in W/m^2.K
11 Tair=40; //Temperature of air in degree C
12 h2=9; //Heat transfer coefficient in W/m^2.K
13
14 //CALCULATIONS
15 Tsw=(Q/(h1*A))+Twater; //Temperature when used in
    water in degree C
16 Tsa=(Q/(h2*A))+Tair; //Temperature when used in air
    in degree C
17

```

```
18 //OUTPUT
19 mprintf('Temperature when used in water is %3.1f
    degree C \n Temperature when used in air is %i
    degree C',Tsw,Tsa)
20
21 //=====END OF PROGRAM
    =====
```

Chapter 3

OneDimensional Steady State Heat Conduction

Scilab code Exa 3.1 Rate of heat loss and interior temperature

```
1 //Chapter –3, Example 3.1 , Page 45
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 l=5; //Length of the wall in m
8 h=4; //Height of the wall in m
9 L=0.25; //Thickness of the wall in m
10 T=[110,40]; //Temperature on the inner and outer
    surface in degree C
11 k=0.7; //Thermal conductivity in W/m.K
12 x=0.20; //Distance from the inner wall in m
13
14 //CALCULATIONS
15 A=l*h; //Arear of the wall in m^2
16 Q=(k*A*(T(1)-T(2)))/L; //Heat transfer rate in W
```

```

17 T=((((T(2)-T(1))*x)/L)+T(1); //Temperature at interior
    point of the wall , 20 cm distant from the inner
    wall in degree C
18
19 //OUTPUT
20 mprintf('a)Heat transfer rate is %i W \n b)
    Temperature at interior point of the wall , 20 cm
    distant from the inner wall is %i degree C',Q,T)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.2 Tempertaure and heat flow

```

1 //Chapter -3, Example 3.2, Page 48
2 //
    =====
3 clc
4 clear
5
6 Di=0.05; //Inner diameter of hollow cylinder in m
7 Do=0.1; //Outer diameter of hollow cylinder in m
8 T=[200,100]; //Inner and outer surface temperature in
    degree C
9 k=70; //Thermal conductivity in W/m.K
10
11 //CALCULATIONS
12 ro=(Do/2); //Outer radius of hollow cylinder in m
13 ri=(Di/2); //Inner radius of hollow cylinder in m
14 Q=((2*3.14*k*(T(1)-T(2)))/(log(ro/ri))); //Heat
    transfer rate in W
15 r1=(ro+ri)/2; //Radius at halfway between ro and ri
    in m
16 T1=T(1)-((T(1)-T(2))*(log(r1/ri)/(log(ro/ri)))); //

```

```

    Temperature of the point halfway between the
    inner and outer surface in degree C
17
18 //OUTPUT
19 mprintf('Heat transfer rate is %3.1f W /m\n
    Temperature of the point halfway between the
    inner and outer surface is %3.1f degree C',Q,T1)
20
21 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.3 Heat flow and teperature

```

1 //Chapter -3, Example 3.3, Page 51
2 //
    =====

3 clc
4 clear
5
6 Di=0.1;//Inner diameter of hollow sphere in m
7 Do=0.3;//Outer diameter of hollow sphere in m
8 k=50;//Thermal conductivity in W/m.K
9 T=[300,100];//Inner and outer surface temperature in
    degree C
10
11 //CALCULATIONS
12 ro=(Do/2);//Outer radius of hollow sphere in m
13 ri=(Di/2);//Inner radius of hollow sphere in m
14 Q=((4*3.14*ro*ri*k*(T(1)-T(2)))/(ro-ri))/1000;//Heat
    transfer rate in W
15 r=ri+(0.25*(ro-ri));//The value at one-fourth way of
    te inner and outer surfaces in m
16 T=((ro*(r-ri)*(T(2)-T(1)))/(r*(ro-ri)))+T(1);//
    Temperature at a point a quarter of the way

```

```

    between the inner and outer surfaces in degree C
17
18 //OUTPUT
19 mprintf('Heat flow rate through the sphere is %3.2f
    kW \nTemperature at a point a quarter of the way
    between the inner and outer surfaces is %i degree
    C',Q,T)
20
21 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.4 Heat loss per square meter surface area

```

1 //Chapter -3, Example 3.4, Page 55
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 L=0.4; //Thickness of the furnace in m
8 T=[300,50]; //Surface temperatures in degree C
9 //k=0.005T-5*10^-6T^2
10
11 //CALCULATIONS
12 q=((1/L)*(((0.005/2)*(T(1)^2-T(2)^2))-((5*10^-6*(T
    (1)^3-T(2)^3))/3))); //Heat loss per square meter
    surface area in W/m^2
13
14 //OUTPUT
15 mprintf('Heat loss per square meter surface area is
    %3.0 f W/m^2 ',q)
16
17 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.5 Rate of heat flow

```
1 //Chapter –3, Example 3.5, Page 55
2 //
3 clc
4 clear
5
6 //INPUT DATA
7 L=0.2; //Thickness of the wall in m
8 T=[1000,200]; //Surface temperatures in degree C
9 ko=0.813; //Value of thermal conductivity at T=0 in W
    /m.K
10 b=0.0007158; //Temperature coefficient of thermal
    conductivity in 1/K
11
12 //CALCULATIONS
13 km=ko*(1+((b*(T(1)+T(2)))/2)); //Constant thermal
    conductivity in W/m.K
14 q=((km*(T(1)-T(2)))/L); //Rate of heat flow in W/m^2
15
16 //OUTPUT
17 mprintf('Rate of heat flow is %3.0f W/m^2',q)
18
19 //=====END OF PROGRAM
    =====
```

Scilab code Exa 3.6 Heat loss per unit length

```
1 //Chapter –3, Example 3.6, Page 58
```

```

2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 r=[0.01,0.02]; //Inner and outer radius of a copper
   cylinder in m
8 T=[310,290]; //Inner and Outer surface temperature in
   degree C
9 ko=371.9; //Value of thermal conductivity at T=0 in W
   /m.K
10 b=(9.25*10^-5); //Temperature coefficient of thermal
   conductivity in 1/K
11
12 //CALCULATIONS
13 Tm=((T(1)-150)+(T(2)-150))/2; //Mean temperature in
   degree C
14 km=ko*(1-(b*Tm)); //Constant thermal conductivity in
   W/m.K
15 q=((2*3.14*km*(T(1)-T(2)))/log(r(2)/r(1)))/1000; //
   Heat loss per unit length in kW/m
16
17 //OUTPUT
18 mprintf('Heat loss per unit length is %3.2f kW/m',q)

```

Scilab code Exa 3.8 Thickness of insulation

```

1 //Chapter -3, Example 3.8, Page 63
2 //


---


3 clc
4 clear

```

```

5
6 //INPUT DATA
7 L1=0.5; //Thickness of the wall in m
8 k1=1.4; //Thermal conductivity in W/m.K
9 k2=0.35; //Thermal conductivity of insulating
    material in W/m.K
10 q=1450; //Heat loss per square metre in W
11 T=[1200,15]; //Inner and outer surface temperatures
    in degree C
12
13 //CALCULATIONS
14 L2=((T(1)-T(2))/q)-(L1/k1))*k2;; //Thickness of the
    insulation required in m
15
16 //OUTPUT
17 fprintf('Thickness of the insulation required is %3
    .3 f m',L2)
18
19 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.9 Rate of heat leaking

```

1 //Chapter -3, Example 3.9, Page 64
2 //
    =====

3 clc
4 clear
5
6 L1=0.006; //Thickness of each glass sheet in m
7 L2=0.002; //Thickness of air gap in m
8 Tb=-20; //Temperature of the air inside the room in
    degree C
9 Ta=30; //Ambient temperature of air in degree C

```

```

10 ha=23.26; //Heat transfer coefficient between glass
    and air in W/m^2.K
11 kglass=0.75; //Thermal conductivity of glass in W/m.K
12 kair=0.02; //Thermal conductivity of air in W/m.K
13
14 //CALCULATIONS
15 q=((Ta-Tb)/((1/ha)+(L1/kglass)+(L2/kair)+(L1/kglass)
    +(1/ha))); //Rate of heat leaking into the room
    per unit area of the door in W/m^2
16
17 //OUTPUT
18 fprintf('Rate of heat leaking into the room per unit
    area of the door is %3.1f W/m^2 ',q)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.10 Heat transfer through the composite wall

```

1 //Chapter –3, Example 3.10, Page 65
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 LA=0.05; //Length of section A in m
8 LB=0.1; //Length of section A in m
9 LC=0.1; //Length of section A in m
10 LD=0.05; //Length of section A in m
11 LE=0.05; //Length of section A in m
12 kA=50; //Thermal conductivity of section A in W/m.K
13 kB=10; //Thermal conductivity of section B in W/m.K
14 kC=6.67; //Thermal conductivity of section C in W/m.K

```



```

15 kD=20; //Thermal conductivity of section D in W/m.K
16 kE=30; //Thermal conductivity of section E in W/m.K
17 Aa=1; //Area of section A in m^2
18 Ab=0.5; //Area of section B in m^2
19 Ac=0.5; //Area of section C in m^2
20 Ad=1; //Area of section D in m^2
21 Ae=1; //Area of section E in m^2
22 T=[800,100]; //Temperature at inlet and outlet
    temperatures in degree C
23
24 //CALCULATIONS
25 Ra=(LA/(kA*Aa)); //Thermal Resistance of section A in
    K/W
26 Rb=(LB/(kB*Ab)); //Thermal Resistance of section B in
    K/W
27 Rc=(LC/(kC*Ac)); //Thermal Resistance of section C in
    K/W
28 Rd=(LD/(kD*Ad)); //Thermal Resistance of section D in
    K/W
29 Re=(LE/(kE*Ae)); //Thermal Resistance of section E in
    K/W
30 Rf=((Rb*Rc)/(Rb+Rc)); //Equivalent resistance of
    section B and section C in K/W
31 R=Ra+Rf+Rd+Re; //Equivalent resistance of all
    sections in K/W
32 Q=((T(1)-T(2))/R)/1000; //Heat transfer through the
    composite wall in kW
33
34 //OUTPUT
35 mprintf('Heat transfer through the composite wall is
    %3.1f kW',Q)
36
37 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.11 Surface temperature and convective conductance

```
1 //Chapter-3, Example 3.11, Page 66
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 T1=2000;//Temperature of hot gas in degree C
8 Ta=45;//Room air temperature in degree C
9 Qr1=23.260;//Heat flow by radiation from gases to
   inside surface of the wall in kW/m^2
10 h=11.63;//Convective heat transfer coefficient in W/
   m^2.
11 C=58;//Thermal conductance of the wall in W/m^2.K
12 Q=9.3;//Heat flow by radiation from external surface
   to the surrounding in kW.m^2
13 T2=1000;//Interior wall temperature in degree C
14
15 //CALCULATIONS
16 qr1=Qr1;//Haet by radiation in kW/m^2
17 qc1=h*((T1-T2)/1000);//Heat by conduction in kW/m^2
18 q=qc1+qr1;//Total heat entering the wall in kW/m^2
19 R=(1/C);//Thermal resistance in m^2.K/W
20 T3=T2-(q*R*1000);//External wall temperature in
   degree C
21 Q1=q-Q;//Heat loss due to convection kW/m^2
22 h4=(Q1*1000)/(T3-Ta);//Convective conductance in W/m
   ^2.K
23
24 mprintf('The surface temperature is %i degree C \
   nThe convective conductance is %3.1f W/m^2.K',T3,
   h4)
25
26 //=====END OF PROGRAM


---


```

Scilab code Exa 3.12 Heat loss and thickness of insulation

```
1 //Chapter –3, Example 3.12, Page 67
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L1=0.125; // Thickness of fireclay layer in m
8 L2=0.5; // Thickness of red brick layer in m
9 T=[1100,50]; // Temperatures at inside and outside the
    furnaces in degree C
10 k1=0.533; // Thermal conductivity of fireclay in W/m.K
11 k2=0.7; // Thermal conductivity of red brick in W/m.K
12
13 //CALCULATIONS
14 R1=(L1/k1); // Resistance of fireclay per unit area in
    K/W
15 R2=(L2/k2); // Resistance of red brick per unit area
    in K/W
16 R=R1+R2; // Total resistance in K/W
17 q=(T(1)-T(2))/R; // Heat transfer in W/m^2
18 T2= T(1)-(q*R1); // Temperature in degree C
19 T3=T(2)+(q*R2*0.5); // Temperature at the interface
    between the two layers in degree C
20 km=0.113+(0.00023*((T2+T3)/2)); // Mean thermal
    conductivity in W/m.K
21 x=((T2-T3)/q)*km; // Thickness of diatomite in m
22
23 //OUTPUT
24 mprintf('Amount of heat loss is %3.1f W/m^2 \n
    Thickness of diatomite is %3.4f m',q,x)
```

```

25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.13 Heat loss from the pipe

```

1 //Chapter –3, Example 3.13, Page 70
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Di=0.1; //I.D of the pipe in m
8 L=0.01; //Thickness of the wall in m
9 L1=0.03; //Thickness of insulation in m
10 Ta=85; //Temperature of hot liquid in degree C
11 Tb=25; //Temperature of surroundings in degree C
12 k1=58; //Thermal conductivity of steel in W/m.K
13 k2=0.2; //Thermal conductivity of insulating material
    in W/m.K
14 ha=720; //Inside heat transfer coefficient in W/m^2.K
15 hb=9; //Outside heat transfer coefficient in W/m^2.K
16 D2=0.12; //Inner diameter in m
17 r3=0.09; //Radius in m
18
19 //CALCULATIONS
20 q=((2*3.14*(Ta-Tb))/((1/(ha*(Di/2)))+(1/(hb*r3))+
    log(D2/Di)/k1)+(log(r3/(D2/2))/k2))); //Heat loss
    fro an insulated pipe in W/m
21
22 //OUTPUT
23 mprintf('Heat loss fro an insulated pipe is %3.2f W/
    m',q)

```

```
24
25 //=====END OF PROGRAM
    =====
```

Scilab code Exa 3.14 Heat loss per meter length of pipe

```
1 //Chapter –3, Example 3.14, Page 71
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Di=0.1; //I.D of the pipe in m
8 Do=0.11; //O.D of the pipe in m
9 L=0.005; //Thickness of the wall in m
10 k1=50; //Thermal conductivity of steel pipe line in W
    /m.K
11 k2=0.06; //Thermal conductivity of first insulating
    material in W/m.K
12 k3=0.12; //Thermal conductivity of second insulating
    material in W/m.K
13 T=[250,50]; //Temperature at inside tube surface and
    outside surface of insulation in degree C
14 r3=0.105; //Radius of r3 in m as shown in fig.3.14 on
    page no.71
15 r4=0.155; //Radius of r4 in m as shown in fig.3.14 on
    page no.71
16
17 //CALCULATIONS
18 r1=(Di/2); //Radius of the pipe in m
19 r2=(Do/2); //Radius of the pipe in m
20 q=((2*3.14*(T(1)-T(2)))/(((log(r2/r1))/k1)+((log(r3/
    r2))/k2)+((log(r4/r3))/k3))); //Loss of heat per
```

```

    metre length of pipe in W/m
21 T3=((q*log(r4/r3))/(2*3.14*k3))+T(2); //Interface
    temperature in degree C
22
23 //OUTPUT
24 mprintf('Loss of heat per metre length of pipe is %3
    .1f W/m \n Interface temperature is %3.1f degree
    C',q,T3)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.15 Change in heat loss

```

1 //Chapter –3, Example 3.15, Page 72
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Di=0.1; //I.D of the pipe in m
8 Do=0.11; //O.D of the pipe in m
9 L=0.005; //Thickness of the wall in m
10 k1=50; //Thermal conductivity of steel pipe line in W
    /m.K
11 k3=0.06; //Thermal conductivity of first insulating
    material in W/m.K
12 k2=0.12; //Thermal conductivity of second insulating
    material in W/m.K
13 T=[250,50]; //Temperature at inside tube surface and
    outside surface of insulation in degree C
14 r3=0.105; //Radius of r3 in m as shown in fig.3.14 on
    page no.71

```

```

15 r4=0.155; //Radius of r4 in m as shown in fig.3.14 on
    page no.71
16
17 //CALCULATIONS
18 r1=(Di/2); //Radius of the pipe in m
19 r2=(Do/2); //Radius of the pipe in m
20 q=((2*3.14*(T(1)-T(2)))/(((log(r2/r1))/k1)+((log(r3/
    r2))/k2)+((log(r4/r3))/k3))); //Loss of heat per
    metre length of pipe in W/m
21
22 //OUTPUT
23 fprintf('Loss of heat per metre length of pipe is %3
    .2 f W/m', q)
24 //Comparing the result with the previous example Ex
    .3.14, it is seen that the loss of heat is
    increased by about 18.11%. Since the purpose of
    insulation is to reduce the loss of heat, it is
    always better to provide the insulating material
    with low thermal conductivity on the surface of
    the tube first
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.16 Mass of steam condensed

```

1 //Chapter -3, Example 3.16, Page 73
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D1=0.1; //O.D of the pipe in m

```

```

8 P=1373; // Pressure of saturated steam in kPa
9 D2=0.2; // Diameter of magnesia in m
10 k1=0.07; // Thermal conductivity of magnesia in W/m.K
11 k2=0.08; // Thermal conductivity of asbestos in W/m.K
12 D3=0.25; // Diameter of asbestos in m
13 T3=20; // Temperature under the canvas in degree C
14 t=12; // Time for condensation in hours
15 l=150; // Length of pipe in m
16 T1=194.14; // Saturation temperature of steam in
    degree C from Table A.6 (Appendix A) at 1373 kPa
    on page no. 643
17 hfg=1963.15; // Latent heat of steam in kJ/kg from
    Table A.6 (Appendix A) at 1373 kPa on page no.
    643
18
19 //CALCULATIONS
20 r1=(D1/2); // Radius of the pipe in m
21 r2=(D2/2); // Radius of magnesia in m
22 r3=(D3/2); // Radius of asbestos in m
23 Q=((2*3.14*l*(T1-T3))/((log(r2/r1)/k1)+(log(r3/r2)/
    k2)))*(3600/1000)); // Heat transfer rate in kJ/h
24 m=(Q/hfg); // Mass of steam condensed per hour
25 m1=(m*t); // Mass of steam condensed in 12 hours
26
27 //OUTPUT
28 fprintf('Mass of steam condensed in 12 hours is %3.2
    f kg',m1)
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.17 Rate of heat flow

```

1 //Chapter –3, Example 3.17, Page 74
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  D1=0.1; //I.D of the first pipe in m
8  D2=0.3; //O.D of the first pipe in m
9  k1=70; //Thermal conductivity of first material in W/
      m.K
10 D3=0.4; //O.D of the second pipe in m
11 k2=15; //Thermal conductivity of second material in W
      /m.K
12 T=[300,30]; //Inside and outside temperatures in
      degree C
13
14 //CALCULATIONS
15 r1=(D1/2); //Inner Radius of first pipe in m
16 r2=(D2/2); //Outer Radius of first pipe in m
17 r3=(D3/2); //Radius of second pipe in m
18 Q=((4*3.14*(T(1)-T(2)))/(((r2-r1)/(k1*r1*r2))+((r3-
      r2)/(k2*r2*r3))))/1000; //Rate of heat flow
      through the sphere in kW
19
20 //OUTPUT
21 mprintf('Rate of heat flow through the sphere is %3
      .2 f kW',Q)
22
23 //=====END OF PROGRAM
      =====

```

Scilab code Exa 3.18 Heat loss and surface temperature

```

1 //Chapter -3, Example 3.18, Page 77
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  Di=0.1; //I.D of a steam pipe in m
8  Do=0.25; //I.D of a steam pipe in m
9  k=1; //Thermal conductivity of insulating material in
      W/m.K
10 T=[200,20]; //Steam temperature and ambient
      temperatures in degree C
11 h=8; //Convective heat transfer coefficient between
      the insulation surface and air in W/m^2.K
12
13 //CALCULATIONS
14 ri=(Di/2); //Inner Radius of steam pipe in m
15 ro=(Do/2); //Outer Radius of steam pipe in m
16 rc=(k/h)*100; //Critical radius of insulation in cm
17 q=((T(1)-T(2))/((log(ro/ri)/(2*3.14*k))+(1/(2*3.14*
      ro*h))))); //Heat loss per metre of pipe at
      critical radius in W/m
18 Ro=(q/(2*3.14*ro*h))+T(2); //Outer surface
      temperature in degree C
19
20 //OUTPUT
21 mprintf('Heat loss per metre of pipe at critical
      radius is %i W/m \n Outer surface temperature is
      %3.2f degree C',q,Ro)
22
23 //=====END OF PROGRAM
      =====

```

Scilab code Exa 3.19 Effect of insulation on the current carrying conductor

```

1 //Chapter -3, Example 3.19, Page 78
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 Di=0.001; //Diameter of copper wire in m
8 t=0.001; //Thickness of insulation in m;
9 To=20; //Temperature of surroundings in degree C
10 Ti=80; //Maximum temperature of the plastic in degree
    C
11 kcopper=400; //Thermal conductivity of copper in W/m.
    K
12 kplastic=0.5; //Thermal conductivity of plastic in W/
    m.K
13 h=8; //Heat transfer coefficient in W/m2.K
14 p=(3*10-8); //Specific electric resistance of copper
    in Ohm.m
15
16 //CALCULATIONS
17 r=(Di/2); //Radius of copper tube in m
18 ro=(r+t); //Radius in m
19 R=(p/(3.14*r*r*0.01)); //Electrical resistance per
    meter length in ohm/m
20 Rth=(1/(2*3.14*ro*h))+log(ro/r)/(2*3.14*kplastic)
    ); //Thermal resistance of convection film
    insulation per metre length
21 Q=((Ti-To)/Rth); //Heat transfer in W
22 I=sqrt(Q/R); //Maximum safe current limit in A
23 rc=(kplastic*100)/h); //Critical radius in cm
24
25 //OUTPUT
26 mprintf('The maximum safe current limit is %3.3f A \
    n As the critical radius of insulation is much
    greater than that provided in the problem, the
    current carrying capacity of the conductor can be

```

```

    raised considerably in increasing the radius of
    plastic covering upto %3.1f cm.\n This may
    however lead to the problem of having too high a
    temperature at the cable centre if the
    temperature inside the plastic coating has to be
    kept within the given limits ',I,rc)
27
28 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.20 Surface temperature and maximum temperature in the wall

```

1 //Chapter –3, Example 3.20 , Page 83
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 L=0.1; //Thickness of the wall in m
8 Q=(4*10^4); //Heat transfer rate in W/m^3
9 h=50; //Convective heat transfer coefficient in W/m
    ^2.K
10 T=20; //Ambient air temperature in degree C
11 k=15; //Thermal conductivity of the material in W/m.K
12
13 //CALCULATIONS
14 Tw=(T+((Q*L)/(2*h))); //Surface temperature in degree
    C
15 Tmax=(Tw+((Q*L*L)/(8*k))); //Maximum temperature in
    the wall in degree C
16
17 //OUTPUT

```

```

18 mprintf('Surface temperature is %i degree C \n
    Maximum temperature in the wall is %3.3f degree C
    ',Tw,Tmax)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.21 Surface temperature

```

1 //Chapter –3, Example 3.21, Page 85
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Do=0.006;//Outer diameter of hallow cylinder in m
8 Di=0.004;//Inner diameter of hallow cylinder in m
9 I=1000;//Current in A
10 T=30;//Temperature of water in degree C
11 h=35000;//Heat transfer coefficient in W/m2.K
12 k=18;//Thermal conductivity of the material in W/m.K
13 R=0.1;//Electrical reisivivity of the material in
    ohm.mm2/m
14
15 //CALCULATIONS
16 ro=(Do/2);//Outer radius of hallow cylinder in m
17 ri=(Di/2);//Inner radius of hallow cylinder in m
18 V=((3.14*(ro2-ri2)));//Vol. of wire in m2
19 Rth=(R/(3.14*(ro2-ri2)*106));//Resistivity in ohm
    /mm2
20 q=((I*I*Rth)/V);//Heat transfer rate in W/m3
21 To=T+(((q*ri*ri)/(4*k))*(((2*k)/(h*ri))-1)*((ro/ri)
    ^2-1)+(2*(ro/ri)2*log(ro/ri)));//Temperature at

```

```

    the outer surface in degree C
22
23 //OUTPUT
24 mprintf('Temperature at the outer surface is %3.2f
    degree C',To)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.22 Heat transfer coefficient and maximum temperature

```

1 //Chapter –3, Example 3.22, Page 88
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.025;//Diameter of annealed copper wire in m
8 I=200;//Current in A
9 R=(0.4*10^-4);//Resistance in ohm/cm
10 T=[200,10];//Surface temperature and ambient
    temperature in degree C
11 k=160;//Thermal conductivity in W/m.K
12
13 //CALCULATIONS
14 r=(D/2);//Radius of annealed copper wire in m
15 Q=(I*I*R*100);//Heat transfer rate in W/m
16 V=(3.14*r*r);//Vol. of wire in m^2
17 q=(Q/V);//Heat loss in conductor in W/m^2
18 Tc=T(1)+((q*r*r)/(4*k));//Maximum temperature in the
    wire in degree C
19 h=((r*q)/(2*(T(1)-T(2))));//Heat transfer
    coefficient in W/m^2.K

```

```

20
21 //OUTPUT
22 fprintf('Maximum temperature in the wire is %3.2f
    degree C \n Heat transfer coefficient is %3.2f W/
    m^2.K',Tc,h)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.23 Diameter of wire and rate of current flow

```

1 //Chapter –3, Example 3.23, Page 89
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 p=100;//Resistivity of nichrome in ohm-cm
8 Q=10000;//Heat input of a heater in W
9 T=1220;//Surface temperature of nichrome in degree C
10 Ta=20;//Temperature of surrounding air in degree C
11 h=1150;//Outside surface coefficient in W/m^2.K
12 k=17;//Thermal conductivity of nichrome in W/m.K
13 L=1;//Length of heater in m
14
15 //CALCULATIONS
16 d=(Q/((T-Ta)*3.14*h))*1000;//Diameter of nichrome
    wire in mm
17 A=(3.14*d*d)/4;//Area of the wire in m^2
18 R=((p*10^-8*L)/A);//Resistance of the wire in ohm
19 I=sqrt(Q/R)/1000;//Rate of current flow in A
20
21 //OUTPUT

```

```

22 mprintf('Diameter of nichrome wire is %3.4f mm \n
    Rate of current flow is %i A',d,I)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.24 Temperature drop

```

1 //Chapter –3, Example 3.24, Page 93
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Do=0.025;//O.D of the rod in m
8 k=20;//Thermal conductivity in W/m.K
9 Q=(2.5*10^6);//Rate of heat removal in W/m^2
10
11 //CALCULATIONS
12 ro=(Do/2);//Outer radius of the rod in m
13 q=((4*Q)/(ro));//Heat transfer rate in W/m^3
14 T=((-3*q*ro^2)/(16*k));//Temperature drop from the
    centre line to the surface in degree C
15
16 //OUTPUT
17 mprintf('Temperature drop from the centre line to
    the surface is %3.3f degree C',T)
18
19 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.25 Temperature at the centre of orange

```
1 //Chapter -3, Example 3.25, Page 95
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 Q=300; //Heat produced by the oranges in W/m^2
8 s=0.08; //Size of the orange in m
9 k=0.15; //Thermal conductivity of the sphere in W/m.K
10
11 //CALCULATIONS
12 q=(3*Q)/(s/2); //Heat flux in W/m^2
13 Tc=10+((q*(s/2)^2)/(6*k)); //Temperature at the
    centre of the sphere in degree C
14
15 //OUTPUT
16 mprintf('Temperature at the centre of the orange is
    %i degree C',Tc)
17
18 //=====END OF PROGRAM


---


