Scilab Textbook Companion for An Introduction To Thermodynamics by Y. V. C Rao[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Introduction

Scilab code Exa 1.1 Determine force required to lift the bell jar off the plate

```
clc
D=50 //diameter of bell jar in cms
Pin=25 //pressure inside bell jar after evacuation with vaccum pump in pascals
Pat=101325 //atmospheric pressure in Pascals
P=Pat-Pin //net pressure acting on bell jar in Pascals
mprintf('Net pressure acting is%iPa\n',P)
A=%pi*(D/100)*(D/100)/4 //area of flat plate on which bell jar is resting in metre square with D converted to metres
F=P*A//net force acting on flat plate in Newton
mprintf('Minimum force required to lift the bell jar off the plate is%fkN',F/1000)//ans may vary due to roundoff error with F converted into kilo newtons
```

Scilab code Exa 1.2 Deteremine pressure drop if density of water is 1000kg per met

```
clc
Rhow=1000 //density of water in  (kg/metre cube)
RhoHg=13.6*(10^3) //density of mercury in  (kg/
    metre cube)
g=9.81 //gravitational constant in  metre/second
    square
h=0.2 //in metres
Pdrop=(RhoHg-Rhow)*g*h
mprintf('The pressure drop with water in manometer
    is%fkPa',Pdrop/1000)//ans may vary due to
    roundoff error with Pdrop converted in kilo
    pascals
```

Scilab code Exa 1.3 Determine final pressure of gas in cylinder

```
clc
Pa=101.325 //atmospheric pressure in kPa
A=0.05 //cross sectional area of piston in metre
    square
k=50 //spring constant in kN/m
V0=0.1 //initial volume of gas in metre cube
V=0.2 //volume of gas at any instant during
    expansion in metre cube
P=Pa+((k*(V-V0))/(A*A)); //force balance equation
mprintf("P=%fkPa",P)//final pressure on gas cylinder
```

Scilab code Exa 1.5 Express flow rate in terms of kmol per min

```
clc
mol1=0.25 //moles of nitrogen present in mixture
mol2=0.75 //moles of hydrogen present in mixture
molmass1=28*(10^(-3))//molar mass of nitrogen in kg
molmass2=2*(10^(-3)) //molar mass of hydrogen in kg
```

```
mixturemass=(mol1*molmass1)+(mol2*molmass2)//mass of mixture of nitrogen and hydrogen
mprintf("One mole mixture=%fkg\n",mixturemass)
Frate1=100 //flow rate of mixture in kg/min
Frate2=Frate1/mixturemass //flow rate in  kmol/min
mprintf("100kg mixure/min=%fkmol/min",Frate2/1000)//ans varies due to roundoff error
```

Chapter 2

Concepts And Definitions

Scilab code Exa 2.2 Calculate the change in kinetic energy of the glider

```
clc
v2=60 //speed of gladiator in km/h
v2=(v2*10^3)/3600 //speed of gladiator in metre/second
mprintf("v2=%fm/s\n",v2)//ans may vary due to roundoff error
v1=0 //initial speed of gladiator
m=150 //mass of gladiator in kg
W=m*((v2*v2)-(v1*v1))/2 //work done on gladiator
mprintf("W=%fkJ\n",W/1000)//ans varies due to roundoff error
vf=10 //final velocity of gladiator in km/h
vf=(10*10^3)/3600 //final velocity in m/s
mprintf("vf=%fm/s\n",vf)//ans may vary due to roundoff error
vi=v2
deltaKE=m*((vf*vf)-(vi*vi))/2 //change in kinetic energy
mprintf("   (KE)=%fkJ",deltaKE/1000)//ans varies due to roundoff error
```

Scilab code Exa 2.3 Calculate work done by gas if volume is inversely proportional

```
clc
P1=500 //initial pressure of gas in kPa
V1=0.2 //initial volume of gas in  metre cube
P2=100 //final pressure of gas in kPa
gama=1.4 //Cp/Cv ratio of gas
W=P1*V1*log(P1/P2)//work done when volume inversely
   proportional to pressure
mprintf("W=%fkJ\n",W)//ans may vary due to round off
    error
V2=((P1*(V1^gama))/P2)^(1/gama)//final volume
mprintf("V2=%fmetre-cube\n",V2)//ans may vary due to
    roundoff error
W=(P2*V2-P1*V1)/(1-gama)//work done when PV^   is
   constant
mprintf("W=%fkJ",W)//ans may vary due to roundoff
   error
```

Scilab code Exa 2.4 Calculate the work done by gas

```
clc
P1=200 //initial pressure in kPa
V1=0.1 //initial volume in metre-cube
P2=500 //final pressure in kPa
V2=0.2 //final volume in metre-cube
W=(P1+P2)*(V2-V1)/2 //work done,obtained after
   derivation in book
mprintf("W=%ikJ",W)
```

Scilab code Exa 2.5 Determine work done by gas in balloon

```
clc
function [I1]=Trapcomposite(f,a,b,n)
    funcprot(0)
    h=(b-a)/n
    x=linspace(a,b,n+1)
    I1=(h/2)*(2*sum(f(x))-f(x(1))-f(x(n+1)))
    funcprot(0)
    endfunction //for integration using numerical method
P1=150 //initial pressure of gas inside balloon in kPa
P2=450 //final pressure inside ballooon in kPa
D1=1 //initial diameter of balloon in metre
K=P1 //from P=k*D*D*D, in kPa/metre cube
D2=(P2/P1)^(1/3) //final diameter of balloon in metre
mprintf("D2=%fm\n",D2)//ans may vary due to roundoff error
deff('[W]=f(D)','W=(K*D.^5*%pi)/2')//work done obtained by integration of PdV using relation P=k*D*D*D
W=Trapcomposite(f,D1,D2,20)//work done
mprintf("W=%fkJ",W)//ans may vary due to roundoff error
```

Chapter 3

Thermodynamic properties of Fluids

Scilab code Exa 3.1 Determine the volume of cylinder by ideas gas law and vander w

```
clc
//following is the function to solve cubic equation
function[x1]=cub(a,b,c,d)
    funcprot(0)
    r=b/a;
    s=c/a;
    t=d/a;
    p=(3*s-r^2)/3;
    q=2*r^3/27-r*s/3+t;
    D=(p/3)^3+(q/2)^2;
    u=(-q/2+sqrt(D))^(1/3);
    v=(-q/2-sqrt(D))^(1/3);
    y1=u+v;
    x1=y1-(r/3);
    funcprot(0)
endfunction
R=8.314*(10^3) //universal gas constant
T=300 //temperature in kelvin
P=60*(10^6) //pressure in Pascals
```

```
v=(R*T)/P //volume of cylinder in metre cube
mprintf("v=%fmetre cube\n",v)//ans may vary due to roundoff error
a=228.296*(10^(-3))//vander waals constant for methane in Pa(metre cube/mol)square
b=0.043*(10^(-3))//vander waaals constant for methane in metre cube/mol
R=8.314 //universal gas constant
v=cub(P,(-(P*b)-(R*T)),a,(-a*b))//(P+a/v*v)*(v-b)=RT(van der Waals equation)
mprintf("v=%fmetre-cube/mol\n",v)//ans may vary due to roundoff error
Tc=190.7 //Tc for methane in kelvin
Pc=46.41 //Pc for methane in bar
a=0.42748*R*R*(Tc^2.5)/(Pc*(10^5)*(T^0.5)) //Redlich-Kwong equation
b=0.0867*R*Tc/(Pc*10^5) //Redlich-Kwong equation
mprintf("a=%fmetre^6Pa/mol-square\n",a)//ans may vary due to roundoff error
mprintf("b=%fmetre-cube/mol\n",b)//ans may vary due to roundoff error
v=cub(P,(-R*T),(-P*b*b-R*T*b+a),(-a*b))//P=(RT/v-b)-(a/v(v+b))
mprintf("v=%fmetre cube/kmol\n",v*1000) //ans may vary due to roundoff error
```

Scilab code Exa 3.2 Pressure developed by gas by ideal gas law and vander waala eq

```
clc
R=8.314*(10^3)//universal gas constant
T=473 //temperature of bath in kelvin
v1=0.6 //volume of steel vessel in metre-cube
P=R*T/v1 //pressure developed by ideal gas law
mprintf("P=%fMPa\n",P*10^-6)//ans may vary due to roundoff error
```

```
a=453.046*(10^-3) //vander waals constant in Pa(
    metre-cube/mol)^2
b=0.057*(10^-3)//vander waals constant in metre cube
    /mol
P=((R*T)/(v1-b))-(a/(v1*v1))//pressure by vander
    waals equation
mprintf("P=%fMPa\n",P*10^-6)//ans may vary due to
    roundofff error
Pc=51.17 //pressure in bars
Tc=283.1 //temperature in kelvin
a=(0.42748*R*R*(Tc^2.5))/((Pc*10^5)*(T^0.5))//
    Redlich-Kwong equation
b=0.0867*R*Tc/(Pc*(10^5))//Redlich-Kwong equation
mprintf("a=%fPam^6/mol square\n",a*10^-6)//ans may
    vary due to roundoff error
mprintf("b=%fm^3/mol\n",b*10^-3)//ans may vary due
    to roundoff error
P=(R*T/(v1-b))-(a/(v1*(v1+b))) //pressure by Redlich
    -Kwong euation
mprintf("P=%fMPa",P*10^-6)//ans may vary due to
    roundoff error
```

Scilab code Exa 3.3 Determine volume of cylinder for storage

```
clc
Pc=46.41*10^5 //pressure for methane in Pascals
Tc=190.7 //temperature for methane in kelvin
P=60*10^6 //methane pressure in pascals
T=300 //methane temperature in kelvins
Pr=P/Pc
mprintf("Pr=%f\n",Pr)//ans may vary due to roundoff
    error
Tr=T/Tc
mprintf("Tr=%f\n",Tr)//ans may vary due to roundoff
    error
```

```
Z=1.34
R=8.314*10^3
v=Z*R*T/P //volume of cylinder for storage
mprintf("v=%fmetre-cube/kmol",v)//ans varies due to
    roundoff error
```

Scilab code Exa 3.4 Determine pressure exerted by ammonia

```
clc
Tc=405.5 //temperature in kelvin
Pc=112.77 //pressure in bar
T=473 //temperature in kelvin
Tr=T/Tc
mprintf("Tr=%f\n",Tr)//ans vary due to roundoff
    error
Pr=1.9 //obtained from compressibility chart in the
    book with given conditions
P=Pc*Pr
mprintf("P=%fMPa",P/10)//ans vary due to roundoff
    error
```

Scilab code Exa 3.5 Rework previous example using pseudo reduced volume

```
clc
Tc=405.5 //temperature in kelvin
Pc=112.77 //pressure in bar
T=473 //temperature in kelvin
Tr=T/Tc //reduced temperature
mprintf("Tr=%f\n",Tr)//ans vary due to roundoff
    error
V=0.1
n=10^3
R=8.314
```

```
vr=Pc*10^5*(V/n)/(R*Tc)//pseudo-reduced volume using compressibility chart
mprintf("vr=%f\n",vr)//ans may vary due to roundoff error
Pr=1.9
P=Pr*Pc//equation for reduced pressure
mprintf("P=%fMPa",P/10)//ans vary due to roundoff error
```

