Scilab Textbook Companion for Engineering Thermodynamics by O. Singh[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

Fundamental Concepts And Definitions

Scilab code Exa 1.1 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh, Chapter 1,Example 1")
h=30*10^-2;//manometer deflection of mercury in m
g=9.78;//acceleration due to gravity in m/s^2
rho=13550;//density of mercury at room temperature in kg/m^3
disp("pressure difference(p)in pa")
disp("p=rho*g*h")
p=rho*g*h
```

Scilab code Exa 1.2 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh, Chapter 1,Example 2")
d=30*10^-2;//diameter of cylindrical vessel in m
h=76*10^-2;//atmospheric pressure in m of mercury
g=9.78;//acceleration due to gravity in m/s^2
rho=13550;//density of mercury at room temperature in kg/m^3
disp("effort required for lifting the lid(E)in N")
disp("E=(rho*g*h)*(3.14*d^2)/4")
E=(rho*g*h)*(3.14*d^2)/4
```

Scilab code Exa 1.3 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh, Chapter 1,Example 3")
h=30*10^-2;// pressure of compressed air in m of mercury
Patm=101*10^3;//atmospheric pressure in pa
g=9.78;//acceleration due to gravity in m/s^2
```

```
rho=13550;//density of mercury at room temperature
    in kg/m^3
disp("pressure measured by manometer is gauge
    pressure(Pg)in kpa")
disp("Pg=rho*g*h/10^3")
Pg=rho*g*h/10^3
disp("actual pressure of the air(P)in kpa")
disp("P=Pg+Patm/10^3")
P=Pg+Patm/10^3
```

Scilab code Exa 1.4 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
    Chapter 1,Example 4")
h=1;//depth of oil tank in m
sg=0.8;//specific gravity of oil
RHOw=1000;//density of water in kg/m^3
g=9.81;//acceleration due to gravity in m/s^2
disp("density of oil(RHOoil)in kg/m^3")
disp("RHOoil=sg*RHOw")
RHOoil=sg*RHOw
disp("gauge pressure(Pg)in kpa")
disp("Pg=RHOoil*g*h/10^3")
Pg=RHOoil*g*h/10^3
```

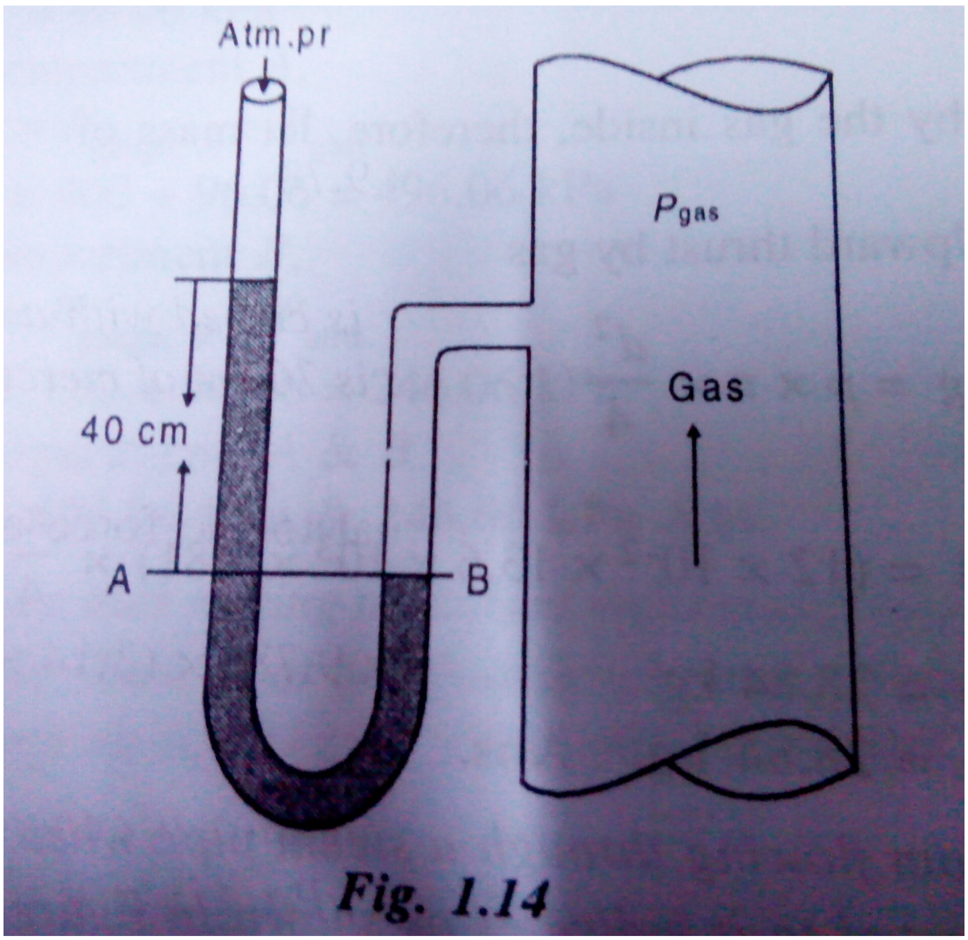

Figure 1.1: Engineering Thermodynamics by Onkar Singh Chapter 1 Example 5

Scilab code Exa 1.5 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 5")
rho=13.6*10^3;//density of mercury in kg/m^3
g=9.81;//acceleration due to gravity in m/s^2
h1=40*10^-2;//difference of height in mercury column
    in m as shown in figure
h2=76*10^-2;//barometer reading of mercury in m
disp("atmospheric pressure(Patm)in kpa")
disp("Patm=rho*g*h2/10^3")
Patm=rho*g*h2/10^3
disp("pressure due to mercury column at AB(Pab)in
   kpa")
disp("Pab=rho*g*h1/10^3")
Pab=rho*g*h1/10^3
disp("pressure exerted by gas(Pgas)in kpa")
disp("Pgas=Patm+Pab")
Pgas=Patm+Pab
```

Scilab code Exa 1.6 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 6

```
// Display mode
mode(0);
```

```
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh, Chapter 1,Example 6")
m=1;//mass of water in kg
h=1000;//height from which water fall in m
Cp=1;//specific heat of water in kcal/kg k
g=9.81;//acceleration due to gravity in m/s^2
disp("by law of conservation of energy")
disp("potential energy(m*g*h)in joule = heat required for heating water(m*Cp*deltaT*1000*4.18) in joule")
disp("so m*g*h = m*Cp*deltaT*4.18*1000")
disp("change in temperature of water(deltaT) in degree celcius")
disp("deltaT=(g*h)/(4.18*1000*Cp)")
deltaT=(g*h)/(4.18*1000*Cp)
```

Scilab code Exa 1.7 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh, Chapter 1,Example 7")
w1=100;//weight of object at standard gravitational acceleration in N
g1=9.81;//acceleration due to gravity in m/s^2
g2=8.5;//gravitational acceleration at some location
```

```
disp("mass of object(m)in kg")
disp("m=w1/g1")
m=w1/g1
disp("spring balance reading=gravitational force in
    mass(F)in N")
disp("F=m*g2")
F=m*g2
```

Scilab code Exa 1.8 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
    Chapter 1,Example 8")
d=15*10^-2;//diameter of cylinder in m
h=12*10^-2;//manometer height difference in m of
    mercury
rho=13.6*10^3;//density of mercury in kg/m^3
g=9.81;//acceleration due to gravity in m/s^2
disp("pressure measured by manometer(P) in pa")
disp("p=rho*g*h")
p=rho*g*h
disp("now weight of piston(m*g) = upward thrust by
    gas(p*%pi*d^2/4)")
disp("mass of piston(m)in kg")
disp("so m=(p*%pi*d^2)/(4*g)")
m=(p*%pi*d^2)/(4*g)
```

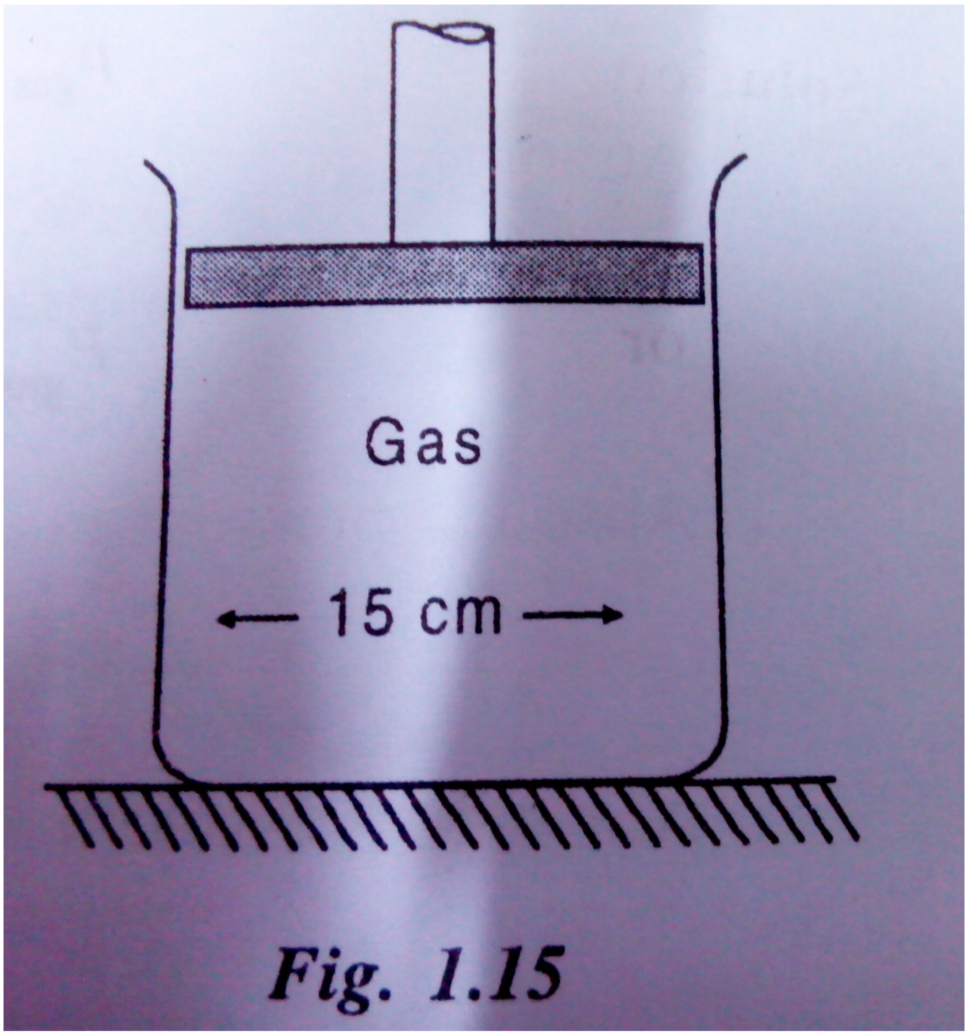

Figure 1.2: Engineering Thermodynamics by Onkar Singh Chapter 1 Example 8

Scilab code Exa 1.9 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 9")
RHOm=13.6*10^3;//density of mercury in kg/m^3
RHOw=1000;//density of water in kg/m^3
h1=76*10^-2;//barometer reading in m of mercury
h2=2*10^-2;//height raised by water in manometer
   tube in m
h3=10*10^-2;//height raised by mercury in manometer
   tube in m
g=9.81;//acceleration due to gravity in m/s^2
disp("balancing pressure at plane BC in figure we
   get")
disp("Psteam+Pwater=Patm+Pmercury")
disp("now 1.atmospheric pressure(Patm)in pa")
disp("Patm=RHOm*g*h1")
Patm=RHOm*g*h1
disp("2.pressure due to water(Pwater)in pa")
disp("Pwater=RHOw*g*h2")
Pwater=RHOw*g*h2
disp("3.pressure due to mercury(Pmercury)in pa")
disp("Pmercury=RHOm*g*h3")
Pmercury=RHOm*g*h3
disp("using balancing equation")
```

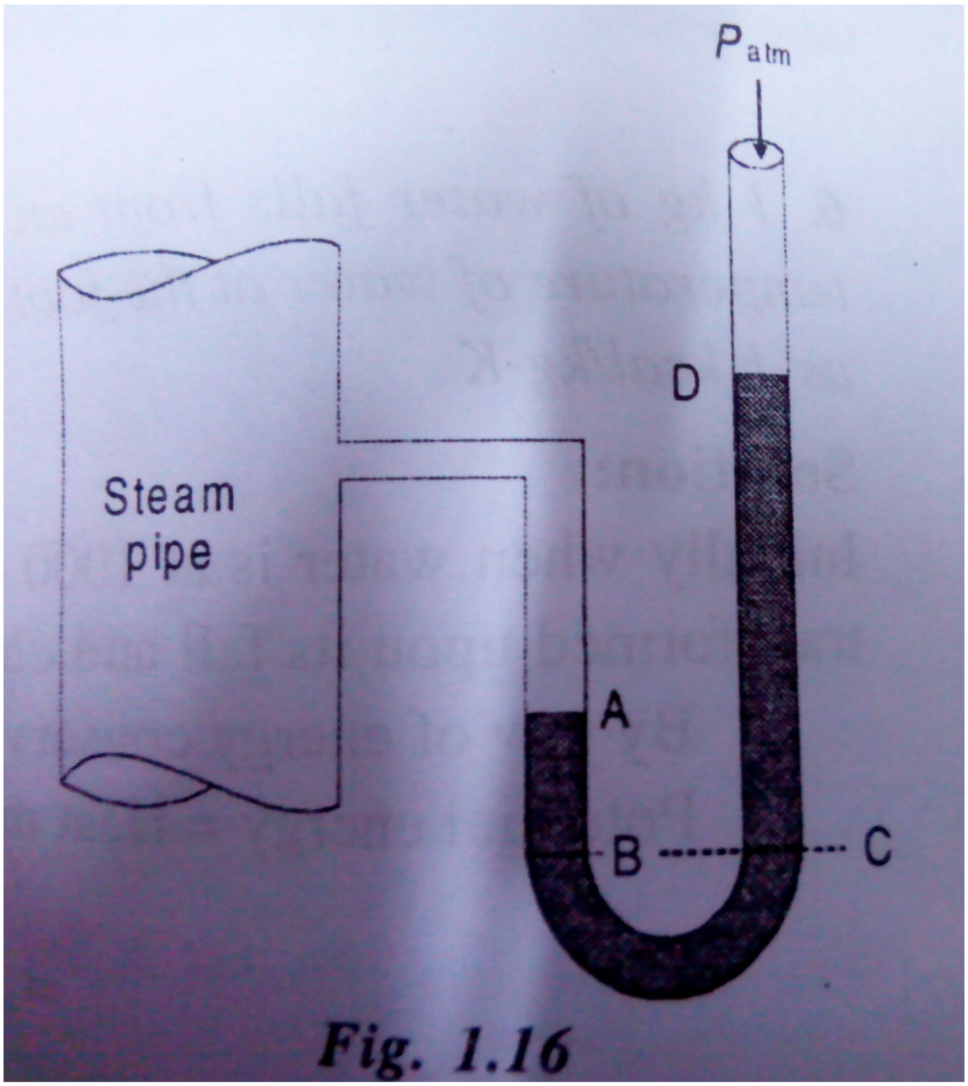

Figure 1.3: Engineering Thermodynamics by Onkar Singh Chapter 1 Example 9

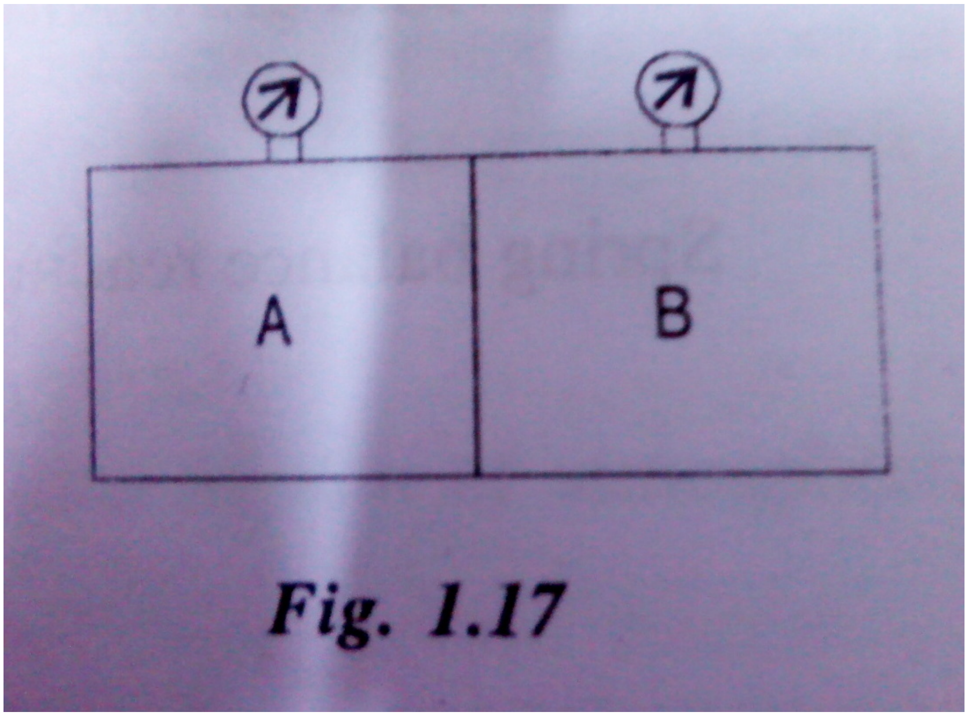

Figure 1.4: Engineering Thermodynamics by Onkar Singh Chapter 1 Example 10

```
disp("Psteam=Patm+Pmercury−Pwater")
disp("so pressure of steam(Psteam)in kpa")
disp("Psteam=(Patm+Pmercury−Pwater)/1000")
Psteam=(Patm+Pmercury-Pwater)/1000
```

Scilab code Exa 1.10 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 10")
h=720*10^-3;//barometer reading in m of Hg
Pga=400;//gauge pressure in compartment A in kpa
Pgb=150;//gauge pressure in compartment B in kpa
rho=13.6*10^3;//density of mercury in kg/m^3
g=9.81;//acceleration due to gravity in m/s^2
disp("atmospheric pressure(Patm)in kpa")
Patm=(rho*g*h)/1000
disp("absolute temperature in compartment A(Pa) in
   kpa")
disp("Paa=Pga+Patm")
Pa=Pga+Patm
disp("absolute temperature in compartment B(Pb) in
   kpa")
disp("Pb=Pgb+Patm")
Pb=Pgb+Patm
disp("absolute pressure in compartments in A & B
   =496.06 kpa & 246.06 kpa")
```

Scilab code Exa 1.11 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
```

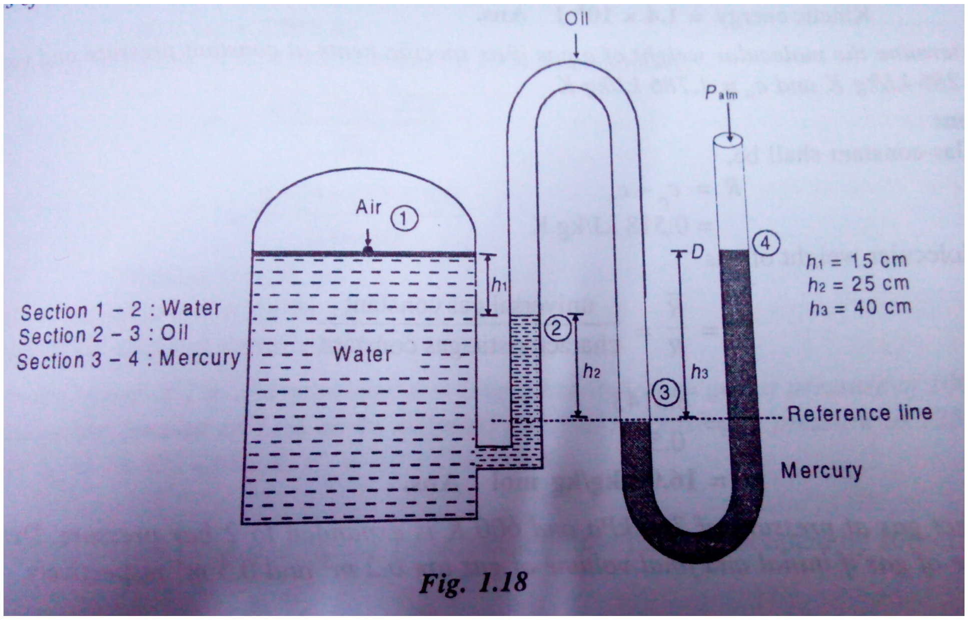

Figure 1.5: Engineering Thermodynamics by Onkar Singh Chapter 1 Example 11

```
   Chapter 1,Example 11")
Patm=90*10^3;//atmospheric pressure in pa
RHOw=1000;//density of water in kg/m^3
RHOm=13600;//density of mercury in kg/m^3
RHOo=850;//density of oil in kg/m^3
g=9.81;//acceleration due to ggravity in m/s^2
h1=.15;//height difference between water column in m
h2=.25;//height difference between oil column in m
h3=.4;//height difference between mercury column in
   m
disp("the pressure of air in air tank can be
   obtained by equalising pressures at some
   reference line")
disp("P1+RHOw*g*h1+RHOo*g*h2 = Patm+RHOm*g*h3")
disp("so P1 = Patm+RHOm*g*h3-RHOw*g*h1-RHOo*g*h2")
disp("air pressure(P1)in kpa")
P1=(Patm+RHOm*g*h3-RHOw*g*h1-RHOo*g*h2)/1000
```

Scilab code Exa 1.12 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 12")
v=750;//relative velocity of object with respect to
   earth in m/sec
F=4000;//gravitational force in N
g=8;//acceleration due to gravity in m/s^2
disp("mass of object(m)in kg")
disp("m=F/g")
m=F/g
disp("kinetic energy(E)in J is given by")
disp("E=m*v^2/2")
E=m*v^2/2
```

Scilab code Exa 1.13 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

```
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 13")
Cp=2.286;//specific heat at constant pressure in kJ/
   kg k
Cv=1.786;//specific heat at constant volume in kJ/kg
    k
R1=8.3143;//universal gas constant in kJ/kg k
disp("characteristics gas constant(R2)in kJ/kg k")
R2=Cp-Cv
disp("molecular weight of gas(m)in kg/kg mol")
m=R1/R2
disp("NOTE=>Their is some calculation mistake while
   calaulating gas constant in book,which is
   corrected above hence answer may vary.")
```

Scilab code Exa 1.14 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 14")
P1=750*10^3;//initial pressure of gas in pa
V1=0.2;//initial volume of gas in m^3
T1=600;//initial temperature of gas in k
P2=2*10^5;//final pressure of gas i pa
V2=0.5;//final volume of gas in m^3
disp("using perfect gas equation")
disp("P1*V1/T1 = P2*V2/T2")
disp("=>T2=(P2*V2*T1)/(P1*V1)")
disp("so final temperature of gas(T2)in k")
```

```
T2=(P2*V2*T1)/(P1*V1)
disp("or final temperature of gas(T2)in degree
   celcius")
T2=T2-273
```

Scilab code Exa 1.15 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 15")
P1=100*10^3;//initial pressure of air in pa
V1=5;//initial volume of air in m^3
T1=300;//initial temperature of gas in k
P2=50*10^3;//final pressure of air in pa
V2=5;//final volume of air in m^3
T2=(7+273);//final temperature of air in K
R=287;//gas constant on J/kg k
disp("from perfect gas equation we get")
disp("initial mass of air(m1 in kg)=(P1*V1)/(R*T1)")
m1=(P1*V1)/(R*T1)
disp("final mass of air(m2 in kg)=(P2*V2)/(R*T2)")
m2=(P2*V2)/(R*T2)
disp("mass of air removed(m)in kg")
m=m1-m2
disp("volume of this mass of air(V) at initial
   states in m^3")
V=m*R*T1/P1
```

Scilab code Exa 1.16 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,Chapter 1,Example 16")
d=1;//diameter of cylinder in m
l=4;//length of cylinder in m
P1=100*10^3;//initial pressureof hydrogen gas in pa
T1=(27+273);//initial temperature of hydrogen gas in k
P2=125*10^3;//final pressureof hydrogen gas in pa
Cp=14.307;//specific heat at constant pressure in KJ/kg k
Cv=10.183;//specific heat at constant volume in KJ/kg k
disp("here V1=V2")
disp("so P1/T1=P2/T2")
disp("final temperature of hydrogen gas(T2)in k")
disp("=>T2=P2*T1/P1")
T2=P2*T1/P1
disp("now R=(Cp-Cv) in KJ/kg k")
R=Cp-Cv
disp("And volume of cylinder(V1)in m^3")
disp("V1=(%pi*d^2*l)/4")
V1=(%pi*d^2*l)/4
disp("mass of hydrogen gas(m)in kg")
disp("m=(P1*V1)/(1000*R*T1)")
m=(P1*V1)/(1000*R*T1)
```

```
disp("now heat supplied(Q)in KJ")
disp("Q=m*Cv*(T2-T1)")
Q=m*Cv*(T2-T1)
```

Scilab code Exa 1.17 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 17

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 17")
V1=2;//volume of first cylinder in m^3
V2=2;//volume of second cylinder in m^3
T=(27+273);//temperature of system in k
m1=20;//mass of air in first vessel in kg
m2=4;//mass of air in second vessel in kg
R=287;//gas constant J/kg k
disp("final total volume(V)in m^3")
disp("V=V1*V2")
V=V1*V2
disp("total mass of air(m)in kg")
disp("m=m1+m2")
m=m1+m2
disp("final pressure of air(P)in kpa")
disp("using perfect gas equation")
disp("P=(m*R*T)/(1000*V)")
P=(m*R*T)/(1000*V)
```

Scilab code Exa 1.18 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 18

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
    Chapter 1,Example 18")
m=5;//mass of CO2 in kg
V=2;//volume of vesssel in m^3
T=(27+273);//temperature of vessel in k
R=8.314*10^3;//universal gas constant in J/kg k
M=44.01;//molecular weight of CO2
disp("1.By considering it as a PERFECT GAS")
disp("gas constant for CO2(Rco2)")
disp("Rco2=R/M")
Rco2=R/M
disp("Also P*V=M*Rco2*T")
disp("pressure of CO2 as perfect ga(P)in N/m^2")
disp("P=(m*Rco2*T)/V ")
P=(m*Rco2*T)/V
disp("2.By considering as a REAL GAS")
disp("values of vanderwaal constants a,b can be seen
     from the table which are")
disp("a=3628.5*10^2 N m^4/(kg mol)^2 ")
disp("b=3.14*10^-2 m^3/kg mol")
a=3628.5*10^2;//vanderwall constant in N m^4/(kg mol
    )^2
b=3.14*10^-2;// vanderwall constant in m^3/kg mol
disp("now specific volume(v)in m^3/kg mol")
disp("v=V*M/m")
v=V*M/m
disp("now substituting the value of all variables in
     vanderwaal equation")
disp("(P+(a/v^2))*(v-b)=R*T")
```

```
disp("pressure of CO2 as real gas(P)in N/m^2")
disp("P=((R*T)/(v-b))-(a/v^2)")
P=((R*T)/(v-b))-(a/v^2)
```

Scilab code Exa 1.19 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 19

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 19")
P=17672;//pressure of steam on kpa
T=712;//temperature of steam in k
Pc=22.09;//critical pressure of steam in Mpa
Tc=647.3;//critical temperature of steam in k
R=0.4615;//gas constant for steam in KJ/kg k
disp("1.considering as perfect gas")
disp("specific volume(V)in m^3/kg")
disp("V=R*T/P")
V=R*T/P
disp("2.considering compressibility effects")
disp("reduced pressure(P)in pa")
disp("p=P/(Pc*1000)")
p=P/(Pc*1000)
disp("reduced temperature(t)in k")
disp("t=T/Tc")
t=T/Tc
disp("from generalised compressibility chart,
   compressibility factor(Z)can be seen for reduced
   pressure and reduced temperatures of 0.8 and 1.1"
   )
```

```
disp("we get Z=0.785")
Z=0.785;//compressibility factor
disp("now actual specific volume(v)in m^3/kg")
disp("v=Z*V")
v=Z*V
```

Scilab code Exa 1.20 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 20

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 20")
d=5;//diameter of ballon in m
T1=(27+273);//temperature of hydrogen in k
P=1.013*10^5;//atmospheric pressure in pa
T2=(17+273);//temperature of surrounding air in k
R=8.314*10^3;//gas constant in J/kg k
disp("volume of ballon(V1)in m^3")
disp("V1=(4/3)*%pi*(d/2)^3")
V1=(4/3)*%pi*(d/2)^3
disp("molecular mass of hydrogen(M)")
disp("M=2")
M=2;//molecular mass of hydrogen
disp("gas constant for H2(R1)in J/kg k")
disp("R1=R/M")
R1=R/M
disp("mass of H2 in ballon(m1)in kg")
disp("m1=(P*V1)/(R1*T1)")
m1=(P*V1)/(R1*T1)
disp("volume of air displaced(V2)=volume of ballon(
```

```
    V1)")
disp("mass of air displaced(m2)in kg")
disp("m2=(P*V1)/(R2*T2)")
disp("gas constant for air(R2)=0.287 KJ/kg k")
R2=0.287*1000;//gas constant for air in J/kg k
m2=(P*V1)/(R2*T2)
disp("load lifting capacity due to buoyant force(m)
    in kg")
disp("m=m2-m1")
m=m2-m1
```

Scilab code Exa 1.21 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 21

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
    Chapter 1,Example 21")
v=0.25;//volume sucking rate of pump in m^3/min
V=20;//volume of air vessel in m^3
disp("let initial receiver pressure(p1)=1 in pa")
p1=1;//initial receiver pressure in pa
disp("so final receiver pressure(p2)=p1/4 in pa")
p2=p1/4
disp("perfect gas equation,p*V*m=m*R*T")
disp("differentiating and then integrating equation
    w.r.t to time(t) ")
disp("we get t=-(V/v)*log(p2/p1)")
disp("so time(t)in min")
t=-(V/v)*log(p2/p1)
```

Scilab code Exa 1.22 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 22

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh ,
    Chapter 1,Example 22")
m=5;//mass of mixture of gas in kg
P=1.013*10^5;//pressure of mixture in pa
T=300;//temperature of mixture in k
M1=28;//molecular weight of nitrogen(N2)
M2=32;//molecular weight of oxygen(O2)
M3=44;//molecular weight of carbon dioxide(CO2)
f1=0.8;//fraction of N2 in mixture
f2=0.18;//fraction of O2 in mixture
f3=0.02;//fraction of CO2 in mixture
k1=1.4;//ratio of specific heat capacities for N2
k2=1.4;//ratio of specific heat capacities for O2
k3=1.3;//ratio of specific heat capacities for CO2
R=8314;//universal gas constant in J/kg k
disp("first calculate gas constants for different
    gases in j/kg k")
disp("for nitrogen ,R1=R/M1")
R1=R/M1
disp("for oxygen ,R2=R/M2")
R2=R/M2
disp("for carbon dioxide ,R3=R/M3")
R3=R/M3
disp("so the gas constant for mixture(Rm)in j/kg k")
disp("Rm=f1*R1+f2*R2+f3*R3")
```

```
Rm=f1*R1+f2*R2+f3*R3
disp("now the specific heat at constant pressure for constituent gases in KJ/kg k")
disp("for nitrogen,Cp1=((k1/(k1-1))*R1)/1000")
Cp1=((k1/(k1-1))*R1)/1000
disp("for oxygen,Cp2=((k2/(k2-1))*R2)/1000")
Cp2=((k2/(k2-1))*R2)/1000
disp("for carbon dioxide,Cp3=((k3/(k3-1))*R3)/1000")
Cp3=((k3/(k3-1))*R3)/1000
disp("so the specific heat at constant pressure for mixture(Cpm)in KJ/kg k")
disp("Cpm=f1*Cp1+f2*Cp2+f3*Cp3")
Cpm=f1*Cp1+f2*Cp2+f3*Cp3
disp("now no. of moles of constituents gases")
disp("for nitrogen,n1=m1/M1 in mol,where m1=f1*m in kg")
m1=f1*m
n1=m1/M1
disp("for oxygen,n2=m2/M2 in mol,where m2=f2*m in kg")
m2=f2*m
n2=m2/M2
disp("for carbon dioxide,n=m3/M3 in mol,where m3=f3*m in kg")
m3=f3*m
n3=m3/M3
disp("total no. of moles in mixture in mol")
disp("n=n1+n2+n3")
n=n1+n2+n3
disp("now mole fraction of constituent gases")
disp("for nitrogen,x1=n1/n")
x1=n1/n
disp("for oxygen,x2=n2/n")
x2=n2/n
disp("for carbon dioxide,x3=n3/n")
x3=n3/n
disp("now the molecular weight of mixture(Mm)in kg/kmol")
```

```
disp("Mm=M1*x1+M2*x2+M3*x3")
Mm=M1*x1+M2*x2+M3*x3
```

Scilab code Exa 1.23 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 23

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 23")
V1=0.18;//volume fraction of O2 in m^3
V2=0.75;//volume fraction of N2 in m^3
V3=0.07;//volume fraction of CO2 in m^3
P=0.5;//pressure of mixture in Mpa
T=(107+273);//temperature of mixture in k
M1=32;//molar mass of O2
M2=28;//molar mass of N2
M3=44;//molar mass of CO2
disp("mole fraction of constituent gases")
disp("x=(ni/n)=(Vi/V)")
disp("take volume of mixture(V)=1 m^3")
V=1;// volume of mixture in m^3
disp("mole fraction of O2(x1)")
disp("x1=V1/V")
x1=V1/V
disp("mole fraction of N2(x2)")
disp("x2=V2/V")
x2=V2/V
disp("mole fraction of CO2(x3)")
disp("x3=V3/V")
x3=V3/V
```

```
disp("now molecular weight of mixture = molar mass(m)")
disp("m=x1*M1+x2*M2+x3*M3")
m=x1*M1+x2*M2+x3*M3
disp("now gravimetric analysis refers to the mass fraction analysis")
disp("mass fraction of constituents")
disp("y=xi*Mi/m")
disp("mole fraction of O2")
disp("y1=x1*M1/m")
y1=x1*M1/m
disp("mole fraction of N2")
disp("y2=x2*M2/m")
y2=x2*M2/m
disp("mole fraction of CO2")
disp("y3=x3*M3/m")
y3=x3*M3/m
disp("now partial pressure of constituents = volume fraction * pressure of mixture")
disp("Pi=xi*P")
disp("partial pressure of O2(P1)in Mpa")
disp("P1=x1*P")
p1=x1*P
disp("partial pressure of N2(P2)in Mpa")
disp("P2=x2*P")
P2=x2*P
disp("partial pressure of CO2(P3)in Mpa")
disp("P3=x3*P")
P3=x3*P
disp("NOTE=>Their is some calculation mistake for partial pressure of CO2(i.e 0.35Mpa)which is given wrong in book so it is corrected above hence answers may vary.")
```

Scilab code Exa 1.24 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 24

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 24")
V=6;//volume of tank in m^3
P1=800*10^3;//pressure of N2 gas tank in pa
T1=480;//temperature of N2 gas tank in k
P2=400*10^3;//pressure of CO2 gas tank in pa
T2=390;//temperature of CO2 gas tank in k
k1=1.4;//ratio of specific heat capacity for N2
k2=1.3;//ratio of specific heat capacity for CO2
R=8314;//universal gas constant in J/kg k
M1=28;//molecular weight of N2
M2=44;//molecular weight of CO2
disp("volume of tank of N2(V1) in m^3")
V1=V/2
disp("volume of tank of CO2(V2) in m^3")
V2=V/2
disp("taking the adiabatic condition")
disp("no. of moles of N2(n1)")
disp("n1=(P1*V1)/(R*T1)")
n1=(P1*V1)/(R*T1)
disp("no. of moles of CO2(n2)")
disp("n2=(P2*V2)/(R*T2)")
n2=(P2*V2)/(R*T2)
disp("total no. of moles of mixture(n)in mol")
disp("n=n1+n2")
n=n1+n2
disp("gas constant for N2(R1)in J/kg k")
disp("R1=R/M1")
R1=R/M1
```

```
disp("gas constant for CO2(R2)in J/kg k")
disp("R2=R/M2")
R2=R/M2
disp("specific heat of N2 at constant volume (Cv1) in J/kg k")
disp("Cv1=R1/(k1-1)")
Cv1=R1/(k1-1)
disp("specific heat of CO2 at constant volume (Cv2) in J/kg k")
disp("Cv2=R2/(k2-1)")
Cv2=R2/(k2-1)
disp("mass of N2(m1)in kg")
disp("m1=n1*M1")
m1=n1*M1
disp("mass of CO2(m2)in kg")
disp("m2=n2*M2")
m2=n2*M2
disp("let us consider the equilibrium temperature of mixture after adiabatic mixing at T")
disp("applying energy conservation principle")
disp("m1*Cv1*(T-T1) = m2*Cv2*(T-T2)")
disp("equlibrium temperature(T)in k")
disp("=>T=((m1*Cv1*T1)+(m2*Cv2*T2))/((m1*Cv1)+(m2*Cv2))")
T=((m1*Cv1*T1)+(m2*Cv2*T2))/((m1*Cv1)+(m2*Cv2))
disp("so the equlibrium pressure(P)in kpa")
disp("P=(n*R*T)/(1000*V)")
P=(n*R*T)/(1000*V)
```

