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

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July 31, 2019

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

Book Description

Title: Heat And Mass Transfer

Author: E. R. G. Eckert And R. M. Drake

Publisher: McGraw Hill Book Company

Edition: 2

Year: 1957

ISBN: 978-0070189249

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

```
clc();
clear;

// To calculate the overall thermal resistance and overall heat transfer coefficient

b = 0.5/12;                         // Thickness of iron wall in ft
k = 30;                             // Thermal conductivity in Btu/hr-ft
h1 = 2;                             // Heat transfer coefficient in Btu/hr-ft
h2 = 2;                             // Heat transfer coefficient in Btu/hr-ft
R = (1/h1)+(1/h2)+(b/k);            // Overall thermal resistance*Area in hr-F/Btu ie. (R/A)
U = 1/R;                            // Overall heat transfer coeficient in Btu/hr-ft^2-F

printf("The overall thermal resistance is %.4f/A hr-F/Btu/A, where A is the area of wall \n",R);
```

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

Scilab code Exa 1.2 Overall heat transfer coefficient

```
clc();
clear;

// To calculate the thermal resistance

b1 = 0.5/12;                          // Thickness of
    iron wall in ft
b2 = 0.0005/12;                       // Thickness of
    air gap in ft
b3 = 1/12;                            // Thickness of
    aluminium wall in ft
k1 = 30;                              // Thermal
    conductivity in Btu/hr-ft^2-F
k2 = 0.015;                           // Thermal
    conductivity in Btu/hr-ft^2-F
k3 = 118;                             // Thermal
    conductivity in Btu/hr-ft^2-F
R = (b1/k1)+(b2/k2)+(b3/k3);          // Thermal
    resistance*Area

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

```
clc();
clear;
```

```
// To calculate the size of heating surface

m1 = 100;                                   // Flow rate of water in lb/hr
ta1 = 50;                                   // Initial temperature of water in F
ta2 = 170;                                  // Final temperature of water
Cp1 = 1;                                    // Heat capacity of water in Btu/lb-F
te1 = 330;                                  // Initial temperatutre in flue gases in F
m2 = 400;                                   // Mass flow rate of flue gases in lb/hr
Cp2 = .25;                                  // Heat capacity of flue gases in Btu/lb-F
q = m1*Cp1*(ta2-ta1);                       // Heat absorbed by water in Btu
te2 = te1-q/(m2*Cp2);                       // Final temperature of flue gases in F
U = 20;                                     // Overall heat transfer in Btu/hr-ft^2-F

// For parallel flow
delte = te1-ta1;                            // Flue tempearture difference in F
delta = te2-ta2;                            // Water temperature difference in F

// Seeing the value of delte/delta=7, we can attain the value of a
a1 = 0.77;
deltm = (delte + delta)/2;                  // Arithmetic mean in F
LMTD1 = a1*deltm;                            // Log mean temperature diffference
A1 = q/(U*LMTD1);                           // Area in ft^2
```

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

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

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

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

// Seeing the value of delta/delte=0.143, we can attain the value of a=0.939
a3 = 0.939;
deltm = (delte + delta)/2;                // Arithmetic mean in F
LMTD3 = a3*deltm;                         // Log mean temperature diffference
A3 = q/(U*LMTD3);                         // Area in ft^2
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`

```
clc();
clear;

// To calculate the length of the well

d = 0.06/12;                          // diameter of the thermometer  in ft
h = 18.5;                             // heat teansfer coefficient in Btu/hr-ft^2-F
k = 32;                               // Thermal conductivity in Btu/hr-ft^2-F
s = 0.036/12;                         // thickness of wall in ft
m = sqrt(h/(k*s));                    // parameter

// Error is less than 0.05% of the dfference between the gas temperature and the tube well temperature. Hence a=m*l

a = 6;                                // a=m*l
l = a/m;                              // Length of
```

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

Scilab code Exa 3.2 `Finned heated surfaces`

```
clc();
clear;

