Scilab Textbook Companion for
Heat And Mass Transfer
by E. R. G. Eckert And R. M. Drake[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Introduction

Scilab code Exa 1.1 Thermal resistance

```
 1  clc ();
 2  clear ;
 3
 4  // To calculate the overall thermal resistance and
        overall heat transfer coefficient
 5
 6  b = 0.5/12;                        // Thickness of
        iron wall in ft
 7  k = 30;                           // Thermal
        conductivity in Btu/hr-ft
 8  h1 = 2;                           // Heat transfer
        coefficient in Btu/hr-ft
 9  h2 = 2;                           // Heat transfer
        coefficient in Btu/hr-ft
10  R = (1/h1)+(1/h2)+(b/k);          // Overall
        thermal resistance*Area in hr-F/Btu ie. (R/A)
11  U = 1/R;                          // Overall heat
        transfer coeficient in Btu/hr-ft^2-F
12
13  printf("The overall thermal resistance is %.4f/A hr-
        F/Btu/A, where A is the area of wall  \n",R);
```

```
14  printf(" The overall heat transfer coefficient is %d
          Btu/hr−ft^2−F",round(U));
```

Scilab code Exa 1.2 Overall heat transfer coefficient

```
1  clc();
2  clear;
3
4  // To calculate the thermal resistance
5
6  b1 = 0.5/12;                          // Thickness of
        iron wall in ft
7  b2 = 0.0005/12;                       // Thickness of
        air gap in ft
8  b3 = 1/12;                            // Thickness of
        aluminium wall in ft
9  k1 = 30;                              // Thermal
        conductivity in Btu/hr−ft^2−F
10 k2 = 0.015;                           // Thermal
        conductivity in Btu/hr−ft^2−F
11 k3 = 118;                             // Thermal
        conductivity in Btu/hr−ft^2−F
12 R = (b1/k1)+(b2/k2)+(b3/k3);          // Thermal
        resistance*Area
13
14 printf("The overall thermal resistance of composite
        wall is %f/A hr−F/Btu, A being the area of wall
        in ft^2",R);
```

Scilab code Exa 1.3 Heat exchanger

```
1  clc();
2  clear;
```

7

```scilab
3
4  // To calculate the size of heating surface
5
6  m1 = 100;                              // Flow rate of
        water in lb/hr
7  ta1 = 50;                             // Initial
      temperature of water in F
8  ta2 = 170;                            // Final
      temperature of water
9  Cp1 = 1;                              // Heat
      capacity of water in Btu/lb-F
10  te1 = 330;                           // Initial
      temperatutre in flue gases in F
11  m2 = 400;                            // Mass flow
      rate of flue gases in lb/hr
12  Cp2 = .25;                           // Heat
      capacity of flue gases in Btu/lb-F
13  q = m1*Cp1*(ta2-ta1);                // Heat
      absorbed by water in Btu
14  te2 = te1-q/(m2*Cp2);                // Final
      temperature of flue gases in F
15  U = 20;                              // Overall heat
        transfer in Btu/hr-ft^2-F
16
17  // For parallel flow
18  delte = te1-ta1;                     // Flue
      tempearture difference in F
19  delta = te2-ta2;                     // Water
      temperature difference in F
20
21  // Seeing the value of delte/delta=7, we can attain
      the value of a
22  a1 = 0.77;
23  deltm = (delte + delta)/2;           // Arithmetic
      mean in F
24  LMTD1 = a1*deltm;                     // Log mean
      temperature diffference
25  A1 = q/(U*LMTD1);                     // Area in ft^2
```

8

```
26  printf("The area of heat exchanger for parallel flow
        is %.2f ft^2 \n ",A1);

27
28  // for counterflow
29  delte = te1-te2;                          // Flue
        tempearture difference in F
30  delta = ta1-ta2;                          // Water
        temperature difference in F

31
32  // Seeing the value of delte/dela=1, a=1.
33  a2 = 1;
34  LMTD2 = a2*deltm;                         // Log mean
        temperature diffference
35  A2 = q/(U*LMTD2);                         // Area in ft
        ^2
36  printf("The area of heat exchanger for counterflow
        flow is %.2f ft^2 \n ",A2);

37
38  // For cross flow
39  delte = te1-ta1;                          // Flue
        tempearture difference in F
40  delta = te2-ta2;                          // Water
        temperature difference in F

41
42  // Seeing the value of delta/delte=0.143, we can
        attain the value of a=0.939
43  a3 = 0.939;
44  deltm = (delte + delta)/2;                // Arithmetic
        mean in F
45  LMTD3 = a3*deltm;                         // Log mean
        temperature diffference
46  A3 = q/(U*LMTD3);                         // Area in ft^2
47  printf("The area of heat exchanger for cross flow is
        %.2f ft^2 \n ",A3);
```

