Scilab Textbook Companion for Refrigeration And Air-Conditioning by G.f. Hundy, A.a. Trott. And Le. Welch[1]

Created by
Ebby George
B.Tech
Mathematics
B.Tech
College Teacher
None
Cross-Checked by
None

April 7, 2018

[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: Refrigeration And Air-Conditioning

Author: G.f. Hundy, A.a. Trott. And Le. Welch

Publisher: Elsevier Ltd

Edition: 4

Year: 2008

ISBN: 9780750685191

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

fundmentals

Scilab code Exa 1.1 Carnot COP

```
clear
// Variable Declaration
T_0=-5+273// K
T_1=35+273// K

// Calculation
COP=(T_0)/(T_1-T_0)// Coefficient of performance
printf("\n Carnot COP= %0.2f error",COP)
```

Scilab code Exa 1.2 The average specific heat capacity

```
clear
// Variable Declaration
T_f=80// Final Temperature in  C
T_i=0// Initial Temperature in  C
h_f=334.91// The specific enthalpy of water in kJ/kg

// Calculation
```

```
C=h_f/(T_f-T_i)// The average specific heat capacity in kJ/(kg K)
printf("\n The average specific heat capacity is %0.3f  kJ/(kg K)", C)
```

Scilab code Exa 1.3 The quantity of heat added

```
clear
// Variable Declaration
P=1.013// Pressure in bar
h_fg=2257// The latent heat of boiling water in kJ/kg
T_b=100 // The boiling point temperature of water in C
m=1 // The mass of water in kg
T_i=30 // The initial temperature of water in  C
C_p=4.19// The specific heat of water in kJ/kg C

// Calculation
Q=m*((C_p*(T_b-T_i))+h_fg)// The quantity of heat added in kJ
printf("\n The quantity of heat added is %0.1f  kJ", Q)
```

Scilab code Exa 1.4 The new pressurep2

```
clear
// Variable Declaration
V_1byV_2=2// Volumetric ratio (given)
p_1=1.01325// The atmospheric pressure in bar(101325 kPa)

// Calculation
```

```
p_2=V_1byV_2*p_1// The new pressure in bar
printf("\n The new pressure,p_2= %0.4f  bar(abs.)",
    p_2)
```

Scilab code Exa 1.5 The final volumeV2

```
clear
// Variable Declaration
V_1=0.75// The initial volume in m**3
T_1=273+20 // The initial temperature of water in K
T_2=273+90 // The final temperature of water in K

// Calculation
V_2=V_1*(T_2/T_1)// The final volume in m**3
printf("\n The final volume,V_2= %0.2f  m**3",V_2)
```

Scilab code Exa 1.6 The volume of an ideal gas

```
clear
// Variable Declaration
R=287// The specific gas constant in J/(kg K)
m=5 // The mass of ideal gas in kg
p=101.325// The atmospheric pressure in kPa
T=273+25// The temperature of an ideal gas in K

// Calculation
V=(m*R*T)/(p*1000)// The volume of an ideal gas in m
    **3
printf("\n The volume of an ideal gas is %0.2f  m**3
    ",V)
```

Scilab code Exa 1.7 The total pressure

```
clear
// Variable Declaration
m_N=0.906// The mass of nitrogen in a cubic metre of
    air in kg
R_N=297// The specific gas constant of nitrogen in J
   /kg K
m_O=0.278// The mass of oxygen in a cubic metre of
   air in kg
R_O=260// The specific gas constant of oxygen in J/
   kg K
m_A=0.015// The mass of argon in a cubic metre of
   air in kg
R_A=208// The specific gas constant of argon in J/kg
    K
T=273.15+20// The temperature of air in K

// Calculation
p_N=m_N*R_N*T// The pressure of nitrogen in Pa
p_O=m_O*R_O*T// The pressure of oxygen in Pa
p_A=m_A*R_A*T// The pressure of argon in Pa
p_t=p_N+p_O+p_A// The total pressure in Pa
printf("\n The total pressure is %0.0f Pa %0.5f bar"
   ,p_t,p_t/10**5)
```

Scilab code Exa 1.8 The rate of heat conductionQt

```
clear
// Variable declaration
t=225// The wall thickness in mm
k=0.60// Thermal conductivity in W/(m K)
L=10// Length in m
h=3// Height in m
delT=25// The temperature difference between the
```

```
    inside and outside faces in K

// Calculation
Q_t=(L*h*k*delT*1000)/(t)// The rate of heat
    conduction in W
printf("\n The rate of heat conduction,Q_t= %0.0f ",
    Q_t)
```

Scilab code Exa 1.9 Mass water flow

```
clear
// Variable declaration
R_i=0.3// The inside surface resistance in (m**2 K)/
   W
R_c=1/2.8// The thermal conductance of plastered
    surface in (m**2 K)/W
R_o=0.05// The outside surface resistance in (m**2 K
    )/W

// Calculation
R_t=R_i+R_c+R_o// The total thermal resistance in (m
    **2 K)/W
U=1/R_t// The overall transmittance in W/(m**2 K)
printf("\n The overall transmittance,U= %0.3f   W/(m
    **2 K)",U)
```

