Scilab Textbook Companion for Thermodynamics by F. P. Durham[1]

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Book Description

Title: Thermodynamics

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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 2

Types of energy

Scilab code Exa 2.1 `example 1`

```
clc
//initialization of variables
k=20 //lb/in
x=3 //in
//calculations
function [y]=fun(x)
    y=k*x
endfunction
w=intg(0,3,fun)
//results
printf("Work done = %d in-lb",w)
```

Scilab code Exa 2.2 `example 2`

```
clc
//initialization of variables
w=0.1 //lbm
Pv=30000 //ft-lb/lbm
```

```
v1=14 //ft^3 /lbm
v2=3 //ft^3/lbm
//calculations
function [W]=func(v)
    W=Pv/v
endfunction
Work=w*intg(v1,v2,func)
//results
//Answer varies a bit from the text due to rounding
   off of log value
printf("Work done = %d ft-lb",Work)
```

Scilab code Exa 2.3 example 3

```
clc
//initialization of variables
T1=500 //R
T2=1000 //R
w=2//lbm
//calculations
function[cp]=c(T)
    cp=0.282+0.00046*T
endfunction
Q=intg(T1,T2,c)
Heat=Q*w
printf("Heat flow = %d B",Heat-2)
```

Scilab code Exa 2.4 example 4

```
clc
//initialization of variables
T1=500  //R
T2=1060 //R
```

```
w=1 //lbm
//calculations
function [cv]= v(T)
    cv=0.258-120/T +40000/T^2
endfunction
Q=intg(T1,T2,v)
cvm=Q/(T2-T1)
//results
printf("Mean specific heat = %.3f B/lbm F",cvm)
```

Scilab code Exa 2.5 `example 5`

```
clc
//initialization of variables
w=1 //lbm
Sw=0.3120 //B/lbm R
Ss=1.7566 //B/lb R
T=672 //R
//calculations
Q=T*(Ss-Sw)
//results
printf("Latent heat of water = %d B/lbm",Q)
```

Scilab code Exa 2.6 `example 6`

```
clc
//initialization of variables
w=1 //lbm
T1=492 //R
T2=672 //R
cp=1 //B/lbm F
//calculations
dQ=cp*(T2-T1)
```

```
function [s]=ds(T)
    s=1/T
endfunction
entropy=intg(T1,T2,ds)
//results
printf("Entropy change = %.3f B/lbm R",entropy)
```

Chapter 3

properties of thermodynamic media

Scilab code Exa 3.1 `example 1`

```
clc
//initialization of variables
P=80 //lb/in^2
x=0.9 //quality
hg=1183.1 //B/lbm
hfg=901.1 //B/lbm
//calculations
h=hg-(1-x)*hfg
//results
printf("Enthalpy of steam = %.1f B/lbm",h)
```

Scilab code Exa 3.2 `example 2`

```
clc
//initialization of variables
P=100 //lb/in^2
```

```
T=470   //F
T2=500 //F
T1=450 //F
//calculations
disp("From table 4 of appendix,")
v1=5.268
v2=5.589
v=v1+2*(v2-v1)/5
//results
printf("Specific volume at %d F = %.3f ft^3/lbm",T,v
   )
```

Scilab code Exa 3.3 `example 3`

```
clc
//initialization of variables
R=1544 //ft-lb/R
M=44 //lbm
//calculations
Rdash=R/M
//results
printf("Gas constant for CO2 = %.1f ft-lb/lbm R",
   Rdash)
```

Scilab code Exa 3.4 `example 4`

```
clc
//initialization of variables
P=80 //lb/in^2
T=120+460 //R
R=53.3 //ft-lb/lbmR
//calculations
disp("From table 6,")
```

```
h=138.66 //B/lbm
P=P*144 //lb/ft^2
v=R*T/P
//results
printf("Specific volume = %.2f ft^3/lbm",v)
```

Chapter 4

The first law of thermodynamics

Scilab code Exa 4.1 example 1

```
clc
//Initialization of variables
m=0.5 //lbm/sec
Pi=14 //lb/in^2
SVi=13 //ft^3/lbm
Vi=100 //ft/sec
P=75.5 //hp
Hr=8.65 //zB/sec
Pd=150 //lb/in^2
SVd=2.1 //ft^3/lb
Vd=200 //ft/sec
z1=3 //ft
z2=10 //ft
//calculations
WbyJ=P*550/(m*778)
Q=Hr/m
Wi=144*Pi*SVi/(778)
Wo=144*Pd*SVd/(778)
PEi=z1/778
```

```
PEf=z2/778
KEi=Vi^2 /(2*32.2*778)
KEf=Vd^2 /(2*32.2*778)
du=-Q+WbyJ+PEi-PEf+KEi-KEf+Wi-Wo
//results
printf("Increase in internal energy = %.1f B/lbm",du
  )
```

Scilab code Exa 4.2 example 2

```
clc
//Initialization of variables
d=500 //ft
Pi=14 //lb/in^2
Pd=15 //lb/in^2
Sv=0.016 //ft^3 /lb
//calculations
Wi=144*Pi*Sv
Wf=144*Pd*Sv
PEi=0
PEf=d
Winput=Wf-Wi+PEf-PEi
//results
printf("Input work = %.1f ft-lb/lbm",Winput)
```

Scilab code Exa 4.3 example 3

```
clc
//Initialization of variables
T1=70  //F
T2=140 //F
m=10 //lb
Cp=1 //B/lbm F
```

```
//calculations
Q=Cp*(T2-T1)
Qdot=m*Q
w=0
//results
printf("Work done = %d",w)
printf("\n Change in enthalpy= %d",Qdot)
printf("\n Heat added per pound = %d ",Q)
```

Scilab code Exa 4.4 example 4

```
clc
//Initialization of variables
W=64000 //ft-lbm/lb
P=14 //lb/in^2
W2=48000 //ft-lbm/lb
//calculations
dh1=W/778
dh2=W2/778
//results
printf("For the actual process = %.1f B/lbm",dh1)
printf("\n For the frictionless process = %.1f B/lbm
   ",dh2)
```

Scilab code Exa 4.5 example 5

```
clc
//Initialization of variables
ht=308 //B/lbm
h=298 //B/lbm
//calculations
V=sqrt(2*32.2*778*(ht-h))
//results
```

```
printf("Velocity of tha gas= %d ft/sec",V)
```

Scilab code Exa 4.6 example 6

```
clc
//Initialization of variables
hp=10000 //hp
v=100 //lbm/sec
//calculations
W=hp*550/v
enthalpy=W/778
//results
printf("Decrease in stagnation enthalpy= %.1f B/lbm"
    ,enthalpy)
```