```

Scilab code Exa 3.26 Total heat dissipated

```
1 //Chapter -3, Example 3.26, Page 102
2 //


---


3 clc
4 clear
5
```

```

6 //INPUT DATA
7 To=140;//Temperature at the junction in degree C
8 Ti=15;//Temperature of air in the room in degree C
9 D=0.003;//Diameter of the rod in m
10 h=300;//Heat transfer coefficient in W/m^2.K
11 k=150;//Thermal conductivity in W/m.K
12
13 //CALCULATIONS
14 P=(3.14*D);//Perimeter of the rod in m
15 A=(3.14*D^2)/4;//Area of the rod in m^2
16 Q=sqrt(h*P*k*A)*(To-Ti);//Total heat dissipated by
    the rod in W
17
18 //OUTPUT
19 mprintf('Total heat dissipated by the rod is %3.3f W
    ',Q)
20
21 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.27 Thermal conductivity

```

1 //Chapter -3, Example 3.27, Page 103
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.025//Diameter of the rod in m
8 Ti=22;//Temperature of air in the room in degree C
9 x=0.1;//Distance between the points in m
10 T=[110,85];//Temperature sat two points in degree C
11 h=28.4;//Heat transfer coefficient in W/m^2.K

```

```

12
13 //CALCULATIONS
14 m=-log((T(2)-Ti)/(T(1)-Ti))/x;// Calculation of m for
    obtaining k
15 P=(3.14*D);//Perimeter of the rod in m
16 A=(3.14*D^2)/4;//Area of the rod in m^2
17 k=((h*P)/((m)^2*A));//Thermal conductivity of the
    rod material in W/m.K
18
19 //OUTPUT
20 mprintf('Thermal conductivity of the rod material is
    %3.1 f W/m.K',k)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.28 Temperature distribution and rate of heat flow

```

1 //Chapter-3, Example 3.28, Page 103
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 L=0.06;//Length of the turbine blade in m
8 A=(4.65*10^-4);//Cross sectional area in m^2
9 P=0.12;//Perimeter in m
10 k=23.3;//Thermal conductivity of stainless steel in
    W/m.K
11 To=500;//Temperature at the root in degree C
12 Ti=870;//Temperature of the hot gas in degree C
13 h=442;//Heat transfer coefficient in W/m^2.K
14

```

```

15 //CALCULATIONS
16 m=sqrt((h*P)/(k*A)); // Calculation of m for
    calculating heat transfer rate
17 X=(To-Ti)/cosh(m*L); //X for calculating tempetarure
    distribution
18 Q=sqrt(h*P*k*A)*(To-Ti)*tanh(m*L); //Heat transfer
    rate in W
19
20 //OUTPUT
21 mprintf('Temperature distribution is given by : T-Ti
    = %i cosh [%3.2 f(%3.2 f-x)] \n
    -----\n
    cosh [%3.2 f(%3.2 f)] \n Heat transfer rate is %3.1 f
    W' ,(To-Ti) ,m,L,m,L,Q)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.29 Rate of heat transfer and temperature

```

1 //Chapter -3, Example 3.29 , Page 104
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 W=1; //Length of the cylinder in m
8 D=0.05; //Diameter of the cylinder in m
9 Ta=45; //Ambient temperature in degree C
10 n=10; //Number of fins
11 k=120; //Thermal conductivity of the fin material in

```

```

    W/m.K
12 t=0.00076; //Thickness of fin in m
13 L=0.0127; //Height of fin in m
14 h=17; //Heat transfer coefficient in W/m^2.K
15 Ts=150; //Surface temperature of cylinder in m
16
17 //CALCULATIONS
18 P=(2*W); //Perimeter of cylinder in m
19 A=(W*t); //Surface area of cylinder in m^2
20 m=sqrt((h*P)/(k*A)); //Calculation of m for
    determining heat transfer rate
21 Qfin=(sqrt(h*P*k*A)*(Ts-Ta)*((tanh(m*L)+(h/(m*k)))/
    (1+((h/(m*k))*tanh(m*L))))); //Heat transfer
    through the fin in kW
22 Qb=h*((3.14*D)-(n*t))*W*(Ts-Ta); //Heat from unfinned
    (base) surface in W
23 Q=((Qfin*10)+Qb); //Total heat transfer in W
24 Ti=((Ts-Ta)/(cosh(m*L)+((h*sinh(m*L))/(m*k)))); //Ti
    to calculate temperature at the end of the fin in
    degree C
25 T=(Ti+Ta); //Temperature at the end of the fin in
    degree C
26
27 //OUTPUT
28 mprintf('Rate of heat transfer is %3.2f W\
    nTemperature at the end of the fin is %3.2f
    degree C',Q,T )
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.31 Rate of heat flow

```

1 //Chapter –3, Example 3.31, Page 109
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  t=0.025; //Thickness of fin in m
8  L=0.1; //Length of fin in m
9  k=17.7; //Thermal conductivity of the fin material in
      W/m.K
10 p=7850; //Density in kg/m3
11 Tw=600; //Temperature of the wall in degree C
12 Ta=40; //Temperature of the air in degree C
13 h=20; //Heat transfer coefficient in W/m2.K
14 I0(1.9)=2.1782; //I0 value taken from table 3.2 on
      page no.108
15 I1(1.9)=1.48871; //I1 value taken from table 3.2 on
      page no. 108
16
17 //CALCULATIONS
18 B=sqrt((2*L*h)/(k*t)); //Calculation of B for
      determining temperature distribution
19 X=((Tw-Ta)/I0(2*B*sqrt(0.1))); //Calculation of X for
      determining temperature distribution
20 Y=(2*B); //Calculation of Y for determining
      temperature distribution
21 Q=(sqrt(2*h*k*t)*(Tw-Ta)*((I1(2*B*sqrt(0.1)))/(I0(2*
      B*sqrt(0.1)))));
22 m=((p*t*L)/2); //Mass of the fin per meter of width
      in kg/m
23 q=(Q/m); //Rate of heat flow per unit mass in W/kg
24
25 //OUTPUT
26 mprintf('Temperature distribution is T=%i+%3.1f(%3.4
      f x)\nRate of heat flow per unit mass of the
      fin is %3.2f W/kg',Ta,X,Y,q)
27
28 //=====END OF PROGRAM

```

Scilab code Exa 3.32 Efficiency of the plate

```
1 //Chapter –3, Example 3.32, Page 116
2 //
3 clc
4 clear
5
6 //INPUT DATA
7 t=0.002; //Thickness of fin in m
8 L=0.015; //Length of fin in m
9 k1=210; //Thermal conductivity of aluminium in W/m.K
10 h1=285; //Heat transfer coefficient of aluminium in W
    /m2.K
11 k2=40; //Thermal conductivity of steel in W/m.K
12 h2=510; //Heat transfer coefficient of steel in W/m
    ^2.K
13
14 //CALCULATIONS
15 Lc=(L+(t/2)); //Corrected length of fin in m
16 mLc1=Lc*sqrt((2*h1)/(k1*t)); //Calculation of mLc for
    efficiency
17 n1=tanh(mLc1)/mLc1; //Efficiency of fin when
    aluminium is used
18 mLc2=Lc*sqrt((2*h2)/(k2*t)); //Calculation of mLc for
    efficiency
19 n2=tanh(mLc2)/mLc2; //Efficiency of fin when steel is
    used
20
21 //OUTPUT
22 mprintf('Efficiency of fin when aluminium is used is
    %3.4f\nEfficiency of fin when steel is used is
```

```

23         %3.3 f',n1,n2)
24 //=====END OF PROGRAM
=====

```

Scilab code Exa 3.33 Heat transfer coefficient

```

1 //Chapter –3, Example 3.33, Page 117
2 //
=====

3 clc
4 clear
5
6 //INPUT DATA
7 k=200; //Thermal conductivity of aluminium in W/m.K
8 t=0.001; //Thickness of fin in m
9 L=0.015; //Width of fin in m
10 D=0.025; //Diameter of the tube in m
11 Tb=170; //Fin base temperature in degree C
12 Ta=25; //Ambient fluid temperature in degree C
13 h=130; //Heat transfer coefficient in W/m^2.K
14
15 //CALCULATIONS
16 Lc=(L+(t/2)); //Corrected length of fin in m
17 r1=(D/2); //Radius of tube in m
18 r2c=(r1+Lc); //Corrected radius in m
19 Am=t*(r2c-r1); //Corrected area in m^2
20 x=Lc^(3/2)*sqrt(h/(k*Am)); //x for calculating
    efficiency
21 n=0.82; //From fig. 3.18 on page no. 112 efficiency
    is 0.82
22 qmax=(2*3.14*(r2c^2-r1^2)*h*(Tb-Ta)); //Maximum heat
    transfer in W
23 qactual=(n*qmax); //Actual heat transfer in W

```



```

24
25 //OUTPUT
26 mprintf('Heat loss per fin is %3.2f W',qactual)
27
28 //=====END OF PROGRAM
=====

```

Scilab code Exa 3.34 Insulation of fin

```

1 //Chapter –3, Example 3.34, Page 117
2 //
=====

3 clc
4 clear
5
6 //INPUT DATA
7 k=16; //Thermal conductivity of fin in W/m.K
8 L=0.1; //Length of fin in m
9 D=0.01; //Diameter of fin in m
10 h=5000; //Heat transfer coefficient in W/m^2.K
11
12 //CALCULATIONS
13 P=(3.14*D); //Perimeter of fin in m
14 A=(3.14*D^2)/4; //Area of fin in m^2
15 m=sqrt((h*P)/(k*A)); //Calculation of m for
    determining heat transfer rate
16 n=tanh(m*L)/sqrt((h*A)/(k*P)); //Calculation of n for
    checking whether installation of fin is
    desirable or not
17 x=(n-1)*100; //Conversion into percentage
18
19 //OUTPUT
20 mprintf('This large fin only produces an increase of
    %i percent in heat dissipation , so naturally

```

```

    this configuration is undesirable',x)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 3.35 Measurement error in temperature

```

1 //Chapter –3, Example 3.35, Page 119
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 k=55.8; //Thermal conductivity of steel in W/m.K
8 t=0.0015; //Thickness of steel tube in m
9 L=0.12; //Length of steel tube in m
10 h=23.3; //Heat transfer coefficient in W/m^2.K
11 T1=84; //Temperature recorded by the thermometer in
    degree C
12 Tb=40; //Temperature at the base of the well in
    degree C
13
14 //CALCULATIONS
15 m=sqrt(h/(k*t)); //Calculation of m for determining
    the temperature distribution
16 x=1/cosh(m*L); //Calculation of x for determining the
    temperature distribution
17 Ti=((T1-(x*Tb))/(1-x)); //Temperature distribution in
    degree C
18 T=(Ti-T1); //Measurement error in degree C
19
20 //OUTPUT
21 fprintf('Measurement error is %3.0f degree C',T)

```

22

23 //=====END OF PROGRAM
=====

Chapter 5

Transient Heat Conduction

Scilab code Exa 5.1 Heat transfer and temperature

```
1 //Chapter -5, Example 5.1, Page 159
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 t=0.5; //Thickness of slab in m
8 A=5; //Area of slab in m2
9 k=1.2; //Thermal conductivity in W/m.K
10 a=0.00177; //Thermal diffusivity in m2/h
11 //Remperarure distribution as  $T=60-50x+12x^2+20x$ 
     $^3-15x^4$ 
12
13 //CALCULATIONS
14 //Partial derivative of T w.r.t x is  $T'=-50+24x+60x$ 
     $^2-60x^3$ 
15 //Partial derivative of T' w.r.t x is  $T''=24+120x$ 
     $+180x^2$ 
16 //Partial derivative of T' w.r.t x is  $T'''=120-360x$ 
```

```

17 x=0;
18 y=-50+(24*x)+(60*x^2)-(60*x^3); //Temperature when x
    =0
19 Qo=(-k*A*y); //Heat entering the slab in W
20 x=0.5;
21 y=-50+(24*x)+(60*x^2)-(60*x^3); //Temperature when x
    =0.5
22 QL=(-k*A*y); //Heat leaving the slab in W
23 R=(Qo-QL); //Rate of heat storage in W
24 x=0;
25 z1=24+(120*x)-(180*x^2); //T' when x=0
26 p1=(a*z1); //Rate of temperature change at one side
    of slab in degree C/h
27 x=0.5;
28 z2=24+(120*x)-(180*x^2); //T' when x=0.5
29 p2=(a*z2); //Rate of temperature change at one side
    of slab in degree C/h
30 //For the rate of heating or cooling to be maximum,
    T''=0
31 x=(120/360);
32
33 //OUTPUT
34 mprintf('a) i) Heat entering the slab is %i W\n ii)
    Heat leaving the slab is %i W\n b) Rate of heat
    storage is %i W\n c) i) Rate of temperature change
    at one side of slab is %3.4f degree C/h\n ii) Rate
    of temperature change at other side of slab is
    %3.4f degree C/h\n d) For the rate of heating or
    cooling to be maximum x= %3.2f ', Qo, QL, R, p1, p2, x)
35
36 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.2 Time taken

```

1 //Chapter -5, Example 5.2, Page 164
2 //

```

```

3 clc
4 clear
5
6
7 //INPUT DATA
8 A=(0.4*0.4); //Area of copper slab in m2
9 t=0.005; //Thickness of copper slab in m
10 T=250; //Uniform teperature in degree c
11 Ts=30; //Surface temperature in degree C
12 Tsl=90; //Slab temperature in degree C
13 p=9000; //Density in kg/m3
14 c=380; //Specific heat in J/kg.K
15 k=370; //Thermal conductivity in W/m.K
16 h=90; //Heat transfer coefficient in W/m2.K
17
18 //CALCULATIONS
19 A1=(2*A); //Area of two sides in m2
20 V=(A*t); //Volume of the slab in m3
21 Lc=(V/A1); //Corrected length in m
22 Bi=((h*Lc)/k); //Biot number
23 t=-log((Tsl-Ts)/(T-Ts))/((h*A1)/(p*c*V)); //Time at
    which slab temperature becomes 90 degree C in s
24 y=(h*A1)/(p*c*V);
25
26 //OUTPUT
27 mprintf('Time at which slab temperature becomes 90
    degree C is %3.2f s',t)
28
29 //=====END OF PROGRAM

```

Scilab code Exa 5.3 Time taken

```
1 //Chapter-5, Example 5.3, Page 164
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 D=0.01;//Outer diameter of the rod in m
8 T=320;//Original temperature in degree C
9 Tl=120;//Temperature of liquid in degree C
10 h=100;//Heat transfer coefficient in W/m^2.K
11 Tf=200;//Final temperature of rod in degree C
12 k=40;//Thermal conductivity in W/m.K
13 c=460;//Specific heat in J/kg.K
14 p=7800;//Density in kg/m^3
15
16 //CALCULATIONS
17 V=(3.14*D^2*1)/4;//Volume of rod in m^3 taking 1m
    length
18 A=(3.14*D*1);//Surface area of rod in m^2 taking 1m
    length
19 Lc=(D/4);//Corrected length in m
20 Bi=((h*Lc)/k);//Biot number
21 t=-log((Tf-Tl)/(T-Tl))/((h*4)/(p*c*D));//Time at
    which rod temperature becomes 200 degree C in s
22
23 //OUTPUT
24 mprintf('Time at which rod temperature becomes 200
    degree C is %3.2f s',t)
25
26 //=====END OF PROGRAM


---


```

Scilab code Exa 5.4 Time required to cool aluminium

```
1 //Chapter -5, Example 5.4, Page 165
2 //


---


3 clc
4 clear
5
6
7 //INPUT DATA
8 w=5.5; //Weight of the sphere in kg
9 Ti=290; //Initial temperature in degree C
10 Tl=15; //Temperature of liquid in degree C
11 h=58; //Heat transfer coefficient in W/m^2.K
12 Tf=95; //Final temperature in degree C
13 k=205; //Thermal conductivity in W/m.K
14 c=900; //Specific heat in J/kg.K
15 p=2700; //Density in kg/m^3
16
17 //CALCULATIONS
18 V=(w/p); //Volume of the sphere in m^3
19 R=((3*V)/(4*3.14))^(1/3); //Radius of sphere in m
20 Lc=(R/3); //Corrected length in m
21 t=-log((Tf-Tl)/(Ti-Tl))/((h*3)/(p*c*R)); //Time at
    which rod temperature becomes 95 degree C in s
22
23 //OUTPUT
24 mprintf('Time at which rod temperature becomes 95
    degree C is %3.0f s',t)
25
26 //=====END OF PROGRAM


---


```


Scilab code Exa 5.5 Heat transfer coefficient

```
1 //Chapter -5, Example 5.5, Page 166
2 //


---


3 clc
4 clear
5
6
7 //INPUT DATA
8 Ti=100; //Temperature of air in degree C
9 t=0.03; //Thickness of slab in m
10 To=210; //Initial temperature of the plate in degree
    C
11 t=300; //Time for attaining temperature in s
12 T=170; //Temperature decreased in degree C
13 c=380; //Specific heat in J/kg.K
14 p=9000; //Density in kg/m^3
15
16 //CALCULATIONS
17 Lc=(t/2); //Corrected length in m
18 h=-log((T-Ti)/(To-Ti))/((t*10^4)/(p*c*Lc)); //Heat
    transfer coefficient in W/m^2.K
19
20 //OUTPUT
21 mprintf('Heat transfer coefficient is %3.2f W/m^2.K'
    ,h)
22
23 //=====END OF PROGRAM


---


```

Scilab code Exa 5.6 Time constant and time period

```
1 //Chapter -5, Example 5.6, Page 167
2 //


---


3 clc
4 clear
5
6
7 //INPUT DATA
8 D=0.00071; //Diameter of thermocouple in m
9 h=600; //Heat transfer coefficient in W/m^2.K
10 c=420; //Specific heat in J/kg.K
11 p=8600; //Density in kg/m^3
12
13 //CALCULATIONS
14 t=(p*c*D)/(4*h); //Time period in s
15 T=exp(-1); //Temperture distribution ratio
16 t1=(4*t); //Total time in s
17
18 //OUTPUT
19 mprintf('Thus at the end of time period t*=%3.3f s
    the temperature difference between the body and
    the source would be %3.3f of the initial
    temperature diffrence. For getting a true reading
    of gas temperature, it should be recorded after
    4t* = %i seconds after the thermocouple has been
    introduced into the stream ',t,T,t1)
20
21 //=====END OF PROGRAM


---


```

Scilab code Exa 5.8 Temperature and total heat

```

1 //Chapter -5, Example 5.8, Page 177
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 x=0.2; //Distance of plane from the wall in m
8 t=10; //Time for heat flow in h
9 T=[25,800]; //Initial and final tempertaure in degree
   C
10 k=0.8; //Thermal conductivity in W/m.K
11 a=0.003; //Thermal diffusivity in m^2/h
12
13 //CALCULATIONS
14 X=(x*(2*sqrt(a*k))); //Calculation of X for erf
   function
15 Y=0.585; //Taking ref(0.577)=0.585 from table 5.1 on
   page no. 175
16 Ti=T(2)-((T(2)-T(1)))*Y; //Temperarture of the plane
   in degree C
17 Qi=((-k*(T(1)-T(2))*exp(-x^2/(4*a*t)))/(sqrt(3.14*a*
   t))); //Instantaneous heat flow rate per unit area
   in W/m^2
18 Q=((2*k*(T(2)-T(1))*3600)/(sqrt((3.14*a)/t)))/10^8;
   //Total heat energy taken up by the wall in 10
   hours in J/m^2
19
20 //OUTPUT
21 mprintf('Temperarture of the plane is %3.2f degree C
   \nInstantaneous heat flow rate per unit area is
   %i W/m^2\nTotal heat energy taken up by the wall
   in 10 hours is %3.3f*10^8 J/m^2',Ti,Qi,Q)
22
23 //=====END OF PROGRAM


---



```

Scilab code Exa 5.9 Time taken to cool

```
1 //Chapter -5, Example 5.9, Page 177
2 //


---


3 clc
4 clear
5
6
7 //INPUT DATA
8 Tc=55; //Tempertaure of the concrete in degree C
9 Ts=35; //Temperature lowered in degree C
10 Tf=45; //Final temperature in degree C
11 x=0.05; //Depth of the slab in m
12 k=1.279; //Thermal conductivity in W/m.K
13 a=0.00177; //Thermal diffusivity in m^2/h
14
15 //CALCULATIONS
16 T=(Tf-Ts)/(Tc-Ts); //Temperature distribution
17 X=0.485; //Taking 0.5=erf(0.482) from table 5.1 on
    page no. 175
18 t=(x^2)/(4*X^2*a); //Time taken to cool the concrete
    to 45 degree C in h
19
20 //OUTPUT
21 mprintf('Time taken to cool the concrete to 45
    degree C is %3.2f h',t)
22
23 //=====END OF PROGRAM


---


```

Scilab code Exa 5.10 Temperature

```
1 //Chapter-5, Example 5.10, Page 178
2 //


---


3 clc
4 clear
5
6
7 //INPUT DATA
8 q=(0.3*10^6); //Heat flux in W/m^2
9 t=(10/60); //Time taken for heat transfer in s
10 Ti=30; //Initial temperature of the slab in degree C
11 x=0.2; //Distance of the plane from the surface in m
12 k=386; //Thermal conductivity in W/m.K
13 a=0.404; //Thermal diffusivity in m^2/h
14
15 //CALCULATIONS
16 Ts=((q*sqrt(3.14*a*t))/k)+Ti; //Surface temperature
    in degree C
17 X=(x/(2*sqrt(a*t))); //X for calculating erf function
18 Y=0.4134; //Taking ref(0.385)=0.4134 from table 5.1
    on page no. 175
19 T=Ts-(Y*(Ts-Ti)); //Tempertaure at a distance of 20
    cm from the surface after 10 min in degree C
20
21 //OUTPUT
22 mprintf('Tempertaure at a distance of 20 cm from the
    surface after 10 min is %3.2f degree C',T)
23
24 //=====END OF PROGRAM
    =====
```

Scilab code Exa 5.11 Time required and depth

```

1 //Chapter -5, Example 5.11, Page 178
2 //


---


3 clc
4 clear
5
6
7 //INPUT DATA
8 a=0.405; //Thermal diffusivity in m2/h
9 Ti=100; //Initial temperture in degree C
10 Tf=0; //Final tempertaure in degree C
11 Tg=(4*100); //Temperature gradient in degree C/m
12 t1=1; //Time taken in m
13
14 //CALCULATIONS
15 t=(Ti-Tf)^2/(Tg^2*3.14*a); //Time required for the
    temperature gradient at the surface to reach 4
    degree/cm in h
16 x=sqrt(2*a*(t1/60)); //The depth at which the rate of
    cooling is maximum after 1 minute in m
17
18 //OUTPUT
19 mprintf('Time required for the temperature gradient
    at the surface to reach 4 degree/cm is %3.3f h \n
    The depth at which the rate of cooling is
    maximum after 1 minute is %3.4f m',t,x)
20
21 //=====END OF PROGRAM


---



```

Scilab code Exa 5.12 Temperature and total thermal energy

```

1 //Chapter -5, Example 5.12, Page 185
2 //

```

```

3  clc
4  clear
5
6
7  //INPUT DATA
8  x=0.1; //Thickness of the slab in m
9  Ti=500; //Initial temperature in degree C
10 Tl=100; //Liquid temperature in degree C
11 h=1200; //Heat transfer coefficient in W/m^2.K
12 t=(1*60); //Time for immersion in s
13 k=215; //Thermal conductivity in W/m.K
14 a=(8.4*10^-5); //Thermal diffusivity in m^2/h
15 c=900; //Specific heat in J/kg/K
16 p=2700; //Density in kg/m^3
17
18 //CALCULATIONS
19 X=(a*t)/(x/2)^2; //Calculation for input in Heisler
    charts
20 B=(k/(h*(x/2))); //Calculation for input in Heisler
    charts
21 T1=0.68; //T value taken from Fig. 5.7 on page no.
    183
22 Tc1=(T1*(Ti-Tl)); //Temperature in degree C
23 To=Tc1+Tl; //Temperature in degree C
24 T2=0.880; //From Fig 5.8 on page no. 184 at x/L=1.0
    and for k/hL=3.583, tempertaure in degree C
25 Tc2=(T2*(To-Tl))+Tl; //Temperature in degree C
26 Y=(h^2*a*t)/(k^2); //Y to calculate the energy losses
27 Bi=(h*(x/2))/k; //Biot number
28 U=0.32; //U/Uo value from Fig. 5.9 on page no.185
29 Uo=(p*c*x*(Ti-Tl)); //For unit area in J/m^2
30 U1=(U*Uo)/(10^6); //Heat removed per unit surface
    area in MJ/m^2
31
32 //OUTPUT
33 mprintf('Temperature at the centreline and the

```

```

    surface 1 minute after the immersion is %3.2f
    degree C \n Heat removed per unit surface area is
    %3.1f*10^6 J/m^2 ',Tc2,U1)
34
35 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.13 Temperature

```

1 //Chapter -5, Example 5.13, Page 186
2 //
    =====

3 clc
4 clear
5
6
7 //INPUT DATA
8 D=0.12; //Diameter of cylinder in m
9 Ti=20; //Initial temperature in degree C
10 Tf=820; //Temperature of furnace in degree C
11 h=140; //Heat transfer coefficient in W/m^2.K
12 Ta=800; //Axis temperature in degree C
13 r=0.054; //Radius in m
14 k=21; //Thermal conductivity in W/m.K
15 a=(6.11*10^-6); //Thermal diffusivity in m^2/h
16
17 //CALCULATIONS
18 Bi=(h*(D/2))/(2*k); //Biot number
19 T=(Ta-Tf)/(Ti-Tf); //Temperature distribution
20 Fo=5.2; //Using Fig.5.10, on page no.187 for 1/(2Bi)
    =2.5
21 t=(Fo*(D/2)^2)/a; //Time required for the axis
    temperature to reach 800 degree C in s
22 r1=(r/(D/2)); //Ratio at a radius of 5.4 cm

```



```

23 X=0.85; //From Fig.5.11 on page no. 188 the
    temperature at r=5.4 i s given by X
24 T1=X*(Ta-Tf)+Tf; //Temperature at a radius of 5.4 cm
    at that tim ein degree C
25
26 //OUTPUT
27 mprintf('Time required for the axis temperature to
    reach 800 degree C is %3.0f s \nTemperature at a
    radius of 5.4 cm at that time is %i degree C',t,
    T1)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.14 Time required for cooling

```

1 //Chapter -5, Example 5.14, Page 189
2 //
    =====

3 clc
4 clear
5
6
7 //INPUT DATA
8 r=0.01; //Radius of the mettalic sphere in m
9 Ti=400; //Initial temperature in degree C
10 h1=10; //Heat transfer coefficient in W/m^2.K
11 Ta=20; //Temperature of air in degree C
12 Tc=355; //Central temperature in degree C
13 Tw=20; //Temperature of water bath in degree C
14 h2=6000; //Heat transfer coefficient in W/m^2.K
15 Tf=50; //Final temperature of the sphere in degree C
16 k=20; //Thermal conductivity in W/m.K
17 a=(6.66*10^-6); //Thermal diffusivity in m^2/h