Scilab code Exa 1.10 The density of dry airrho

```
clear
//
// Variable declaration
T_f=3// The temperature of fluid in  C
T_wi=11.5// The temperature of water at inlet in  C
```

```
T_wo=6.4// The temperature of water at outlet in   C
A=420// The surface area in m**2
U=110// The thermal transmittance in W/(m**2 K)

// Calculation
delT_max=T_wi-T_f// The maximum temperature
   difference in K
delT_min=T_wo-T_f// The minimum temperature
   difference in K
LMTD=(delT_max-delT_min)/log(delT_max/delT_min)
Q_f=U*A*LMTD// The amount of heat transfer in W
printf("\n The logarithmic mean temperature
   difference is %0.3f  K",LMTD)
printf("\n The amount of heat transfer is %0.0f W (
   round off error) or %0.0f ",Q_f,Q_f/1000)
```

Chapter 2

the refrigeration cycle

Scilab code Exa 2.1 `The Carnot COP for the ideal vapour compression cycle`

```
clear
// Variable Declaration
T_l=0+273// The required cooling temperature of room in C
T_h=30+273// The temperature of outside air in C
T_e=-5+273// The evaporating temperature of Refrigeration cycle in C
T_c=35+273// The Condensing temperature of Refrigeration cycle in C
deltaT=5// The temperature difference at the evaporator and the condenser in K
h_i=249.7// Enthalpy of fl uid entering evaporator in kJ/kg
h_e=395.6// Enthalpy of saturated vapour leaving evaporator in kJ/kg
h_sup=422.5// Enthalpy of superheated vapour leaving compressor in kJ/kg

// Calculation
CarnotCOP=T_l/(T_h-T_l)
printf("\n The Carnot COP for the process is %0.1f
```

```
", CarnotCOP)
// For Refrigeration cycle,
CarnotCOP=T_e/(T_c-T_e)
printf("\n The Carnot COP for the refrigeration
    cycle is %0.1f  ", CarnotCOP)
// For R134a,
Q=h_e-h_i// Cooling effect in kJ/kg
W_in=h_sup-h_e// Compressor energy input in kJ/kg
COP=Q/W_in// Ideal R134a vapour compression cycle
    COP
printf("\n The Carnot COP for the ideal vapour
    compression cycle  is %0.1f  ", COP)
```

Chapter 6

condensers and cooling towers

Scilab code Exa 6.1 `The Condensing temperature at 15C`

```
clear
// Variable declaration
Q_1=12// Heat load in kW
T_c1=50// The condensing temperature in  C
T_o1=35// The maximum outdoor temperature in  C
T_o2=15// The reduced outdoor temperature in  C
Q_2=8// The reduced heat load in kW

// Calculation
deltaT=T_c1-T_o1// Temperature Difference in K
CR=Q_1*10**3/deltaT// Condenser Rating in W/K
CR=CR*10**-3// Condenser Rating in kW/K
deltaT_15=Q_2/CR// Temperature Difference at 15 C
T_c2=T_o2+deltaT_15//The Condensing temperature at
   15 C
printf("\n Cooling Rating= %0.1f  kW/K",CR)
printf("\n Temperature Difference at 15 C=%2.0f C"
   ,deltaT_15)

printf("\n The Condensing temperature at 15 C=%2.0
   f C",T_c2)
```

Scilab code Exa 6.2 LMTD

```
clear
// Variable declaration
deltaT=5.2// The temperature rise in K
E=930// Total duty at the condenser in kW
C_pw=4.187// The specific heat of water in kJ/kg K

// Calculation
mdot=E/(deltaT*C_pw)// The amount of water required
    in kg/s
printf("\n %0.3f kg/s water flow is required.",mdot)
```

Scilab code Exa 6.3 Evaporation rate

```
clear
// Variable declaration
E_t=880// Total duty at the condenser in kW
E_wcp=15// Total duty at water-circulating pump in
    kw

// Calculation
E=E_t+E_wcp// Total tower duty in kW
w_er=E*0.41*10**-3// Evaporation rate in kg/s
Cr_80=30// Circulation rate in kg/s
Cr_160=60// Circulation rate in kg/s
w_air=E*0.06// Air flow rate in kg/s
printf("\n \nEvaporation rate=%0.2f kg/s \
    nCirculation rate,80times=%2.0f kg/s \
    nCirculation rate,160times=%2.0f kg/s \nAir flow
    rate=%2.0f kg/s",w_er,Cr_80,Cr_160,w_air)
```