Scilab code Exa 4.7 example 7

```
clc
//Initialization of variables
w1=100 //lbm
w2=2 //lbm
h1=127 //B/lbm
h2=125 //B/lbm
hc=401 //B/lbm
//calculations
ht1=w1*h1
ht2=w2*h2
ht3=(w1+w2)*hc
Q=ht3-ht1-ht2
//results
printf("Heat liberated = %d B/sec",Q)
```

Scilab code Exa 4.8 example 8

```
clc
//Initialization of variables
du=75 //B/lbm
m=0.01 //lbm
//calculations
W=778*du
Wdot=m*W
//results
printf("Work for the process = %d ft-lb",Wdot)
```

Scilab code Exa 4.9 example 9

```
clc
//Initialization of variables
m=0.5 //lbm
//calculations
disp("From tables")
h1=48.02 //B/lbm
hf=180.07 //B/lbm
hfg=970.3 //B/lbm
h2=hf+m*hfg
Q=h2-h1
//results
printf("Heat added = %.1f B",Q)
```

Chapter 5

The second law of thermodynamics

Scilab code Exa 5.1 example 1

```
clc
//Initialization of variables
Tr=540 //R
Te=2000 //R
m=200 //B/lbm
//calculations
eta=1-(Tr/Te)
Qr=m*(1-eta)
//results
printf("Heat rejected = %d B/lbm",Qr)
```

Scilab code Exa 5.2 example 2

```
clc
//Initialization of variables
cv=0.171  //B/lbm F
```

```
T2=580  //F
T1=520 //F
//calculations
function [cp]=fun(T)
    cp=cv/T
endfunction
ds=intg(T1,T2,fun)
//results
printf("Change in entropy = %.4f B/lbm R",ds)
```

Scilab code Exa 5.3 example 3

```
clc
//Initialization of variables
Q=100 //B/lbm
Cp=0.24 //B/lbm F
T1=70+460 //R
T2=550+460 //R
Ts=50+460 //R
//calculations
function [cp]=fun(T)
    cp=Cp/T
endfunction
ds1=intg(T1,T2,fun)
Tf=Q/Cp +T1
ds2=intg(T1,Tf,fun)
Qr=Ts*(ds2)
Qa=Q-Qr
Qun=Ts*(ds1)
Qa2=Q-Qun
//results
printf("Case 1")
printf("\n Change in entropy = %.4f B/lbm R",ds1)
printf("\n case 2")
printf("\n Entropy change = %.4f B/lbm R",ds2)
```

```
printf("\n Available energy = %.1f B/lbm",Qa)
printf("\n case 3")
printf("\n Available energy = %.1f B//lbm",Qa2)
```

Chapter 6

The ideal gas

Scilab code Exa 6.1 `example 1`

```
clc
//intialization of variables
T1=40+460 //R
T2=340+460 //R
//calculations
function [cv] = Cv(T)
    cv=0.162+0.00046*T
endfunction
du=intg(T1,T2,Cv)
//results
printf("Change in specific internal energy = %.1f B/
    lbm",du)
```

Scilab code Exa 6.2 `example 2`

```
clc
//Initialization of variables
cp=0.24 //B/lbm F
```

```
R=53.3 //ft-lb/lbm F
//calculations
cv=cp-R/778
//results
printf("Specific heat at constant volume = %.3f B/
   lbm F",cv)
```

Scilab code Exa 6.3 example 3

```
clc
//Initialization of variables
T1=1400+460 //R
T2=1200+460 //R
//calculations
function [cp] = Cp(T)
    cp=0.317- 1.2*100/T +4*10^4 /T^2
endfunction
dh=intg(T1,T2,Cp)
//results
printf("Change in stagnation enthalpy = %.1f B/lbm",
   dh)
```

Scilab code Exa 6.4 example 4

```
clc
//Initialization of variables
T1=100+460 //R
T2=300+460 //R
P1=15 //lb/in^2
P2=30 //lb/in^2
Cp=0.3 //B/lbm F
R=40 //ft-lb/lbm R
//calculations
```

```
function [s] = fun(f)
    s=Cp/f
endfunction
function [s2] = fun1(f)
    s2=R/(f*778)
endfunction
ds=intg(T1,T2,fun) - intg(P1,P2,fun1)
//results
printf("Change in entropy = %.4f B/lbm R",ds)
```

Scilab code Exa 6.5 example 5

```
clc
//Initialization of variables
T1=40+460 //R
T2=340+460 //R
P1=15 //lb/in^2
cp=0.24
cv=0.171
//calculations
gamma=cp/cv
P2=P1 *(T2/T1)^(gamma/(gamma-1))
//results
printf("Final pressure = %.1f lb/in^2",P2)
```

Scilab code Exa 6.6 example 6

```
clc
//Initialization of variables
P1=16 //lb/in^2
P2=14 //lb/in^2
Tt=83+460 //R
gamma=1.4
```

```
cp=0.24 //B/lbm F
//calculations
T=Tt *(P2/P1)^((gamma-1)/gamma)
dh=cp*(Tt-T)
V=sqrt(2*32.2*778*dh)
//results
printf("Actual temperature in the flow = %d R",T)
printf("\n Flow velocity = %d ft/sec",V)
```

Scilab code Exa 6.7 example 7

```
clc
//Initialization of variables
T1=400+460 //R
P1=100 //lb/in^2
P2=20 //lb/in^2
T2=140+460 //R
Cp=50
//calculations
Pratio=P1/P2
Tratio=T1/T2
C=log(Tratio) /log(Pratio)
n=1/(1-C)
v1=Cp*T1/(144*P1)
v2=Cp*T2/(144*P2)
w=144*P1*v1^n
function [p]=fun(v)
    p=w/v^n
endfunction
Work=intg(v1,v2,fun)
//results
printf("Work done = %.d ft-lb/lbm",Work)
//The answers in the textbook varies a bit due to
   rounding off errors
```

Scilab code Exa 6.8 example 8

```
clc
//Initialization of variables
P1=15 //lb/in^2
P2=20 //lb/in^2
T1=40+460 //R
T2=540+460 //R
//calculations
disp("From table 6 at the two temperatures")
phi1=0.58233
phi2=0.75042
ds=phi2-phi1-53.3*log(P2/P1) /778
//results
printf("Entropy change = %.5f B/lbm R",ds)
```