Chapter 3

Steady heat conduction

Scilab code Exa 3.1 Heat exchanger

```
1  clc();
2  clear;
3
4  // To calculate the length of the well
5
6  d = 0.06/12;                        // diameter of
        the thermometer in ft
7  h = 18.5;                           // heat teansfer
        coefficient in Btu/hr−ft^2−F
8  k = 32;                             // Thermal
        conductivity in Btu/hr−ft^2−F
9  s = 0.036/12;                       // thickness of
        wall in ft
10 m = sqrt(h/(k*s));                  // parameter
11
12 // Error is less than 0.05% of the dfference between
        the gas temperature and the tube well
        temperature. Hence a=m*l
13
14 a = 6;                              // a=m*l
15 l = a/m;                            // Length of
```

```
          well in ft
16 printf("The length of well is %.2f ft",l)
```

Scilab code Exa 3.2 Finned heated surfaces

```
1 clc();
2 clear;
3
4 // To determine the effectiveness of iron fins of
       0.14 inch thickness
5 // For heat transfer to air
6 b = 0.12/12;                    // Thickness of iron fins
       in ft
7 k = 33;                        // Mean thermal
       conductivity of iron in Btu/hr−ft^2
8 Hamin = 2;                      // Minimum heat ransfer
       coefficient with air in Btu/hr−ft^2−F
9 Hamax = 20;                     // Minimum heat ransfer
       coefficient with air in Btu/hr−ft^2−F
10 // Inserting the higher value of heat transfer
       coefficient
11 m1 = 2*k/(Hamax*b);         // Characteristic value
12 // haracteristic value is quite high
13 printf("Since m = %d, hence the heat transfer from
       iron fins to air is advantageous \n",m1);
14
15 // For heat transfer to water
16
17 Hwmin = 100;                      // Minimum heat ransfer
       coefficient with air in Btu/hr−ft^2−F
18 Hwmax = 1000;                     // Minimum heat ransfer
       coefficient with air in Btu/hr−ft^2−F
19 // Inserting the higher value of heat transfer
       coefficient
20 m2 = 2*k/(Hwmax*b);           // Characteristic value
```

11

```
21 // Characteristic value is quite low
22 printf("Since m = %.1f, hence the heat transfer from
       iron fins to water is not advantageous \n",m2);
```

Scilab code Exa 3.3 Rectangular fins

```
1 clc();
2 clear;
3
4 // To study the effect of adding fins to the
       cylindrical barrel of an air cooled engine
5
6 l1= 3/12;                              // Length of
       fins in ft
7 l2 = 4/12;
8 h = 50;                               // Heat transfer
       coefficient in Btu/hr-ft-F
9 k = 28;                               // Thermal
       conductivity in Btu/hr-ft-F
10 T1 = 250;                            // Cylinder wall
       temperature in F
11 T2 = 70;                             // Air
       temperature in F
12 th = T1-T2;                          // Temperature
       difference
13 b = 0.09/12;                         // Thickness of
       fins in ft
14 m = 2*h/(b*k);                       //
       Characteristic parameter
15 // Seeing the value of length and m, yhe bessel
       functions can be found out
16
17 I2 = 188/7.26;                           // Magnitudes
       of bessel functions
18 I0 = 41.0/5.45;
```

12

```
19  I1 = 37.2/5.45;
20  K2 = 0.0;
21  K0 = 0.0022/5.45;
22  K1 = 0.0024/5.45;
23
24  q1 = 2*%pi*0.27*k*sqrt(m)*th*(I2*l2*m*K1*l1-K2*l2*m*
        I1*l1)/(144*(I2*l2*sqrt(m)*K0*l1*sqrt(m)+K2*l2*
        sqrt(m)*I0*l1*sqrt(m)));
25  // Heat loss by finned surface
26  q2 = 0.27/144*2*%pi*3*h*th;             // heat loss
        from barred surface
27
28  printf("the heat loss from the cylindrical barrel in
          presence of fins is %d Btu/hr \n ",q1);
29  printf("the heat loss from the bare cylindrical
        barrel is %d Btu/hr \n ",q2)
```

Scilab code Exa 3.4 Minimum width fins

```
1   clc();
2   clear;
3
4   // To study the effect of adding fins to the
        cylindrical barrel of an air cooled engine
5
6   l1= 3/12;                               // Length of
        fins in ft
7   l2 = 4/12;
8   h = 50;                                 // Heat transfer
        coefficient in Btu/hr-ft-F
9   k = 28;                                 // Thermal
        conductivity in Btu/hr-ft-F
10  T1 = 250;                               // Cylinder wall
        temperature in F
11  T2 = 70;                                // Air
```