```

```

18 c=1000; // Specific heat in J/kg/K
19 p=3000; // Density in kg/m^3
20
21 //CALCULATIONS
22 Bi1=(h1*r)/(3*k); // Biot number
23 t=((p*r*c*log((Ti-Ta)/(Tc-Ta)))/(3*h1)); // Time
    required for cooling in air in s
24 Bi2=(h2*r)/(3*k); // Biot number
25 X=1/(3*Bi2); // X value for lumped capacity method
26 T=(Tf-Ta)/(Tc-Ta); // Temperature distribution
27 Fo=0.5; // Using Fig.5.13, on page no.190
28 t1=(Fo*r^2)/a; // Time required for cooling in water
    in s
29 Z=0.33; // Using Fig.5.14, on page no.191
30 Tr=Z*(Tf-Ta)+Ta; // Surface temperature at the end of
    cooling in degree C
31
32 //OUTPUT
33 mprintf('Time required for cooling in air is %3.0f s
    \nTime required for cooling in water is %3.1f s
    \nSurface temperature at the end of cooling is %3
    .0f degree C',t,t1,Tr)
34
35 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.15 Temperature

```

1 //Chapter -5, Example 5.15, Page 192
2 //
    =====
3 clc
4 clear
5

```

```

6
7 //INPUT DATA
8 Ti=250; //Temperature of aluminium slab in degree C
9 Tc=50; //Convective environment temperature in degree
    C
10 h=500; //Heat transfer coefficient in W/m^2.K
11 x=0.05; //Depth of the plane in m
12 t=(1*3600); //Time in s
13 k=215; //Thermal conductivity in W/m.K
14 a=(8.4*10^-5); //Thermal diffusivity in m^2/h
15
16 //CALCULATIONS
17 X=(h*sqrt(a*t))/k; //X for calculating Temperature
18 Y=(x/(2*sqrt(a*t))); //Y for calculating Temperature
19 Z=0.62; //From Fig. 5.16 on page no.193
20 T=(Z*(Tc-Ti)+Ti); //Temperature at a depth of 5 cm
    after 1 hour in degree C
21
22 //OUTPUT
23 mprintf('Temperature at a depth of 5 cm after 1 hour
    is %3.0f degree C',T)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.16 Centreline temperature

```

1 //Chapter -5, Example 5.16, Page 196
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA

```

```

7 D=0.08; //Diameter of the cylinder in m
8 L=0.16; //Length of the cylinder in m
9 Ti=800; //Initial tempertaure in degree C
10 Tm=30; //Temperature of the medium in degree C
11 h=120; //Heat transfer coefficient in W/m^2.K
12 t=(30*60); //Time for cooling in s
13 k=23.5; //Thermal conductivity in W/m.K
14 a=0.022; //Thermal diffusivity in m^2/h
15
16 //CALCULATIONS
17 Bi2=(h*(D/2))/k; //2 times the Biot number
18 X=(a*t)/(D/2)^2; //X for calculating C(R)
19 CR=0.068; //From Fig.5.10 on page no.187
20 Bi1=(k/(h*L)); //Biot number
21 Y=(a*t)/L^2; //Y for calculating P(X)
22 PX=0.54; //From Fig.5.7 on page no.183
23 T=CR*PX; //Temperature at the centre of the cylinder
    in degree C
24 T30=T*(Ti-Tm)+Tm; //Temperature at the centre of
    cylinder 30 minutes after cooling is initiated in
    degree C
25
26 //OUTPUT
27 mprintf('Temperature at the centre of cylinder 30
    minutes after cooling is initiated is %3.2f
    degree C',T30)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.17 Temperature

```

1 //Chapter -5, Example 5.17, Page 197
2 //

```

```

3  clc
4  clear
5
6
7  //INPUT DATA
8  L=[0.5,0.4,0.2]; //Lengths of sides of a rectangular
    steel billet in m
9  Ti=30; //Initial temperature in degree C
10 Tf=1000; //Final temperature in degree C
11 t=(90*60); //Time for heating in s
12 h=185; //Heat transfer coefficient in W/m^2.K
13 k=37; //Thermal conductivity in W/m.K
14 a=0.025; //Thermal diffusivity in m^2/h
15
16 //CALCULATIONS
17 L1=L/2; //L values of the parallelepiped in m
18 Bi1=(h*L(1))/k; //Biot number
19 X1=(a*t)/L(1)^2; //X1 for calculating P(X1)
20 PX1=0.68; //P(X1) value from From Fig.5.7 on page no
    .183
21 Bi2=(h*L(2))/k; //Biot number
22 X1=(a*t)/L(2)^2; //X1 for calculating P(X2)
23 PX2=0.57; //P(X2) value from From Fig.5.7 on page no
    .183
24 Bi3=(h*L(3))/k; //Biot number
25 Y=(1/Bi3); //Inverse of Biot number
26 X1=(a*t)/L(3)^2; //X1 for calculating P(X3)
27 PX3=0.22; //P(X3) value from From Fig.5.7 on page no
    .183
28 T=PX1*PX2*PX3; //Temperature at the centre of billet
    in degree C
29 T1=T*(Ti-Tf)+Tf; //Temperature at the centre of
    cylinder 90 minutes after heating is initiated in
    degree C
30
31 //OUTPUT
32 mprintf('Temperature at the centre of cylinder 90

```

```

    minutes after heating is initiated is %3.2f
    degree C',T1)
33
34 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.18 Surface temperature

```

1 //Chapter -5, Example 5.18, Page 202
2 //
    =====

3 clc
4 clear
5
6
7 //INPUT DATA
8 Ti=30; //Initial temperature of the slab in degree C
9 q=(2*10^5); //Constant heat flux in W/m^2
10 k=400; //Thermal conductivity in W/m.K
11 a=(117*10^-6); //Thermal diffusivity in m^2/h
12 n=0.075; //Nodal spacing in m
13 x=0.15; //Depth in m
14 t=(4*60); //Time elapsed in s
15
16 //CALCULATION
17 R=(x^2/(a*t)); //R value for t1
18 t1=(n^2/(R*a)); //Value of t1 in s
19 To=121.9; //The surface temperature after 4 min in
    degree C from the table on page no. 203
20 T2=64; //Temperature at 0.15 m from the surface after
    4 minutes in degree C from the table on page no.
    203
21
22 //OUTPUT

```

```

23 mprintf('The surface temperature after 4 min is %3.1
    f degree C \n Temperature at 0.15 m from the
    surface after 4 minutes is %i degree C',To,T2)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.19 Time elapsed

```

1 //Chapter -5, Example 5.19, Page 205
2 //
    =====
3 clc
4 clear
5
6
7 //INPUT DATA
8 t=0.6;//Thickness of the wall in m
9 x=0.1;//x value taken from Fig.Ex. 5.19 on page no.
    205
10 Ti=20;//Initial temperature in degree C
11 T=[150,300];//Temperatures of the sides of the wall
    in degree C
12 Tf=150;//Final temperature of the wall in degree C
13 a=(1.66*10-3);//Thermal diffusivity in m2/h
14
15 //CALCULATIONS
16 t=(x2/(2*a));//Length of one time increment in h
17 t1=(9*t);//Elapsed time in h
18
19 //OUTPUT
20 mprintf('Elapsed time before the centre of the wall
    attains a temperature of 150 degree C is %3.0f h'
    ,t1)

```

```
21
22 //=====END OF PROGRAM
    =====
```

Scilab code Exa 5.20 Temperature

```
1 //Chapter -5, Example 5.20, Page 206
2 //
    =====

3 clc
4 clear
5
6
7 //INPUT DATA
8 k=0.175; //Thermal conductivity in W/m.K
9 a=(0.833*10^-7); //Thermal diffusivity in m^2/h
10 Th=144; //Heated temeparture in degree C
11 Tc=15; //Cooled temperature in degree C
12 x=0.02; //Thickness of the plate in m
13 h=65; //Heat transfer coefficient in W/m^2.K
14 t=(4*60); //Tiem elapsed in s
15
16 //CALCULATIONS
17 s=0.002; //Space increment in m from FIG. Ex. 5.20 on
    page no. 207
18 t1=(s^2/(2*a)); //Time increment for the space
    increment in s
19 x1=(k/h); //Convective film thickness in mm
20 Tn=114; //Temperature at the centre in degree C from
    Fig. Ex.5.20 on page no. 207
21 Ts=50; //Surface temperature in degree C from Fig. Ex
    .5.20 on page no. 207
22
23 //OUTPUT
```



```

24 mprintf('Temperature at the centre is %i degree C \
    nSurface temperature is %i degree C',Tn,Ts)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.21 Amplitude of temperature and time lag

```

1 //Chapter -5, Example 5.21, Page 213
2 //
    =====
3 clc
4 clear
5
6
7 //INPUT DATA
8 t=24;//Time period in h
9 T=[-10,10];//Range of temperatures in degree C
10 x=0.1;//Depth in m
11 c=1970;//Specific heat in J/kg/K
12 p=1000;//Density in kg/m^3
13 k=0.349;//Thermal conductivity in W/m.K
14 ta=5;//Time in h
15
16 //CALCULATIONS
17 w=(2*3.14)/t;//Angular velocity in rad/h
18 Tm=(T(1)+T(2))/2;//Mean teperature in degree C
19 Tmax=T(2)-Tm;//Maximum temperature in degree C
20 a=((k*3600)/(p*c));//Thermal diffusivity in m^2/h
21 Txmax=Tmax*exp(-sqrt(w/(2*a))*x);//Amplitude of
    temperature variation in degree C
22 t1=sqrt(1/(2*a*w))*x;//Time lag of temperature wave
    at a depth of 0.1 m in h
23 t2=(3.14/w);//Time for surface temperature is

```

```

    minimum in h
24 t3=t2+ta; //Time in h
25 Tx=Tmax*exp(-sqrt(w/(2*a))*x)*cos((w*t3)-(x*x*sqrt(w
    /(2*a)))); //Temperature at 0.1m 5 hours after the
    surface temperature reaches the minimum in
    degree C
26
27 //OUTPUT
28 mprintf('Amplitude of temperature variation at a
    depth of 0.1m is %3.2f degree C \n Time lag of
    temperature wave at a depth of 0.1 m is %3.2f h \
    n Temperature at 0.1m 5 hours after the surface
    temperature reaches the minimum is %3.3f degree C
    ',Txmax,t1,Tx)
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.22 Time lag and heat flow

```

1 //Chapter -5, Example 5.22, Page 214
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=[800,200]; //Limits in which temperature varies in
    degree C
8 t=12; //Cycle time in h
9 x=0.1; //Depth of penetration in m
10 k=1.8; //Thermal conductivity in W/m.K
11 a=0.02; //Thermal diffusivity in m^2/h
12

```

```

13 //CALCULATIONS
14 w=(2*3.14)/t;//Angular velocity in rad/h
15 t1=sqrt(1/(2*a*w))*x;//Time lag in h
16 Tmax=(T(1)-T(2))/2;//Range of maximum temperature in
    degree C
17 q=((2*k*Tmax)/sqrt(w*a))*(3600/1000);//Heat flow
    through the surface in kJ/m^2
18
19 //OUTPUT
20 mprintf('(i)Time lag of the temperature wave at a
    depth of 10 cm from the inner surface is %3.2f h
    \n(ii)The flow through a surface located at a
    distance of 10 cm from the surface during the
    first six hours interval while the temperature is
    above the mean value is %i kJ/m^2',t1,q)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.23 Depth of penetration

```

1 //Chapter -5, Example 5.23, Page 215
2 //
    =====
3 clc
4 clear
5
6
7 //INPUT DATA
8 N=2000;//Speed of the engine
9 a=0.06;//Thermal diffusivity in m^2/h
10
11 //CALCULATIONS
12 t=1/(60*N);//Period of on oscillation in h

```

```

13 x=(1.6*sqrt(3.14*a*t))*1000; //Depth of penetration
    in mm
14
15 //OUTPUT
16 mprintf('Depth of penetration of the temperature
    oscillation into the cylinder wall of a single
    acting cylinder two stroke IC engine is%3.0f mm',
    x)
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 5.24 Instantaneous heat removal rate

```

1 //Chapter -5, Example 5.24, Page 218
2 //
    =====
3 clc
4 clear
5
6
7 //INPUT DATA
8 Tc=55; //Tempaerature of concrete hyway in degree C
9 Tl=35; //Temperature lowered in degree C
10 Tf=45; //Final temperature in degree C
11 x=0.05; //Depth in m
12 k=1.279; //Thermal conductivity in W/m.K
13 a=(1.77*10^-3); //Thermal diffusivity in m^2/h
14
15 //CALCULATIONS
16 t=1.4; //Time taken from page no. 219 in h
17 q=2*(k*(Tl-Tf))/(sqrt(3*a*t)); //Instantaneous heat
    removal rate in W/m^2
18

```

```
19 //OUTPUT
20 mprintf('Instantaneous heat removal rate is %3.1f W/
    m^2 ',q)
21
22 //=====END OF PROGRAM
    =====
```

Chapter 6

Fundamentals of convective heat transfer

Scilab code Exa 6.2 Type of flow

```
1 //Chapter -6, Example 6.2, Page 241
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L=1; //Length of the palte in m
8 W=1; //Width of the plate in m
9 v=2.5; //Velocity of air in m/s
10 Re=(5*10^5); //Reynolds number at the transition from
    laminar to turbulent
11 p=(0.85*10^-5); //Dynamic viscosity in N.s/m^2
12 r=1.12; //Density in kg/m^3
13
14 //CALCULATIONS
15 x=(p*Re)/(r*v); //Calculated length in m
16
```

```

17 //OUTPUT
18 mprintf('Since the actual length of the plate is %i
        m, which is less than %3.2f m, the flow is
        laminar over the entire length of plate',L,x)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 6.6 Maximum temperature rise and heat flux

```

1 //Chapter –6, Example 6.6 , Page 247
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 p=0.8; //Dynamic viscosity in N.s/m^2
8 k=0.15; //Thermal conductivity in W/m.K
9 Tb=10; //Temperature of bearing in degree C
10 Ts=30; //Temperature of the shaft in degree C
11 C=0.002; //Clearance between bearing and shaft in m
12 U=6; //Velocity in m/s
13
14 //CALCULATIONS
15 qb=(((p*U^2)/(2*C))-((k/C)*(Ts-Tb)))/1000; //Surface
        heat flux at the bearing in kW/m^2
16 qs=(((p*U^2)/(2*C))-((k/C)*(Ts-Tb)))/1000; //Surface
        heat flux at the shaft in kW/m^2
17 Tmax=Tb+(((p*U^2)/(2*k))*(0.604-0.604^2))+((Ts-Tb)
        *0.604); //Maximum temperature in degree C occurs
        when ymax=0.604L
18
19 //OUTPUT

```

```

20 mprintf('Maximum temperature rise is %3.3f degree C
    \n Heat fux to the bearing is %3.1f kW/m^2 \n
    Heat fux to the shaft is %3.1f kW/m^2',Tmax,qb,qs
    )
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 6.7 Type of flow and entry length

```

1 //Chapter –6, Example 6.7, Page 257
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D=0.02;//I.D of the tube in m
8 Q=1.5;//Flow rate in litres per minute
9 k=(1*10-6);//kinematic viscosity in m2/s
10
11 //CALCULATIONS
12 um=((Q/60)*10-3)/(3.14*(D2/4));//Average velocity
    in m/s
13 Re=(um*D)/k;//Reynolds number
14 x=0.05*D*Re;//Entry length in m
15
16 //OUTPUT
17 mprintf('Since Re which is %3.0f less than 2300, the
    flow is laminar. \n Entry length is %3.3f m',Re,
    x)
18
19 //=====END OF PROGRAM
    =====

```

Scilab code Exa 6.8 Head loss and power required

```
1 //Chapter -6, Example 6.8, Page 257
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L=3000; //Diatance transported in m
8 D=0.02; //I.D of the tube in m
9 Q=1.5; //Flow rate in litres per minute
10 k=(1*10^-6); //kinematic viscosity in m^2/s
11 pw=1000; //Density of water in kg/m^3
12
13 //CALCULATIONS
14 um=((Q/60)*10^-3)/(3.14*(D^2/4)); //Average velocity
    in m/s
15 Re=(um*D)/k; //Reynolds number
16 x=0.05*D*Re; //Entry length in m
17 hL=((64/Re)*L*um^2)/(2*D*9.81) //Head loss in m
18 P=(pw*9.81*(3.14/4)*D^2*um*hL); //Power required to
    maintain this flow rate in W
19
20 //OUTPUT
21 mprintf('Head loss is %3.2f m \n Power required to
    maintain this flow rate is %3.4f W',hL,P)
22
23 //=====END OF PROGRAM
    =====
```

Scilab code Exa 6.9 Pressure drop

```
1 //Chapter-6, Example 6.9, Page 258
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L=100;//Length of rectangular duct in m
8 A=[0.02,0.025];//Area of duct in m^2
9 Tw=40;//Temperature of water in degree C
10 v=0.5;//Velocity of flow in m/s
11 k=(0.66*10^-6);//kinematic viscosity in m^2/s
12 p=995;//Density of water in kg/m^3
13
14 //CALCULATIONS
15 P=2*(A(1)+A(2));//Perimeter of the duct in m
16 Dh=(4*(A(1)*A(2)))/P//Hydraulic diameter of the duct
    in m
17 Re=(v*Dh)/k;//Reynolds number
18 f=0.316*Re^(-0.25);//Friction factor
19 hL=(f*L*v^2)/(2*Dh*9.81);//Head loss in m
20 P=(hL*9.81*p)/10^4;//Pressure drop in smooth
    rectangular duct in 10^4 N/m^2
21
22 //OUTPUT
23 mprintf('Pressure drop in smooth rectangular duct is
    %3.4f*10^4 N/m^2',P)
24
25 //=====END OF PROGRAM


---


```

Chapter 7

Forced Convection Systems

Scilab code Exa 7.1 Thickness of hydrodynamic boundary layer and skin friction coefficient

```
1 //Chapter-7, Example 7.1, Page 275
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 Ta=20;//Temperature of air in degree C
8 Tp=134;//Temperature of heated plate in degree C
9 v=3;//Velocity of flow in m/s
10 L=2;//Length of plate in m
11 W=1.5;//Width of plate in m
12 x=0.4;//Distance of plane from the plate in m
13 k=(15.06*10^-6);//Kinematic viscosity in m^2/s
14
15 //CALCULATIONS
16 Re=(v*x)/k;//Reynold number
17 q=((5*x)/sqrt(Re))*1000;//Thickness of boundary
    layer in mm
```

```

18 Cfx=(0.664/sqrt(Re))/10^-3;//Local skin friction
    coefficient *10^-3
19
20 //OUTPUT
21 mprintf('Thickness of boundary layer is %3.1f mm \
    nLocal skin friction coefficient is %3.2f*10^-3',
    q,Cfx)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.2 Local heat transfer coefficient

```

1 //Chapter -7, Example 7.2, Page 275
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ta=20;//Temperature of air in degree C
8 Tp=134;//Temperature of heated plate in degree C
9 v=3;//Velocity of flow in m/s
10 L=2;//Length of plate in m
11 W=1.5;//Width of plate in m
12 x=0.4;//Distance of plane from the plate in m
13 k=(15.06*10^-6);//Kinematic viscosity in m^2/s
14
15 //CALCULATIONS
16 Tf=(Ta+Tp)/2;//Film temperature in degree C
17 pw=0.998;//Density of air at 77 degree C
18 Cp=1009;//Specific heat of air at 77 degree C
19 kw=(20.76*10^-6);//Kinematic viscosity of air at 77
    degree C

```

```

20 k=0.03; //Thermal conductivity of air at 77 degree C
21 Pr=0.697; //prantl number of air at 77 degree C
22 Re=(v*x)/kw; //Reynolds number
23 Nu=(0.332*Re^0.5*Pr^(1/3)); //Nusselts number
24 h=(Nu*k)/x; //Heat transfer coefficient in W/m^2.K
25 h1=(h*2); //Average value of heat transfer
    coefficient in W/m^2.K
26 Q=h1*x*W*(Tp-Ta); //Heat flow in W
27 Q1=(2*Q); //Heat flow from both sides of the plate in
    W
28
29 //OUTPUT
30 mprintf('Heat flow from both sides of the plate is
    %3.0 f W', Q1)
31
32 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.3 Boundary layer thickness and total drag force

```

1 //Chapter -7, Example 7.3, Page 282
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Ta=20; //Temperature of air in degree C
8 v=3; //Velocity of flow in m/s
9 L=2; //Length of plate in m
10 W=1; //Width of plate in m
11 x1=0.3; //Initial point of the boundary layer in m
12 x2=0.8; //Final point of the boundary layer in m
13 p=1.17; //Density of air at 20 degree C in kg/m^3

```

```

14 k=(15*10^-6); //Kinematic viscosity in m^2/s
15 Re=(5*10^5); //Reynolds number at the transition from
    laminar to turbulent
16
17 //CALCULATIONS
18 x=(k*Re)/v; // Critical length in m
19 Re1=(v*L)/k; //Reynolds number
20 q=(4.64*L)/sqrt(Re1)*1000; //Boundary layer thickness
    at the trailing edge of plate in mm
21 ts=1.292*(0.5*p*v^2)*sqrt(1/Re1); //Average shear
    stress in N/m^2
22 F=(2*L*ts); //Drag force on the two sides of the
    plate in N
23 q80=(4.64*x2)/sqrt((v*x2)/k); //Boundray layer
    thickness at x=0.8 m
24 q30=(4.64*x1)/sqrt((v*x1)/k); //Boundray layer
    thickness at x=0.3 m
25 m=((5/8)*p*v*(q80-q30))/10^-3; //Mass flow of air in
    kg/s
26
27 //OUTPUT
28 mprintf('Boundary layer thickness at the trailing
    edge of plate is % 3.2f mm \nDrag force on the
    two sides of the plate is %3.4f N \nMass flow of
    air is %3.1f*10^-3 kg/s ',q,F,m)
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.4 Rate of heat to be removed

```

1 //Chapter -7, Example 7.4, Page 283
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  P=8; //Pressure of air in kN/m^2
8  Ta=250; //Temperature of air in degree C
9  L=1; //Length of the palte in m
10 W=0.3; //Width of the plate in m
11 v=8; //Velocity of air in m/s
12 Tp=78; //Temperature of plate in degree C
13
14 //CALCULATIONS
15 Tf=(Ta+Tp)/2; //Film temperature in degree C
16 Cp=1018; //Specific heat of air at 164 degree C and 1
    atm pressure
17 kw=(30.8*10^-6); //Kinematic viscosity of air at 164
    degree C and 1 atm pressure
18 k=0.0364; //Thermal conductivity of air at 164 degree
    C and 1 atm pressure
19 Pr=0.69; //prant number of air at 164 degree C and 1
    atm pressure
20 k1=kw*(101330/(P*1000)); //Kinematic viscosity of air
    at 164 degree C and 8kN/m^2 pressure
21 Re=(v*L)/k1; //Reynolds number
22 h=0.662*(k/L)*sqrt(Re)*Pr^(1/3); //Heat transfer
    coefficient in W/m.K
23 Q=2*h*L*W*(Ta-Tp); //Rate of heat removal in W
24
25 //OUTPUT
26 mprintf('Rate of heat removal is %3.1f W',Q)
27
28 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.5 Drag force

```

1 //Chapter -7, Example 7.5, Page 286
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 P=8;//Pressure of air in kN/m^2
8 Ta=250;//Temperature of air in degree C
9 L=1;//Length of the palte in m
10 W=0.3;//Width of the plate in m
11 v=8;//Velocity of air in m/s
12 Tp=78;//Temperature of plate in degree C
13 R=287;//Universal gas constant in J/kg.K
14
15 //CALCULATIONS
16 Tf=(Ta+Tp)/2;//Film temperature in degree C
17 Cp=1018;//Specific heat of air at 164 degree C and 1
    atm pressure
18 kw=(30.8*10^-6);//Kinematic viscosity of air at 164
    degree C and 1 atm pressure
19 k=0.0364;//Thermal conductivity of air at 164 degree
    C and 1 atm pressure
20 Pr=0.69;//prant number of air at 164 degree C and 1
    atm pressure
21 k1=kw*(101330/(P*1000));//Kinematic viscosity of air
    at 164 degree C and 8kN/m^2 pressure
22 Re=(v*L)/k1;//Reynolds number
23 h=0.662*(k/L)*sqrt(Re)*Pr^(1/3);//Heat transfer
    coefficient in W/m.K
24 Q=2*h*L*W*(Ta-Tp);//Rate of heat removal in W
25 p=(P*1000)/(R*(Tf+273));//Density in kg/m^3
26 St=(h/(p*Cp*v));//Stanton number
27 Cfx2=(St*Pr^(2/3));//Colburn factor
28 ts=(Cfx2*p*v^2);//Average shear stress in N/m^2
29 D=(ts*W*L);//Drag force on one side of plate in N
30 D2=(2*D)/10^-3;//Total drag force on both sides of

```



```

    plate in N
31
32 //OUTPUT
33 mprintf('The drag force exerted on the plate is %3.2
    f*10-3 N',D2)
34
35 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.6 Thickness of boundary layer and heat transfer coefficient

```

1 //Chapter -7, Example 7.6, Page 289
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 L=1; //Length of the palte in m
8 W=1; //Width of the plate in m
9 Ts=10; //Temperature of free strem air in degree C
10 v=80; //Velocity of free stream air in m/s
11
12 //CALCULATIONS
13 k=0.025; //Thermal conductivity of air at 10 degree C
14 Pr=0.72; //prant number of air at 10 degree C
15 v1=(14.15*10-6); //Kinematic viscosity of air at 10
    degree C
16 Re=(v*L)/v1; //Reynolds number
17 q=0.381*L*Re(-1/5); //Thickness of the boundary
    layer at the trailing edge of the plate in m
18 Nu=(0.037*Re(4/5)*Pr(1/3)); //Nusselts number
19 h=(Nu*k)/L; //Mean value of the heat transfer

```

```

    coefficient in W/m^2.K
20
21 //OUTPUT
22 mprintf('Thickness of the boundary layer at the
    trailing edge of the plate is %3.4f m \nMean
    value of the heat transfer coefficient is %3.0f W
    /m^2.K',q,h)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.7 Friction coefficient and heat transfer coefficient

```

1 //Chapter -7, Example 7.7, Page 290
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ta=0;//Temperature of air stream in degree C
8 Tp=90;//Temperature of heated plate in degree C
9 v=75;//Speed of air in m/s
10 L=0.45;//Length of the palte in m
11 W=0.6;//Width of the plate in m
12 Re=(5*10^5);//Reynolds number at the transition from
    laminar to turbulent
13
14 //CALCULATIONS
15 Tf=(Ta+Tp)/2;//Film temperature in degree C
16 k=0.028;//Thermal conductivity of air at 10 degree C
17 Pr=0.698;//prant number of air at 10 degree C
18 v1=(17.45*10^-6);//Kinematic viscosity of air at 10
    degree C

```

```

19 x=(Re*v1)/v;//Critical length in m
20 Re1=(v*L)/v1;//Reynolds number
21 Cf1=((0.074/Re1^(1/5))-(1740/Re1))/10^-3;//Average
    value of friction coefficient *10^-3
22 Nu=((0.037*Re1^(4/5))-870)*Pr^(1/3);//Nusselts
    number
23 h=(Nu*k)/L;//Heat transfer coefficient in W/m^2.K
24 Q=(2*h*L*W*(Tp-Ta));//Rate of energy dissipation in
    W
25
26 //OUTPUT
27 fprintf('Average value of friction coefficient is %3
    .2f*10^-3 \nHeat transfer coefficient is %3.0f W/
    m^2.K \nRate of energy dissipation is %i W',Cf1,h
    ,Q)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.8 Heat loss

```

1 //Chapter -7, Example 7.8, Page 296
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D=0.3;//Diameter of cylinder in m
8 L=1.7;//Height of cylinder in m
9 Ts=30;//Surface temperature in degree C
10 v=10;//Speed of wind in m/s
11 Ta=10;//Temperature of air in degree C
12