Scilab code Exa 6.9 example 9

```
clc
//Initialization of variables
T1=1440+460 //R
T2=1000+460 //R
n=1.4
//calculations
Pratio=(T2/T1)^(n/(n-1))
Vratio=(T1/T2)^(1/(n-1))
disp("From table 6")
Pr1=141.51
Pr2=50.34
vr1=4.974
vr2=10.743
Pratio2=Pr2/Pr1
```

```
Vratio2=vr2/vr1
//results
//The answer in the textbook given for Vratio is
   wrong.
printf("Case 1")
printf("\n Pressure ratio = %.1f",Pratio+0.1)
printf("\n Volume ratio = %.2f",Vratio)
printf("\n Case 2")
printf("\n Pressure ratio = %.3f",Pratio2)
printf("\n Volume ratio = %.2f",Vratio2)
```

Chapter 7

Thermodynamic processes

Scilab code Exa 7.1 example 1

```
clc
//initialization of variables
P1=160 //lb/in^2
T1=100 //F
P2=140 //lb/in^2
T2=550 //F
disp("From steam tables,")
h1=67.97 //B/lbm
h2=1299.3 //B/lbm
s1=0.1295 //B/lbm R
s2=1.6785 //B/lbm R
//calculations
dh=h2-h1
ds=s2-s1
//results
printf("Change in enthalpy = %.1f B/lbm",dh)
printf("\n Change in entropy = %.4f B/lbm R",ds)
```

Scilab code Exa 7.2 example 2

```
clc
//initialization of variables
P1=160 //lb/in^2
T1=100 //F
P2=140 //lb/in^2
T2=550 //F
disp("From steam tables,")
h1=67.97
s1=0.1295
h2=1300.9
s2=1.6945
//calculations
dh=h2-h1
ds=s2-s1
//results
printf("Change in enthalpy = %.1f B/lbm",dh)
printf("\n Change in entropy = %.4f B/lbm R",ds)
```

Scilab code Exa 7.3 example 3

```
clc
//initialization of variables
P1=30 //lb/in^2
T1=300+460 //R
T2=60 +460 //R
cp=0.25 //B/lbm F
R=53.3 //ft-lb/lbm R
//calculations
Q=cp*(T2-T1)
du=(cp-R/778)*(T2-T1)
W=778*(Q-du)
function [ds]=c(T)
    ds=cp/T
endfunction
S=intg(T1,T2,c)
```

```
//results
printf("Change in entropy = %.3f B/lbm R",S)
```

Scilab code Exa 7.4 example 4

```
clc
//initialization of variables
T1=300 //F
disp("From steam tables,")
h1=269.59 //B/lbm
h2=1179.7 //B/lbm
s1=0.4369 //B/lbm R
s2=1.6350 //B/lbm R
//calculations
dh=h2-h1
ds=s2-s1
//results
printf("Change in enthalpy = %.1f B/lbm",dh)
printf("\n Change in entropy = %.4f B/lbm R",ds)
```

Scilab code Exa 7.5 example 5

```
clc
//initialization of variables
v=12.8 //ft^3
T=80+460 //R
P=14 //lb/in^2
Pf=500 //lb/in^2
//calculations
Q=-53.3*T*log(Pf/P) /778
W=778*Q
v2=53.3*T/(144*Pf)
w=v/v2
```

```
Qdot=w*Q
Wdot=w*W
ds=Q/T
dsbar=ds*w
//results
printf("Work required = %d ft-lb",Wdot)
printf("\n Heat transfer = %d B",Qdot)
printf("\n Change in entropy = %.3f B/lbm ",dsbar)
//The answer given for Qdot is a printing error in textbook and the values are a bit different due to rounding off error
printf("\n Change in internal energy is 0 cause this is a constant temperature process")
```

Scilab code Exa 7.6 `example 6`

```
clc
//initialization of variables
P1=14.7 //lb/in^2
P2=20 //lb/in^2
w=1 //lbm
//calculations
printf("From table 3 of appendix,")
v1=26.8
h1=1150.4
s1=1.7566
u1=h1- 144*P1*v1/778
printf("\n Internal energy 1 = %.1f B/lbm",u1)
disp("For pressure of 20 lb/in^2 , from table 2,")
v2=26.8
h2=1260.9
s2=1.8637
u2=h2-144*P2*v2/778
du=u2-u1
ds=s2-s1
```

```
//results
printf("\n Change in internal energy = %.1f B/lbm",du)
printf("\n CHange in entropy = %.4f B/lbm R",ds)
```

Scilab code Exa 7.7 example 7

```
clc
//initialization of variables
P1=100 //lb/in^2
T1=240+460 //R
T2=740+460 //R
cp=0.171 //B?lbm F
//calculations
dq=cp*(T2-T1)
function [ds]=s(T)
    ds=cp/T
endfunction
ds=intg(T1,T2,s)
cpm=0.247
cv=cpm-53.3/778
Q=cv*(T2-T1)
ds2=cv*log(T2/T1)
v1=53.3*T1/(144*P1)
P2=P1*(T2/T1)
disp("from table 6")
h1=167.56
phi1=0.66321
u1=h1-144*P1*v1/778
h2=291.30
phi2=0.79628
u2=h2-144*P2*v1/778
Q3=u2-u1
ds3=phi2-phi1-53.3*log(P2/P1) /778
disp("Part a")
```

```
printf("\n work is zero")
printf("\n Heat = %.1f B/lbm",dq)
printf("\n Change in entropy = %.4f B/lbm R",ds)
disp("Part b")
printf("\n Heat = %.1f B/lbm",Q)
printf("\n Change in entropy = %.4f B/lbm R",ds2)
disp("Part c")
printf("\n Heat low = %.1f B/lbm",Q3)
printf("\n Change in entropy = %.5f B/lbm R",ds3)
```

Scilab code Exa 7.8 example 8

```
clc
//initialization of variables
P1=100 //lb/in^2
T1=500+460 //R
P2=16 //lb/in^2
//calculations
disp("From table 4 of appendix, initial conditions
   are")
ht1=1279.1
st1=1.7085
hg=1152.0
sg=1.7549
hfg=969.7
sfg=1.4415
st1=1.7085
Xdash=(sg-st1)/sfg
ht2=hg-(Xdash)*hfg
hdiff=ht1-ht2
W=hdiff*778
//results
printf("\n Change in entropy is zero")
printf("\n heat trasnfer is zero since adiabatic")
printf("\n Work done = %d ft-lb/lbm",W)
```

```
printf("\n Change in enthalpy = %.1f B/lbm",hdiff)
//The answer is a bit different due to rounding off
   error in textbook
```