Scilab code Exa 6.4 The drop in dry bulb temperature

```
clear
// Variable declaration
Cc=700// The cooling capacity in kW
P_c=170// The compressor power in kW
c_b=0.0012// Concentration of solids in bleed-off (
   kg/kg)
c_m=0.00056// Concentration of solids in make-up
   water in kg/kg

// Calculation
E_tc=Cc+P_c// Cooling tower capacity in kW
h_fg=2420// Latent heat of water vapour in kJ/kg
w_e=E_tc*10**3/h_fg// Rate of evaporation in g/s
w_m=(w_e*(c_b))/(c_b-c_m)// Rate of make up in kg/s
w_bo=w_m-w_e// Rate of bleed off in kg/s
printf("\n \nRate of make up=%0.2f kg/s \nRate of
   bleed off=%0.2f kg/s",w_m/1000,w_bo/1000)
```

Chapter 10

component selection and balancing

Scilab code Exa 10.1 LMTD

```
clear
//
// Variable declaration
w_a=8.4// The mass flow rate of air in kg/s
R=3.8// Rating of an air-cooling evaporator in kW/k
T_a=-15// Entering air temperature in  C
T_r=-21// Refrigerant temperature in  C

// Calculation
deltaT=(T_a+273)-(T_r+273)// Rating LMTD in K
E=R*deltaT// Rated duty in kW
C_pair=1.006// kJ/kg.K
T_ar=E/(C_pair*w_a)// Reduction in air temperature in  C
T_al=T_a-T_ar// Air leaving temperature in  C
deltaT_min=(T_al+273)-(T_r+273)// K
deltaT_max=deltaT// K
LMTD=(deltaT_max-deltaT_min)/(log(deltaT_max/deltaT_min))
```

```
printf("\n \nLMTD=%1.1f K",LMTD)
```

Scilab code Exa 10.3 Actual evaporator capacity

```
clear
// Variable declaration
P_c=10// kW
T_e=-35// Evaporating temperature in  C
T_c=40// Condensing temperature in  C
T_s=5// Subcooling temperature in K
T_cin=20// Compressor inlet temperature in  C
T_cout=0// Zero subcooling temperature in  C

// Calculation
//(a)
v_s1=146.46// m**3/kg
v_s2=135.25// m**3/kg
v_sr=v_s1/v_s2// The ratio of specific volume
// Assuming the compressor pumps the same volume
    flowrate:
m_1bym_2=v_sr// Flow rate ratio
printf("\n \nFlow rate ratio,m_2/m_1=%1.3f",m_1bym_2
    )

//(b)
h_1=392.51// Suction gas enthalpy at 20 C in kJ/kg
h_2=375.19// Suction gas enthalpy at 0 C in kJ/kg
h_f=257.77// Liquid enthalpy at the expansion valve
    inlet at 40 C in kJ/kg
dh_1=h_1-h_f// Evaporator enthalpy difference at
    rating condition in kJ/kg
dh_2=h_2-h_f// Evaporator enthalpy difference with 0
     C suction in kJ/kg
dh_r=dh_2/dh_1// Enthalpy difference ratio
C_c=P_c*m_1bym_2*dh_r// Compressor capacity
```

```
corrected for suction temperature change in kW
printf("\n \nCompressor capacity corrected for suction temperature change=%1.2f kW",C_c)

//(c)
h_f=249.67// Liquid enthalpy at the expansion valve inlet at 35 C in kJ/kg
dh=h_2-h_f// Evaporator enthalpy difference at application condition in kJ/kg
dh_r=dh/dh_1// Enthalpy difference ratio
C_cact=P_c*m_1bym_2*dh_r// Actual compressor capacity in kW
printf("\n \nActual compressor capacity=%2.2f kW",C_cact)

//(d)
h_g=350.13// Suction gas enthalpy at evaporator outlet, -30 C (5 K superheat) in kJ/kg
dh_e=h_g-h_f// Useful evaporator enthalpy difference in kJ/kg
dh_r=dh_e/dh_1// Enthalpy difference ratio
C_eact=P_c*m_1bym_2*dh_r// Actual evaporator capacity in kW
printf("\n \nActual evaporator capacity=%1.2f kW",C_eact)
```

Scilab code Exa 10.4 Break even time

```
clear
// Variable declaration
T_c1=30// Condensing temperature for larger condenser in C
T_c2=35// Condensing temperature for smaller condenser in C
Rc_1=242// Rated capacity of plant for larger
```

```
condenser in kW
Rc_2=218// Rated capacity of plant for smaller condenser in kW
Rt_1=1802// Running time (kW-h)
Rt_2=2000// Running time (kW-h)
Ci_1=60// Compressor electrical input power in kW
Ci_2=70// Compressor electrical input power in kW
Ec_1=11533// Electricity cost per year ( )
Ec_2=14933// Electricity cost per year ( )
C_1=14000// Cost of the larger condenser in
C_2=8500// Cost of the smaller condenser in

// Calculation
Es=Ec_2-Ec_1// Cost of the larger condenser in
Bet=(C_1-C_2)*Es**-1// Break-even time in years
printf("\n Break-even time=%1.1f years",Bet)
```