```

```

13 //CALCULATIONS
14 Tf=(Ta+Ts)/2;//Film temperature in degree C
15 k=0.0259;//Thermal conductivity of air at 20 degree
    C
16 Pr=0.707;//prant number of air at 20 degree C
17 v1=(15*10^-6);//Kinematic viscosity of air at 20
    degree C
18 Re=(v*D)/v1;//Reynolds number
19 Nu=0.027*Re^0.805*Pr^(1/3)//Nusselts number
20 h=(Nu*k)/D;//Heat transfer coefficent in W/m^2.K
21 Q=(h*3.14*D*L*(Ts-Ta));//Rate of heat loss in W
22
23 //OUTPUT
24 mprintf('Rate of heat loss is %3.1f W',Q)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.9 Heat transfer rate and percentage of power lost

```

1 //Chapter -7, Example 7.9, Page 297
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ta=27;//Temperature of air stream in degree C
8 v=0.3;//Velodity of air in m/s
9 Q=100;//Poer of electric bulb in W
10 Te=127;//Temperature of electric bulb in degree C
11 D=0.06;//Diameter of sphere in m
12
13 //CALCULATIONS

```

```

14 Tf=(Ta+Te)/2; //Film temperature in degree C
15 k=0.03; //Thermal conductivity of air at 77 degree C
16 Pr=0.697; //prant number of air at 77 degree C
17 v1=(2.08*10^-5); //Kinematic viscosity of air at 77
    degree C
18 Re=(v*D)/v1; //Reynolds number
19 h=(k*0.37*Re^0.6)/D; //Heat transfer coefficient in W
    /m^2.K
20 Q=(h*3.14*D^2*(Te-Ta)); //Heat transfer rate in W
21 Qp=(Q*100)/100; //Percentage of heat lost by forced
    convection
22
23 //OUTPUT
24 mprintf("Heat transfer rate is %3.2f W \nPercentage
    of power lost due to convection is %3.2f percent
    ',Q,Qp)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.10 Heat transfer coefficient and current intensity

```

1 //Chapter -7, Example 7.10, Page 297
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D=0.015; //Diamter of copper bus bar in m
8 Ta=20; //Temperature of air stream in degree C
9 v=1; //Velocity of air in m/s
10 Ts=80; //Surface temperature in degree C
11 p=0.0175; //Resistivity of copper in ohm mm^2/m

```

```

12
13 //CALCULATIONS
14 Tf=(Ta+Ts)/2;//Film temperature in degree C
15 k=0.02815;//Thermal conductivity of air at 50 degree
    C
16 Pr=0.703;//prant number of air at 50 degree C
17 v1=(18.9*10^-6);//Kinematic viscosity of air at 50
    degree C
18 Re=(v*D)/v1;//Reynolds number
19 Nu=0.3+(((0.62*sqrt(Re)*Pr^(1/3))/(1+(0.4/Pr)^(2/3)))
    ^(1/4))*(1+(Re/28200)^(5/8))^(4/5));//Nusselts
    number
20 h=(Nu*k)/D;//Heat transfer coefficent in W/m^2.K
21 I=1000*3.14*D*sqrt((h*(Ts-Ta)*D)/(4*p));//Current in
    A
22
23 //OUTPUT
24 mprintf('Heat transfer coefficient between the bus
    bar and cooling air is %3.2f W/m^2.K \nMaximum
    admissible current intensity for the bus bar is
    %3.0f A',h,I)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.11 Rate of heat transfer

```

1 //Chapter -7, Example 7.11, Page 298
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA

```

```

7 Ta=30; //Temperature of air stream in degree C
8 v=25; //Velocity of stream in m/s
9 x=0.05; //Side of a square in m
10 D=0.05; //Diameter of circular cylinder in m
11 Ts=124; //Surface temperature in degree C
12
13 //CALCULATIONS
14 Tf=(Ta+Ts)/2; //Film temperature in degree C
15 k=0.03; //Thermal conductivity of air at 77 degree C
16 Pr=0.7; //prantL number of air at 77 degree C
17 v1=(20.92*10^-6); //Kinematic viscosity of air at 77
    degree C
18 Re=(v*D)/v1; //Reynolds number
19 Nu1=0.027*Re^0.805*Pr^(1/3); //Nussults number for
    circulat tube
20 h1=(Nu1*k)/D; //Heat tansfer coefficient for circular
    tube in W/m^2.K
21 Nu2=0.102*Re^0.675*Pr^(1/3); //Nussults number for
    square tube
22 h2=(Nu2*k)/D; //Heat transfer coefficient for square
    tube in W/m^2.K
23
24 //OUTPUT
25 mprintf('Heat transfer coefficient for circular tube
    is %3.1f W/m^2.K \nHeat transfer coefficient for
    square tube is %3.2f W/m^2.K',h1,h2)
26
27 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.12 Heat transfer coefficient and pressure drop

```

1 //Chapter -7, Example 7.12, Page 302
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  n=7; //Number of rows of tube
8  Ta=15; //Temperature of air in degree C
9  v=6; //Velocity of air in m/s
10 ST=0.0205; //Transverse pitch in m
11 SD=0.0205; //Longitudinal pitch in m
12 D=0.0164; //Outside diameter of the tube in m
13 Ts=70; //Surface temperature in degree C
14
15 //CALCULATIONS
16 Tf=(Ta+Ts)/2; //Film temperature in degree C
17 k=0.0274; //Thermal conductivity of air at 42.5
    degree C
18 Pr=0.705; //prant number of air at 42.5 degree C
19 v1=(17.4*10^-6); //Kinematic viscosity of air at 42.5
    degree C
20 p=1.217; //Density in kg/m^3
21 vmax=(v*ST)/(ST-D); //Maximum velocity in m/s
22 Re=(vmax*D)/v1; //Reynolds number
23 Nu=(1.13*0.518*Re^0.556*Pr^(1/3))*0.97; //Nusselts
    number
24 h=(Nu*k)/D; //Heat transfer coefficent in W/m^2.K
25 f=0.4; //From Fig. 7.10 on page no 303
26 g=1.04; //From Fig. 7.10 on page no 303
27 dp=(n*f*p*vmax^2*g)/2; //Pressure drop in N/m^2
28
29 //OUTPUT
30 mprintf('Heat transfer coefficent is %3.2f W/m^2.K \
    nPressure drop is %3.0f N/m^2',h,dp)
31
32 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.13 Convection coefficient

```
1 //Chapter -7, Example 7.13, Page 304
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 n=7; //Number of rows of tube
8 Ta=15; //Temperature of air in degree C
9 v=6; //Velocity of air in m/s
10 ST=0.0205; //Transverse pitch in m
11 SD=0.0205; //Longitudinal pitch in m
12 D=0.0164; //Outside diameter of the tube in m
13 Ts=70; //Surface temperature in degree C
14
15 //CALCULATIONS
16 Tf=(Ta+Ts)/2; //Film temperature in degree C
17 k=0.0253; //Thermal conductivity of air at 15 degree
   C
18 Pr=0.710; //prant number of air at 15 degree C
19 v1=(14.82*10^-6); //Kinematic viscosity of air at 15
   degree C
20 p=1.217; //Density in kg/m^3
21 Pr1=0.701; //prant number of air at 70 degree C
22 vmax=(v*ST)/(ST-D); //Maximum velocity in m/s
23 Re=(vmax*D)/v1; //Reynolds number
24 Nu=0.35*Re^0.6*(Pr/Pr1)^0.25; //
25 h=(Nu*k)/D; //Heat transfer coefficient in W/m^2.K
26
27 mprintf(' Heat transfer coefficient is %3.1f W/m^2.K
   which is 10 percent more than that obtained in
```

```

    the previous example',h)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.14 Convective heat transfer coefficient

```

1 //Chapter -7, Example 7.14, Page 305
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 m=0.314; //Mass flow rate of air in m3/s
8 n1=7; //Number of tubes in the direction of flow
9 n2=8; //Number of tubes perpendicular to the
    direction of flow
10 L=1.25; //Length of each tube in m
11 D=0.019; //Outer diameter in m
12 ST=0.0286; //Transverse pitch in m
13 SD=0.038; //Longitudinal pitch in m
14 Ta=200; //Temperature of air in degree C
15 Ts=96; //Surface temperature in degree C
16
17 //CALCULATIONS
18 Tf=(Ta+Ts)/2; //Film temperature in degree C
19 k=0.039; //Thermal conductivity of air at 15 degree C
20 Pr=0.688; //prantl number of air at 15 degree C
21 v1=(3*10-5); //Kinematic viscosity of air at 15
    degree C
22 vmax=(m/((ST*n2*L)-(D*n2*L))); //Maximum velocity in
    m/s
23 Re=(vmax*D)/v1; //Reynolds number

```

```

24 Nu=(0.299*Re^0.602*Pr^(1/3)); //Nusselts number
25 X=0.96; //From Table 7.5 on page no.302
26 Nux=(X*Nu); //Average nusselts number
27 h=(Nux*k)/D; //Convective heat transfer coefficient
    in W/m^2.K
28
29 //OUTPUT
30 mprintf('Convective heat transfer coefficient is %3
    .2 f W/m^2.K',h)
31
32 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.15 Average temperature of the fluid

```

1 //Chapter -7, Example 7.15, Page 310
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D=0.2; //Diameter of pipeline in m
8 //velocity profile is given by  $u=96r-190r^2$  m/s
9 //Temperature profile is given by  $T=100(1-2r)$  degree
    C
10
11 //CALCULATIONS
12 vmax=(64*(D/2))-(95*(D/2)^2); //Mean velocity in m/s
13 T=(2/(vmax*(D/2)^2))*(((9600*(D/2)^3)/3)-((38200*(D
    /2)^4)/4)+((38000*(D/2)^5)/5)); //Average
    temperature of the fluid in degree C
14
15 //OUTPUT

```

```

16 mprintf('Average temperature of the fluid is %3.2f
    degree C',T)
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.16 Length and heat transfer coefficient

```

1 //Chapter -7, Example 7.16, Page 311
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Di=0.025;//I.D of the tube in m
8 Do=0.04;//O.D of the tube in m
9 m=5;//Mass flow rate of water in kg/m
10 T=[20,70];//Temperature at entry and exit of water
    in degree C
11 Q=10^7;//Heat in W/m^3
12 Ts=80;//Surface temperature in degree C
13 Cp=4179;//Specific heat of water in J/kg.K
14
15 //CALCULATIONS
16 Tb=(T(1)+T(2))/2;//Film temperature in degree C
17 L=((4*(m/60)*Cp*(T(2)-T(1)))/(3.14*(Do^2-Di^2)*Q));
    //Length of tube in m
18 qs=((Q*(Do^2-Di^2))/(4*Di));//Heat flux at the
    surface in W/m^2
19 h=(qs/(Ts-T(2)));//Heat transfer coefficient at the
    outlet in W/m^2.K
20
21 //OUTPUT

```

```

22 mprintf('Length of tube is %3.3f m \nHeat transfer
    coefficient at the outlet is %3.0f W/m^2.K',L,h)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.17 Heat transfer coefficient and heat transfer rate

```

1 //Chapter –7, Example 7.17, Page 312
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 k=0.175;//Thermal conductivity in W/m.K
8 Di=0.006;//I.D of the tube in m
9 L=8;//Length of the tube in m
10 dT=50;//Mean temperature difference in degree C
11
12 //CALCULATIONS
13 h=(3.66*k)/Di;//Heat transfer coefficient in W/m^2.K
14 Q=(h*3.14*Di*L*dT);//Heat transfer rate in W
15
16 //OUTPUT
17 mprintf('Heat transfer coefficient is %3.2f W/m^2.K
    \nHeat transfer rate is %3.0f W',h,Q)
18
19 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.18 Heat transfer coefficient and length of the tube

```

1 //Chapter -7, Example 7.18, Page 312
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 Ti=25;//Initial temperature of water in degree C
8 D=0.05;//Diamter of the tube in m
9 Re=1600;//Reynolds number
10 q=800;//Heat flux in W/m
11 Tf=50;//Final temperature of water in degree C
12
13 //CALCULATIONS
14 k=0.61;//Thermal conductivity of water at 25 degree
    C in W/m.K
15 u=(915*10^-6);//Dynamic viscosity in N.s/m^2
16 m=(Re*3.14*D*u)/4;//Mass flow rate of water in kg/s
17 h=(4.364*k)/D;//Heat transfer coefficient in W/m^2.K
18 qs=(q/(3.14*D));//Constant heat flux in W/m^2
19 Cp=4178;//Specific heat of water in J/kg.K
20 L=((m*Cp*(Tf-Ti))/q);//Length of the tube in m
21
22 //OUTPUT
23 mprintf('Average heat transfer coefficient is %3.2f
    W/m^2.K \nLength of the tube is %3.3f m',h,L)
24
25 //=====END OF PROGRAM

```

Scilab code Exa 5.19 Nusselt number

```

1 //Chapter -7, Example 7.19, Page 314
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  Di=0.015; //I.D of the tube in m
8  Tb=60; //Temperature of the tube in degree C
9  m=10; //Flow rate of water in ml/s
10 Ti=20; //Temperature of water at entry in degree C
11 x=1; //Distance form the plane in m
12 Tx=34; //Temperature of water at 1 m distance in
    degree C
13
14 //CALCULATIONS
15 Tbm=(Ti+Tx)/2; //Mean value of bulk temperature in
    degree C
16 pw=997; //Density of air at 27 degree C in kg/m^3
17 Cp=4180; //Specific heat of air at 27 degree C in J/
    kg.K
18 u=(855*10^-6); //Dynamic viscosity of air at 27
    degree C in N.s/m^2
19 k=0.613; //Thermal conductivity of air at 27 degree C
    in W/m.K
20 Pr=5.83; //prantl number of air at 27 degree C
21 us=(464*10^-6); //Dynamic viscosity of air at 60
    degree C in Ns/m^2
22 um=(m*10^-6)/((3.14/4)*Di^2); //Mean speed in m/s
23 Re=(pw*um*Di)/u; //Reynolds number
24 Nu=3.66+(((0.0668*(Di/x)*Re*Pr)/(1+(0.04*((Di/x)*Re*
    Pr)^(2/3))))); //Nusselts number in Haussen
    correlation
25 Nux=(1.86*((Re*Pr)/(x/Di))^(1/3)*(u/us)^0.14); //
    Nusselsts number in Sieder - Tate correlation
26
27 //OUTPUT
28 mprintf('Nusselts number in Haussen correlation is
    %3.2f \nNusselsts number in Sieder - Tate

```

```

    correlation is %3.3f',Nu,Nux)
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.20 Heat transfer coefficient

```

1 //Chapter -7, Example 7.20, Page 318
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Tw=50; //Temperature of water in degree C
8 Di=0.005; //Inner diameter of the tube in m
9 L=0.5; //Length of the tube in m
10 v=1; //Mean velocity in m/s
11 Ts=30; //Surface temperature in degree C
12
13 //CALCULATIONS
14 Tf=(Tw+Ts)/2; //Film temperature in degree C
15 k=0.039; //Thermal conductivity of air at 15 degree C
16 Pr=0.688; //prant number of air at 15 degree C
17 p=990; //Density of air at 50 degree C in kg/m^3
18 Cp=4178; //Specific heat of air at 50 degree C in J/
    kg.K
19 v1=(5.67*10^-7); //Kinematic viscosity of air at 50
    degree C
20 v2=(6.57*10^-7); //Kinematic viscosity of air at 40
    degree C
21 Re=(v*Di)/v1; //Reynolds number
22 h=((0.316/8)*((v*Di*10)/v2)^(-0.25)*p*Cp*v*(4.34)
    ^(-2/3)); //Heat transfer coefficient using the

```



```

    Colburn analogy in W/m^2.K
23
24 //OUTPUT
25 mprintf('Heat transfer coefficient using the Colburn
    analogy is %3.0 f W/m^2.K',h)
26
27 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.21 Heat transfer coefficient and heat transfer rate

```

1 //Chapter -7, Example 7.21, Page 319
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ti=50;//Temperature of water at inlet in degree C
8 D=0.015;//Diameter of tube in m
9 L=3;//Length of the tube in m
10 v=1;//Velocity of flow in m/s
11 Tb=90;//Temperature of tube wall in degree C
12 Tf=64;//Exit temperature of water in degree C
13
14 //CALCULATIONS
15 Tm=(Ti+Tf)/2;//Bulk mean temperature in degree C
16 p=990;//Density of air at 57 degree C in kg/m^3
17 Cp=4184;//Specific heat of air at 57 degree C in J/
    kg.K
18 u=(0.517*10^-6);//Kinematic viscosity of air at 57
    degree C in m^2/s
19 k=0.65;//Thermal conductivity of air at 57 degree C
    in W/m.K

```

```

20 Pr=3.15; //prantl number of air at 57 degree C
21 Re=(v*D)/u; //Reynolds number
22 Nu=(0.023*Re^(4/5)*Pr^0.4); //Nusselts number
23 h=(Nu*k)/D; //Heat transfer coefficient in W/m^2.K
24 Q=(h*3.14*D*L*(Tb-Tm))/1000; //Rate of heat
    transferred in kW
25
26 //OUTPUT
27 mprintf('Heat transfer coefficient is %3.0f W/m^2.K
    \nRate of heat transfered is %3.2f kW',h,Q)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.22 Heat transfer coefficient

```

1 //Chapter -7, Example 7.22, Page 320
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.022; //Diamter of the tube in m
8 v=2; //Average velocity in m/s
9 Tw=95; //Temperature of tube wall in degree C
10 T=[15,60]; //Initial and final temperature of water
    in degree C
11
12 //CALCULATIONS
13 Tm=(T(1)+T(2))/2; //Bulk mean temperature in degree C
14 p=990; //Density of air at 37.5 degree C in kg/m^3
15 Cp=4160; //Specific heat of air at 37.5 degree C in J
    /kg.K

```

```

16 u=(0.69*10^-3); //Dynamic viscosity of air at 37.5
    degree C in Ns/m^2
17 k=0.63; //Thermal conductivity of air at 37.5 degree
    C in W/m.K
18 us=(0.3*10^-3); //Dynamic viscosity of air at 37.5
    degree C in Ns/m^2
19 Re=(p*v*D)/u; //Reynolds number
20 Pr=(u*Cp)/k; //Prantl number
21 Nu=(0.027*Re^(4/5)*Pr^(1/3)*(u/us)^0.14); //Nusselts
    number
22 h=(Nu*k)/D; //Heat transfer coefficient in W/m^2.K
23
24 //OUTPUT
25 mprintf('Heat transfer coefficient is %3.0f W/m^2.K'
    ,h)
26
27 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.23 Heat transfer coefficient

```

1 //Chapter -7, Example 7.23, Page 320
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D=0.05; //Diamter of the tube in m
8 T=147; //Average temperature in degree C
9 v=0.8; //Flow vwlocity in m/s
10 Tw=200; //Wall temperature in degree C
11 L=2; //Length of the tube in m
12

```

```

13 //CALCULATIONS
14 p=812.1; //Density in kg/m^3 of oil at 147 degree C
15 Cp=2427; //Specific heat of oil at 147 degree C in J/
    kg.K
16 u=(6.94*10^-6); //Kinematic viscosity of oil at 147
    degree C in m^2/s
17 k=0.133; //Thermal conductivity of oil at 147 degree
    C in W/m.K
18 Pr=103; //prantl number of oil at 147 degree C
19 Re=(v*D)/u; //Reynolds number
20 Nu=(0.036*Re^0.8*Pr^(1/3)*(D/L)^0.055); //Nussults
    number
21 h=(Nu*k)/D; //Average heat transfer coefficient in W/
    m^2.K
22
23 //OUTPUT
24 fprintf('Average heat transfer coefficient is %3.1f
    W/m^2.K',h)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.24 Heat leakage

```

1 //Chapter -7, Example 7.24, Page 321
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 D=[0.4,0.8]; //Dimensions of the trunk duct in m
8 Ta=20; //Temperature of air in degree C
9 v=7; //Velocity of air in m/s

```

```

10 v1=(15.06*10^-6); //Kinematic viscosity in m^2/s
11 a=(7.71*10^-2); //Thermal diffusivity in m^2/h
12 k=0.0259; //Thermal conductivity in W/m.K
13
14 //CALCULATIONS
15 Dh=(4*(D(1)*D(2)))/(2*(D(1)+D(2))); //Value of Dh in
    m
16 Re=(v*Dh)/v1; //Reynolds number
17 Pr=(v1/a)*3600; //Prantl number
18 Nu=(0.023*Re^(4/5)*Pr^0.4); //Nussults number
19 h=(Nu*k)/Dh; //Heat transfer coefficient in W/m^2.K
20 Q=(h*(2*(D(1)+D(2)))); //Heat leakage per unit length
    per unit difference in W
21
22 //OUTPUT
23 fprintf('Heat leakage per unit length per unit
    difference is %3.2f W',Q)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.25 Heat transfer coefficient

```

1 //Chapter -7, Example 7.25, Page 322
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Di=0.03125; //I.D of the annulus in m
8 Do=0.05; //O.D of the annulus in m
9 Ts=50; //Outer surface temperature in degree C
10 Ti=16; //Temeperature at which air enters in degree C

```

```

11 Tf=32; //Temperature at which air exits in degree C
12 v=30; //Flow rate in m/s
13
14 //CALCULATIONS
15 Tb=(Ti+Tf)/2; //Mean bulk temperature of air in
    degree C
16 p=1.614; //Density in kg/m^3 of air at 24 degree C
17 Cp=1007; //Specific heat of air at 24 degree C in J/
    kg.K
18 u=(15.9*10^-6); //Kinematic viscosity of air at 24
    degree C in m^2/s
19 k=0.0263; //Thermal conductivity of air at 24 degree
    C in W/m.K
20 Pr=0.707; //prantl number of air at 24 degree C
21 Dh=(4*(3.14/4)*(Do^2-Di^2))/(3.14*(Do+Di)); //
    Hydraulic diameter in m
22 Re=(v*Dh)/u; //Reynolds number
23 Nu=(0.023*Re^0.8*Pr^0.4); //Nussults number
24 h=(Nu*k)/Dh; //Heat transfer coefficient in W/m^2.K
25
26 //OUTPUT
27 fprintf('Heat transfer coefficient is %3.1f W/m^2.K'
    ,h)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 7.26 Minimum length of the tube

```

1 //Chapter -7, Example 7.26, Page 324
2 //
    =====
3 clc
4 clear

```

```

5
6 //INPUT DATA
7 T=[120,149]; // Initail and final temperatures in
    degree C
8 m=2.3; //Mass flow rate in kg/s
9 D=0.025; //Diameter of the tube in m
10 Ts=200; //Surface temperature in degree C
11
12 //CALCULATIONS
13 Tb=(T(1)+T(2))/2; //Bulk mean temperature in degree C
14 p=916; //Density in kg/m^3 of air at 134.5 degree C
15 Cp=1356.6; //Specific heat of air at 134.5 degree C
    in J/kg.K
16 u=(0.594*10^-6); //Kinematic viscosity of air at
    134.5 degree C in m^2/s
17 k=84.9; //Thermal conductivity of air at 134.5 degree
    C in W/m.K
18 Pr=0.0087; //prantl number of air at 134.5 degree C
19 Q=(m*Cp*(T(2)-T(1)))/1000; //Total heat transfer in
    kW
20 v=(m/(p*(3.14/4)*D^2)); //Velocity of flow in m/s
21 Re=(v*D)/u; //Reynolds number
22 Pe=(Pr*Re); //Peclet number
23 Nu=(4.82+(0.0185*Pe^0.827)); //Nussults number
24 h=(Nu*k)/D; //Heat transfer coefficient in W/m^2.K
25 L=((Q*1000)/(h*3.14*D*(Ts-Tb))); //Minimum length of
    the tube in m if the wall temperature is not to
    exceed 200 degree C
26
27 //OUTPUT
28 mprintf('Minimum length of the tube if the wall
    temperature is not to exceed 200 degree C is %3.3
    f m',L)
29
30 //=====END OF PROGRAM
    =====

```

Chapter 8

Natural Convection

Scilab code Exa 8.1 Boundary layer thickness

```
1 //Chapter -8, Example 8.1, Page 340
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L=0.3; //Length of the glass plate in m
8 Ta=27; //Temperature of air in degree C
9 Ts=77; //Surface temperature in degree C
10 v=4; //Velocity of air in m/s
11
12 //CALCULATIONS
13 Tf=(Ta+Ts)/2; //Film temperature in degree C
14 k=0.02815; //Thermal conductivity in W/m.K
15 v1=(18.41*10^-6); //Kinematic viscosity in m^2/s
16 Pr=0.7; //Prantl number
17 b=(3.07*10^-3); //Coefficient of thermal expansion in
    1/K
18 Gr=(9.81*b*(Ts-Ta)*L^3)/v1^2; //Grashof number
```



```

19 q=L*((3.93*(1/sqrt(Pr))*(0.952+Pr)^0.25*Gr^(-0.25)))
    ;//Boundary layer thickness at the trailing edge
    of the plate in free convection in m
20 Re=(v*L)/v1;//Reynolds number
21 q1=(5*L)/sqrt(Re);//Boundary layer thickness at the
    trailing edge of the plate in forced convection
    in m
22
23 //OUTPUT
24 mprintf('Boundary layer thickness at the trailing
    edge of the plate in free convection is % 3.4f m
    \nBoundary layer thickness at the trailing edge
    of the plate in forced convection is %3.4f m',q,
    q1)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.2 Heat transfer coefficient

```

1 //Chapter –8, Example 8.2, Page 341
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 L=0.3;//Length of the glass plate in m
8 Ta=27;//Temperature of air in degree C
9 Ts=77;//Surface temperature in degree C
10 v=4;//Velocity of air in m/s
11
12 //CALCULATIONS
13 Tf=(Ta+Ts)/2;//Film temperature in degree C

```

```

14 k=0.02815; //Thermal conductivity in W/m.K
15 v1=(18.41*10^-6); //Kinematic viscosity in m^2/s
16 Pr=0.7; //Prantl number
17 b=(3.07*10^-3); //Coefficient of thermal expansion in
    1/K
18 Gr=(9.81*b*(Ts-Ta)*L^3)/v1^2; //Grashof number
19 Re=(v*L)/v1; //Reynolds number
20 Nu=(0.677*sqrt(Pr)*(0.952+Pr)^(-0.25)*Gr^0.25); //
    Nusselts number
21 h=(Nu*k)/L; //Heat transfer coefficient for natural
    convection in W/m^2.K
22 Nux=(0.664*sqrt(Re)*Pr^(1/3)); //Nusselts number
23 hx=(Nux*k)/L; //Heat transfer coefficient for forced
    convection in W/m^2.K
24
25 //OUTPUT
26 mprintf('Heat transfer coefficient for natural
    convection is %3.1f W/m^2.K \nHeat transfer
    coefficient for forced convection is %3.2f W/m^2.
    K',h,hx)
27
28 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.3 Heat transfer coefficient and rate of heat transfer

```

1 //Chapter -8, Example 8.3, Page 343
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 L=0.609; //Height of the metal plate in m

```