Scilab code Exa 1.25 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 25

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 25")
m1=2;//mass of H2 in kg
m2=3;//mass of He in kg
T=100;//temperature of container in k
Cp1=11.23;//specific heat at constant pressure for
   H2 in KJ/kg k
Cp2=5.193;//specific heat at constant pressure for
   He in KJ/kg k
disp("since two gases are non reacting therefore
   specific heat of final mixture(Cp)in KJ/kg k can
   be obtained by following for adiabatic mixing")
disp("so the specific heat at constant pressure(Cp)
   in KJ/kg k")
disp("Cp=((Cp1*m1)+Cp2*m2)/(m1+m2)")
Cp=((Cp1*m1)+Cp2*m2)/(m1+m2)
```

Scilab code Exa 1.26 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 26

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 26")
m1=18;//mass of hydrogen(H2) in kg
m2=10;//mass of nitrogen(N2) in kg
m3=2;//mass of carbon dioxide(CO2) in kg
R=8.314;//universal gas constant in KJ/kg k
```

```
Pi=101.325;//atmospheric pressure in kpa
T=(27+273.15);//ambient temperature in k
M1=2;//molar mass of H2
M2=28;//molar mass of N2
M3=44;//molar mass of CO2
disp("gas constant for H2(R1)in KJ/kg k")
disp("R1=R/M1")
R1=R/M1
disp("gas constant for N2(R2)in KJ/kg k")
disp("R2=R/M2")
R2=R/M2
disp("gas constant for CO2(R3)in KJ/kg k")
disp("R3=R/M3")
R3=R/M3
disp("so now gas constant for mixture(Rm)in KJ/kg k"
   )
disp("Rm=(m1*R1+m2*R2+m3*R3)/(m1+m2+m3)")
Rm=(m1*R1+m2*R2+m3*R3)/(m1+m2+m3)
disp("considering gas to be perfect gas")
disp("total mass of mixture(m)in kg")
disp("m=m1+m2+m3")
m=m1+m2+m3
disp("capacity of vessel(V)in m^3")
disp("V=(m*Rm*T)/Pi")
V=(m*Rm*T)/Pi
disp("now final temperature(Tf) is twice of initial
   temperature(Ti)")
disp("so take k=Tf/Ti=2")
k=2;//ratio of initial to final temperature
disp("for constant volume heating,final pressure(Pf)
   in kpa shall be")
disp("Pf=Pi*k")
Pf=Pi*k
```

Scilab code Exa 1.27 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 27

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 1,Example 27")
T1=(27+273);//initial temperature of air in k
T2=500;//final temperature of air in k
disp("let inlet state be 1 and exit state be 2")
disp("by charles law volume and temperature can be
   related as")
disp("(V1/T1)=(V2/T2)")
disp("(V2/V1)=(T2/T1)")
disp("or (((%pi*D2^2)/4)*V2)/(((%pi*D1^2)/4)*V1)=T2/
   T1")
disp("since    K.E=0")
disp("so (D2^2/D1^2)=T2/T1")
disp("D2/D1=sqrt(T2/T1)")
disp("say(D2/D1)=k")
disp("so exit to inlet diameter ratio(k)")
k=sqrt(T2/T1)
```

Scilab code Exa 1.28 Engineering Thermodynamics by Onkar Singh Chapter 1 Example 28

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
```

```
clc;
disp("Engineering Thermodynamics by Onkar Singh,Chapter 1,Example 29")
V=2;//volume of vessel in m^3
P1=76;//initial pressure or atmospheric pressure in cm of Hg
T=(27+273.15);//temperature of vessel in k
p=70;//final pressure in cm of Hg vaccum
R=8.314;//universal gas constant in KJ/kg k
M=2;//molecular weight of H2
disp("gas constant for H2(R1)in KJ/kg k")
disp("R1=R/M")
R1=R/M
disp("say initial and final ststes are given by 1 and 2")
disp("mass of hydrogen pumped out shall be difference of initial and final mass inside vessel")
disp("final pressure of hydrogen(P2)in cm of Hg")
disp("P2=P1-p")
P2=P1-p
disp("therefore pressure difference(P)in kpa")
disp("P=((P1-P2)*101.325)/76")
P=((P1-P2)*101.325)/76
disp("mass pumped out(m)in kg")
disp("m=((P1*V1)/(R1*T1))-((P2*V2)/(R1*T2))")
disp("here V1=V2=V and T1=T2=T")
disp("so m=(V*(P1-P2))/(R1*T)")
m=(V*P)/(R1*T)
disp("now during cooling upto 10 degree celcius,the process may be consider as constant volume process")
disp("say state before and after cooling are denoted by suffix 2 and 3")
T3=(10+273.15);//final temperature after cooling in k
disp("final pressure after cooling(P3)in kpa")
disp("P3=(T3/T)*P2*(101.325/76)")
```

```
P3=(T3/T)*P2*(101.325/76)
```

Chapter 2

Zeroth Law Of Thermodynamics

Scilab code Exa 2.1 Engineering Thermodynamics by Onkar Singh Chapter 2 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 2,Example 1")
Tf=98.6;//temperature of body in farenheit
disp("degree celcius and farenheit are related as
   follows")
disp("Tc=(Tf-32)/1.8")
disp("so temperature of body in degree celcius")
Tc=(Tf-32)/1.8
```

Scilab code Exa 2.2 Engineering Thermodynamics by Onkar Singh Chapter 2 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 2,Example 2")
t1=0;//ice point temperature in degree celcius
p1=3;//thermometric property for ice point
t2=100;//steam point temperature in degree celcius
p2=8;//thermometric property for steam point
p3=6.5;//thermometric property for any temperature
disp("using thermometric relation")
disp("t=a*log(p)+(b/2)")
disp("for ice point,b/a=")
b=2*log(p1)
disp("so b=2.1972*a")
disp("for steam point")
a=t2/(log(p2)-(2.1972/2))
disp("and b=")
b=2.1972*a
disp("thus, t=a*log(p3)+(b/2) in degree celcius")
t=a*log(p3)+(b/2)
disp("so for thermodynamic property of 6.5,t=302.83
   degree celcius")
```

Scilab code Exa 2.3 Engineering Thermodynamics by Onkar Singh Chapter 2 Example 3

```
// Display mode
mode(0);
```

```
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
    Chapter 2,Example 3")
disp("emf equation")
disp("E=(0.003*t)-((5*10^-7)*t^2))+(0.5*10^-3)")
disp("using emf equation at ice point,E_0 in volts")
t=0;//ice point temperature in degree celcius
disp("E_0=(0.003*t)-((5*10^-7)*t^2)+(0.5*10^-3)")
E_0=(0.003*t)-((5*10^-7)*t^2)+(0.5*10^-3)
disp("using emf equation at steam point,E_100 in
    volts")
t=100;//steam point temperature in degree celcius
disp("E_100=(0.003*t)-((5*10^-7)*t^2)+(0.5*10^-3)")
E_100=(0.003*t)-((5*10^-7)*t^2)+(0.5*10^-3)
disp("now emf at 30 degree celcius using emf
    equation(E_30)in volts")
t=30;//temperature of substance in degree celcius
E_30=(0.003*t)-((5*10^-7)*t^2)+(0.5*10^-3)
disp("now the temperature(T) shown by this
    thermometer")
disp("T=((E_30-E_0)/(E_100-E_0))*(T_100-T_0) in
    degree celcius")
T_100=100;//steam point temperature in degree
    celcius
T_0=0;//ice point temperature in degree celcius
T=((E_30-E_0)/(E_100-E_0))*(T_100-T_0)
disp("NOTE=>In this question,values of emf at 100
    and 30 degree celcius is calculated wrong in book
     so it is corrected above so the answers may vary
    .")
```

Scilab code Exa 2.4 Engineering Thermodynamics by Onkar Singh Chapter 2 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
   Chapter 2,Example 4")
t1=0;//temperature at ice point
t2=100;//temperature at steam point
t3=50;//temperature of gas
disp("emf equation,e=0.18*t-5.2*10^-4*t^2 in
   millivolts")
disp("as ice point and steam points are two
   reference points,so")
disp("at ice point,emf(e1)in mV")
e1=0.18*t1-5.2*10^-4*t1^2
disp("at steam point,emf(e2)in mV")
e2=0.18*t2-5.2*10^-4*t2^2
disp("at gas temperature,emf(e3)in mV")
e3=0.18*t3-5.2*10^-4*t3^2
disp("since emf variation is linear so,temperature(t
   )in degree celcius at emf of 7.7 mV")
t=((t2-t1)/(e2-e1))*e3
disp("temperature of gas using thermocouple=60.16
   degree celcius")
disp("% variation in temperature reading with
   respect to gas thermometer reading of 50 degree
   celcius")
variation=((t-t3)/t3)*100
```

Scilab code Exa 2.5 Engineering Thermodynamics by Onkar Singh Chapter 2 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh,
    Chapter 2,Example 5")
disp("let the conversion relation be X=aC+b")
disp("where C is temperature in degree celcius,a&b
    are constants and X is temperature in X degree ")
disp("at freezing point,temperature=0 degree celcius
    ,0 degree X")
disp("so by equation X=aC+b")
X=0;//temperature in degree X
C=0;//temperature in degree celcius
disp("we get b=0")
b=0;
disp("at boiling point,temperature=100 degree
    celcius,1000 degree X")
X=1000;//temperature in degree X
C=100;//temperature in degree celcius
a=(X-b)/C
disp("conversion relation")
disp("X=10*C")
disp("absolute zero temperature in degree celcius
    =-273.15")
disp("absolute zero temperature in degree X=")
10*-273.15
```

Chapter 3

First Law Of Thermodynamics

Scilab code Exa 3.1 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 1")
p=689;//pressure of gas in cylinder in kpa
v1=0.04;//initial volume of fluid in m^3
v2=0.045;//final volume of fluid in m^3
W_paddle=-4.88;//paddle work done on the system in
   KJ
disp("a> work done on piston(W_piston)in KJ can be
   obtained as")
disp("W_piston=pdv")
function y = f(v), y=p, endfunction
W_piston=intg(v1,v2,f)
```

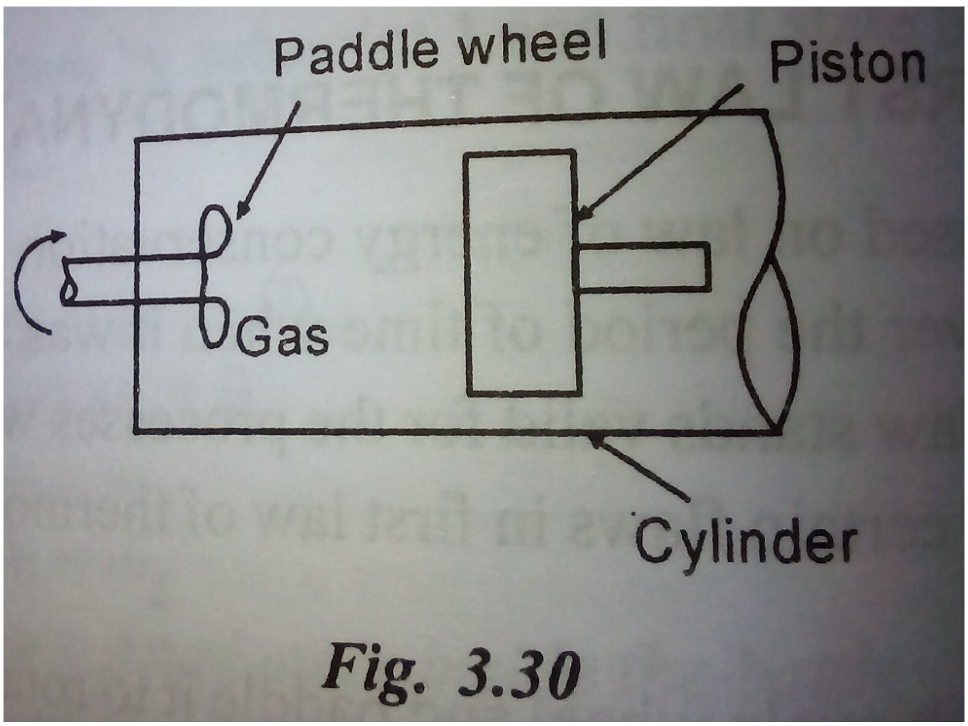

Figure 3.1: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 1

```
disp("b> paddle work done on the system(W_paddle)=-4.88 KJ")
disp("net work done of system(W_net)in KJ")
disp("W_net=W_piston+W_paddle")
W_net=W_piston+W_paddle
disp("so work done on system(W_net)=1.435 KJ")
```

Scilab code Exa 3.2 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 2")
m=0.5;//mass of gas in kg
u1=26.6;//internal energy of gas at 200 degree celcius
u2=37.8;//internal energy of gas at 400 degree celcius
W=0;//work done by vessel in KJ
disp("as the vessel is rigid therefore work done shall be zero")
disp("W=0")
disp("from first law of thermodynamics,heat required(Q)in KJ")
disp("Q=U2-U1+W=Q=m(u2-u1)+W")
Q=m*(u2-u1)+W
disp("so heat required =5.6 KJ")
```

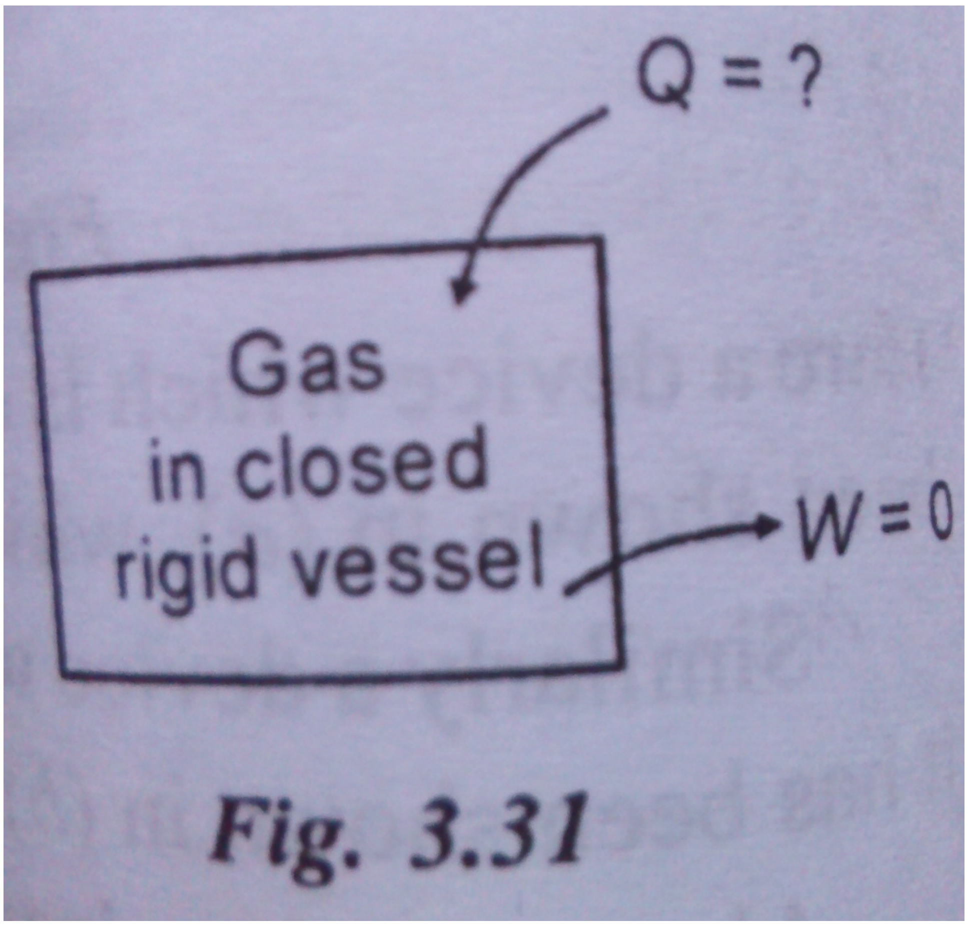

Figure 3.2: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 2

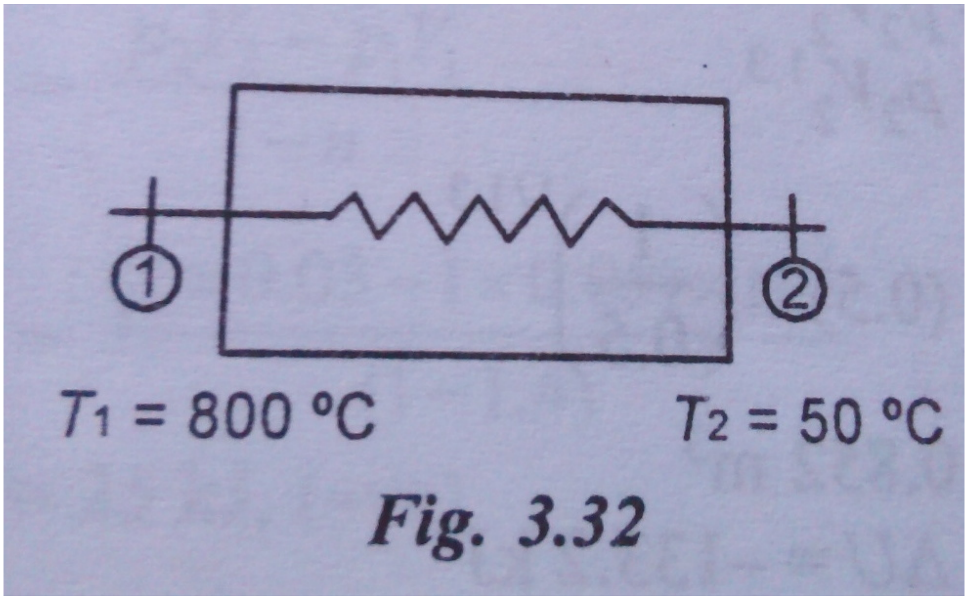

Figure 3.3: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 3

Scilab code Exa 3.3 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 3")
m=50;//rate at which carbon dioxide passing through
   heat exchanger in kg/hr
```

```
T2=800;//initial temperature of carbon dioxide in degree celcius
T1=50;//final temperature of carbon dioxide in degree celcius
Cp=1.08;//specific heat at constant pressure in KJ/kg K
disp("by steady flow energy equation")
disp("q+h1+C1^2/2+g*z1=h2+C2^2/2+g*z2+w")
disp("let us assume changes in kinetic and potential energy is negligible,during flow the work interaction shall be zero")
disp("q=h2-h1")
disp("rate of heat removal(Q)in KJ/hr")
disp("Q=m(h2-h1)=m*Cp*(T2-T1)")
Q=m*Cp*(T2-T1)
disp("heat should be removed at the rate of 40500 KJ/hr")
```

Scilab code Exa 3.4 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 4")
v=0.78;//volume of cylinder in m^3
p=101.325;//atmospheric pressure in kPa
disp("total work done by the air at atmospheric pressure of 101.325 kPa")
disp("W=(pdv)cylinder+(pdv)air")
disp("0+p*(delta v)")
```

```
disp("work done by air(W)=-p*v in KJ")
W=-p*v
disp("so work done by surrounding on system =79.03 KJ")
```

Scilab code Exa 3.5 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 5")
m=5;//mass of gas in kg
p1=1*10^3;//initial pressure of gas in KPa
V1=0.5;//initial volume of gas in m^3
p2=0.5*10^3;//final pressure of gas in KPa
n=1.3;//expansion constant
disp("given p*v^1.3=constant")
disp("assuming expansion to be quasi-static,the work may be given as")
disp("W=m(p*dv)=(p2*V2-p1*V1)/(1-n)")
disp("from internal energy relation,change in specific internal energy")
disp("deltau=u2-u1=1.8*(p2*v2-p1*v1)in KJ/kg")
disp("total change,deltaU=1.8*m*(p2*v2-p1*v1)=1.8*(p2*V2-p1*V1)in KJ")
disp("using p1*V1^1.3=p2*V2^1.3")
disp("V2=V1*(p1/p2)^(1/1.3)in m^3")
V2=V1*(p1/p2)^(1/1.3)
disp("take V2=.852 m^3")
V2=0.852;//final volume of gas in m^3
```

```
disp("so deltaU in KJ")
deltaU=1.8*(p2*V2-p1*V1)
disp("and W in KJ")
W=(p2*V2-p1*V1)/(1-n)
disp("from first law")
disp("deltaQ=deltaU+W in KJ")
deltaQ=deltaU+W
disp("heat interaction=113.5 KJ")
disp("work interaction=246.7 KJ")
disp("change in internal energy=-113.2 KJ")
```

Scilab code Exa 3.6 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 3 Example 6")
p1=1;//initial pressure of gas in MPa
v1=0.05;//initial volume of gas in m^3
p2=2;//final pressure of gas in MPa
n=1.4;//expansion constant
disp("final state volume(v2)in m^3")
disp("v2=((p1/p2)^(1/1.4))*v1")
v2=((p1/p2)^(1/1.4))*v1
disp("take v2=0.03 m^3")
v2=0.03;//final volume of gas in m^3
disp("now internal energy of gas is given by U=7.5*p
    *v-425")
disp("change in internal energy(deltaU)in KJ")
disp("deltaU=U2-U1=7.5*p2*v2-7.5*p1*v1")
```

```
disp("deltaU=7.5*10^3*(p2*v2-p1*v1)")
deltaU=7.5*10^3*(p2*v2-p1*v1)
disp("for quasi-static process")
disp("work(W) in KJ,W=p*dv")
disp("W=(p2*v2-p1*v1)/(1-n)")
W=((p2*v2-p1*v1)/(1-n))*10^3
disp("from first law of thermodynamics,")
disp("heat interaction(deltaQ)=deltaU+W")
deltaQ=deltaU+W
disp("heat=50 KJ")
disp("work=25 KJ(-ve)")
disp("internal energy change=75 KJ")
disp("if 180 KJ heat transfer takes place,then from
    1st law,")
disp("deltaQ=deltaU+W")
disp("since end states remain same,therefore deltaU
    i.e change in internal energy remains unaltered."
    )
disp("W=180-75")
W=180-75
disp("W=105 KJ")
```

Scilab code Exa 3.7 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 3 Example 7")
M=16;//molecular weight of gas
p1=101.3;//initial pressure of gas in KPa
```

```
p2=600;//final pressure of gas in KPa
T1=(273+20);//initial temperature of gas in K
R1=8.3143*10^3;//universal gas constant in J/kg K
Cp=1.7;//specific heat at constant pressure in KJ/kg
    K
n=1.3;//expansion constant
T2=((p2/p1)^(n-1/n))
disp("characteristics gas constant(R)in J/kg K")
disp("R=R1/M")
R=R1/M
disp("take R=0.520,KJ/kg K")
R=0.520;//characteristics gas constant in KJ/kg K
disp("Cv=Cp-R,inKJ/kg K")
Cv=Cp-R
disp("y=Cp/Cv")
y=Cp/Cv
y=1.44;//ratio of specific heat at constant pressure
    to constant volume
disp("for polytropic process,v2=((p1/p2)^(1/n))*v1
    in m^3")
disp("now,T2=T1*((p2/p1)^((n-1)/n)),in K")
T2=T1*((p2/p1)^((n-1)/n))
disp("work(W)in KJ/kg")
disp("W=R*((T1-T2)/(n-1))")
W=R*((T1-T2)/(n-1))
W=257.78034;//work done in KJ/kg
disp("for polytropic process,heat(Q)in KJ/K")
disp("Q=((y-n)/(y-1))*W")
Q=((y-n)/(y-1))*W
```

Scilab code Exa 3.8 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 8

```
// Display mode
mode(0);
```

```
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 8")
T1=(627+273);//initial temperature of air in nozzle in K
T2=(27+273);//temperature at which air leaves nozzle in K
Cp=1.005*10^3;//specific heat at constant pressure in J/kg K
disp("applying steady flow energy equation with inlet and exit states as 1,2 with no heat and work interaction and no change in potential energy")
disp("h1+C1^2/2=h2+C2^2/2")
disp("given that C1=0,negligible inlet velocity")
disp("so C2=sqrt(2(h1-h2))=sqrt(2*Cp*(T1-T2))")
disp("exit velocity(C2)in m/s")
C2=sqrt(2*Cp*(T1-T2))
disp("so exit velocity=1098.2 m/s")
```

Scilab code Exa 3.9 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 9")
W=-200;//shaft work in KJ/kg of air
```

```
deltah=100;//increase in enthalpy in KJ/kg of air
Q1=-90;//heat transferred to water in KJ/kg of air
disp("work interaction ,W=-200 KJ/kg of air")
disp("increase in enthalpy of air=100 KJ/kg of air")
disp("total heat interaction ,Q=heat transferred to
    water + heat transferred to atmosphere")
disp("writing steady flow energy equation on
    compressor ,for unit mass of air entering at 1 and
     leaving at 2")
disp("h1+C1^2/2+g*z1+Q=h2+C2^2/2+g*z2+W")
disp("assuming no change in potential energy and
    kinetic energy")
disp("deltaK.E=deltaP.=0")
disp("total heat interaction(Q)in KJ/kg of air")
disp("Q=deltah+W")
Q=deltah+W
disp("Q=heat transferred to water + heat transferred
     to atmosphere=Q1+Q2")
disp("so heat transferred to atmosphere(Q2)in KJ/kg
    of air")
Q2=Q-Q1
```

Scilab code Exa 3.10 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 3 Example 10")
n=500;//total number of persons
q=50;//heat requirement per person in kcal/hr
```

```
h1=80;//enthalpy of hot water enter in pipe in kcal/kg
h2=45;//enthalpy of hot water leaves the pipe in kcal/kg
g=9.81;//acceleartion due to gravity in m/s^2
deltaz=10;//difference in elevation of inlet and exit pipe in m
disp("above problem can be solved using steady flow energy equations upon hot water flow")
disp("Q+m1*(h1+C1^2/2+g*z1)=W+m2*(h2+C2^2/2+g*z2)")
disp("here total heat to be supplied(Q)in kcal/hr")
Q=n*q
disp("so heat lost by water(-ve),Q=-25000 kcal/hr")
Q=-25000//heat loss by water in kcal/hr
disp("there shall be no work interaction and change in kinetic energy,so,steady flow energy equation shall be,")
disp("Q+m*(h1+g*z1)=m*(h2+g*z2)")
disp("so water circulation rate(m)in kg/hr")
disp("so m=Q*10^3*4.18/(g*deltaz-(h1-h2)*10^3*4.18")
m=Q*10^3*4.18/(g*deltaz-(h1-h2)*10^3*4.18)
disp("water circulation rate(m)in kg/min")
m=m/60
```

Scilab code Exa 3.11 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

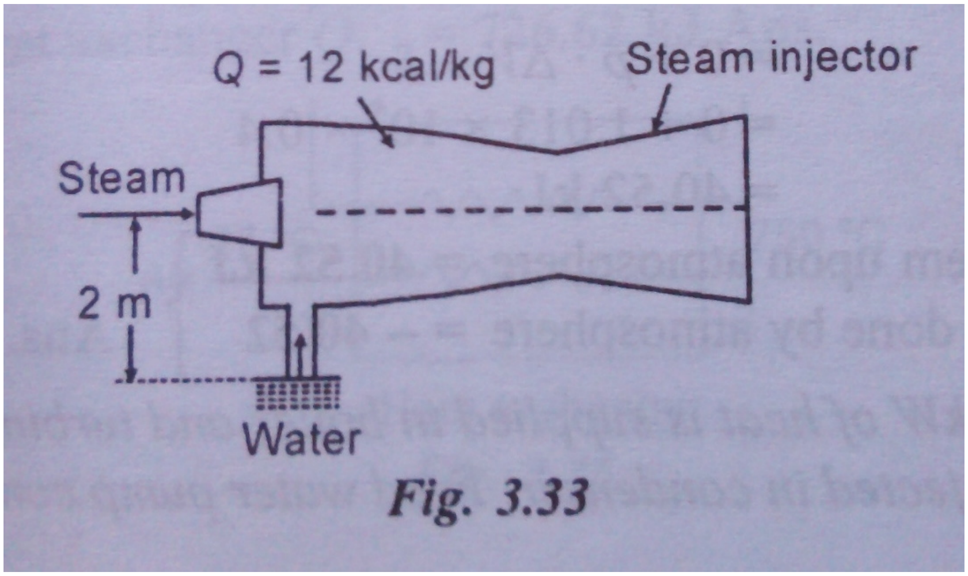

Figure 3.4: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 11

```
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 11")
v1=50;//velocity of steam entering injector in m/s
v2=25;//velocity of mixture leave injector in m/s
h1=720;//enthalpy of steam entering injector in kcal/kg
h2=24.6;//enthalpy of water entering injector in kcal/kg
h3=100;//enthalpy of steam leaving injector in kcal/kg
h4=100;//enthalpy of water leaving injector in kcal/kg
deltaz=2;//depth from axis of injector in m
q=12;//heat loss from injector to surrounding through injector
g=9.81;//acceleration due to gravity in m/s^2
disp("let mass of steam to be supplied per kg of water lifted be(m) kg.applying law of energy conservation upon steam injector,for unit mass of
```

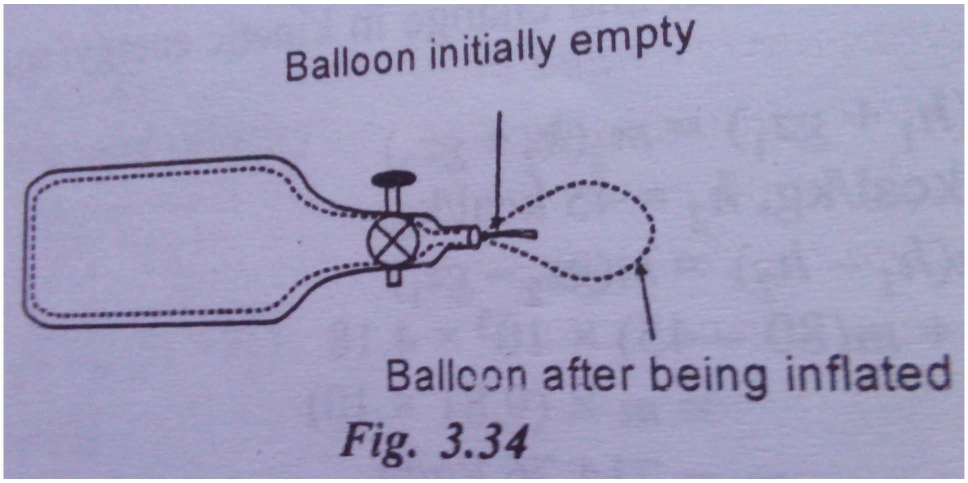

Figure 3.5: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 12

```
    water lifted")
disp("energy with steam entering + energy with water
    entering = energy with mixture leaving + heat
    loss to surrounding")
disp("m*(v1^2/2+h1*10^3*4.18)+h2*10^3*4.18+g*deltaz
    =(1+m)*(h3*10^3*4.18+v2^2/2)+m*q*10^3*4.18")
disp("so steam suppling rate(m)in kg/s per kg of
    water")
disp("m=((h3*10^3*4.18+v2^2/2)-(h2*10^3*4.18+g*
    deltaz))/((v1^2/2+h1*10^3*4.18)-(h3*10^3*4.18+v2
    ^2/2)-(q*10^3*4.18))")
m=((h3*10^3*4.18+v2^2/2)-(h2*10^3*4.18+g*deltaz))/((
    v1^2/2+h1*10^3*4.18)-(h3*10^3*4.18+v2^2/2)-(q
    *10^3*4.18))
disp("NOTE=>here enthalpy of steam entering injector
    (h1)should be taken 720 kcal/kg instead of 72
    kcal/kg otherwise the steam supplying rate comes
    wrong.")
```

Scilab code Exa 3.12 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 12")
p=1.013*10^5;//atmospheric pressure in pa
deltav=0.4;//change in volume in m^3
disp("here let us assume that the pressure is always equal to atmospheric presure as ballon is flexible,inelastic and unstressed and no work is done for stretching ballon during its filling figure shows the boundary of system before and after filling ballon by firm line and dotted line respectively.")
disp("displacement work, W=(p.dv)cylinder+(p.dv)ballon")
disp("(p.dv)cylinder=0,as cylinder is rigid")
disp("so work done by system upon atmosphere(W)in KJ, W=(p*deltav)/1000")
W=(p*deltav)/1000
disp("and work done by atmosphere=-40.52 KJ")
```

Scilab code Exa 3.13 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 13

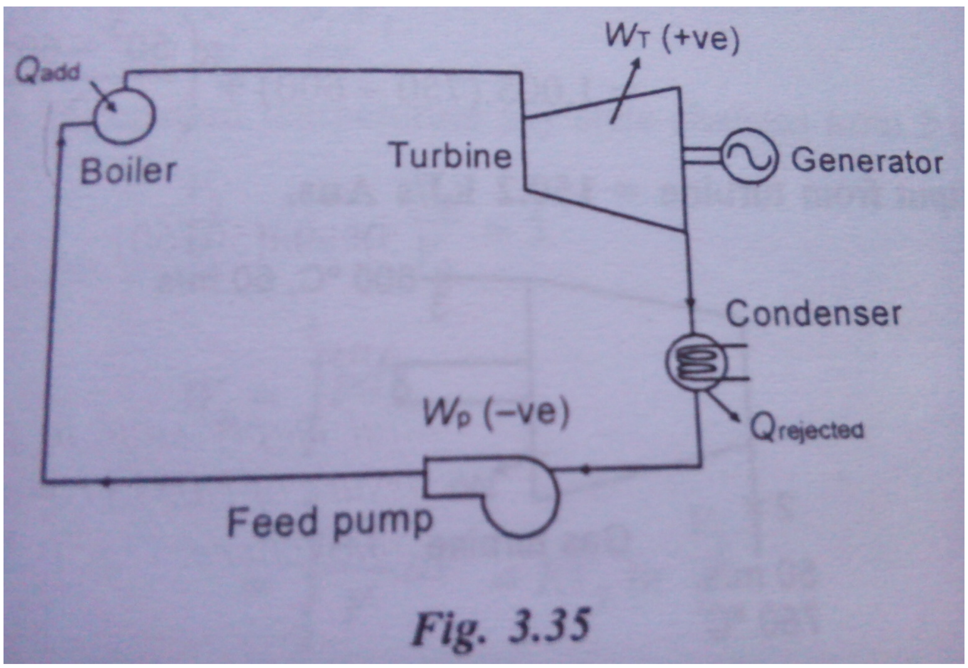

Figure 3.6: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 13")
Qadd=5000;//heat supplied in boiler in J/s
disp("work done by turbine(Wt)in J/s is 25% of heat
   added i.e")
disp("Wt=.25*Qadd")
Wt=.25*Qadd
disp("heat rejected by condensor(Qrejected)in J/s is
    75% of head added i.e")
disp("Qrejected=.75*Qadd")
Qrejected=.75*Qadd
disp("and feed water pump work(Wp)in J/s is 0.2% of
   heat added i.e")
disp("Wp=(-)0.002*Qadd")
Wp=0.002*Qadd
disp("capacity of generator(W)=(Wt-Wp)/1000 in Kw")
W=(Wt-Wp)/1000
```

Scilab code Exa 3.14 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

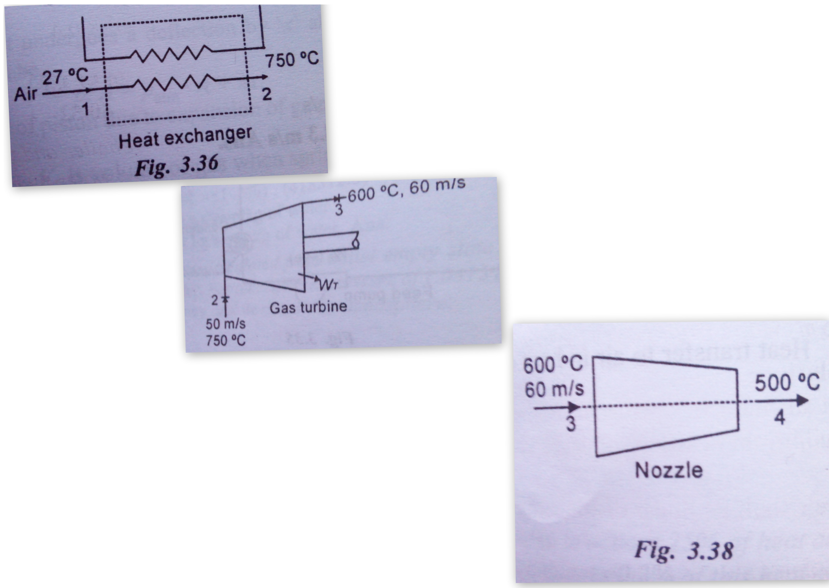

Figure 3.7: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 14