Chapter 11

installation and construction

Scilab code Exa 11.1 Net room load

```
clear
// Variable declaration
T_c=34// The condensing temperature in  C
T_s=30// The subcooled temperature in  C
g=9.81// m/s**2

// Calculation
P_c=15.69// Saturation pressure at 34 C in bar
P_s=14.18// Saturation pressure at 30 C in bar
dp=P_c-P_s// Permissible pressure drop in bar
rho=1022// Specific mass of liquid in kg/m**3
H=(dp*10**5)/(rho*g)// Possible loss in static head
   in m
printf("\n Possible loss in static head=%2.1f m",H)
```

Scilab code Exa 11.2 Partial pressure of non condensible gas

```
clear
```

```
// Variable declaration
T_a=20// The ambient temperature in  C
m_p=10// g

// Calculation
P_v=10.34// Vapour pressure of R407C at 20 C in bar abs
P_o=11.70// Observed pressure in bar abs
P_p=P_o-P_v// Partial pressure of non-condensible gas in bar abs
M_m=(0.23*52)+(0.25*120)+(0.52*102)// Molecular mass
printf("\n \nPartial pressure of non-condensible gas =%1.2f bar abs \n Molecular mass=%2.0f",P_p,M_m)
```

Chapter 15

cold storage

Scilab code Exa 15.1 The store volume

```
clear
// Variable declaration
n=2// The number of two pellet truck doors
m_n=300//The number of traffic movements per day
t=30// seconds

// Calculation
T=n*m_n*t// The time for the door openings seconds per day
A=2.2*3.2// The cross sectional area in m**2
v=1// m/s
I=A*T*v// The air infiltration in m**3/d
V=50*70*10// The store volume in m**3
R=I/V// The rate of air change per day
printf("\n \nThe store volume is %5.0f m**3. \nThe rate of air change is %1.1f per day.",V,R)
```

Scilab code Exa 15.2 The rate of air change with dehumidification

```
clear
// Variable declaration
T=5//  The dry bulb temperature in
R=3.6// The rate of air change per day
V=35000// The store volume in m**3
v_spa=0.8// The specific volume in m**3/kg
q=600// m**3/h
n=2// The number of two pellet truck doors
h_1=15.9// kJ/kg
h_2=-24.3// kJ/kg
T_1=20//  C
T_2=-25//  C
t=24// Time duration for one day in hours
t_s=24*60*60// Time duration for one day in seconds

// Calculation
R_woh=V*R/v_spa// The rate of air change without dehumidification in kg/day
Q_woh=R_woh*(h_1-h_2)/t_s// The cooling load without dehumidification in kW
R_wh=q*n*t/v_spa// The rate of air change with dehumidification in kg/day
Q_wh=R_wh*(T_1-T_2)/t_s// The cooling load with dehumidification in kW
printf("\n \nThe rate of air change without dehumidification is %5.0f kg/day. \nThe cooling load without dehumidification %2.1f kW(calculation error).",R_woh,Q_woh)

printf("\n \nThe rate of air change with dehumidification is %5.0f kg/day. \nThe cooling load with dehumidification %2.2f kW.",R_wh,Q_wh)
```

Chapter 18

refrigeration load estimation

Scilab code Exa 18.1 `The cooling loadQ`

```
clear
// Variable declaration
T_1=15//   C
T_2=0//   C
C_pw=4.187// The specific heat capacity of water in
    kJ/kg.k
m=20*10**3// The mass flow rate of water in kg/day
h_l=334// kJ/kg
t=24*3600// The time available for cooling in s

// Calculation
Q=(m*((C_pw*T_1)+334))/t// The cooling load in kW
printf("\n The cooling load,Q=%2.0f kW.",Q)
```

Scilab code Exa 18.2 `The cooling loadQ`

```
clear
// Variable declaration
```

```
T_1=22//  C
T_2=1//  C
C_p=3.1// The specific heat capacity of meat in kJ/
    kg.K
m=8*10**3// The mass of meat in kg
t=14*3600// The time available for cooling in s

// Calculation
Q=(m*((C_p*(T_1-T_2))))/t// The cooling load in kW
printf("\n The cooling load,Q=%2.1f kW.",Q)
```