Scilab code Exa 3.6 Determine temperature of ethane in cylinder

```
clc
M=30 //molar mass for ethane in kg/kmol
Tc=305.43 //temperature in kelvin
Pc=4.884 //pressure in MPa
P=70 //pressure in bar
Pr=(P*10^5)/(Pc*10^6)
mprintf("Pr=%f\n",Pr)//ans vary due to roundoff error
M1=7 //mass of ethane present in kg
Moles=(M1/M)*1000 //moles of ethane
mprintf("Moles of ethane=%fmol\n",Moles)
V=0.1 //volume of ethane in metre-cube
v=V/Moles
R=8.314
vr=Pc*10^6*v/(R*Tc)
mprintf("vr=%f\n",vr)//ans may vary due to roundoff error
Tr=1.4
T=Tr*Tc
mprintf("T=%f K",T)//ans may vary due to roundoff error
```

Scilab code Exa 3.10 Using Molier diagram detremine final temperature and change i

```
clc
//Ex 3_7,3_8,3_9 and 3_10 use Molier Diagram
h1=3275
h2=2725
deltah=h2-h1
mprintf("deltah=%fkJ/kg",deltah)
```

Scilab code Exa 3.11 Determine 1saturation pressure and latent heat of vaporisatio

```
clc
T=200//temperature in degree celsius
P=15.549 //pressure in bars
hf=852.37
hg=2790.9
hfg=hg-hf
mprintf("Saturation pressure=%f bar\n",P)
mprintf("Latent heat of vaporisation=%f kJ/kg\n",hfg
   )
vg=0.1272 //in metre-cube/kg
ug=(hg*10^3)-(P*10^5*vg)
mprintf("ug=%fkJ/kg",ug/1000)//ans may vary due to
   roundoff error
```

Scilab code Exa 3.12 Calculate specific volume enthalpy and internal energy

```
clc
X=0.85
vg=0.8854 //in metre-cube/kg
vf=0.001060 //in metre-cube/kg
hf=504.7 //in kJ/kg
hg=2706.3 //in kJ/kg
```

```
v=(X*vg)+(1-X)*vf
mprintf("v=%f metre-cube/kg\n",v)//ans may vary due
   to roundoff error
h=(X*hg)+(1-X)*hf
mprintf("h=%f kJ/kg\n",h)
P=2 //pressure in bar
u=(h*10^3)-(P*10^5*v)
mprintf("u=%fkJ/kg",u/1000)//ans varies due to
   roundoff error
```

Scilab code Exa 3.13 `Estimate specific volume and specific enthalpy`

```
clc
P1=30 //pressure in bar
P2=35 //pressure in bar
P3=32 //pressure in bar
vg1=0.06663 //at P1
vg2=0.05703 //at P2
hg1=2802.3 //at P1
hg2=2802 //at P2
vg=vg1+((vg2-vg1)*(P3-P1)/(P2-P1))
hg=hg1+((hg2-hg1)*(P3-P1)/(P2-P1))
mprintf("vg=%f metre-cube/kg\n",vg)
mprintf("hg=%f kJ/kg\n",hg)
```

Scilab code Exa 3.14 `Determine the state of steam`

```
clc
hf=504.7
hg=2706.3
h=2600
X=(h-hf)/(hg-hf)//from relation h=Xhg+(1-X)hf
```

```
mprintf("X=%f",X)//ans may vary due to roundoff
    error
```

Scilab code Exa 3.15 Estimate specific volume and specific enthalpy

```
clc
P1=24
P2=26
T1=300
T2=400
v1=0.10336 //at P1 and T1
v2=0.09483 //at P2 and T1
v3=0.12522 //at P1 and T2
v4=0.11526 //at P2 and T2
h1=3013.4
h2=3007.4
h3=3242.3
h4=3239
P3=25
h5=h1+(((h2-h1)*(P3-P1))/(P2-P1))//interpolation at
    T=300
v5=v1+(((v2-v1)*(P3-P1))/(P2-P1))//interpolation at
    T=300
h6=h3+(((h4-h3)*(P3-P1))/(P2-P1))//interpolation at
    T=400
v6=v3+(((v4-v3)*(P3-P1))/(P2-P1))//interpolation at
    T=400
T3=350
h7=h5+(((h6-h5)*(T3-T1))/(T2-T1))//interpolation at
    T=350
v7=v5+(((v6-v5)*(T3-T1))/(T2-T1))//interpolation at
    T=350
mprintf("v=%fmetre-cube/kg\n",v7)//ans may vary due
    to roundoff error
mprintf("h=%fkJ/kg\n",h7)//ans may vary due to
```

```
roundoff error
```

Scilab code Exa 3.17 Determine proportions by volume of liquid and vapor

```
clc
vc=0.00317
vf=0.0010434
vg=1.694
X=(vc-vf)/(vg-vf)
mprintf("X=%f\n",X)
mprintf("volume of liquid=%fmetre-cube\n",(1-X)*vf)
mprintf("Volume of vapor=%fmetre-cube\n",X*vg)
mprintf("Ratio of liquid to vapor by volume=%f\n",((1-X)*vf)/(X*vg))//ans may vary due to roundoff error
```

Chapter 5

First law of thermodynamics

Scilab code Exa 5.1 Determine temperature of steama and quality of steam and masse

```
clc
v1=0.8854 //in metre-cube/kg
V=0.1 //in metre-cube
m=V/v1 //total mass
mprintf("m=%fkg\n",m)//ans vary due to roundoff error
v2=v1
vf=0.001053 //in metre-cube/kg
vg=1.159 //in metre-cube/kg
T=111.37 //in degree celsius
X2=(v2-vf)/(vg-vf)//quality of steam
mprintf("X2=%f\n",X2)//ans vary due to roundoff error
mvapor=X2*m
mprintf("Mass of vapor=%fkg\n",mvapor)//ans may vary due to roundoff error
mliquid=m-mvapor
mprintf("Mass of liquid=%fkg",mliquid)//ans may vary due to roundoff error
```

Scilab code Exa 5.2 Determine work done on helium and final pressure

```
clc
P1=100 //pressure in kPa
V1=1 //volume in metre-cube
T1=20 //temperature in celsius
R=8.314*10^3
T2=60 //temperature in celsius
N=(P1*10^3*V1)/(R*(T1+273.15))//conversion of celsius to kelvin
mprintf("N=%fkmol\n",N)//ans ma vary due to roundoff error
Cv=12.4717 //in kJ/kmolK
deltaT=T2-T1
deltaU=N*Cv*deltaT
mprintf("DeltaU=%fkJ\n",deltaU)//ans vary due to roundoff error
W=-deltaU
mprintf("w=%fkJ\n",W)//ans vary due to roundoff error
P2=P1*(T2+273.15)/(T1+273.15)//conversion of degree to kelvin
mprintf("P2=%fkPa",P2)//ans in the textbook is wrong
```

Scilab code Exa 5.3 Calculate amount of heat interaction and work done by system

```
clc
hf=417.54 //in kJ/kg
hg=2675.4 //in kJ/kg
vf=0.0010434 //in metre-cube/kg
vg=1.694 //in metre-cube/kg
P=100 //pressure in kPa
```

```
W=P*10^3*(vg-vf)
mprintf("W=%fkJ\n",W*10^-3)//ans vary due to
   roundoff error
q=hg-hf
mprintf("q=%fkJ\n",q)
```

Scilab code Exa 5.4 Calculate work done by ice and amountof energy transfered as h

```
clc
dw=999.8 //density of water in kg/metre-cube
dice=916.23 //density of ice in kg/metre-cube
P=100 //pressure in kPa
vw=1/dw
mprintf("vw=%fmetre-cube/kg\n",vw)//ans vary due to
   roundoff error
vi=1/dice
mprintf("vi=%fmetre-cube/kg\n",vi)
W=P*10^3*(vw-vi)
mprintf("W=%fJ\n",W)//ans may vary due to roundoff
   error
deltaU=334.98 //in kJ
q=deltaU+(W*10^-3)
mprintf("q=%fkJ\n",q)//ans may vary due to roundoff
   error
```

Scilab code Exa 5.5 Calculate work done by steam and energy transferred as heat

```
clc
hf=640.12 //in kJ/kg
hg=2747.5 //in kJ/kg
X1=0.75
h1=(X1*hg)+(1-X1)*hf
```

```
mprintf("h1=%fkJ/kg\n",h1)//ans vary due to roundoff
    error
h2=2855.1 //in kJ/kg
q=h2-h1
mprintf("q=%fkJ/kg\n",q)//ans vary due to roundoff
   error
vf=0.0010928 //in metre-cube/kg
vg=0.3747 //in metre-cube/kg
v1=(X1*vg)+(1-X1)*vf
mprintf("v1=%fmetre-cube/kg\n",v1)//ans vary due to
   roundoff error
P=5*10^5
v2=0.425 //in metre-cub/kg
W=P*(v2-v1)
mprintf("W=%fkJ/kg\n",W*10^-3)//ans vary due to
   roundof error
```

Scilab code Exa 5.6 Calculate heat and work interactions associated with compressi

```
clc
R=8.314
T=300
a=422.546
b=0.0373
v1=30
v2=5
W=integrate('((R*T)/(v-b))-(a/(v.^2))','v',v1,v2)
mprintf("W=%fkJ/kmol\n",W)//ans may vary due to
   roundoff error
deltaU=a*(1/v1-1/v2)
mprintf("U2-U1=%fkJ/kmol\n",deltaU)//ans vary due to
    roundoff error
Q=deltaU+W
mprintf("Q=%fkJ/kmol\n",Q)//ans vary due to roundoff
    error
```

Scilab code Exa 5.7 Calculate final temperature adnm compression ratio and work do

```
clc
T1=300 //temperature in kelvin
P1=100 //pressure in kPa
P2=2 //pressure in MPa
gama=1.4 //Cp/Cv ratio
T2=T1*(((P2*10^6)/(P1*10^3))^((gama-1)/gama))
mprintf("T2=%fK\n",T2)//ans vary due to roundoff
    error
Cr=(T1*P2*10^6)/(P1*10^3*T2)
mprintf("Compression ratio=%f\n",Cr)//ans vary due
    to roundoff error
R=8.314
W=R*(T1-T2)/(gama-1)
mprintf("W=%fkJ/mol",W/1000)//ans vary due to
    roundoff error
```

Scilab code Exa 5.8 Determine final condition of steam and work done

```
clc
h1=3456.2//in kJ/kg
v1=0.11608//in metre-cube
P1=3//in MPa
u1=(h1*10^3)-(P1*10^6*v1)
mprintf("u1=%fkJ/kg\n",u1/1000)
P2=100//in kPa
sf=1.3027//in kJ/kg K
sg=7.3598//in kJ/kg K
s2=7.2345//in kJ/kg K
s1=s2//isentropic process
```

```
X2=(s1-sf)/(sg-sf)//entropy equation using quality factor
mprintf("X2=%f\n",X2)//ans vary due to roundoff error
hg=2675.4//in kJ/kg
hf=417.54//in kJ/kg
vg=1.694//in metre-cube/kg
vf=0.0010434//in metre-cube/kg
h2=(hg*X2)+(1-X2)*hf//enthalpy equation using quality factor
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff error
v2=(vg*X2)+(1-X2)*vf//specific volume eqaution using quality factor
mprintf("v2=%fmetre-cube/kg\n",v2)//ans vary due to roundoff error
u2=(h2*10^3)-(P2*10^3*v2)//first law of thermodynamics
mprintf("u2=%fkJ/kg\n",u2/1000)//ans vary due to roundoff error
W=u1-u2//first law of thermodynamics
mprintf("W=%fkJ/kg",W/1000)//ans vary due to roundoff errror
```