13

```
            temperature in F
12  th = T1-T2;                              // Temperature
        difference
13  b = 0.09/12;                             // Thickness of
        fins in ft
14  m = 2*h/(b*k);                           //
        Characteristic parameter
15  // Seeing the value of length and m, yhe bessel
        functions can be found out
16
17  I2 = 188/7.26;                              // Magnitudes
        of bessel functions
18  I0 = 41.0/5.45;
19  I1 = 37.2/5.45;
20  K2 = 0.0;
21  K0 = 0.0022/5.45;
22  K1 = 0.0024/5.45;
23
24  q1 = 2*%pi*0.27*k*sqrt(m)*th*(I2*l2*m*K1*l1-K2*l2*m*
        I1*l1)/(144*(I2*l2*sqrt(m)*K0*l1*sqrt(m)+K2*l2*
        sqrt(m)*I0*l1*sqrt(m)));
25  // Heat loss by finned surface
26  q2 = 0.27/144*2*%pi*3*h*th;            // heat loss
        from barred surface
27
28  printf("the heat loss from the cylindrical barrel in
         presence of fins is %d Btu/hr \n ",q1);
29  printf("the heat loss from the bare cylindrical
        barrel is %d Btu/hr \n ",q2)
```

Scilab code Exa 3.5 Wall with heat sources

```
1  clc;
2  clear;
3
```

```
4  // To find the tempearure difference in the plane
       wall with heat sources
5  d1 = 0.55;                              // Inside diameter
       of copper wire
6  d2 = 0.8;                               // Outside
       diameter of copper wire
7  phi = 0.6;                              // Fraction of
       copper in wire
8  j = 1300;                               // Current density
       in conductors in amp/in^2
9  p = 9.5*10^(-6);                        // Specific
       resistance in ohm-in^2/ft
10 h = 4;                                  // Heat transfer
       coefficient on both sides ofcoil
11 k = 0.2;                                // Thermal
       conductivity of coil in Btu/hr-ft-F
12 T0 = 70;                                // Temperature of
       air in degF
13 // Considering it as a plane wall with a thickness
       of 0.25 ft
14 b = 0.125;                              // half the
       thickness of wall in ft
15 l = 0.0625;                             // Distance
       between the two walls
16 q = j*j*p*phi*144*3.412;                // Generation of
       heat in Btu/hr-ft-F
17 th0 = (4730*l*l/(2*k))+(4730*l/h);          //
       Teperature difference in F
18 t0 = T0+th0;                            // Temperature at
       the center in F
19
20 printf("The temperature at the centre of the pool is
       %.1f degF \n",t0);
```

Scilab code Exa 3.6 2D steady state conduction

```scilab
1  clc();
2  clear;
3
4  // To determine the shape factor for the heat flow
       through a square duct whose surface temperatures
       are constant
5
6  // Since the duct is symmetrical. Only one of the
       corners is to be considered
7  Nc = 20;                          // Number of heat flow
       lanes
8  Nr = 7;                           // Number of temperature
        increments
9  S = Nc/Nr;                        // Shape factor
10 printf("The Shape factor for heat flow through
       square duct is %.2f \n ",S);
11 printf("And the heat transfer through conduction is
       %.2f kL(t1-t2)",S);
```

Chapter 4

Unsteady heat conduction

Scilab code Exa 4.1 Unsteady state conduction

```
1 clc();
2 clear;
3
4 // To measure an unsteady state temperature with a
      thermometer and half value time
5
6 // Half value time is the time within which the
      initial difference etween the true and indicated
      temperature is reduced to half its initial value
7
8 l = 0.01/2;                          // Length of
      cylindrical tube in ft
9 a = 0.178;                           // Thermal
      diffusivity in ft^2/hr
10 k = 5;                              // Thermal
      conductivity in Btu/hr-ft-F
11 h = 10;                             // Heat
      transfer coefficient in Btu/hr-ft^2-F
12 Bi = h*l/k;                         // Biot number
13
14 // For half time
```

```
15  th = 0.693*l*l*3600/(Bi*a);          // Half time in
        hr
16
17  printf("The half time for unsteady change
        temperature change is %d sec",th);
```

Scilab code Exa 4.2 Lag of thermometer

```
1  clc();
2  clear;
3
4  // To calculate the lag of thermometer used in
       initial example while the oven is heating
5
6  r = 0.01;                              // Radius of
       cylindrical tube in ft
7  a = 0.178;                             // Thermal
       diffusivity in ft^2/hr
8  k = 5;                                 // Thermal
       conductivity in Btu/hr-ft-F
9  h = 2;                                 // Heat
       transfer coefficient in Btu/hr-ft^2-F
10 s = 400;                               // Rate of
       temperature change
11 tlag = r*k*s/(2*a*h);
12
13 printf("The lag of thermometer while the oven is
       heating at the rate of 400F/hr is %.1f F",tlag);
```