Scilab code Exa 18.6 `Case3Cooling loadQf`

```
clear
// Variable declaration
m=1000// The capacity of meat store in tonnes
m_l=50// The amount of meat leaving the store in t/
    day
m_s=300// The amount of meat arrives from the ships
    in t/day
t=24*3600// Time in s

// Calculation
// Case(1)
m=90// t/day
T_1=2//  C
T_2=-12//  C
C=3.2// Specific heat capacity in kJ/(kg.K)
T_fp=-1// Freezing point of meat in  C
h_fg=225// Latent heat of freezing in kJ/kg
C_fm=1.63// Specific heat of frozen meat in kJ/(kg.K
    )
Q_f=(m*1000*((C*3)+h_fg+(C_fm*11)))/(t)// Cooling
    load in kW
printf("\n \nCase(1):Cooling load,Q_f=%3.0f kW",Q_f)
```

```
// Case(2)
Q_f=(m_s*10**3*(C_fm*T_1))/t// Cooling load in kW
printf("\n \nCase(2):Cooling load,Q_f=%2.0f kW",Q_f)

// Case(3)
Q_f=(m_l*10**3*((C*3)+h_fg+(C_fm*11)))/t// Cooling
    load in kW
printf("\n \nCase(3):Cooling load,Q_f=%3.0f kW",Q_f)
```

Chapter 21

air treatment fundamentals

Scilab code Exa 21.1 Heat inputQ

```
clear
// Variable declaration
m_a=68// The mass flow rate of air in kg/s
T_1=16// The temperature of air at inlet in C
T_2=34// The temperature of air at outlet in C
T_win=85// The temperature of hot water at inlet in C
T_wout=74// The temperature of hot water at outlet in C
C_pa=1.02// The specific heat capacity of air in kJ/kg.K
C_pw=4.187// The specific heat capacity of water in kJ/kg.K

// Calculation
Q=m_a*C_pa*(T_2-T_1)// Heat input in kW
m_w=Q/(C_pw*(T_win-T_wout))// The mass flow rate of water in kg/s
printf("\n \nHeat input,Q=%4.0f kW \nThe mass flow rate of water,Q=%2.0f kg/s",Q,m_w)
```

Scilab code Exa 21.2 The air supply temperaturet

```
clear
// Variable declaration
Q=500// The amount of heat required for the building
    in kW
T=19// The temperature at which air enters the
    heater coil in C
m_a=68// // The mass flow rate of air in kg/s
C_pa=1.02// The specific heat capacity of air in kJ/
    kg.K

// Calculation
t=T+(Q/(m_a*C_pa))// The air supply temperature in
    C
printf("\n The air-supply temperature,t=%2.1f C",t)
```

Scilab code Exa 21.3 hc

```
clear
// Variable declaration
T_ra=21// The temperature of the returning air
H=50// % saturation
T_d=28// The dry bulb temperature in C
T_w=20// The wet bulb temperature in C
m_a=20// The mass flow rate of returning air in kg/s
m_b=3// The mass flow rate of outside air in kg/s
x_ra=0.0079// The moisture content in kg/kg
x_oa=0.0111// The moisture content in kg/kg
h_a=41.8// The enthalpy in kJ/kg
h_b=56.6// The enthalpy in kJ/kg

```

```
// Calculation
// Method (b)
t_c=((T_ra*m_a)+(T_d*m_b))/(m_a+m_b)//  C
g_c=((x_ra*m_a)+(x_oa*m_b))/(m_a+m_b)// kg/kg
h_c=((h_a*m_a)+(h_a*m_b))/(m_a+m_b)// kJ/kg dry air
printf("\n \nThe condition of the mixture, t_c=%2.1
    f C",t_c)

printf("\n \n  g_c=%0.4f kg/kg",g_c)

printf("\n \n  h_c=%2.1f kJ/kg dry air",h_c)
```

Scilab code Exa 21.5 The Carnot COP for the ideal vapour compression cycle

```
clear
// Variable declaration
T_s=100// The temperature of steam in  C
T_d=21// The dry bulb temperature in  C
H=50// % saturation
x_ab=0.0079// Moisture content of air before in kg/
    kg
x_a=0.0067// Moisture added in kg/kg
C_ps=1.972// The specific heat capacity of the steam
     in kJ/kg C
C_pa=1.006// The specific heat capacity of air in kJ
    /kg.K

// Calculation
x=x_ab+x_a// Final moisture content in kg/kg
t=((x_a*C_ps*T_s)+(C_pa*T_d))/(((x_a*C_ps)+(C_pa)))
    // The final dry bulb temperature in  C
printf("\n \nFinal moisture content=%0.4f kg/kg \
    nThe final dry bulb temperature, t=%2.2f C",x,t)
```

Scilab code Exa 21.6 The final condition

```
clear
// Variable declaration
T_d1=23// The dry bulb temperature in  C
T_w=5// The temperature of water in  C
H=50// % saturation
n_s=0.7// Saturation efficiency in %
x_a=0.0089// Moisture content in kg/kg
x_b=0.0054// Moisture content in kg/kg

// Calculation
//(a)
printf("\n (a) By construction on the chart ( Figure
    21.7 ), the final condition is 10.4  C dry bulb
   ,82 percents saturation")

//(b)
T_d2=T_d1-(n_s*(T_d1-T_w))// The final dry bulb
   temperature in  C
x_f=x_a-(n_s*(x_a-x_b))// kg/kg
printf("\n \n(b)The final condition,\n  The final
   dry bulb temperature=%2.1f  C \n  The moisture
   content=%0.5f kg/kg",T_d2,x_f)
```