Scilab code Exa 5.9 Determine work done on gas and change in internal energy and f

```
clc
P1=100*10^3
P2=10^6
gama=1.4
T1=300 //temperature in kelvin
T2=T1*((P2/P1)^((gama-1)/gama))
mprintf("T2=%fK\n",T2)//ans may vary due to roundoff error
R=8.314
```

```
W=(R*(T1-T2))/(gama-1)
mprintf("W=%fJ/mol",W)//ans vary due to roundoff
   error
```

Scilab code Exa 5.10 Determine pressure temperature at end of compression Work don

```
clc
P1=100*10^3
v1=1
v2=1/16
n=1.25
T1=300
P2=P1*((v1/v2)^n)
mprintf("P2=%fMPa\n",P2/(10^6))
T2=(T1*P2*v2)/(P1*v1)
mprintf("T2=%fK\n",T2)
R=8.314
W=(R*(T1-T2))/(n-1)
mprintf("W=%fkJ/mol\n",W/1000)
gama=1.4
q=((R*(T2-T1))/(gama-1))+W
mprintf("q=%fkJ/mol",q/1000)
```

Scilab code Exa 5.11 Determine pressure and temperature after equilibrium

```
clc
P1=200//pressure in kPa
V1=1//volume in metre-cube
R=8.314//universal gas constant
T1=127 //temperature in degree celsius
NHe=(P1*10^3*V1)/(R*(T1+273))//ideal gas law
mprintf("NHe=%fmol\n",NHe)//ans vary due to roundoff
    error
```

```
P2=400 //pressure in kPa
V2=1//volume in metre-cube
T2=227 //temperature in degree celsius
NN2=(P2*10^3*V2)/(R*(T2+273))//ideal gas law
mprintf("NN2=%fmol\n",NN2)//ans vary due to roundoff
    error
CvHe=1.5*R
CvN2=2.5*R
Tf=((NHe*CvHe*(T1+273))+(NN2*CvN2*(T2+273)))/((NN2*
   CvN2)+(NHe*CvHe))//temperature in kelvin from
   linear equation
mprintf("Tf=%fK\n",Tf)//ans vary due to roundoff
   error
Vf=2//volume in metre-cube
Pf=((NHe+NN2)*R*Tf)/Vf//ideal gas law
mprintf("Pf=%fkPa",Pf/1000)//ans vary due to
   roundoff error
```

Scilab code Exa 5.12 Determine final temperature and pressue of water in tank

```
clc
v1=0.0011145
V=0.05
mliquid=V/v1
mprintf("Mass of liquid=%fkg\n",mliquid)//ans may
   vary due to roundoff error
h1=719.12
P1=0.792*10^3
u1=h1-(P1*v1)
mprintf("u1=%fkJ/kg\n",u1)//ans may vary due to
   roundoff error
v2=1/mliquid
mprintf("v2=%fmetre-cube/kg\n",v2)//ans may vary due
    to roundoff error
u2=u1
```

```
T=147.73 //temperature in Kelvin
vf=1.088*10^-3
hf=622.4
vg=0.41845
hg=2742.55
X2=(v2-vf)/(vg-vf)
mprintf("X2=%f\n",X2)//ans vary due to roundoff
    error
h2=(X2*hg)+(1-X2)*hf
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff
    error
P2=4.5*10^5
u2=(h2*10^3)-(P2*v2)
mprintf("u2=%fkJ/kg\n",u2/1000)//ans may vary due to
    roundoff error
```

Scilab code Exa 5.13 Compare work required for heating by constant volume followed

```
clc
Pa=500*10^3
T1=300 //temperature in kelvin
T2=300
P1=100*10^3
Ta=(Pa*T1)/P1
mprintf("Ta=%fK\n",Ta)
Cv=20.93
Cp=29.302
ua=Ta*Cv
u1=T1*Cv
mprintf("ua-u1=%fkJ/mol\n",(ua-u1)/1000)//ans vary
    due to roundoff error
q1a=ua-u1
qa2=Cp*(T2-Ta)
q=qa2
mprintf("qa2=%fkJ/mol\n",qa2/1000)//ans vary due to
```

```
roundoff error
deltau=Cv*(T2-Ta)
mprintf("u2−ua=%fkJ/mol\n",deltau/1000)//ans vary due to roundoff error
W=q-deltau
mprintf("W=%fkJ/mol\n",W/1000)//aans vary due to roundoff error
R=8.314
P1=100
P2=500
T=T1
W=R*T*log(P1/P2)
mprintf("W=%fkJ/mol\n",W/1000)//ans vary due to roundoff error
gama=1.4
Tb=T1*((P2/P1)^(gama-1))
mprintf("Tb=%fK\n",Tb)//ans vary due to roundoff error
ub=Cv*Tb
u1=Cv*T1
deltau=ub-u1
mprintf("ub−u1=%fkJ/mol\n",deltau/1000)//ans vary due to roundoff error
W=-deltau
mprintf("Total Work done=%fkJ/mol\n",W/1000)//ans vary due to roundoff error
```

Scilab code Exa 5.14 Determine steam temperature in cylinder and energy transfer a

```
clc
P1=2//pressure in bar
vg=0.8854//in metre−cube/kg
Pa=1//pressure in bar
K=250//spring constant in kN/m
A=0.05//cross−sectional area in metre−square
```

```
h1=2706.3//in kJ/kg
v1=vg
V1=vg/10
P2=4 //pressure in bar
V0=V1-(((((P1-Pa)*10^5)*(A*A))/(K*10^3))//from force
    balance equation
mprintf("V0=%fmetre-cube\n",V0)//ans vary due to
    roundoff error
V2=((((P2-Pa)*10^5)*(A*A))/(K*10^3))+V0//from force
    balance equation
mprintf("V2=%fmeter-cube\n",V2)//ans may vary due to
     roundoff error
Tc=500//temperature in degree celsius
Td=600//temperature in degree celsius
vc=0.8892//in metre-cube/kg
vd=1.0054//in metre-cube/kg
v2=V2*10
T=Tc+(((Td-Tc)/(vd-vc))*(v2-vc))//by interpolation
mprintf("T=%fdegree-celsius\n",T)//ans vary due to
    roundoff error
h2=3515.2//in kJ/kg
u2=(h2*10^3)-(P2*10^5*v2)//first law of
    thermodynamics
mprintf("u2=%fkJ/kg\n",u2/1000)//ans vary due to
    roundoff error
W=(((P1+P2)*10^5)*(V2-V1))/2//from P-V diagram in
    textbook
mprintf("W=%fkJ\n",W/1000)//ans vary due to roundoff
     error
u1=(h1*10^3)-(P1*10^5*v1)//first law of
    thermodynamics
deltaU=u2-u1
Q=(deltaU/10^4)+(W/1000)//first law of
    thermodynamics
mprintf("Q=%fkJ",Q)//ans vary due to roundoff error
```

Chapter 6

First Law analysis of processes

Scilab code Exa 6.1 Estimate power output of turbine

```
clc
mi=1 //in kg/second
me=mi
m=mi
Q=-10 //in kJ/s
hi=3276.6 //in kJ/kg
vi=80 //in metre/second
Zi=10 //in metres
hg=2584.8
hf=191.83
Xe=0.95
he=(hg*Xe)+(1-Xe)*hf
mprintf("he=%fkJ/kg\n",he)//ans vary due to roundoff error
g=9.81
Ze=3
ve=150 //in metre/second
Ws=(Q*10^3)-((((he*10^3)+(ve^2/2)+(g*Ze))-((hi*10^3)+(vi^2/2)+(g*Zi)))*m)//from the first law of thermodynamics
mprintf("Ws=%fkW\n",Ws/1000)//ans vary due to
```

```
roundoff error
```

Scilab code Exa 6.2 Determine exit velocity of steam

```
clc
he=2609.9 //in kJ/kg
hi=3072.1 //in kJ/kg
ve=sqrt(2*(hi-he)*10^3)
mprintf("ve=%fm/s",ve)//ans vary due to roundoff
    error
```

Scilab code Exa 6.3 Determine quality of steam in mains

```
clc
hf=762.61 //in kJ/kg
hg=2776.2 //in kJ/kg
he=2696.12 //in kJ/kg
hi=he//isenthalpic process
X=(hi-hf)/(hg-hf)
mprintf("X=%f",X)//ans vary due to roundoff error
```

Scilab code Exa 6.4 Determine throttling pressure of referigerant and state of ref

```
clc
h3=75.1134 //in kJ/kg
hf=12.5201 //in kJ/kg
hg=176.1723 //in kJ/kg
X=(h3-hf)/(hg-hf)
mprintf("X=%f\n",X)//ans vary due to roundoff error
```

Scilab code Exa 6.5 Determine minimum quality of wet steam at 20 bar

```
clc
he=2686.16 //in kJ/kg
hf=908.59 //in kJ/kg
hg=2797.2 //in kJ/kg
X=(he-hf)/(hg-hf)
mprintf("X=%f",X)//ans vary due to roundoff error
```

Scilab code Exa 6.6 Determine the quality of wet steam

```
clc
h3=2686.16 //in kJ/kg
hf=1008.4 //in kJ/kg
hg=2802.3 //in kJ/kg
h2=h3
X2=(h2-hf)/(hg-hf)
mprintf("X2=%f\n",X2)//ans vary due to roundoff error
m1=1000 //mass of wet steam in grams
mc=30 //mass of condensate in grams
X1=X2*(1-(mc/m1))
mprintf("X1=%f",X1)//ans may vary due to roundoff error
```

Scilab code Exa 6.7 Determine temperature of air in cylinder at end of filling and

```
clc
T=300 //temperature in Kelvin
```

```
gama=1.4
Tf=gama*T
mprintf("Tf=%iK\n",Tf)
P=50*10^5 //pressure in Pascals
V=0.1 //volume in metre-cube
R=8.314
N=(P*V)/(R*Tf)
mprintf("N=%f\n",N)//ans vary due to roundoff error
molmass=28.97 //molar mass of air
mprintf("Mass of air filled in cylinder=%fkg",N*
    molmass*10^-3)//ans vary due to roundoff error
```

Scilab code Exa 6.8 Determine temperature of steam in tank at end of filling

```
clc
P=20 //pressure in bar
T1=600
h=3689.2 //in kJ/kg for T1
v=0.1995 //in metre-cube/kg for T1
u1=((h*10^3)-((P*10^5)*v))/1000 //conversion into kJ
    /kg
mprintf("u=%fkJ/kg\n",u1)
T2=700
h=3916.5 //in kJ/kg for T2
v=0.2232 //in metre-cube/kg for T2
u2=((h*10^3)-((P*10^5)*v))/1000 //conversion into kJ
    /kg
mprintf("u=%fkJ/kg\n",u2)
uf=3467.3 //in kJ/kg
T=T1+(((T2-T1)/(u2-u1))*(uf-u1))//by interpolation
mprintf("T=%fcelsius",T)//ans vary due to roundoff
    error
```