```
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 14")
T1=(27+273);//ambient temperature in K
T2=(750+273);//temperature of heated air inside heat exchanger in K
T3=(600+273);//temperature of hot air leaves turbine in K
T4=(500+273);//temperature at which air leaves nozzle in K
Cp=1.005;//specific heat at constant pressure in KJ/kg K
C2=50;//velocity of hot air enter into gas turbine in m/s
C3=60;//velocity of air leaving turbine enters a nozzle in m/s
disp("in heat exchanger upon applying S.F.E.E with assumption of no change in kinetic energy,no work interaction,no change in potential energy,for
```

```
unit mass flow rate of air,")
disp("h1+Q1_2=h2")
disp("Q1_2=h2-h1")
disp("so heat transfer to air in heat exchanger(Q1_2)in KJ")
disp("Q1_2=Cp*(T2-T1)")
Q1_2=Cp*(T2-T1)
disp("in gas turbine let us use S.F.E.E,assuming no change in potential energy,for unit mass flow rate of air")
disp("h2+C2^2/2=h3+C3^2/2+Wt")
disp("Wt=(h2-h3)+(C2^2-C3^2)/2")
disp("so power output from turbine(Wt)in KJ/s")
disp("Wt=Cp*(T2-T3)+(C2^2-C3^2)*10^-3/2")
Wt=Cp*(T2-T3)+(C2^2-C3^2)*10^-3/2
disp("applying S.F.E.E upon nozzle assuming no change in potential energy,no work and heat interactions,for unit mass flow rate,")
disp("h3+C=h4+C4^2/2")
disp("C4^2/2=(h3-h4)+C3^2/2")
disp("velocity at exit of nozzle(C4)in m/s")
disp("C4=sqrt(2*(Cp*(T3-T4)+C3^2*10^-3/2))")
C4=sqrt(2*(Cp*(T3-T4)+C3^2*10^-3/2))
```

Scilab code Exa 3.15 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 15")
```

```
T1=400;//initial temperature of gas in K
R=8.314;//gas constant in
disp("for constant pressure heating,say state
    changes from 1 to 2")
disp("Wa=p1*dv")
disp("Wa=p1*(v2-v1)")
disp("it is given that v2=2v1")
disp("so Wa=p1*v1=R*T1")
disp("for subsequent expansion at constant
    temperature say state from 2 to 3")
disp("also given that v3/v1=6,v3/v2=3")
disp("so work=Wb=p*dv")
disp("on solving above we get Wb=R*T2*ln(v3/v2)=R*T2
    *log3")
disp("temperature at 2 can be given by perfect gas
    consideration as,")
disp("T2/T1=v2/v1")
disp("or T2=2*T1")
disp("now total work done by air W=Wa+Wb=R*T1+R*T2*
    log3=R*T1+2*R*T1*log3 in KJ")
disp("so W=R*T1+2*R*T1*log(3)in KJ")
W=R*T1+2*R*T1*log(3)
```

Scilab code Exa 3.16 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
```

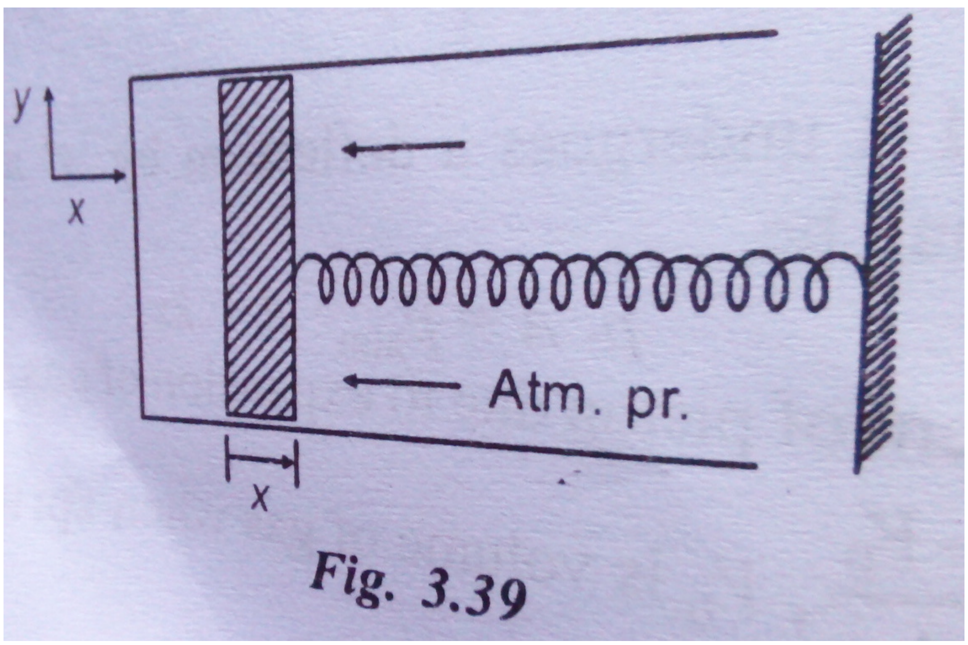

Figure 3.8: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 16

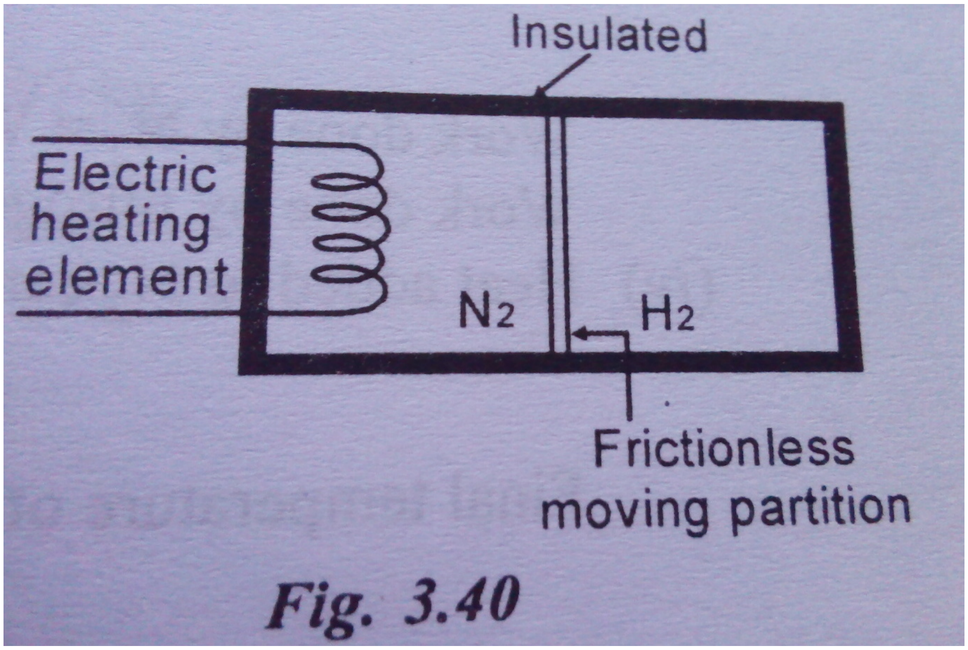

Figure 3.9: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 17

```
   Chapter 3 Example 16")
Pi=0.5*10^6;//initial pressure of gas in pa
Vi=0.5;//initial volume of gas in m^3
Pf=1*10^6;//final pressure of gas in pa
disp("NOTE=>this question contain derivation which
   cannot be solve using scilab so we use the result
    of derivation to proceed further ")
disp("we get W=(Vf-Vi)*((Pi+Pf)/2)")
disp("also final volume of gas in m^3 is Vf=3*Vi")
Vf=3*Vi
disp("now work done by gas(W)in J")
 W=(Vf-Vi)*((Pi+Pf)/2)
```

Scilab code Exa 3.17 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 17

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 17")
Cp_H2=14.307;//specific heat of H2 at constant pressure in KJ/kg K
R_H2=4.1240;//gas constant for H2 in KJ/kg K
Cp_N2=1.039;//specific heat of N2 at constant pressure in KJ/kg K
R_N2=0.2968;//gas constant for N2 in KJ/kg K
T1=(27+273);//ambient temperature in K
v1=0.5;//initial volume of H2 in m^3
p1=0.5*10^6;//initial pressure of H2 in pa
v2=0.25;//final volume of H2 in m^3
p2=1.324*10^6;//final pressure of H2 in pa
disp("with the heating of N2 it will get expanded while H2 gets compressed simultaneously. compression of H2 in insulated chamber may be considered of adiabatic type.")
disp("adiabatic index of compression of H2 can be obtained as,")
disp("Cp_H2=R_H2*(y_H2/(y_H2-1))")
disp("y_H2=Cp_H2/(Cp_H2-R_H2)")
y_H2=Cp_H2/(Cp_H2-R_H2)
disp("adiabatic index of expansion for N2,Cp_N2=R_N2*(y_N2/(y_N2-1))")
disp("y_N2=Cp_N2/(Cp_N2-R_N2)")
y_N2=Cp_N2/(Cp_N2-R_N2)
disp("i>for hydrogen,p1*v1^y=p2*v2^y")
disp("so final pressure of H2(p2)in pa")
disp("p2=p1*(v1/v2)^y_H2")
```

```
p2=p1*(v1/v2)^y_H2
disp("ii>since partition remains in equlibrium throughout hence no work is done by partition.it is  a case similar to free expansion ")
disp("partition work=0")
disp("iii>work done upon H2(W_H2)in J,")
disp("W_H2=(p1*v1-p2*v2)/(y_H2-1)")
W_H2=(p1*v1-p2*v2)/(y_H2-1)
disp("work done upon H2(W_H2)=-2*10^5 J")
disp("so work done by N2(W_N2)=2*10^5 J ")
W_N2=2*10^5;//work done by N2 in J
disp("iv>heat added to N2 can be obtained using first law of thermodynamics as")
disp("Q_N2=deltaU_N2+W_N2=>Q_N2=m*Cv_N2*(T2-T1)+W_N2")
disp("final temperature of N2 can be obtained considering it as perfect gas")
disp("therefore, T2=(p2*v2*T1)/(p1*v1)")
disp("here p2=final pressure of N2 which will be equal to that of H2 as the partition is free and frictionless")
disp("p2=1.324*10^6 pa,v2=0.75 m^3")
v2=0.75;//final volume of N2 in m^3
disp("so now final temperature of N2(T2)in K")
T2=(p2*v2*T1)/(p1*v1)
T2=1191.6;//T2 approx. equal to 1191.6 K
disp("mass of N2(m)in kg=(p1*v1)/(R_N2*T1)")
m=(p1*v1)/(R_N2*1000*T1)
m=2.8;//m approx equal to 2.8 kg
disp("specific heat at constant volume(Cv_N2)in KJ/kg K,Cv_N2=Cp_N2-R_N2")
Cv_N2=Cp_N2-R_N2
disp("heat added to N2,(Q_N2)in KJ")
disp("Q_N2=(m*Cv_N2*1000*(T2-T1))+W_N2")
Q_N2=((m*Cv_N2*1000*(T2-T1))+W_N2)/1000
```

Scilab code Exa 3.18 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 18

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 18")
p1=0.5*10^6;//initial pressure of air in pa
p2=1.013*10^5;//atmospheric pressure in pa
v1=2;//initial volume of air in m^3
v2=v1;//final volume of air in m^3
T1=375;//initial temperature of air in K
Cp_air=1.003;//specific heat at consatnt pressure in
    KJ/kg K
Cv_air=0.716;//specific heat at consatnt volume in
   KJ/kg K
R_air=0.287;//gas constant in KJ/kg K
y=1.4;//expansion constant for air
disp("let initial states and final states of air
   inside cylinder be given by m1,p1,v1,,T1 and m2,
   p2,v2,T2 respectively.it is case of emptying of
   cylinder")
disp("initial mass of air(m1)in kg")
disp("m1=(p1*v1)/(R_air*1000*T1)")
m1=(p1*v1)/(R_air*1000*T1)
disp("for adiabatic expansion during release of air
   through valve from 0.5 Mpa to atmospheric
   pressure")
disp("T2=T1*(p2/p1)^((y-1)/y)in K")
T2=T1*(p2/p1)^((y-1)/y)
```

```
disp("final mass of air left in tank(m2)in kg")
disp("m2=(p2*v2)/(R_air*1000*T2)")
m2=(p2*v2)/(R_air*1000*T2)
disp("writing down energy equation for unsteady flow system")
disp("(m1-m2)*(h2+C^2/2)=(m1*u1-m2*u2)")
disp("or (m1-m2)*C^2/2=(m1*u1-m2*u2)-(m1-m2)*h2")
disp("kinetic energy available for running turbine(W)in KJ")
disp("W=(m1*u1-m2*u2)-(m1-m2)*h2=(m1*Cv_air*1000*T1-m2*Cv_air*1000*T2)-(m1-m2)*Cp_air*1000*T2")
disp("W=(m1*Cv_air*1000*T1-m2*Cv_air*1000*T2)-(m1-m2)*Cp_air*1000*T2")
W=((m1*Cv_air*1000*T1-m2*Cv_air*1000*T2)-(m1-m2)*Cp_air*1000*T2)/1000
disp("amount of work available=482.66 KJ")
```

Scilab code Exa 3.19 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 19

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 3 Example 19")
p1=0.5*10^6;//initial pressure of air in pa
v1=0.5;//initial volume of air in m^3
T1=(27+273);//initial temperature of air in K
p2=1*10^6;//final pressure of air in pa
v2=0.5;//final volume of air in m^3
T2=500;//final temperature of air in K
R=8314;//gas constant in J/kg K
```

```
Cv=0.716;//specific heat at constant volume in KJ/kg K
disp("using perfect gas equation for the two chambers having initial states  as 1 and 2 and final states as 3")
disp("n1=(p1*v1)/(R*T1)")
n1=(p1*v1)/(R*T1)
disp("now n2=(p2*v2)/(R*T2)")
n2=(p2*v2)/(R*T2)
disp("for tank being insulated and rigid we can assume,deltaU=0,W=0,Q=0,so writing deltaU,")
deltaU=0;//change in internal energy
disp("deltaU=n1*Cv*(T3-T1)+n2*Cv*(T3-T2)")
disp("final temperature of gas(T3)in K")
disp("T3=(deltaU+Cv*(n1*T1+n2*T2))/(Cv*(n1+n2))")
T3=(deltaU+Cv*(n1*T1+n2*T2))/(Cv*(n1+n2))
disp("using perfect gas equation for final mixture,")
disp("final pressure of gas(p3)in Mpa")
disp("p3=((n1+n2)*R*T3)/(v1+v2)")
p3=((n1+n2)*R*T3)/(v1+v2)
disp("so final pressure and temperature =0.75 Mpa and 409.11 K")
```

Scilab code Exa 3.20 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 20

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

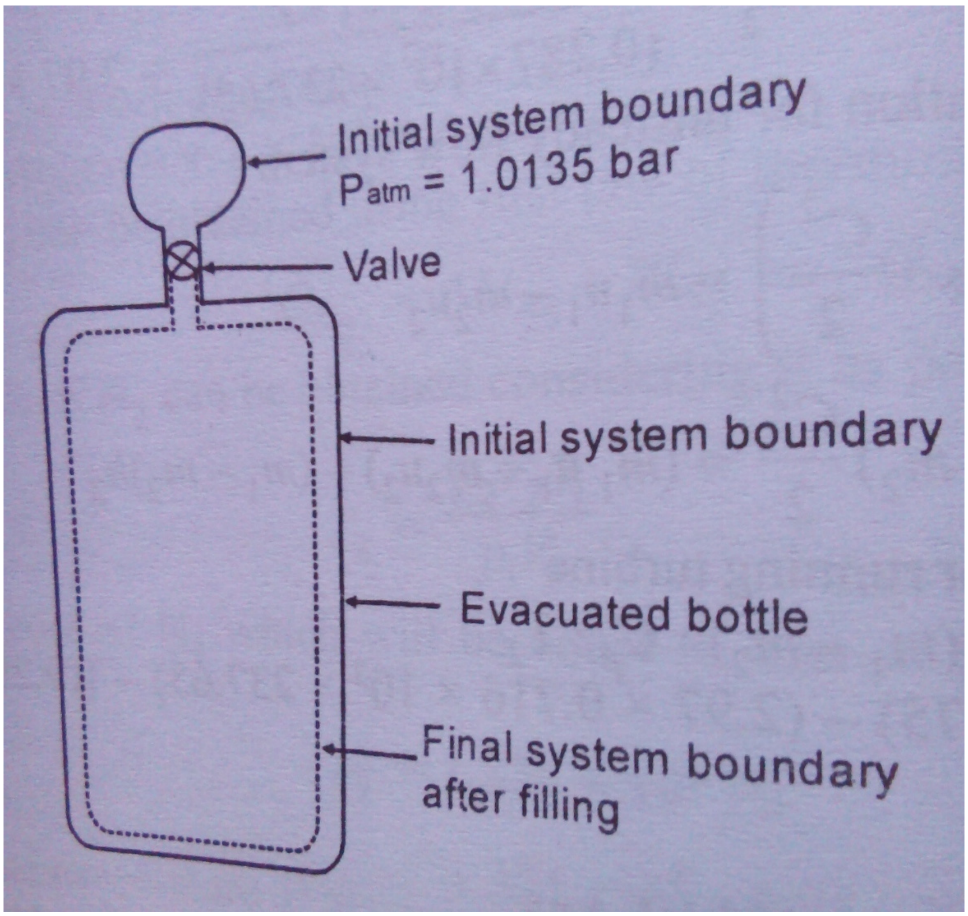

Figure 3.10: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 20

```
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 20")
v1=0;//initial volume of air inside bottle in m^3
v2=0.5;//final volume of air inside bottle in m^3
p=1.0135*10^5;//atmospheric pressure in pa
disp("displacement work,W=p*(v1-v2)in N.m")
W=p*(v1-v2)
disp("so heat transfer(Q)in N.m")
disp("Q=-W")
Q=-W
```

Scilab code Exa 3.21 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 21

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 21")
p1=35*10^5;//initial pressure of air in pa
v1=0.3;//initial volume of air in m^3
T1=(40+273);//initial temperature of air in K
p2=1*10^5;//final pressure of air in pa
v2=0.3;//final volume of air in m^3
y=1.4;//expansion constant
R=0.287;//gas constant in KJ/kg K
Cv=0.718;//specific heat at constant volume in KJ/kg
    K
Cp=1.005;//specific heat at constant pressure in KJ/
   kg K
disp("here turbogenerator is fed with compressed air
    from a compressed air bottle.pressure inside
```

```
   bottle gradually decreases from 35 bar to 1 bar.
   expansion from 35 bar to 1 bar occurs
   isentropically.thus,for the initial and final
   states of pressure,volume,temperatureand mass
   inside bottle being given as p1,v1,T1 & m1 and p2
   ,v2,T2 & m2 respectively.it is transient flow
   process similar to emptying of the bottle.")
disp("(p2/p1)^((y-1)/y)=(T2/T1)")
disp("final temperature of air(T2)in K")
disp("T2=T1*(p2/p1)^((y-1)/y)")
T2=T1*(p2/p1)^((y-1)/y)
disp("by perfect gas law,initial mass in bottle(m1)
   in kg")
disp("m1=(p1*v1)/(R*1000*T1)")
m1=(p1*v1)/(R*1000*T1)
disp("final mass in bottle(m2)in kg")
disp("m2=(p2*v2)/(R*1000*T2)")
m2=(p2*v2)/(R*1000*T2)
disp("energy available for running turbo generator
   or work(W)in KJ")
disp("W+(m1-m2)*h2=m1*u1-m2*u2")
disp("W=(m1*Cv*T1-m2*Cv*T2)-(m1-m2)*Cp*T2")
W=(m1*Cv*T1-m2*Cv*T2)-(m1-m2)*Cp*T2
disp("this is maximum work that can be had from the
   emptying of compresssed air bottle between given
   pressure limits")
disp("turbogenerator actual output(P1)=5 KJ/s")
P1=5;//turbogenerator actual output in KJ/s
disp("input to turbogenerator(P2)in KJ/s")
P2=P1/0.6
disp("time duration for which turbogenerator can be
   run(deltat)in seconds")
disp("deltat=W/P2")
deltat=W/P2
disp("duration=160 seconds approx.")
```

Scilab code Exa 3.22 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 22

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 22")
p1=1.5*10^5;//initial pressure of air in pa
T1=(77+273);//initial temperature of air in K
p2=7.5*10^5;//final pressure of air in pa
n=1.2;//expansion constant for process 1-2
R=0.287;//gas constant in KJ/kg K
m=3;//mass of air in kg
disp("different states as described in the problem
   are denoted as 1,2and 3 and shown on p-V diagram"
   )
disp("process 1-2 is polytropic process with index
   1.2")
disp("(T2/T1)=(p2/p1)^((n-1)/n)")
disp("final temperature of air(T2)in K")
disp("T2=T1*(p2/p1)^((n-1)/n)")
T2=T1*((p2/p1)^((n-1)/n))
disp("at state 1,p1*v1=m*R*T1")
disp("initial volume of air(v1)in m^3")
disp("v1=(m*R*1000*T1)/p1")
v1=(m*R*1000*T1)/p1
disp("final volume of air(v2)in m^3")
disp("for process 1-2,v2=((p1*v1^n)/p2)^(1/n)")
```

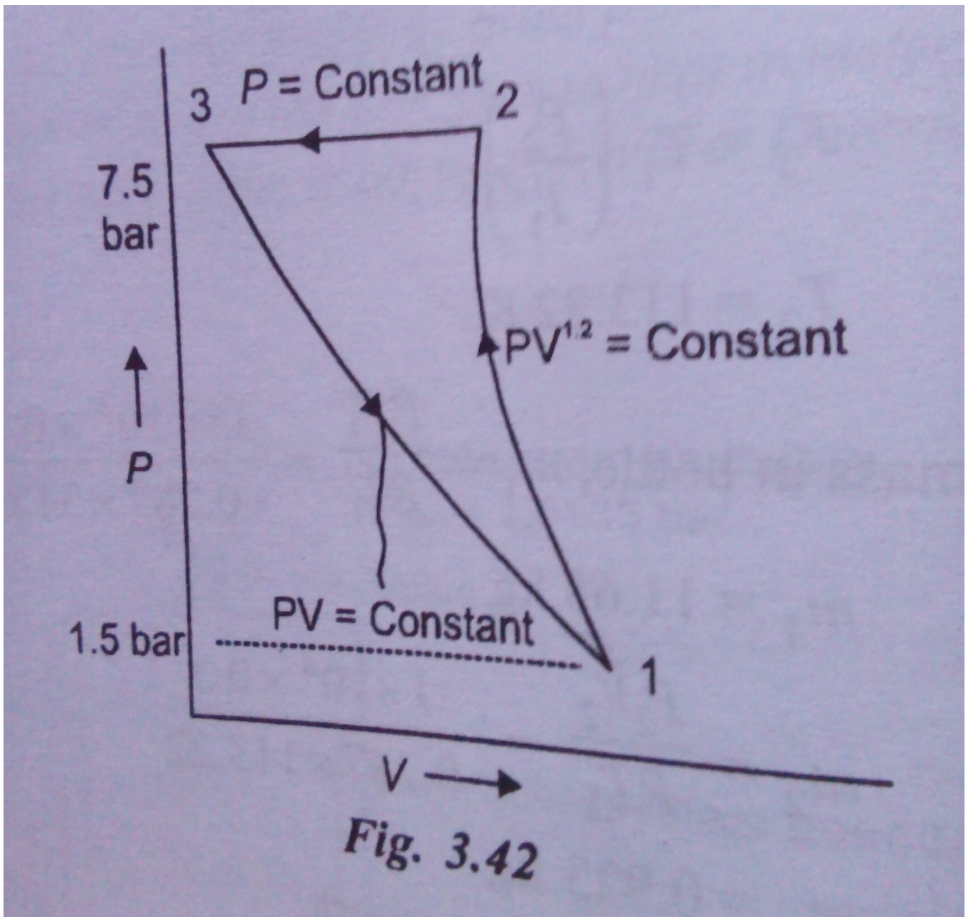

Figure 3.11: Engineering Thermodynamics by Onkar Singh Chapter 3 Example 22

```
v2=((p1*v1^n)/p2)^(1/n)
disp("for process 2−3 is constant pressure process
   so p2*v2/T2=p3*v3/T3")
disp("v3=v2*T3/T2 in m^3")
disp("here process 3−1 is isothermal process so T1=
   T3")
T3=T1;//process 3−1 is isothermal
v3=v2*T3/T2
disp("during process 1−2 the compression work(W1_2)
   in KJ")
disp("W1_2=(m*R*(T2−T1)/(1−n))")
W1_2=(m*R*(T2-T1)/(1-n))
disp("work during process 2−3(W2_3)in KJ,")
disp("W2_3=p2*(v3−v2)/1000")
W2_3=p2*(v3-v2)/1000
disp("work during process 3−1(W3_1)in KJ")
disp("W3_1=p3*v3*log(v1/v3)/1000")
p3=p2;//pressure is constant for process 2−3
W3_1=p3*v3*log(v1/v3)/1000
disp("net work done(W_net)in KJ")
disp("W_net=W1_2+W2_3+W3_1")
W_net=W1_2+W2_3+W3_1
disp("net work=−71.27 KJ")
disp("here −ve workshows work done upon the system.
   since it is cycle,so")
disp("W_net=Q_net")
disp("phi dW=phi dQ=−71.27 KJ")
disp("heat transferred from system=71.27 KJ")
```

Scilab code Exa 3.23 Engineering Thermodynamics by Onkar Singh Chapter 3 Example 23

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 3 Example 23")
Cp=1.005;//specific heat at constant pressure in KJ/
   kg K
Cv=0.718;//specific heat at constant volume in KJ/kg
    K
y=1.4;//expansion constant
p1=40*10^5;//initial temperature of air in pa
v1=0.15;//initial volume of air in m^3
T1=(27+273);//initial temperature of air in K
p2=2*10^5;//final temperature of air in pa
v2=0.15;//final volume of air in m^3
R=0.287;//gas constant in KJ/kg K
disp("initial mass of air in bottle(m1)in kg ")
disp("m1=(p1*v1)/(R*1000*T1)")
m1=(p1*v1)/(R*1000*T1)
disp("now final temperature(T2)in K")
disp("T2=T1*(p2/p1)^((y-1)/y)")
T2=T1*(p2/p1)^((y-1)/y)
T2=127.36;//take T2=127.36 approx.
disp("final mass of air in bottle(m2)in kg")
disp("m2=(p2*v2)/(R*1000*T2)")
m2=(p2*v2)/(R*1000*T2)
m2=0.821;//take m2=0.821 approx.
disp("energy available for running of turbine due to
    emptying of bottle(W)in KJ")
disp("W=(m1*Cv*T1-m2*Cv*T2)-(m1-m2)*Cp*T2")
W=(m1*Cv*T1-m2*Cv*T2)-(m1-m2)*Cp*T2
disp("work available from turbine=639.09 KJ")
```

Chapter 4

Second Law Of Thermodynamics

Scilab code Exa 4.1 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
  Chapter 4 Example 1")
disp("NOTE=>This question is fully theoritical hence
   cannot be solve using scilab.")
```

Scilab code Exa 4.2 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 2

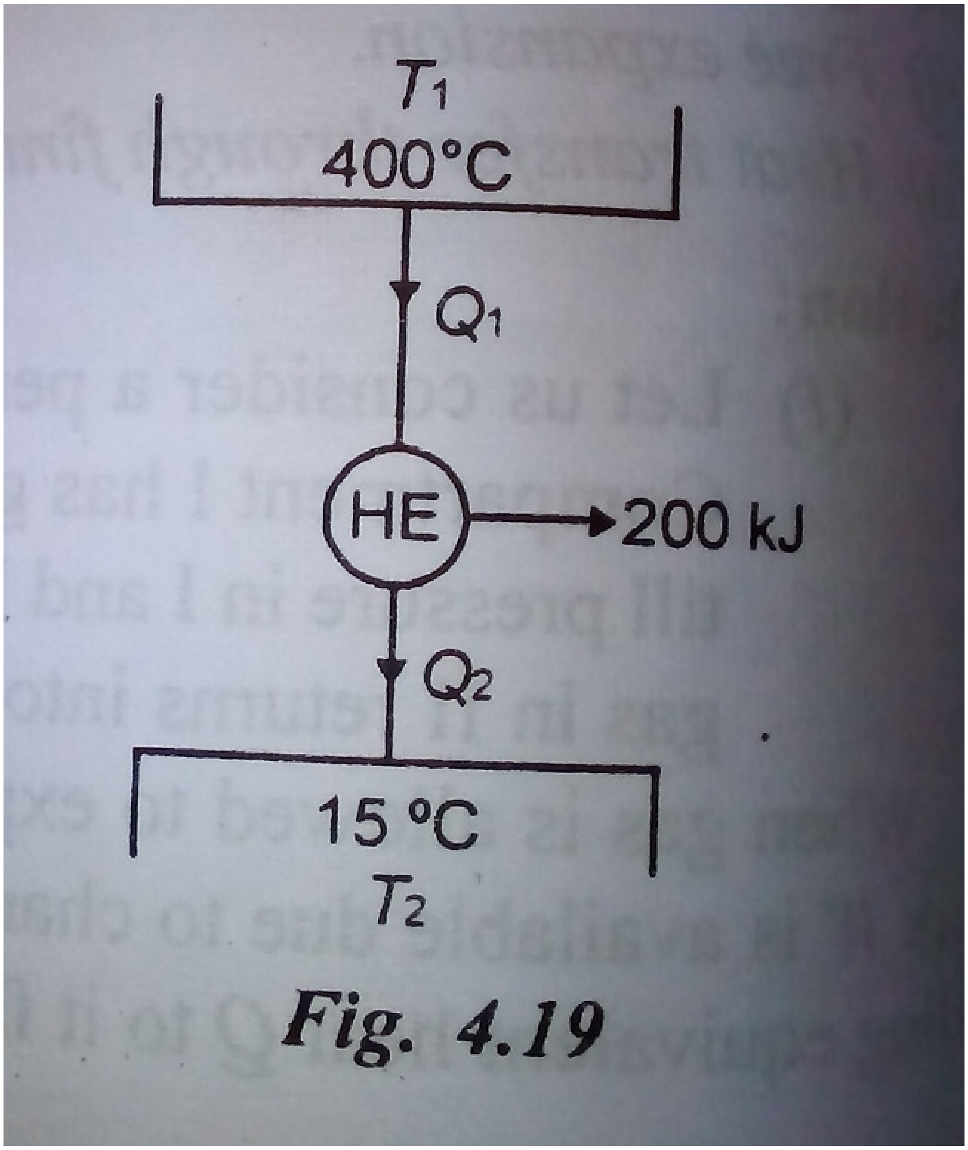

Figure 4.1: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 2")
T1=(400+273);//temperature of source in K
T2=(15+273);//temperature of sink in K
W=200;//work done in KJ
disp("in carnot engine from thermodynamics
   temperature scale")
disp("Q1/Q2=T1/T2")
disp("W=Q1-Q2=200 KJ")
disp("from above equations Q1 in KJ is given by")
disp("Q1=(200*T1)/(T1-T2)")
Q1=(200*T1)/(T1-T2)
disp("and Q2 in KJ")
disp("Q2=Q1-200")
Q2=Q1-200
disp("so heat supplied(Q1) in KJ")
Q1
```

Scilab code Exa 4.3 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

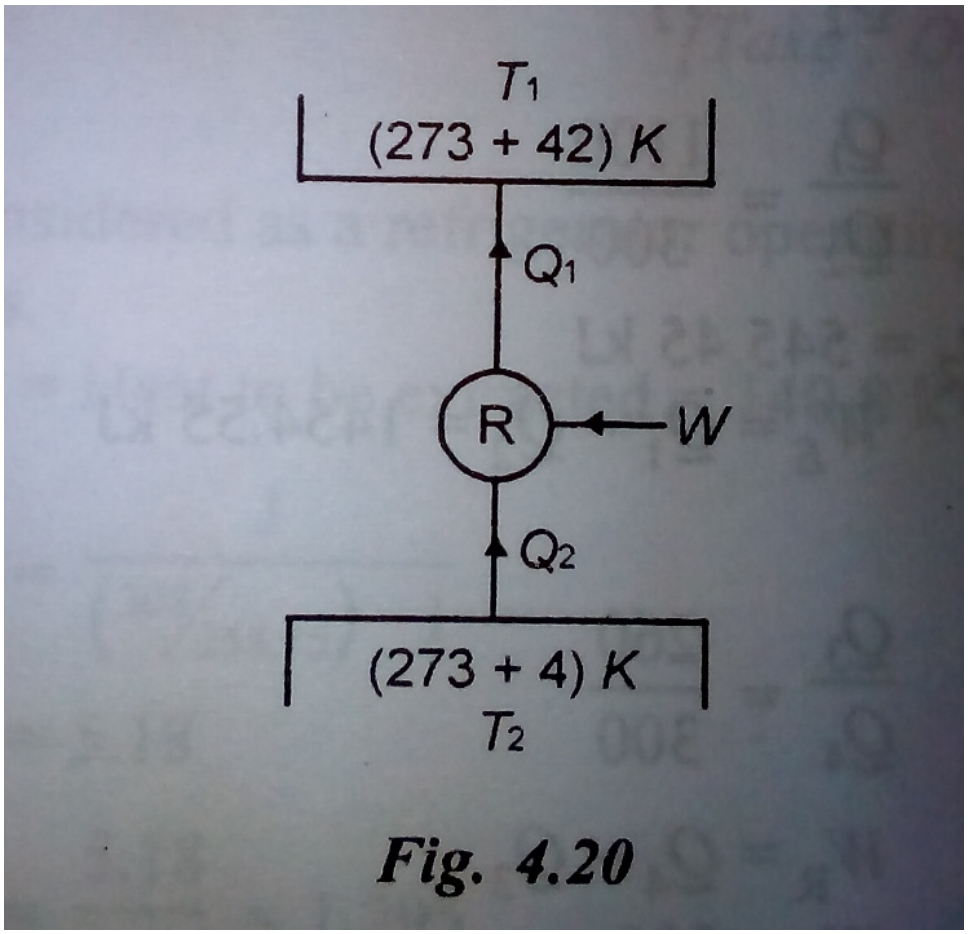

Figure 4.2: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 3