// To determine the effectiveness of iron fins of 0.14 inch thickness
// For heat transfer to air
b = 0.12/12;                    // Thickness of iron fins in ft
k = 33;                         // Mean thermal conductivity of iron in Btu/hr-ft^2
Hamin = 2;                      // Minimum heat ransfer coefficient with air in Btu/hr-ft^2-F
Hamax = 20;                     // Minimum heat ransfer coefficient with air in Btu/hr-ft^2-F
// Inserting the higher value of heat transfer coefficient
m1 = 2*k/(Hamax*b);             // Characteristic value
// haracteristic value is quite high
printf("Since m = %d, hence the heat transfer from iron fins to air is advantageous \n",m1);

// For heat transfer to water

Hwmin = 100;                      // Minimum heat ransfer coefficient with air in Btu/hr-ft^2-F
Hwmax = 1000;                     // Minimum heat ransfer coefficient with air in Btu/hr-ft^2-F
// Inserting the higher value of heat transfer coefficient
m2 = 2*k/(Hwmax*b);               // Characteristic value
```

```
// Characteristic value is quite low
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

```
clc();
clear;

// To study the effect of adding fins to the
   cylindrical barrel of an air cooled engine

l1= 3/12;                                    // Length of
   fins in ft
l2 = 4/12;
h = 50;                                      // Heat transfer
    coefficient in Btu/hr-ft-F
k = 28;                                      // Thermal
   conductivity in Btu/hr-ft-F
T1 = 250;                                    // Cylinder wall
    temperature in F
T2 = 70;                                     // Air
   temperature in F
th = T1-T2;                                  // Temperature
   difference
b = 0.09/12;                                 // Thickness of
   fins in ft
m = 2*h/(b*k);                               //
   Characteristic parameter
// Seeing the value of length and m, yhe bessel
   functions can be found out

I2 = 188/7.26;                                // Magnitudes
   of bessel functions
I0 = 41.0/5.45;
```

```
I1 = 37.2/5.45;
K2 = 0.0;
K0 = 0.0022/5.45;
K1 = 0.0024/5.45;

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)));
// Heat loss by finned surface
q2 = 0.27/144*2*%pi*3*h*th;          // heat loss from barred surface

printf("the heat loss from the cylindrical barrel in presence of fins is %d Btu/hr \n ",q1);
printf("the heat loss from the bare cylindrical barrel is %d Btu/hr \n ",q2)
```

Scilab code Exa 3.4 Minimum width fins

```
clc();
clear;

// To study the effect of adding fins to the cylindrical barrel of an air cooled engine

l1= 3/12;                              // Length of fins in ft
l2 = 4/12;
h = 50;                                // Heat transfer coefficient in Btu/hr-ft-F
k = 28;                                // Thermal conductivity in Btu/hr-ft-F
T1 = 250;                              // Cylinder wall temperature in F
T2 = 70;                               // Air
```

```
temperature in F
th = T1-T2;                              // Temperature difference
b = 0.09/12;                             // Thickness of fins in ft
m = 2*h/(b*k);                           // Characteristic parameter
// Seeing the value of length and m, yhe bessel functions can be found out

I2 = 188/7.26;                             // Magnitudes of bessel functions
I0 = 41.0/5.45;
I1 = 37.2/5.45;
K2 = 0.0;
K0 = 0.0022/5.45;
K1 = 0.0024/5.45;

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)));
// Heat loss by finned surface
q2 = 0.27/144*2*%pi*3*h*th;              // heat loss from barred surface

printf("the heat loss from the cylindrical barrel in presence of fins is %d Btu/hr \n ",q1);
printf("the heat loss from the bare cylindrical barrel is %d Btu/hr \n ",q2)
```

Scilab code Exa 3.5 `Wall with heat sources`

```
clc;
clear;