```

8 Ts=161; //Temperature of the wall in degree C
9 Ta=93; //Temperature of air in degree C
10
11 //CALCULATIONS
12 Tf=(Ts+Ta)/2; //Film temperature in degree C
13 k=0.0338; //Thermal conductivity in W/m.K
14 v1=(26.4*10^-6); //Kinematic viscosity in m^2/s
15 Pr=0.69; //Prantl number
16 b=0.0025; //Coefficient of thermal expansion in 1/K
17 a=(38.3*10^-6); //Thermal diffusivity in m^2/s
18 Ra=((9.81*b*L^3*(Ts-Ta))/(v1*a)); //Rayleigh number
19 Nu=(0.68+((0.67*Ra^0.25)/(1+(0.492/Pr)^(9/16)))^(4/9)
    ); //Nussults number
20 h=(Nu*k)/L; //Heat transfer coefficient in W/m^2.K
21 Q=(h*L*(Ts-Ta)); //Rate of heat transfer in W
22
23 //OUTPUT
24 mprintf('Heat transfer coefficient is %3.3f W/m^2.K
    \nRate of heat transfer is %3.2f W',h,Q)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.4 Convective heat loss

```

1 //Chapter-8, Example 8.4, Page 344
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 W=0.5; //Width of the radiator in m
8 L=1; //Height of the radiator in m

```

```

9 Ts=84; //Surface temperature in degree C
10 Ta=20; //Room temperature in degree C
11
12 //CALCULATIONS
13 Tf=(Ts+Ta)/2; //Film temperature in degree C
14 k=0.02815; //Thermal conductivity in W/m.K
15 v1=(18.41*10^-6); //Kinematic viscosity in m^2/s
16 Pr=0.7; //Prantl number
17 b=0.003077; //Coefficient of thermal expansion in 1/K
18 Ra=((9.81*b*L^3*(Ts-Ta)*Pr)/(v1^2)); //Rayleigh
    number
19 Nu=(0.825+((0.387*Ra^(1/6))/(1+(0.492/Pr)^(9/16))
    ^(8/27)))^2; //Nussults number
20 h=(Nu*k)/L; //Heat transfer coefficient in W/m^2.K
21 Q=(h*W*L*(Ts-Ta)); //Convective heat loss in W
22
23 //OUTPUT
24 mprintf('Convective heat loss from the radiator is
    %3.2 f W',Q)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.5 Rate of heat input

```

1 //Chapter-8, Example 8.5, Page 345
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 L=0.8; //Height of the plate in m
8 W=0.08; //Width of the plate in m

```

```

 9 Ts=170; //Surface temperature in degree C
10 Tw=70; //Temperature of water in degree C
11 Tf=130; //Final temperature in degree C
12
13 //CALCULATIONS
14 Tb=(Ts+Tw)/2; //Film temperature in degree C
15 p=960.63; //Density in kg/m^3
16 k=0.68; //Thermal conductivity in W/m.K
17 v1=(0.294*10^-6); //Kinematic viscosity in m^2/s
18 b=0.00075; //Coefficient of thermal expansion in 1/K
19 Cp=4216; //Specific heat in J/kg.K
20 a=(1.68*10^-7); //Thermal diffusivity in m^2/s
21 Lc=(W/2); //Characteristic length in m
22 Ra=((9.81*b*Lc^3*(Tf-Tw))/(v1*a)); //Rayleigh number
23 Nu1=(0.15*Ra^(1/3)); //Nusselts number
24 h1=(Nu1*k)/Lc; //Heat transfer coefficient at top
    surface in W/m^2.K
25 Nu2=0.27*(Ra)^(0.25); //Nusselts number
26 h2=(Nu2*k)/Lc; //Heat transfer coefficient at bottom
    surface in W/m^2.K
27 Q=((h1+h2)*W*L*(Tf-Tw))/1000; //Rate of heat input to
    the plate in kW
28
29 //OUTPUT
30 mprintf('Rate of heat input to the plate necessary
    to maintain the temperature at %3.0f degree C is
    %3.2f kW',Tf,Q)
31
32 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.6 Heat gained by the duct

```

1 //Chapter –8, Example 8.6, Page 346
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  L=0.3; //Height of the duct in m
8  W=0.6; //Width of the duct in m
9  Ts=15; //Surface temperature in degree C
10 Ta=25; //Temeprature of air in degree C
11
12 //CALCULATIONS
13 Tb=(Ts+Ta)/2; //Film temperature in degree C
14 p=1.205; //Density in kg/m^3
15 k=0.02593; //Thermal conductivity in W/m.K
16 v1=(15.06*10^-6); //Kinematic viscosity in m^2/s
17 b=0.00341; //Coefficient of thermal expansion in 1/K
18 Cp=1005; //Specific heat in J/kg.K
19 Pr=0.705; //Prantl number
20 Ra=((9.81*b*L^3*(Ta-Ts)*Pr)/(v1^2)); //Rayleigh
    number
21 Nux=(0.59*Ra^(0.25)); //Nusselts number
22 hx=(Nux*k)/L; //Heat transfer coefficient in W/m^2.K
23 Lc=(W/2); //Characteristic length in m
24 Nu1=(0.15*Ra^(1/3)); //Nussults number
25 h1=(Nu1*k)/Lc; //Heat transfer coefficient at top
    surface in W/m^2.K
26 Nu2=0.27*(Ra)^(0.25); //Nusselts number
27 h2=(Nu2*k)/Lc; //Heat transfer coefficient at bottom
    surface in W/m^2.K
28 Q=((2*hx*L)+(W*(h1+h2)))*(Ta-Ts); //Rate of heat
    gained per unit length in W/m
29
30 //OUTPUT
31 mprintf('Rate of heat gained per unit length is %3.2
    f W/m',Q)
32
33 //=====END OF PROGRAM

```

Scilab code Exa 8.7 Coefficient of heat transfer

```
1 //Chapter –8, Example 8.7, Page 348
2 //
3 clc
4 clear
5
6 //INPUT DATA
7 LH=0.08; //Horizontal length in m
8 LV=0.12; //Vertical length in m
9 Ts=50; //Surface temperature in degree C
10 Ta=0; //Tempeprature of air in degree C
11
12 //CALCULATIONS
13 L=(LH*LV)/(LH+LV); // Characteristic length in m
14 Tb=(Ts+Ta)/2; //Film temperature in degree C
15 p=0.707; //Density in kg/m^3
16 k=0.0263; //Thermal conductivity in W/m.K
17 v1=(15.89*10^-6); //Kinematic viscosity in m^2/s
18 b=(1/300); //Coefficient of thermal expansion in 1/K
19 Pr=0.707; //Prantl number
20 Gr=((9.81*b*L^3*(Ts-Ta))/(v1^2)); //Grashof number
21 Nu=0.55*Gr^(0.25); //Nussults number
22 h=(Nu*k)/L; //Heat transfer coefficient in W/m^2.K
23
24 //OUTPUT
25 mprintf('Heat transfer coefficient is %3.2 f W/m^2.K'
26         ,h)
27 //=====END OF PROGRAM
```

Scilab code Exa 8.8 Rate of heat loss

```
1 //Chapter –8, Example 8.8, Page 349
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 D=0.2; //Outer diameter of the pipe in m
8 Ts=100; //Surface temperature in degree C
9 Ta=20; //Temperature of air in degree C
10 L=3; //Length of pipe in m
11
12 //CALCULATIONS
13 Tf=(Ts+Ta)/2; //Film temperature in degree C
14 k=0.02896; //Thermal conductivity in W/m.K
15 v1=(18.97*10-6); //Kinematic viscosity in m2/s
16 b=(1/333); //Coefficient of thermal expansion in 1/K
17 Pr=0.696; //Prantl number
18 Gr=((9.81*b*L3*(Ts-Ta))/(v12)); //Grashof number
19 Ra=(Gr*Pr); //Rayleigh number
20 Nu=(0.1*Ra(1/3)); //Nussults number
21 h=(Nu*k)/L; //Heat transfer coefficient in W/m2.K
22 Q=(h*3.14*D*(Ts-Ta)); //Rate of heat loss per meter
    length of pipe in W/m
23
24 //OUTPUT
25 mprintf('Rate of heat loss per meter length of pipe
    is %3.2 f W/m', Q)
26
27 //=====END OF PROGRAM
    =====
```

Scilab code Exa 8.9 Rate of heat loss

```
1 //Chapter –8, Example 8.9 , Page 350
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 D=0.1; //Outer diamter of the pipe in m
8 Ta=30; //Ambient temperature of air degree C
9 Ts=170; //Surface temperature in degree C
10 e=0.9; //Emissivity
11
12 //CALCULATIONS
13 Tb=(Ts+Ta)/2; //Film temperature in degree C
14 k=0.0321; //Thermal conductivity in W/m.K
15 v1=(23.13*10^-6); //Kinematic viscosity in m^2/s
16 b=0.00268; //Coefficient of thermal expansion in 1/K
17 Pr=0.688; //Prantl number
18 Ra=((9.81*b*D^3*(Ts-Ta)*Pr)/(v1^2)); //Rayleigh
    number
19 Nu=(0.6+((0.387*Ra^(1/6))/(1+(0.559/Pr)^(9/16)))
    ^(8/27)))^2; //Nussults number
20 h=(Nu*k)/D; //Heat transfer coefficient in W/m^2.K
21 Q=(h*3.1415*D*(Ts-Ta))+(e*3.1415*D*5.67*10^-8*((Ts
    +273)^4-(Ta+273)^4)); //Total heat loss per meter
    length of pipe in m
22
23 //OUTPUT
24 mprintf('Total heat loss per meter length of pipe is
    %3.2 f W/m',Q)
25
```

```
26 //=====END OF PROGRAM
    =====
```

Scilab code Exa 8.10 Coefficient of heat transfer and current intensity

```
1 //Chapter –8, Example 8.10, Page 351
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ta=25; //Temperature of air in degree C
8 Ts=95; //Surface temperature of wire in degree C
9 D=0.0025; //Diameter of wire in m
10 R=6; //Resistivity in ohm/m
11
12 //CALCULATIONS
13 Tf=(Ts+Ta)/2; //Film temperature in degree C
14 k=0.02896; //Thermal conductivity in W/m.K
15 v1=(18.97*10^-6); //Kinematic viscosity in m^2/s
16 b=(1/333); //Coefficient of thermal expansion in 1/K
17 Pr=0.696; //Prantl number
18 Gr=((9.81*b*D^3*(Ts-Ta))/(v1^2)); //Grashof number
19 Ra=(Gr*Pr); //Rayleigh number
20 Nu=(1.18*Ra^(1/8)); //Nussults number
21 h=(Nu*k)/D; //Heat transfer coefficient in W/m^2.K
22 Q=(h*3.14*D*(Ts-Ta)); //Rate of heat loss per unit
    length of wire in W/m
23 I=sqrt(Q/R); //Maximum current intensity in A
24
25 //OUTPUT
26 mprintf('Heat transfer coefficient is %3.2f W/m^2.K
    \nMaximum current intensity is %3.2f A',h,I)
```

```

27
28 //=====END OF PROGRAM

```

Scilab code Exa 8.11 Rate of convective heat loss

```

1 //Chapter -8, Example 8.11, Page 352
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.01;//Diameter of spherical steel ball in m
8 Ts=260;//Surface temperature in degree C
9 Ta=20;//Temperature of air in degree C
10
11 //CALCULATIONS
12 Tf=(Ts+Ta)/2;//Film temperature in degree C
13 k=0.0349;//Thermal conductivity in W/m.K
14 v1=(27.8*10^-6);//Kinematic viscosity in m^2/s
15 b=(1/413);//Coefficient of thermal expansion in 1/K
16 Pr=0.684;//Prantl number
17 Ra=((9.81*b*D^3*(Ts-20)*Pr)/(v1^2));//Rayleigh
    number
18 Nu=(2+(0.43*Ra^0.25));//Nusselts number
19 h=(k*Nu)/D;//Heat transfer coefficient in W/m^2.K
20 Q=(h*3.14*D^2*(Ts-Ta));//Rate of heat loss in W
21
22 //OUTPUT
23 mprintf('Rate of convective heat loss is %3.2f W',Q)
24
25 //=====END OF PROGRAM

```

Scilab code Exa 8.12 Rate of heat loss

```
1 //Chapter –8, Example 8.12, Page 353
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 D=0.1; //Outer diamter of the pipe in m
8 Ta=30; //Ambient temperature of air degree C
9 Ts=170; //Surface temperature in degree C
10 e=0.9; //Emissivity
11
12 //CALCULATIONS
13 h=(1.32*((Ts-Ta)/D)^0.25); //Heat transfer
    coefficient in W/m^2.K
14 q=(h*3.1415*D*(Ts-Ta)); //Heat transfer in W/m
15
16 //OUTPUT
17 mprintf('Heat loss due to free convection is %3.2f W
    /m', q)
18
19 //=====END OF PROGRAM
    =====
```

Scilab code Exa 8.13 Thermal conductivity and heat flow

```
1 //Chapter –8, Example 8.13, Page 355
```

```

2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 L=0.015; //Thickness of the slot in m
8 D=2; //Dimension of square plate in m
9 T1=120; //Temperature of plate 1
10 T2=20; //Temperature of plate 2
11
12 //CALCULATIONS
13 Tf=(T1+T2)/2; //Film temperature in degree C
14 k=0.0295; //Thermal conductivity in W/m.K
15 v1=(2*10^-5); //Kinematic viscosity in m^2/s
16 b=(1/343); //Coefficient of thermal expansion in 1/K
17 Gr=((9.81*b*L^3*(T1-T2))/(v1^2)); //Grashof number
18 ke=(0.064*k*Gr^(1/3)*(D/L)^(-1/9)); //Effective
    thermal conductivity in W/m.K
19 Q=(ke*D^2*(T1-T2))/L; //Rate of heat transfer in W
20
21 //OUTPUT
22 mprintf('Effective thermal conductivity is %3.4f W/m
    .K \nRate of heat transfer is %3.1f W',ke,Q)
23
24 //=====END OF PROGRAM


---



```

Scilab code Exa 8.14 Free convection heat transfer

```

1 //Chapter -8, Example 8.14, Page 356
2 //


---



```

```

3  clc
4  clear
5
6  //INPUT DATA
7  d=0.0254; //Distance between the plates in m
8  Tl=60; //Temperature of the lower panel in degree C
9  Tu=15.6; //Temperature of the upper panel in degree C
10
11 //CALCULATIONS
12 Tf=(Tl+Tu)/2; //Film temperature in degree C
13 p=1.121; //Density in kg/m^3
14 k=0.0292; //Thermal conductivity in W/m.K
15 v1=(0.171*10^-4); //Kinematic viscosity in m^2/s
16 b=(3.22*10^-3); //Coefficient of thermal expansion in
    1/K
17 Pr=0.7; //Prantl number
18 Gr=((9.81*b*d^3*(Tl-Tu))/(v1^2)); //Grashof number
19 Nu=(0.195*Gr^0.25); //Nussults number
20 q=(Nu*k*(Tl-Tu))/d; //Heat flux across the gap in W/m
    ^2
21
22 //OUTPUT
23 mprintf('Free convection heat transfer is %3.1f W/m
    ^2',q)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.15 Convective heat transfer coefficient

```

1 //Chapter-8, Example 8.15, Page 359
2 //
    =====
3  clc

```

```

4  clear
5
6  //INPUT DATA
7  p=3; //Pressure of air in atm
8  r1=0.075; //Radius of first sphere in m
9  r2=0.1; //Radius of second sphere in m
10 L=0.025; //Distance in m
11 T1=325; //Temperature of first sphere in K
12 T2=275; //Temperature of second sphere in K
13 R=287; //Universal gas constant in J/
14
15 //CALCULATIONS
16 Tf=(T1+T2)/2; //Film temperature in degree C
17 d=(p/(R*Tf)); //Density in kg/m^3
18 k=0.0263; //Thermal conductivity in W/m.K
19 v1=(5.23*10^-6); //Kinematic viscosity in m^2/s
20 b=(1/300); //Coefficient of thermal expansion in 1/K
21 Pr=0.707; //Prantl numbe
22 Gr=((9.81*b*L^3*(T1-T2))/(v1^2)); //Grashof number
23 Ra=(Gr*Pr); //Rayleigh number
24 Ra1=((L/((4*r1*r2)^4))*(Ra/((2*r1)^(-7/5)+(2*r2)
    ^(-7/5))^5))^0.25; //Equivalent Rayleigh's number
25 ke=(k*0.74*((Pr*Ra1)/(0.861+Pr))^0.25); //Effective
    thermal conductivity in W/m.K
26 Q=(ke*3.14*4*r1*r2*(T1-T2))/L; //Rate of heat loss in
    W
27
28 //OUTPUT
29 mprintf('Convection heat transfer rate is %3.2f W',Q
    )
30
31 //=====END OF PROGRAM
    =====

```

Scilab code Exa 8.16 Heat transfer

```

1 //Chapter –8, Example 8.16 , Page 362
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 p=1;//Pressure of air in atm
8 Ta=27;//Temperature of air in degree C
9 D=0.02;//Diamter of the tube in m
10 v=0.3;//Velocity of air in m/s
11 Ts=127;//Surface temperature in degree C
12 L=1;//Length of the tube in m
13
14 //CALCULATIONS
15 k=0.0262;//Thermal conductivity in W/m.K
16 v1=(1.568*10^-5);//Kinematic viscosity in m^2/s
17 Pr=0.708;//Prantl number
18 b=(1/300);//Coefficient of thermal expansion in 1/K
19 ub=(1.847*10^-5);//Dynamic viscosity in Ns/m^2
20 us=(2.286*10^-5);//Viscosity of wall in Ns/m^2
21 Re=(v*D)/v1;//Reynolds number
22 Gr=((9.81*b*D^3*(Ts-Ta))/(v1^2));//Grashof number
23 Gz=(Re*Pr*(D/L));//Graetz number
24 Nu=(1.75*(ub/us)^0.14*(Gz+(0.012*(Gz*Gr^(1/3)))^(4/3)
    ))^(1/3));//Nussults number
25 h=(k*Nu)/D;//Heat transfer coefficient in W/m^2.K
26 Q=(h*3.14*D*L*(Ts-Ta));//Heat transfer in W
27
28 //OUTPUT
29 mprintf('Heat transfer in the tube is %3.2f W',Q)
30
31 //=====END OF PROGRAM

```

Chapter 9

Thermal radiation basic relations

Scilab code Exa 9.1 Rate of solar radiation

```
1 //Chapter -9, Example 9.1, Page 378
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 T=5527; //Temperature of black body in degree C
8 D=(1.39*10^6); //Diameter of the sun in km
9 L=(1.5*10^8); //Distance between the earth and sun in
   km
10
11 //CALCULATIONS
12 q=(5.67*10^-8*(T+273)^4*D^2)/(4*L^2); //Rate of solar
   radiation in W/m^2
13
14 //OUTPUT
15 mprintf('Rate of solar radiation on a plane normal
```

```

    to sun rays is %3.0f W/m^2',q)
16
17 //=====END OF PROGRAM
    =====

```

Scilab code Exa 9.2 Fraction of thermal radiation emitted by the surface

```

1 //Chapter -9, Example 9.2, Page 383
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=(727+273); //Temperature of black body in K
8 l1=1; //Wavelength in micro meter
9 l2=5; //Wavelength in micro meter
10 F1=0.0003; //From Table 9.2 on page no. 385
11 F2=0.6337; //From Table 9.2 on page no. 385
12
13 //CALCULATIONS
14 a=(5.67*10^-8*T^4)/1000; //Heat transfer in kW/m^2
15 F=(F2-F1)*a; //Fraction of thermal radiation emitted
    by the surface in kW/m^2
16
17 //OUTPUT
18 mprintf('Fraction of thermal radiation emitted by
    the surface is %3.1f kW/m^2',F)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 9.3 Hemispherical transmittivity

```
1 //Chapter -9, Example 9.3, Page 384
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 t=0.8; //Transmittivity of glass in the region except
      in the wave length region [0.4,3]
8 T=5555; //Temperature of black body in K
9
10 //CALCULATIONS
11 ao=0; //a0 in micro K
12 a1=(0.4*T); //a1 for the wavelength 0.4 micro meter
      in micro K
13 a2=(3*T); //a1 for the wavelength 3 micro meter in
      micro K
14 F0=0; //From Table 9.2 on page no.385
15 F1=0.10503; //From Table 9.2 on page no.385
16 F2=0.97644; //From Table 9.2 on page no.385
17 t1=t*(F2-F1); //Average hemispherical transmittivity
      of glass
18
19 //OUTPUT
20 mprintf('Average hemispherical transmittivity of
      glass is %3.2f',t1)
21
22 //=====END OF PROGRAM


---


```

Scilab code Exa 9.4 Surface temperature and emmusive power

```

1 //Chapter -9, Example 9.4, Page 386
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 l=0.5; //Wavelength at maximum intensity of radiation
      in micro meter
8
9 //CALCULATIONS
10 T=(0.289*10^-2)/(l*10^-6); //Temperature according to
      Wien's displacement law in degree C
11 E=(5.67*10^-8*T^4)/10^6; //Emissive power using
      Stefan-Boltzmann law in MW/m^2
12
13 //OUTPUT
14 mprintf('Surface temperature is %3.0f K \nEmissive
      power is %3.1f MW/m^2',T,E)
15
16 //=====END OF PROGRAM


---



```

Scilab code Exa 9.5 Emmissivity and wave length

```

1 //Chapter -9, Example 9.5, Page 389
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 Ts=(827+273); //Surface temperature in degree C

```

```

8 E=(1.37*10^10); //Emmision power in W/m^3
9
10 //CALCULATIONS
11 Eblmax=(1.307*10^-5*Ts^5); //Maximum emissive power
    in W/m^3
12 e=(E/Eblmax); //Emissivity of the body
13 lmax=((0.289*10^-2)/Ts)/10^-6; //Wavelength
    corresponding to the maximum spectral intensity of
    radiation in micro meter
14
15 //OUTPUT
16 mprintf('Wavelength corresponding to the maximum
    spectral intensity of radiation is %3.2f micro
    meter ',lmax)
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 9.6 True temperature of the body

```

1 //Chapter -9, Example 9.6, Page 389
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=(1400+273); //Temperature of the body in K
8 l=0.65; //Wavelength in micro meter
9 e=0.6; //Emissivity
10
11 //CALCULATIONS
12 T=(1/((1/T)-((1*10^-6*log(1/e))/(1.439*10^-2)))); //
    Temperature of the body in K

```

```

13 Tb=(T-273); //Temperature of the body in degree C
14
15 //OUTPUT
16 mprintf('Temperature of the body is %3.0f degree C',
    Tb)
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 9.7 Rate of absorption and emission

```

1 //Chapter –9, Example 9.7, Page 391
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ts=(37+273); //Temperature of metallic bar in K
8 T=1100; //Interior temperature in K
9 a=0.52; //Absorptivity at 1100 K
10 e=0.8; //Emissivity at 310 K
11 //CALCULATIONS
12 Q=(a*5.67*10^-8*T^4)/1000; //Rate of absorption in kW
    /m^2
13 E=(e*5.67*10^-8*Ts^4)/1000; //Rate of emissin in kW/m
    ^2
14
15 //OUTPUT
16 mprintf('Rate of absorption is %3.2f kW/m^2 \nRate
    of emissin is %3.2f kW/m^2 ',Q,E)
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 9.8 Energy absorbed and transmitted

```
1 //Chapter –9, Example 9.8, Page 391
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 e1=0.3//Emissivity of glass upto 3 micro meter
8 e2=0.9;//Emissivity of glass above 3 micro meter
9 t=0.8;//Transmittivity of glass in the region except
   in the wave length region [0.4,3]
10
11 //CALCULATIONS
12 E=(5.67*10-8*57804)/106;//Emissive power in MW/m2
13 F1=0.10503;//From Table 9.2 on page no.385
14 F2=0.97644;//From Table 9.2 on page no.385
15 I=(E*106*(F2-F1))/106;//Total incident radiation
   in MW/m2
16 T=(t*I);//Total radiation transmitted in MW/m2
17 t1=(e1*I);//Absorbed radiation in MW/m2 in
   wavelength [0.4,3] micro meter
18 t2=(e1*E*F1);//Absorbed radiation in MW/m2 in
   wavelength not in the range [0.4,3] micro meter
19 t3=(e2*(1-F2)*E);//Absorbed radiation in MW/m2 in
   wavelength greater than 3 micro meter
20 R=(t1+t2+t3);//Total radiation absorbed in MW/m2
21
22 //OUTPUT
23 mprintf('Total radiation transmitted is %3.2f MW/m2
   \nTotal radiation absorbed is %3.2f MW/m2',T,R)
```

24

25 //=====END OF PROGRAM
=====

Chapter 10

Radiative Heat exchange between surfaces

Scilab code Exa 10.1 Surface temperature

```
1 //Chapter –10, Example 10.1, Page 403
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 I=1350; //Solar Irradiation in W/m^2
8 L=(1.5*10^8); //Approximate distance in km
9 D=(1.39*10^6); //Approximate diameter in km
10
11
12 //CALCULATIONS
13 E=(I*(L*1000)^2*3.14)/((3.14/4)*(D*1000)^2); //
    Emissive power of Earth
14 Ts=(E/(5.67*10^-8))^0.25; //Surface temperature of
    sun in K
15
```

```

16 //OUTPUT
17 mprintf('Surface temperature of sun is %3.0f K',Ts)
18
19 //=====END OF PROGRAM
=====

```

Scilab code Exa 10.4 Net exchange of energy

```

1 //Chapter -10, Example 10.4, Page 409
2 //
=====

3 clc
4 clear
5
6 //INPUT DATA
7 S=1; //Side of a square in m
8 L=0.4; //Distance between the plates in m
9 T1=900; //Temperature of one plate in degree C
10 T2=400; //Temperature of the other plate in degree C
11
12 //CALCULATIONS
13 R=(S/L); //Ratio of the side of the square to the
           distance between plates
14 F12=0.415; //From Fig.10.4 on page no.409
15 Q=(5.67*10^-8*S*S*F12*((T1+273)^4-(T2+273)^4))/1000;
           //The net heat transfer in kW
16
17 //OUTPUT
18 mprintf('The net exchange of energy due to radiation
           between the plates is %3.1f kW',Q)
19
20 //=====END OF PROGRAM
=====

```

Scilab code Exa 10.5 Shape factor

```
1 //Chapter –10, Example 10.5, Page 411
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 A51=2; //Ratio of areas A5 and A1
8 A21=1; //Ratio of areas A2 and A1
9 F56=0.15; //Shape factor
10 F53=0.11; //Shape factor
11 F26=0.24; //Shape Factor
12 F23=0.2; //Shape Factor
13
14 //CALCULATIONS
15 F14=(A51*(F56-F53))-(A21*(F26-F23)); //Shape factor
16
17 //OUTPUT
18 mprintf('Shape factor F14 is %3.2f',F14)
19
20 //=====END OF PROGRAM