```
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 3")
T1=315;//temperature of reservoir 1 in K
T2=277;//temperature of reservoir 2 in K
Q2=2;//heat extracted in KJ/s
disp("from thermodynamic temperature scale")
disp("Q1/Q2=T1/T2")
disp("so Q1=Q2*(T1/T2)in KJ/s")
Q1=Q2*(T1/T2)
disp("power/work input required(W)=Q1-Q2 in KJ/s ")
W=Q1-Q2
disp("power required for driving refrigerator=W in
   KW")
W
```

Scilab code Exa 4.4 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 4")
T1=(827+273);//temperature of high temperature
   reservoir in K
T2=(27+273);//temperature of low temperature
   reservoir in K
T3=(-13+273);//temperature of reservoir 3 in K
Q1=2000;//heat ejected by reservoir 1 in KJ
disp("we can writefor heat engine,Q1/Q2=T1/T2")
```

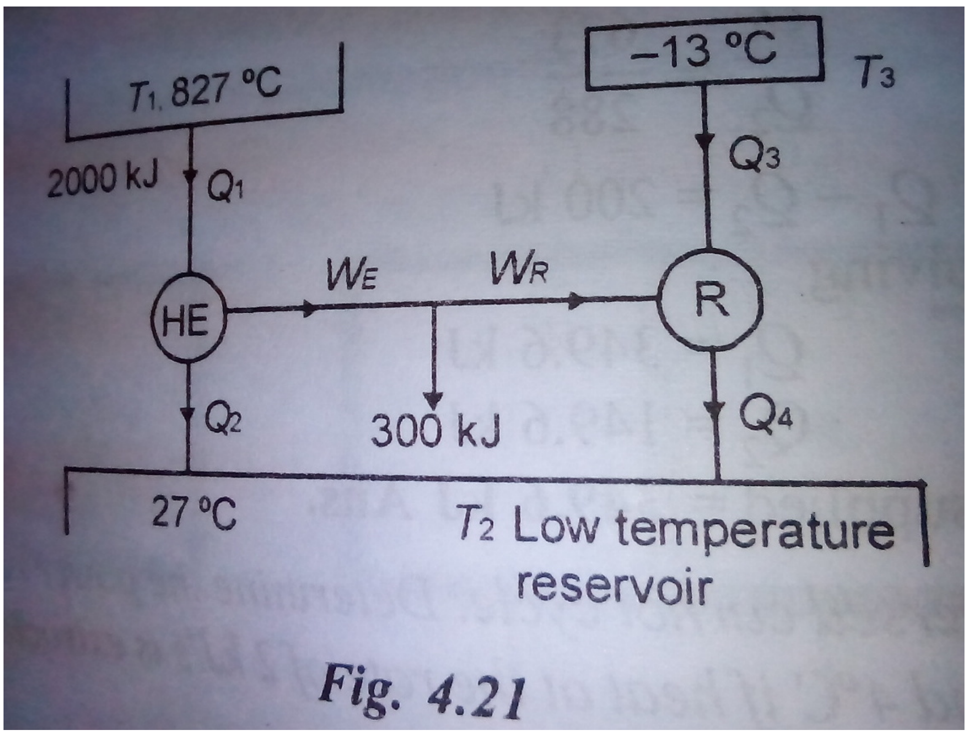

Figure 4.3: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 4

```
disp("so Q2=Q1*(T2/T1) in KJ")
Q2=Q1*(T2/T1)
disp("so We=Q1-Q2 in KJ")
We=Q1-Q2
disp("for refrigerator,Q3/Q4=T3/T4 eq 1")
T4=T2;//temperature of low temperature reservoir in K
disp("now We-Wr=300")
disp("so Wr=We-300 in KJ")
Wr=We-300
disp("and Wr=Q4-Q3=1154.55 KJ eq 2 ")
disp("solving eq1 and eq 2 we get")
disp("Q4=(1154.55*T4)/(T4-T3)in KJ")
Q4=(1154.55*T4)/(T4-T3)
disp("and Q3=Q4-Wr in KJ")
Q3=Q4-Wr
disp("total heat transferred to low teperature reservoir(Q) =Q2+Q4 in KJ")
Q=Q2+Q4
disp("hence heat transferred to refrigerant=Q3 in KJ")
Q3
disp("and heat transferred to low temperature reservoir=Q in KJ")
Q
```

Scilab code Exa 4.5 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
```

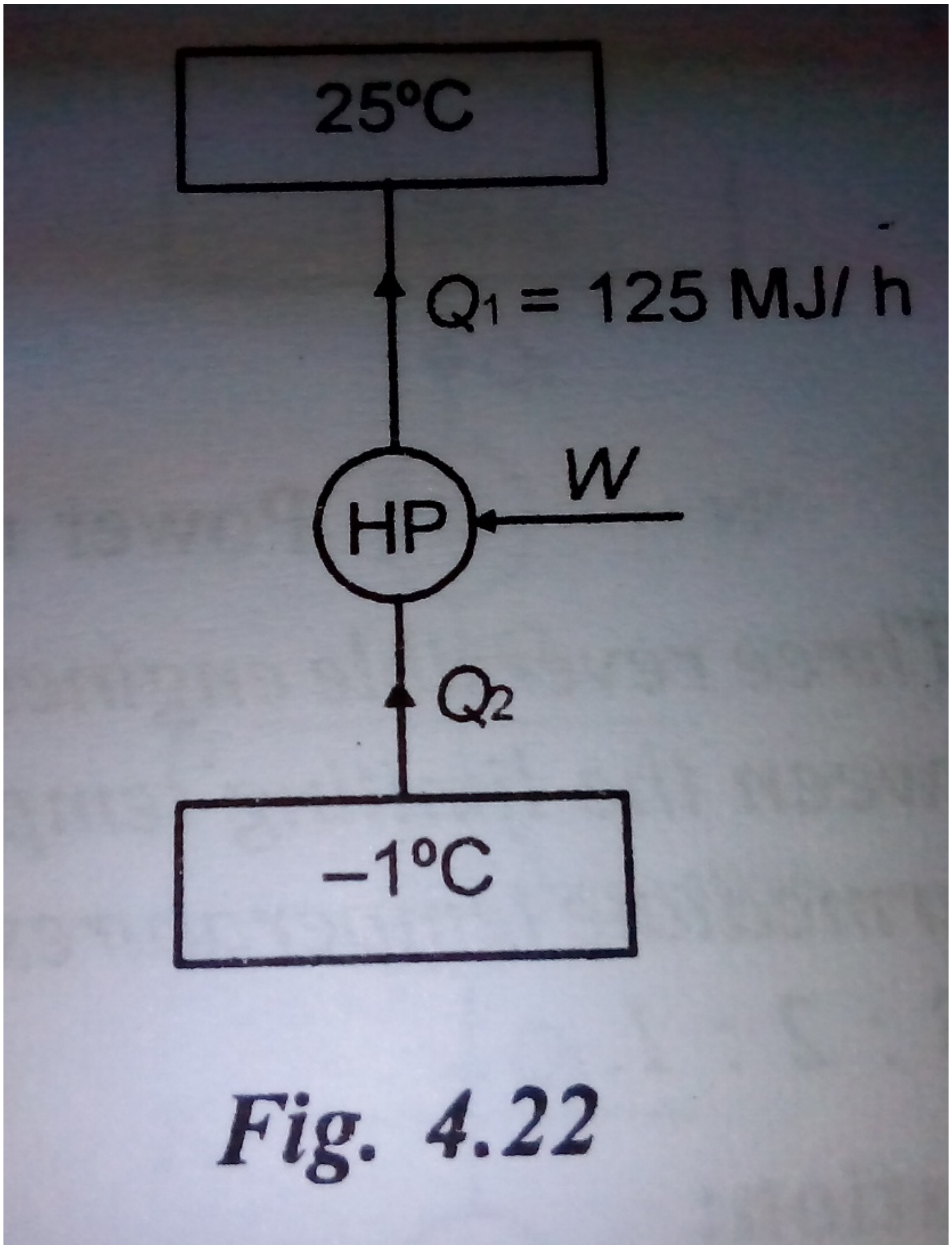

Figure 4.4: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 5

```
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 4 Example 5")
T1=(25+273.15);//temperature of inside of house in K
T2=(-1+273.15);//outside temperature in K
Q1=125;//heating load in MJ/Hr
disp("COP_HP=Q1/W=Q1/(Q1-Q2)=1/(1-(Q2/Q1))")
disp("also we know K=Q1/Q2=T1/T2")
disp("so K=T1/T2")
K=T1/T2
disp("so COP_HP=1/(1-(Q2/Q1)=1/(1-(1/K))")
COP_HP=1/(1-(1/K))
disp("also COP_HP=Q1/W")
disp("W=Q1/COP_HP in MJ/Hr")
W=Q1/COP_HP
disp("or W=1000*W/3600 in KW")
W=1000*W/3600
disp("so minimum power required(W)in KW ")
W
```

Scilab code Exa 4.6 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 4 Example 6")
T1=(-15+273.15);//inside temperature in K
```

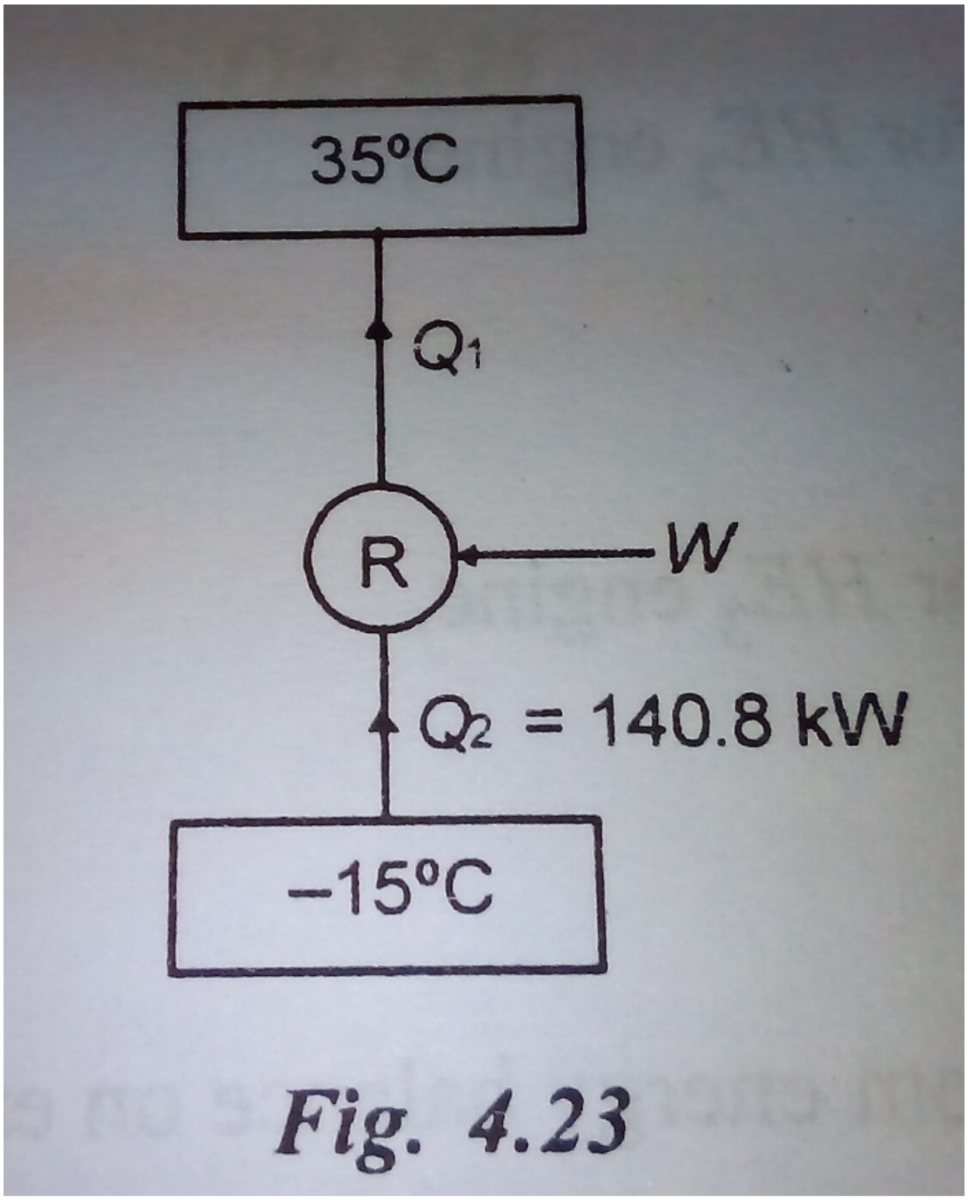

Figure 4.5: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 6

```
T2=(35+273);//atmospheric temperature in K
Q2=40;//refrigeration capacity of storage plant in tonnes
disp("cold storage plant can be considered as refrigerator operating between given temperatures limits")
disp("capacity of plant=heat to be extracted=Q2 in KW")
disp("we know that,one ton of refrigeration as 3.52 KW ")
disp("so Q2=Q2*3.52 in KW")
Q2=Q2*3.52
disp("carnot COP of plant(COP_carnot)=1/((T2/T1)-1)")
COP_carnot=1/((T2/T1)-1)
disp("performance is 1/4 of its carnot COP")
disp("COP=COP_carnot/4")
COP=COP_carnot/4
disp("also actual COP=Q2/W")
disp("W=Q2/COP in KW")
W=Q2/COP
disp("hence power required(W)in KW")
W
```

Scilab code Exa 4.7 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 4 Example 7")
```

```
T1=(1150+273);//temperature of source in K
T2=(27+273);//temperature of sink in K
disp("highest efficiency is that of carnot engine,so
    let us find the carnot cycle efficiency for
   given temperature limits")
disp("n=1-(T2/T1)")
n=1-(T2/T1)
disp("or n=n*100 %")
n=n*100
```

Scilab code Exa 4.8 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 8")
T1=(27+273);//temperature of source in K
T2=(-8+273);//temperature of sink in K
Q=7.5;//heat leakage in KJ/min
disp("here heat to be removed continuously from
   refrigerated space(Q)in KJ/s")
Q=Q/60
disp("for refrigerated ,COP shall be Q/W=1/((T1/T2)
   -1)")
disp("W=Q*((T1/T2)-1) in KW")
W=Q*((T1/T2)-1)
disp("so power required(W)in KW")
W
```

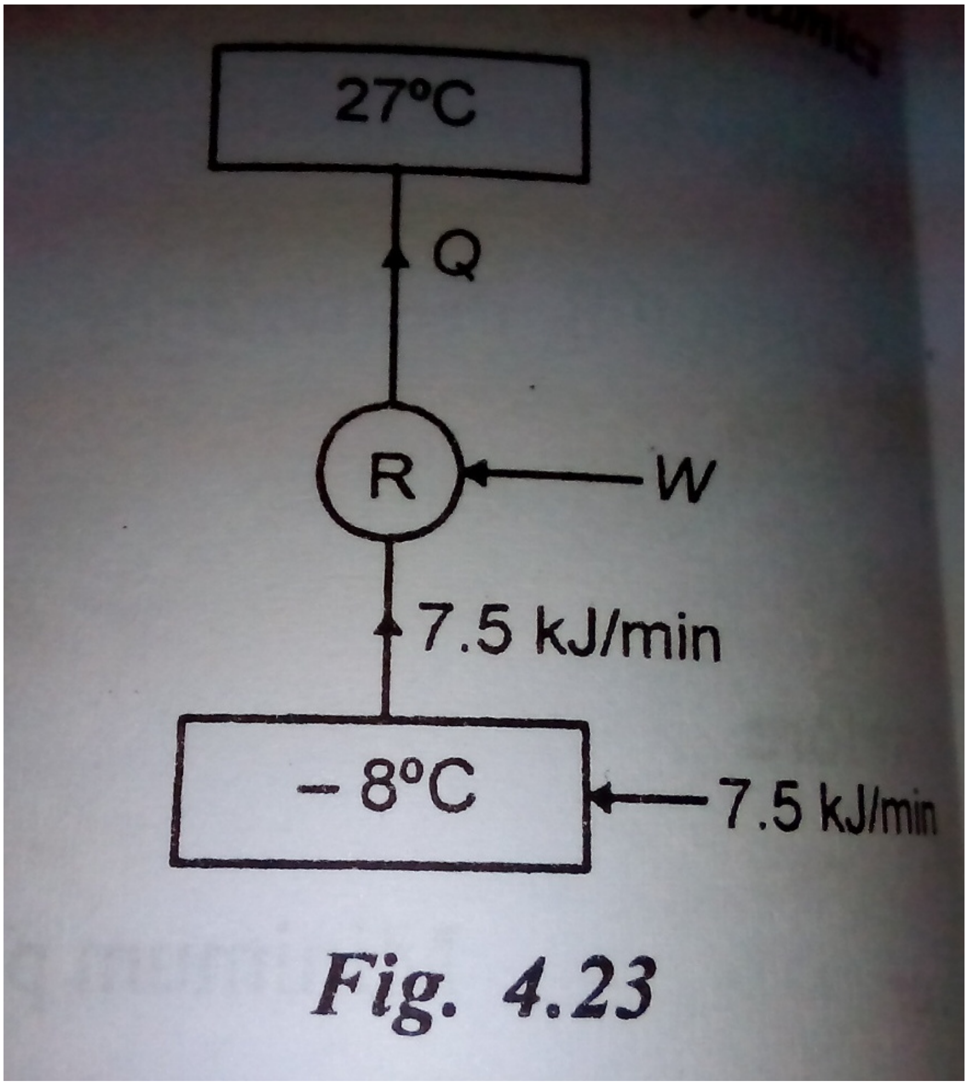

Figure 4.6: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 8

Scilab code Exa 4.9 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 9")
T1=1100;//temperature of high temperature reservoir
   in K
T4=300;//temperature of low temperature reservoir in
    K
disp("here W1:W2:W3=3:2:1")
disp("efficiency of engine,HE1,")
disp("W1/Q1=(1-(T2/1100))")
disp("so Q1=(1100*W1)/(1100-T2)")
disp("for HE2 engine,W2/Q2=(1-(T3/T2))")
disp("for HE3 engine,W3/Q3=(1-(300/T3))")
disp("from energy balance on engine,HE1")
disp("Q1=W1+Q2=>Q2=Q1-W1")
disp("above gives,Q1=(((1100*W1)/(1100-T2))-W1)=W1*(
   T2/(1100-T2))")
disp("substituting Q2 in efficiency of HE2")
disp("W2/(W1*(T2/(1100-T2)))=1-(T3/T2)")
disp("W2/W1=(T2/(1100-T2))*(T2-T3)/T2=((T2-T3)
   /(1100-T2))")
disp("2/3=(T2-T3)/(1100-T2)")
disp("2200-2*T2=3*T2-3*T3")
disp("5*T2-3*T3=2200")
```

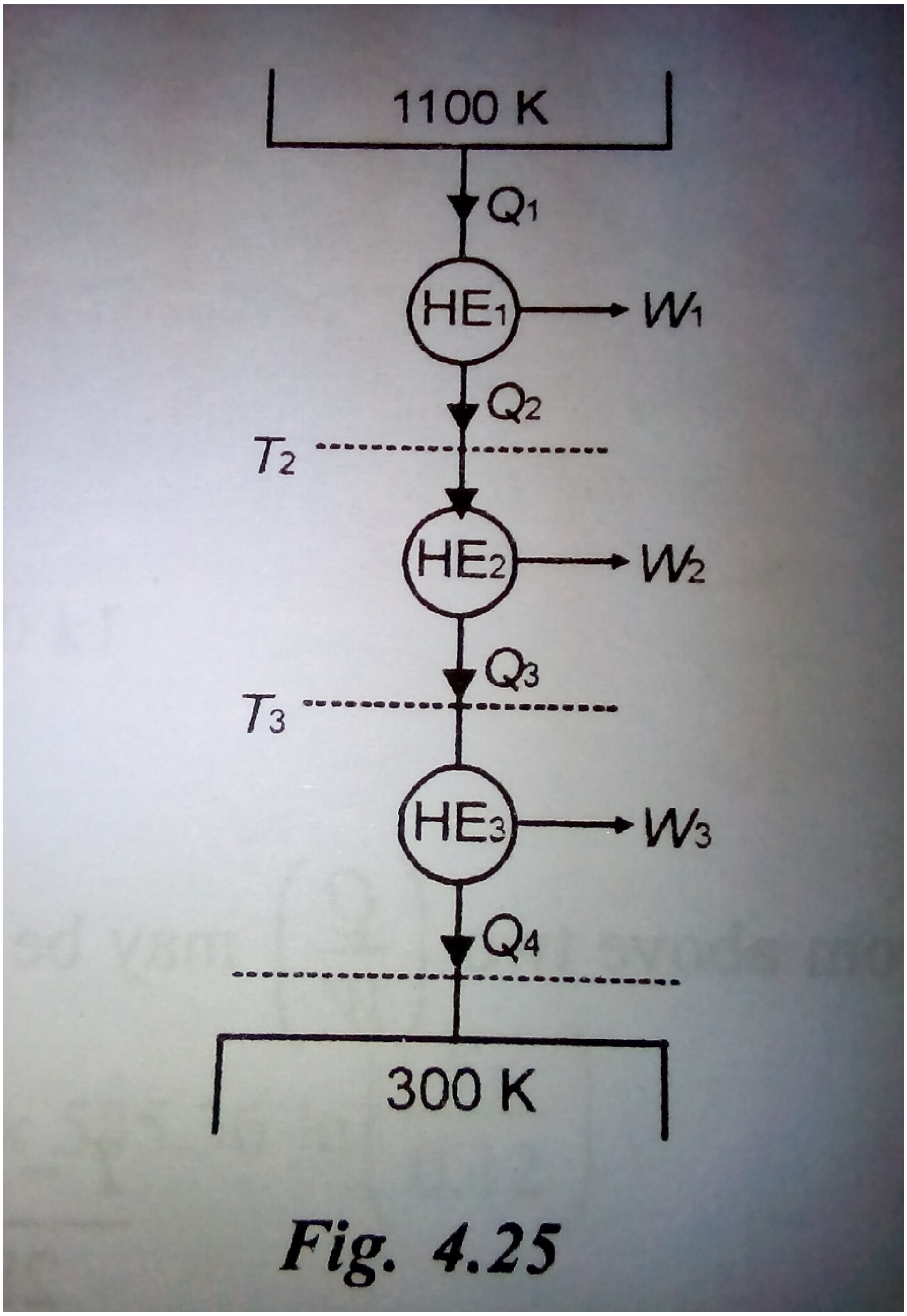

Figure 4.7: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 9

```
disp("now energy balance on engine HE2 gives,Q2=W2+Q3")
disp("substituting in efficiency of HE2,")
disp("W2/(W2+Q3)=(T2-T3)/T2")
disp("W2*T2=(W2+Q3)*(T2-T3)")
disp("Q3=(W2*T3)/(T2-T3)")
disp("substituting Q3 in efficiency of HE3,")
disp("W3/((W2*T3)/(T2-T3))=(T3-300)/T3")
disp("W3/W2=(T3/(T2-T3))*(T3-300)/T3")
disp("1/2=(T3-300)/(T2-T3)")
disp("3*T3-T2=600")
disp("solving equations of T2 and T3,")
disp("we get,T3=(600+(2200/5))/(3-(3/5))in K")
T3=(600+(2200/5))/(3-(3/5))
disp("and by eq 5,T2 in K")
T2=(2200+3*T3)/5
disp("so intermediate temperature are 700 K and 433.33 K")
```

Scilab code Exa 4.10 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 4 Example 10")
T1=800;//temperature of source in K
T2=280;//temperature of sink in K
disp("efficiency of engine,W/Q1=(800-T)/800")
```

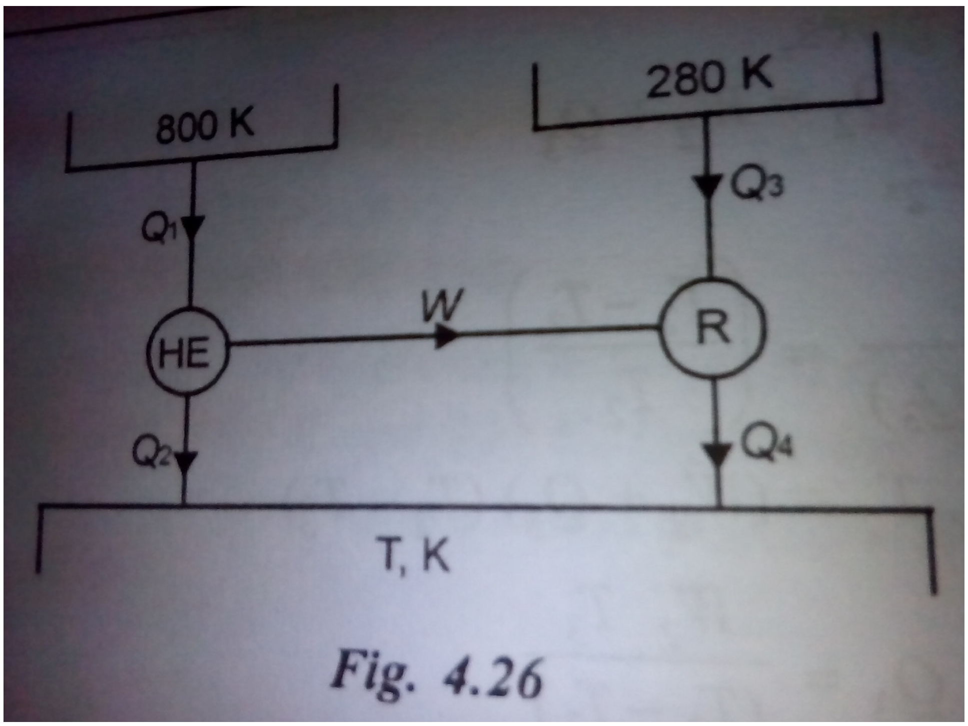

Figure 4.8: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 10

```
disp("for refrigerator ,COP=Q3/W=280/(T-280)")
disp("it is given that Q1=Q3=Q")
disp("so ,from engine ,W/Q=(800-T)/800")
disp("from refrigerator ,Q/W=280/(T-280)")
disp("from above two(Q/W)may be equated ,")
disp("(T-280)/280=(800-T)/800")
T=2*280*800/(800+280)
disp("so temperature(T)in K")
T
disp("efficiency of engine(n)is given as")
disp("n=(800-T)/800")
n=(800-T)/800
disp("COP of refrigerator is given as")
disp("COP=280/(T-280)")
COP=280/(T-280)
```

Scilab code Exa 4.11 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 11")
n_carnot=0.5;//efficiency of carnot power cycle
m=0.5;//mass of air in kg
p2=7*10^5;//final pressure in pa
v2=0.12;//volume in m^3
R=287;//gas constant in J/kg K
Q_23=40*1000;//heat transfer to the air during
```

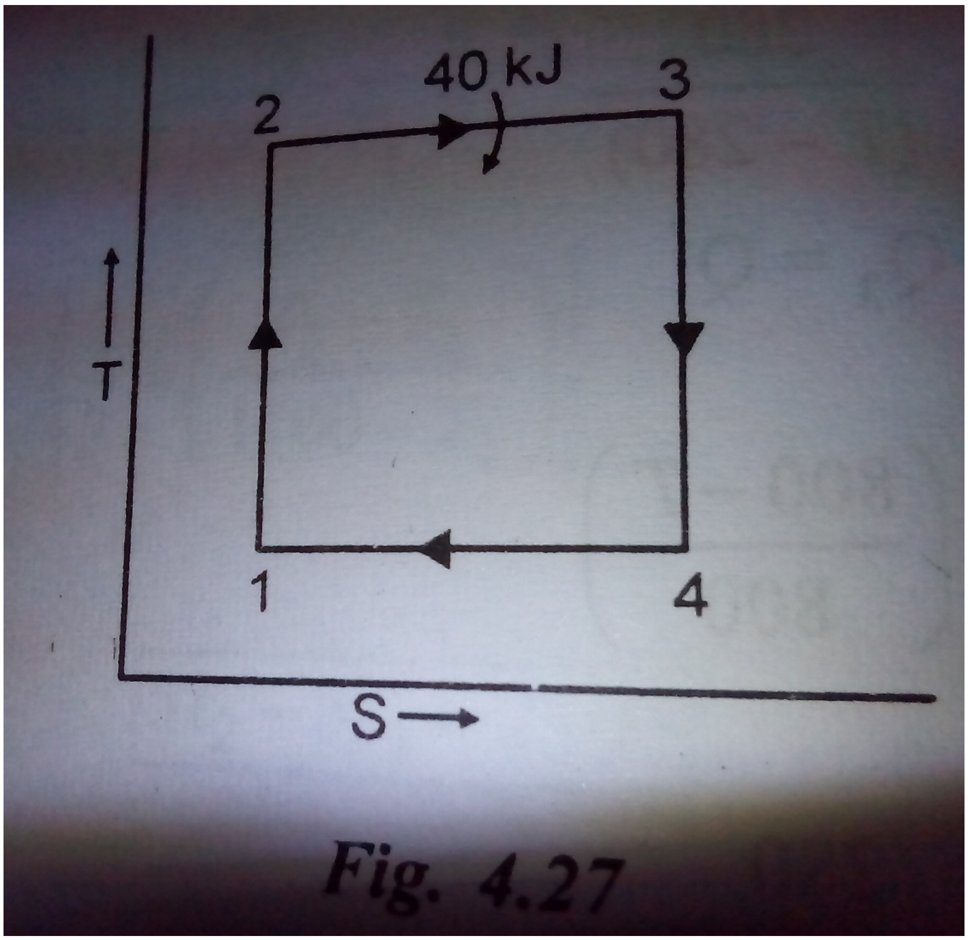

Figure 4.9: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 11

```
    isothermal expansion in J
Cp=1.008;//specific heat at constant pressure in KJ/kg K
Cv=0.721;//specific heat at constant volume in KJ/kg K
disp("let thermodynamic properties be denoted with respect to salient states;")
disp("n_carnot=1-T1/T2")
disp("so T1/T2=1-0.5")
1-0.5
disp("so T1/T2=0.5")
disp("or T2=2*T1")
disp("corresponding to state 2,p2*v2=m*R*T2")
disp("so temperature(T2)=p2*v2/(m*R) in K")
T2=p2*v2/(m*R)
disp("heat transferred during process 2-3(isothermal expansion),Q_23=40 KJ")
disp("Q_23=W_23=p2*v2*log(v3/v2)")
disp("so volume(v3)=v2*exp(Q_23/(p2*v2)) in m^3")
v3=v2*exp(Q_23/(p2*v2))
disp("temperature at state 1,T1=T2/2 in K")
T1=T2/2
disp("during process 1-2,T2/T1=(p2/p1)^((y-1)/y)")
disp("here expansion constant(y)=Cp/Cv")
y=Cp/Cv
disp("so pressure(p1)=p2/(T2/T1)^(y/(y-1)) in pa")
p1=p2/(T2/T1)^(y/(y-1))
disp("p1 in bar")
p1=p1/10^5
disp("thus p1*v1=m*R*T1")
disp("so volume(v1)=m*R*T1/(p1*10^5) in m^3")
v1=m*R*T1/(p1*10^5)
disp("heat transferred during process 4-1(isothermal compression)shall be equal to the heat transferred during process2-3(isothermal expansion).")
disp("for isentropic process,dQ=0,dW=dU")
disp("during process 1-2,isentropic process,W_12=-m*
```

```
   Cv*(T2-T1) in KJ")
disp("Q_12=0,")
W_12=-m*Cv*(T2-T1)
disp("W_12=-105.51 KJ(-ve work)")
disp("during process 3-4,isentropic process,W_34=-m*
   Cv*(T4-T3) in KJ")
disp("Q_31=0,")
T4=T1;
T3=T2;
W_34=-m*Cv*(T4-T3)
disp("ANS:")
disp("W_34=+105.51 KJ(+ve work)")
disp("so for process 1-2,heat transfer=0,work
   interaction=-105.51 KJ")
disp("for process 2-3,heat transfer=40 KJ,work
   intercation=40 KJ")
disp("for process 3-4,heat transfer=0,work
   interaction=+105.51 KJ")
disp("for process 4-1,heat transfer=-40 KJ,work
   interaction=-40 KJ")
disp("maximum temperature of cycle=585.36 KJ")
disp("minimum temperature of cycle=292.68 KJ")
disp("volume at the end of isothermal expansion
   =0.1932 m^3")
```

Scilab code Exa 4.12 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
```

```
Chapter 4 Example 12")
W=840;//work done by reservoir in KJ
disp("let us assume that heat engine rejects Q2 and Q3 heat to reservior at 300 K and 200 K respectively.let us assume that there are two heat engines operating between 400 K and 300 K temperature reservoirs and between 400 K and 200 K temperature reservoirs.let each heat engine receive Q1_a and Q1_b from reservoir at 400 K as shown below")
disp("thus,Q1_a+Q1_b=Q1=5*10^3 KJ...............eq1")
disp("Also,Q1_a/Q2=400/300,or Q1_a=4*Q2/3...............eq2")
disp("Q1_b/Q3=400/200 or Q1_b=2*Q3...............eq3")
disp("substituting Q1_a and Q1_b in eq 1")
disp("4*Q2/3+2*Q3=5000...............eq4")
disp("also from total work output,Q1_a+Q1_b-Q2-Q3=W")
disp("5000-Q2-Q3=840")
disp("so Q2+Q3=5000-840=4160")
disp("Q3=4160-Q2")
disp("sunstituting Q3 in eq 4")
disp("4*Q2/3+2*(4160-Q2)=5000")
disp("so Q2=(5000-2*4160)/((4/3)-2) in KJ")
Q2=(5000-2*4160)/((4/3)-2)
disp("and Q3=4160-Q2 in KJ")
Q3=4160-Q2
disp("here negative sign with Q3 shows that the assumed direction of heat is not correct and actually Q3 heat will flow from reservoir to engine.actual sign of heat transfers and magnitudes are as under:")
disp("Q2=4980 KJ,from heat engine")
disp("Q3=820 KJ,to heat engine")
```

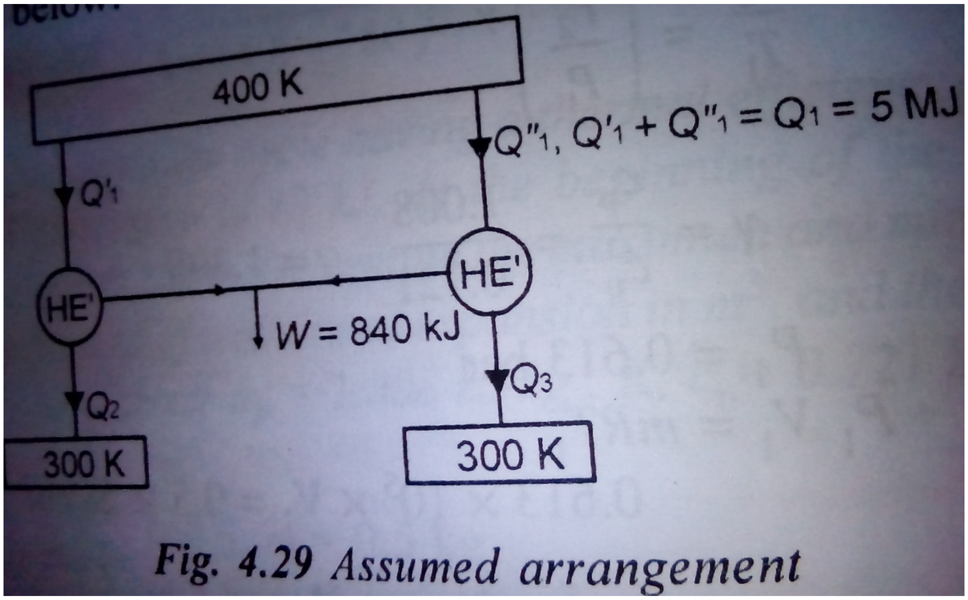

Figure 4.10: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 12

Scilab code Exa 4.13 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);1
clear;
clc;
```

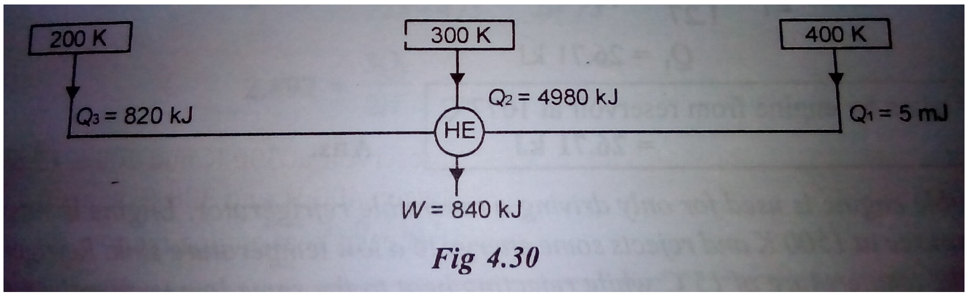

Figure 4.11: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 12