```

```
// To find the tempearure difference in the plane wall with heat sources
d1 = 0.55;                              // Inside diameter of copper wire
d2 = 0.8;                               // Outside diameter of copper wire
phi = 0.6;                              // Fraction of copper in wire
j = 1300;                               // Current density in conductors in amp/in^2
p = 9.5*10^(-6);                        // Specific resistance in ohm-in^2/ft
h = 4;                                  // Heat transfer coefficient on both sides ofcoil
k = 0.2;                                // Thermal conductivity of coil in Btu/hr-ft-F
T0 = 70;                                // Temperature of air in degF
// Considering it as a plane wall with a thickness of 0.25 ft
b = 0.125;                              // half the thickness of wall in ft
l = 0.0625;                             // Distance between the two walls
q = j*j*p*phi*144*3.412;                // Generation of heat in Btu/hr-ft-F
th0 = (4730*l*l/(2*k))+(4730*l/h);              // Teperature difference in F
t0 = T0+th0;                            // Temperature at the center in F

printf("The temperature at the centre of the pool is %.1f degF \n",t0);
```

Scilab code Exa 3.6 2D steady state conduction

```
clc();
clear;

// To determine the shape factor for the heat flow through a square duct whose surface temperatures are constant

// Since the duct is symmetrical. Only one of the corners is to be considered
Nc = 20;                    // Number of heat flow lanes
Nr = 7;                     // Number of temperature increments
S = Nc/Nr;                  // Shape factor
printf("The Shape factor for heat flow through square duct is %.2f \n ",S);
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

```
clc();
clear;

// To measure an unsteady state temperature with a
   thermometer and half value time

// Half value time is the time within which the
   initial difference etween the true and indicated
   temperature is reduced to half its initial value

l = 0.01/2;                              // Length of
   cylindrical tube in ft
a = 0.178;                               // Thermal
   diffusivity in ft^2/hr
k = 5;                                   // Thermal
   conductivity in Btu/hr-ft-F
h = 10;                                  // Heat
   transfer coefficient in Btu/hr-ft^2-F
Bi = h*l/k;                              // Biot number

// For half time
```

```
th = 0.693*l*l*3600/(Bi*a);           // Half time in hr

printf("The half time for unsteady change temperature change is %d sec",th);
```

Scilab code Exa 4.2 Lag of thermometer

```
clc();
clear;

// To calculate the lag of thermometer used in initial example while the oven is heating

r = 0.01;                              // Radius of cylindrical tube in ft
a = 0.178;                             // Thermal diffusivity in ft^2/hr
k = 5;                                 // Thermal conductivity in Btu/hr-ft-F
h = 2;                                 // Heat transfer coefficient in Btu/hr-ft^2-F
s = 400;                               // Rate of temperature change
tlag = r*k*s/(2*a*h);

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

```
clc();
clear
```

```
// To find the time required for the billet to remain in the oven

A = 2;                                      // Length of steel billet in ft
B = 2;                                      // Breadth of billet in ft
C = 4;                                      // Height of billet in ft
To = 70;                                    // Initial temperature of billet n F
Tf = 750;                                   // Maximum temp. of billet in F
T = 700;                                    // Temperature for which time has to be found out
k = 25;                                     // Thermal conductivity in Btu/hr-ft^2-F
a = 0.57;                                   // Thermal diffusivity in ft^2/hr
h = 100;                                    // Heat transfer coeff. in Btu/hr-ft

BiA = h*A/k;                                // Biot number
BiB = h*B/k;
BiC = h*C/k;
t = 1.53;                                  // Assumed temperature in F
s1 = a*t/A^2;                               // Parameters
s2 = a*t/B^2;
s3 = a*t/C^2;

// Seeing the values of Bi and s and comparing from the table

// T/Toa=0.302 and T/Tob=0.805 and (T/Toa)^2*T/Toc=0.0735

```

```
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

```
clc();
clear;

// To calculate the time needed to estabilish a steady state temperature distribution in the walls and in the room
tf = 70;                              // Final temperature of the wall in F
hi = 1.2;                             // Inner heat transfer coefficint of wall i Btu/hr-ft^2-degF
ho = 3.0;                              // Outer heat transfer coefficient in Btu/hr-ft^2-degF
a = 0.012;                             // Thermal diffusivity in ft^2/hr
x = 1.3;                              // Thickness of wall in ft