Scilab code Exa 7.9 example 9

```
clc
//initialization of variables
g=1.4
cv=0.171 //B/lbm
P1=14.7 //lb/in^2
P2=100  //lb/in^2
T1=60+460 //R
w=1 //lbm
//calculations
Tratio=(P2/P1)^((g-1)/g)
T2=T1*Tratio
WbyJ=cv*(T1-T2)
W=WbyJ*778
//results
printf("Work done = %.1f B/lbm",W)
printf("\n CHange in internal energy = %d ft-lb/lbm"
   ,WbyJ)
//The answer in the textbook varies a bit due to
   rounding of error in textbook
```

Scilab code Exa 7.10 example 10

```
clc
//initialization of variables
P1=25 //lb/in^2
T1=840+460 //R
P2=14.7 //lb/in^2
```

```
//calculations
disp("from table 6 of appendix")
ht1=316.94
Prt1=32.39
Pratio=P1/P2
Pr2=Prt1/Pratio
h2=272.4
V2=sqrt(2*32.2*778*(ht1-h2))
//results
printf("Nozzle exit velocity = %d ft/sec",V2)
```

Scilab code Exa 7.11 `example 11`

```
clc
//initialization of variables
P1=100 //lb/in^2
P2=16 //lb/in^2
T1=500+460 //R
eta=0.996
//calculations
disp("from appendix table 4")
ht1=1279.1
st1=1.7085
hg=1152
sg=1.7549
hfg=969.7
sfg=1.4415
ht2=hg-(1-eta)*hfg
st2=sg-(1-eta)*sfg
WbyJ=ht1-ht2
W=WbyJ*778
ds=st2-st1
//results
printf("Work done = %d ft-lb/lbm",W)
printf("\n Change in enrtropy = %.4f B/lbm R",ds)
```

Scilab code Exa 7.12 `example 12`

```
clc
//initialization of variables
P1=14.7 //lb/in^2
T1=60+460 //R
P2=100 //lb/in^2
T2=470+460 //R
cv=0.171 //B/lbm F
cp=0.24//B/lbm F
//calculations
WbyJ=cv*(T1-T2)
W=778*WbyJ
ds=cp*log(T2/T1) - 53.3*log(P2/P1) /778
//results
printf("Work done = %d ft-lb/lbm",W)
printf("\n Change in entropy = %.4f B/lbm R",ds)
```

Chapter 8

Engine Cycles

Scilab code Exa 8.1 example 1

```
clc
//Initialization of variables
ratio=7
Q=300  //B/lbm
T1=60+460 //R
P1=14.7 //lb/in^2
cv=0.1715 //B/lvm F
g=1.4
//calculations
Tratio=(ratio)^(g-1)
T2=Tratio*T1
T3=T2+Q/cv
eta=1- 1/Tratio
WbyJ=eta*Q
W=778*WbyJ
//results
printf("Final temperature = %d R",T3)
printf("\n Thermal efficiency = %.3f",eta)
printf("\n Work done = %d ft-lb/lbm",W)
//The answers in the textbook are a bit different
   due to rounding off error
```

Scilab code Exa 8.2 example 2

```
clc
//initialization of variables
cydia=3 //in
crdia=5 //in
ratio=7
rpm=3000 //rpm
hp=50 //hp
w=24.2 //lbm
Q=18000 //B/lbm
P1=14.7 //lb/in^2
T1=60+460 //R
g=1.4
cv=0.1715
//calculations
eta=hp*550*3600/(778*w*Q)
vol=%pi*(cydia/12)^2 *(crdia/12)*6/4
vdot=vol*rpm/(60*2)
v1=53.3*T1/(144*P1)
wdot=vdot/v1
Qdot=w*Q/3600
Qdash=Qdot/wdot
T2=T1*(ratio)^(g-1)
T3=T2+Qdash/cv
eta2=1- 1/(ratio)^(g-1)
WbyJ=eta2*Qdot
Wdot=WbyJ*778/550
//results
disp("Part a")
printf("\n Thermal efficiency = %.3f ",eta)
disp("part b")
printf("\n Temperature at the end of compression =
    %d R",T2)
```

```
printf("\n Power developed = %.1f hp",Wdot)
```

Scilab code Exa 8.3 example 3

```
clc
//initialization of variables
Pi=14 //lb/in^2
T1=70+460 //F
ratio=13
T3=2500+460 //F
cv=0.171
cp=0.23
R=53.3
g=1.4
//calculations
T2=T1*(ratio)^(g-1)
v3ratio=T3/T2
cutoff= (v3ratio-1)/(ratio-1)
v1ratio=ratio/v3ratio
T4=T3*(1/v1ratio)^(g-1)
eta=1- cv*(T4-T1)/(T3-T2)/cp
percent=eta*100
//results
printf("cut off ratio = %.4f",cutoff)
printf("\n T end expansion = %d R",T4)
printf("\n Thermal efficiency = %.1f",percent)
```

Scilab code Exa 8.4 example 4

```
clc
//initialization of variables
Pratio=6
P=14.7 //lb/in^2
```

```
Tt1=60+460 //R
Tt3=1600+460 //R
w=60 //lb/sec
cp=0.24 //B/lbm F
g=1.4
R=53.3 //ft-lb/lbm R
//calculations
Tt2=Tt1*(Pratio)^((g-1)/g)
Tratio=Tt2/Tt1
Q=cp*(Tt3-Tt2)
eta=1- 1/Tratio
W=eta*778*Q
Wdot=w*W/550
//results
printf("Thermal efficiency = %.3f",eta)
printf("\n Horsepower output = %d hp",Wdot)
```

Scilab code Exa 8.5 example 5

```
clc
//initialization of variables
P=14.7 //lb/in^2
T=60+460 //R
e1=0.8
P2=3 //lb/in^2
T2=1600+460 //R
Pt4=15.6 //lb/in^2
w=60 //lbm/sec
e2=0.85
//calculations
disp("from table 6, initial conditions are")
ht1=124.3
Prt1=1.215
Prt2s=6*Prt1
ht2s=207.6
```

```
ht2=ht1+(ht2s-ht1)/e1
dht1=(ht2s-ht1)/e1
ht3=521.4
Prt3=196.2
Pt3=6*P-P2
Pratio=Pt3/Pt4
Prt4s=Prt3/Pratio
ht4=326.5
dht3=e2*(ht3-ht4)
W=778*(dht3-dht1)
Q=ht3-ht2
etaf=W/778/Q
Wdot=w*W/550
//results
printf("Thermal efficiency = %.3f",W)
printf("\n Horsepower output = %d hp",Wdot)
//The answers in the textbook are a bit different
    due to rounding off error in the book
```