```
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 13")
T2=(77+273);//temperature of reservoir 2
T1=(1077+273);//temperature of reservoir 1
T3=(3+273);//temperature of reservoir 3
disp("arrangement for heat pump and heat engine
   operating togrther is shown here.engine and pump
   both reject heat to reservoir at 77 degree
   celcius(350 K)")
disp("for heat engine")
disp("ne=W/Q1=1-T2/T1")
disp("so (Q1-Q2)/Q1=")
1-T2/T1
disp("and Q2/Q1=")
1-0.7407
disp("Q2=0.2593*Q1")
disp("for heat pump,")
disp("COP_HP=Q4/(Q4-Q3)=T4/(T4-T3)")
T4=T2;
T4/(T4-T3)
disp("Q4/Q3=")
4.73/3.73
disp("Q4=1.27*Q3")
disp("work output from engine =work input to pump")
disp("Q1-Q2=Q4-Q3=>Q1-0.2593*Q1=Q4-Q4/1.27")
disp("so Q4/Q1=")
```

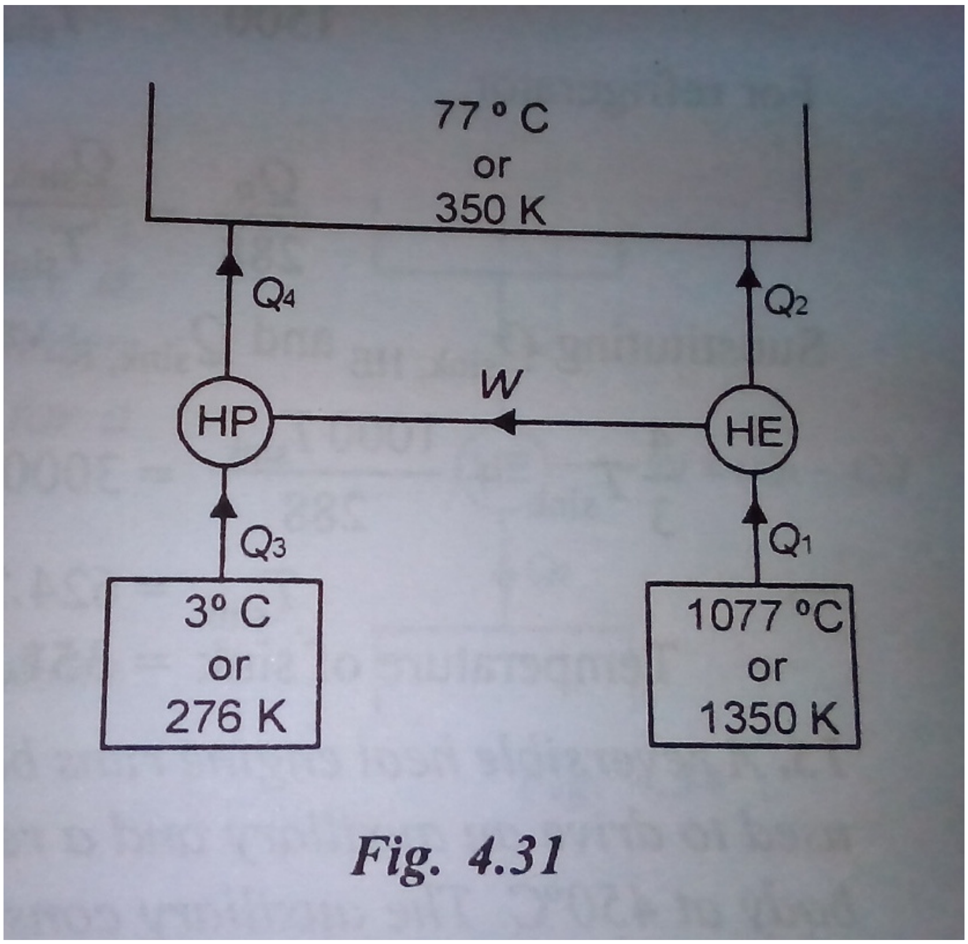

Figure 4.12: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 13

```
(1-0.2593)/(1-(1/1.27))
disp("so Q4=3.484*Q1")
disp("also it is given that Q2+Q4=100")
disp("subtituting Q2 and Q4 as function of Q1 in
   following expression,")
disp("Q2+Q4=100")
disp("so 0.2539*Q1+3.484*Q1=100")
disp("so energy taken by engine from reservoir at
   1077 degree celcius(Q1)in KJ")
disp("Q1=100/(0.2539+3.484)in KJ")
Q1=100/(0.2539+3.484)
disp("NOTE=>In this question expression for
   calculating Q1 is written wrong in book which is
   corrected above.")
```

Scilab code Exa 4.14 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 14")
Q_source=2000;//heat supplied by heat engine in KJ/s
T_source=1500;//temperature of source in K
T_R=(15+273);//temperature of reservoir in K
Q_sink=3000;//heat received by sink in KJ/s
disp("let temperature of sink be T_sink K")
disp("Q_sink_HE+Q_sink_R=3000 ........eq 1")
disp("since complete work output from engine is used
```

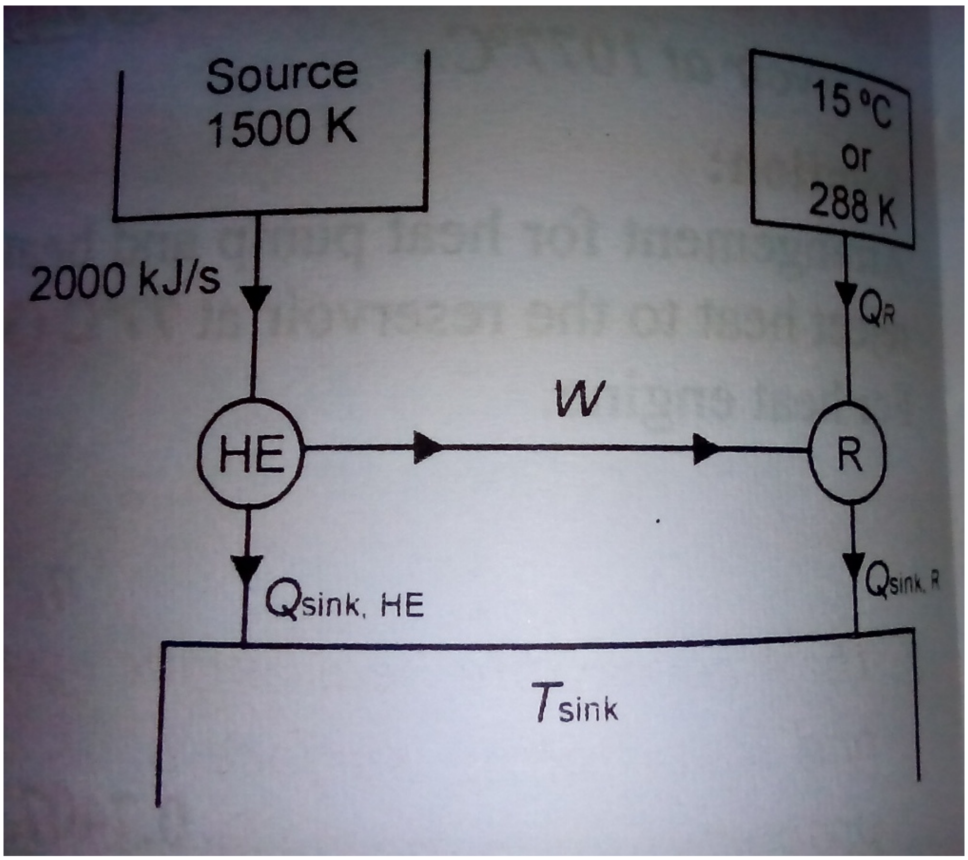

Figure 4.13: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 14

```
    to run refrigerator so,")
disp("2000-Q_sink_HE=Q_sink_R-Q_R .........eq 2")
disp("by eq 1 and eq 2,we get Q_R in KJ/s")
Q_R=3000-2000
disp("also for heat engine,2000/1500=Q_sink_HE/
    T_sink")
disp("=>Q_sink_HE=4*T_sink/3")
disp("for refrigerator,Q_R/288=Q_sink_R/T_sink=>
    Q_sink_R=1000*T_sink/288")
disp("substituting Q_sink_HE and Q_sink_R values")
disp("4*T_sink/3+1000*T_sink/288=3000")
disp("so temperature of sink(T_sink)in K")
disp("so T_sink=3000/((4/3)+(1000/288))")
T_sink=3000/((4/3)+(1000/288))
disp("T_sink in degree celcius")
T_sink=T_sink-273
```

Scilab code Exa 4.15 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 4 Example 15")
T1=(500+273);//temperature of source in K
T2=(200+273);//temperature of sink in K
T3=(450+273);//temperature of body in K
disp("let the output of heat engine be W.so W/3 is
    consumed for driving auxiliary and remaining 2*W
```

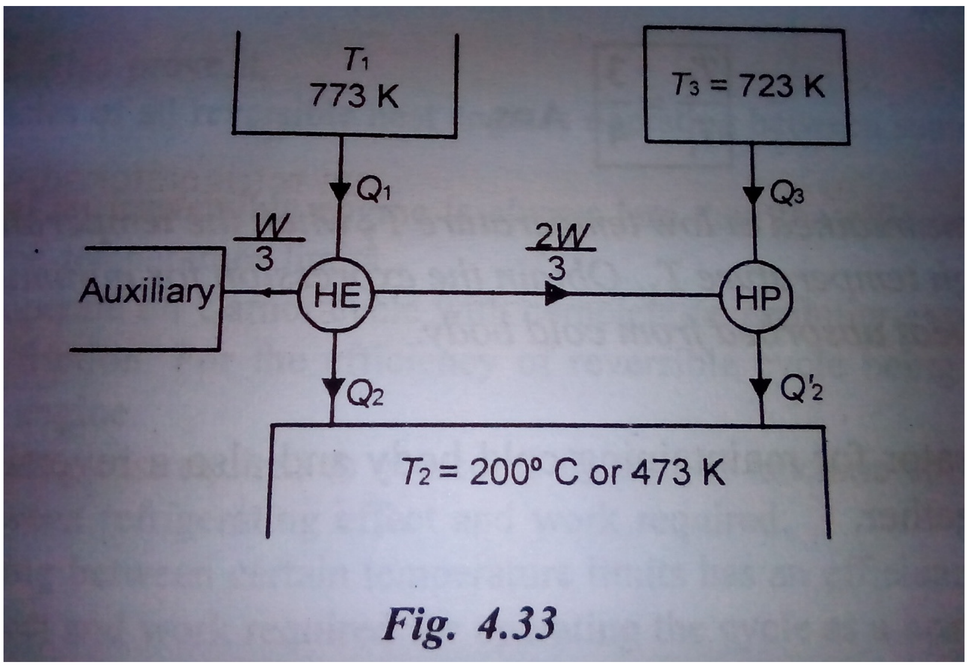

Figure 4.14: Engineering Thermodynamics by Onkar Singh Chapter 4 Example 15

```
   /3 is consumed for driving heat pump for heat
   engine,")
disp("n=W/Q1=1-(T2/T1)")
n=1-(T2/T1)
disp("so n=W/Q1=0.3881")
disp("COP of heat pump=T3/(T3-T2)=Q3/(2*W/3)")
COP=T3/(T3-T2)
disp("so 2.892=3*Q3/2*W")
disp("Q3/Q1=")
2*COP*n/3
disp("so ratio of heat rejected to body at 450
   degree celcius to the heat supplied by the
   reservoir=0.7482")
```

Scilab code Exa 4.16 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 16")
disp("NOTE=>In question no. 16,condition for minimum
    surface area for a given work output is
   determine which cannot be solve using scilab
   software.")
```

Scilab code Exa 4.17 Engineering Thermodynamics by Onkar Singh Chapter 4 Example 17

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 4 Example 17")
disp("NOTE=>In question no. 17 expression for (
   minimum theoretical ratio of heat supplied from
   source to heat absorbed from cold body) is
   derived which cannot be solve using scilab
   software.")
```

Chapter 5

Entropy

Scilab code Exa 5.1 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 1")
p1=5;//initial pressure of air
T1=(27+273);//temperature of air in K
p2=2;//final pressure of air in K
R=0.287;//gas constant in KJ/kg K
Cp_air=1.004;//specific heat of air at constant pressure in KJ/kg K
disp("entropy change may be given as,")
disp("s2-s1=((Cp_air*log(T2/T1)-(R*log(p2/p1))")
disp("here for throttling process h1=h2=>Cp_air*T1=Cp_air*T2=>T1=T2")
disp("so change in entropy(deltaS)in KJ/kg K")
disp("deltaS=(Cp_air*log(1))-(R*log(p2/p1))")
```

```
deltaS=(Cp_air*log(1))-(R*log(p2/p1))
```

Scilab code Exa 5.2 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 5 Example 2")
T1=(27+273);//temperature of water in K
T2=(100+273);//steam temperature of water in K
m=5;//mass of water in kg
q=2260;//heat of vaporisation at 100 degree celcius
   in KJ/kg
Cp=4.2;//specific heat of water at constant pressure
    in KJ/kg K
M=18;//molar mass for water/steam
R1=8.314;//gas constant in KJ/kg K
disp("total entropy change=entropy change during
   water temperature rise(deltaS1)+entropy change
   during water to steam change(deltaS2)+entropy
   change during steam temperature rise(deltaS3)")
disp("deltaS1=Q1/T1,where Q1=m*Cp*deltaT")
disp("heat added for increasing water temperature
   from 27 to 100 degree celcius(Q1)in KJ")
disp("Q1=m*Cp*(T2-T1)")
Q1=m*Cp*(T2-T1)
disp("deltaS1=Q1/T1 in KJ/K")
deltaS1=Q1/T1
disp("now heat of vaporisation(Q2)=m*q in KJ")
Q2=m*q
```

```
disp("entropy change during phase transformation(
    deltaS2)in KJ/K")
disp("deltaS2=Q2/T2")
deltaS2=Q2/T2
disp("entropy change during steam temperature rise(
    deltaS3)in KJ/K")
disp("deltaS3=m*Cp_steam*dT/T")
disp("here Cp_steam=R*(3.5+1.2*T+0.14*T^2)*10^-3 in
    KJ/kg K")
disp("R=R1/M in KJ/kg K")
R=R1/M
T2=(100+273.15);//steam temperature of water in K
T3=(400+273.15);//temperature of steam in K
disp("now deltaS3=(m*R*(3.5+1.2*T+0.14*T^2)*10^-3)*
    dT/T in KJ/K")
function y = f(T), y =(m*R*(3.5+1.2*T+0.14*T^2)
    *10^-3)/T , endfunction
deltaS3 = intg(T2, T3, f)
disp("total entropy change(deltaS)=deltaS1+deltaS2+
    deltaS3 in KJ/K")
deltaS3=51.84;//approximately
deltaS=deltaS1+deltaS2+deltaS3
```

Scilab code Exa 5.3 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 5 Example 3")
R1=8.314;//gas constant in KJ/kg K
```

```
M=32;//molar mass for O2
T1=(27+273);//initial temperature of O2 in K
p1=125;//initial pressure of O2 in Kpa
p2=375;//final pressure of O2 in Kpa
Cp=1.004;//specific heat of air at constant pressure
    in KJ/kg K
disp("gas constant for oxygen(R)in KJ/kg K")
disp("R=R1/M")
R=R1/M
disp("for reversible process the change in entropy
    may be given as")
disp("deltaS=(Cp*log(T2/T1))-(R*log(p2/p1))in KJ/kg
    K")
T2=T1;//isothermal process
deltaS=(Cp*log(T2/T1))-(R*log(p2/p1))
disp("so entropy change=deltaS in KJ/kg K")
deltaS
```

Scilab code Exa 5.4 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 5 Example 4")
T1=(150+273.15);//temperature of copper block in K
T2=(25+273.15);//temperature of sea water in K
m=1;//mass of copper block in kg
C=0.393;//heat capacity of copper in KJ/kg K
disp("entropy change in universe(deltaS_universe)=
    deltaS_block+deltaS_water")
```

```
disp("where deltaS_block=m*C*log(T2/T1)")
disp("here hot block is put into sea water,so block shall cool down upto sea water at 25 degree celcius as sea may be treated as sink")
disp("therefore deltaS_block=m*C*log(T2/T1)in KJ/K")
deltaS_block=m*C*log(T2/T1)
disp("heat loss by block =heat gained by water(Q)in KJ")
disp("Q=-m*C*(T1-T2)")
Q=-m*C*(T1-T2)
disp("therefore deltaS_water=-Q/T2 in KJ/K")
deltaS_water=-Q/T2
disp("thus deltaS_universe=(deltaS_block+deltaS_water)*1000 in J/K")
deltaS_universe=(deltaS_block+deltaS_water)*1000
```

Scilab code Exa 5.5 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 5")
m=1;//mass of copper block in kg
T=(27+273);//temperature of copper block in K
h=200;//height from which copper block dropped in sea water in m
C=0.393;//heat capacity for copper in KJ/kg K
g=9.81;//acceleration due to gravity in m/s^2
disp("deltaS_universe=(deltaS_block+deltaS_seawater)")
```

```
disp("since block and sea water both are at same temperature so,")
disp("deltaS_universe=deltaS_seawater")
disp("conservation of energy equation yields,")
disp("Q-W=deltaU+deltaP.E+deltaK.E")
disp("since in this case,W=0,deltaK.E=0,deltaU=0")
disp("Q=deltaP.E")
disp("change in potential energy=deltaP.E=m*g*h in J")
deltaPE=m*g*h
Q=deltaPE
disp("deltaS_universe=deltaS_seawater=Q/T in J/kg K")
deltaS_universe=Q/T
disp("entropy change of universe(deltaS_universe)in J/kg K")
deltaS_universe
```

Scilab code Exa 5.6 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 6")
m1=1;//mass of first copper block in kg
m2=0.5;//mass of second copper block in kg
T1=(150+273.15);//temperature of first copper block in K
T2=(0+273.15);//temperature of second copper block in K
```

```
Cp_1=0.393;//heat capacity for copper block 1 in KJ/
    kg K
Cp_2=0.381;//heat capacity for copper block 2 in KJ/
    kg K
disp("here deltaS_universe=deltaS_block1+
    deltaS_block2")
disp("two blocks at different temperatures shall
    first attain equilibrium temperature.let
    equilibrium temperature be Tf")
disp("then from energy conservation")
disp("m1*Cp_1*(T1-Tf)=m2*Cp_2*(Tf-T2)")
disp("Tf=((m1*Cp_1*T1)+(m2*Cp_2*T2))/(m1*Cp_1+m2*
    Cp_2)in K")
Tf=((m1*Cp_1*T1)+(m2*Cp_2*T2))/(m1*Cp_1+m2*Cp_2)
disp("hence,entropy change in block 1(deltaS1),due
    to temperature changing from Tf to T1")
disp("deltaS1=m1*Cp_1*log(Tf/T1)in KJ/K")
deltaS1=m1*Cp_1*log(Tf/T1)
disp("entropy change in block 2(deltaS2)in KJ/K")
disp("deltaS2=m2*Cp_2*log(Tf/T2)")
deltaS2=m2*Cp_2*log(Tf/T2)
disp("entropy change of universe(deltaS)=deltaS1+
    deltaS2 in KJ/K")
deltaS=deltaS1+deltaS2
```

Scilab code Exa 5.7 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
```

```
Chapter 5 Example 7")
disp("NOTE=>in this question formula is derived
    which cannot be solve using scilab software")
```

Scilab code Exa 5.8 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 5 Example 8")
T1=1800;//temperature of high temperature reservoir
    in K
T2=300;//temperature of low temperature reservoir in
     K
Q1=5;//heat addition in MW
W=2;//work done in MW
disp("for irreversible operation of engine,")
disp("rate of entropy generation=Q1/T1+Q2/T2")
disp("W=Q1-Q2=>Q2=Q1-W in MW")
Q2=Q1-W
disp("entropy generated(deltaS_gen)in MW")
disp("deltaS_gen=Q1/T1+Q2/T2")
Q1=-5;//heat addition in MW
deltaS_gen=Q1/T1+Q2/T2
disp("work lost(W_lost)in MW")
disp("W_lost=T2*deltaS_gen")
W_lost=T2*deltaS_gen
```

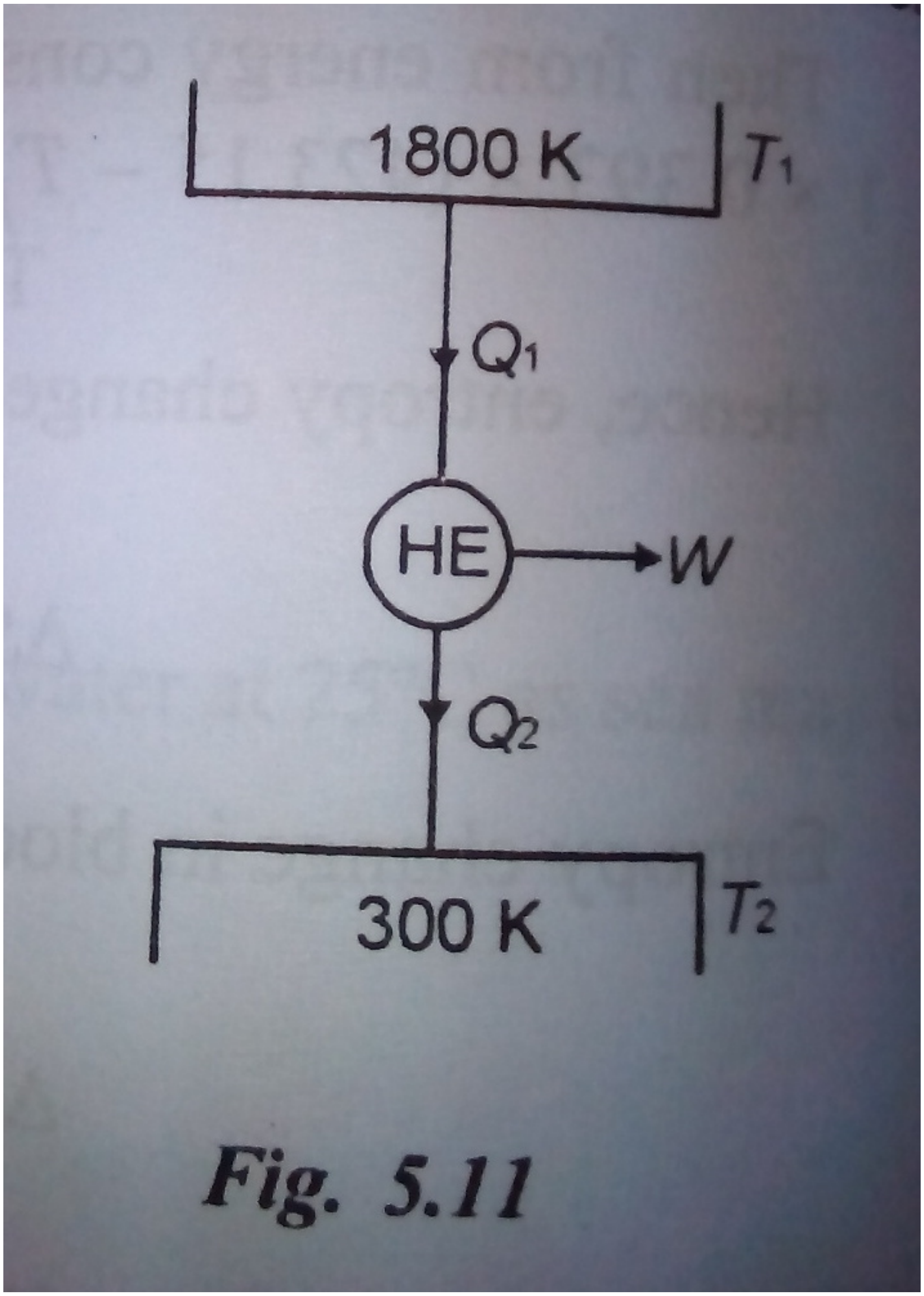

Figure 5.1: Engineering Thermodynamics by Onkar Singh Chapter 5 Example 8

Scilab code Exa 5.9 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 9")
T1=500;//temperature of system in K
T2=300;//temperature of reservoir in K
disp("system and reservoir can be treated as source and sink.device thought of can be a carnot engine operating between these two limits.maximum heat available from system shall be the heat rejected till its temperature drops from 500 K to 300 K")
disp("therefore,maximum heat(Q1)=(C*dT)in J")
disp("here C=0.05*T^2+0.10*T+0.085 in J/K")
disp("so Q1=(0.05*T^2+0.10*T+0.085)*dT")
function y = f(T), y = (0.05*T^2+0.10*T+0.085), endfunction
Q1 = intg(T1, T2, f)
Q1=-Q1
disp("entropy change of system,deltaS_system=C*dT/T in J/K")
disp("so deltaS_system=(0.05*T^2+0.10*T+0.085)*dT/T")
function y = k(T), y = (0.05*T^2+0.10*T+0.085)/T, endfunction
deltaS_system = intg(T1, T2, k)
```

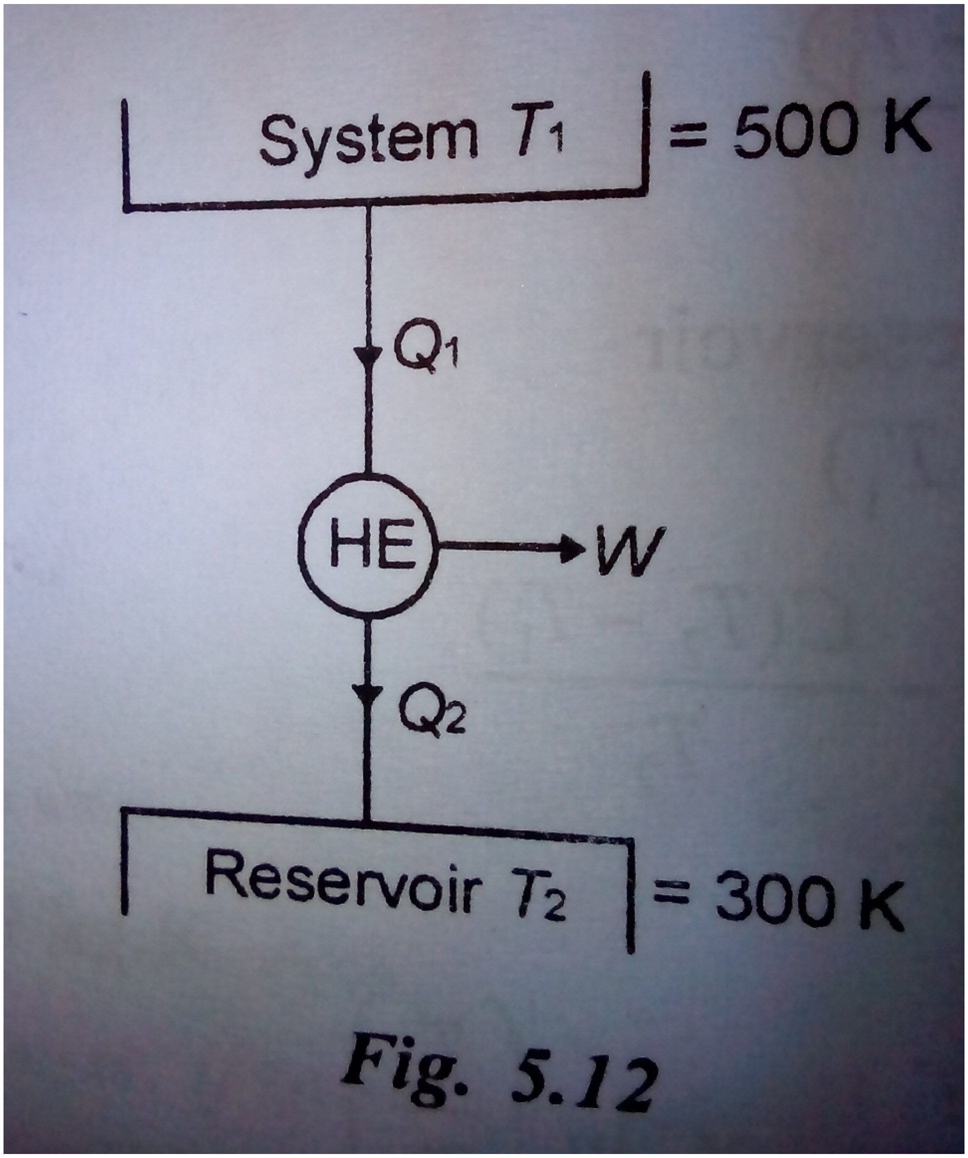

Figure 5.2: Engineering Thermodynamics by Onkar Singh Chapter 5 Example 9

```
disp("deltaS_reservoir=Q2/T2=(Q1-W)/T2")
disp("also,we know from entropy principle,
    deltaS_universe is greater than equal to 0")
disp("deltaS_universe=deltaS_system+deltaS_reservoir
    ")
disp("thus,upon substituting,deltaS_system+
    deltaS_reservoir is greater than equal to 0")
disp("W is less than or equal to(Q1+deltaS_system*T2
    )/1000 in KJ")
W=(Q1+deltaS_system*T2)/1000
disp("hence maximum work=W in KJ")
W
```

Scilab code Exa 5.10 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 5 Example 10")
p1=3;//initial pressure in Mpa
v1=0.05;//initial volume in m^3
v2=0.3;//final volume in m^3
disp("for reversible adiabatic process governing
    equation for expansion,")
disp("P*V^1.4=constant")
disp("also,for such process entropy change=0")
disp("using p2/p1=(v1/v2)^1.4 or v=(p1*(v1^1.4)/p)
    ^(1/1.4)")
disp("final pressure(p2)in Mpa")
disp("p2=p1*(v1/v2)^1.4")
```

```
p2=p1*(v1/v2)^1.4
disp("from first law,second law and definition of
   enthalpy;")
disp("dH=T*dS+v*dP")
disp("for adiabatic process of reversible type,dS=0"
   )
dS=0;//for adiabatic process of reversible type
disp("so dH=v*dP")
disp("integrating both side H2-H1=deltaH=v*dP in KJ"
   )
p1=3*1000;//initial pressure in Kpa
p2=244;//final pressure in Kpa
disp("so enthalpy change(deltaH)in KJ")
function y = f(p), y =(p1*(v1^1.4)/p)^(1/1.4),
   endfunction
deltaH = intg(p2, p1, f)
disp("and entropy change=0")
```

Scilab code Exa 5.11 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 5 Example 11")
m=2;//mass of air in kg
v1=1;//initial volume of air in m^3
v2=10;//final volume of air in m^3
R=287;//gas constant in J/kg K
disp("during free expansion temperature remains same
    and it is an irreversible process.for getting
```

```
change in entropy let us approximate this expansion process as a reversible isothermal expansion")
disp("a> change in entropy of air(deltaS_air)in J/K")
disp("deltaS_air=m*R*log(v2/v1)")
deltaS_air=m*R*log(v2/v1)
disp("b> during free expansion on heat is gained or lost to surrounding so,")
disp("deltaS_surrounding=0")
disp("entropy change of surroundings=0")
deltaS_surrounding=0;//entropy change of surroundings
disp("c> entropy change of universe(deltaS_universe) in J/K")
disp("deltaS_universe=deltaS_air+deltaS_surrounding")
deltaS_universe=deltaS_air+deltaS_surrounding
```

Scilab code Exa 5.12 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 12")
m=0.5;//mass of air in kg
p1=1.013*10^5;//initial pressure of air in pa
p2=0.8*10^6;//final pressure of air in pa
T1=800;//initial temperature of air in K
n=1.2;//polytropic expansion constant
```

```
y=1.4;//expansion constant for air
Cv=0.71;//specific heat at constant volume in KJ/kg K
disp("let initial and final states be denoted by 1 and 2")
disp("for poly tropic process pressure and temperature can be related as")
disp("(p2/p1)^((n-1)/n)=T2/T1")
disp("so temperature after compression(T2)=T1*(p2/p1)^((n-1)/n) in K")
T2=T1*(p2/p1)^((n-1)/n)
disp("substituting in entropy change expression for polytropic process,")
disp("entropy change(deltaS)inKJ/kg K")
disp("deltaS=Cv*((n-y)/(n-1))*log(T2/T1)")
deltaS=Cv*((n-y)/(n-1))*log(T2/T1)
disp("NOTE=>answer given in book i.e -244.54 KJ/kg K is incorrect,correct answer is -.24454 KJ/kg K")
disp("total entropy change(deltaS)=m*deltaS*1000 in J/K")
deltaS=m*deltaS*1000
```

Scilab code Exa 5.13 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 13")
disp("NOTE=>In question no. 13,formula for maximum work is derived which cannot be solve using
```

```
scilab software")
```

Scilab code Exa 5.14 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 14")
Q1=500;//heat supplied by source in kcal/s
T1=600;//temperature of source in K
T2=300;//temperature of sink in K
disp("clausius inequality can be used for cyclic process as given below;consider 1 for source and 2 for sink")
disp("K=dQ/T=Q1/T1-Q2/T2")
disp("i> for Q2=200 kcal/s")
Q2=200;//heat rejected by sink in kcal/s
disp("K=Q1/T1-Q2/T2 in kcal/s K")
K=Q1/T1-Q2/T2
disp("as K is not greater than 0,therefore under these conditions engine is not possible")
disp("ii> for Q2=400 kcal/s")
Q2=400;//heat rejected by sink in kcal/s
disp("K=Q1/T1-Q2/T2 in kcal/s K")
K=Q1/T1-Q2/T2
disp("as K is less than 0,so engine is feasible and cycle is reversible")
disp("iii> for Q2=250 kcal/s")
Q2=250;//heat rejected by sink in kcal/s
disp("K=Q1/T1-Q2/T2 in kcal/s K")
```

```
K=Q1/T1-Q2/T2
disp("as K=0,so engine is feasible and cycle is
    reversible")
```

Scilab code Exa 5.15 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 5 Example 15")
p1=0.5;//initial pressure of air in Mpa
T1=400;//initial temperature of air in K
p2=0.3;//final pressure of air in Mpa
T2=350;//initial temperature of air in K
R=0.287;//gas constant in KJ/kg K
Cp=1.004;//specific heat at constant pressure in KJ/
    kg K
disp("let the two points be given as states 1 and 2,
    ")
disp("let us assume flow to be from 1 to 2")
disp("so entropy change(deltaS1_2)=s1-s2=Cp*log(T1/
    T2)-R*log(p1/p2)in KJ/kg K")
deltaS1_2=Cp*log(T1/T2)-R*log(p1/p2)
disp("deltaS1_2=s1-s2=0.01254 KJ/kg K")
disp("it means s2 > s1 hence the assumption that
    flow is from 1 to 2 is correct as from second law
     of thermodynamics the entropy increases in a
    process i.e s2 is greater than or equal to s1")
disp("hence flow occurs from 1 to 2 i.e from 0.5 MPa
    ,400K to 0.3 Mpa & 350 K")
```