Scilab code Exa 6.9 Estimate mass of steam that enters the tank

```
clc
P1=10^6 //pressure in pascal
P2=4*10^6 //pressure in pascal
h0=2776.2 //in kJ/kg
v0=0.1943 //in metre-cube/kg
hi=3215.7 //in kJ/kg
u0=h0-(v0*(P1/1000))
mprintf("u0=%fkJ/kg\n",u0)//ans vary due to roundoff error
V=2 //in metre-cube
m0=V/v0
mi=m0
mprintf("mo=%fkg\n",m0)//ans vary due to roundoff error
Tf=425 //final temperature assumed in celsius
hf=3273.03 //in kJ/kg
vf=0.0766 //in metre-cube/kg
uf=hf-(vf*(P2/1000))
mprintf("uf=%fkJ/kg\n",uf)//ans vary due to roundoff error
mf=V/vf
mprintf("mf=%fkg\n",mf)//ans vary due to roundoff error
mprintf("Final temperature=%iCelsius\n",Tf)//since mf(hi-uf)=m0(hi-u0) at this temperature
mprintf("Mass of steam that enters tank=%fkg",mf-mi) //ans vary due to roundoff error
```

Scilab code Exa 6.10 Determien presure of gas inside tank when pressure reaches 10

```
clc
//after derivation in the book
T=600
```

```
Tf=(7*T)/6
mprintf("Tf=%iK",Tf)
```

Scilab code Exa 6.11 Determine temperature of air left in cylinder and mass of air

```
clc
Pf=30*10^5 //pressure in pascal
P0=50*10^5 //pressure in pascal
T0=300 //temperature in Kelvin
gama=1.4
Tf=T0*((Pf/P0)^((gama-1)/gama))
mprintf("Tf=%fK\n",Tf)//ans vary due to roundoff error
V=0.1 //volumme in metre-cube
M=28.97*10^-3 //molar mass of air
R=8.314
mprintf("m0-mf=%fkg",(M*V/R)*((P0/T0)-(Pf/Tf)))//ans vary due to roundoff error
```

Scilab code Exa 6.12 Estimate final pressure in the tank

```
clc
m1=1000 //mass of wet steam in kg
vg1=0.06663
vf1=0.0012163
V=(2*m1)/((1/vf1)+(1/vg1))
P1=3*10^5
mprintf("V=%fmetre-cube\n",V)//ans vary due to roundoff error\n
mf=V/(2*vf1)
mg=V/(2*vg1)
mprintf("mass of liquid=%fkg\n",mf)//ans vary due to roundoff erorr
```

```
mprintf("mass of steam=%fkg\n",mg)//ans vary due to roundoff error
m2=900 //mass in kg
X1=mg/m1
mprintf("X1=%f\n",X1)//ans vary due to roundoff error
hg1=2802.3
hf1=1008.4
h1=(X1*hg1)+((1-X1)*hf1)
mprintf("h1=%fkJ/kg\n",h1)//ans vary due to roundoff error
u1=(h1*10^3)-(P1*(V/m1))
mprintf("u1=%fkJ/kg\n",u1/1000)//ans vary due to roundoff error
P2=15*10^5 //pressure assumed
vg2=0.1317
vf2=0.0011538
v2=V/m2
mprintf("v2=%fmetre-cube/kg\n",v2)//ans vary due to roundoff error
X=(v2-vf2)/(vg2-vf2)
mprintf("X=%f\n",X)//ans vary due to roundoff error
hg2=2789.8
hf2=844.67
h2=(X*hg2)+((1-X)*hf2)
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff error
u2=(h2*10^3)-(P2*v2)
mprintf("u2=%fkJ/kg\n",u2/1000)//ans vary due to roundoff error
he=(hg1+hg2)/2
LHS=(m1-m2)*he
RHS=(m1*u1)-(m2*u2)
mprintf("RHS=%fkJ\n",RHS/1000)//ans in textbook is wrong
mprintf("LHS=%fkJ\n",LHS)//ans vary due to roundoff error
P3=14*10^5 //pressure assumed
```

```
hg3=2787.8
hf3=830.08
vg3=0.1407
vf3=0.0011489
X=(v2-vf3)/(vg3-vf3)
mprintf("X=%f\n",X)//ans vary due to roundoff error
h2=(X*hg3)+((1-X)*hf3)
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff error
u2=(h2*10^3)-(P3*v2)
mprintf("u2=%fkJ/kg\n",u2/1000)//ans vary due to roundoff error
he=(hg1+hg3)/2
LHS=(m1-m2)*he
RHS=(m1*u1)-(m2*u2)
mprintf("LHS=%fkJ\n",LHS)//ans vary due to roundoff error
mprintf("RHS=%fkJ\n",RHS/1000)//ans in the textbook is wrong
P4=13.8*10^5 //pressure assumed
hg4=2787.32
hf4=827
vg4=0.1428
vf4=0.0011478
X=(v2-vf4)/(vg4-vf4)
mprintf("X=%f\n",X)//ans vary due to roundoff error
h2=(X*hg4)+((1-X)*hf4)
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff error
u2=(h2*10^3)-(P4*v2)//ans may vary due to roundoff error
mprintf("u2=%fkJ/kg\n",u2/1000)//ans vary due to roundoff error
he=(hg1+hg4)/2
LHS=(m1-m2)*he
RHS=(m1*u1)-(m2*u2)
mprintf("LHS=%fkJ\n",LHS)//ans vary due to roundoff error
```

```
mprintf("RHS=%fkJ\n",RHS/1000)//ans in textbook is wrong
mprintf("Final pressure=%fbar",P4*10^-5)//since LHS and RHS differ by 0.2 percent
```

Scilab code Exa 6.13 Determine soichiometric air fuel ratio for comustion of C5H12

```
clc
O2=8 //moles of oxygen in combustion equation of C5H12
N2=8*3.7619 //moles of nitrogen in combustion equation of C5H12
C5H12=1 //moles of C5H12 in combustion equation of C5H12
mprintf("Air-fuel ratio=%fmol air/mol fuel\n",(O2+N2)/C5H12)//air-fuel ratio for combustion of C5H12
molmass1=72 //molar mass of C5H12
molmass2=28.97 //molar mass of air
mprintf("Air-fuel ratio=%fkg air/kg fuel\n",((O2+N2)*molmass2)/(molmass1*C5H12))//ans vary due to roundoff error
a=5//moles of CO2(product side) in combustion equation of C5H12 with 150 percent theoretical air
b=6//moles of H2O(product side) in combustion equation of C5H12 with 150 percent theoretical air
c=45.14//moles of N2(product side) in combustion equation of C5H12 with 150 percent theoretical air
d=4//moles of O2(product side) in combustion equation of C5H12 with 150 percent theoretical air
Totalmol=a+b+c+d
CO2=a/Totalmol
```

```
mprintf("CO2=%f\n",CO2)//ans vary due to roundoff
    error
H2O=b/Totalmol
mprintf("H2O=%f\n",H2O)//ans vary due to roundoff
    error
N2=c/Totalmol
mprintf("N2=%f\n",N2)//ans vary due to roundoff
    error
O2=d/Totalmol
mprintf("O2=%f",O2)//ans vary due to roundoff error
```

Scilab code Exa 6.14 Calculate product composition assuming complete combustion of

```
clc
O2=0.19 //moles of O2
N2a=0.19*3.7619 //moles of N2
CO=0.26 //moles of CO in fuel
H2=0.12 //moles of H2 in fuel
CO2=0.07 //moles of CO2 in fuel
N2b=0.55 //moles of N2 in fuel
mprintf("Theoretical ari-fuel ratio=%f mole air/mole
     fuel\n",(O2+N2a)/(CO+H2+CO2+N2b))//ans vary due
    to roundoff error
CO2=0.33 //moles in product after combustion
H2O=0.12//moles in product after combustion
O2=0.038//moles in product after combustion
N2=1.408//moles in product after combustion
//product analysis
sigmaNi=CO2+H2O+O2+N2
a=CO2/sigmaNi //for CO2
b=H2O/sigmaNi //for H2O
c=O2/sigmaNi //for O2
d=N2/sigmaNi //for N2
mprintf("yi=.\n%f\n%f\n%f\n%f",a,b,c,d)//ans may
    vary due to roundoff error
```

Scilab code Exa 6.15 Determine actual air fuel ratio for the combustion process an

```
clc
a=83.56 //moles of nitrogen in product
b=3.7619
y=a/b
mprintf("y=%f\n",y)//ans vary due to roundoff error
c=(9.27+2.31)//moles of carbon in product
d=5
x=c/d
mprintf("x=%f\n",x)//ans vary due to roundoff error
e=(12*x)
z=e/2
mprintf("z=%f\n",z)//ans vary due to roundoff error
t=(y+a)/x
mprintf("Actual air-fuel ratio is given by%f mol air
   /mol fuel\n",t)//ans vary due to roundoff error
s=38.095
mprintf("percent theoretical air=%f\n",(t/s)*100)//
   ans vary due to roundoff error
```

Scilab code Exa 6.16 Determine composition of fuel on mass basis and air fuel rati

```
clc
r=83.56 //moles of nitrogen in product
b=3.7619
z=r/b
mprintf("z=%f\n",z)//ans vary due to roundoff error
c=9.27 //moles of carbon in product
d=2.31 //moles of carbon in product
x=c+d
```

```
mprintf("x=%f\n",x)//ans vary due to roundoff error
e=4.86 //moles of nitrogen
a=(z-c-(d/2)-e)*2
mprintf("a=%f\n",a)//ans vary due to roundoff error
y=2*a
mprintf("y=%f\n",y)//ans vary due to roundoff error
g=12
carbon=(x*g)/((x*g)+y)
mprintf("carbon=%fpercent\n",carbon*100)//ans vary
    due to roundoff error
hydrogen=y/((x*g)+y)
mprintf("hydrogen=%fpercent\n",hydrogen*100)//ans
    vary due to roundoff error
h=28.97
s=((z+r)*h)/((x*g)+y)
mprintf("Air-fuel ratio=%fkg air/kg fuel\n",s)//ans
    vary due to roundoff error
O2=25.43
N2=95.665
t=((O2+N2)*h)/((x*g)+y)
mprintf("theoretical air-fuel ratio=%f kg air/kg
    fuel\n",t)//ans vary due to roundoff error
pert=(s/t)*100
mprintf("Percent theoretical air=%fpercent\n",pert)
    //ans vary due to roundoff error
mprintf("Percent deficit air=%fpercent\n",100-pert)
    //ans vary due to roundoff error
```

Scilab code Exa 6.17 Calculate standard heat for given reaction

```
clc
a=5//moles of solid carbon
b=6//moles of H2
deltaHf1=-146.5
deltaHf2=-393.8
```

```
deltaHf3=-242
deltaH=(a*deltaHf2)+(b*deltaHf3)-deltaHf1
mprintf("deltaH298=%fkJ",deltaH)
```

Scilab code Exa 6.18 Estimate standard heat for given reaction

```
clc
hg=2547.3 //in kJ/kg
hf=104.77 //in kJ/kg
deltaH=hg-hf
mass=18 //molar mass of water
moles=1000/mass //moles of water in kg
mprintf("DeltaH=%fkJ/kg=%fkJ/mol\n",deltaH,deltaH/moles)//ans vary due to roundoff error
deltaHst=-3274.5 //standard from Ex6_17.sce
deltaH=deltaHst+(6*(-deltaH/moles))
mprintf("deltaH298=%fkJ",deltaH)//ans vary due to roundoff error
```