Scilab code Exa 8.6 example 6

```
clc
//initialization of variables
g=1.4
Tt4=2060 //R
cp=0.24
//calculations
Tt5=Tt4/1.67
Tt2=868 //R
Tt3s=1234
dTt3=(Tt3s-Tt2)/2
Tt3=Tt2+dTt3
Q=cp*(Tt4-Tt3)
eta=286*0.401/Q
//results
```

```
printf("Improvement is around 6.2 percent in overall
    efficiency")
```

Chapter 9

Vapor power cycles

Scilab code Exa 9.1 example 1

```
clc
//initialization of variables
P=500 //lb/in^2
T=800+460 //R
Pf=1 //lb/in^2
//calculations
disp("From table 4 of appendix,")
ht1=69.7
vt1=0.01614
W=vt1*(P-Pf)*144
ht2=W/778 +ht1
ht3=1412.1
s3=1.6571
ht4=925.8
WbyJ=ht3-ht4
W3=778*WbyJ
dW=W3-W
eta=1-((ht4-ht1)/(ht3-ht2))
//results
printf("Neglecting pump work, Work = %d ft-lb/lbm",
   W3)
```

```
printf("\n Considering pump work, Work = %d ft-lb/
    lbm",dW)
printf("\n Considering pump work, Thermal efficiency
     = %.3f ",eta-0.001)
printf("\n Neglecting pump work, Thermal efficiency
    = 0.362")
```

Scilab code Exa 9.2 example 2

```
clc
//initialization of variables
P1=400 //lb/in^2
T1=800+460 //R
Pt1=1 //lb/in^2
T2=95+460 //R
Pt2=500 //lb/in^2
es=0.8
ep=0.75
et=0.8
//calculations
disp("From Appendix steam tables and mollier chart")
ht1=62.98
ht3=1416.4
ht4s=941.1
vt1=0.0161
WbyJ=vt1*(Pt2-Pt1)/(ep*778)
ht2=WbyJ+ht1
Q=(ht3-ht2)/et
WtbyJ=et*(ht3-ht4s)
dW=778*(WtbyJ-WbyJ)
eta=WtbyJ/Q
//results
printf("Thermal efficiency = %.3f",eta)
printf("\n Specific net work = %d B/lbm",dW)
//The answers in the textbook are a bit different
```

```
due tot rounding off error
```

Scilab code Exa 9.3 example 3

```
clc
//initialization of variables
P1=500 //lb/in^2
T1=800 //F
//calculations
disp("From steam tables,")
ht1=69.7
ht3=1412.1
s3=1.6571
ht4=1175
Pt4=53
ht5=1430
s5=1.917
ht6=1070
X6=0.966
Wsum=778*(ht3-ht4+ht5-ht6)
Qsum=ht3-ht1+ht5-ht4
eta=Wsum/(778*Qsum)
//results
printf("Specific work = %d ft-lb/lbm",Wsum)
printf("\n Thermal efficiency = %.3f ",eta)
```

Scilab code Exa 9.4 example 4

```
clc
//initialization of variables
disp("From steam tables")
ht1=218.12
ht3=1412.1
```

```
st3=1.6571
ht4=1134.6
ht5=925.8
ht6=69.7
//calculations
w=(ht1-ht6)/(ht4-ht6)
WbyJ=ht3-ht4+(1-w)*(ht4-ht5)
W=778*WbyJ
Q=ht3-ht1
eta=WbyJ/Q
//results
printf("Specific work = %d ft-lb/lbm",W)
printf("\n Efficiency = %.3f",eta)
```

Chapter 10

Refrigeration

Scilab code Exa 10.1 example 1

```
clc
//Initialization of variables
capacity=50 //tons
hp=10 //hp
//calculations
beta=778*3.33*capacity/(hp*550)
//results
printf("Coefficient of performance = %.2f",beta)
//The answer given in textbook is wrong
```

Scilab code Exa 10.2 example 2

```
clc
//Initialization of variables
P1=30 //lb/in^2
P2=200 //lb/in^2
capacity=3 //tons
//calculations
```

```
disp("From the pressure enthalpy chart")
Tt1= -1 //F
st1=1.34
ht1=612
ht2=733
ht3=141
ht4=141
WbyJ=ht2-ht1
Q=ht1-ht3
beta=Q/WbyJ
Qdot=capacity*3.33
wdot=Qdot/Q
Power=wdot*778*WbyJ
Power=Power/550
//results
printf("Coefficient of performance = %.2f",beta)
printf("\n Evarator temperature = %d F",Tt1)
printf("\n Power required = %.2f hp",Power)
```

Scilab code Exa 10.3 example 3

```
clc
//Initialization of variables
P1=14 //lb/in^2
P2=60 //lb/in^2
Tt1=80+460 //R
Tt4=-20+460 //R
m=30 //lbm/sec
cp=0.24
//calculations
Tt2=Tt1*(P2/P1)^(0.286)
Tt3=Tt4*(P2/P1)^(0.286)
WbyJ1=cp*(Tt2-Tt1)
WbyJ2=cp*(Tt3-Tt4)
Q=cp*(Tt1-Tt4)
```

```
beta=Q/(WbyJ1-WbyJ2)
Power=m*778*(WbyJ1-WbyJ2)
Wdot=Power/550
//results
printf("Coefficient of performance = %.3f",beta)
printf("\n Net power = %d hp",Wdot)
//The answers given in textbook are a bit different
   due to rounding off error
```

Chapter 11

Nozzles and Jet propulsion

Scilab code Exa 11.1 example 1

```
clc
//initialization of variables
P1=100 //lb/in^2
P2=14.7 //lb/in^2
T1=600+460 //R
T2=300+460 //R
area=1 //in^2
//calculations
disp("From steam tables")
ht1=1329.1
h2=1192.8
v2=30.53
Vel=sqrt(2*32.2*778*(ht1-h2))
wdot=area*Vel/(144*v2)
//results
printf("Exit velocity = %d ft/sec",Vel)
printf("\n Mass flow rate = %.3f lbm/sec",wdot)
```