// Assuming the rate of heat trasfer to the inside of a wall is constant
// And since the wall is divided into six sections
delx = x/6;                          // Thickness of sections in ft
t = (delx)^2/(2*a);                   // time required in hr
printf("the time needed to estabilish a steady state temperature distribution in the walls and in the room is %.2f hr",t);
```

Scilab code Exa 4.5 `Periodic heat conduction`

```
clc();
clear;

// To calculate the depth and yearly temperature
   fluctuations penetrate the ground

a = 0.039;                                          //
   thermal diffusivity of claylike soil
to = 24;                                            //
   time for daily fluctuations in hr
x = 1.6*sqrt(%pi*a*to);                             //
   depth of penetration for daily fluctuation in ft
xy = sqrt(365)*x;                                   //
   depth of penetration for yearly fluctuation in ft

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`

```
clc();
clear;

// To calculate the depth of penetration of the
   temperature oscillation into the cylinder wall

rpm = 2000;                              //
   Revolutions per minute of motor
```

```
a = 0.64;                                   // Thermal diffusivity in ft^2/hr
to = 1/(60*rpm);                            // Period of oscillation in hr
x = 1.6*sqrt(%pi*a*to);                     // depth of penetration in hr
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

```
clc();
clear;

// To calculate the depth of penetration of the temperature oscillation into the cylinder wall

rpm = 2000;                                 // Revolutions per minute of motor
a = 0.64;                                   // Thermal diffusivity in ft^2/hr
to = 1/(60*rpm);                            // Period of oscillation in hr
x = 1.6*sqrt(%pi*a*to);                     // depth of penetration in hr
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

```
clc();
clear;

//*****Data*****//
x = 4/12;// [thickness of plate, inch]
v = 33;// [fps]
n = 15.4*10^(-5);// [kinematic viscosity, feet^2/s]
//************//

Re = v*x/n;// [Reynold's number]
delta = 4.64*x*12/sqrt(Re);// [Boundary layer
   thickness ,ft]
printf("Boundary layer thickness at 4 in. distance
   is %.4f in.",delta);
```

Scilab code Exa 6.2 turbulent boundary layer

```
clc();
clear;

// To calculate the thickness of turbulent boundary
   layer at a distance of 12 inch
x = 12/12;                                // Distance
   from leading edge in ft
v = 33;                                   // Stream
   flowing velocity in ft
n = 15.4*10^(-5);                         // kinematic
   viscosity , feet^2/s

Re = v*x/n ;                              // reynolds
   number
delta = 0.376*x/(Re^0.2);                 // Boundary
   layer thickness ,ft
delb = 0.036*delta*12;                    // Turbulent
   layer thickness , in
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

```
clc();
clear;


// to calculate the heat tranaferv coefficient for a plate in an air stream

x = 4/12;                        // distance from leading edge in ft
u = 33;                          // air velocity in fps
Ts = 125;                        //
Tw = 255;                        // surface temperature in F
k = 0.0178;                      // Thermal conductivity in Btu/hr-ft-F
Re = 46600;                      // Reynolds number
Pr = 0.695;                      // Prandtls number

Nu = 0.332*Re^.5*Pr^(1/3);       // Nusselt number
```

```
h = Nu*k/x;                        // Local heat transfer
    coefficient
ha = h*12;                         // Heat transfer
    coefficient average
b = 1;                             // Width of plate in ft
x = 4/12;                          // Length of plate

q = ha*b*x*(Ts-Tw);                // Heat loss in Btu/hr

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

```
clc();
clear;

// To find the amount of heat transferred to the air

Tw = 200;                                // Wall
    temperature in F
delp = 14.2;                             // Pressure
    pressure in lb/in^2
d = 0.8/12;                              // Diameter in ft
R = delp*%pi*d^2/4;                      // resistance of
    tube
Tb = 137;                                // bulk
    temperature of wall in F

q = R*32.2*0.24*3600*(Tw-Tb)/100;           // Heat loss
    in Btu/hr
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`