Scilab code Exa 6.20 Estimate standard heat for given reaction

```
clc
CO2=52.32
H2O=38.49
C5H12=247
O2=33.62
e=5 //moles of CO2
g=6 //moles of H2O
h=8 //moles of O2
deltaCp=(e*CO2)+(g*H2O)-C5H12-(h*O2)
mprintf("deltaCp=%f\n",deltaCp)//ans vary due to roundoff error
deltaH298=-3274.5
```

```
t1=298
t2=800
deltaH800=deltaH298+(deltaCp*(10^-3)*(t2-t1))
mprintf("deltaH800=%fkJ",deltaH800)//ans vary due to roundoff error
```

Scilab code Exa 6.21 Obtain general expression for standard heat of reaction using

```
clc
m1=5
m2=6
m3=8
//values from appendix are used below given in book
deltaa=m1*19.8+m2*32.24-(-3.626)-m3*28.11
mprintf("deta a=%E\n",deltaa)//ans in the textbook is wrong
deltab=(m1*7.334+m2*0.1924-48.73-m3*(-3.68*10^-4))*10^-2
mprintf("deltab=%E\n",deltab)//ans vary due to roundoff error
deltac=((m1*-5.602)+m2*1.055-(-25.8)-m3*1.746)*10^-5
mprintf("deltac=%E\n",deltac)//ans vary due to roundoff error
deltad=(m1*1.715+(m2*-0.3596)-5.305-(m3*-1.065))*10^-8
mprintf("deltad=%E\n",deltad)//ans vary due to roundoff error
T=298
deltaH298=-3274.5*10^3
deltaH0=deltaH298-(deltaa*T)+((deltab/2)*(T*T))-((deltac/3)*(T*T*T))-((deltad/4)*(T*T*T*T))
mprintf("deltaH0=%EkJ\n",deltaH0/1000)//ans in the textbook is wrong
```

Scilab code Exa 6.22 Estimate adiabatic flame temperature that can be reached

```
clc
deltaHp=3274.5 //in kJ
a=5
b=6
c=2
d=37.619
CO2=62.75
H2O=52.96
O2=38.67
N2=37.13
e=((a*CO2)+(b*H2O)+(c*O2)+(d*N2))*10^-3
T1=298
T=(deltaHp+(e*T1))/e
mprintf("T=%fK",T)//ans vary due to roundoff error
```

Chapter 7

Second law of thermodynamics

Scilab code Exa 7.1 Determine max possinle efficiency of the heat engine operating

```
clc
T2=300 //temperature in Kelvin
T1=420 //temperature in Kelvin
Eta=1-(T2/T1)
mprintf("maximum possible efficiency=%f",Eta)//ans
    vary due to roundoff error
```

Scilab code Exa 7.2 The agreement upon claim made in book

```
clc
T2=300
T1=1400
Eta=1-(T2/T1)
mprintf("Eta=%f\n",Eta)//ans vary due to roundoff
    error
Q1=65 //in kJ/min
W=60 //in kJ/min
mprintf("efficiency claimed by inventor=%f",W/Q1)//
    ans vary due to roundoff error
```

Scilab code Exa 7.3 Estimate minimum power required to run referigearator

```
clc
TL=270
TH=300
COPR=TL/(TH-TL)
mprintf("COPR=%i\n",COPR)
QL=5*10^6 //in kJ/h
W=(QL/3600)/COPR
mprintf("W=%fkW",W)//ans vary due to roundoff error
```

Scilab code Exa 7.4 Calcuate COP of referigerator and work output

```
clc
TL=4.2
TH=305
COPR=TL/(TH-TL)
mprintf("COPR=%f\n",COPR)//ans vary due to roundoff
    error
QL=83.3
W=QL/COPR
mprintf("W=%fkJ",W)//ans vary due to roundoff error
```

Scilab code Exa 7.5 Estimate fraction of time for which compressor runs for same c

```
clc
TL=250
TH=291
COPR=TL/(TH-TL)
```

```
mprintf("COPR=%f\n",COPR)//ans vary due to roundoff error
QL=4*10^4
W=QL/COPR
mprintf("W=%fkJ/d\n",W)//ans vary due to roundoff error
CW=200 //compressor work in watts
mprintf("Fraction of time compressor runs=%f\n",W/((CW*3600*24)/1000))//ans vary due to roundoff error
TH=310
COPR=TL/(TH-TL)
mprintf("COPR=%f\n",COPR)//ans vary due to roundoff error
W=QL/COPR
mprintf("W=%fkJ/d\n",W)//ans vary due to roundoff error
mprintf("fraction of time the compressor runs=%f\n",W/((CW*3600*24)/1000))//ans vary due to roundoff error
```

Scilab code Exa 7.6 Determine 1energy removed as heat from cld body by referigerat

```
clc
TA=27+273 //temperature in kelvin
TL=0+273//temperature in kelvin
T1=150+273//temperature in kelvin
mprintf("QL/Q1=%f\n",(TL*(T1-TA))/(T1*(TA-TL)))//ans vary due to roundoff error
mprintf("(Q2+QH)/Q1=%f",(TA*(T1-TL))/(T1*(TA-TL)))//ans vary due to roundoff error
```

Scilab code Exa 7.7 Whaat will be del Q by delT if engine is reversible and work d

```
clc
Q1=50
Q2=Q1
T1=480
T2=300
mprintf("integral(dQ/T)=%fkJ/min K\n",(Q1/T1)-(Q2/T2
    ))
Eta=1-(T2/T1)
mprintf("Eta=%f\n",Eta)
W=Eta*Q1
mprintf("Eta*Q1=%fkJ/min\n",W)
Q2=Q1-W
mprintf("Q2=%fkJ/min",Q2)
```

Scilab code Exa 7.8 Determine heat interactons with other two reservoirs

```
clc
Q=[1 1;(1/4) (1/3)]//matrix for (A),(B) LHS
R=[1500;(2500/6)] //matrix for (A),(B),RHS
S=inv(Q)*R//solving equation A and B
Q2=S(1,1)
Q3=S(2,1)
mprintf("Q2=%fkJ\n",Q2)
mprintf("Q3=%ikJ\n",Q3)
```

Scilab code Exa 7.9 Estimate the entropy change of reservoir for the given conditi

```
clc
T=500 //temperature in Kelvin
W=250 //watts of motor
h=2*3600 //time of operation in seconds
Q=W*h
deltaS=Q/T
```

```
mprintf("deltaS=%fkJ/K",deltaS/1000)//ans in textbook is wrong
```

Scilab code Exa 7.10 Determine entropy change of air

```
clc
R=8.314
gama=1.4
Cv=R/(gama-1)
mprintf("Cv=%fJ/mol K\n",Cv)
T2=370
T1=300
deltas=Cv*log(T2/T1)
mprintf("delta s=%fJ/mol K",deltas)//ans vary due to roundoff error
```

Scilab code Exa 7.11 Calculate entropy change associated with fusion and vaporisat

```
clc
T1=273
T2=373
hsf=334.92
hfg=2256.94
mprintf("Ssf=%fkJ/kg K\n",hsf/T1)//ans vary due to roundoff error
mprintf("Sfg=%fkJ/kg K\n",hfg/T2)//ans vary due to roundoff error
```

Scilab code Exa 7.12 Estimate entropy change of steel and oil and system consistin

```
clc
m1=30 //mass of steel
m2=150 //mass of oil
Cp1=0.46 //steel
Cp2=2.5 //oil
T1=700 //steel
T2=300 //oil
T=((m1*Cp1*T1)+(m2*Cp2*T2))/((m1*Cp1)+(m2*Cp2))
mprintf("T=%fK\n",T)//ans vary due to roundoff error
deltaSsteel=integrate('m1*Cp1/T','T',T1,T)
mprintf("deltaSsteel=%fkJ/K\n",deltaSsteel)//ans
    vary due to roundoff error
deltaSoil=integrate('m2*Cp2/T','T',T2,T)
mprintf("deltaSoil=%fkJ/K\n",deltaSoil)//ans vary
    due to roundoff error
deltaSuni=deltaSsteel+deltaSoil
mprintf("deltaSuni=%fkJ/k",deltaSuni)//ans vary due
    to roundoff error
```

Scilab code Exa 7.13 Determine entropy change for given conditions

```
clc
P1=1
P2=2
T1=300
T2=500
R=8.314
Cp=(7*R)/2
deltas=(Cp*log(T2/T1))-(R*log(P2/P1))
mprintf("deltas=%fkJ/kmol K",deltas)//ans vary due
    to roundoff error
```

Scilab code Exa 7.14 Estimate change in entropy when partition is removed and gase

```
clc
YA=0.5//mole fraction of oxygen
YB=0.5//mole fraction of nitrogen
R=8.314//universal gas constant
deltasMix=-R*((YA*log(YA))+(YB*log(YB)))//molar entropy change associated with mixing of non identical gases
mprintf("deltasMix=%fper mol of mixture",deltasMix) //ans vary due to roundoff error
```

Scilab code Exa 7.15 Calculate change of entropy of universe associated with the p

```
clc
h1=2870.5
s1=7.5072
h2=504.7
s2=1.5301
deltassteam=s2-s1
deltaSsys=deltassteam
mprintf("deltassteam=%fkJ/kg\n",deltassteam)
q=h2-h1
Q=-q
mprintf("q=%fkJ\n",q)
Tsur=300
deltaSsur=Q/Tsur
mprintf("deltaSsur=%fkJ/K\n",deltaSsur)
deltaSuni=deltaSsys+deltaSsur
mprintf("deltaSsur=%fkJ/K",deltaSuni)
```

Scilab code Exa 7.16 Calculate work done by steam

```
clc
P1=1*10^6 //pressure in Pascal
```

```
h1=3052.1
v1=0.258
s1=7.1251
u1=h1-(P1*10^-3*v1)
mprintf("u1=%fkJ/kg\n",u1)//ans vary due to roundoff error
s2=s1
sf=1.3027
sg=7.3598
hf=417.54
hg=2675.4
vf=0.001043
vg=1.6940
X2=(s1-sf)/(sg-sf)
mprintf("X2=%f\n",X2)//ans vary due to roundoff error
h2=(hg*X2)+(1-X2)*hf
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff error
v2=(vg*X2)+(1-X2)*vf
mprintf("v2=%f metre-cube/kg\n",v2)//ans vary due to roundoff error
P2=100 //in kPa
u2=h2-(P2*v2)
mprintf("u2=%fkJ/kg\n",u2)//ans vary due to roundoff error
W=u1-u2
mprintf("W=%fkJ/kg",W)//ans vary due to roundoff error
```

Scilab code Exa 7.17 Determine rate of steam flow into turbine

```
clc
si=7.0248
sg=7.3598
```

```
sf=1.3027
Xe=(si-sf)/(sg-sf)
mprintf("Xe=%f\n",Xe)//ans vary due to roundoff
    error
hg=2675.4
hf=417.54
hi=2947.95
he=(hg*Xe)+(1-Xe)*hf
mprintf("he=%fkJ/kg\n",he)//ans vary due to roundoff
     error
Ws=20*10^3
m=-(Ws/(he-hi))
mprintf("m=%fkg/s",m)//ans vary due to roundoff
    error
```