Scilab code Exa 4.3 Infinite flat plate

```
1  clc();
2  clear
```

```
 3
 4  // To find the time required for the billet to
       remain in the oven
 5
 6  A = 2;                                        // Length of
       steel billet in ft
 7  B = 2;                                        // Breadth of
       billet in ft
 8  C = 4;                                        // Height of
       billet in ft
 9  To = 70;                                      // Initial
       temperature of billet n F
10  Tf = 750;                                     // Maximum
       temp. of billet in F
11  T = 700;                                      // Temperature
       for which time has to be found out
12  k = 25;                                       // Thermal
       conductivity in Btu/hr−ft^2−F
13  a = 0.57;                                     // Thermal
       diffusivity in ft^2/hr
14  h = 100;                                      // Heat
       transfer coeff. in Btu/hr−ft
15
16  BiA = h*A/k;                                  // Biot number
17  BiB = h*B/k;
18  BiC = h*C/k;
19  t = 1.53;                                     // Assumed
       temperature in F
20  s1 = a*t/A^2;                                 // Parameters
21  s2 = a*t/B^2;
22  s3 = a*t/C^2;
23
24  // Seeing the values of Bi and s and comparing from
       the table
25
26  // T/Toa=0.302 and T/Tob=0.805 and (T/Toa)^2*T/Toc
       =0.0735
27
```

19

```
28  printf ("The time required for the centre temperature
        to reach 700 F under the conditions specified in
        the problem is t=%.2f hr",t);
```

Scilab code Exa 4.4 Semi infinite solid

```
1  clc ();
2  clear;
3
4  // To calculate the time needed to estabilish a
        steady state temperature distribution in the
        walls and in the room
5  tf = 70;                               // Final
        temperature of the wall in F
6  hi = 1.2;                              // Inner heat
        transfer coefficint of wall i Btu/hr-ft^2-degF
7  ho = 3.0;                              // Outer heat
        transfer coefficient in Btu/hr-ft^2-degF
8  a = 0.012;                             // Thermal
        diffusivity in ft^2/hr
9  x = 1.3;                               // Thickness of
        wall in ft
10
11 // Assuming the rate of heat trasfer to the inside
        of a wall is constant
12 // And since the wall is divided into six sections
13 delx = x/6;                            // Thickness of
        sections in ft
14 t = (delx)^2/(2*a);                    // time
        required in hr
15 printf ("the time needed to estabilish a steady state
        temperature distribution in the walls and in the
        room is %.2f hr",t);
```

20

Scilab code Exa 4.5 Periodic heat conduction

```
1  clc();
2  clear;
3
4  // To calculate the depth and yearly temperature
       fluctuations penetrate the ground
5
6  a = 0.039;                                      //
       thermal diffusivity of claylike soil
7  to = 24;                                        //
       time for daily fluctuations in hr
8  x = 1.6*sqrt(%pi*a*to);                         //
       depth of penetration for daily fluctuation in ft
9  xy = sqrt(365)*x;                               //
       depth of penetration for yearly fluctuation in ft
10
11 printf("The depth of penetration for daily
       fluctuation is %.2f ft and depth of penetration
       for yearly fluctuation is %.2f ft",x, xy);
```

Scilab code Exa 4.6 Semi infinite solid

```
1  clc();
2  clear;
3
4  // To calculate the depth of penetration of the
       temperature oscillation into the cylinder wall
5
6  rpm = 2000;                                     //
       Revolutions per minute of motor
```

21

```
 7  a = 0.64;                              // Thermal
        diffusivity in ft^2/hr
 8  to = 1/(60*rpm);                       // Period of
        oscillation in hr
 9  x = 1.6*sqrt(%pi*a*to);                // depth of
        penetration in hr
10  printf("the depth of penetration of the temperature
        oscillation into the cylinder wall is %.5f ft",x)
        ;
```

Scilab code Exa 4.7 depth of penetration

```
 1  clc();
 2  clear;
 3
 4  // To calculate the depth of penetration of the
        temperature oscillation into the cylinder wall
 5
 6  rpm = 2000;                            //
        Revolutions per minute of motor
 7  a = 0.64;                              // Thermal
        diffusivity in ft^2/hr
 8  to = 1/(60*rpm);                       // Period of
        oscillation in hr
 9  x = 1.6*sqrt(%pi*a*to);                // depth of
        penetration in hr
10  printf("the depth of penetration of the temperature
        oscillation into the cylinder wall is %.5f ft",x)
        ;
```