---


```

Scilab code Exa 10.8 Net heat exchange

```
1 //Chapter –10, Example 10.8, Page 415
2 //


---


```

```

3  clc
4  clear
5
6  //INPUT DATA
7  Th=40; //Radiating heating panel in degree C
8  Tb=5; //Temperature of black plane in degree C
9  Tc=31; //Temperature of ceiling in degree C
10 A=(10*12); //Area in m^2
11
12 //CALCULATIONS
13 F56=0.075; //Using Fig.10.2 on page no. 408
14 F63=0.04; //Using Fig.10.2 on page no. 408
15 F12=0.052; //Shape factor
16 F1w=(1-F12); //Shape factor between the floor and all
    the walls but the window
17 Q12=(A*F12*5.67*10^-8*((Th+273)^4-(Tb+273)^4)); //
    Heat exchange between the floor and window in W
18 Q1=(5.67*10^-8*A*((Th+273.15)^4-((F12*(Th+273.15)^4)
    -(F1w*(Tb+273.15)^4))))/1000; //Net heat given up
    by the floor in kW
19
20 //OUTPUT
21 mprintf('Heat exchange between the floor and window
    is %3.0f W \nNet heat given up by the floor is %3
    .1f kW',Q12,Q1)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.14 Net heat exchange and equilibrium temperature

```

1 //Chapter -10, Example 10.14, Page 424
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  A2=(6*2); //Area of windows in m^2
8  A1=(10*12); //Area of floor in m^2
9  Th=40; //Radiating heating panel in degree C
10 Tb=5; //Temperature of black plane in degree C
11 F12=0.052; //Shape factor
12
13 //CALCULATIONS
14 F12a=((A2-(A1*F12^2))/(A1+A2-(2*A1*F12))); //Shape
    factor
15 Q12=(A1*F12a*5.67*10^-8*((Th+273)^4-(Tb+273)^4)); //
    Net heat exchange in W
16 X=(((A2/A1)-F12)/(1-F12)); //X value for equilibrium
    temperature
17 T=(((Th+273)^4+(X*(Tb+273)^4))/(X+1))^0.25; //
    Equilibrium temperature in K
18
19 //OUTPUT
20 mprintf('Net heat exchange is %3.0f W \nEquilibrium
    temperature is %3.2f K',Q12,T)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.15 Radiant heat exchange

```

1  //Chapter -10, Example 10.15, Page 430
2  //
    =====
3  clc
4  clear

```

```

5
6 //INPUT DATA
7 D=0.2;//Diameter of each disc in m
8 L=2;//Distance between the plates in m
9 T=[800+273,300+273]);//Temperatures of the plates in
   K
10 e=[0.3,0.5]);//Emissivities of plates
11
12 //CALCULATIONS
13 e1=(e(1)*e(2));//Equivalent emissivity
14 R=(D/L);//Ratio between diameter and distance
   between the plates
15 F=0.014;//F value from Fig.10.4 from page no. 409
16 Q=(e1*(3.14/4)*D^2*F*5.67*10^-8*((T(1)^4-(T(2)^4))))
   ;//Radiant heat exchange for the plates in W
17
18 //OUTPUT
19 mprintf('Radiant heat exchange for the plates is %3
   .2 f W',Q)
20
21 //=====END OF PROGRAM
   =====

```

Scilab code Exa 10.16 Radiant heat exchange

```

1 //Chapter –10, Example 10.16 , Page 430
2 //
   =====
3 clc
4 clear
5
6 //INPUT DATA
7 e=0.8;//Emissivity of brick wall
8 D1=[6,4]);//Width and Height in m

```

```

9 L=0.04; //Distance from the wall in m
10 D2=[0.2,0.2]; //Dimensions of the furnace wall in m
11 D3=[1,1]; //Dimensions at lower and left of the
    centre of the wall in m
12 T=[1523+273,37+273]; //Furnace temperature and wall
    temperature in degree C
13
14 //CALCULATIONS
15 F12=0.033; //Shape factor from Fig.10.3 on page no.
    409
16 F13=0.05; //Shape factor from Fig.10.3 on page no.
    409
17 F14=0.12; //Shape factor from Fig.10.3 on page no.
    409
18 F15=0.08; //Shape factor from Fig.10.3 on page no.
    409
19 Fow=(F12+F13+F14+F15); //Shape factor between opening
    and wall
20 Q=(e*L*Fow*5.67*10^-8*(T(1)^4-T(2)^4))/1000; //Net
    radiation exchange in kW
21
22 //OUTPUT
23 mprintf('Net radiation exchange between the opening
    and the wall is %3.1f kW',Q)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.17 Reduction in heat loss

```

1 //Chapter –10, Example 10.17, Page 431
2 //
    =====
3 clc

```

```

4 clear
5
6 //INPUT DATA
7 D=[2,1,1]; //Dimensions of the tank in m
8 A=8; //Area of the tank in m^2
9 e=0.9; //Surface emissivity
10 Ts=25+273; //Surface temperature in K
11 Ta=2+273; //Ambient temperature in K
12 e1=0.5; //Emissivity of aluminium
13
14 //CALCULATIONS
15 Q=(e*A*5.67*10^-8*(Ts^4-Ta^4))/1000; //Heat lost by
    radiation in kW
16 r=((e-e1)/e)*Q; //Reduction in heat loss if the tank
    is coated with an aluminium paint in kW
17
18 //OUTPUT
19 mprintf('Heat lost by radiation is %3.2f kW \
    nReduction in heat loss if the tank is coated
    with an aluminium paint is %3.3f kW',Q,r)
20
21 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.18 Loss of heat

```

1 //Chapter -10, Example 10.18, Page 432
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.2; //Outer diameter of the pipe in m

```



```

8 Ta=30+273; //Temperature of the air in K
9 Ts=400+273; //Surface temperature in K
10 e=0.8; //Emissivity of the pipe surface
11 D1=0.4; //Diamter of brick in m
12 e1=0.91; //Emissivity of brick
13
14 //CALCULATIONS
15 Q=(e*3.14*D*5.67*10^-8*(Ts^4-Ta^4))/1000; //Loss of
    heat by thermal radiation in kW/m
16 e2=(1/((1/e)+((D/D1)*((1/e1)-1))))); //Equivalent
    emissivity
17 Q1=(e2*3.14*D*5.67*10^-8*(Ts^4-Ta^4))/1000; //Heat
    loss when brick is used in kW/m
18 r=(Q-Q1)*1000; //Reduction in heat loss in W/m
19
20 //OUTPUT
21 mprintf('Loss of heat by thermal radiation is %3.1f
    *10^3 W/m \nReduction in heat loss is %3.0f W/m',
    Q,r)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.19 Radiation heat transfer

```

1 //Chapter -10, Example 10.19, Page 433
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 e=0.03; //Emissivity of silver
8 T2=-153+273; //Temperature of the outer surface of

```

```

    the inner wall in K
9  T1=27+273; //Temperature of the inner surface of the
    outer wall in K
10 D1=0.42; //Diameter of first sphere in m
11 D2=0.6; //Diameter of the second sphere in m
12 V=220; //Rate of vapourization in kJ/kg
13
14 //CALCULATIONS
15 e1=(1/((1/e)+((D1/D2)^2*((1/e)-1)))); //Equivalent
    emissivity
16 A=(4*3.14*(D1/2)^2); //Area in m^2
17 Q=(e1*A*5.67*10^-8*(T1^4-T2^4))/(1000/3600); //
    Radiation heat transfer through walls into the
    vessel in kJ/h
18 R=(Q/V); //Rate of evaporation in kg/h
19
20 //OUTPUT
21 mprintf('Radiation heat transfer through walls into
    the vessel is %3.3f kJ/h \nRate of evaporation of
    liquid oxygen is %3.4f kg/h',Q,R)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.20 Net radiant heat exchange

```

1 //Chapter -10, Example 10.20, Page 433
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=[800+273,300+273]; //Temperatures of the plates in

```

```

      K
8  e=[0.3,0.5]; // Emissivities of the plates
9
10 //CALCULATIONS
11 Q=((5.67*10^-8*(T(1)^4-T(2)^4))/((1/e(1))+((1/e(2))
      -1))/1000; //Net radiant heat exchange in kW/m^2
12
13 //OUTPUT
14 mprintf('Net radiant heat exchange is %3.2f kW/m^2',
      Q)
15
16 //=====END OF PROGRAM
      =====

```

Scilab code Exa 10.21 Loss of heat

```

1 //Chapter -10, Example 10.21, Page 434
2 //
      =====
3 clc
4 clear
5
6 //INPUT DATA
7 T1=127+273; //Temperature of the outer side of the
      brick setting in K
8 T2=50+273; //Temperature of the inside of the steel
      plate in K
9 e1=0.6; //Emissivity of steel
10 e2=0.8; //Emissivity of fireclay
11
12 //CALCULATIONS
13 Q=((5.67*10^-8*(T1^4-T2^4))/((1/e1)+((1/e2))-1)); //
      Net radiant heat exchange in W/m^2
14

```

```

15 //OUTPUT
16 mprintf('Net radiant heat exchange is %3.0f W/m^2',Q
    )
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.22 Net heat transfer

```

1 //Chapter –10, Example 10.22, Page 445
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=1;//Dimension of the plate in m
8 L=0.5;//Distance between the plates in m
9 Ts=27+273;//Surface temperature of the walls in K
10 T=[900+273,400+273];//Temperature of the plates in K
11 e=[0.2,0.5];//Emissivities of the plates
12
13 //CALCULATIONS
14 F12=0.415;//From Fig.10.4 on page no.409
15 F13=(1-F12);//Shape factor
16 F23=(1-F12);//Shape factor
17 R1=(1-e(1))/(e(1)*D*D);//Resistance for 1
18 R2=(1-e(2))/(e(2)*D*D);//Resistance for 2
19 R3=0;//Resistance for 3
20 A1F12I=(1/(D*D*F12));//Inverse of the product of
    area and Shape factor
21 A1F13I=(1/(D*D*F13));//Inverse of the product of
    area and Shape factor
22 A2F23I=(1/(D*D*F23));//Inverse of the product of

```

```

    area and Shape factor
23 Eb1=(5.67*10^-8*T(1)^4)/1000; //Emissive power of 1
    in kW/m^2
24 Eb2=(5.67*10^-8*T(2)^4)/1000; //Emissive power of 2
    in kW/m^2
25 Eb3=(5.67*10^-8*Ts^4); //Emissive power of 3 in W/m^2
26 J1=25; //Radiosity at node 1 in kW/m^2
27 J2=11.53; //Radiosity at node 2 in kW/m^2
28 J3=0.46; //Radiosity at node 3 in kW/m^2
29 Q1=((Eb1-J1)/R1); //Total heat loss by plate 1 in kW
30 Q2=((Eb2-J2)/R2); //Total heat loss by plate 2 in kW
31 Q3=((J1-J3)/(A1F13I))+((J2-J3)/(A2F23I)); //Total
    heat received by the room in kW
32
33 //OUTPUT
34 mprintf('Total heat loss by plate 1 is %3.1f kW \
    nTotal heat loss by plate 2 is %3.1f kW \nTotal
    heat received by the room is %3.2f kW',Q1,Q2,Q3)
35
36 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.23 Percentage reduction in heat transfer and temperature of the shield

```

1 //Chapter -10, Example 10.23, Page 447
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=[800+273,300+273]; //Temperatures of the plates in
    K

```

```

8 e=[0.3,0.5]; //Emissivities of the plates
9 e3=0.05; //Emissivity of aluminium
10
11 //CALCULATIONS
12 q=((5.67*10^-8*(T(1)^4-T(2)^4))/((1/e(1))+(1/e(2))
    -1))/1000; //Heat transfer without the shield in
    kW/m^2
13 R1=(1-e(1))/e(1); //Resistance in 1
14 R2=(1-e(2))/e(2); //Resistance in 2
15 R3=(1-e3)/e3; //Resistance in 3
16 R=(R1+(2*R2)+(2*R3)); //Total resistance
17 q1=((5.67*10^-8*(T(1)^4-T(2)^4))/R)/1000; //Heat
    transfer with shield in kW/m^2
18 r=((q-q1)*100)/q; //Reduction in heat transfer
19 X1=((1/e3)+(1/e(2))-1); //X1 for tempearture T3
20 X2=((1/e(1))+(1/e3)-1); //X1 for tempearture T3
21 T3=(((X1*T(1)^4)+(X2*T(2)^4))/(X2+X1))^0.25; //
    Temperature of the sheild in K
22 T3c=T3-273; //Temperature of the sheild in degree C
23
24 //OUTPUT
25 mprintf('Percentage reduction in heat transfer is %3
    .0f percent \nTemperature of the sheild is %3.2f
    degree C',r,T3c)
26
27 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.24 Number of screens

```

1 //Chapter -10, Example 10.24, Page 448
2 //
    =====
3 clc

```

```

4 clear
5
6 //INPUT DATA
7 Q=79; //Reduction in net radiation from the surfaces
8 e1=0.05; //Emissivity of the screen
9 e2=0.8; //Emissivity of the surface
10
11 //CALCULATIONS
12 n=((Q*((2/e2)-1))-((2/e2)+1))/((2/e1)-1); //Number
    of screens to be placed between the two surfaces
    to achieve the reduction in heat exchange
13
14 //OUTPUT
15 mprintf('Number of screens to be placed between the
    two surfaces to achieve the reduction in heat
    exchange is%3.0f',n)
16
17 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.25 Loss of heat and reduction in heat

```

1 //Chapter –10, Example 10.25, Page 449
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 e=0.8; //Emissivity of the pipe
8 D=0.275; //Diameter of the pipe in m
9 Ts=500+273; //Surface temperature in K
10 Te=30+273; //Temperature of enclosure in K
11 D1=0.325; //Diamter of the steel screen in m

```

```

12 e1=0.7; //Emissivity of steel screen
13 Tsc=240+273; //Temperature of screen in K
14
15 //CALCUATIONS
16 Q=(e*5.67*10^-8*3.14*D*(Ts^4-Te^4))/1000; //Loss of
    heat per unit length by radiation in kW/m
17 e2=(1/((1/e)+((D/D1)*((1/e1)-1))))); //Equivalent
    emissivity
18 Q1=(e2*5.67*10^-8*3.14*D*(Ts^4-Tsc^4))/1000; //
    Radiant heat exchange per unit length of header
    with screen in kW/m
19 R=(Q-Q1); //Reduction in heat by radiation due to the
    provision of the screen in kW/m
20
21 //OUTPUT
22 mprintf('Loss of heat per unit length by radiation
    is %3.1f kW/m \nReduction in heat by radiation
    due to the provision of the screen is %3.2f kW/m'
    ,Q,R)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.26 Error in temperature

```

1 //Chapter -10, Example 10.26, Page 451
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 e=0.6; //Emissivity of thermocouple
8 Ta=20+273; //Ambient temperature in K

```



```

 9 Tt=500+273; //Temperature from the thermocouple in K
10 e=0.3; //Emissivity of radiation shield
11 h=200; //Convective heat transfer coefficient in W/m
    ^2.K
12 Ts=833; //Temperature in K
13
14 //CALCULATIONS
15 T=((5.67*10^-8*e*(Tt^4-Ta^4))/(h*1000))+Tt; //
    Temperature of the shield in K
16 T1=(Ts-T); //Error between the thermocouple
    temperature and gas temperature in K
17 Ts=825; //Surface temperature with radiation shield
    in K
18 Tc=829; //Thermocouple temperature with radiation
    shield in K
19 e=(Tc-Ts); //Error between the thermocouple
    temperature and gas temperature with the shielded
    thermocouple arrangement in K
20
21 //OUTPUT
22 fprintf('Error between the thermocouple temperature
    and gas temperature is%3.0f K \nError between the
    thermocouple temperature and gas temperature
    with the shielded thermocouple arrangement is%3.0
    f K',T1,e)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.27 Rate of heat loss

```

1 //Chapter -10, Example 10.27, Page 452
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  D=0.2; //Diameter of pipe in m
8  Ta=30+273; //Temperature of air in K
9  Ts=200+273; //Temperature of surface in K
10 e=0.8; //Emissivity of the pipe
11
12 //CALCULATIONS
13 Q=(e*5.67*10-8*3.14*D*(Ts4-Ta4)); //Heat lost by
    thermal radiation in W/m
14 T=(Ta+Ts)/2; //Film temperature in degree C
15 k=0.03306; //Thermal conductivity in W/m.K
16 v1=(24.93*10-6); //Kinematic viscosity in m2/s
17 b=(1/388); //Coefficient of thermal expansion in 1/K
18 Pr=0.687; //Prantl number
19 Ra=((9.81*b*D3*(Ts-Ta)*Pr)/(v12)); //Rayleigh
    number
20 Nu=(0.53*(Ra)0.25); //Nussults number
21 h=(k*Nu)/D; //Heat transfer coefficient in W/m2.K
22 Q1=(h*3.14*D*(Ts-Ta)); //Heat lost by convection in W
    /m
23 Q2=(Q+Q1); //Total heat lost per meter length in W/m
24
25 //OUTPUT
26 mprintf('Heat lost by thermal radiation is %3.0f W/m
    \nHeat lost by convection is %3.1f W/m',Q,Q1)
27
28 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.28 Heat transfer coefficient

1 //Chapter –10, Example 10.28, Page 453

```

2 //
=====

3 clc
4 clear
5
6 //INPUT DATA
7 Ts=200+273; //Temperature of stream main in K
8 Ta=30+273; //Room temperature in K
9 h=17.98; //Heat transfer coefficient in W/m^2.K
10 e=0.8; //Emissivity of the pipe surface
11
12 //CALCULATIONS
13 q=(5.67*10^-8*e*(Ts^4-Ta^4)); //Heat transfer by
    radiation in W/m^2
14 hr=(q/(Ts-Ta)); //Heat transfer coefficient due to
    radiation in W/m^2.K
15 hc=(h-hr); //Heat transfer coefficient due to
    convection in W/m^2.K
16
17 //OUTPUT
18 mprintf('Heat transfer coefficient due to radiation
    is %3.1f W/m^2.K \nHeat transfer coefficient due
    to convection is %3.2f W/m^2.K',hr,hc)
19
20 //=====END OF PROGRAM
=====

```

Scilab code Exa 10.29 Extinction coefficient for radiation

```

1 //Chapter –10, Example 10.29, Page 461
2 //
=====

3 clc

```

```

4 clear
5
6 //INPUT DATA
7 t=0.05;//Thickness of the gas layer in m
8 r=0.1;//Remaining radiation intensity
9
10 //CALCULATIONS
11 a=(-1/t)*2.3*(log(r)/log(10));//Extinction
    coefficient per m
12
13 //OUTPUT
14 mprintf('Extinction coefficient is %3.2f/m',a)
15
16 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.30 Emmissivity of the mixture

```

1 //Chapter -10, Example 10.30, Page 462
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 A=30;//Total surface area in m^2
8 V=10;//Volume in m^3
9 Ts=1000;//Temperature of the furnace in degree C
10 p=2;//Total pressure in atm
11 ph2o=0.1;//Partial pressure of water vapour in atm
12 pco2=0.3;//Partial pressure of CO2
13
14 //CALCULATIONS
15 lms=(3.6*V)/A;//Mean beam length in m

```

```

16 pco2lms=(pco2*lms); //pco2lms in m.atm
17 eco2=0.16; //From Fig.10.23 on page no. 458
18 cco2=1.11; //From Fig.10.23 on page no. 458
19 cco2eco2=(cco2*eco2); //cco2eco2 value
20 ph2olms=(ph2o*lms); //ph2olms in m.atm
21 eh2o=0.12; //From Fig.10.24 on page no. 459
22 P=(p+ph2o)/2; //P value in atm
23 ch2o=1.43; //From Fig.10.26 on page no. 460
24 ch2oeh2o=(ch2o*eh2o); //ch2oeh2o value
25 P1=(ph2o/(ph2o+pco2)); //Ratio of pressures
26 X=(pco2lms+ph2olms); //X value in m.atm
27 e=0.035; //Error value from Fig. 10.27 on page no.461
28 et=(cco2eco2+ch2oeh2o-e); //Total emissivity of the
    gaseous mixture
29
30 //OUTPUT
31 mprintf('Emissivity of the gaseous mixture is %3.4f'
    ,et)
32
33 //=====END OF PROGRAM
    =====

```

Scilab code Exa 10.31 Net radiation exchange and coefficient of heat transfer

```

1 //Chapter –10, Example 10.31, Page 463
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Tg=950+273; //Flue gas temperature in K
8 p=1; //Total pressure in atm

```

```

9  pco2=0.1; //Percent of co2
10 ph2o=0.04; //Percent of h2o
11 D=0.044; //Diameter of the tube in m
12 e=0.8; //Emissivity of grey surface
13 Tw=500+273; //Uniform temperature in K
14
15 //CALCULATIONS
16 lms=(3*0.044); //lms value from Table 10.2 on page no
    . 457
17 pco2lms=(pco2*lms); //pco2lms in m.atm
18 ph2olms=(ph2o*lms); //ph2olms in m.atm
19 eco2=0.05; //From Fig.10.23 on page no. 458
20 eh2o=0.005; //From Fig.10.24 on page no. 459
21 b=1.05; //Correction factor from Fig. 10.28 on page
    no. 461
22 eg=0.061; //Total emissivity of gaseous mixture
23 ag=((0.056*(Tg/Tw)^0.65)+(b*0.021)); // Absorbptivity
    of the gases
24 q=(0.5*(e+1)*5.67*10^-8*((eg*Tg^4)-(ag*Tw^4))); //
    Heat transfer rate by radiation in W/m^2
25 hr=(q/(Tg-Tw)); //Radiation heat transfer coefficient
    in W/m^2.degree C
26
27 //OUTPUT
28 mprintf('Net radiation exchange between the gas and
    the tube walls is %3.0f W/m^2 \nRadiation heat
    transfer coefficient is %3.2f W/m^2.degree C',q,
    hr)
29
30 //=====END OF PROGRAM
    =====

```

Chapter 11

Boiling and Condensation

Scilab code Exa 11.1 Temperature of the surface

```
1 //Chapter –11, Example 11.1, Page 480
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 Tsat=100; //Saturation temperature of water in degree
   C
8 p1=957.9; //Density of liquid in kg/m^3
9 Cpl=4217; //Specific heat in J/kg.K
10 u=(279*10^-6); //Dynamic viscosity in N.s/m^2
11 Pr=1.76; //Prantl number
12 hjg=2257; //Enthalpy in kJ/kg
13 s=(58.9*10^-3); //Surface tension in N/m
14 pv=0.5955; //Density of vapour in kg/m^3
15 m=30; //Rate of water in kg/h
16 D=0.3; //Diameter in m
17
18 //CALCULATIONS
```

```

19 q=(m*hjg*1000)/(3600*3.14*(D^2/4)); //Heat transfer
    in W/m^2
20 Ts=Tsat+(((q/(u*hjg*1000))*sqrt(s/(9.81*(p1-pv))))))
    ^0.33
21
22 //OUTPUT
23 mprintf('Temperature of the bottom surface of the
    pan is %3.2f degree C',Ts)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.2 Burnout heat flux

```

1 //Chapter –11, Example 11.2, Page 481
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Tsat=100; //Saturation temperature of water in degree
    C
8 p1=957.9; //Density of liquid in kg/m^3
9 Cp1=4217; //Specific heat in J/kg.K
10 u=(279*10^-6); //Dynamic viscosity in N.s/m^2
11 Pr=1.76; //Prantl number
12 hjg=2257; //Enthalpy in kJ/kg
13 s=(58.9*10^-3); //Surface tension in N/m
14 pv=0.5955; //Density of vapour in kg/m^3
15 m=30; //Rate of water in kg/h
16 D=0.3; //Diameter in m
17
18 //CALCULATIONS

```



```

19 q=(0.18*hjg*1000*pv*((s*9.81*(p1-pv))/pv^2)^0.25)
    /10^6; //Burnout heat flux in MW/m^2
20
21 //OUTPUT
22 mprintf('Burnout heat flux is %3.3f MW/m^2',q)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.3 Heat transfer coefficient and power dissipation

```

1 //Chapter -11, Example 11.3, Page 481
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.0016; //Diameter of the wire in m
8 T=255; //Temperature difference in degree C
9 p1=957.9; //Density of liquid in kg/m^3
10 Cpl=4640; //Specific heat in J/kg.K
11 u=(18.6*10^-6); //Dynamic viscosity in N.s/m^2
12 hjg=2257; //Enthalpy in kJ/kg
13 k=(58.3*10^-3); //Thermal conductivity in W/m.K
14 pv=31.54; //Density of vapour in kg/m^3
15 Ts=628; //Surface temperature in K
16 Tsat=373; //Saturation temperature in K
17
18 //CALCULATIONS
19 hc=(0.62*((k^3*pv*(p1-pv)*9.81*((hjg*1000)+(0.4*Cpl*
    T))))/(u*D*T))^0.25); //Convective heat transfer
    coefficient in W/m^2.K
20 hr=((5.67*10^-8)*(Ts^4-Tsat^4))/(Ts-Tsat); //

```

```

Radiative heat transfer coefficient in W/m^2.K
21 hm=(hc+(0.75*hr)); //Mean heat transfer coefficient
    in W/m^2.K
22 Q=(hm*3.14*D*T)/1000; //Power dissipation rate per
    unit length of the heater in kW/m
23
24 //OUTPUT
25 mprintf('Mean heat transfer coefficient is %3.1f W/m
    ^2.K \nPower dissipation rate per unit length of
    the heater is %3.3f kW/m',hm,Q)
26
27 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.4 Heat transfer coefficient

```

1 //Chapter –11, Example 11.4, Page 485
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Ts=10; //Surface temperature in degree C
8 p1=10; //Pressure of water in atm
9
10 //CALCULATIONS
11 hp=(5.56*Ts^0.4); //Heat transfer coefficient in kW/m
    ^2.K
12 hp1=(5.56*(2*Ts)^3*p1^0.4); //Heat transfer
    coefficient in kW/m^2.K
13 hp2=(5.56*Ts^3*(2*p1)^0.4); //Heat transfer
    coefficient in kW/m^2.K
14 x1=(hp1/hp)/1000; //Ratio of heat transfer

```

```

    coefficients
15 x2=(hp2/hp)*100; //Ratio of heat transfer
    coefficients
16
17 //OUTPUT
18 mprintf('Heat transfer coefficient becomes%3.0f
    times the original value in the first case \nHeat
    transfer coefficient is increased only by 32
    percent in the second case',x1)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.5 Heat transfer

```

1 //Chapter –11, Example 11.5, Page 485
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 p=6; //Pressure of water in atm
8 D=0.02; //Diameter of the tube in m
9 Ts=10; //Wall temperature in degree C
10 L=1; //Length of the tube in m
11
12 //CALCULATIONS
13 p1=(p*1.0132*10^5)/10^6; //Pressure in MN/m^2
14 h=(2.54*Ts^3*exp(p1/1.551)); //Heat transfer
    coefficient in W/m^2.K
15 Q=(h*3.14*D*L*Ts); //Heat transfer rate in W/m
16
17 //OUTPUT

```

```

18 mprintf('Heat transfer rate is %3.1f W/m',Q)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.6 Thickness of condensate film

```

1 //Chapter –11, Example 11.6, Page 489
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 p=2.45; //Pressure of dry saturated steam in bar
8 h=1; //Height of vertical tube in m
9 Ts=117; //Tube surface temperature in degree C
10 d=0.2; //Distance from upper end of the tube in m
11
12 //CALCULATIONS
13 Tsat=127; //Saturation temperature of water in degree
    C
14 p1=941.6; //Density of liquid in kg/m^3
15 k1=0.687; //Thermal conductivity in W/m.K
16 u=(227*10^-6); //Dynamic viscosity in N.s/m^2
17 hfg=2183; //Enthalpy in kJ/kg
18 pv=1.368; //Density of vapour in kg/m^3
19 q=((4*k1*u*10*d)/(9.81*p1*(p1-pv)*hfg*1000))^0.25)
    *1000; //Thickness of condensate film in mm
20 h=(k1/(q/1000)); //Local heat transfer coefficient at
    x=0.2 in W/m^2.K
21
22 //OUTPUT
23 mprintf('Thickness of condensate film is %3.2f mm\

```

```

    nLocal heat transfer coefficient at x=0.2 is %3.0
    f W/m^2.K',q,h)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.7 Rate of heat transfer and condensate mass flow rate