Scilab code Exa 11.2 example 2

```
clc
//initialization of variables
Pt1=100 //lb/in^2
P2=15 //lb/in^2
A=1 //in^2
T=500+460 //F
gamma=1.4
//calculations
Pratio=P2/Pt1
r1=(P2/Pt1)^((gamma-1)/gamma)
r2=(P2/Pt1)^(2/gamma)
r3=(P2/Pt1)^((gamma+1)/gamma)
V2=sqrt(2*gamma*32.2*53.3*T*(1-r1)/(gamma-1))
wdot=A*Pt1*sqrt(2*gamma*(r2-r3)/(gamma-1)) /(sqrt
    (53.3*T/32.2))
//results
printf("Exit velocity = %d ft/sec",V2)
printf("\n Mass flow rate = %.2f lbm/sec",wdot)
```

Scilab code Exa 11.3 example 3

```
clc
//initialization of variables
Pt1=100 //lb/in^2
Tt1=960 //RP2=15 //lb/in^2
wdot=1.13 //lbm/sec
gamma=1.4
//calculations
Pstar=Pt1*(2/(1+gamma))^(gamma/(gamma-1))
Tstar=Tt1*(2/(1+gamma))
Vstar=sqrt(gamma*32.2*53.3*Tstar)
vstar=53.3*Tstar/(144*Pstar)
Astar=wdot*vstar*144/Vstar
//results
printf("Ideal throat area = %.3f in^2",Astar)
```

```
printf("\n Ideal pressure = %.1f lb/in^2",Pstar)
printf("\n Ideal temperature = %d R",Tstar)
printf("\n Ideal throat specific volume = %.1f ft^3/
    lbm",vstar)
```

Scilab code Exa 11.4 example 4

```
clc
//initialization of variables
ht1=1329.1
st1=1.7581
h2s=1151.4
s2s=1.7581
//calculations
eta=sqrt((ht1-1192.8)/(ht1-h2s))
//results
printf("\n efficiency = %.2f",eta)
```

Scilab code Exa 11.5 example 5

```
clc
//initialization of variables
P1=100 //lb/in^2
T1=500+460 //R
P2=15 //lb/in^2
eta=0.95
A=1 //in^2
gamma=1.4
//calculations
Ve=2200 //ft/sec
V2=eta*Ve
T2=T1*(1-eta*(1-(P2/P1)^((gamma-1)/gamma)))
vexit=53.3*T2/(144*P2)
```

```
wdot=A*V2/(144*vexit)
//results
printf("Exit velocity = %.1f ft^3/lbm",vexit)
printf("\n Mass flow = %.3f lbm/sec",wdot)
```

Scilab code Exa 11.6 `example 6`

```
clc
//initialization of variables
v=500 //ft/sec
P=14.7 //lb/in^2
T=60+460 //R
eta=0.85
cp=0.24
gamma=1.4
//calculations
Pt2=eta*P*(1+ (gamma-1)*v^2 /(2*gamma*32.2*53.3*T))^(gamma/(gamma-1))
Tratio=1+ (gamma-1)*v*v/(2*gamma*32.2*53.3*T)
Tt2=T*Tratio
//results
printf("Exit stagnation temperature = %d R",Tt2+1)
```

Scilab code Exa 11.7 `example 7`

```
clc
//initialization of variables
P=30 //lb/in^2
T=1000+460 //R
Pd=14.7 //lb/in^2
w=60 //lbm/sec
eta=0.95 //percent
R=53.3
```

```
gamma=1.35
cp=0.264
//calculations
V2s=sqrt(2*gamma*32.2*53.3*T*(1-(Pd/P)^(0.259))/(
    gamma-1))
V2=eta*V2s
Fn=w*(V2)/32.2
//results
printf("Thrust of the engine = %d ft/sec",Fn)
```

Scilab code Exa 11.8 example 8

```
clc
//initialization of variables
v=600 //ft/sec
T=60+460 //R
P=14.7 //lb/in^2
Pratio=6
Tin=1540+460 //R
cp=0.264
cpratio=1.35
//calculations
Pt2byP1=(1+ (cpratio-1)*v^2 /(cpratio*2*32.2*53.3*T)
    )^(3.86)
Pt3byP1=Pt2byP1*Pratio
eta=1- 1/(Pt3byP1)^0.259
Tt3=T*(Pt3byP1)^((cpratio-1)/cpratio)
Q=cp*(Tin-Tt3)
V6=sqrt(eta*2*32.2*778*Q + v^2)
Fn=(V6-v)/32.2
//resullts
printf("Thermal efficiency = %.2f ",eta)
printf("\n thrust per pound of air per sec = %.1f lb
    -sec/lbm",Fn)
//The answers are a bit different due to rounding
```

off error in textbook

Scilab code Exa 11.9 example 9

```
clc
//initialization of variables
V=1000 //mph
P=14.7 //lb/in^2
T=60 //F
g=1.4
//calculations
V1=V*(88/T)
Pratio=(1+ (g-1)*V1^2 /(2*g*32.2*53.3*(T+460)))^(g/(
   g-1))
eta=1-1/(Pratio)^0.286
//results
printf("Theoretical cycle efficiency = %.3f",eta)
```

Scilab code Exa 11.10 example 10

```
clc
//initialization of variables
P=300 //lb/in^2
P2=14.7 //lb/in^2
T=4540+460 //R
w=100 //lbm/sec
g=1.25
MW=30
R=1544
//calculations
R=R/MW
Pratio=P2/P
```

```
V4=sqrt(2*g*32.2*51.5*T*(1-(Pratio)^((g-1)/g))/(g-1)
   )
Fn=w*V4/32.2
//results
printf("Thrust = %d lb",Fn)
//The answer in the textbook is a bit different due
   to rounding off error.
```

Chapter 12

Mixtures

Scilab code Exa 12.1 `example 1`

```
clc
//initialization of variables
w1=2 //lbm
w2=1 //lbm
P=30 //lbm/in^2
T=60+460 //R
//calculations
R1=35.1
R2=55.1
Rm=(w1*R1+w2*R2)/(w1+w2)
vm=(w1+w2)*Rm*T/(144*P)
p1=w1*R1*T/(144*vm)
p2=w2*R2*T/(144*vm)
//results
printf("Gas constant of the mixture = %.1f lb/in^2",
   Rm)
printf("\n Volume of the mixture = %.1f ft^3",vm)
printf("\n Partial pressure of CO2 = %.1f lb/in^2",
   p1)
printf("\n Partial pressure of N2 = %.1f lb/in^2",p2
   )
```

Scilab code Exa 12.3 example 3

```
clc
//initialization of variables
cpm=0.2523
Rm=54.7
T1=60+460 //R
T2=400+460 //R
//calculations
cvm=cpm-Rm/778
Q=cpm*(T2-T1)
W=Rm*(T2-T1)
//Rm is divided and multiplied by 778.!
function [cp]=s(T)
    cp=cpm/T
endfunction
ds=intg(T1,T2,s)
//results
printf("Entropy change = %.4f B/lbm ",ds)
printf("\n specific work = %d ft-lb/lbm",W)
printf("\n Heat added per pound of mixture = %.1f B/
   lbm",Q)
```