Scilab code Exa 5.16 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 5 Example 16")
disp("NOTE=>In question no. 16,value of n is derived
    which cannot be solve using scilab software.")
```

Scilab code Exa 5.17 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 17

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 5 Example 17")
Q12=1000;//heat added during process 1-2 in KJ
Q34=800;//heat added during process 3-4 in KJ
T1=500;//operating temperature for process 1-2
T3=400;//operating temperature for process 3-4
```

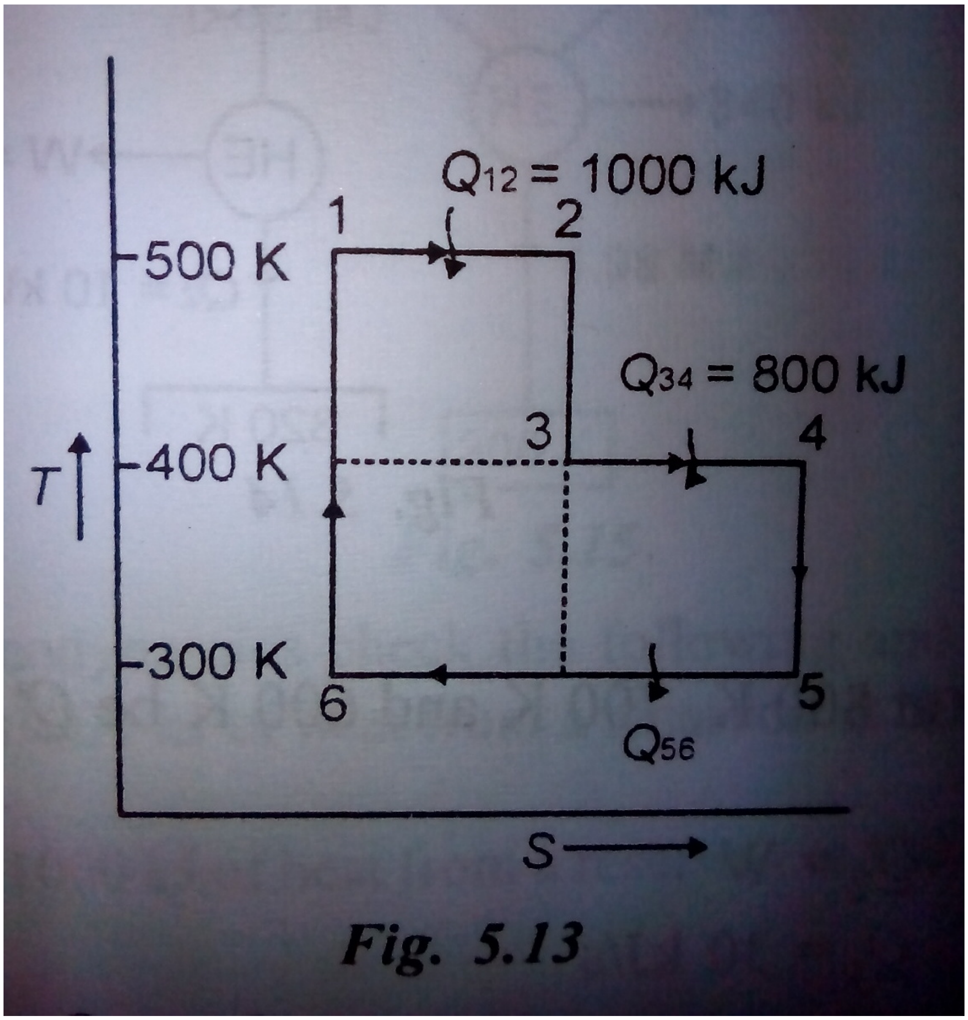

Figure 5.3: Engineering Thermodynamics by Onkar Singh Chapter 5 Example 17

```
T5=300;//operating temperature for process 5-6
T2=T1;//isothermal process
T4=T3;//isothermal process
T6=T5;//isothermal process
disp("total heat added(Q)in KJ")
disp("Q=Q12+Q34")
Q=Q12+Q34
disp("for heat addition process 1-2")
disp("Q12=T1*(s2-s1)")
disp("deltaS=s2-s1=Q12/T1 in KJ/K")
deltaS=Q12/T1
disp("or heat addition process 3-4")
disp("Q34=T3*(s4-s3)")
disp("deltaS=s4-s3=Q34/T3 in KJ/K")
deltaS=Q34/T3
disp("or heat rejected in process 5-6(Q56)in KJ")
disp("Q56=T5*(s5-s6)=T5*((s2-s1)+(s4-s3))=T5*(deltaS
   +deltaS)")
Q56=T5*(deltaS+deltaS)
disp("net work done=net heat(W_net)in KJ")
disp("W_net=(Q12+Q34)-Q56")
W_net=(Q12+Q34)-Q56
disp("thermal efficiency of cycle(n)=W_net/Q")
n=W_net/Q
disp("or n=n*100 %")
n=n*100
disp("so work done=600 KJ and thermal efficiency
   =33.33 %")
```

Scilab code Exa 5.18 Engineering Thermodynamics by Onkar Singh Chapter 5 Example 18

```
// Display mode
```

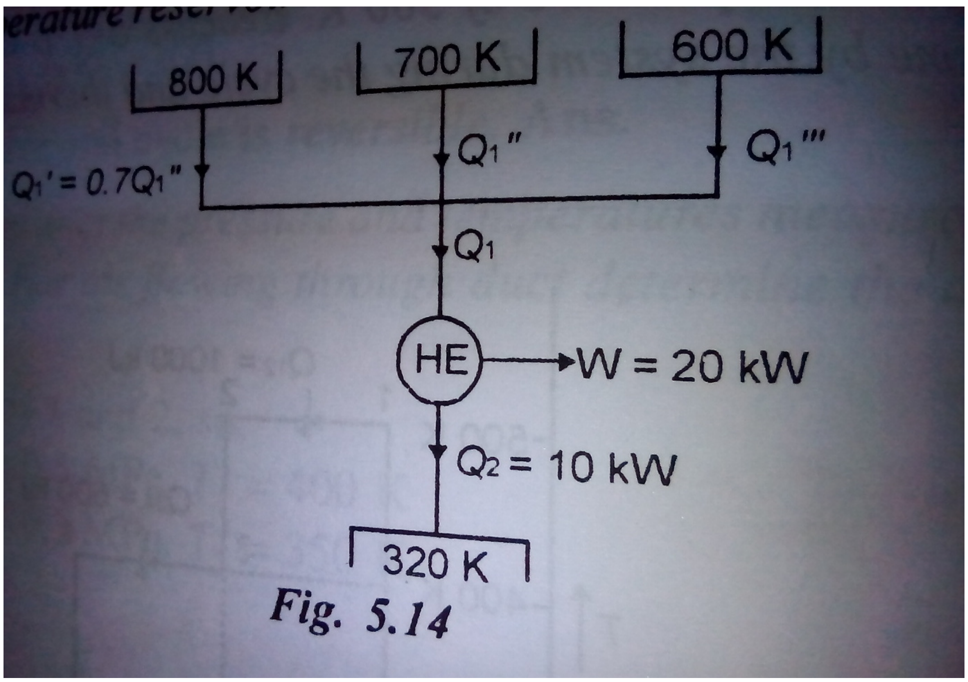

Figure 5.4: Engineering Thermodynamics by Onkar Singh Chapter 5 Example 18

```
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 5 Example 18")
T1_a=800;//temperature of reservoir a in K
T1_b=700;//temperature of reservoir b in K
T1_c=600;//temperature of reservoir c in K
T2=320;//temperature of sink in K
W=20;//work done in KW
Q2=10;//heat rejected to sink in KW
disp("let heat supplied by reservoir at 800 K,700 K,600 K be Q1_a , Q1_b , Q1_c")
disp("here Q1-Q2=W")
disp("so heat supplied by source(Q1)=W+Q2 in KW")
Q1=W+Q2
disp("also given that,Q1_a=0.7*Q1_b.......eq 1")
disp("Q1_c=Q1-(0.7*Q1_b+Q1_b)")
disp("Q1_c=Q1-1.7*Q1_b........eq 2")
disp("for reversible engine")
disp("Q1_a/T1_a+Q1_b/T1_b+Q1_c/T1_c-Q2/T2=0......eq 3")
disp("substitute eq 1 and eq 2 in eq 3 we get, ")
disp("heat supplied by reservoir of 700 K(Q1_b)in KJ/s")
disp("Q1_b=((Q2/T2)-(Q1/T1_c))/((0.7/T1_a)+(1/T1_b)-(1.7/T1_c))")
Q1_b=((Q2/T2)-(Q1/T1_c))/((0.7/T1_a)+(1/T1_b)-(1.7/T1_c))
disp("so heat supplied by reservoir of 800 K(Q1_a)in KJ/s")
disp("Q1_a=0.7*Q1_b")
Q1_a=0.7*Q1_b
disp("and heat supplied by reservoir of 600 K(Q1_c) in KJ/s")
disp("Q1_c=Q1-1.7*Q1_b")
```

```
Q1_c=Q1-1.7*Q1_b
disp("so heat supplied by reservoir at 800 K(Q1_a)")
Q1_a
disp("so heat supplied by reservoir at 700 K(Q1_b)")
Q1_b
disp("so heat supplied by reservoir at 600 K(Q1_c)")
Q1_c=-Q1_c
disp("NOTE=>answer given in book for heat supplied
    by reservoir at 800 K,700 K,600 K i.e Q1_a=61.94
    KJ/s,Q1_b=88.48 KJ/s,Q1_c=120.42 KJ/s is wrong
    hence correct answer is calculated above.")
```

Chapter 6

Thermodynamic Properties Of Pure Substance

Scilab code Exa 6.1 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 1")
disp("NOTE=>In question no. 1 expression for various
    quantities is derived which cannot be solve
   using scilab software.")
```

Scilab code Exa 6.2 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;

disp("Engineering Thermodynamics by Onkar Singh
    Chapter 6 Example 2")
disp("during throttling ,h1=h2")
disp("at state 2,enthalpy can be seen for
    superheated steam using Table 4 at 0.05 Mpa and
    100 degree celcius")
disp("thus h2=2682.5 KJ/kg")
h2=2682.5;
disp("at state 1,before throttling")
disp("hf_10Mpa=1407.56 KJ/kg")
hf_10Mpa=1407.56;
disp("hfg_10Mpa=1317.1 KJ/kg")
hfg_10Mpa=1317.1;
disp("h1=hf_10Mpa+x1*hfg_10Mpa")
h1=h2;//during throttling
disp("dryness fraction(x1)may be given as")
disp("x1=(h1-hf_10Mpa)/hfg_10Mpa")
x1=(h1-hf_10Mpa)/hfg_10Mpa
```

Scilab code Exa 6.3 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 3

```
// Display mode
mode(0);
```

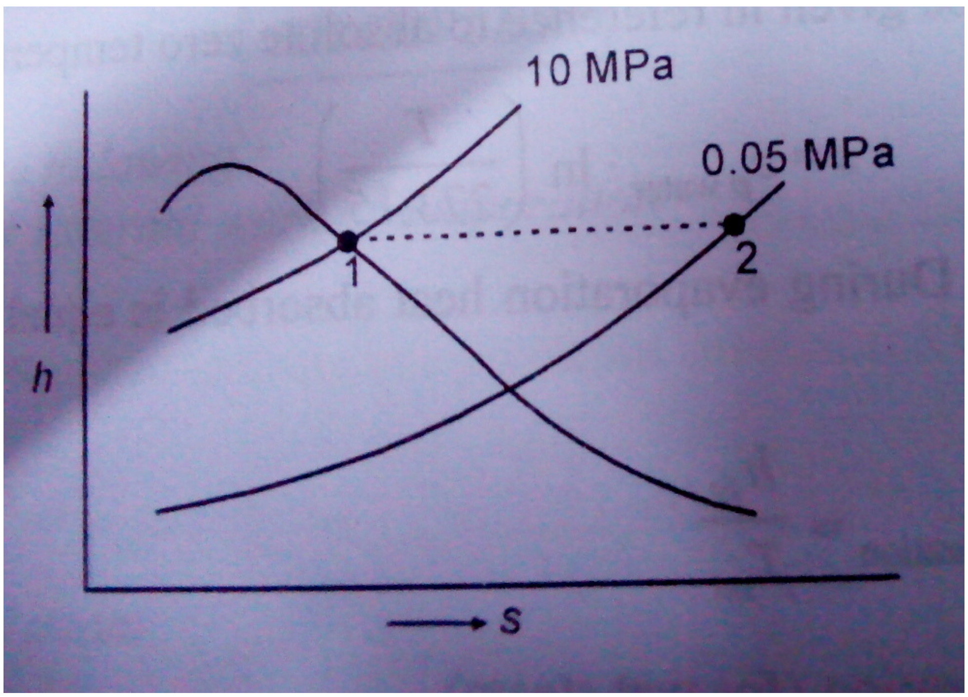

Figure 6.1: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 2

```
// Display warning for floating point exception
ieee(1);
clear;
clc;

disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 3")
h=2848;//enthalpy in KJ/kg
p=12*1000;//pressure in Kpa
v=0.017;//specific volume in m^3/kg
disp("internal energy(u)=h-p*v in KJ/kg")
u=h-p*v
```

Scilab code Exa 6.4 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;

disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 4")
m=5;//mass of steam in kg
p=2;//pressure of steam in Mpa
T_superheat=(300+273.15);//temperature of superheat
   steam in K
Cp_water=4.18;//specific heat of water at constant
   pressure in KJ/kg K
Cp_superheat=2.1;//specific heat of superheat steam
   at constant pressure in KJ/kg K
```

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Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat liquid s_f	Evap. s_{fg}	Sat vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.2: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 4

```
disp("steam state 2 Mpa and 300 degree celcius lies
   in superheated region as saturation temperature
   at 2 Mpa is 212.42 degree celcius and hfg=1890.7
   KJ/kg")
T_sat=(212.42+273.15);//saturation temperature at 2
   Mpa in K
hfg_2Mpa=1890.7;
disp("entropy of unit mass of superheated steam with
    reference to absolute zero(S)in KJ/kg K")
disp("S=Cp_water*log(T_sat/273.15)+(hfg_2Mpa/T_sat)
   +(Cp_superheat*log(T_superheat/T_sat))")
S=Cp_water*log(T_sat/273.15)+(hfg_2Mpa/T_sat)+(
   Cp_superheat*log(T_superheat/T_sat))
disp("entropy of 5 kg of steam(S)in KJ/K")
disp("S=m*S")
S=m*S
```

Scilab code Exa 6.5 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 5")
rho=1000;//density of water in kg/m^3
g=9.81;//acceleration due to gravity in m/s^2
h=0.50;//depth from above mentioned level in m
disp("boiling point =110 degree celcius,pressure at
   which it boils=143.27 Kpa(from steam table,sat.
   pressure for 110 degree celcius)")
p_boil=143.27;//pressure at which pond water boils
```

```
in Kpa
disp("at further depth of 50 cm the pressure(p)in
   Kpa")
disp("p=p_boil-((rho*g*h)*10^-3)")
p=p_boil-((rho*g*h)*10^-3)
disp("boiling point at this depth=Tsat_138.365")
disp("from steam table this temperature
   =108.866=108.87 degree celcius")
disp("so boiling point = 108.87 degree celcius")
```

Scilab code Exa 6.6 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 6")
V=0.5;//capacity of rigid vessel in m^3
disp("in a rigid vessel it can be treated as
   constant volume process.")
disp("so v1=v2")
disp("since final state is given to be critical
   state,then specific volume at critical point,")
disp("v2=0.003155 m^3/kg")
v2=0.003155;//specific volume at critical point in m
```

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Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001157	0.12736	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001164	0.11521	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001173	0.10441	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001181	0.09479	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001190	0.08619	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001199	0.07849	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001209	0.07158	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001219	0.06537	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001229	0.05976	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001240	0.05471	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083
250	3.973	0.001251	0.05013	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001263	0.04598	1104.28	1596.7	2600.9	1109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001276	0.04221	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001289	0.03877	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001302	0.03564	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001317	0.03279	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001332	0.03017	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001348	0.02777	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001366	0.02557	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001384	0.02354	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001404	0.02167	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001425	0.019948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001447	0.018350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230

Figure 6.3: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 5

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Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.4: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 5

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Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Specific volume m^3/kg Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Internal energy kJ/kg Evap. u_{fg}	Internal energy kJ/kg Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Enthalpy kJ/kg Evap. h_{fg}	Enthalpy kJ/kg Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Entropy kJ/(kg.K) Evap. s_{fg}	Entropy kJ/(kg.K) Sat. vapour s_g
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001157	0.12736	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001164	0.11521	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001173	0.10441	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001181	0.09479	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001190	0.08619	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001199	0.07849	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001209	0.07158	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001219	0.06537	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001229	0.05976	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001240	0.05471	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083
250	3.973	0.001251	0.05013	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001263	0.04598	1104.28	1596.7	2600.9	1109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001276	0.04221	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001289	0.03877	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001302	0.03564	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001317	0.03279	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001332	0.03017	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001348	0.02777	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001366	0.02557	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001384	0.02354	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001404	0.02167	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001425	0.019948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001447	0.018350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230

Figure 6.5: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 6

```
    ^3/kg
disp("at 100 degree celcius saturation temperature,
    from steam table")
disp("vf_100 =0.001044 m^3/kg,vg_100=1.6729 m^3/kg")
vf_100=0.001044;
vg_100=1.6729;
disp("and vfg_100=vg_100-vf_100 in m^3/kg")
 vfg_100=vg_100-vf_100
disp("thus for initial quality being x1")
disp("v1=vf_100+x1*vfg_100")
disp("so x1=(v1-vf_100)/vfg_100")
v1=v2;//rigid vessel
x1=(v1-vf_100)/vfg_100
disp("mass of water initially=total mass*(1-x1)")
disp("total mass of fluid/water(m)=V/v2 in kg")
m=V/v2
disp("volume of water(v)=m*vf_100 in m^3")
v=m*vf_100
```

Scilab code Exa 6.7 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 6 Example 7")
disp("on mollier diadram(h-s diagram)the slope of
    isobaric line may be given as")
disp("(dh/ds)_p=cons =slope of isobar")
disp("from 1st and 2nd law combined;")
disp("T*ds=dh-v*dp")
```

```
disp("(dh/ds)_p=cons = T")
disp("here temperature,T=773.15 K")
disp("here slope=(dh/ds))p=cons = 773.15")
```

Scilab code Exa 6.8 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 6 Example 8")
x=.10;//quality is 10%
disp("at 0.15Mpa,from steam table;")
disp("hf=467.11 KJ/kg,hg=2693.6 KJ/kg")
hf=467.11;
hg=2693.6;
disp("and hfg=hg-hf in KJ/kg")
hfg=hg-hf
disp("vf=0.001053 m^3/kg,vg=1.1593 m^3/kg")
vf=0.001053;
vg=1.1593;
disp("and vfg=vg-vf in m^3/kg")
vfg=vg-vf
disp("sf=1.4336 KJ/kg,sg=7.2233 KJ/kg")
sf=1.4336;
sg=7.2233;
disp("and sfg=sg-sf in KJ/kg K")
sfg=sg-sf
disp("enthalpy at x=.10(h)in KJ/kg")
```

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Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.6: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 8

```
disp("h=hf+x*hfg")
h=hf+x*hfg
disp("specific volume,(v)in m^3/kg")
disp("v=vf+x*vfg")
v=vf+x*vfg
disp("entropy (s)in KJ/kg K")
disp("s=sf+x*sfg")
s=sf+x*sfg
```

Scilab code Exa 6.9 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 6 Example 9")
p1=1*1000;//initial pressure of steam in Kpa
V1=0.05;//initial volume of steam in m^3
x1=.8;//dryness fraction is 80%
V2=0.2;//final volume of steam in m^3
p2=p1;//constant pressure process
disp("work done during constant pressure process(W)=p1*(V2-V1)in KJ")
W=p1*(V2-V1)
disp("now from steam table at p1,vf=0.001127 m^3/kg,vg=0.19444 m^3/kg,uf=761.68 KJ/kg,ufg=1822 KJ/kg")
vf=0.001127;
vg=0.19444;
uf=761.68;
ufg=1822;
```

```
disp("so v1=vf+x1*vg in m^3/kg")
v1=vf+x1*vg
disp("now mass of steam(m)=V1/v1 in kg")
m=V1/v1
m=0.32097;//take m=0.32097 approx.
disp("specific volume at final state(v2)in m^3/kg")
disp("v2=V2/m")
v2=V2/m
disp("corresponding to this specific volume the
    final state is to be located for getting the
    internal energy at final state at 1 Mpa")
disp("v2>vg_1Mpa")
disp("hence state lies in superheated region,from
    the steam table by interpolation we get
    temperature as;")
disp("state lies between temperature of 1000 degree
    celcius and 1100 degree celcius")
disp("so exact temperature at final state(T)in K")
T=1000+((100*(.62311-.5871))/(.6335-.5871))
disp("thus internal energy at final state,1 Mpa
    ,1077.61 degree celcius;")
disp("u2=4209.6 KJ/kg")
u2=4209.6;
disp("internal energy at initial state(u1)in KJ/kg")
disp("u1=uf+x1*ufg")
u1=uf+x1*ufg
disp("from first law of thermodynamics,Q-W=deltaU")
disp("so heat added(Q)=(U2-U1)+W=m*(u2-u1)+W in KJ")
Q=m*(u2-u1)+W
```

Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat liquid s_f	Evap. s_{fg}	Sat vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.7: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 9

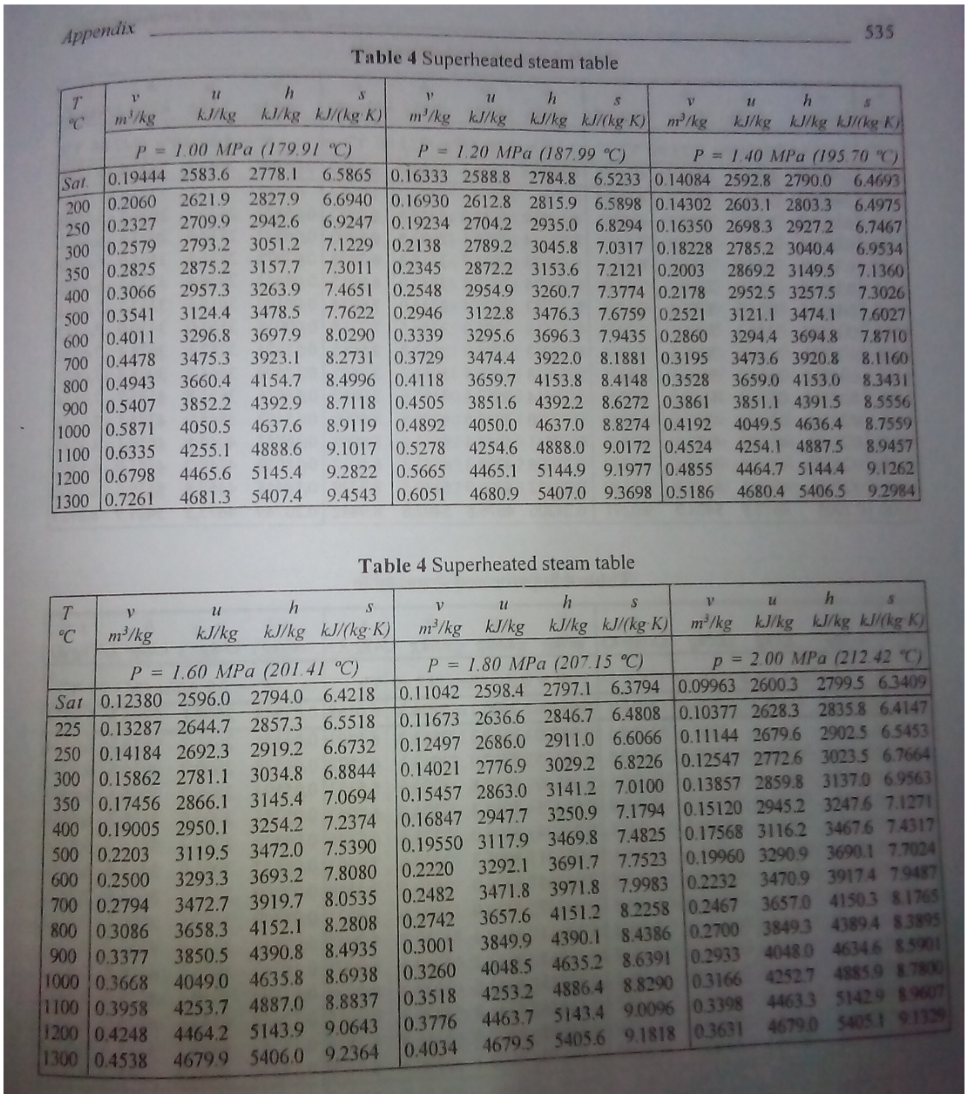

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Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.00 MPa (179.91 °C)				P = 1.20 MPa (187.99 °C)				P = 1.40 MPa (195.70 °C)			
Sat.	0.19444	2583.6	2778.1	6.5865	0.16333	2588.8	2784.8	6.5233	0.14084	2592.8	2790.0	6.4693
200	0.2060	2621.9	2827.9	6.6940	0.16930	2612.8	2815.9	6.5898	0.14302	2603.1	2803.3	6.4975
250	0.2327	2709.9	2942.6	6.9247	0.19234	2704.2	2935.0	6.8294	0.16350	2698.3	2927.2	6.7467
300	0.2579	2793.2	3051.2	7.1229	0.2138	2789.2	3045.8	7.0317	0.18228	2785.2	3040.4	6.9534
350	0.2825	2875.2	3157.7	7.3011	0.2345	2872.2	3153.6	7.2121	0.2003	2869.2	3149.5	7.1360
400	0.3066	2957.3	3263.9	7.4651	0.2548	2954.9	3260.7	7.3774	0.2178	2952.5	3257.5	7.3026
500	0.3541	3124.4	3478.5	7.7622	0.2946	3122.8	3476.3	7.6759	0.2521	3121.1	3474.1	7.6027
600	0.4011	3296.8	3697.9	8.0290	0.3339	3295.6	3696.3	7.9435	0.2860	3294.4	3694.8	7.8710
700	0.4478	3475.3	3923.1	8.2731	0.3729	3474.4	3922.0	8.1881	0.3195	3473.6	3920.8	8.1160
800	0.4943	3660.4	4154.7	8.4996	0.4118	3659.7	4153.8	8.4148	0.3528	3659.0	4153.0	8.3431
900	0.5407	3852.2	4392.9	8.7118	0.4505	3851.6	4392.2	8.6272	0.3861	3851.1	4391.5	8.5556
1000	0.5871	4050.5	4637.6	8.9119	0.4892	4050.0	4637.0	8.8274	0.4192	4049.5	4636.4	8.7559
1100	0.6335	4255.1	4888.6	9.1017	0.5278	4254.6	4888.0	9.0172	0.4524	4254.1	4887.5	8.9457
1200	0.6798	4465.6	5145.4	9.2822	0.5665	4465.1	5144.9	9.1977	0.4855	4464.7	5144.4	9.1262
1300	0.7261	4681.3	5407.4	9.4543	0.6051	4680.9	5407.0	9.3698	0.5186	4680.4	5406.5	9.2984

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.60 MPa (201.41 °C)				P = 1.80 MPa (207.15 °C)				p = 2.00 MPa (212.42 °C)			
Sat	0.12380	2596.0	2794.0	6.4218	0.11042	2598.4	2797.1	6.3794	0.09963	2600.3	2799.5	6.3409
225	0.13287	2644.7	2857.3	6.5518	0.11673	2636.6	2846.7	6.4808	0.10377	2628.3	2835.8	6.4147
250	0.14184	2692.3	2919.2	6.6732	0.12497	2686.0	2911.0	6.6066	0.11144	2679.6	2902.5	6.5453
300	0.15862	2781.1	3034.8	6.8844	0.14021	2776.9	3029.2	6.8226	0.12547	2772.6	3023.5	6.7664
350	0.17456	2866.1	3145.4	7.0694	0.15457	2863.0	3141.2	7.0100	0.13857	2859.8	3137.0	6.9563
400	0.19005	2950.1	3254.2	7.2374	0.16847	2947.7	3250.9	7.1794	0.15120	2945.2	3247.6	7.1271
500	0.2203	3119.5	3472.0	7.5390	0.19550	3117.9	3469.8	7.4825	0.17568	3116.2	3467.6	7.4317
600	0.2500	3293.3	3693.2	7.8080	0.2220	3292.1	3691.7	7.7523	0.19960	3290.9	3690.1	7.7024
700	0.2794	3472.7	3919.7	8.0535	0.2482	3471.8	3971.8	7.9983	0.2232	3470.9	3917.4	7.9487
800	0.3086	3658.3	4152.1	8.2808	0.2742	3657.6	4151.2	8.2258	0.2467	3657.0	4150.3	8.1765
900	0.3377	3850.5	4390.8	8.4935	0.3001	3849.9	4390.1	8.4386	0.2700	3849.3	4389.4	8.3895
1000	0.3668	4049.0	4635.8	8.6938	0.3260	4048.5	4635.2	8.6391	0.2933	4048.0	4634.6	8.5901
1100	0.3958	4253.7	4887.0	8.8837	0.3518	4253.2	4886.4	8.8290	0.3166	4252.7	4885.9	8.7800
1200	0.4248	4464.2	5143.9	9.0643	0.3776	4463.7	5143.4	9.0096	0.3398	4463.3	5142.9	8.9607
1300	0.4538	4679.9	5406.0	9.2364	0.4034	4679.5	5405.6	9.1818	0.3631	4679.0	5405.1	9.1329

Figure 6.8: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 9

Scilab code Exa 6.10 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 6 Example 10")
p1=800;//initial pressure of steam in Kpa
T1=200;//initial temperature of steam in degree
    celcius
disp("here steam is kept in rigid vessel,therefore
    its specific volume shall remain constant")
disp("it is superheated steam as Tsat=170.43 degree
    celcius at 800 Kpa")
disp("from superheated steam table;v1=0.2404 m^3/kg"
    )
disp("at begining of condensation specific volume =
    0.2404 m^3/kg")
disp("v2=0.2404 m^3/kg")
v2=0.2404;
disp("this v2 shall be specific volume corresponding
     to saturated vapour state for condensation.")
disp("thus v2=vg=0.2404 m^3/kg")
vg=v2;
disp("looking into steam table vg=0.2404 m^3/kg
    shall lie between temperature 175 degree celcius(
    vg=0.2168 m^3/kg)and 170 degree celcius(vg=0.2428
     m^3/kg)and pressure 892 Kpa(175 degree celcius)
    and 791.7 Kpa(170 degree celcius).")
disp("by interpolation,temperature at begining of
    condensation(T2)in K")
T2=175-((175-170)*(0.2404-0.2167))/(0.2428-.2168)
disp("similarily,pressure(p2)in Kpa")
p=892-(((892-791.7)*(0.2404-0.2168))/(0.2428-0.2168)
```

```
)
```

Scilab code Exa 6.11 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 11")
p2=200;//feed water pump pressure in Kpa
disp("from 1st and 2nd law;")
disp("T*ds=dh-v*dp")
disp("for isentropic process,ds=0")
disp("hence dh=v*dp")
disp("i.e (h2-h1)=v1*(p2-p1)")
disp("corresponding to initial state of saturated
   liquid at 30 degree celcius;from steam table;")
disp("p1=4.25 Kpa,vf=v1=0.001004 m^3/kg")
p1=4.25;
v1=0.001004;
disp("therefore enthalpy change(deltah)=(h2-h1)=v1*(
   p2-p1)in KJ/kg")
deltah=v1*(p2-p1)
```

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Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat liquid s_f	Evap. s_{fg}	Sat vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1,3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.9: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 10

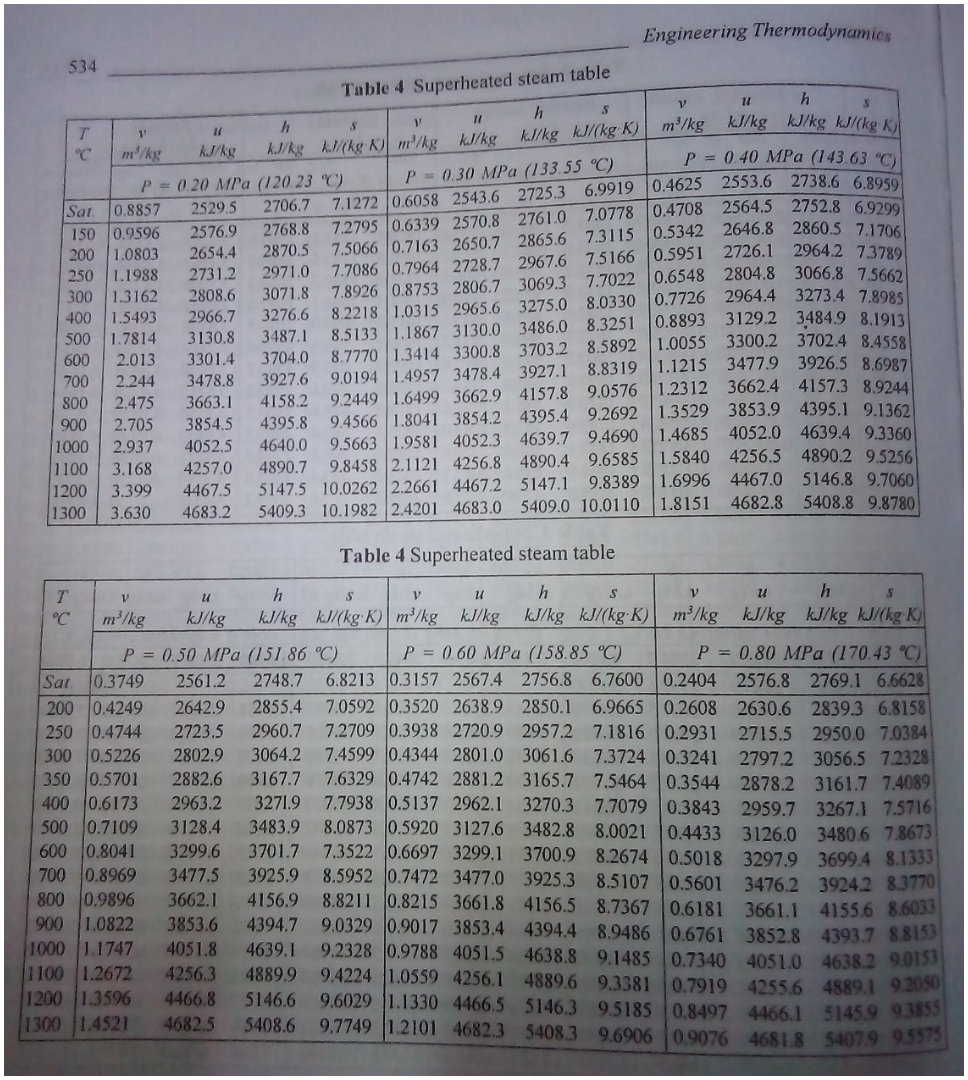

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Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.20 MPa (120.23 °C)				*P* = 0.30 MPa (133.55 °C)				*P* = 0.40 MPa (143.63 °C)			
Sat.	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2312	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.5663	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.50 MPa (151.86 °C)				*P* = 0.60 MPa (158.85 °C)				*P* = 0.80 MPa (170.43 °C)			
Sat.	0.3749	2561.2	2748.7	6.8213	0.3157	2567.4	2756.8	6.7600	0.2404	2576.8	2769.1	6.6628
200	0.4249	2642.9	2855.4	7.0592	0.3520	2638.9	2850.1	6.9665	0.2608	2630.6	2839.3	6.8158
250	0.4744	2723.5	2960.7	7.2709	0.3938	2720.9	2957.2	7.1816	0.2931	2715.5	2950.0	7.0384
300	0.5226	2802.9	3064.2	7.4599	0.4344	2801.0	3061.6	7.3724	0.3241	2797.2	3056.5	7.2328
350	0.5701	2882.6	3167.7	7.6329	0.4742	2881.2	3165.7	7.5464	0.3544	2878.2	3161.7	7.4089
400	0.6173	2963.2	3271.9	7.7938	0.5137	2962.1	3270.3	7.7079	0.3843	2959.7	3267.1	7.5716
500	0.7109	3128.4	3483.9	8.0873	0.5920	3127.6	3482.8	8.0021	0.4433	3126.0	3480.6	7.8673
600	0.8041	3299.6	3701.7	7.3522	0.6697	3299.1	3700.9	8.2674	0.5018	3297.9	3699.4	8.1333
700	0.8969	3477.5	3925.9	8.5952	0.7472	3477.0	3925.3	8.5107	0.5601	3476.2	3924.2	8.3770
800	0.9896	3662.1	4156.9	8.8211	0.8215	3661.8	4156.5	8.7367	0.6181	3661.1	4155.6	8.6033
900	1.0822	3853.6	4394.7	9.0329	0.9017	3853.4	4394.4	8.9486	0.6761	3852.8	4393.7	8.8153
1000	1.1747	4051.8	4639.1	9.2328	0.9788	4051.5	4638.8	9.1485	0.7340	4051.0	4638.2	9.0153
1100	1.2672	4256.3	4889.9	9.4224	1.0559	4256.1	4889.6	9.3381	0.7919	4255.6	4889.1	9.2050
1200	1.3596	4466.8	5146.6	9.6029	1.1330	4466.5	5146.3	9.5185	0.8497	4466.1	5145.9	9.3855
1300	1.4521	4682.5	5408.6	9.7749	1.2101	4682.3	5408.3	9.6906	0.9076	4681.8	5407.9	9.5575