Scilab code Exa 7.18 Check the feasibility of the device

```
clc
T1=350
Te1=450
Te2=250
P1=250
P2=100
R=8.314
Cp=(7*R)/2
me1=(Cp*log(Te1/T1))-(R*log(P2/P1))
me2=(Cp*log(Te2/T1))-(R*log(P2/P1))
mprintf("me1(se1-si)+me2(se2-si)=%fkJ/K",me1+me2)//
    ans vary due to roundoff error
```

Scilab code Exa 7.19 Determine the fraction of available energy lost

```
clc
```

```
T=298 //temperature in kelvin
T1=523 //temperature in kelvin
T2=773 //temperature in kelvin
mprintf("Fraction of available energy lost=%f",(T
   *((1/T1)-(1/T2)))/(1-(T/T2)))//ans vary due to
   roundoff error
```

Scilab code Exa 7.20 Determine maximum useful work per kg of steam

```
clc
h1=3025
v1=0.1255
s1=6.7696
h2=2875.4
v2=2.172
s2=7.8349
P1=20*10^5
P0=10^5
u1=h1-(P1*10^-3*v1)
u2=h2-(P0*10^-3*v2)
mprintf("u1=%fkJ/kg\n",u1)//ans vary due to roundoff
    error
mprintf("u2=%fkJ/kg\n",u2)//ans vary due to roundoff
    error
T0=298
mprintf("phi1-phi2=%fkJ/kg",(u1+(P0*v1*10^-3)-(T0*s1
   ))-(u2+(P0*v2*10^-3)-(T0*s2)))//ans in textbook
   is wrong
```

Scilab code Exa 7.21 Estimate loss in availability in heat exchange process

```
clc
h1=2775.8
```

```
h2=167.456
h3=104.77
h4=146.56
s1=7.5984
s2=0.5721
s3=0.367
s4=0.5049
m3=((h2-h1)*10^4)/(h3-h4)
mprintf("m3=%fkg/h\n",m3)//ans vary due to roundoff error
T0=300
delta=(-10^4*T0*(s2-s1))-(m3*T0*(s4-s3))
mprintf("Net change in availability=%fkJ",delta)//ans vary due to roundoff error
```

Chapter 8

Thermodynamic Relations

Scilab code Exa 8.1 Calculate work that can be obtained during expansion process

```
clc
P1=10 //pressure in bar
P2=1 //pressure in bar
h1=3052.1*10^3
v1=0.258
u1=h1-(P1*10^5*v1)
mprintf("u1=%fkJ/kg\n",u1/1000)//ans vary due to
   roundoff error
s1=7.1251 //in kJ/kg K
s2=s1
sg=7.3598
sf=1.3027
X2=(s2-sf)/(sg-sf)
mprintf("X2=%f\n",X2)//ans vary due to roundoff
   error
hg=2675.4
hf=417.54
h2=(X2*hg)+(1-X2)*hf
mprintf("h2=%fkJ/kg\n",h2)//ans vary due to roundoff
    error
vg=1.694
```

```
vf=0.0010434
v2=(X2*vg)+(1-X2)*vf
mprintf("v2=%fmetre-cube/kg\n",v2)//ans vary due to roundoff error
u2=(h2*10^3)-(P2*10^5*v2)
mprintf("u2=%fkJ/kg\n",u2/1000)//ans vary due to roundoff error
W=u1-u2
mprintf("W=%fkJ",W/1000)//ans vary due to roundoff error
```

Scilab code Exa 8.2 Minimum amount of work required for compresion process if surr

```
clc
R=8.314
P2=10^6//pressure in pascals
P1=100*10^3 //pressure in pascal
deltas=-R*log(P2/P1)
mprintf("s2-s1=%fkJ/kmol K\n",deltas)//ans vary due to roundoff error
T0=300
Wmin=-T0*deltas
mprintf("Wmin=%fkJ/kmol K",Wmin)//ans vary due to roundoff error
```

Scilab code Exa 8.3 Calculate power output from an adiabatic and reversible steam

```
clc
hi=2947.95
si=7.0248
se=si
sg=7.3598
sf=1.3027
```

```
Xe=(se-sf)/(sg-sf)
mprintf("Xe=%g\n",Xe)//ans vary due to roundoff error
hg=2675.4
hf=417.54
he=(Xe*hg)+(1-Xe)*hf
mprintf("he=%fkJ/kg\n",he)//ans vary due to roundoff error
W=hi-he
mprintf("W=%fkJ/s",W)//ans vary due to roundoff error
```

Scilab code Exa 8.4 Determine minimum power required to separate one kmol per h of

```
clc
R=8.314
T0=300
X1=0.79
X2=0.21
deltag=R*T0*((X1*log(X1))+(X2*log(X2)))
mprintf("ge-gi=%fJ/mol\n",deltag)//ans vary due to roundoff error
W=(-deltag*10^3)/3600
mprintf("W=%fW\n",W)//ans vary due to roundoff error
```

Scilab code Exa 8.9 Estimate the rise in temperature if liquid water at 25 celsius

```
clc
P1=0.1 //pressure in MPa
P2=10 //pressure in MPa
T=298
Cp=4.2
beeta=2.07*10^-4
```

```
vf=0.0010029
a=(T*vf*beeta)/(Cp*10^3)
mprintf("delT/delP=%E\n",a)//ans vary due to
    roundoff error
deltaP=P2-P1
deltaT=a*deltaP*10^6
mprintf("deltaT=%fcelsius",deltaT)//ans vary due to
    roundoff error
```

Scilab code Exa 8.10 Determine temperature at which water boils in pressure cooker

```
clc
P2=200
P1=101.325
hfg=2256.94*18
R=8.314
T1=373
T2=1/((1/T1)-((log(P2/P1))/(hfg/R)))//from the
    equation formed in book
mprintf("T2=%fcelsius",T2)//ans vary due to roundoff
     error
```

Scilab code Exa 8.11 Estimate latent heat of vaporisation of water at 120 celsius

```
clc
T1=100
T2=120
CPf=4.23
CPg=1.55
h1=2256.94
deltahfg=(CPg-CPf)*(T2-T1)
mprintf("hfg2-hfg1=%f\n",deltahfg)
hfg=h1+deltahfg
```

```
mprintf("hfg at 120 celsius=%fkJ/kg",hfg)
```

Scilab code Exa 8.12 `Calculate entropy change accompanying the process`

```
clc
hsf=334.92
T1=273.15
T2=263.15
CPf=4.186
CPs=2.093
a=(hsf/T1)+((CPf-CPs)*log(T2/T1))
mprintf("(hsf/T)2=%f\n",a)//ans vary due to roundoff
    error
deltas=-a
mprintf("deltas=%fkJ/kg K",deltas)//ans vary due to
   roundoff error
```

Chapter 9

Power And Referigeration Cycles

Scilab code Exa 9.1 Calculate1 thermal efficiency of power plant 2rate of steam pr

```
clc
h1=137.77
v1=0.0010052
P1=0.005 //presurre in MPa
P2=3 //pressure in MPa
WP=v1*(P2-P1)*10^6
mprintf("WP=%fkJ/kg\n",WP/1000)//ans vary due to roundoff error
EtaP=0.8
h2apostrophe=h1+((WP/1000)/EtaP)
mprintf("h2apostrophe=%fkJ/kg\n",h2apostrophe)//ans vary due to roundoff error
h4=2995.1
s4=6.5422
q1=h4-h2apostrophe
mprintf("q1=%fkJ/kg\n",q1)//ans vary due to roundoff error
s5=s4
sf=0.4763
```

```
hf=137.77
sg=8.396
hg=2561.6
X5=(s5-sf)/(sg-sf)
mprintf("X5=%f\n",X5)//ans vary due to roundoff error
h5=(X5*hg)+(1-X5)*hf
mprintf("h5=%fkJ/kg\n",h5)//ans vary due to roundoff error
EtaT=0.85
deltaH=EtaT*(h4-h5)
mprintf("h4-h5=%fkJ/kg\n",deltaH)//ans vary due to roundoff error
Eta=(deltaH-(h2apostrophe-h1))/(h4-h2apostrophe)
mprintf("Eta=%f\n",Eta)//ans vary due to roundoff error
Pout=deltaH-(h2apostrophe-h1)
mprintf("Power output per kg of steam=%fkJ\n",Pout)//ans vary due to roundoff error
mprintf("Steam production rate for 1 MW power output=%fkg/s\n",(10^3)/Pout)//ans vary due to roundoff error
mprintf("Thermal efficinecy of Rankine cycle=%f",(h4-h5-(WP/1000))/(h4-h2apostrophe))//ans vary due to roundoff error
```

Scilab code Exa 9.2 Calculate thermal efficiency of plant

```
clc
h4=3456.2
s4=7.2345
s5=s4
T5=265.8
h5=2989.59
EtaT=0.8
```

```
WT1=EtaT*(h4-h5)
mprintf("WT1actual=%fkJ/kg\n",WT1)//ans vary due to
    roundoff error
h5apostrophe=h4-WT1
mprintf("h5apostrophe=%fkJ/kg\n",h5apostrophe)//ans
    vary due to roundoff error
h6=3482.7
s6=8.0027
s7=s6
sg=8.396
sf=0.4763
X7=(s7-sf)/(sg-sf)
mprintf("X7=%f\n",X7)//ans vary due to roundoff
    error
hf=137.77
hg=2561.6
h7=(hg*X7)+(1-X7)*hf
mprintf("h7=%fkJ/kg\n",h7)//ans vary due to roundoff
     error
WT2=EtaT*(h6-h7)
mprintf("WT2=%fkJ/kg\n",WT2)//ans in the textbook is
     wrong
P2=3 //pressure in MPa
P1=0.005 //pressure in MPa
v=0.0010052
WP=v*(P2-P1)*10^6
mprintf("WP=%fkJ/kg\n",WP/1000)//ans vary due to
    roundoff error
EtaP=0.6
deltaH=(WP/1000)/EtaP
mprintf("h2apostrophe-h1=%fkJ/kg\n",deltaH)//ans
    vary due to roundoff error
h1=137.77
h2apostrophe=h1+deltaH
mprintf("h2apostrophe=%fkJ/kg\n",h2apostrophe)//ans
    vary due to roundoff error
Eta=(WT1+WT2-(WP/1000))/((h4-h2apostrophe)+(h6-
    h5apostrophe))
```

```
mprintf("Eta=%f",Eta)//ans vary due to roundoff error
```