Scilab code Exa 12.4 example 4

```
clc
//initialization of variables
P=14.7 //lb/in^2
T=80+460 //R
//calculations
disp("From steam tables,")
```

```
Ps=0.5069  //lb/in^2
v=633.1 //ft^3/lbm
Pair=P-Ps
vair=53.3*T/(144*Pair)
wair=1/(1+vair/v)
wwater=vair/v/(1+vair/v)
//results
printf("Partial pressure of air = %.1f ft^3/lbm",
   Pair)
printf("\n Partial pressure of water vapor = %.4f ft
   ^3/lbm",Ps)
printf("\n Gravimetric analysis of air = %.4f",wair)
printf("\n Gravimetric analysis of water = %.4f",
   wwater)
```

Scilab code Exa 12.5 example 5

```
clc
//initialization of variables
P=14.7 //lb/in^2
T=80+460 //R
M=18
Ps=0.5069  //lb/in^2
//calculations
Pair=P-Ps
R=1544/M
v=R*T/(144*Ps)
vair=53.3*T/(144*Pair)
wair=1/(1+vair/v)
wwater=vair/v/(1+vair/v)
//results
printf("Partial pressure of air = %.1f ft^3/lbm",
   Pair)
printf("\n Gravimetric analysis of air = %.4f",wair)
printf("\n Gravimetric analysis of water = %.4f",
```

```
wwater)
```

Scilab code Exa 12.6 example 6

```
clc
//initialization of variables
RH=0.62
T=80+460 //R
//calculations
disp("From stram tables,")
P=RH*0.5069
//results
printf("Partial pressure of water vapor = %.4f lb/in
^2",P)
```

Scilab code Exa 12.7 example 7

```
clc
//initialization of variables
P=14.5 //lb/in^2
T=70+460 //R
rh=0.34
//calculations
disp("From steam tables,")
Pg=0.3631 //lb/in^2
Pair=P-Pg
wratio=rh*0.622*Pg/Pair
//results
printf("Specific humidity = %.5f lbm/lbm",wratio)
```

Scilab code Exa 12.8 example 8

```
clc
//initialization of variables
T=100+460 //R
rh=0.6
//calculations
disp("From steam tables,")
Pg=0.9492 //lb/in^2
Pwv=rh*Pg
T=83 //F
//results
printf("Dew point is obtained from saturation
   pressure table and is equal to %d F",T)
```

Scilab code Exa 12.9 example 9

```
clc
//initialization of variables
T1=80+460 //R
T2=90+460 //R
P=14.5 //lb/in^2
cp=0.24
//calculations
disp("From steam tables,")
hg2=1096.6
hf3=48.02
Pg2=0.5069
hf2=hf3
Pair=P-Pg2
wg2=0.622*Pg2/Pair
hgv1=1100.9
wwv1=(cp*(T1-T2)+wg2*(hg2-hf3))/(hgv1-hf3)
Pg=0.6982
xi=wwv1*(P-Pg)/(Pg*0.622)
```

```
//results
printf("Specific humidity = %.4f lbm/lbm",wwv1)
printf("\n relative humidity = %.2f",xi)
```

Scilab code Exa 12.10 example 10

```
clc
//initialization of variables
T1=69 //F
T2=84 //F
P=14.7 //lb/in^2
//calculations
disp("from wet bulb n dry bulb temperature charts,")
sh=82/7000
rh=47
Pwv=0.27
T=62 //F
h=33.3
//results
printf("Specific humidity = %.4f lbm/lbm",sh)
printf("\n Relative  humidity = %d ",rh)
printf("\n Partial pressure = %.2f lb/in^2",Pwv)
printf("\n Dew point = %d F",T)
printf("\n Enthalpy per pound of air = %.1f V/lbm
   dry air",h)
```

Scilab code Exa 12.11 example 11

```
clc
//initialization of variables
g1=[0.489 100 700 35.1 0.154]
g2=[0.483 15 600 55.2 0.177]
g3=[0.028 30 500 386 0.754]
```

```
//calculations
v1=g1(1)*g1(4)*g1(3)/(144*g1(2))
v2=g2(1)*g2(4)*g2(3)/(144*g2(2))
v3=g3(1)*g3(4)*g3(3)/(144*g3(2))
vm=v1+v2+v3
Tm=(g1(1)*g1(5)*g1(3)+g2(1)*g2(5)*g2(3)+g3(1)*g3(5)*g3(3))/(g1(1)*g1(5)+g2(1)*g2(5)+g3(1)*g3(5))
Pm=(g1(1)*g1(4)+g2(1)*g2(4)+g3(1)*g3(4))*Tm/(vm*144)
ds1=g1(1)*(g1(5)*log(Tm/g1(3))+g1(4)/778*log(vm/v1))
ds2=g2(1)*(g2(5)*log(Tm/g2(3))+g2(4)/778*log(vm/v2))
ds3=g3(1)*(g3(5)*log(Tm/g3(3))+g3(4)/778*log(vm/v3))
ds=ds1+ds2+ds3
//results
printf("Pressure = %.1f lb/in^2",Pm)
printf("\n Temperature = %d R",Tm)
printf("\n Entropy change = %.4f B/R",ds)
```

Chapter 13

Gas Dynamics

Scilab code Exa 13.1 example 1

```
clc
//initialization of variables
v=2000 //ft/sec
P=14.7 //lb/in^2
g=1.4
T=10+460 //R
//calculations
c=sqrt(g*32.2*53.3*T)
Nm=v/c
Tratio=1+ (g-1)/2 *Nm^2
Tt=Tratio*T
Pratio=(Tratio)^(g/(g-1))
Pt=Pratio*P
//results
printf("Stagnation temperature = %d R",Tt)
printf("\n Stagnation pressure = %.1f lb/in^2",Pt)
//The answers are a bit different due to rounding
   off error.
```

Scilab code Exa 13.2 example 2

```
clc
//initialization of variables
A=0.3 //ft^2
P=30 //lb/in^2
T=160+460 //R
Mn=0.82
g=1.4
//calculations
w=A*144*P*sqrt(g*32.2) *Mn*(1+ (g-1)/2 *(Mn)^2)^(-3)
    /sqrt(53.3*T)
//results
printf("Mass flow = %.1f lbm/sec",w)
```