Scilab code Exa 21.7 Actual evaporator capacity

```
clear
// Variable declaration
m_w=4// The mass of water in kg
m_a=1// The mass of air in kg
h_ab=45.79// Enthalpy of air before in kJ/kg
```

```
h_aa=26.7// Enthalpy of air after in kJ/kg
C_pw=4.187// The specific heat capacity of water in kJ/kg.K

// Calculation
Q_l=h_ab-h_aa// Heat lost per kilogram air in kJ
Q_g=Q_l/m_w// Heat gain per kilogram water in kJ
dT=Q_g/C_pw// Temperature rise of water in K
printf("\n Temperature rise of water=%1.0f K",dT)
```

Scilab code Exa 21.8 The drop in dry bulb temperature

```
clear
// Variable declaration
T_d1=24// The dry bulb temperature in  C
T_d2=7// The dry bulb temperature in  C
H=45// % saturation
cf=0.78// Contact factor
h_1=45.85// The enthalpy in kJ/kg
h_2=22.72// The enthalpy in kJ/kg

// Calculation
//(a) By construction on the chart ( Figure 21.9 ), 10.7  C dry bulb, 85% saturation.
//(b) By calculation, the dry bulb will drop 78% of 24 to 7  C:
dT=T_d1-(cf*(T_d1-T_d2))// The drop in dry bulb temperature in  C
dh=h_1-(cf*(h_1-h_2))// The drop in enthalpy in kJ/kg
printf("\n \nThe drop in dry bulb temperature=%2.1f C \nThe drop in enthlpy=%2.2f kJ/kg",dT,dh)
```

Scilab code Exa 21.10 `Taking the condition at 5C`

```
clear
// Variable declaration
T_d=23// The dry bulb temperature in  C
H=40// % saturation
SH=36// The sensible heat to be removed in kW
LH=14// The latent heat in kW

// Calculation
// Plotting on the chart ( Figure 21.10 ) from 23  C
   /40% and using the ratio
R=SH/(SH+LH)
printf("\n The process line meets the saturation
   curve at − 1 C , giving the ADP (which meansthat
   condensate will collect on the fins as frost).")

printf("\n Taking the condition at 5  C  dry bulb and
    measuring the proportion along theprocess line
   gives a coil contact factor of 75")
```

Chapter 22

practical air treatment cycles

Scilab code Exa 22.1 The amount of water to be evaporated

```
clear
// Variable declaration
T_d=37// The dry bulb temperature of air in C
H=24// % saturation
n_s=75// Saturation efficiency in %
h=62.67// The entering enthalpy in kJ/kg

// Calculation
// By construction on the chart, or from tables, the ultimate saturation condition would be 21.5 C, and 75% of the drop from 37 C to 21.5 C gives a final dry bulb of 25.4 C.
h_fg=2425// The average latent heat of water over the working range in kJ/kg
q=(h_fg)**-1// The amount of water to be evaporated in kg/(s kW)
printf("\n The amount of water to be evaporated is %0.3f kg/(s kW)",q)
```

Scilab code Exa 22.2 The total pressure

```
clear
// Variable declaration
T_d=37// The dry bulb temperature of air in  C
T_w=25.4// The cooling temperature of water in  C
cf=0.80// Contact factor

// Calculation
T_df=T_d-(cf*(T_d-T_w))// The dry bulb temperature (final) in  C
printf("\n The dry bulb temperature (final)=%2.1f  C point D ",T_df)
printf("\n \nThe wet bulb is now 18.9  C and the enthalpy is 53 kJ/kg.")
```

Scilab code Exa 22.3 The final volumeV2

```
clear
// Variable declaration
T_d=26// The dry bulb temperature of air in  C
T_w=20// The wet bulb temperature of water in  C
T_win=29// The temperature of water at inlet in  C
T_wout=24// The temperature of water at outlet in  C
C_pw=4.187// The specific heat capacity of water in kJ/kg.K

// Calculation
Q=C_pw*(T_win-T_wout)// Heat from water in kJ/kg
h_ain=57.1// Enthalpy of entering air in kJ/kg
h_aout=78.1// Enthalpy of leaving air in kJ/kg
printf("\n \nHeat from water=%2.0f kJ/kg \nEnthalpy of entering air=57.1 kJ/kg \nEnthalpy of leaving air=78.1 kJ/kg",Q)
```

```
printf("\n From the chart, the air leaves at approximately 25.7 C dry bulb")
```

Chapter 23

air conditioning load estimation

Scilab code Exa 23.1 U factor

```
clear
//Variable declaration
R_si=0.3// The inside resistance in (m**2 K)/W
R_1=0.040/0.09// The thermal resistance of concrete panels in (m**2 K)/W
R_2=0.050/0.037// The thermal resistance of insulation in (m**2 K)/W
R_3=0.012/0.16// The thermal resistance of plaster board in (m**2 K)/W
R_so=0.07// The outside resistance in (m**2 K)/W

//Calculation
U=1/(R_si+R_1+R_2+R_3+R_so)// U factor in W/(m**2 K)
printf("\n U factor=%0.2f W/(m**2 K)",U)
```