Figure 6.10: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 10

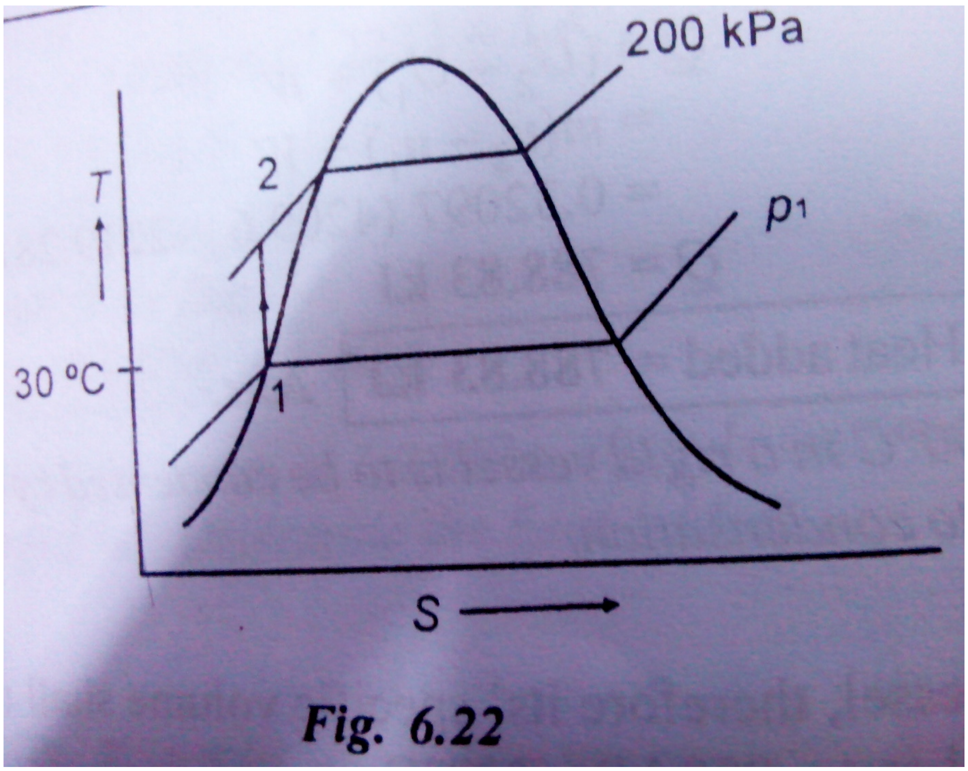

Figure 6.11: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 11

Scilab code Exa 6.12 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 6 Example 12")
V=2;//volume of vessel in m^3
disp("from steam table at 150 degree celcius")
disp("vf=0.001091 m^3/kg,vg=0.3928 m^3/kg")
Vf=0.001091;
Vg=0.3928;
disp("so volume occupied by water(Vw)=3*V/(3+2) in m^3")
Vw=3*V/(3+2)
disp("and volume of steam(Vs)=2*V/(3+2) in m^3")
Vs=2*V/(3+2)
disp("mass of water(mf)=Vw/Vf in kg")
mf=Vw/Vf
disp("mass of steam(mg)=Vs/Vg in kg")
mg=Vs/Vg
disp("total mass in tank(m)=mf+mg in kg")
m=mf+mg
disp("quality or dryness fraction(x)")
disp("x=mg/m")
x=mg/m
```

APPENDIX

Table 1 Ideal-gas specific heats of various common gases at 300 K

Gas	Formula	Gas constant R kJ/(kg.K)	c_p kJ/(kg.K)	c_v kJ/(kg.K)	γ
Air	–	0.2870	1.005	0.718	1.400
Argon	Ar	0.2081	0.5203	0.3122	1.667
Butane	C_4H_{10}	0.1433	1.7164	1.5734	1.091
Carbon dioxide	CO_2	0.1889	0.846	0.657	1.289
Carbon monoxide	CO	0.2968	1.040	0.744	1.400
Ethane	C_2H_6	0.2765	1.7662	1.4897	1.186
Ethylene	C_2H_4	0.2964	1.5482	1.2518	1.237
Helium	He	2.0769	5.1926	3.1156	1.667
Hydrogen	H_2	4.1240	14.307	10.183	1.405
Methane	CH_4	0.5182	2.2537	1.7354	1.299
Neon	Ne	0.4119	1.0299	0.6179	1.667
Nitrogen	N_2	0.2968	1.039	0.743	1.400
Octane	C_8H_{18}	0.0729	1.7113	1.6385	1.044
Oxygen	O_2	0.2598	0.918	0.658	1.395
Propane	C_3H_8	0.1885	1.6794	1.4909	1.126
Steam	H_2O	0.4615	1.8723	1.4108	1.327

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg		Internal energy kJ/kg			Enthalpy kJ/kg			Entropy kJ/(kg.K)		
		Sat. liquid v_f	Sat. vapour v_g	Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.4	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2409.8	2309.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	7.6824
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	7.6122
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	7.5445
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	7.4791
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	7.4159

Figure 6.12: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 11

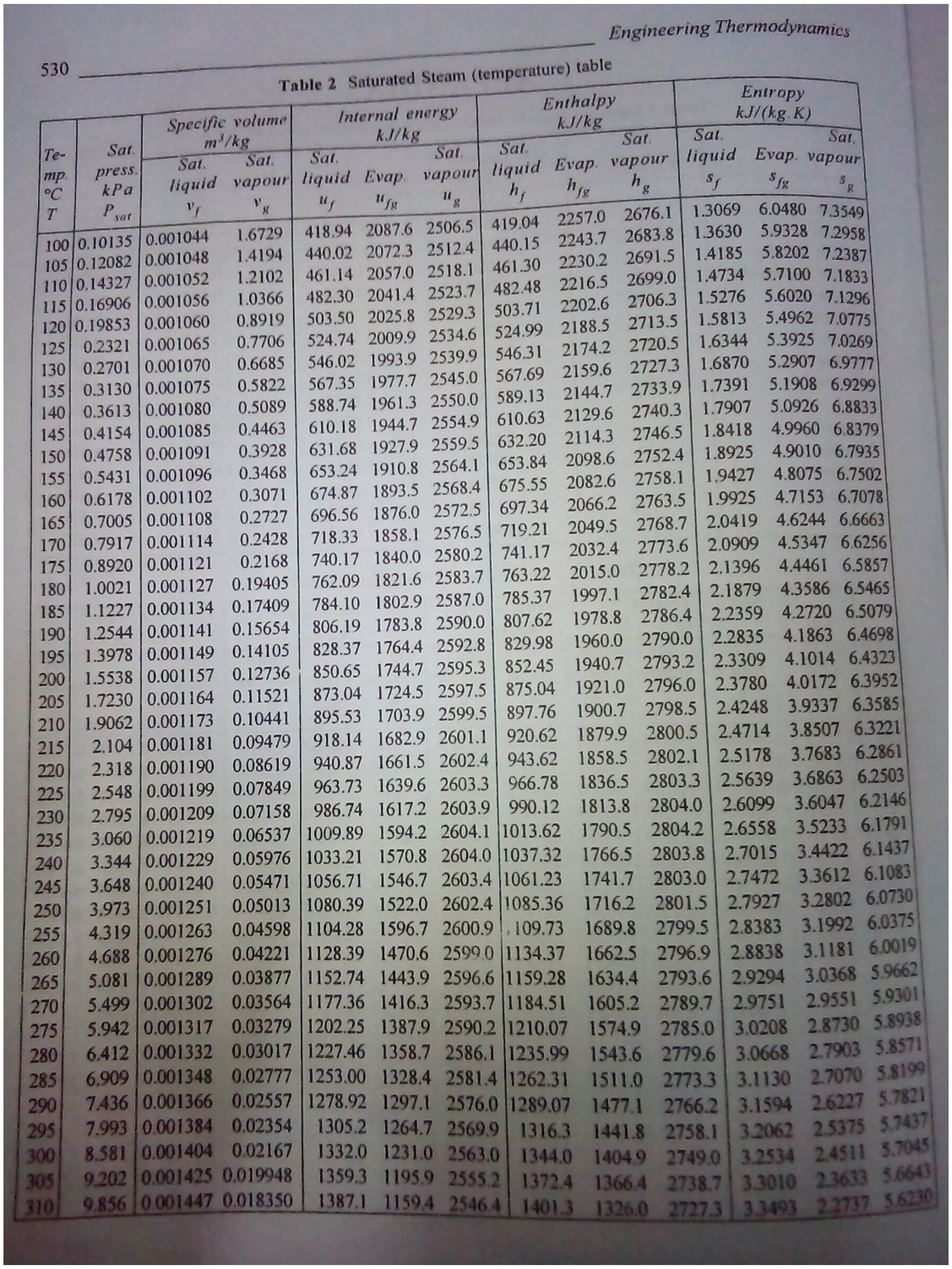
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Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001157	0.12736	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001164	0.11521	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001173	0.10441	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001181	0.09479	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001190	0.08619	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001199	0.07849	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001209	0.07158	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001219	0.06537	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001229	0.05976	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001240	0.05471	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083
250	3.973	0.001251	0.05013	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001263	0.04598	1104.28	1596.7	2600.9	.109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001276	0.04221	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001289	0.03877	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001302	0.03564	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001317	0.03279	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001332	0.03017	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001348	0.02777	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001366	0.02557	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001384	0.02354	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001404	0.02167	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001425	0.019948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001447	0.018350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230

Figure 6.13: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 12

```
disp("NOTE=>answer given in book for mass=1103.99 kg
    is incorrect and correct answer is 1101.945
   which is calculated above.")
```

Scilab code Exa 6.13 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 13")
disp("fron S.F.S.E on steam turbine;")
disp("W=h1-h2")
disp("initially at 4Mpa,300 degree celcius the steam
    is super heated so enthalpy from superheated
   steam or mollier diagram")
disp("h1=2886.2 KJ/kg,s1=6.2285 KJ/kg K")
h1=2886.2;
s1=6.2285;
disp("reversible adiabatic expansion process has
   entropy remaining constant.on mollier diagram the
    state 2 can be simply located at intersection of
    constant temperature line for 50 degree celcius
   and isentropic expansion line.")
disp("else from steam tables at 50 degree celcius
   saturation temperature;")
disp("hf=209.33 KJ/kg,sf=0.7038 KJ/kg K")
hf=209.33;
sf=0.7038;
disp("hfg=2382.7 KJ/kg,sfg=7.3725 KJ/kg K")
hfg=2382.7;
```

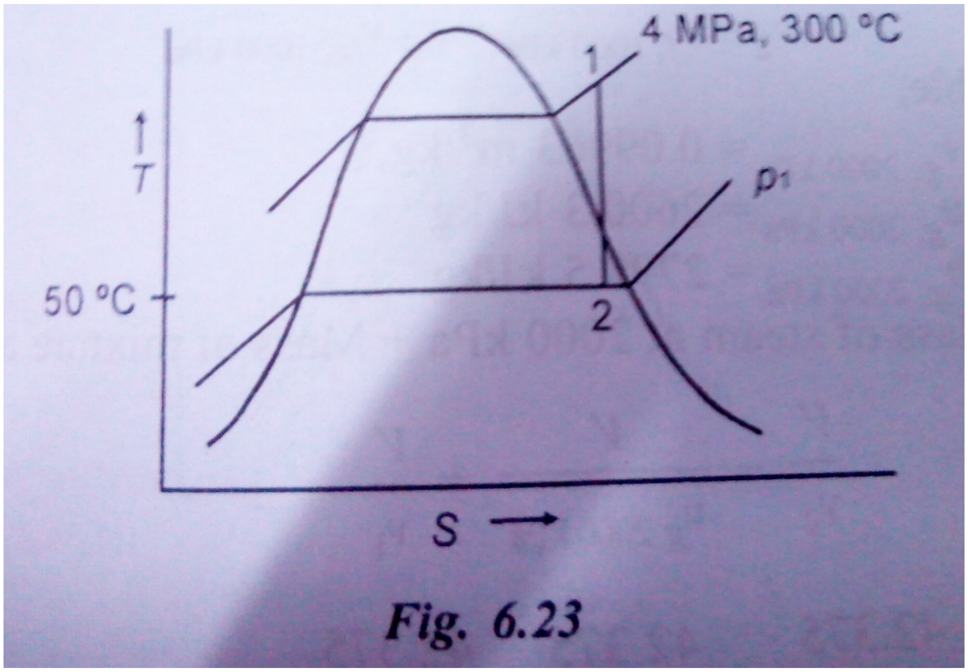

Figure 6.14: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 13

```
sfg=7.3725;
disp("here s1=s2,let dryness fraction at 2 be x2")
disp("x2=(s1-sf)/sfg")
x2=(s1-sf)/sfg
disp("hence enthalpy at state 2")
disp("h2=hf+x2*hfg in KJ/kg")
h2=hf+x2*hfg
disp("steam turbine work(W)in KJ/kg")
disp("W=h1-h2")
W=h1-h2
disp("so turbine output=W")
W
```

Scilab code Exa 6.14 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 6 Example 14")
x1=0.5;//dryness fraction
m1=100;//mass of steam in kg
v1=0.8475;//
disp("it is constant volume process")
disp("volume of vessel(V)=mass of vapour * specific volume of vapour")
disp("initial specific volume,v1")
disp("v1=vf_100Kpa+x1*vfg_100 in m^3/kg")
disp("at 100 Kpa from steam table;")
disp("hf_100Kpa=417.46 KJ/kg,uf_100Kpa=417.36 KJ/kg,vf_100Kpa=0.001043 m^3/kg,hfg_100Kpa=2258 KJ/kg,ufg_100Kpa=2088.7 KJ/kg,vg_100Kpa=1.6940 m^3/kg")
hf_100Kpa=417.46;
uf_100Kpa=417.36;
vf_100Kpa=0.001043;
hfg_100Kpa=2258;
ufg_100Kpa=2088.7;
vg_100Kpa=1.6940;
disp(" here vfg_100Kpa=vg_100Kpa-vf_100Kpa in m^3/kg")
vfg_100Kpa=vg_100Kpa-vf_100Kpa
```

```
disp("so v1=vf_100Kpa+x1*vfg_100Kpa in m^3/kg")
v1=vf_100Kpa+x1*vfg_100Kpa
disp("and volume of vessel(V)=m1*x1*v1 in m^3")
V=m1*x1*v1
disp("enthalpy at 1,h1=hf_100Kpa+x1*hfg_100Kpa in KJ/kg")
h1=hf_100Kpa+x1*hfg_100Kpa
disp("internal energy in the beginning=U1=m1*u1 in KJ")
U1=m1*(uf_100Kpa+x1*ufg_100Kpa)
disp("let the mass of dry steam added be m,final specific volume inside vessel,v2")
disp("v2=vf_1000Kpa+x2*vfg_1000Kpa")
disp("at 2000 Kpa,from steam table,")
disp("vg_2000Kpa=0.09963 m^3/kg,ug_2000Kpa=2600.3 KJ/kg,hg_2000Kpa=2799.5 KJ/kg")
vg_2000Kpa=0.09963;
ug_2000Kpa=2600.3;
hg_2000Kpa=2799.5;
disp("total mass inside vessel=mass of steam at2000 Kpa+mass of mixture at 100 Kpa")
disp("V/v2=V/vg_2000Kpa+V/v1")
disp("so v2=1/((1/vg_2000Kpa)+(1/v1))in m^3/kg")
v2=1/((1/vg_2000Kpa)+(1/v1))
disp("here v2=vf_1000Kpa+x2*vfg_1000Kpa in m^3/kg")
disp("at 1000 Kpa from steam table,")
disp("hf_1000Kpa=762.81 KJ/kg,hfg_1000Kpa=2015.3 KJ/kg,vf_1000Kpa=0.001127 m^3/kg,vg_1000Kpa=0.19444 m^3/kg")
hf_1000Kpa=762.81;
hfg_1000Kpa=2015.3;
vf_1000Kpa=0.001127;
vg_1000Kpa=0.19444;
disp("here vfg_1000Kpa=vg_1000Kpa-vf_1000Kpa in m^3/kg")
vfg_1000Kpa=vg_1000Kpa-vf_1000Kpa
disp("so x2=(v2-vf_1000Kpa)/vfg_1000Kpa")
x2=(v2-vf_1000Kpa)/vfg_1000Kpa
```

```
disp("for adiabatic mixing,(100+m)*h2=100*h1+m*hg_2000Kpa")
disp("so mass of dry steam at 2000 Kpa to be added(m)in kg")
disp("m=(100*(h1-h2))/(h2-hg_2000Kpa)")
m=(100*(h1-(hf_1000Kpa+x2*hfg_1000Kpa)))/((hf_1000Kpa+x2*hfg_1000Kpa)-hg_2000Kpa)
disp("quality of final mixture=x2")
x2
```

Scilab code Exa 6.15 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 6 Example 15")
p_vaccum=71.5;//recorded condenser vaccum in cm of mercury
p_barometer=76.8;//barometer reading in cm of mercury
T_cond=35;//temperature of condensation in degree celcius
T_hotwell=27.6;//temperature of hot well in degree celcius
m_cond=1930;//mass of condensate per hour
m_w=62000;//mass of cooling water per hour
```

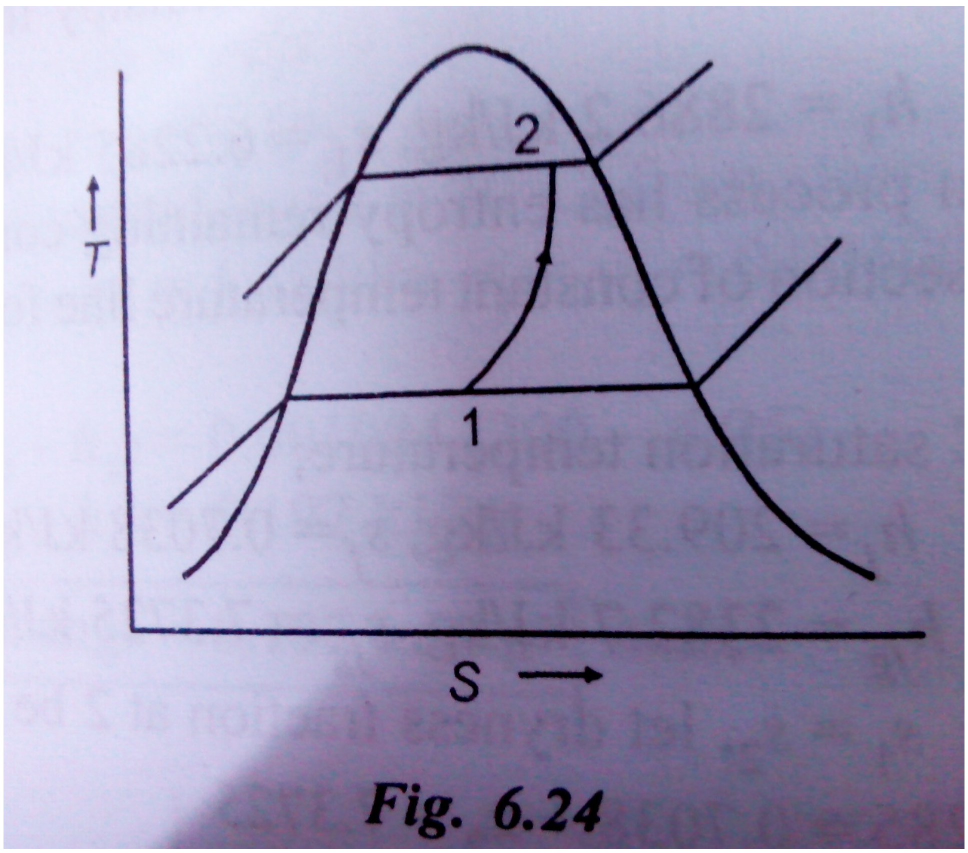

Figure 6.15: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 14

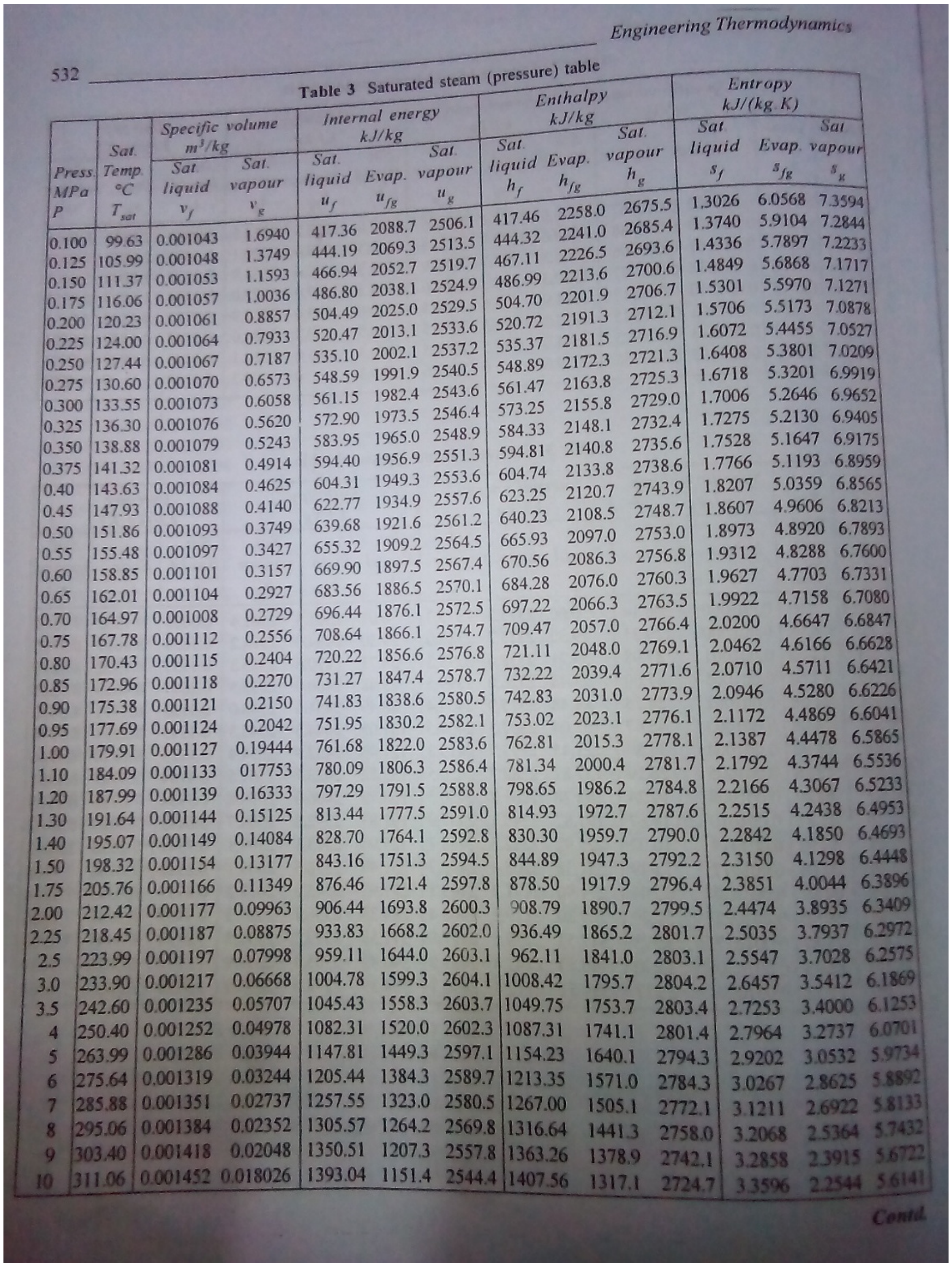

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Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat liquid s_f	Evap. s_{fg}	Sat vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.16: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 14

```
Ti=8.51;//initial temperature in degree celcius
To=26.24;//outlet temperature in degree celcius
disp("from dalton law of partial pressure the total
    pressure inside condenser will be sum of partial
    pressures of vapour and liquid inside.")
disp("condenser pressure(p_condenser)=(p_barometer-
    p_vaccum)*101.325/73.55 in Kpa")
p_condenser=(p_barometer-p_vaccum)*101.325/73.55
disp("partial pressure of steam corresponding to35
    degree celcius from steam table;")
disp("p_steam=5.628 Kpa")
p_steam=5.628;//partial pressure of steam
disp("enthalpy corresponding to 35 degree celcius
    from steam table,")
disp("hf=146.68 KJ/kg,hfg=2418.6 KJ/kg")
hf=146.68;
hfg=2418.6;
disp("let quality of steam entering be x")
disp("from energy balance;")
disp("mw*(To-Ti)*4.18=m_cond*(hf+x*hfg-4.18*
    T_hotwell)")
disp("so dryness fraction of steam entering(x)is
    given as")
disp("x=(((m_w*(To-Ti)*4.18)/m_cond)-hf+4.18*
    T_hotwell)/hfg")
x=(((m_w*(To-Ti)*4.18)/m_cond)-hf+4.18*T_hotwell)/
    hfg
```

Scilab code Exa 6.16 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 16

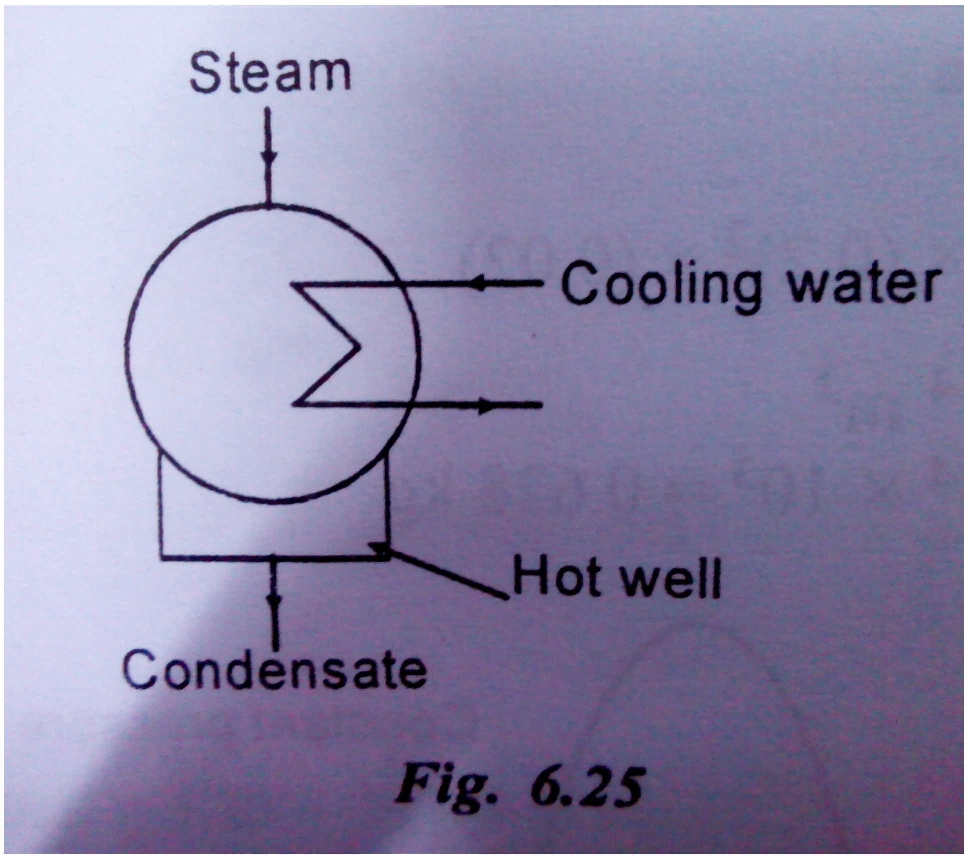

Figure 6.17: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 15

APPENDIX

Table 1 Ideal-gas specific heats of various common gases at 300 K

Gas	Formula	Gas constant R kJ/(kg.K)	c_p kJ/(kg.K)	c_v kJ/(kg.K)	γ
Air	–	0.2870	1.005	0.718	1.400
Argon	Ar	0.2081	0.5203	0.3122	1.667
Butane	C_4H_{10}	0.1433	1.7164	1.5734	1.091
Carbon dioxide	CO_2	0.1889	0.846	0.657	1.289
Carbon monoxide	CO	0.2968	1.040	0.744	1.400
Ethane	C_2H_6	0.2765	1.7662	1.4897	1.186
Ethylene	C_2H_4	0.2964	1.5482	1.2518	1.237
Helium	He	2.0769	5.1926	3.1156	1.667
Hydrogen	H_2	4.1240	14.307	10.183	1.405
Methane	CH_4	0.5182	2.2537	1.7354	1.299
Neon	Ne	0.4119	1.0299	0.6179	1.667
Nitrogen	N_2	0.2968	1.039	0.743	1.400
Octane	C_8H_{18}	0.0729	1.7113	1.6385	1.044
Oxygen	O_2	0.2598	0.918	0.658	1.395
Propane	C_3H_8	0.1885	1.6794	1.4909	1.126
Steam	H_2O	0.4615	1.8723	1.4108	1.327

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.4	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2409.8	2309.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	7.6824
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	7.6122
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	7.5445
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	7.4791
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	7.4159

Figure 6.18: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 6 Example 16")
F=10;//force applied externally upon piston in KN
d=.2;//diameter in m
h=0.02;//depth to which water filled in m
P_atm=101.3;//atmospheric pressure in Kpa
rho=1000;//density of water in kg/m^3
Q=600;//heat supplied to water in KJ
T=150;//temperature of water in degree celcius
disp("heating of water in vessel as described above is a constant pressure heating. pressure at which process occurs(p)=F/A+P_atm in Kpa")
disp("area(A)=%pi*d^2/4 in m^2")
A=%pi*d^2/4
disp("so p1=F/A+P_atm in Kpa")
p1=F/A+P_atm
disp("now at 419.61 Kpa,hf=612.1 KJ/kg,hfg=2128.7 KJ/kg,vg=0.4435 m^3/kg")
hf=612.1;
hfg=2128.7;
vg=0.4435;
disp("volume of water contained(V1)=%pi*d^2*h/4 in m^3")
V1=%pi*d^2*h/4
disp("mass of water(m)=V1*rho in kg")
m=V1*rho
disp("heat supplied shall cause sensible heating and latent heating")
disp("hence,enthalpy change=heat supplied")
disp("Q=((hf+x*hfg)-(4.18*T)*m)")
disp("so dryness fraction of steam produced(x)can be calculated as")
```

```
disp("so x=((Q/m)+4.18*T-hf)/hfg")
x=((Q/m)+4.18*T-hf)/hfg
disp("internal energy of water(U1)in KJ,initially")
h1=4.18*T;//enthalpy of water in KJ/kg
disp("U1=m*h1-p1*V1")
U1=m*h1-p1*V1
U1=393.5;//approx.
disp("finally,internal energy of wet steam(U2)in KJ"
    )
disp("U2=m*h2-p2*V2")
disp("here V2=m*x*vg in m^3")
V2=m*x*vg
disp("hence U2=(m*h2)-p2*V2")
p2=p1;//constant pressure process
U2=(m*(hf+x*hfg))-p2*V2
U2=940.71;//approx.
disp("hence change in internal energy(U)=U2-U1 in KJ
    ")
U=U2-U1
disp("work done(W)=p*(V2-V1)in KJ")
p=p1;
W=p*(V2-V1)
```

Scilab code Exa 6.17 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 17

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
```

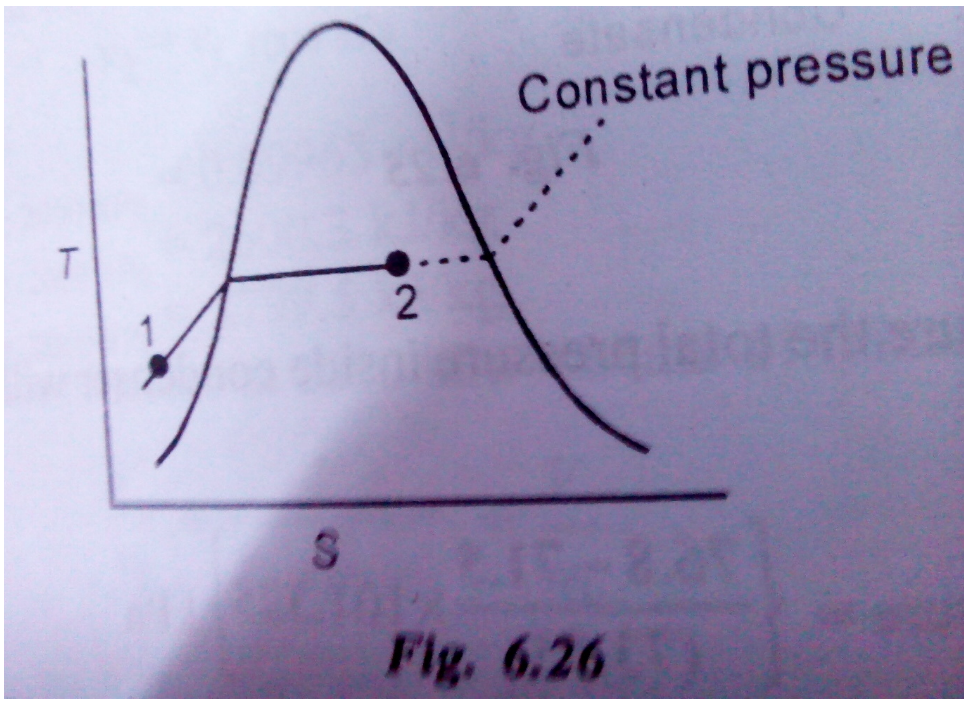

Figure 6.19: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 16

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Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.20: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 16

```
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 6 Example 17")
ms=40;//mass of steam in kg
mw=2.2;//mass of water in kg
p1=1.47;//pressure before throttling in Mpa
T2=120;//temperature after throttling in degree
    celcius
p2=107.88;//pressure after throttling in Kpa
Cp_sup=2.09;//specific heat of superheated steam in
    KJ/kg K
disp("consider throttling calorimeter alone,")
disp("degree of superheat(T_sup)in degree celcius")
disp("T_sup=T2-101.8")
T_sup=T2-101.8
disp("enthalpy of superheated steam(h_sup)in KJ/kg")
disp("h_sup=h+T_sup*Cp_sup")
disp("at 120 degree celcius,h=2673.95 KJ/kg from
    steam table")
h=2673.95;
h_sup=h+T_sup*Cp_sup
disp("now enthalpy before throttling = enthalpy
    after throttling")
disp("hf+x2*hfg=h_sup")
disp("here at 1.47 Mpa,hf=840.513 KJ/kg,hfg=1951.02
    KJ/kg from steam table")
hf=840.513;
hfg=1951.02;
disp("so x2=(h_sup-hf)/hfg")
x2=(h_sup-hf)/hfg
disp("for seperating calorimeter alone,dryness
    fraction,x1=(ms-mw)/ms")
x1=(ms-mw)/ms
disp("overall dryness fraction(x)=(x1*x2)")
x=x1*x2
```