Chapter 6

Flow along surfaces and its channels

Scilab code Exa 6.1 Laminar flow

```
1  clc();
2  clear;
3
4  //*****Data*****//
5  x = 4/12;// [thickness of plate, inch]
6  v = 33;// [fps]
7  n = 15.4*10^(-5);// [kinematic viscosity, feet^2/s]
8  //************//
9
10 Re = v*x/n;// [Reynold's number]
11 delta = 4.64*x*12/sqrt(Re);// [Boundary layer
      thickness ,ft]
12 printf("Boundary layer thickness at 4 in. distance
      is %.4f in.",delta);
```

Scilab code Exa 6.2 turbulent boundary layer

```
 1  clc();
 2  clear;
 3
 4  // To calculate the thickness of turbulent boundary
        layer at a distance of 12 inch
 5  x = 12/12;                              // Distance
        from leading edge in ft
 6  v = 33;                                 // Stream
        flowing velocity in ft
 7  n = 15.4*10^(-5);                       // kinematic
        viscosity , feet^2/s
 8
 9  Re = v*x/n ;                            // reynolds
        number
10  delta = 0.376*x/(Re^0.2);              // Boundary
        layer thickness ,ft
11  delb = 0.036*delta*12;                 // Turbulent
        layer thickness , in
12  printf("The turbulent boundarty layer thickness is %
        .3f ft",delb);
```

Chapter 7

Forced convection in laminar flow

Scilab code Exa 7.1 Plate in longitudinal flow

```
1 clc();
2 clear;
3
4
5 // to calculate the heat tranaferv coefficient for a
      plate in an air stream
6
7 x = 4/12;                          // distance from
      leading edge in ft
8 u = 33;                            // air velocity in fps
9 Ts = 125;                          //
10 Tw = 255;                         // surface temperature
      in F
11 k = 0.0178;                       // Thermal conductivity
       in Btu/hr-ft -F
12 Re = 46600;                       // Reynolds number
13 Pr = 0.695;                       // Prandtls number
14
15 Nu = 0.332*Re^.5*Pr^(1/3);    // Nusselt number
```

25

```scilab
16  h = Nu*k/x;                         // Local heat transfer
        coefficient
17  ha = h*12;                          // Heat transfer
        coefficient average
18  b = 1;                              // Width of plate in ft
19  x = 4/12;                           // Length of plate
20
21  q = ha*b*x*(Ts-Tw);                 // Heat loss in Btu/hr
22
23  printf("The heat transfer coefficient for a plate in
        an air stream is %.2f Btu/hr-ft^2-F ",h);
```

Chapter 8

Forced convection in turbulent flow

Scilab code Exa 8.1 Analogy between momentum and heat

```
1 clc();
2 clear;
3
4 // To find the amount of heat transferred to the air
5
6 Tw = 200;                          // Wall
      temperature in F
7 delp = 14.2;                       // Pressure
      pressure in lb/in^2
8 d = 0.8/12;                        // Diameter in ft
9 R = delp*%pi*d^2/4;                // resistance of
      tube
10 Tb = 137;                         // bulk
      temperature of wall in F
11
12 q = R*32.2*0.24*3600*(Tw-Tb)/100;    // Heat loss
      in Btu/hr
13 printf("The heat loss from the tube well to the air
      when the plate is heated to a temperature of 200
```

F is %d Btu/hr",q);

Scilab code Exa 8.2 Flow in a tube

```
1  clc();
2  clear;
3
4  // To find the extent of heating of water and heat
       transfer
5
6  d = 0.24/12;                      // Diameter of tubes
          in ft
7  l = 24/12;                        // Length of tubes
         in ft
8  v = 3;                            // velocity of
        cooling water in ft/sec
9  T = 140;                          // Temperature of
        cooling water in F
10 n = 0.514*10^-5;                  // Kinematic
       viscosity in ft^2/sec
11 Pr = 3.02;                        // Prandtls number
12 k = 0.376;                        // Thermal
       conductivity in Btu/hr-ft-F
13 Re = d*v/n;                       // Reynolds number
14 A = 1.5;                          // Experimental
       constant
15 // Turbulent flow
16 // Greater part of the flow is developed , A=1.5
       from the table
17
18 St = 0.0384*(v*d/n)^-(1/4)/(1+A*(v*d/n)^-(1/8)*(Pr
       -1));    // Strantons number
19 Nu = Re*Pr*St;
                                                      //
       Nusselt number
```

28

```
20  h = Nu*k/d;                                    // Heat
        transfer  coefficient
21
22  printf("The  heat  transfer  coefficient  of  heating  of
        waterr  is  %d  Btu/hr−ft^2−F",h);
```