Scilab code Exa 23.2 Sensible heatQs

```
clear
```

```
//Variable declaration
T_d1=21// The dry bulb temperature of air in C
H=45// % saturation
T_d2=27// The dry bulb temperature of air in C
T_wb1=20// The wet bulb temperature of air in C
m=1.35// The mass flow rate of air in kg/s
C_pa=1.006// The specific heat capacity of air in kJ/kg.K
C_pw=4.187// The specific heat capacity of water in kJ/kg.K

//Calculation
 // 1.Total heat:
h_2=57.00// Enthalpy at 27 C DB, 20 C WB in kJ/kg
h_1=39.08// Enthalpy at 21 C DB, 45% sat in kJ/kg
dh=17.92// Heat to be removed in kJ/kg
Q_t=dh*m// Total heat in kW
printf("\n Total heat,Q_t=%2.1f kW", Q_t)


// 2.Latent heat:
x_2=0.0117// Moisture at 27 C DB, 20 C WB in kg/kg
x_1=0.0070// Moisture at 21 C DB, 45% sat in kg/kg
dx=x_2-x_1// Moisture to be removed in kg/kg
Q_l=dx*m*2440// Latent heat in kW
printf("\n Latent heat,Q_l=%2.1f kW", Q_l)


// 3.Sensible heat:
Q_s=(C_pa+((C_pw*x_2)))*(T_d2-T_d1)*m// Sensible heat in kW
printf("\n Sensible heat,Q_s=%1.1f kW", Q_s)
```

Scilab code Exa 23.3 `Net room load`

```
clear
//Variable declaration
Q_tl=15// Total lighting load
P_ra=90// % of load taken from return air
P_a=25// % of load rejected to ambient

//Calculation
Q_ra=Q_tl*(P_ra*10**-2)// Picked up by return air in
    kW
Q_a=Q_ra*(P_a*10**-2)// Rejected to ambient in kW
Q_net=Q_tl-Q_a// Net room load in kW
printf("\n \nNet room load=%2.3f kW",Q_net)
```

Chapter 24

air movement

Scilab code Exa 24.1 The density of dry air

```
clear
// Variable declaration
Z=4500// Altitude in m
p=575// mbar barometric pressure
t=-10// Temperature in  C

// Calculation
rho=1.2*(p/1013.25)*((273.15+20)/(273.15+t))// The density of dry air in kg/m**3
printf("\n The density of dry air,rho=%0.2f kg/m**3",rho)
```

Scilab code Exa 24.2 Kinetic energy

```
clear
// Variable declaration
V=1// The volume of air in m**3
t=20// The dry bulb temperature in  C
```

```
H=60// % saturation
p=101.325// The pressure in kPa
v=7// The velocity in m/s
v_s=0.8419// The specific volume in m**3/kg

// Calculation
m=V/v_s// Mass in kg
Ke=(m*v**2)/2// Kinetic energy in kg/(m s**2)
printf("\n Kinetic energy=%2.1f kg/(m s**2)",Ke)
```

Scilab code Exa 24.3 The amount of Static regain

```
clear
// Variable declaration
v_e=8// The entering velocity of air in m/s
v_l=5.5// The leaving velocity of air in m/s
fl=20// Friction losses in %
m=1.2// Masss in kg

// Calculation
P_e=(m*v_e**2)/2// Velocity pressure entering expansion in Pa
P_l=(m*v_l**2)/2// Velocity pressure leaving expansion in Pa
FL=fl*10**-2*(P_e-P_l)// Friction losses in Pa
Sr=(1-(fl*10**-2))*(P_e-P_l)// Static regain in Pa
printf("\n The amount of Static regain=%2.1f Pa",Sr)
```

Chapter 25

air conditioning methods

Scilab code Exa 25.1 Air flow for sensible heat

```
clear
//
// Variable Declaration
T_d=21// The dry bulb temperature in C
Q=14// Internal load in kW
H=50// % saturation
Q_l=1.5// Latent heat gain in kW
T_ain=12// The inlet air temperature in C
C_p=1.02// The specific heat capacity of air in kJ/kg.K

// Calculation
deltaT=T_d-T_ain// Air temperature rise through room in K
m=Q/(deltaT*C_p)// Air flow for sensible heat in kg/s
x=0.007857// Moisture content of room air , 21 , 50%
x_p=Q_l/(2440*m)// Moisture to pick up
x_ain=x-x_p// Moisture content of entering air
printf("\n \n Air flow for sensible heat=%1.3f kg/s \nMoisture content of entering air=%0.5f",m,x_ain
```

)