Scilab code Exa 9.3 Calculate thermal eficiency of power plant

```
clc
hf1=191.83//in kJ/kg
hg1=2584.8//in kJ/kg
hf2=604.67//in kJ/kg
hg2=2737.6//in kJ/kg
sf1=0.6493//in kJ/kg K
sg1=8.1511//in kJ/kg K
sf2=1.7764//in kJ/kg K
sg2=6.8943//in kJ/kg K
h1=191.83//in kJ/kg
h2=h1
h3=604.67//in kJ/kg
h4=h3
h7=2995.7//in kJ/kg
s7=6.5422//in kJ/kg K
s8=s7
X8=(s8-sf2)/(sg2-sf2)//entropy equation using quality factor
mprintf("X8=%f\n",X8)//ans vary due to roundoff error
h8=(X8*hg2)+(1-X8)*hf2//enthalpy equation using quality factor
mprintf("h8=%fkJ/kg\n",h8)//ans vary due to roundoff error
s9=s7
X9=(s9-sf1)/(sg1-sf1)//entropy equation using quality factor
mprintf("X9=%f\n",X9)//ans vary due to roundoff error
h9=(X9*hg1)+(1-X9)*hf1//enthalpy equation using
```

```
quality factor
mprintf("h9=%fkJ/kg\n",h9)//ans vary due to roundoff error
Yapostrophe=(h3-h2)/(h8-h2)//fraction of steam extracted from the turbine for preheating
mprintf("Yapostrophe=%f\n",Yapostrophe)//ans vary due to roundoff error
Eta=((h7-h4)-((1-Yapostrophe)*(h9-h1)))/(h7-h4)//thermal efficiency of steam power plant
mprintf("Eta=%f",Eta)//ans vary due to roundoff error
```

Scilab code Exa 9.4 Calculate 1temperature and pressure of terminal points 2therma

```
clc
T1=300
P1=100 //pressure in kPa
ro=8 //=V1/V2
gama=1.4
T2=T1*ro^(gama-1)
mprintf("T2=%fK\n",T2)//ans vary due to roundoff error
P2=P1*ro^gama
mprintf("P2=%fkPa\n",P2)//ans vary due to roundoff error
deltau=1840
Cv=0.7176
T3=(deltau/Cv)+T2
mprintf("T3=%fK\n",T3)//ans vary due to roundoff error
P3=(P2*T3)/T2
mprintf("P3=%fkPa\n",P3)//ans vary due to roundoff error
a=1/8 //=V3/V4
T4=T3*a^(gama-1)
```

```
mprintf("T4=%fK\n",T4)//ans vary due to roundoff
   error
P4=P3*a^gama
mprintf("P4=%fkPa\n",P4)//ans vary due to roundoff
   error
Eta=1-(1/ro)^(gama-1)
mprintf("Thermal efficiency=%f\n",Eta)//ans vary due
    to roundoff error
q1=deltau
mprintf("Work done=%fkJ/kg\n",q1*Eta)//ans vary due
   to roundoff error
N=1
R=8.314*10^3
P1=28.97 //pressure in bar
V1=(N*R*T1)/(P1*10^5)
mprintf("V1=%fmetre-cube/kg\n",V1)//ans vary due to
   roundoff error
V2=V1/ro
mprintf("V2=%fmetre-cube/kg\n",V2)//ans vary due to
   roundoff error
Pm=(q1*Eta)/(V1-V2)
mprintf("Pm=%fkPa",Pm)//ans vary due to roundoff
   error
```

Scilab code Exa 9.5 Determine compression ratio and thermal efficiency and net wor

```
clc
P3=7 //pressure in MPa
P1=0.1//pressure in MPa
T1=310.15 //temperature in kelvin
T3=2973.15 //temperature in kelvin
ro=(P3*T1)/(T3*P1)
mprintf("ro=%f\n",ro)//ans vary due to roundoff
   error
gama=1.4
```

```
Eta=1-(1/ro)^(gama-1)
mprintf("Eta=%f\n",Eta)//ans vary due to roundoff error
T2=T1*(ro^(gama-1))
mprintf("T2=%fK\n",T2)//ans vary due to roundoff error
Cv=0.7176
q1=Cv*(T3-T2)
mprintf("q1=%fkJ/kg\n",q1)//ans vary due to roundoff error
W=q1*Eta
mprintf("W=%fkJ/kg",W)//ans vary due to roundoff error
```

Scilab code Exa 9.6 Calculate 1compression ratio 2cutoff ratio 3thermal efficiency

```
clc
P2=4 //pressure in MPa
P1=0.1 //pressure in MPa
gama=1.4
T1=323
ro=(P2/P1)^(1/gama)
mprintf("ro=%f\n",ro)//ans vary due to roundoff error
T2=(P2*T1*(1/ro))/P1
mprintf("T2=%fK\n",T2)//ans vary due to roundoff error
q1=600
CP=1.0047
T3=(q1/CP)+T2
mprintf("T3=%fK\n",T3)//ans vary due to roundoff error
P3=P2
rc=(T3/T2)
mprintf("rc=%f\n",rc)//ans vary due to roundoff
```

```
Eta=1-((1/(gama*ro^(gama-1)))*(((rc^gama)-1)/(rc-1)))
mprintf("Eta=%f\n",Eta)//ans vary due to roundoff error
mprintf("Work done=%fkJ/kg",Eta*q1)//ans vary due to roundoff error
```

Scilab code Exa 9.7 Determine 1max temperature of cycle 2cutoff ratio 3energy adde

```
clc
ro=16
gama=1.4
T1=310.15 //temperature in kelvin
T2=T1*(ro^(gama-1))
mprintf("T2=%fK\n",T2)//ans vary due to roundoff error
deltas=1.2
CP=1.0047
T3=(%e^(deltas/CP))*T2
mprintf("T3=%fK\n",T3)//ans vary due to roundoff error
q1=CP*(T3-T2)
rc=T3/T2
mprintf("rc=%f\n",rc)//ans vary due to roundoff error
mprintf("q1=%fkJ/kg\n",q1)//ans vary due to roundoff error
Eta=1-(((rc^gama)-1)/((gama*ro^(gama-1))*(rc-1)))
mprintf("Eta=%f",Eta)//ans vary due to roundoff error
```

Scilab code Exa 9.8 Determine 1temperature and pressure at each state of cycle 2co

```
clc
P1=100 //pressure in kPa
T1=300 //temperature in kelvin
rp=8
P2=P1*rp
gama=1.4
mprintf("P2=%fkPa\n",P2)//ans vary due to roundoff error
T2=T1*rp^((gama-1)/gama)
mprintf("T2=%fK\n",T2)//ans vary due to roundoff error
P3=P2
T3=1300
Tmax=T3
T4=T3*(1/rp)^((gama-1)/gama)
mprintf("T4=%fK\n",T4)//ans vary due to roundoff error
P4=P1
Cp=1.0047
Wc=-Cp*(T2-T1)
mprintf("Wc=%fkJ/kg\n",Wc)//ans vary due to roundoff error
WT=Cp*(T3-T4)
mprintf("WT=%fkJ/kg\n",WT)//ans vary due to roundoff error
Wnet=WT+Wc
mprintf("Net Work done=%fkJ/kg\n",Wnet)//ans vary due to roundoff error
q1=Cp*(T3-T2)
mprintf("Energy added=%fkJ/kg\n",q1)//ans vary due to roundoff error
Eta=Wnet/q1
mprintf("Thermal efficiency=%f",Eta)//ans vary due to roundoff error
```

Scilab code Exa 9.9 Calculate 1COP of referigerator 2capacity 3power required 4COP

```
clc
h2=203.1063
s2=0.6825
sf=0.0736
sg=0.7094
hf=17.9517
hg=178.9017
s1=s2
X1=(s1-sf)/(sg-sf)
mprintf("X1=%f\n",X1)//ans vary due to roundoff
   error
h1=(X1*hg)+(1-X1)*hf
mprintf("h1=%fkJ/kg\n",h1)//ans vary due to roundoff
    error
h3=75.1134
h4=h3
COPR=(h1-h4)/(h2-h1)
mprintf("COPR=%f\n",COPR)//ans vary due to roundoff
   error
m=0.05
mprintf("Capacity of refrigerator=%fkW\n",m*(h1-h4))
   //ans vary due to roundoff error
Preq=m*(h2-h1)
mprintf("Power required=%fkW\n",Preq)//ans vary due
   to roundoff error
TL=253 //in kelvin
TH=313 //in kelvin
COP=TL/(TH-TL)
mprintf("COP=%f",COP)//ans vary due to roundoff
   error
```

Scilab code Exa 9.10 Calculate 1referigerant flow rate through system 2energy inpu

```
clc
h1=178.8372
hg=h1
h4=75.1013
h3=h4
Eabs=211
m=Eabs/(h1-h4)
mprintf("m=%fkg/min\n",m)//ans vary due to roundoff
    error
Etrans=300
W=Etrans-Eabs
mprintf("W=%fkJ/min\n",W)//ans vary due to roundoff
    error
COPR=Eabs/W
mprintf("COPR=%f\n",COPR)//ans vary due to roundoff
    error
```

Chapter 10

Gas Vapor Mixtures And Psychometry

Scilab code Exa 10.1 Determine molar mass of fuel and gravimetric analysis

```
clc
y1=0.4 //CH4
y2=0.2 //C2H6
y3=0.25 //H2
y4=0.15 //N2
M1=16
M2=30
M3=2
M4=28
m1=0.64
m2=0.6
m3=0.05
m4=0.42
M=(y1*M1)+(y2*M2)+(y3*M3)+(y4*M4)
mprintf("M=%fkg/kmol\n",M)
m=m1+m2+m3+m4
mprintf("m=%fkg\n",m)
yCH4=m1/m
mprintf("phi1=%f\n",yCH4)//ans vary due to roundoff
```

```
error
yC2H6=m2/m
mprintf("phi2=%f\n",yC2H6)//ans vary due to roundoff error
yH2=m3/m
mprintf("phi3=%f\n",yH2)//ans vary due to roundoff error
yN2=m4/m
mprintf("phi4=%f\n",yN2)//ans vary due to roundoff error
N=100
N1=N*y1
N2=N*y2
N3=N*y3
N4=N*y4
mprintf("Ni=.\n%f\n%f\n%f\n%f",N1,N2,N3,N4)
```

Scilab code Exa 10.2 Calculate partial pressure of constituents and express in mas

```
clc
y1=0.2 //O2
y2=0.5 //N2
y3=0.1 //H2O
y4=0.2 //CO2
P=100 //in kPa
p1=P*y1
p2=P*y2
p3=P*y3
p4=P*y4
mprintf("pi=.(in kPa)\n%f\n%f\n%f\n%f\n",p1,p2,p3,p4)
M1=32
M2=28
M3=18
M4=44
```

```
M=(y1*M1)+(y2*M2)+(y3*M3)+(y4*M4)
mprintf("Molar mass of mixture=%ikg/kmol\n",M)
m1=M1*y1
m2=M2*y2
m3=M3*y3
m4=M4*y4
mprintf("mi=.(kg*10^3)\n%f\n%f\n%f\n%f\n",m1,m2,m3,m4)
phi1=m1/M
phi2=m2/M
phi3=m3/M
phi4=m4/M
mprintf("phi i=.\n%f\n%f\n%f\n%f\n",phi1,phi2,phi3,phi4)
P=p1+p2+p3
mprintf("Final pressure=%ikPa\n",P)
y1=p1/P
y2=p2/P
y3=p3/P
mprintf("yi=.\n%f\n%f\n%f\n",y1,y2,y3)
m1=M1*y1
m2=M2*y2
m3=M3*y3
mprintf("mi=.\n%f\n%f\n%f\n",m1,m2,m3)
phi1=m1/M
phi2=m2/M
phi3=m3/M
mprintf("phi i=.\n%f\n%f\n%f\n",phi1,phi2,phi3)
M=(y1*M1)+(y2*M2)+(y3*M3)
mprintf("Molar mass=%f\n",M)//ans vary due to roundoff error
```