```

1 //Chapter –11, Example 11.7, Page 491
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 D=0.05; //Diameter of the tube in m
8 L=2; //Length of the tube in m
9 Ts=84; //Outer surface temperature in degree C
10 Tsat=100; //Saturation temperature of water in degree
    C
11 Tf=(Tsat+Ts)/2; //Film temperature in degree C
12 p1=963.4; //Density of liquid in kg/m^3
13 u=(306*10^-6); //Dynamic viscosity in N.s/m^2
14 hfg=2257; //Enthalpy in kJ/kg
15 pv=0.596; //Density of vapour in kg/m^3
16 k1=0.677; //Thermal conductivity in W/m.K
17
18 //CALCULATIONS
19 hL=(1.13*((9.81*p1*(p1-pv)*k1^3*hfg*1000)/(u*16*L))
    ^0.25); //Heat transfer coefficient in W/m^2.K
20 Ref=((4*hL*L*2)/(hfg*1000*u)); //Reynolds number
21 Q=(hL*3.14*D*L*10); //Heat transfer rate in W
22 m=(Q/(hfg*1000))*3600; //Condensate mass flow rate in
    kg/h

```

```

23
24 //OUTPUT
25 mprintf('Heat transfer rate is %3.0f W \n Condensate
          mass flow rate is %3.1f kg/h',Q,m)
26
27 //=====END OF PROGRAM
          =====

```

Scilab code Exa 11.8 Heat transfer rate

```

1 //Chapter -11, Example 11.8, Page 492
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 h=2.8; //Height of the plate in m
8 T=54; //Temperature of the plate in degree C
9 Tsat=100; //Saturation temperature of water in degree
           C
10 Tf=(Tsat+T)/2; //Film temperature in degree C
11 p1=937.7; //Density of liquid in kg/m^3
12 u=(365*10^-6); //Dynamic viscosity in N.s/m^2
13 hfg=2257; //Enthalpy in kJ/kg
14 pv=0.596; //Density of vapour in kg/m^3
15 k1=0.668; //Thermal conductivity in W/m.K
16
17 //CALCULATIONS
18 Re=(0.00296*((p1*9.81*(p1-pv)*k1^3*(Tsat-T)^3*h^3)/(
           u^5*(hfg*1000)^3))^(5/9)); //Reynolds number
19 hL=(0.0077*((9.81*p1*(p1-pv)*k1^3)/u^2)^(1/3)*Re
           ^0.4); //Heat transfer coefficient in W/m^2.K
20 Q=(hL*h*(Tsat-T))/1000; //Heat transfer rate per unit

```

```

        width in kW/m
21
22 //OUTPUT
23 mprintf('Heat transfer rate per unit width is %3.2f
        kW/m',Q)
24
25 //=====END OF PROGRAM
        =====

```

Scilab code Exa 11.9 Rate of formation of condensate

```

1 //Chapter –11, Example 11.9 , Page 494
2 //
        =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=100; //Temperature of dry steam in degree C
8 Do=0.025; //Outer diameter of the pipe in m
9 Ts=84; //Surface temmperture of pipe in degree C
10 Tf=(T+Ts)/2; //Film temperature in degree C
11 p1=963.4; //Density of liquid in kg/m^3
12 u=(306*10^-6); //Dynamic viscosity in N.s/m^2
13 hfg=2257; //Enthalpy in kJ/kg
14 pv=0.596; //Density of vapour in kg/m^3
15 k1=0.677; //Thermal conductivity in W/m.K
16
17 //CALCULATIONS
18 h=(0.725*((9.81*p1*(p1-pv)*k1^3*hfg*1000)/(u*(T-Ts)*
        Do))^0.25); //Heat transfer coefficient in W/m^2.K
19 q=(h*3.14*Do*(T-Ts))/1000; //Heat transfer per unit
        length in kW/m
20 m=(q/hfg)*3600; //Total mass flow of condensate per

```

```

    unit length in kg/h
21
22 //OUTPUT
23 mprintf('Rate of formation of condensate per unit
    length is %3.2f kg/h',m)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 11.10 Condensation rate

```

1 //Chapter –11, Example 11.10, Page 494
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 m=50; //Mass of vapour per hour
8 n=100; //Number of tubes
9 D=0.01; //Diameter of the tube in m
10 L=1; //Length of the tube in m
11 n1=10; //Array of 10*10
12
13 //CALCULATIONS
14 mr=((0.725/1.13)*(L/(n1*D))^0.25); //Ratio of
    horizontal and vertical position
15 mv=(m/mr); //Mass flow rate in the vertical position
    in kg/h
16
17 //OUTPUT
18 mprintf('Mass flow rate in the vertical position is
    %3.2f kg/h',mv)
19

```


20 //=====END OF PROGRAM

=====

Chapter 12

Heat Exchangers

Scilab code Exa 12.1 Overall heat transfer coefficient

```
1 //Chapter –12, Example 12.1, Page 503
2 //


---


3 clc
4 clear
5
6 //INPUT
7 T=80; //Bulk Temperature of water in degrees C
8 Di=0.0254; //Inner diameter of steel pipe in m
9 Do=0.0288; //Outer diameter of steel pipe in m
10 k=50; //Thermal conductivity of steel in W/m.K
11 ho=30800; //Average convection coefficient in W/m^2.K
12 v=0.50; //Velocity of water in m/s
13
14 //INPUT DATA FROM HEAT AND MASS TRANSFER DATA BOOK
    FOR WATER AT BULK TEMPERATURE OF 80 degree C
15 d=974; //Density in kg/m^3
16 v1=0.000000364; //Kinematic viscosity in m^2/s
17 k1=0.6687; //Thermal conductivity in W/m.K
18 Pr=2.2; //Prantl Number
```

```

19
20 //CALCULATIONS
21 Re=(v*Di)/v1; //Reynold's number
22 Nu=(0.023*Re^0.8*Pr^0.4); //Nusselts number
23 hi=Nu*(k1/Di); //Heat transfer coefficient in W/m^2.K
24 ri=(Di/2); //Inner radius of steel pipe in m
25 ro=(Do/2); //Outer radius of steel pipe in m
26 U=(1/((1/ho)+((ro/k)*log(ro/ri))+(ro/(ri*hi)))); //
    Overall heat transfer coefficient in W/m^2.K
27
28 //OUTPUT
29 fprintf('Overall heat transfer coefficient is %3.1f
    W/m^2.K',U)
30
31 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.2 Overall heat transfer coefficient

```

1 //Chapter -12, Example 12.2, Page 504
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Do=0.0254; //Outer Diameter of heat exchanger tube in
    m
8 Di=0.02286; //Inner Diameter of heat exchanger tube
    in m
9 k=102; //Thermal conductivity of the tube in W/m.K
10 hi=5500; //Heat transfer coefficients at the inner
    side of tube in W/m^2.K
11 ho=3800; //Heat transfer coefficients at the outer

```

```

    side of tube in W/m^2.K
12 Rfi=0.0002; //Fouling factor in m^2.W.K
13 Rfo=0.0002; //Fouling factor in m^2.W.K
14
15 //CALCULATIONS
16 ro=(Do/2); //Outer radius of heat exchanger tube in m
17 ri=(Di/2); //Inner radius of heat exchanger tube in m
18 U=(1/((1/ho)+Rfo+((ro/k)*log(ro/ri))+((ro*Rfi)/ri)+(
    ro/(ri*hi)))); // Overall heat transfer coefficient
    in W/m^2.K
19
20 //OUTPUT
21 mprintf('Overall heat transfer coefficient is %i W/m
    ^2.K',U)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.3 Heat exchanger area

```

1 //Chapter -12, Example 12.3, Page 509
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 mh=10000; //Mass flow rate of oil in kg/h
8 ch=2095; //Specific heat of oil J/kg.K
9 Thi=80; //Inlet temperature of oil in degree C
10 Tho=50; //Outlet temperature of oil in degree C
11 mc=8000; //Mass flow rate of water in kg/h
12 Tci=25; //Inlet temperature of water in degree C
13 U=300; //Overall heat ransfer coefficient in W/m^2.K

```

```

14 cc=4180;//Specific heat of water in J/kg.K
15
16 //CALCULATIONS
17 Q=(mh*ch*(Thi-Tho));//Heat transfer rate in W
18 Tco=((Q/(mc*cc))+Tci);//Outlet temperature of water
    in degree C
19 T=(Thi-Tco);//Temperature difference between oil
    inlet temperature and water outlet temperature in
    degree C
20 t=(Tho-Tci);//Temperature difference between oil
    outlet temperature and water inlet temperature in
    degree C
21 A=((Q/U)*log(t/T))/(3600*(t-T));//Area of heat
    exchanger in m^2
22
23 //OUTPUT
24 mprintf('Area of heat exchanger is %3.2f m^2',A)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.4 Heat exchanger area

```

1 //Chapter -12, Example 12.4, Page 510
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Ch=2500;//Capacity rate of hot oil in W/K
8 Thi=360;//Temperature of hot fluid at the entrance
    of heat exchanger in degree C
9 Tho=300;//Temperature of hot fluid at the exit of

```

```

    heat exchanger in degree C
10 Tci=30; //Temperature of cold fluid at the entrance
    of heat exchanger in degree C
11 Tco=200; //Temperature of hot fluid at the exit of
    heat exchanger in degree C
12 U=800; //Overall heat transfer coefficient in W/m^2.K
13
14 //CALCULATIONS
15 Q=(Ch*(Thi-Tho)); //Heat transfer from the oil in W
16 //Parallel flow
17 T1=Thi-Tci; //Temperature difference between hot
    fluid inlet temperature and cold fluid inlet
    temperature in degree C
18 T2=Tho-Tco; //Temperature difference between hot
    fluid outlet temperature and cold fluid outlet
    temperature in degree C
19 Tlm1=((T1-T2)/log(T1/T2)); //LMTD for parallel flow
    arrangement in degree C
20 A1=(Q/(U*Tlm1)); //Area of heat exchanger in m^2
21 //Counter flow
22 t1=Thi-Tco; //Temperature difference between hot
    fluid inlet temperature and cold fluid outlet
    temperature in degree C
23 t2=Tho-Tci; //Temperature difference between hot
    fluid outlet temperature and cold fluid inlet
    temperature in degree C
24 Tlm2=((t1-t2)/log(t1/t2)); //LMTD for counter flow
    arrangement in degree C
25 A2=(Q/(U*Tlm2)); //Area of heat exchanger in m^2
26
27 //OUTPUT
28 mprintf('Area of heat exchanger in parallel flow
    arrangement is %3.3f m^2 \n Area of heat
    exchanger in counter flow arrangement is %3.3f m
    ^2 ',A1,A2)
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.5 Length of heat exchanger

```
1 //Chapter –12, Example 12.5, Page 511
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 ch=2130; // Specific heat of oil in J/kg.K
8 T1=160; // Temperature of hot fluid (oil) at the
           // entrance of heat exchanger in degree C
9 T2=60; // Temperature of hot fluid (oil) at the exit
           // of heat exchanger in degree C
10 t1=25; // Temperature of cold fluid (water) at the
           // entrance of heat exchanger in degree C
11 d=0.5; // Inner diameter of the tube in m
12 mc=2; // Mass flow rate of cooling water in kg/s
13 D=0.7; // outer annulus outer diameter in m
14 mh=2; // Mass flow rate of hot oil in kg/s
15 U=250; // Overall heat transfer coefficient in W/m^2.K
16 cc=4186; // Specific heat of water in J/kg.K
17
18 //CALCULATIONS
19 Q=(mh*ch*(T1-T2)); // Required heat transfer rate in
           // W
20 t2=((Q/(mc*cc))+t1); // Outer water temperature in
           // degree C
21 T=T1-t2; // Change in temperature between inlet
           // temperature of hot fluid and outlet temperature of
           // cold fluid in degree C
22 t=T2-t1; // Change in temperature between outlet
           // temperature of hot fluid and inlet temperature of
```

```

    cold fluid in degree C
23 Tlm=((T-t)/(log(T/t))); //Value of LMTD in degree C
24 L=(Q/(U*3.14*d*Tlm)); //Length of the heat exchanger
    in m
25
26 //OUTPUT
27 mprintf('Length of the heat exchanger is %3.2f m',L)
28
29 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.6 Surface area and rate of condensation of steam

```

1 //Chapter -12, Example 12.6, Page 512
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=120; //Saturated steam temperature in degree C
8 U=1800; //Heat transfer coefficient in W/m^2.K
9 m=1000; //mass flow rate of water in kg/h
10 t1=20; //Inlet temperature of water in degree C
11 t2=90; //Outlet tmperature of water in degree C
12 hfg=2200; //Enthalpy of steam in kJ/kg
13 c=4186; //Specific het of water in J/kg.K
14
15 //CALCULATIONS
16 Tlm((((T-t1)-(T-t2))/(log((T-t1)/(T-t2)))); //LMTD in
    a condenser in degree C
17 Q=((m/3600)*c*(t2-t1)); //Rate of heat transfer in W
18 A=(Q/(U*Tlm)); //Surface area of heat exchanger in m
    ^2

```



```

19 ms=((Q*3600)/(hfg*1000)); //Rate of condensation of
    steam in kg/h
20
21 //OUTPUT
22 mprintf('Surface area of heat exchanger is %3.2f m^2
    \n Rate of condensation of steam is %3.1f kg/h',
    A,ms)
23
24 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.7 Effective log mean temperature difference

```

1 //Chapter -12, Example 12.7, Page 516
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=100; //Temperature of saturated steam in degree C
8 t1=30; //Inlet temperature of water in degree C
9 t2=70; //Exit temperature of water in degree C
10
11 //CALCULATIONS
12 //COUNTER FLOW
13 Tc=(T-t2); //Temperature difference between saturated
    steam and exit water temperature in degree C
14 tc=(T-t1); //Temperature difference between saturated
    steam and inlet water temperature in degree C
15 Tlmc=((Tc-tc)/log(Tc/tc)); //LMTD for counter flow in
    degree C
16 //PARALLEL FLOW
17 Tp=(T-t1); //Temperature difference between saturated

```

```

    steam and inlet water temperature in degree C
18  tp=(T-t2); //Temperature difference between saturated
    steam and exit water temperature in degree C
19  Tlmp=((Tp-tp)/log(Tp/tp)); //LMTD for counter flow in
    degree C
20  //CROSS FLOW
21  R=((T-T)/(t2-t1)); //R value for Correction factor F
22  P=((t2-t1)/(T-t1)); //P value for Correction Factor F
23  F=1; //Referring to Fig.12.12 in page no 515
24  Tlmx=(F*Tlmc); //LMTD for cross flow in degree C
25
26  //OUTPUT
27  mprintf('The effective log mean temperature
    difference for: \n i)COUNTER FLOW is %3.1f degree
    C \n ii)PARALLEL FLOW is %3.1f degree C \n iii)
    CROSS FLOW is %3.1f degree C',Tlmc,Tlmp,Tlmx)
28
29  //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.8 Area of heat exchanger

```

1  //Chapter -12, Example 12.8, Page 516
2  //
    =====

3  clc
4  clear
5
6  //INPUT DATA
7  Ti=18; //Inlet temperature of Shell fluid in degree C
8  To=6.5; //Outlet temperature of Shell fluid in degree
    C
9  ti=-1.1; //Inlet temperature of Tube fluid in degree
    C

```

```

10 to=2.9; //Outlet temperature of Tube fluid in degree
    C
11 U=850; //Overall heat transfer coefficient in W/m^2.K
12 Q=6000; //Design heat load in W
13
14 //CALCULATIONS
15 T=(Ti-to); //Temperature difference between shell
    side inlet fluid and tube side outlet fluid in
    degree C
16 t=(To-ti); //Temperature difference between shell
    side outlet fluid and tube side inlet fluid in
    degree C
17 Tlm=((T-t)/log(T/t)); //LMTD for a counterflow
    arrangement in degree C
18 P=((to-ti)/(Ti-ti)); //P value to calculate
    correction factor
19 R=((Ti-To)/(to-ti)); //R value to calculate
    correction factor
20 F=0.97 //Taking correction factor from fig. 12.9 on
    page no.514
21 A=(Q/(U*F*Tlm)); //Area of shell and tube heat
    exchanger in m^2
22
23 //OUTPUT
24 mprintf('Area of shell-and-tube heat exchanger is %3
    .2f m^2',A)
25
26 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.9 Area of heat exchanger

```

1 //Chapter -12, Example 12.9, Page 517
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  Q=6000; //Taking design heat load value in W from
      Example no. 12.8 on page no.516
8  U=850; //Taking overall heat transfer coefficient
      value in W/m^2.K from Example no. 12.8 on page no
      .516
9  T1m=10.92 //Taking LMTD for a counterflow arrangement
      in degree C from Example no. 12.8 on page no.517
10 R=2.875; //Taking R value from Example no. 12.8 on
      page no.517
11 P=0.209; //Taking P value from Example no. 12.8 on
      page no.517
12 F=0.985; //Taking correction factor from Fig. 12.10
      on page no.514
13
14 //CALCULATIONS
15 A=(Q/(U*F*T1m)); //Area of shell-and-tube heat
      exchanger in m^2
16
17 //OUTPUT
18 mprintf('Area of shell aand tube heat exchanger is
      %3.3 f m^2 ',A)
19
20 //=====END OF PROGRAM
      =====

```

Scilab code Exa 12.10 Surface area

```

1 //Chapter -12, Example 12.10, Page 517
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  Ti=360;//Inlet temperature of hot fluid in degree C
   taken from Example no. 12.4 on page no. 510
8  To=300;//Outlet temperature of hot fluid in degree C
   taken from Example no. 12.4 on page no. 510
9  ti=30;//Inlet temperature of cold fluid in degree C
   taken from Example no. 12.4 on page no. 510
10 to=200;//Outlet temperature of cold fluid in degree
    C taken from Example no. 12.4 on page no. 510
11 U=800;//Overall heat transfer coefficient in W/m^2.K
   taken from Example no. 12.4 on page no. 510
12 Q=150000;//Calculated heat transfer rate in W from
   Example no. 12.4 on page no. 510
13 Tlm=210.22//Calculated LMTD for counterflow
   arrangement in degree C taken from Example no.
   12.4 on page no. 511
14
15 //CALCULATIONS
16 P=((to-ti)/(Ti-ti));//P value for calculation of
   correction factor
17 R=((Ti-To)/(to-ti));//R value for calculation of
   correction factor
18 F=0.98;//Correction Factor value taken from Fig
   .12.11 on page no.515
19 A=(Q/(U*F*Tlm));//Required surface area in a cross
   flow heat exchanger in m^2
20
21 //OUTPUT
22 mprintf('The required surface area in a cross flow
   heat exchanger is %3.2f m^2',A)
23
24 //=====END OF PROGRAM
   =====

```

Scilab code Exa 12.11 Number of tube passes and number of tubes per pass

```
1 //Chapter -12, Example 12.11, Page 518
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 mc=4; //Mass flow rate of cold water in kg/s
8 Tci=38; //Inlet Temperature of cold water in degree C
9 Tco=55; //Outlet Temperature of cold water in degree
   C
10 D=0.02; //Diameter of the tube in m
11 v=0.35; //Velocity of water in m/s
12 Thi=95; //Inlet Temperature of hot water in degree C
13 mh=2; //Mass flow rate of hot water in kg/s
14 L=2; //Length of the tube in m
15 U=1500; //Overall heat transfer coefficient in W/m^2.
   K
16 c=4186; //Specific heat of water in J/kg.K
17 d=1000; //Density of water in kg/m^3
18
19 //CALCULATIONS
20 Q=(mc*c*(Tco-Tci)); //Heat transfer rate for cold
   fluid in W
21 Tho=(Thi-(Q/(mh*c))); //Outlet temperature of hot
   fluid in degree C
22 T=Thi-Tco; //Difference of temperature between hot
   water inlet and cold water outlet in degree C
23 t=Tho-Tci; //Difference of temperature between hot
   water outlet and cold water inlet in degree C
```

```

24 Tlm=((T-t)/log(T/t)); //LMTD for counterflow heat
    exchanger
25 A=(Q/(U*Tlm)); //Area of heat exchanger in m^2
26 A1=(mc/(d*v)); //Total flow area in m^2
27 n=((A1*4)/(3.14*D^2)); //Number of tubes
28 L=(A/(36*3.14*D)); //Length of each tube taking n=36
    in m
29 N=2; //Since this length is greater than the
    permitted length of 2m, we must use more than one
    tube pass. Let us try 2 tube passes
30 P=((Tco-Tci)/(Thi-Tci)); //P value for calculation of
    correction factor
31 R=((Thi-Tho)/(Tco-Tci)); //R value for calculation of
    correction factor
32 F=0.9; //Corrcion Factor from Fig.12.9 on page no.
    514
33 A2=(Q/(U*F*Tlm)); //Total area required for one shall
    pass,2 tube pass exchanger in m^2
34 L1=(A2/(2*36*3.14*D)); //Length of tube per pass
    taking n=36 in m
35
36 //OUTPUT
37 mprintf('Number of tubes per pass is %i \n Number of
    passes is %i \n Length of tube per pass is %3.3f
    m',n,N,L1)
38
39 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.12 Surface area and temperature

```

1 //Chapter –12, Example 12.12, Page 524
2 //

```

```

3  clc
4  clear
5
6  //INPUT DATA
7  mh=250; //Mass flow rate of hot liquid in kg/h
8  ch=3350; //Specific heat of hot liquid in J/kg.K
9  Thi=120; //Inlet temperature of hot liquid in degree
    C
10 mc=1000; //Mass flow rate of cold liquid in kg/h
11 Tci=10; //Inlet temperature of cold liquid in degree
    C
12 U=1160; //Overall heat transfer coefficient in W/m^2.
    K
13 A=0.25; //Surface area of heat exchanger in m^2
14 cc=4186; //Specific heat of cold liquid in J/kg.K
15
16 //CALCULATIONS
17 Cc=((mc*cc)/3600); //Heat capacity rate for cold
    liquid in W/K
18 Ch=((mh*ch)/3600); //Heat capacity rate for hot
    liquid in W/K
19 Cmin=min(Cc,Ch); //Minimum heat capacity rate in W/K
20 Cmax=max(Cc,Ch); //Maximum heat capacity rate in W/K
21 r=(Cmin/Cmax); //Ratio of min amd max heat capacity
    rates
22 NTU=((U*A)/Cmin); //Number of transfer units
23 e=((1-exp(-NTU*(1+r)))/(1+r)); //Effectiveness for a
    parallel flow heat exchanger
24 Qmax=(Cmin*(Thi-Tci)); //Maximum possible heat
    transfer rate in W
25 Q=(e*Qmax); //Actual rate of heat transfer in W
26 Tco=((Q/Cc)+Tci); //Outlet temperature of cold liquid
    in degree C
27 Tho=(Thi-(Q/Ch)); //Outlet temperature of hot liquid
    in degree C
28
29
30 //OUTPUT

```



```

31 mprintf('Effectiveness for a parallel flow heat
    exchanger is %3.3f \n Outlet temperature of water
    is %3.2f degree C \n Outlet temperature of
    cooled liquid is %3.2f degree C',e,Tco,Tho)
32
33 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.13 Total heat transfer and surface temperature

```

1 //Chapter -12, Example 12.13, Page 527
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Tci=15;//Inlet temperature of water in degree C
8 mc=1300;//Mass flow rate of water in kg/h
9 ch=2000;//Specific heat of oil in J/kg.K
10 mh=550;//Mass flow rate of oil in kg/h
11 Thi=94;//Inlet temperature of oil in degree C
12 A=1;//Area of heat exchanger in m^2
13 U=1075;//Overall heat transfer coefficient in W/m^2.
    K
14 cc=4186;//Specific heat of water in J/kg.K
15
16 //CALCULATIONS
17 Cc=((mc*cc)/3600);//Heat capacity of water in W/K
18 Ch=((mh*ch)/3600);//Heat capacity of oil in W/K
19 Cmin=min(Cc,Ch);//Minimum heat capacity in W/K
20 Cmax=max(Cc,Ch);//Maximum heat capacity in W/K
21 r=(Cmin/Cmax);//Ratio of min and max heat capacity
22 NTU=((U*A)/Cmin);//Number of transfer Units

```

```

23 e=0.94//Effectiveness of heat exchanger from Fig.
    12.15 on page no.524
24 Qmax=(Cmin*(Thi-Tci));//Maximum possible heat
    transfer rate in W
25 Q=(e*Qmax);//Actual heat transfer rate in W
26 Tco=((Q/Cc)+Tci);//Outlet Temperature of water in
    degree C
27 Tho=(Thi-(Q/Ch));//Outlet Temperature of oil in
    degree C
28
29 //OUTPUT
30 mprintf('The total heat transfer is %3.1f W \n
    Outlet Temperature of water is %i degree C \n
    Outlet Temperature of oil is %3.2f degree C',Q,
    Tco,Tho)
31
32 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.14 Parameters of heat exchanger

```

1 //Chapter –12, Example 12.14, Page 528
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 N=3000;//Number of brass tubes
8 D=0.02;//Diameter of brass tube in m
9 Tci=20;//Inlet temperature of cooling water in
    degree C
10 mc=3000;//Mass flow rate of cooling water in kg/s
11 ho=15500;//Heat transfer coefficient for

```

```

    condensation in W/m^2.K
12 Q=(2.3*10^8); //Heat load of the condenser in W
13 Thi=50; //Temperature at which steam condenses in
    degree C
14 hfg=2380 //Enthalpy of liquid vapour mixture in kJ/kg
15 m=1; //Flow rate of each tube in kg/s
16 Cc=4180; //Specific heat of water in J/kg.K
17
18 //Properties of water at 300K from data book
19 Cc=4186; //Specific heat in J/kg.K
20 mu=(855*10^-6); //Dynamic viscosity in Ns/m^2
21 k=0.613; //Thermal Conductivity in W/mK
22 Pr=5.83 //Prantl number
23
24 //CALCULATIONS
25 Tco=((Q/(mc*Cc))+Tci); //Outlet temperature of
    cooling water in degree C
26 Re=((4*m)/(3.1415*D*mu)); //Reynold's number
27 Nu=(0.023*Re^(4/5)*Pr^(2/5)); //Nusselts number
28 hi=(Nu*(k/D)); //Heat transfer coefficient in W/m^2.K
29 U=(1/((1/ho)+(1/hi))); //Overall heat transfer
    coefficient in W/m^2.K
30 Cmin=(mc*Cc); //Minimum heat capacity in W/K
31 Qmax=(Cmin*(Thi-Tci)); //Maximum heat transfer rate
    in W
32 e=(Q/Qmax); //Effectiveness of heat transfer
33 NTU=0.8; //Number of transfer units from Fig. 12.16
    on page no.525
34 A=((NTU*Cmin)/U); //Area of heat exchanger in m^2
35 L=(A/(2*N*3.1415*D)); //Length of tube per pass in m
36 ms=(Q/(hfg*1000)); //Amount of steam condensed in kg/
    s
37
38 //OUTPUT
39 mprintf('The outlet temperature of the cooling water
    is %3.2f degree C \n The overall heat transfer
    coefficient is %3.1f W/m^2.K \n Tube length per
    pass using NTU method is %3.2f m \n The rate of

```

```

    condensation of steam is %3.0 f kg/s ',Tco,U,L,ms)
40
41 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.15 Exit temperature

```

1 //Chapter –12, Example 12.15, Page 530
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 Tci=5;//Inlet temperature of water in degree C
8 mc=4600;//Mass flow rate of water in kg/h
9 mh=4000;//Mass flow rate of air in kg/h
10 Thi=40;//Inlet temperature of air in degree C
11 U=150;//Overall heat transfer coefficient in W/m^2.K
12 A=25;//Area of heat exchanger in m^2
13 Cc=4180;//Specific heat of water in J/kg.K
14 Ch=1010;//Specific heat of air in J/kg.K
15
16 //CALCULATIONS
17 C1=((mh*Ch)/3600);//Heat capacity of air in W/K
18 C2=((mc*Cc)/3600);//Heat capacity of water in W/K
19 Cmin=min(C1,C2);//Minimum value of heat capacity in
    W/K
20 Cmax=max(C1,C2);//Maximum value of heat capacity in
    W/K
21 r=(Cmin/Cmax);//Ratio of min and max heat capacity
    in W/K
22 NTU=((U*A)/Cmin);//Number of heat transfer units
23 e=0.92;//Effectiveness of heat exchanger from Fig.