Scilab code Exa 8.3 plane plate in longitudinal flow

```
1  clc();
2  clear;
3
4  // To  find  the  heat  transfer  coefficient  at  x = 12
        in.
5
6  Tp = 176;                          // Temperature  of  plate
            in  F
7  Ta = 68;                           // Tempearture  of  air
        stream  in  F
8  Tm = (Tp+Ta)/2;                    // Maen  temperature  in
        F
9  u = 30;                            // Velocity  in  fps
10 n = 19.45*10^-5;                   // Dynamic  visosity  in
        ft^2/sec
11 v = 30;                            // Velocity  in  fps
12 Pr = 0.703;                        // Prandtls  number
13 x = 12/12;                         // distance  in  ft
14 k = 0.0162;                        // Thermal  conductivity
        in  Btu/hr−ft^2−F
15 Re = v*x/n;                        // Reynolds  number
16 // The  boundary  layer  must  be  laminar  or  turbulent
17
18 St =   0.0296*(Re)^-(1/5)/(1+1.75*0.87*(Re)^-(1/10)*(
        Pr-1));    // Strantons  number
19 Nu = Re*Pr*St;                                    // Nusselt
        number
```

```
20  h = Nu*k/x;                                    // Heat
        transfer coefficient
21
22  printf("The heat transfer coefficient of heating of
        water for laminar is %.2f Btu/hr-ft^2-F",h)
23
24  // If the flow is laminar
25  Nu1 = 0.332*Re^(1/2)*Pr^(1/3);                 //
        Nusselt number
26  h1 = Nu1*k/x;                                  // Heat
        transfer coefficient
27  printf(" \n The heat transfer coefficient for
        turbilent layer is %.2f Btu/hr",h1);
```

Chapter 10

Special heat transfer processes

Scilab code Exa 10.1 Dimensional analysis

```
1  clc();
2  clear;
3
4  // To calculate the heat transfer coefficient from
       the plate to the air
5
6  Tw = 196;                        // Temperature of plate
         in F
7  Ts = 79;                         // Temperature of the
       air in F
8  u = 587;                         // velocity in air in
       fps
9  x = 4/12;                        // Length of plate in
       ft
10 n = 20.4*10^-5;                  // Kinematic velocity
11 Cp = 1200;                       // Specific heat
       capacity
12 Re = u*x/n;                      // Reynolds number
13 r = 0.845;                       // Temperature recovery
         factor
14 tr = Ts+r*u*u/Cp;                // Dynamic temperature
```

```
                in F
15  Pr = 0.697;                            // Pradtls number
16  p = 0.0657;                            // Density in lb/ft^3
17  t = 144.1;                             // Corresponding
        temperature in F
18  St =  0.0296*(Re)^-(1/5)/(1+1.75*0.87*(Re)^-(1/10)*(
        Pr-1));
19  // Strantons number
20
21  h = p*u*St*3600;                       // Heat transfer
        coefficient
22  hav = 1.215*h;                         // Average heat
        transfer coefficient
23
24  printf("The heat transfer coefficient from the palte
         to the air is %.1f Btu/hr-ft^2-F",hav);
```

Chapter 11

Free convection

Scilab code Exa 11.1 Laminar heat transfer

```scilab
1  clc();
2  clear;
3
4  // To calculate the local heat transfer coefficient
5
6  Ts = 200;                              // Temperature
       of steam in F
7  Ta = 68;                               // Air
       temerature in F
8  n = 24.21*10^-5;                       // Kinematic
       viscosity in ft^2/sec
9  k = 0.0181;                            // Thermal
       conductivity in Btu/hr-ft-F
10 g = 32.2;                              // Gravity
11 b = 1/528;                             // Expansion
       coefficient
12 x = 8/12;                              // Distance
       from lower end
13 th = Ts-Ta;                            // Temperature
       difference in F
14 Gr = g*b*th*x^3/(n^2);                 // Grashops
```

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```
            number
15  Pr = 0.694;                                    // Prandtls
            number
16  del = x*3.93*Pr^(-0.5)*((0.952+Pr)^1/4)*Gr^(-0.25);
17  // Boundary layer thickness
18  h = 2*k/del;                                   // film heat
            transfer coefficient
19  hav = 4*h/3;                                   // Avg heat
            transfer cioefficient
20  printf("The average heat transfer coefficient over
            the length of 8 in. is %.2f Btu/hr-ft^2-F",h);
```

Chapter 12

Condensation and evaporation

Scilab code Exa 12.1 Film coefficient

```
1  clc();
2  clear;
3
4   // To calculate the heat transfer coefficient
5
6  L = 1029;                    // Heat of evaporation
      in Btu/lb
7  n = 0.654*10^-5;             // Kinematic viscosity
      in Btu/hr-ft-F
8  p = 62;                      // density in lb/ft^3
9  k = 0.367;                   // Thermal conductivity
       in Btu/hr-ft^2-F
10 g = 32.2;                    // Gravity
11 x = 3/12;                    // Distance from upper
      edge in ft
12 ts = 114;                    // Saturation
      temperature in F
13 tw = 105;                    // Wall temperature in
      F
14
15 h = (g*k^3*p*L*3600/(4*n*x*(ts-tw)))^0.25;     //
```