```
clc();
clear;

// To find the extent of heating of water and heat transfer

d = 0.24/12;                    // Diameter of tubes in ft
l = 24/12;                      // Length of tubes in ft
v = 3;                          // velocity of cooling water in ft/sec
T = 140;                        // Temperature of cooling water in F
n = 0.514*10^-5;                // Kinematic viscosity in ft^2/sec
Pr = 3.02;                      // Prandtls number
k = 0.376;                      // Thermal conductivity in Btu/hr-ft-F
Re = d*v/n;                     // Reynolds number
A = 1.5;                        // Experimental constant
// Turbulent flow
// Greater part of the flow is developed , A=1.5 from the table

St = 0.0384*(v*d/n)^-(1/4)/(1+A*(v*d/n)^-(1/8)*(Pr-1));   // Strantons number
Nu = Re*Pr*St;                                                // Nusselt number
```

```
h = Nu*k/d;                                 // Heat transfer coefficient

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`

```
clc();
clear;

// To find the heat transfer coefficient at x = 12 in.

Tp = 176;                        // Temperature of plate in F
Ta = 68;                         // Tempearture of air stream in F
Tm = (Tp+Ta)/2;                  // Maen temperature in F
u = 30;                          // Velocity in fps
n = 19.45*10^-5;                 // Dynamic visosity in ft^2/sec
v = 30;                          // Velocity in fps
Pr = 0.703;                      // Prandtls number
x = 12/12;                       // distance in ft
k = 0.0162;                      // Thermal conductivity in Btu/hr-ft^2-F
Re = v*x/n;                      // Reynolds number
// The boundary layer must be laminar or turbulent

St =  0.0296*(Re)^-(1/5)/(1+1.75*0.87*(Re)^-(1/10)*(Pr-1));    // Strantons number
Nu = Re*Pr*St;                              // Nusselt number
```

```
h = Nu*k/x;                                    // Heat transfer coefficient

printf("The heat transfer coefficient of heating of water for laminar is %.2f Btu/hr-ft^2-F",h)

// If the flow is laminar
Nu1 = 0.332*Re^(1/2)*Pr^(1/3);                 // Nusselt number
h1 = Nu1*k/x;                                  // Heat transfer coefficient
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

```
clc();
clear;

// To calculate the heat transfer coefficient from
   the plate to the air

Tw = 196;                          // Temperature of plate
    in F
Ts = 79;                           // Temperature of the
   air in F
u = 587;                           // velocity in air in
   fps
x = 4/12;                          // Length of plate in
   ft
n = 20.4*10^-5;                    // Kinematic velocity
Cp = 1200;                         // Specific heat
   capacity
Re = u*x/n;                        // Reynolds number
r = 0.845;                         // Temperature recovery
    factor
tr = Ts+r*u*u/Cp;                  // Dynamic temperature
```

```
in F
Pr = 0.697;                    // Pradtls number
p = 0.0657;                    // Density in lb/ft^3
t = 144.1;                     // Corresponding temperature in F
St =  0.0296*(Re)^-(1/5)/(1+1.75*0.87*(Re)^-(1/10)*(Pr-1));
// Strantons number

h = p*u*St*3600;                    // Heat transfer coefficient
hav = 1.215*h;                    // Average heat transfer coefficient

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`

```
clc();
clear;

// To calculate the local heat transfer coefficient

Ts = 200;                                   // Temperature of steam in F
Ta = 68;                                    // Air temerature in F
n = 24.21*10^-5;                            // Kinematic viscosity in ft^2/sec
k = 0.0181;                                 // Thermal conductivity in Btu/hr-ft-F
g = 32.2;                                   // Gravity
b = 1/528;                                  // Expansion coefficient
x = 8/12;                                   // Distance from lower end
th = Ts-Ta;                                 // Temperature difference in F
Gr = g*b*th*x^3/(n^2);                      // Grashops
```

```
   number
Pr = 0.694;                                    // Prandtls
   number
del = x*3.93*Pr^(-0.5)*((0.952+Pr)^1/4)*Gr^(-0.25);
// Boundary layer thickness
h = 2*k/del;                                   // film heat
   transfer coefficient
hav = 4*h/3;                                   // Avg heat
   transfer cioefficient
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`