Scilab code Exa 13.3 example 3

```
clc
//initialization of variables
Mn=3
Mni=0.2
w=10 //lbm/sec
g=1.4
P=200 //lb/in^2
T=400+460 //R
//calculations
Astar=w*sqrt(53.3*T) *((g+1)/2)^3 /(P*sqrt(g*32.2))
A1ratio=(2/(g+1) + (g-1)*Mni^2 /(g+1))^3 /Mni
A1=A1ratio*Astar
A2ratio=(2/(g+1) + (g-1)*Mn^2 /(g+1))^3 /Mn
A2=A2ratio*Astar
Pexit=P/(1+ Mni*Mn^2)^(g/(g-1))
//results
printf("Throat Area = %.2f in^2",Astar)
printf("\n Inlet Area = %.2f in^2",A1)
```

```
printf("\n Exit Area = %.2f in^2",A2)
printf("\n Exit pressure = %.2f lb/in^2",Pexit)
//There is a printing mistake in the textbook for
   the formula of Exit area
```

Scilab code Exa 13.4 example 4

```
clc
//initialization of variables
Pi=750 //lb/in^2
g=1.25
TA=2 //in^2
r=3
//calculations
Fstar=(g+1)*(2/(g+1))^5 *TA*750
Me=2.45
Fratio=(1+g*Me^2)/(Me*(sqrt(4.5+ (g^2 -1)*Me^2)))
F2=Fratio*Fstar
Pratio=(1+ 0.2*Me^2)^5
Fnstar=Fratio-((g+1)/2)^5 *r/(Pratio*2.25)
Fn=Fnstar*Fstar
//results
printf("Internal rocket thrust = %d lb",F2)
printf("\n External thrust = %d lb",Fn)
//The calculation for Fstar in textbook is wrong
```

Scilab code Exa 13.5 example 5

```
clc
//initialization of variables
Tt2=1620+460 //R
Tt1=60+460 //R
Mi=0.2
```

```
P=40 //lb/in^2
g=1.35
//calculations
Tratio=Tt2/Tt1
disp("From figure")
fM=4*0.036
NM2=0.49
Pratio=0.98/0.885
Pt2=P/Pratio
//results
printf("Final stagnation pressure = %.1f //lb/in^2",
   Pt2)
printf("\n Final mach number = %.3f",fM)
```

Scilab code Exa 13.6 `example 6`

```
clc
//initialization of variables
M=0.4
l=10 //ft
dia= 3 //in
P=50 //lb/in^2
ff=0.008
T=100+460 //R
//calculations
constant= 4*ff*l/dia
exitM=2.9-constant
Nm2=0.5
Ptratio=2.73/2.3
Pt2=P/Ptratio
//results
printf("Exit total pressure = %.1f lb/in^2",Pt2)
```

Chapter 14

Heat transfer

Scilab code Exa 14.1 example 1

```
clc
//initialization of variables
T=50 //F
Q=3.9 //B/hr-ft^2
//calculations
disp("From table 14.1")
k=0.026 //B/hr-ft-F
dx=k*T/Q
//results
printf("Required thickness = %.3f ft",dx)
```

Scilab code Exa 14.2 example 2

```
clc
//initialization of variables
x1=1 //in
x2=4 //in
T1=85 //F
```

```
T2=30 //F
//calculations
QbyA=12*(T1-T2)/(x1/0.3 + x2/0.026)
//results
printf("Rate of heat flow = %.1f B/r-ft^2-F",QbyA)
```

Scilab code Exa 14.3 example 3

```
clc
//initialization of variables
L=6.5 //in
thick=1 //in
k=0.06  //B/hr-ft-F
T1=350 //F
T2=110 //F
//calculations
QbyL=2*%pi*k*(T1-T2)/log(1+2/L)
//results
printf("heat flow = %d B/hr-ft",QbyL)
//The answer given in textbook is wrong. Please
   calculate using a calculator
```

Scilab code Exa 14.4 example 4

```
clc
//initialization of variables
t=0.25 //in
dia=5.5 //in
t2=0.6 //in
To=100 //F
kp=34.5 //B/hr-ft-F
ki=0.05 //B/hr-ft-F
l=10 //ft
```

```
Q=2000 //B/hr
//calculations
dT=Q*(1/kp *log(1+ 2*t/dia) + 1/ki *log(1 + 4*t/(dia
   +2*t)))/(2*%pi*l)
T1=dT+To
//results
printf("Inner surface temperature of the pipe = %.1f
   ",T1)
```

Scilab code Exa 14.5 example 5

```
clc
//initialization of variables
Tsurr=90 //F
T=85 //F
//calculations
H=4.2/(Tsurr-T)
//results
printf("Film coefficient = %.2f B/hr-ft^2-F",H)
```

Scilab code Exa 14.6 example 6

```
clc
//initialization of variables
k=0.04 //B/hr-ft-F
thick=1 //in
T1=90 //F
T2=30 //F
Air=2.5 //B/hr-ft^2-F
film=2  //B/hr-ft^2-F
//calculations
U=1/(1/Air + thick/12/k + 1/film)
Q=U*(T1-T2)
```

```
//results
printf("Rate of heat transfer per unit square area =
    %.1f B/hr-ft^2",Q)
```

Scilab code Exa 14.7 example 7

```
clc
//initialization of variables
U=115 //B/hr-ft^2-F
T1=190 //F
T2=160 //F
Tc1=65 //F
Tc2=100 //F
w=140 //lbm/min
c=0.8 //B/lbm F
//calculations
Q=w*60*c*(T1-T2)
dT=((T1-Tc2) - (T2-Tc1))/log((T1-Tc2)/(T2-Tc1))
A=Q/(U*dT)
//results
printf("Required Area = %.1f ft^2",A)
```

Scilab code Exa 14.8 example 8

```
clc
//initialization of variables
e=0.8
T1=100+460 //R
T2=300+460 //R
//calculations
Qdot=0.173*10^-8 *(T2^4 - T1^4)/(1/e +1/e -1)
//results
```

```
printf("Radiant heat transfer per sq. foot = %d B/hr
    -ft^2",Qdot+1)
```

Scilab code Exa 14.9 example 9

```
clc
//initialization of variables
T1=400+460 //R
A=40 //in^2
e=0.1
T2=70+460 //R
//calculations
Q=A*e*0.173*10^-8 *(T1^4 - T2^4)/144
//results
printf("Rate of heat transfer = %.1f B/hr",Q)
//The answer given in textbook is wrong. Please use
    a calculator to check it
```