Scilab code Exa 25.2 Mass water flow

```
clear
//
// Variable declaration
// From example 25.1
Q_i=14// Internal load in kW
Q_l=1.5// Latent heat gain in kW
Q_f=0.9// The fan motor power in kW
T_win=5// The temperature of water at inlet in  C
T_wout=10.5// The temperature of water at outlet in
     C
C_pw=4.19// The specific heat capacity in kJ/kg.K

// Calculation
Q=Q_i+Q_l+Q_f// Total cooling load in kW
m_w=Q/(C_pw*(T_wout-T_win))// Mass water flow in kg/
   s
printf("\n \nMass water flow=%0.2f kg/s",m_w)
```

Scilab code Exa 25.3 Required refrigerant mass flow

```
clear
//
// Variable declaration
// From example 25.2
Q=16.4// Total load in kW
T_in=33// The temperature at liquid R134a enters the
    expansion valve in  C
T_out=9// The temperature at liquid  R134a leaves
   the cooler in  C
```

```
T_e=5//  The temperature at which liquid  R134a evaporates in  C

// Calculation
h_v=405.23// Enthalpy of R134a,superheated to 9 C in kJ/kg
h_f=246.71// Enthalpy of liquid R134a at 33 C in kJ/kg
Re=h_v-h_f// Refrigerating effect in kJ/kg
m_r=Q/Re// Required refrigerant mass flow in kg/s
printf("\n Required refrigerant mass flow=%0.3f kg/s",m_r)
```

Scilab code Exa 25.4 Mass water flow

```
clear
//
// Variable declaration
T_d1=13// The dry bulb temperature in  C
m_a=0.4// The flow rate of primary air in kg/s
T_win=12// The temperature of water at inlet in  C
T_wout=16// The temperature of water at outlet in  C
H=72// % saturation
T_d2=21// The dry bulb temperature in  C
// From example 25.1
Q_i=14// Internal load in kW
Q_l=1.5// Latent heat gain in kW
C_pw=4.19// The specific heat capacity in kJ/kg.K
C_pa=1.02// The specific heat capacity of air in kJ/kg.K

// Calculation
x_a=0.006744// Moisture in primary air, 13 C DB, 72% sat
```

```
x_r=Q_l/(2440*m_a)// Moisture removed in kg/kg
x_rise=x_a+x_r// Moisture in room air will rise to
    in kg/kg
// which corresponds to a room condition of 21 C
    dry bulb, 53% saturation
Q_a=m_a*C_pa*(T_d2-T_d1)// Sensible heat removed by
    primary air in kW
Q_w=Q_i-Q_a// Heat to be removed by water in kW
m_w=Q_w/(C_pw*(T_wout-T_win))// Mass water flow in
    kg/s
printf("\n \nMass water flow=%0.2f kg/s",m_w)
```

Chapter 29

commissioning and maintenance

Scilab code Exa 29.1 LMTD at 85 percentage air flow

```
clear
//
// Variable declaration
T_e=3// The evaporating temperature in  C
T_in=20// The temperature of air entering coil in
    C
T_out=11// The temperature of air off coil at full
   air flow in  C
T_c=35// The condensing temperature in  C
af=(1-0.15)// The reduced air flow

// Calculation
LMTD=((T_in-T_e)-(T_out-T_e))/log((T_in-T_e)/(T_out-
   T_e))// K
T_aoff=T_in-(T_in-T_out)/af// Air off coil at 85%
   air flow ( C )
Cp=(af)**0.8// Coil performance at 85% air flow ( C
   )
LMTD_85=LMTD/Cp// LMTD at 85% air flow in K
```

```
printf("\n \n LMTD at 85 percentage air flow=%2.1f K
    (error)",LMTD_85)
```

Chapter 30

efficiency running cost and carbon footprint

Scilab code Exa 30.1 `HP Running cost`

```
clear
// Variable declaration
P=15// kW
n_b=85// The effiency of the gas boiler in %
SCOP=3// An average or seasonal COP (SCOP) of heat
   pump

// Calcualtion
// For the gas boiler
R_pf=17.65// Rate of primary fuel use in kW
m_co2=0.19// The mass of carbon in kg
R_co2=R_pf*m_co2// Rate of CO_2 emission in kg/h
// For example
Gp=3// p/kWh
Rc=R_pf*Gp// Boiler Running cost in p per hour of
   heating
printf("\n Boiler Running cost=%2.0fp per hour of
   heating.",Rc)

```

```
// For heat pump
T_R_pf=10//  Rate of primary fuel use in kW (total)
R_pf=5// Rate of primary fuel use in kW
m_co2=0.43// The mass of carbon in kg
R_co2=R_pf*m_co2,// Rate of CO_2 emission in kg/h

// For example
Ep=9// p/kWh
Rc=R_pf*Ep// HP Running cost in p per hour of heating
printf("\n HP Running cost=%2.0fp per hour of heating.",Rc)
```