```
clc();
clear;

 // To calculate the heat transfer coefficient

L = 1029;                       // Heat of evaporation in Btu/lb
n = 0.654*10^-5;                // Kinematic viscosity in Btu/hr-ft-F
p = 62;                         // density in lb/ft^3
k = 0.367;                      // Thermal conductivity in Btu/hr-ft^2-F
g = 32.2;                       // Gravity
x = 3/12;                       // Distance from upper edge in ft
ts = 114;                       // Saturation temperature in F
tw = 105;                       // Wall temperature in F

h = (g*k^3*p*L*3600/(4*n*x*(ts-tw)))^0.25;     //
```

```
Heat transfer coefficient
hav = h*4/3;                                   // Avg heat transfer coefficient

printf("The average heat transfer coefficient is %d Btu/hr-ft^2-F",hav);
```

Scilab code Exa 12.2 Vertical wall

```
clc();
clear;

 // To calculate the heat exchange by radiatiojn between two walls

 t1 = 2500;                       // Temperature of saturated steam in F
 t2 = 600;                        // External temperature of tube walls in F
 e = 0.8;                         // Emmisivity of tube wall arrangement
 p = 0.87;                        // Emperical factor
 A = 148.5;                       // Area of the wall in ft^2
 s = 0.173*10^-8;                 // Stephens boltzmanns constant
 q = s*e*A*p*(((t1+460)^4)-((t2+460)^4));     // heat loss in Btu/hr

 printf("The heat exchange per unit area is %.2f Btu/hr",q);
```

Chapter 14

Heat exchange by radiation

Scilab code Exa 14.1 Radiation between two walls

```
clc();
clear;

 // To calculate the heat exchange by radiation
    between two walls

 t1 = 212;                              // Temperature of
    contents in the bottle in F
 t2 = 68;                               // Ambient
    temperature in F

 e = 0.02 ;                             // Emmisivity of
    silver
 e12 = 1/(2/e-1);                       // Exchange factor
  s = 0.173*10^-8;                      // Stephens
     boltzmanns constant

 q = s*e12*((t1+460)^4-(t2+460)^4);     // Heat loss
    in Btu/hr
 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

```
clc();
clear;

// To calculate the heat exchange by radiation
   between two walls

t1 = 2500;                          // Temperature of
   saturated steam in F
t2 = 600;                           // Temperature of
   tube wall in F
p = 0.87;                           // Emperical factor
A = 148.5;                          // Area of tube
   walls
A1 = 168.8;                         // Area of walls
   lined with cooling tubes
e = 0.8 ;                          // Emmisivity of
   silver
 s = 0.173*10^-8;                   // Stephens
    boltzmanns constant

q = p*s*e*A*((t1+460)^4-(t2+460)^4);     // Heat
   loss in Btu/hr
L = 649.4;                                 // Latent
   heat of vapourization in Btu/lb
m = q/L;                                   //
   Generation of steam in lb/hr
A2 = A1*%pi/2;                             // Area of
    tube in ft^2
h = q/A2;                                  // Heat
   absorption rate
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

```
clc();
clear;

// To find the division of the heating surface
t1 = 2500;                              // temperature of contenets of the bottle in F
t2 = 600;                               // Ambient temperature in F
e1 = 0.048;                             // Interchange factor in 1800 F
e2 = 0.044;                             // Interchange factor in 600 F
e = 0.94;                               // Emmisivity of walls
p = 1;                                  // Emperical factor
F = 2*0.88;                              // Shape factor
s = 0.173*10^-8;                        // Stephens boltzmanns constant

h = s*e*p*F*((t1+460)^4-(t2+460)^4)/(%pi*(t1-t2));
// Heat transfer coefficient


// Heat transfer for the tubes within the convective surface
// Radiation of CO2 and waterin the combustion gases
L = 0.5;                                 // Eqivalent length of gas layer
Tg = 1800;                               // Gas temperature in F
Tw = 600;                                // Surface
```