```
         Heat transfer coefficient
16  hav = h*4/3;                                   //
        Avg heat transfer coefficient
17
18  printf("The average heat transfer coefficient is %d
        Btu/hr-ft^2-F",hav);
```

Scilab code Exa 12.2 Vertical wall

```
1  clc();
2  clear;
3
4   // To calculate the heat exchange by radiatiojn
        between two walls
5
6   t1 = 2500;                        // Temperature of
        saturated steam in F
7   t2 = 600;                         // External
        temperature of tube walls in F
8   e = 0.8;                          // Emmisivity of tube
        wall arrangement
9   p = 0.87;                         // Emperical factor
10  A = 148.5;                        // Area of the wall in
        ft^2
11  s = 0.173*10^-8;                  // Stephens boltzmanns
        constant
12  q = s*e*A*p*(((t1+460)^4)-((t2+460)^4));    // heat
        loss in Btu/hr
13
14  printf("The heat exchange per unit area is %.2f Btu
        /hr",q);
```

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Chapter 14

Heat exchange by radiation

Scilab code Exa 14.1 Radiation between two walls

```scilab
1  clc();
2  clear;
3
4   // To calculate the heat exchange by radiation
        between two walls
5
6   t1 = 212;                           // Temperature of
        contents in the bottle in F
7   t2 = 68;                            // Ambient
        temperature in F
8
9   e = 0.02 ;                          // Emmisivity of
        silver
10  e12 = 1/(2/e-1);                    // Exchange factor
11   s = 0.173*10^-8;                   // Stephens
        boltzmanns constant
12
13  q = s*e12*((t1+460)^4-(t2+460)^4);     // Heat loss
        in Btu/hr
14  printf("The heat flow per unit area of the inner
        wall is %.2f Btu/hr-ft^2",q);
```

Scilab code Exa 14.2 Radiation of flames

```scilab
1  clc();
2  clear;
3
4   // To calculate the heat exchange by radiation
        between two walls
5
6   t1 = 2500;                        // Temperature of
        saturated steam in F
7   t2 = 600;                         // Temperature of
        tube wall in F
8   p = 0.87;                         // Emperical factor
9   A = 148.5;                        // Area of tube
        walls
10  A1 = 168.8;                       // Area of walls
        lined with cooling tubes
11  e = 0.8 ;                         // Emmisivity of
        silver
12   s = 0.173*10^-8;                 // Stephens
         boltzmanns constant
13
14  q = p*s*e*A*((t1+460)^4-(t2+460)^4);    // Heat
        loss in Btu/hr
15  L = 649.4;                        // Latent
        heat of vapourization in Btu/lb
16  m = q/L;                          //
        Generation of steam in lb/hr
17  A2 = A1*%pi/2;                    // Area of
         tube in ft^2
18  h = q/A2;                         // Heat
        absorption rate
19  printf("The heat absorption per square foot of tube
         area is %d Btu/hr-ft^2" ,h);
```

Scilab code Exa 14.3 Heat transfer coefficient for radiation

```scilab
1  clc();
2  clear;
3
4  // To find the division of the heating surface
5  t1 = 2500;                           // temperature of
        contenets of the bottle in F
6  t2 = 600;                            // Ambient
        temperature in F
7  e1 = 0.048;                          // Interchange factor
         in 1800 F
8  e2 = 0.044;                          // Interchange factor
         in 600 F
9  e = 0.94;                            // Emmisivity of
        walls
10  p = 1;                              // Emperical factor
11  F = 2*0.88;                          // Shape factor
12  s = 0.173*10^-8;                    // Stephens
        boltzmanns constant
13
14  h = s*e*p*F*((t1+460)^4-(t2+460)^4)/(%pi*(t1-t2));
15  // Heat transfer coefficient
16
17
18  // Heat transfer for the tubes within the
        convective surface
19  // Radiation of CO2 and waterin the combustion
        gases
20  L = 0.5;                            // Eqivalent length
        of gas layer
21  Tg = 1800;                          // Gas temperature
        in F
22  Tw = 600;                           // Surface
```