```

```

12.18 on page no.526
24 Q=(e*Cmin*(Thi-Tci)); //Heat transfer rate in W
25 Tco=((Q/C2)+Tci); //Outlet temperature of water in
    degree C
26 Tho=(Thi-(Q/C1)); //Outlet temperature of air in
    degree C
27
28 //OUTPUT
29 mprintf('The exit temperature of water is %3.1f
    degree C \n The exit temperature of air is %3.1f
    degree C',Tco,Tho)
30
31 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.16 Outlet temperature

```

1 //Chapter -12, Example 12.16, Page 532
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 A=15.82; //Total outside area of heat exchanger in m
    ^2
8 Thi=110; //Inlet temperature of oil in degree C
9 Ch=1900; //Specific heat of oil in J/kg.K
10 mh=170.9; //Mass flow rate of oil in kg/min
11 mc=68; //Mass flow rate of water in kg/min
12 Tci=35; //Inlet temperature of water in degree C
13 U=320; //Overall heat transfer coefficient in W/m^2.K
14 Cc=4186; //Specific heat of water in J/kg.K
15

```

```

16 //CALCULATIONS
17 C1=((mh*Ch)/60); //Heat capacity of oil in W/K
18 C2=((mc*Cc)/60); //Heat capacity of water in W/K
19 D=(U*A*((1/C1)-(1/C2))); //Constant
20 r=(C1/C2); //Ratio of heat capacity of oil and water
21 Tho=Thi-(((Thi-Tci)*(1-exp(D)))/(r-exp(D))); //Outlet
    temperature of oil in degree C
22 Tco=Tci+(r*(Thi-Tho)); //Outlet temperature of water
    in degree C
23
24 //OUTPUT
25 mprintf('The exit temperature of oil is %3.2f degree
    C \n The exit temperature of water is %3.1f
    degree C',Tho,Tco)
26
27 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.17 Outlet temperature

```

1 //Chapter-12, Example 12.17, Page 533
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 Tci=20; //Inlet temperature of water in degree C
8 Tco=50; //Outlet temperature of water in degree C
9 Th=120; //Temperature at which steam condenses in
    degree C
10 newTci=15; //New Inlet temperature of water in degree
    C
11

```

```

12 //CALCULATIONS
13 newTco=(((Tco-Tci)*(Th-newTci))/(Th-Tci))+newTci;//
    New outlet temperature of water in degree C
14
15 //OUTPUT
16 mprintf('New outlet temperature of water is %3.1f
    degree C',newTco)
17
18 //=====END OF PROGRAM
    =====

```

Scilab code Exa 12.18 Diameter and length of heat exchanger

```

1 //Chapter -12, Example 12.18, Page 534
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=100;//Total length of tubes in m
8 //ct=10000 Rs - Cost of the tubes in Rs
9 //cs=(15000*D^3*L) Cost of the shell in Rs
10 //cf=(2000*D*L) Cost of the floor space occupied by
    the exchanger in Rs
11
12 //CALCULATIONS
13 //Cost=(ct+cs+cf) Total first cost in Rs
14 //Cost=(10000+(15000*D^3*L)+(2000*D*L))
15 //The constraint requires the heat exchanger to
    include 100m tubes such that (((3.1414*D^2)/4)*L
    *200)=100
16 //L=(2/(3.1415*D^2))
17 //Substitute L in the equation in line 8

```

```

18 //Cost=(10000+(15000*D^3*(2/(3.1415*D^2)))+(2000*D
    *(2/(3.1415*D^2))))
19 //Cost=(10000+((30000*D)/3.1415)+(4000/(3.1415*D)))
20 //For optimizaation partial derivative of Cost w.r.t
    D should be zero
21 //((30000/3.1415)-(4000/(3.1415*D^2)))=0
22 D=((3.1415*4000)/(3.1415*30000))^0.5;//Diameter of
    the exchanger in m
23 L=(2/(3.1415*D^2));//Length of the exchanger in m
24 Cost=(10000+(15000*D^3*L)+(2000*D*L));//Optimal cost
    in Rs
25
26 //Output
27 mprintf('The diameter of the exchanger is %3.3f m \n
    The Length of the exchanger is %3.2f m \n
    Optimal cost is %3.0f Rs',D,L,Cost)
28
29 //=====END OF PROGRAM
    =====

```

Chapter 13

Diffusion Mass Transfer

Scilab code Exa 13.1 Average molecular weight

```
1 //Chapter –13, Example 13.1, Page 544
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 ro2=0.21; //Ratio of O2 in the mixture
8 rn2=0.79; //Ratio of N2 in the mixture
9 T=(25+273); //Temperature of container in degree C
10 p=1; //Total pressure in atm
11
12 //CALCULATIONS
13 Co2=(ro2*10^5)/(8314*T); //Molar concentration of O2
    in K.mol/m^3
14 Cn2=(rn2*10^5)/(8314*T); //Molar concentration of N2
    in K.mol/m^3
15 po2=(32*Co2); //Mass density in kg/m^3
16 pn2=(28*Cn2); //Mass density in kg/m^3
17 p=(po2+pn2); //Overall mass density in kg/m^3
```

```

18 mo2=(po2/p); //Mass fraction of O2
19 mn2=(pn2/p); //Mass fraction of N2
20 M=(ro2*32)+(rn2*28); //Average molecular weight
21
22 //OUTPUT
23 mprintf('Molar concentration of O2 is %3.4f K.mol/m
^3 \n Molar concentration of N2 is %3.3f K.mol/m
^3 \n Mass density of O2 is %3.3f kg/m^3 \n Mass
density of N2 is %3.3f kg/m^3 \n Mole fraction of
O2 is %3.2f \n Mole fraction of N2 is %3.2f \n
Mass fraction of O2 is %3.3f \n Mass fraction of
N2 is %3.3f \n Average molecular weight is %3.2f'
,Co2 ,Cn2 ,po2 ,pn2 ,ro2 ,rn2 ,mo2 ,mn2 ,M)
24
25 //=====END OF PROGRAM
=====

```

Scilab code Exa 13.2 Mass and molar average velocities and flux

```

1 //Chapter –13, Example 13.2, Page 545
2 //
=====
3 clc
4 clear
5
6 //INPUT DATA
7 yh2=0.4; //Mole fraction og H2
8 yo2=0.6; //Mole fraction of O2
9 vh2=1; //velocity of H2 in m/s
10 vo2=0; //velocity of O2 in m/s
11
12 //CALCULATIONS
13 V=(yh2*vh2)+(yo2*vo2); //Molar average velocity in m/
s

```

```

14 M=(yh2*2)+(yo2*32); //Molecular weight of the mixture
15 mh2=(yh2*2)/M; //Mass fraction of H2
16 mo2=(yo2*32)/M; //Mass fraction of O2
17 v=(mh2*vh2)+(mo2*vo2); //Mass average velocity in m/s
18 x1=(mh2*vh2); //Mass flux
19 x2=(mo2*vo2); //Mass flux
20 y1=(v*vh2); //Molar flux
21 y2=(yo2*vo2); //Molar flux
22 jh2=(mh2*(vh2-v)); //Mass diffusion flux
23 jo2=(mo2*(vo2-v)); //Mass diffusion flux
24 Jh2=(yh2*(vh2-V)); //Molar diffusion flux
25 Jo2=(yo2*(vo2-V)); //Molar diffusion flux
26
27 //OUTPUT
28 mprintf('Molar average velocity is %3.1f m/s \nMass
    average velocity is %3.2f m/s \n Mass flux of H2
    when it is stationary is %3.2fp kg/m2.s3 \nMass
    flux of O2 when it is stationary is %3.0f kg/m^2.
    s \nMolar flux of H2 when it is stationary is %3
    .2fC k.mol/m^2.s \nMolar flux of O2 when it is
    stationary is %3.0f k.mol/m^2.s \nMass diffusion
    flux of H2 across a surface moving with mass
    average velocity is %3.4fp kg/m^2.s \nMass
    diffusion flux of O2 across a surface moving with
    mass average velocity is %3.4fp kg/m^2.s \
    nMolar diffusion flux across a surface moving
    with molar average velociy for H2 is %3.2fC k.mol
    /m^2.s \nMolar diffusion flux across a surface
    moving with molar average velociy for O2 is %3.2
    fC k.mol/m^2.s ',V,v,x1,x2,y1,y2,jh2,jo2,Jh2,Jo2)
29
30 //=====END OF PROGRAM
    =====

```

Scilab code Exa 13.3 Diffusion flux

```

1 //Chapter -13, Example 13.3, Page 557
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 t=0.001; //Thickness of the membrane in m
8 CA1=0.02; //Concentration of helium in the membrane
   at inner surface in k.mol/m3
9 CA2=0.005; //Concentration of helium in the membrane
   at outer surface in k.mol/m3
10 DAB=10-9; //Binary diffusion coefficient in m2/s
11
12 //CALCULATIONS
13 Nax=((DAB*(CA1-CA2))/t)/10-9; //Diffusion flux of
   helium through the plastic in k.mol/sm2 *10-9
14
15 //OUTPUT
16 mprintf('Diffusion flux of helium through the
   plastic is %3.0f*10-9 k.mol/sm2',Nax)
17
18 //=====END OF PROGRAM

```

Scilab code Exa 13.4 Initial rate of leakage

```

1 //Chapter -13, Example 13.4, Page 557
2 //

```

```

3 clc
4 clear
5

```

```

6 //INPUT DATA
7 T=273+25; //Temperature of Helium gas in K
8 p=4; //Pressure of helium gas in bar
9 Di=0.1; //Inner diamter of wall in m
10 Do=0.003; //Outer diamter of wall in m
11 DAB=(0.4*10^-13); //Binary diffusion coefficient in m
    ^2/s
12 S=(0.45*10^-3); //S value for differentiation
13
14 //CALCULATIONS
15 A=(3.14*Di^2); //Area in m^2
16 V=(3.14*Di^3)/6; //Volume in m^3
17 R=0.08316 //Gas constant in m^3 bar/kmol.K
18 d=((-6*R*T*DAB*S*p)/(Do*Di))/10^-11; //Decrease of
    pressure with time in bar/s*10^-11
19
20 //OUTPUT
21 mprintf('Initial rate of leakage for the system is
    provided by the decrease of pressure with time
    which is %3.2f*10^-11 bar/s',d)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 13.5 Loss of oxygen by diffusion

```

1 //Chapter -13, Example 13.5, Page 558
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 po2=2; //Pressure of O2 in bar

```

```

8 Di=0.025; //inside diamter of the pipe in m
9 L=0.0025; //Wall thickness in m
10 a=(0.21*10^-2); // Diffusivity of O2 in m^2/s
11 S=(3.12*10^-3); // Solubility of O2 in k.mol/m^3.bar
12 DAB=(0.21*10^-9); // Binary diffusion coefficient in m
    ^2/s
13
14 //CALCULATIONS
15 CAi=(S*po2); // Concentration of O2 on inside surface
    in kmol/m^3
16 RmA=((log((Di+(2*L))/Di))/(2*3.14*DAB)); // Diffusion
    resistance in sm^2
17 Loss=(CAi/RmA)/10^-11; // Loss of O2 by diffusion per
    meter length of pipe *10^-11
18
19 //OUTPUT
20 mprintf('Loss of O2 by diffusion per meter length of
    pipe is %3.2f*10^-11 kmol/s',Loss)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 13.6 Mass transfer rate

```

1 //Chapter -13, Example 13.6, Page 560
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 p=1; // Pressure of system in atm
8 T=25+273; // Temperature of system in K
9 pco2=(190/760); // Partial pressure of CO2 at one end

```

```

    in atm
10 pco2o=(95/760); // Partial pressure of CO2 at other
    end in atm
11 DAB=(0.16*10^-4); // Binary diffusion coefficient in m
    ^2/s from Table 13.3
12 R=0.08205 // Gas constant in m^3 atm/kmol.K
13
14 //CALCULATIONS
15 NAX=(DAB*(pco2-pco2o))/(R*T*p); // Equimolar counter
    diffusion in kmol/m^2s
16 M=(NAX*3.14*(0.05^2/4)*3600); // Mass transfer rate in
    kmol/h
17 MCO2=(M*44)/10^-5; // Mass flow rate of CO2 in kg/h
    *10^-5
18 Mair=(29*-M)/10^-5; // Mass flow rate of air in kg/h
    *10^-5
19
20 //OUTPUT
21 mprintf('Mass transfer rate of CO2 is %3.2f*10^-5 kg
    /h \nMass transfer rate of air is %3.2f*10^-5 kg/
    h',MCO2,Mair)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 13.7 Diffusion rate

```

1 // Chapter -13, Example 13.7, Page 563
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA

```

```

7 T=27+273; //Temperature of water in K
8 D=0.02; //Diameter of the tube in m
9 L=0.4; //Length of the tube in m
10 DAB=(0.26*10^-4); //Diffusion coefficient in m^2/s
11
12 //CALCULATIONS
13 p=1.0132; //Atmospheric pressure in bar
14 pA1=0.03531; //Vapour pressure in bar
15 m=((p*10^5*3.14*(D/2)^2*18*DAB)/(8316*T*L))
    *(1000*3600)*log(p/(p-pA1)); //Diffusion rate of
    water in gram per hour
16
17 //OUTPUT
18 mprintf('Diffusion rate of water is %3.4f gram per
    hour ',m)
19
20 //=====END OF PROGRAM
    =====

```

Scilab code Exa 13.8 Diffusion coefficient

```

1 //Chapter -13, Example 13.8, Page 564
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=25+273; //Temperature of water in K
8 D=0.02; //Diameter of the tube in m
9 L=0.08; //Length of the tube in m
10 m=(8.54*10^-4); //Diffusion coefficient in kg/h
11
12 //CALCULATIONS

```



```

13 p=1.0132; // Atmospheric pressure in bar
14 pA1=0.03165; // Vapour pressure in bar
15 DAB=((m/3600)*8316*T*L)/(p*10^5*3.14*(D/2)^2*18*log
      (p/(p-pA1))*10^2))/10^-4; // Diffusion coefficient
      of water in m^2/s *10^-4
16
17 //CALCULATIONS
18 mprintf('Diffusion coefficient of water is %3.3f
      *10^-4 m^2/s ',DAB)
19
20 //=====END OF PROGRAM
      =====

```

Scilab code Exa 13.9 Time required

```

1 //Chapter -13, Example 13.9, Page 569
2 //
      =====
3 clc
4 clear
5
6 //INPUT DATA
7 CA_s=0.02; //Carbon mole fraction
8 CA_o=0.004; //Content of steel
9 CA=0.012; //Percent of depth
10 d=0.001; //Depth in m
11 H=(6*10^-10); //Diffusivity of carbon in m^2/s
12
13 //CALCULATIONS
14 X=(CA-CA_s)/(CA_o-CA_s); //Calculation for erf function
15 n=0.48; //erf(n)=0.5; n=0.48
16 t=((d/(n*2))^2/(3600*H))*3600; //Time required to
      elevate the carbon content of steel in s
17

```

```
18 //OUTPUT
19 mprintf('Time required to elevate the carbon content
    of steel is %3.2f s',t)
20
21 //=====END OF PROGRAM
    =====
```

Chapter 14

Convective Mass Transfer

Scilab code Exa 14.1 Convection mass transfer coefficient

```
1 //Chapter -14, Example 14.1, Page 574
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 D=0.025; //Diameter of the cylinder in m
8 R=(2*10^-6); //Rate of sublime in kg/s
9 C=(6*10^-6); //Saturated vapour concentration in kmol
   /m^3
10 W=128; //Molecular weight in kg/kmol
11
12 //CALCULATIONS
13 q=(R/W); //Molar transfer rate in k.mol/sm
14 h=(q/(%pi*D*C)); //Convective mass transfer
   coefficient in m/s
15
16 //OUTPUT
17 printf('Convective mass transfer coefficient is %3
```

```

    .3 f m/s ',h)
18
19 //=====END OF PROGRAM
    =====

```

Scilab code Exa 14.2 Local Mass transfer coefficient

```

1 //Chapter -14, Example 14.2, Page 576
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 pA=-0.9; //Partial pressure of water vapour in atm
8 t=0.0025; //Boundary layer thickness in m
9
10 //CALCULATIONS
11 //pA=(exp(-33.35y)-0.9)
12 y=0;
13 pAs1=exp(-33.35*y)-0.9; //Partial pressure in atm
14 y=t;
15 pAs2=exp(-33.35*y)-0.9; //Partial pressure in atm
16 //partial derivative of pA wrt y is -33.35exp(y)-0.9
17 x=0;
18 X=(-33.35*exp(x))-pA; //Partial derivative value at x
    =0
19 DAB=(0.26*10^-4) //DAB value in m^2/s
20 h=(DAB*X)/(pAs2-pAs1); //Local mass transfer
    coefficient in m/s
21
22 //OUTPUT
23 mprintf('Local mass transfer coefficient is %3.4f m/
    s ',h)

```

```
24
25 //=====END OF PROGRAM
    =====
```

Scilab code Exa 14.3 Mass Transfer coefficient

```
1 //Chapter -14, Example 14.3, Page 583
2 //
    =====

3 clc
4 clear
5
6 //INPUT DATA
7 T=27; //Temperature of dry air in degree C
8 p=1; //Pressure of dry air in atm
9 L=0.5; //Length of the plate in m
10 v=50; //Velocity in m/s
11
12 //CALCULATIONS
13 DAB=(0.26*10^-4) //DAB value in m^2/s
14 p=1.16; //Density in kg/m^3
15 u=(184.6*10^-7); //Dynamic viscosity in N.s/m^2
16 Pr=0.707; //Prantl number
17 Sc=(u/(p*DAB)); //Schmidt number
18 Re=(p*v*L)/u; //Reynolds number
19 jm=(0.0296*(Re^(-1/5))); //jm value
20 h=(jm*v)/Sc^(2/3); //Mass transfer coefficient of
    water vapour in m/s
21
22 //OUTPUT
23 mprintf('Mass transfer coefficient of water vapour
    is %3.3f m/s',h)
24
25 //=====END OF PROGRAM
```

Scilab code Exa 14.4 Mass transfer coefficient

```
1 //Chapter -14, Example 14.4, Page 583
2 //
3 clc
4 clear
5
6 //INPUT DATA
7 T=27; //Temperature of swimming pool in degree C
8 h=0.4; //Relative humidity
9 v=2; //Speed of wind in m/s
10 v1=(15.89*10^-6); //Kinematic viscosity in m^2/s
11 p=0.0436; //Density in kg/m^3
12 DAB=(0.26*10^-4) //DAB value in m^2/s
13 L=15; //Length in m
14
15
16 //CALCULATIONS
17 Sc=(v1/DAB); //Schmidt number
18 Re=(v*L)/v1; //Reynolds number
19 ShL=(((0.037*Re^(4/5))-870)*Sc^(1/3)); //Equivalent
    Schmidt number
20 h1=(ShL*(DAB/L))/10^-3; //Mass transfer coefficient
    for evaporation in mm/s
21
22 //OUTPUT
23 mprintf('Mass transfer coefficient for evaporation
    is %3.1f*10^-3 m/s ',h1)
24
25 //=====END OF PROGRAM=====
```

Scilab code Exa 14.5 Average mass transfer coefficient

```
1 //Chapter –14, Example 14.5, Page 585
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 T=25; //Temperature of air in degree C
8 v=3; //Velocity in m/s
9 D=0.01; //Diameter of tube in m
10 L=1; //Length of tube in m
11
12 //CALCULATIONS
13 v1=(15.7*10-6); //Kinematic viscosity in m2/s
14 DAB=(0.62*10-5) //DAB value in m2/s
15 Re=(v*D)/v1; //Reynolds number
16 Sh=3.66; //Schmidt number
17 h=(Sh*DAB)/D; //Average mass transfer coefficient in
    m/s
18
19 //OUTPUT
20 mprintf('Average mass transfer coefficient is %3.5f
    m/s ',h)
21
22 //=====END OF PROGRAM


---


```

Scilab code Exa 14.6 Mass transfer coefficient

```

1 //Chapter -14, Example 14.6, Page 586
2 //


---


3 clc
4 clear
5
6 //INPUT DATA
7 T=25; //Temperature of air in degree C
8 v=5; //Velocity in m/s
9 D=0.03; //Diameter of tube in m
10 DAB=(0.82*10^-5) //DAB value in m^2/s
11
12 //CALCULATIONS
13 v1=(15.7*10^-6); //Kinematic viscosity in m^2/s
14 Sc=(v1/DAB); //Schnidt number
15 Re=(v*D)/v1; //Reynolds number
16 h=(0.023*Re^(4/5)*Sc^(1/3)*DAB)/D; //Mass transfer
    coefficient in m/s
17
18 //OUTPUT
19 mprintf('Mass transfer coefficient is %3.4f m/s',h)
20
21 //=====END OF PROGRAM


---



```

Scilab code Exa 14.7 Steady state temperature

```

1 //Chapter -14, Example 14.7, Page 589
2 //


---


3 clc
4 clear
5

```



```

6 //INPUT DATA
7 Ta=40+273;//Temperature of air in K
8 w=100;//Molecular weight in kg/k.mol
9 H=120;//Latent heat of vapourisation of volatile
    liquid in kJ/kg
10 p=3530;//Saturated vapour pressure in N/m^2
11 DAB=(0.2*10^-4);//DAB value in m^2/s
12
13 //CALCULATIONS
14 p1=1.16;//Density in kg/m^2
15 Cp=1.007;//Specific heat in J/kg.K
16 a=(22.5*10^-6);//Diffusivity in m^2/s
17 X=((H*100*p*10^-3)/(8.315*p1*Cp*(a/DAB)^(2/3)));//X
    value for temperature
18 T=(Ta+sqrt((Ta^2-(4*X))))*0.5;//Temperature in K
19
20 //OUTPUT
21 mprintf('Steady state temperature of cold water
    inside the pot is %3.1f K',T)
22
23 //=====END OF PROGRAM
    =====

```

Scilab code Exa 14.8 True air temperature

```

1 //Chapter -14, Example 14.8, Page 590
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=22+273;//Thermometer reading in K
8

```

```

9 //CALCULATIONS
10 p=2617;//Pressure in N/m^2
11 hfg=2449;//Enthalpy in kJ/kg
12 p1=(p*18)/(8315*T);//Density in kg/m^3
13 p2=(1.0132*10^5)/(287*T);//Density in kg/m^3
14 Cp=1.008;//Specific heat in kJ/kg.K
15 a=(26.2*10^-6);//Diffusivity in m^2/s
16 DAB=(0.26*10^-4);//DAB value in m^2/s
17 Ts=((T-273)+((hfg*1000*p1)/(p2*Cp*1000)));//True air
    temperature in degree C
18
19 //OUTPUT
20 mprintf('True air temperature is %3.2f degree C',Ts)
21
22 //=====END OF PROGRAM
    =====

```

Scilab code Exa 14.9 Relative humidity

```

1 //Chapter -14, Example 14.9, Page 591
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=50;//Temperature of air stream in degree C
8 Tb=22;//Bulb temperature in degree C
9
10 //CALCULATIONS
11 Tf=(T+Tb)/2;//Film temperature in degree C
12 p=1.14;//Density in kg/m^3
13 Cp=1.006;//Specific heat in J/kg.K
14 Pr=0.7;//Prantl number

```

```

15 u=(2*10^-5); //Dynamic viscosity in Ns/m^2
16 DAB=(0.26*10^-4); //DAB value in m^2/s
17 Sc=(u/(p*DAB)); //Schmidt nuber
18 Le=(Sc/Pr); //Lewis number
19 p1=0.01920; //Density in kg/m^3
20 hfg=2449; //Enthalpy in kJ/kg
21 pA=0.0064; //Density in kg/m^3
22 psat=(1/12.23); //Saturation density in kg/m^3
23 RH=(pA/0.0817)*100; //Relative humidity
24
25 //OUTPUT
26 mprintf('Relative humidity of the airstream is %3.2 f
           percent ',RH)
27
28 //=====END OF PROGRAM
           =====

```

Scilab code Exa 14.10 Specific humidity

```

1 //Chapter -14, Example 14.10, Page 592
2 //

```

```

3 clc
4 clear
5
6 //INPUT DATA
7 Td=27; //Dry bulb teperature in degree C
8 Tw=17; //Wet bulb temperature in degree C
9 Pr=0.74; //Prantl number
10 Sc=0.6; //Schmidt number
11 Mv=18; //Molecular weight of vapour
12 Ma=29; //Molecular weight of air
13 Cp=1004; //Specific heat in J/kg.K
14 p=(1.0132*10^5); //Pressure in N/m^2

```

```

15
16 //CALCULATIONS
17 pv2=1917;//Saturation presure of air at 17 degree C
    in N/m^2
18 hfg=2461;//Enthalpy in kJ/kg
19 w2=(Mv*pv2)/(Ma*(p-pv2));//Weight in kg/kg of dry
    air
20 w1=w2-((Cp*(Pr/Sc)^(2/3)*(Td-Tw))/(hfg*1000));//
    Specific humidity of air in kg/kg of dry air
21
22 //OUTPUT
23 mprintf('Specific humidity of air is %3.5f kg/kg of
    dry air ',w1)
24
25 //=====END OF PROGRAM
    =====

```

Scilab code Exa 14.11 Rate of evaporation

```

1 //Chapter -14, Example 14.11, Page 592
2 //
    =====
3 clc
4 clear
5
6 //INPUT DATA
7 T=27;//Temperature of swimming pool in degree C
8 Ts=37;//Surface temperature in degree C
9 h=0.4;//Relative humidity
10 D1=5;//Dimension of swimming pool in m
11 D2=15;//Dimension of swimming pool in m
12 v=2;//Speed of wind in m/s
13 v1=(15.89*10^-6);//Kinematic viscosity in m^2/s
14 p=0.0436;//Density in kg/m^3

```

```

15 DAB=(0.26*10^-4) //DAB value in m^2/s
16 Sc=(v1/DAB); //Schmidt number
17 Re=(v*D2)/v1; //Reynolds number
18 ShL=(((0.037*Re^(4/5))-870)*Sc^(1/3)); //Equivalent
    Schmidt number
19 h1=(ShL*(DAB/D2)); //Mass transfer coefficient for
    evaporation in m/s
20
21 //CALCULATIONS
22 Psat=3531; //Partial pressure of water vapour in N/m
    ^2
23 pi=(0.4*6221); //Saturation pressure of water vapour
    in N/m^2
24 pt=101325; //Total pressure of air in N/m^2
25 pAs=(18*Psat)/(8361*(T+273)); //Density at the water
    surface in kg/m
26 pAi=(18*pi)/(8316*(T+273)); //Density at the water
    surface in kg/m
27 n=(h1*(pAs-pAi)*3600*24); //Rate of evaporation of
    water in kg/m^2 day
28 L=(n*D1*D2); //Total water loss from the swimming
    pool in kg/day
29
30 //OUTPUT
31 mprintf('Rate of evaporation of water is %3.1f kg/
    day',L)
32
33 //=====END OF PROGRAM
    =====

```