```
temperature of tubes in F

// From the table the emmisivity of carbon dioxide can be known
ec1 = 0.06;                         // Emmmisivity of CO2 at 1800F
ec2 = 0.055;                        // Emmisivity of Co2 at 600F
ew = 0.8;                           // Emmisivity of tube wall
qc = s*ew*p*(ec1*(Tg+460)^4-ec2*(t2+460)^4);
// Heat loss by carbon dioxide in Btu/hr

// From the table the emmisivity of water can be known
eh1 = 0.0176;                         // Emmmisivity of water at 1800F
eh2 = 0.0481;                         // Emmisivity of water at 600F
qh = s*ew*p*(eh1*(Tg+460)^4-eh2*(t2+460)^4);
// Heat loss by water in Btu/hr

qg = qc + qh;                          // Heat heat flow by gas radiation
hg = qg/(Tg-t2);                       // Heat transfer coeffcoent by gas radiation
printf("The heat transfer coefficient by gas radiation is %.2f Btu/hr-ft^2 \n",hg);

// Heat transfer by convection can be found out using values iun the table
hc = 8.14;                              // Heat transfer by convection in Btu/hr-ft^2-F
 printf(" The heat transfer coefficient by gas radiation is %.2f Btu/hr-ft^2\n",hc);

ht = hc + hg;                          // Total heat transfer coefficient for convective surface
```

```
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

```
clc();
clear;

// To calculate the siffusion coefficient

 T = 87.5;                          // Constant temperature of tube
 p1 = 0.6543;                       // Saturation pressure in psi
 p = 14.22;                         // Ambient pressure
 e = 5.165*10^-5;                   // Rate of evaporation in lb/hr
 A = 0.755;                         // Area of tube in in^2
 m = e*144/A;                       // Mass flux in lb/hr-ft^2
 M = 18.0165;                       // Molecular weight of water
 R = 1545/M;                        // Gas constant
 l = 2.527/12;                      // Length of tube in ft
```

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

Scilab code Exa 16.2 Evaporation rate

```
clc();
clear;

// To calculatevthe amount of water evaporated per hour per square feet from the water surface

u = 10;                  // Flow of air stream in fps
r = 33.3;                // Relative humidity
T = 519;                 // Temperature in Rankine
p = 0.1130;              // Partial pressure of water vapour
x = 4/12;                // Water surface in the wind direction
n = 15.99*10^-5;         // Kinematic viscosity
k = 0.0149;              // Thermal conductivity in Btu/hr-ft-F
Re = u*x/n;              // reynolds number
D = 1.127;               // Diffusion coefficient in ft^2/sec
R = 85.74;               // Gas constant in Imperial in Imperial units

hd =0.664*Re^0.5*(n*3600/D)^(1/3)*D/x;          // Heat transfer coefficient
Pr = 0.710;                                    // Prandtls number
Nu = 0.664*sqrt(Re)*Pr^(1/3);                  //
```

```
    Nusselt number
h = Nu*k/x;                                    // Heat
    transfer coefficient
ps = 0.2473;                                   //
    Saturation pressure of water vapour
m = hd*(ps-p)*144/(R*T);                           //
    Water vapour formation rate in lb/hr-ft^2

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

```
clc();
clear;

// To determine the specific heat of air

p = 14.7;                              // Pressure in psi
    .
Tb = 68;                               // Dry bulb
    temperature in F
Tw = 50;                               // Wet bulb
    temperature in F

// In the enthalpy-specific heat diagram, the
    isotherm 50F in the supersaturated region must be
     extended until it intersects the isotherm 68F.
// The point of intersection gives the state of
    moist air and its specific heat capacity can be
    read
s = 0.0037;                           // Specific heat
    capacity

printf("Tne specific humidity of air is %.4f lb of
```

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