```
          temperature of tubes in F
23
24  // From the table the emmisivity of carbon dioxide
        can be known
25  ec1 = 0.06;                           // Emmmisivity of
        CO2 at 1800F
26  ec2 = 0.055;                          // Emmisivity of Co2
         at 600F
27  ew = 0.8;                             // Emmisivity of
        tube wall
28  qc = s*ew*p*(ec1*(Tg+460)^4-ec2*(t2+460)^4);
29  // Heat loss by carbon dioxide in Btu/hr
30
31  // From the table the emmisivity of water can be
      known
32  eh1 = 0.0176;                         // Emmmisivity of
        water at 1800F
33  eh2 = 0.0481;                         // Emmisivity of
        water at 600F
34  qh = s*ew*p*(eh1*(Tg+460)^4-eh2*(t2+460)^4);
35  // Heat loss by water in Btu/hr
36
37  qg = qc + qh;                         // Heat heat flow
         by gas radiation
38  hg = qg/(Tg-t2);                      // Heat transfer
        coeffcoent by gas radiation
39  printf("The heat transfer coefficient by gas
        radiation is %.2f Btu/hr-ft^2 \n",hg);
40
41  // Heat transfer by convection can be found out
        using values iun the table
42  hc = 8.14;                            // Heat transfer
         by convection in Btu/hr-ft^2-F
43   printf(" The heat transfer coefficient by gas
         radiation is %.2f Btu/hr-ft^2\n",hc);
44
45  ht = hc + hg;                         // Total heat
        transfer coefficient for convective surface
```

```
46
47   printf("The covective surface have greater heat
         transfer coefficients than the radiating surface
         . Therefore it is advantageous to line the whole
         combustion chamber with narrowly spaced cooling
         tubes");
```

Chapter 16

Mass transfer

Scilab code Exa 16.1 Diffusion

```scilab
1  clc();
2  clear;
3
4  // To calculate the siffusion coefficient
5
6   T = 87.5;                       // Constant
        temperature of tube
7   p1 = 0.6543;                    // Saturation pressure
         in psi
8   p = 14.22;                      // Ambient pressure
9   e = 5.165*10^-5;                // Rate of evaporation
         in lb/hr
10  A = 0.755;                      // Area of tube in in
        ^2
11  m = e*144/A;                    // Mass flux in lb/hr-
        ft^2
12  M = 18.0165;                    // Molecular weight of
         water
13  R = 1545/M;                     // Gas constant
14  l = 2.527/12;                   // Length of tube in
        ft
```

```
15  D = m*R*(T+460)*l/(p*144*log(p/(p-p1)));
                    // Diffusion coefficient
16  printf("The diffusion coefficient of water vapour
      over air is %.3f ft^2/hr",D)
```

Scilab code Exa 16.2 Evaporation rate

```
1  clc();
2  clear;
3
4  // To calculatevthe amount of water evaporated per
      hour per square feet from the water surface
5
6  u = 10;                     // Flow of air stream in
      fps
7  r = 33.3;                   // Relative humidity
8  T = 519;                    // Temperature in Rankine
9  p = 0.1130;                 // Partial pressure of
      water vapour
10  x = 4/12;                  // Water surface in the
      wind direction
11  n = 15.99*10^-5;           // Kinematic viscosity
12  k = 0.0149;                // Thermal conductivity
      in Btu/hr-ft-F
13  Re = u*x/n;                // reynolds number
14  D = 1.127;                 // Diffusion coefficient
      in ft^2/sec
15  R = 85.74;                 // Gas constant in
      Imperial in Imperial units
16
17  hd =0.664*Re^0.5*(n*3600/D)^(1/3)*D/x;           //
      Heat transfer coefficient
18  Pr = 0.710;                                      //
      Prandtls number
19  Nu = 0.664*sqrt(Re)*Pr^(1/3);                    //
```

```
    Nusselt  number
20  h  =  Nu*k/x;                                    //  Heat
      transfer  coefficient
21  ps  =  0.2473;                                   //
      Saturation  pressure  of  water  vapour
22  m  =  hd*(ps-p)*144/(R*T);                       //
      Water  vapour  formation  rate  in  lb/hr-ft^2
23
24  printf("The  rate  of  amount  of  water  evaporated  per
        sq.  foot  is  %.3f  lb/hr-ft^2",m);
```

Scilab code Exa 16.3 Evaporation of water into air

```
1  clc();
2  clear;
3
4  // To determine the specific heat of air
5
6  p = 14.7;                              // Pressure in psi
      .
7  Tb = 68;                               // Dry bulb
      temperature in F
8  Tw = 50;                               // Wet bulb
      temperature in F
9
10 // In the enthalpy-specific heat diagram, the
      isotherm 50F in the supersaturated region must be
       extended until it intersects the isotherm 68F.
11 // The point of intersection gives the state of
      moist air and its specific heat capacity can be
      read
12 s = 0.0037;                            // Specific heat
      capacity
13
14 printf("Tne specific humidity of air is %.4f lb of
```

```
water per pound of dry air",s);
```