Scilab code Exa 10.4 Predict temperature of gas mixture and evaluate entropy chang

```
clc
```

```
y1=0.75 //H2
y2=0.25 //N2
CP1=28.6455
CP2=29.1783
CP=(y1*CP1)+(y2*CP2)
mprintf("CP=%fkJ/kmol K\n",CP)//ans vary due to roundoff error
Cv1=20.3311
Cv2=20.8641
Cv=(y1*Cv1)+(y2*Cv2)
mprintf("Cv=%fkJ/kmol K\n",Cv)//ans vary due to roundoff error
gama=CP/Cv
mprintf("gamma=%f\n",gama)//ans vary due to roundoff error
P1=100 //pressure in kPa
P2=500 //pressure in kPa
T1=300
T2=T1*((P2/P1)^((gama-1)/gama))
mprintf("T2=%fK\n",T2)//ans vary due to roundoff error
ws=-CP*(T2-T1)
mprintf("-ws=%fkJ/kmol\n",-ws)//ans vary due to roundoff error
M1=2.016
M2=28.013
M=(y1*M1)+(y2*M2)
mprintf("Molar mass=%fkg/kmol\n",M)//ans vary due to roundoff error
Ws=-(-ws/M)
mprintf("-Ws=%fkJ/kg of mixture\n",-Ws)//ans vary due to roundoff error
R=8.314
deltas1=(CP1*log(T2/T1))-(R*log(P2/P1))
mprintf("s2-s1=%fkJ/kmol K\n",deltas1)//ans vary due to roundoff error
deltas2=(CP2*log(T2/T1))-(R*log(P2/P1))
mprintf("s2-s1=%fkJ/kmol K\n",deltas2)//ans vary due
```

```
    to roundoff error
deltas=(y1*deltas1)+(y2*deltas2)
mprintf("s2-s1=%fkJ/kmol K",deltas)//ans vary due to
    roundoff error
```

Scilab code Exa 10.5 Determine amount of methane to be added and final pressure of

```
clc
y1=0.6 //H2
y2=0.4 //CH4
p1=60 //in kPa
p2=40 //in kPa
T=300 //in kelvin
V=5 //in metre-cube
R=8.314*10^3
N1=(p1*10^3*V)/(R*T)
mprintf("NH2=%fkmol\n",N1)//ans vary due to roundoff
    error
N2=(p2*10^3*V)/(R*T)
mprintf("NCH4=%fkmol\n",N2)//ans vary due to
   roundoff error
y1=0.5
y2=0.5
mprintf("Total methane to be added=%fkmol\n",(N1-N2)
   )//ans vary due to roundoff error
N2=N1
N=N1+N2
Pf=(N*R*T)/V
mprintf("Pf=%fkPa",Pf/1000)//ans vary due to
   roundoff error
```

Scilab code Exa 10.6 Determine 1final temperature of gas mixture 2composition of m

```
clc
P1=100 //pressure in kPa
V=2 //in metre-cube
R=8.314*10^3
T0=300 //in kelvin
N1=(P1*10^3*V)/(R*T0)
mprintf("N1=%fkmol\n",N1)//ans vary due to roundoff error
NHe0=0.0401
Nair0=0.0401
CvHe=12.4717
Cvair=20.7889
U0=((NHe0*CvHe)+(Nair0*Cvair))*T0
mprintf("Uo=%fkJ\n",U0)//ans vary due to roundoff error
Pf=4 //pressure in MPa
a=(Pf*10^6*V)/R
CPHe=20.786
THe=600
Nairf=0.0401
b=a/(CPHe*THe)
c=-NHe0+(U0/(CPHe*THe))
d=c+Nairf-(CvHe*b)
e=(Nairf*c)-(Nairf*Cvair*b)
f=1
//the above are the coefficients of quadratic equation formed for NHEf obtained from equation formed in book
NHef=(-d+sqrt(d^2-4*f*e))/(2*f)
mprintf("NHe=%fkmol\n",NHef)//ans vary due to roundoff error
Tf=a/(NHef+Nairf)
mprintf("Tf=%fK\n",Tf)//ans vary due to roundoff error
yHe=NHef/(NHef+Nairf)
mprintf("yHe=%f\n",yHe)//ans vary due to roundoff error
yair=Nairf/(NHef+Nairf)
```

```
mprintf("yair=%f\n",yair)//ans vary due to roundoff error
mprintf("Helium that enters tank=%fkmol",NHef-Nairf)//ans vary due to roundoff error
```

Scilab code Exa 10.7 Determine specific humidity and dew point and mass of water v

```
clc
Ps=4.241 //pressure in kPa
phi=0.6
pw=Ps*phi
mprintf("Partial pressure of water vapor=%fkPa\n",pw)//ans vary due to roundoff error
P=101.325 //in kPa
pa=P-pw
mprintf("pa=%fkPa\n",pa)//ans vary due to roundoff error
w=0.622*(pw/pa)
mprintf("w=%f kg water/kg dry air\n",w)//ans vary due to roundoff error
Mw=18
R=8.314*10^3
T=303 //temperature in kelvin
V=100 //in metre-cube
mprintf("Mass of water vapor=%fkg\n",(pw*10^3*V*Mw)/(R*T))//ans vary due to roundoff error
Ma=28.97
mprintf("Mass of dry air=%fkg\n",(pa*10^3*V*Ma)/(R*T))//ans vary due to roundoff error
Ps=8.2578
phi=0.9
pw=Ps*phi
mprintf("pw=%fkPa",pw)//ans vary due to roundoff error
```

Scilab code Exa 10.8 Determine specific humidity and relative humidity of air

```
clc
Ps=4.241 //in kPa
pw2=Ps
P=101.325 //in kPa
pa=P-pw2
w2=0.622*(pw2/pa)
mprintf("w2=%f kg H2O/kg dry air\n",w2)//ans vary
    due to roundoff error
hfg2=2430.74
hg1=2574.4
hf2=125.66
Cp=1.005
T1=40 //in celsius
T2=30 //in celsius
w1=(Cp*(T2-T1)+w2*hfg2)/(hg1-hf2)
mprintf("w1=%f kg H2O/kg dry air\n",w1)//ans vary
    due to roundoff error
pw=P/(1+(0.622/w1))
mprintf("pw=%fkPa\n",pw)//ans vary due to roundoff
    error
Ps=7.375
phi1=pw/Ps
mprintf("phi1=%f",phi1)//ans vary due to roundoff
    error
```

Scilab code Exa 10.9 Determine specific humidity and relative humidity and partial

```
clc
//Ex uses data from Ex10_8.sce
//we first write Ex10_7 for it
```

```
Ps=4.241 //in kPa
pw2=Ps
P=101.325 //in kPa
pa=P-pw2
w2=0.622*(pw2/pa)
hfg2=2430.74
hg1=2574.4
hf2=125.66
Cp=1.005
T1=40 //in celsius
T2=30 //in celsius
w1=(Cp*(T2-T1)+w2*hfg2)/(hg1-hf2)
pw=P/(1+(0.622/w1))
ha1=Cp*T1
h1star=ha1+(w1*hg1)
mprintf("h1star=%fkJ/kg dry air",h1star)//ans vary
    due to roundoff error
```

Scilab code Exa 10.10 Determine state of resulting mixture

```
clc
phi1=0.9
Ps=2.337
pw=phi1*Ps
mprintf("pw=%fkPa\n",pw)//ans vary due to roundoff
    error
P=101.325
Pa=P-pw
w1=0.622*(pw/Pa)
mprintf("w1=%f kg H2O/kg dry air\n",w1)//ans vary
    due to roundoff error
Mw=pw/P
mprintf("Mole fraction of water=%f\n",Mw)//ans vary
    due to roundoff error
R=8.314*10^3
```

```
T=293
v1=(R*T)/(P*10^3)
mprintf("v1=%fmetre-cube/kmol\n",v1)//ans vary due to roundoff error
ma1=((1-Mw)*(10/v1))*28.97
mprintf("Flow rate of dry air=%f kg/min\n",ma1)//ans vary due to roundoff error
TDB=40
phi2=0.2
w2=0.009
pw=1.3 //in kPa
Mw=pw/P
mprintf("Mole fraction of water vapor=%f\n",Mw)//ans vary due to roundoff error
v2=(R*(TDB+273))/(P*10^3)
mprintf("v2=%fmetre-cube/kmol\n",v2)//ans vary due to roundoff error
ma2=((1-Mw)*(30/v2))*28.97
mprintf("ma2=%fkg/min\n",ma2)//ans in textbook is wrong
w3=(w2+w1*(ma1/ma2))/(1+(ma1/ma2))
mprintf("w3=%f kg H20/kg dry air\n",w3)//ans vary due to roundoff error
h1star=54
h2star=64
h3star=(h2star+h1star*(ma1/ma2))/(1+(ma1/ma2))
mprintf("h3star=%fkJ/kg dry air",h3star)//ans vary due to roundoff error
```

Scilab code Exa 10.11 Determine volume of atmospheric air that can be mixed with c

```
clc
w3=0.011
w2=0.009
w1=0.0118
```

```
P=101.325 //in bar
pw1=1.8
pw2=1.3
a=(w2-w3)/(w3-w1)
mprintf("ma1/ma2=%f\n",a)//ans vary due to roundoff error
pa1=P-pw1
pa2=P-pw2
V1=10
T1=293.15
T2=313.15
V2=(pa1*V1*T2)/(a*pa2*T1)
mprintf("V2=%fmetre-cube/min",V2)//ans vary due to roundoff error
```

Scilab code Exa 10.12 Determine the rates of heating and cooling required and calc

```
clc
phi1=0.8
TDB=40 //in celsius
w1=0.0284
pw1=4.4 //in kPa
h1star=114
P=101.325
R=8.314*10^3
V=1
M=28.97
T1=313.15
pa1=P-pw1
ma1=(pa1*10^3*V*M)/(R*T1)
mprintf("ma1=%fkg/s dry air\n",ma1)//ans vary due to roundoff error
w4=0.0056
h4star=34.5
w2=w4
```

```
h2star=20.5
mw=ma1*(w1-w2)
mprintf("mw=%fkg/s\n",mw)//ans vary due to roundoff error
hw3=25.21
Qc=ma1*(h1star-h2star)-(mw*hw3)
mprintf("Qc=%fkJ/s\n",Qc)//ans vary due to roundoff error
ma2=ma1
Q=ma2*(h4star-h2star)
mprintf("Q=%fkJ/s",Q)//ans vary due to roundoff error
```

Scilab code Exa 10.14 Estimate amount of water required to operate coler for 5 hou

```
clc
TDB=49
phi1=0.2
w1=0.0147
w2=0.023
ma1=1
mw=ma1*(w2-w1)
mprintf("mw=%fkg/s\n",mw)
mprintf("Water required to operate coler for 5 hours =%fkg",mw*5*3600)
```

Scilab code Exa 10.15 Determine the makeup water required and air flow rate

```
clc
w1=0.009
h1star=64.5
w2=0.029
h2star=109.5
```

```
h3=167.45
h4=125.66
mw3=1000
ma=(mw3*(h3-h4))/((h2star-h1star)-((w2-w1)*h4))
mprintf("ma=%fkg/s\n",ma)//ans vary due to roundoff
    error
mprintf("Make up water required=%fkg/s",ma*(w2-w1))
    //ans vary due to roundoff error
```