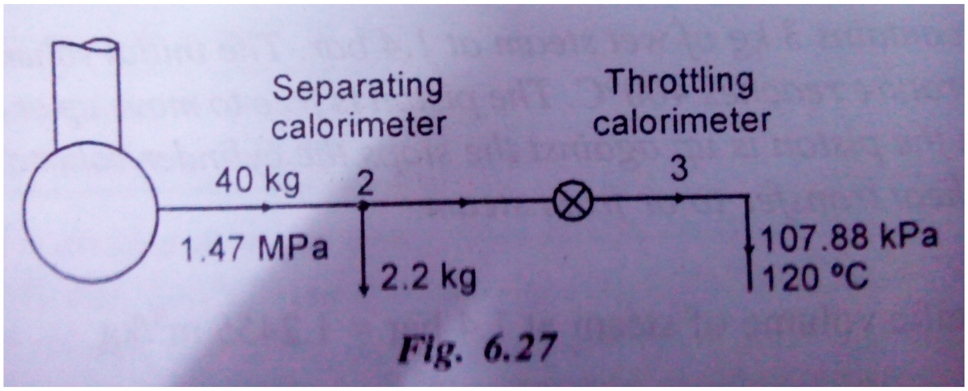

Figure 6.21: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 17

Scilab code Exa 6.18 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 18

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 18")
v=0.4;//volume of air in part A and part B in m^3
p1=10*10^5;//initial pressure of steam in pa
p2=15*10^5;//final pressure of steam in pa
```

Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.22: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 18

```
disp("here heat addition to part B shall cause
   evaporation of water and subsequently the rise in
    pressure.")
disp("final,part B has dry steam at 15 bar.In order
   to have equilibrium the part A shall also have
   pressure of 15 bar.thus heat added")
disp("Q=v*(p2-p1)/1000in KJ")
Q=v*(p2-p1)/1000
disp("final enthalpy of dry steam at 15 bar,h2=
   hg_15bar")
disp("h2=2792.2 KJ/kg from steam table")
h2=2792.2;
disp("let initial dryness fraction be x1,initial
   enthalpy,")
disp("h1=hf_10bar+x1*hfg_10bar.........eq1")
disp("here at 10 bar,hf_10bar=762.83 KJ/kg,hfg_10bar
   =2015.3 KJ/kg from steam table")
hf_10bar=762.83;
hfg_10bar=2015.3;
disp("also heat balance yields,")
disp("h1+Q=h2")
disp("so h1=h2-Q in KJ/kg")
h1=h2-Q
disp("so by eq 1=>x1=(h1-hf_10bar)/hfg_10bar")
x1=(h1-hf_10bar)/hfg_10bar
disp("heat added(Q)in KJ")
Q
disp("and initial quality(x1)")
x1
```

Scilab code Exa 6.19 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 19

```
// Display mode
mode(0);
```

```
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 6 Example 19")
m=3;//mass of wet steam in kg
p=1.4;//pressure of wet steam in bar
V1=2.25;//initial volume in m^3
V2=4.65;//final volume in m^3
T=400;//temperature of steam in degreee celcius
disp("from steam table,vg=1.2455 m^3/kg,hf=457.99 KJ
   /kg,hfg=2232.3 KJ/kg")
vg=1.2455;
hf=457.99;
hfg=2232.3;
disp("specific volume of wet steam in cylinder,v1=V1
   /m in m^3/kg")
v1=V1/m
disp("dryness fraction of initial steam(x1)=v1/vg")
x1=v1/vg
x1=0.602;//approx.
disp("initial enthalpy of wet steam,h1=hf+x1*hfg in
   KJ/kg")
h1=hf+x1*hfg
disp("at 400 degree celcius specific volume of steam
   ,v2=V2/m in m^3/kg")
v2=V2/m
disp("for specific volume of 1.55 m^3/kg at 400
   degree celcius the pressure can be seen from the
   steam table.From superheated steam tables the
   specific volume of 1.55 m^3/kg lies between the
   pressure of 0.10 Mpa (specific volume 3.103 m^3/
   kg at400 degree celcius)and 0.20 Mpa(specific
   volume 1.5493 m^3/kg at 400 degree celcius)")
disp("actual pressure can be obtained by
   interpolation")
p2=.1+((0.20-0.10)/(1.5493-3.103))*(1.55-3.103)
```

```
disp("p2=0.20 MPa(approx.)")
p2=0.20;
disp("saturation temperature at 0.20 Mpa(t)=120.23
    degree celcius from steam table")
t=120.23;
disp("finally the degree of superheat(T_sup)in K")
disp("T_sup=T-t")
T_sup=T-t
disp("final enthalpy of steam at 0.20 Mpa and 400
    degree celcius,h2=3276.6 KJ/kg from steam table")
h2=3276.6;
disp("heat added during process(deltaQ)in KJ")
disp("deltaQ=m*(h2-h1)")
deltaQ=m*(h2-h1)
disp("internal energy of initial wet steam,u1=uf+x1*
    ufg in KJ/kg")
disp("here at 1.4 bar,from steam table,uf=457.84 KJ/
    kg,ufg=2059.34 KJ/kg")
uf=457.84;
ufg=2059.34;
u1=uf+x1*ufg
disp("internal energy of final state,u2=u at 0.2 Mpa
    ,400 degree celcius")
disp("u2=2966.7 KJ/kg")
u2=2966.7;
disp("change in internal energy(deltaU)in KJ")
disp("deltaU=m*(u2-u1)")
deltaU=m*(u2-u1)
disp("form first law of thermodynamics,work done(
    deltaW)in KJ")
disp("deltaW=deltaQ-deltaU")
deltaW=deltaQ-deltaU
disp("so heat transfer(deltaQ)in KJ")
deltaQ
disp("and work transfer(deltaW)in KJ")
deltaW
disp("NOTE=>In book value of u1=1707.86 KJ/kg is
    calculated wrong taking x1=0.607,hence correct
```

```
value of u1 using x1=0.602 is 1697.5627 KJ/kg")
disp("and corresponding values of heat transfer=
    4424.2962 KJ and work transfer=616.88424 KJ.")
```

Scilab code Exa 6.20 Engineering Thermodynamics by Onkar Singh Chapter 6 Example 20

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 6 Example 20")
disp("here throttling process is occuring therefore
    enthalpy before and after expansion remains same.
    Let initial and final states be given by 1 and 2.
    Initial enthalpy,from steam table.")
disp("at 500 degree celcius,h1_10bar_500oc=3478.5 KJ
    /kg,s1_10bar_500oc=7.7622 KJ/kg K,v1_10bar_500oc
    =0.3541 m^3/kg")
h1_10bar_500oc=3478.5;
s1_10bar_500oc=7.7622;
v1_10bar_500oc=0.3541;
disp("finally pressure becomes 1 bar so finally
    enthalpy(h2) at this pressure(of 1 bar)is also
    3478.5 KJ/kg which lies between superheat
    temperature of 400 degree celcius and 500 degree
    celcius at 1 bar.Let temperature be T2,")
h2=h1_10bar_500oc;
```

Table 3 Saturated steam (pressure) table

Press. MPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat liquid s_f	Evap. s_{fg}	Sat vapour s_g
0.100	99.63	0.001043	1.6940	417.36	2088.7	2506.1	417.46	2258.0	2675.5	1.3026	6.0568	7.3594
0.125	105.99	0.001048	1.3749	444.19	2069.3	2513.5	444.32	2241.0	2685.4	1.3740	5.9104	7.2844
0.150	111.37	0.001053	1.1593	466.94	2052.7	2519.7	467.11	2226.5	2693.6	1.4336	5.7897	7.2233
0.175	116.06	0.001057	1.0036	486.80	2038.1	2524.9	486.99	2213.6	2700.6	1.4849	5.6868	7.1717
0.200	120.23	0.001061	0.8857	504.49	2025.0	2529.5	504.70	2201.9	2706.7	1.5301	5.5970	7.1271
0.225	124.00	0.001064	0.7933	520.47	2013.1	2533.6	520.72	2191.3	2712.1	1.5706	5.5173	7.0878
0.250	127.44	0.001067	0.7187	535.10	2002.1	2537.2	535.37	2181.5	2716.9	1.6072	5.4455	7.0527
0.275	130.60	0.001070	0.6573	548.59	1991.9	2540.5	548.89	2172.3	2721.3	1.6408	5.3801	7.0209
0.300	133.55	0.001073	0.6058	561.15	1982.4	2543.6	561.47	2163.8	2725.3	1.6718	5.3201	6.9919
0.325	136.30	0.001076	0.5620	572.90	1973.5	2546.4	573.25	2155.8	2729.0	1.7006	5.2646	6.9652
0.350	138.88	0.001079	0.5243	583.95	1965.0	2548.9	584.33	2148.1	2732.4	1.7275	5.2130	6.9405
0.375	141.32	0.001081	0.4914	594.40	1956.9	2551.3	594.81	2140.8	2735.6	1.7528	5.1647	6.9175
0.40	143.63	0.001084	0.4625	604.31	1949.3	2553.6	604.74	2133.8	2738.6	1.7766	5.1193	6.8959
0.45	147.93	0.001088	0.4140	622.77	1934.9	2557.6	623.25	2120.7	2743.9	1.8207	5.0359	6.8565
0.50	151.86	0.001093	0.3749	639.68	1921.6	2561.2	640.23	2108.5	2748.7	1.8607	4.9606	6.8213
0.55	155.48	0.001097	0.3427	655.32	1909.2	2564.5	665.93	2097.0	2753.0	1.8973	4.8920	6.7893
0.60	158.85	0.001101	0.3157	669.90	1897.5	2567.4	670.56	2086.3	2756.8	1.9312	4.8288	6.7600
0.65	162.01	0.001104	0.2927	683.56	1886.5	2570.1	684.28	2076.0	2760.3	1.9627	4.7703	6.7331
0.70	164.97	0.001008	0.2729	696.44	1876.1	2572.5	697.22	2066.3	2763.5	1.9922	4.7158	6.7080
0.75	167.78	0.001112	0.2556	708.64	1866.1	2574.7	709.47	2057.0	2766.4	2.0200	4.6647	6.6847
0.80	170.43	0.001115	0.2404	720.22	1856.6	2576.8	721.11	2048.0	2769.1	2.0462	4.6166	6.6628
0.85	172.96	0.001118	0.2270	731.27	1847.4	2578.7	732.22	2039.4	2771.6	2.0710	4.5711	6.6421
0.90	175.38	0.001121	0.2150	741.83	1838.6	2580.5	742.83	2031.0	2773.9	2.0946	4.5280	6.6226
0.95	177.69	0.001124	0.2042	751.95	1830.2	2582.1	753.02	2023.1	2776.1	2.1172	4.4869	6.6041
1.00	179.91	0.001127	0.19444	761.68	1822.0	2583.6	762.81	2015.3	2778.1	2.1387	4.4478	6.5865
1.10	184.09	0.001133	017753	780.09	1806.3	2586.4	781.34	2000.4	2781.7	2.1792	4.3744	6.5536
1.20	187.99	0.001139	0.16333	797.29	1791.5	2588.8	798.65	1986.2	2784.8	2.2166	4.3067	6.5233
1.30	191.64	0.001144	0.15125	813.44	1777.5	2591.0	814.93	1972.7	2787.6	2.2515	4.2438	6.4953
1.40	195.07	0.001149	0.14084	828.70	1764.1	2592.8	830.30	1959.7	2790.0	2.2842	4.1850	6.4693
1.50	198.32	0.001154	0.13177	843.16	1751.3	2594.5	844.89	1947.3	2792.2	2.3150	4.1298	6.4448
1.75	205.76	0.001166	0.11349	876.46	1721.4	2597.8	878.50	1917.9	2796.4	2.3851	4.0044	6.3896
2.00	212.42	0.001177	0.09963	906.44	1693.8	2600.3	908.79	1890.7	2799.5	2.4474	3.8935	6.3409
2.25	218.45	0.001187	0.08875	933.83	1668.2	2602.0	936.49	1865.2	2801.7	2.5035	3.7937	6.2972
2.5	223.99	0.001197	0.07998	959.11	1644.0	2603.1	962.11	1841.0	2803.1	2.5547	3.7028	6.2575
3.0	233.90	0.001217	0.06668	1004.78	1599.3	2604.1	1008.42	1795.7	2804.2	2.6457	3.5412	6.1869
3.5	242.60	0.001235	0.05707	1045.43	1558.3	2603.7	1049.75	1753.7	2803.4	2.7253	3.4000	6.1253
4	250.40	0.001252	0.04978	1082.31	1520.0	2602.3	1087.31	1741.1	2801.4	2.7964	3.2737	6.0701
5	263.99	0.001286	0.03944	1147.81	1449.3	2597.1	1154.23	1640.1	2794.3	2.9202	3.0532	5.9734
6	275.64	0.001319	0.03244	1205.44	1384.3	2589.7	1213.35	1571.0	2784.3	3.0267	2.8625	5.8892
7	285.88	0.001351	0.02737	1257.55	1323.0	2580.5	1267.00	1505.1	2772.1	3.1211	2.6922	5.8133
8	295.06	0.001384	0.02352	1305.57	1264.2	2569.8	1316.64	1441.3	2758.0	3.2068	2.5364	5.7432
9	303.40	0.001418	0.02048	1350.51	1207.3	2557.8	1363.26	1378.9	2742.1	3.2858	2.3915	5.6722
10	311.06	0.001452	0.018026	1393.04	1151.4	2544.4	1407.56	1317.1	2724.7	3.3596	2.2544	5.6141

Contd.

Figure 6.23: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 19

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Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.20 MPa (120.23 °C)				*P = 0.30 MPa (133.55 °C)*				*P = 0.40 MPa (143.63 °C)*			
Sat.	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2312	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.5663	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.50 MPa (151.86 °C)				*P = 0.60 MPa (158.85 °C)*				*P = 0.80 MPa (170.43 °C)*			
Sat.	0.3749	2561.2	2748.7	6.8213	0.3157	2567.4	2756.8	6.7600	0.2404	2576.8	2769.1	6.6628
200	0.4249	2642.9	2855.4	7.0592	0.3520	2638.9	2850.1	6.9665	0.2608	2630.6	2839.3	6.8158
250	0.4744	2723.5	2960.7	7.2709	0.3938	2720.9	2957.2	7.1816	0.2931	2715.5	2950.0	7.0384
300	0.5226	2802.9	3064.2	7.4599	0.4344	2801.0	3061.6	7.3724	0.3241	2797.2	3056.5	7.2328
350	0.5701	2882.6	3167.7	7.6329	0.4742	2881.2	3165.7	7.5464	0.3544	2878.2	3161.7	7.4089
400	0.6173	2963.2	3271.9	7.7938	0.5137	2962.1	3270.3	7.7079	0.3843	2959.7	3267.1	7.5716
500	0.7109	3128.4	3483.9	8.0873	0.5920	3127.6	3482.8	8.0021	0.4433	3126.0	3480.6	7.8673
600	0.8041	3299.6	3701.7	7.3522	0.6697	3299.1	3700.9	8.2674	0.5018	3297.9	3699.4	8.1333
700	0.8969	3477.5	3925.9	8.5952	0.7472	3477.0	3925.3	8.5107	0.5601	3476.2	3924.2	8.3770
800	0.9896	3662.1	4156.9	8.8211	0.8215	3661.8	4156.5	8.7367	0.6181	3661.1	4155.6	8.6033
900	1.0822	3853.6	4394.7	9.0329	0.9017	3853.4	4394.4	8.9486	0.6761	3852.8	4393.7	8.8153
1000	1.1747	4051.8	4639.1	9.2328	0.9788	4051.5	4638.8	9.1485	0.7340	4051.0	4638.2	9.0153
1100	1.2672	4256.3	4889.9	9.4224	1.0559	4256.1	4889.6	9.3381	0.7919	4255.6	4889.1	9.2050
1200	1.3596	4466.8	5146.6	9.6029	1.1330	4466.5	5146.3	9.5185	0.8497	4466.1	5145.9	9.3855
1300	1.4521	4682.5	5408.6	9.7749	1.2101	4682.3	5408.3	9.6906	0.9076	4681.8	5407.9	9.5575

Figure 6.24: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 19

```
disp("h_1bar_400oc=3278.2 KJ/kg, h_1bar_500oc=3488.1 KJ/kg from steam table")
h_1bar_400oc=3278.2;
h_1bar_500oc=3488.1;
disp("h2=h_1bar_400oc+(h_1bar_500oc-h_1bar_400oc)*(T2-400)/(500-400)")
disp("so final temperature(T2)in K")
disp("T2=400+((h2-h_1bar_400oc)*(500-400)/(h_1bar_500oc-h_1bar_400oc))")
T2=400+((h2-h_1bar_400oc)*(500-400)/(h_1bar_500oc-h_1bar_400oc))
disp("entropy for final state(s2)in KJ/kg K")
disp("s2=(s_1bar_400oc+((s_1bar_500oc-s_1bar_400oc)*(495.43-400)/(500-400)))")
disp("here from steam table,s_1bar_400oc=8.5435 KJ/kg K,s_1bar_500oc=8.8342 KJ/kg K")
s_1bar_400oc=8.5435;
s_1bar_500oc=8.8342;
s2=s_1bar_400oc+((s_1bar_500oc-s_1bar_400oc)*(495.43-400)/(500-400))
disp("so change in entropy(deltaS)in KJ/kg K")
disp("deltaS=s2-s1_10bar_500oc")
deltaS=s2-s1_10bar_500oc
disp("final specific volume,v2=v_1bar_400oc+((v_1bar_500oc-v_1bar_400oc)*(95.43)/(500-400)) in m^3/kg")
disp("here from steam table,v_1bar_500oc=3.565 m^3/kg,v_1bar_400oc=3.103 m^3/kg")
v_1bar_500oc=3.565;
v_1bar_400oc=3.103;
v2=v_1bar_400oc+((v_1bar_500oc-v_1bar_400oc)*(95.43)/(500-400))
disp("percentage of vessel volume initially occupied by steam=v1_1bar_500oc*100/v2")
v1_10bar_500oc*100/v2
```

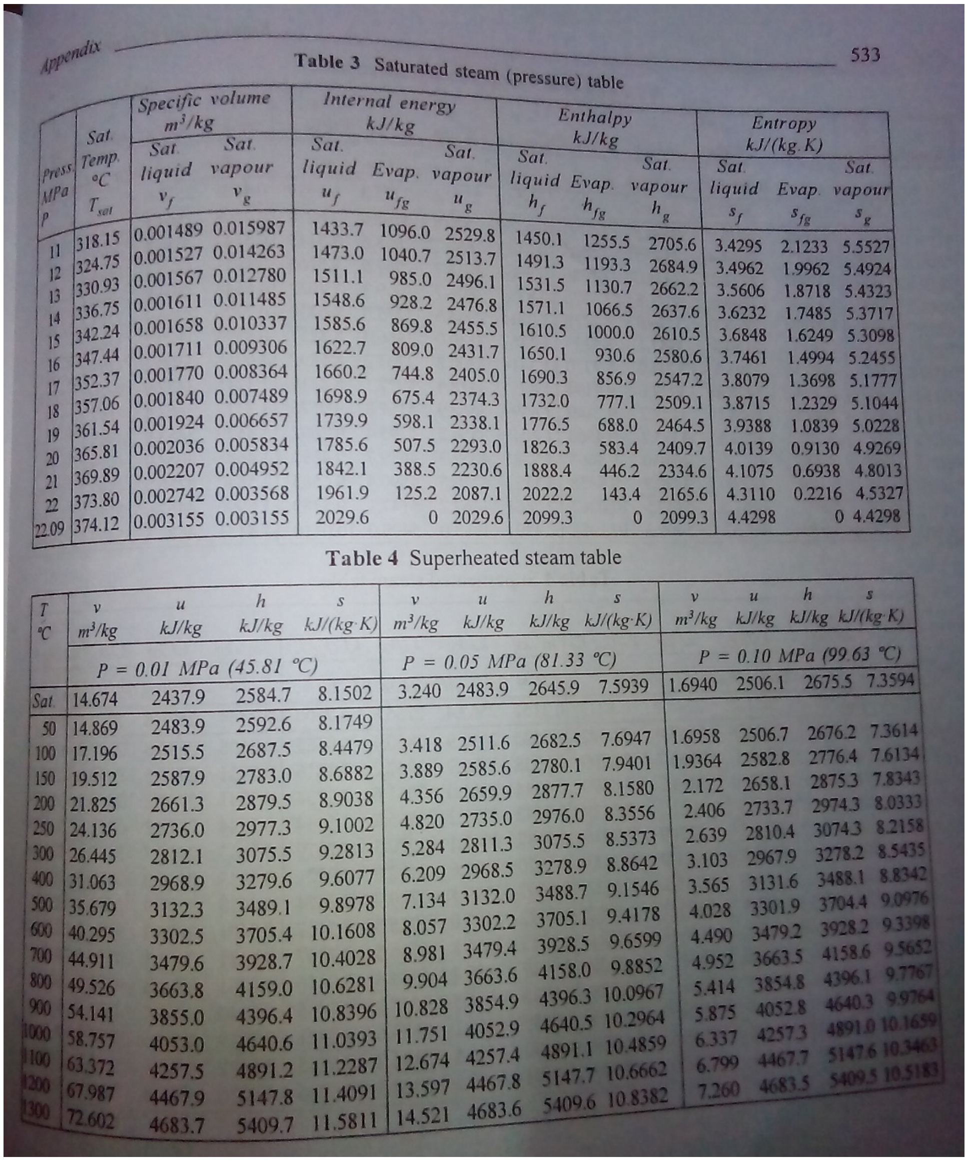

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Table 3 Saturated steam (pressure) table

Press. MPa p	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
11	318.15	0.001489	0.015987	1433.7	1096.0	2529.8	1450.1	1255.5	2705.6	3.4295	2.1233	5.5527
12	324.75	0.001527	0.014263	1473.0	1040.7	2513.7	1491.3	1193.3	2684.9	3.4962	1.9962	5.4924
13	330.93	0.001567	0.012780	1511.1	985.0	2496.1	1531.5	1130.7	2662.2	3.5606	1.8718	5.4323
14	336.75	0.001611	0.011485	1548.6	928.2	2476.8	1571.1	1066.5	2637.6	3.6232	1.7485	5.3717
15	342.24	0.001658	0.010337	1585.6	869.8	2455.5	1610.5	1000.0	2610.5	3.6848	1.6249	5.3098
16	347.44	0.001711	0.009306	1622.7	809.0	2431.7	1650.1	930.6	2580.6	3.7461	1.4994	5.2455
17	352.37	0.001770	0.008364	1660.2	744.8	2405.0	1690.3	856.9	2547.2	3.8079	1.3698	5.1777
18	357.06	0.001840	0.007489	1698.9	675.4	2374.3	1732.0	777.1	2509.1	3.8715	1.2329	5.1044
19	361.54	0.001924	0.006657	1739.9	598.1	2338.1	1776.5	688.0	2464.5	3.9388	1.0839	5.0228
20	365.81	0.002036	0.005834	1785.6	507.5	2293.0	1826.3	583.4	2409.7	4.0139	0.9130	4.9269
21	369.89	0.002207	0.004952	1842.1	388.5	2230.6	1888.4	446.2	2334.6	4.1075	0.6938	4.8013
22	373.80	0.002742	0.003568	1961.9	125.2	2087.1	2022.2	143.4	2165.6	4.3110	0.2216	4.5327
22.09	374.12	0.003155	0.003155	2029.6	0	2029.6	2099.3	0	2099.3	4.4298	0	4.4298

Table 4 Superheated steam table

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.01 MPa (45.81 °C)				P = 0.05 MPa (81.33 °C)				P = 0.10 MPa (99.63 °C)			
Sat.	14.674	2437.9	2584.7	8.1502	3.240	2483.9	2645.9	7.5939	1.6940	2506.1	2675.5	7.3594
50	14.869	2483.9	2592.6	8.1749					1.6958	2506.7	2676.2	7.3614
100	17.196	2515.5	2687.5	8.4479	3.418	2511.6	2682.5	7.6947	1.9364	2582.8	2776.4	7.6134
150	19.512	2587.9	2783.0	8.6882	3.889	2585.6	2780.1	7.9401	2.172	2658.1	2875.3	7.8343
200	21.825	2661.3	2879.5	8.9038	4.356	2659.9	2877.7	8.1580	2.406	2733.7	2974.3	8.0333
250	24.136	2736.0	2977.3	9.1002	4.820	2735.0	2976.0	8.3556	2.639	2810.4	3074.3	8.2158
300	26.445	2812.1	3075.5	9.2813	5.284	2811.3	3075.5	8.5373	3.103	2967.9	3278.2	8.5435
400	31.063	2968.9	3279.6	9.6077	6.209	2968.5	3278.9	8.8642	3.565	3131.6	3488.1	8.8342
500	35.679	3132.3	3489.1	9.8978	7.134	3132.0	3488.7	9.1546	4.028	3301.9	3704.4	9.0976
600	40.295	3302.5	3705.4	10.1608	8.057	3302.2	3705.1	9.4178	4.490	3479.2	3928.2	9.3398
700	44.911	3479.6	3928.7	10.4028	8.981	3479.4	3928.5	9.6599	4.952	3663.5	4158.6	9.5652
800	49.526	3663.8	4159.0	10.6281	9.904	3663.6	4158.0	9.8852	5.414	3854.8	4396.1	9.7767
900	54.141	3855.0	4396.4	10.8396	10.828	3854.9	4396.3	10.0967	5.875	4052.8	4640.3	9.9764
1000	58.757	4053.0	4640.6	11.0393	11.751	4052.9	4640.5	10.2964	6.337	4257.3	4891.0	10.1659
1100	63.372	4257.5	4891.2	11.2287	12.674	4257.4	4891.1	10.4859	6.799	4467.7	5147.6	10.3463
1200	67.987	4467.9	5147.8	11.4091	13.597	4467.8	5147.7	10.6662	7.260	4683.5	5409.5	10.5183
1300	72.602	4683.7	5409.7	11.5811	14.521	4683.6	5409.6	10.8382				

Figure 6.25: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 20

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Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.00 MPa (179.91 °C)				P = 1.20 MPa (187.99 °C)				P = 1.40 MPa (195.70 °C)			
Sat.	0.19444	2583.6	2778.1	6.5865	0.16333	2588.8	2784.8	6.5233	0.14084	2592.8	2790.0	6.4693
200	0.2060	2621.9	2827.9	6.6940	0.16930	2612.8	2815.9	6.5898	0.14302	2603.1	2803.3	6.4975
250	0.2327	2709.9	2942.6	6.9247	0.19234	2704.2	2935.0	6.8294	0.16350	2698.3	2927.2	6.7467
300	0.2579	2793.2	3051.2	7.1229	0.2138	2789.2	3045.8	7.0317	0.18228	2785.2	3040.4	6.9534
350	0.2825	2875.2	3157.7	7.3011	0.2345	2872.2	3153.6	7.2121	0.2003	2869.2	3149.5	7.1360
400	0.3066	2957.3	3263.9	7.4651	0.2548	2954.9	3260.7	7.3774	0.2178	2952.5	3257.5	7.3026
500	0.3541	3124.4	3478.5	7.7622	0.2946	3122.8	3476.3	7.6759	0.2521	3121.1	3474.1	7.6027
600	0.4011	3296.8	3697.9	8.0290	0.3339	3295.6	3696.3	7.9435	0.2860	3294.4	3694.8	7.8710
700	0.4478	3475.3	3923.1	8.2731	0.3729	3474.4	3922.0	8.1881	0.3195	3473.6	3920.8	8.1160
800	0.4943	3660.4	4154.7	8.4996	0.4118	3659.7	4153.8	8.4148	0.3528	3659.0	4153.0	8.3431
900	0.5407	3852.2	4392.9	8.7118	0.4505	3851.6	4392.2	8.6272	0.3861	3851.1	4391.5	8.5556
1000	0.5871	4050.5	4637.6	8.9119	0.4892	4050.0	4637.0	8.8274	0.4192	4049.5	4636.4	8.7559
1100	0.6335	4255.1	4888.6	9.1017	0.5278	4254.6	4888.0	9.0172	0.4524	4254.1	4887.5	8.9457
1200	0.6798	4465.6	5145.4	9.2822	0.5665	4465.1	5144.9	9.1977	0.4855	4464.7	5144.4	9.1262
1300	0.7261	4681.3	5407.4	9.4543	0.6051	4680.9	5407.0	9.3698	0.5186	4680.4	5406.5	9.2984

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.60 MPa (201.41 °C)				P = 1.80 MPa (207.15 °C)				p = 2.00 MPa (212.42 °C)			
Sat	0.12380	2596.0	2794.0	6.4218	0.11042	2598.4	2797.1	6.3794	0.09963	2600.3	2799.5	6.3409
225	0.13287	2644.7	2857.3	6.5518	0.11673	2636.6	2846.7	6.4808	0.10377	2628.3	2835.8	6.4147
250	0.14184	2692.3	2919.2	6.6732	0.12497	2686.0	2911.0	6.6066	0.11144	2679.6	2902.5	6.5453
300	0.15862	2781.1	3034.8	6.8844	0.14021	2776.9	3029.2	6.8226	0.12547	2772.6	3023.5	6.7664
350	0.17456	2866.1	3145.4	7.0694	0.15457	2863.0	3141.2	7.0100	0.13857	2859.8	3137.0	6.9563
400	0.19005	2950.1	3254.2	7.2374	0.16847	2947.7	3250.9	7.1794	0.15120	2945.2	3247.6	7.1271
500	0.2203	3119.5	3472.0	7.5390	0.19550	3117.9	3469.8	7.4825	0.17568	3116.2	3467.6	7.4317
600	0.2500	3293.3	3693.2	7.8080	0.2220	3292.1	3691.7	7.7523	0.19960	3290.9	3690.1	7.7024
700	0.2794	3472.7	3919.7	8.0535	0.2482	3471.8	3971.8	7.9983	0.2232	3470.9	3917.4	7.9487
800	0.3086	3658.3	4152.1	8.2808	0.2742	3657.6	4151.2	8.2258	0.2467	3657.0	4150.3	8.1765
900	0.3377	3850.5	4390.8	8.4935	0.3001	3849.9	4390.1	8.4386	0.2700	3849.3	4389.4	8.3895
1000	0.3668	4049.0	4635.8	8.6938	0.3260	4048.5	4635.2	8.6391	0.2933	4048.0	4634.6	8.5901
1100	0.3958	4253.7	4887.0	8.8837	0.3518	4253.2	4886.4	8.8290	0.3166	4252.7	4885.9	8.7800
1200	0.4248	4464.2	5143.9	9.0643	0.3776	4463.7	5143.4	9.0096	0.3398	4463.3	5142.9	8.9607
1300	0.4538	4679.9	5406.0	9.2364	0.4034	4679.5	5405.6	9.1818	0.3631	4679.0	5405.1	9.1329

Figure 6.26: Engineering Thermodynamics by Onkar Singh Chapter 6 Example 20

Chapter 7

Availability And General Thermodynamic Relations

Scilab code Exa 7.1 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 1")
C2=150;//leave velocity of steam in m/s
m=2.5;//steam mass flow rate in kg/s
disp("let us neglect the potential energy change
   during the flow.")
disp("applying S.F.E.E,neglecting inlet velocity and
    change in potential energy,")
disp("W_max=(h1-To*s1)-(h2+C2^2/2-To*s2)")
disp("W_max=(h1-h2)-To*(s1-s2)-C2^2/2")
disp("from steam tables,")
disp("h1=h_1.6Mpa_300=3034.8 KJ/kg,s1=s_1.6Mpa_300
```

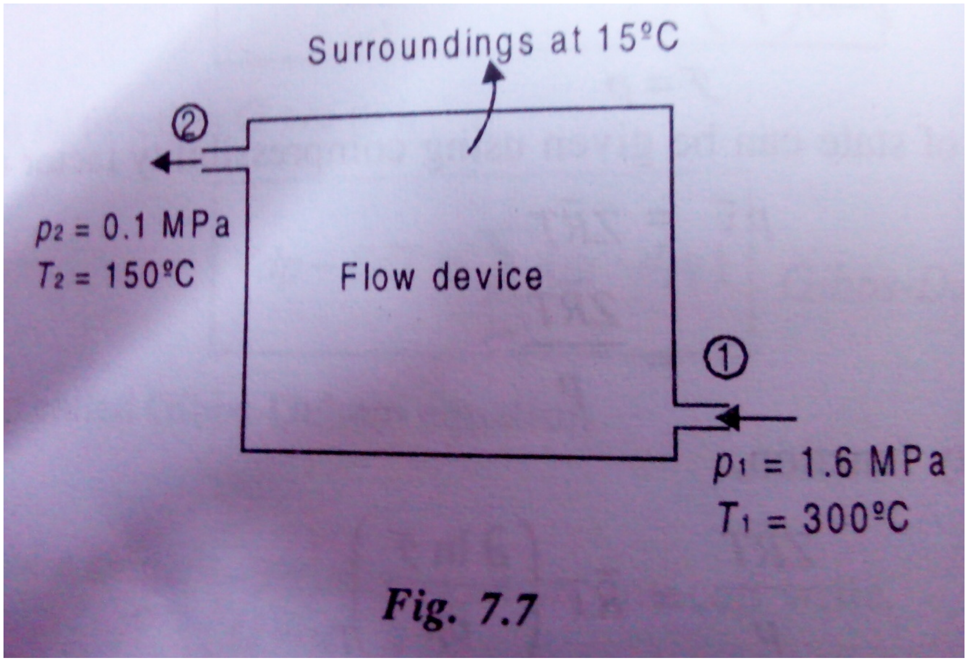

Figure 7.1: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 1

```
    =6.8844 KJ/kg, h2=h_0.1Mpa_150=2776.4 KJ/kg, s2=
    s_150Mpa_150=7.6134 KJ/kg")
h1=3034.8;
s1=6.8844;
h2=2776.4;
s2=7.6134;
disp("given To=288 K")
To=288;
disp("so W_max in KJ/kg")
W_max=(h1-h2)-To*(s1-s2)-(C2^2/2*10^-3)
disp("maximum possible work(W_max)=m*W_max in KW")
W_max=m*W_max
```

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.60 MPa (201.41 °C)				P = 1.80 MPa (207.15 °C)				p = 2.00 MPa (212.42 °C)			
Sat	0.12380	2596.0	2794.0	6.4218	0.11042	2598.4	2797.1	6.3794	0.09963	2600.3	2799.5	6.3409
225	0.13287	2644.7	2857.3	6.5518	0.11673	2636.6	2846.7	6.4808	0.10377	2628.3	2835.8	6.4147
250	0.14184	2692.3	2919.2	6.6732	0.12497	2686.0	2911.0	6.6066	0.11144	2679.6	2902.5	6.5453
300	0.15862	2781.1	3034.8	6.8844	0.14021	2776.9	3029.2	6.8226	0.12547	2772.6	3023.5	6.7664
350	0.17456	2866.1	3145.4	7.0694	0.15457	2863.0	3141.2	7.0100	0.13857	2859.8	3137.0	6.9563
400	0.19005	2950.1	3254.2	7.2374	0.16847	2947.7	3250.9	7.1794	0.15120	2945.2	3247.6	7.1271
500	0.2203	3119.5	3472.0	7.5390	0.19550	3117.9	3469.8	7.4825	0.17568	3116.2	3467.6	7.4317
600	0.2500	3293.3	3693.2	7.8080	0.2220	3292.1	3691.7	7.7523	0.19960	3290.9	3690.1	7.7024
700	0.2794	3472.7	3919.7	8.0535	0.2482	3471.8	3971.8	7.9983	0.2232	3470.9	3917.4	7.9487
800	0.3086	3658.3	4152.1	8.2808	0.2742	3657.6	4151.2	8.2258	0.2467	3657.0	4150.3	8.1765
900	0.3377	3850.5	4390.8	8.4935	0.3001	3849.9	4390.1	8.4386	0.2700	3849.3	4389.4	8.3895
1000	0.3668	4049.0	4635.8	8.6938	0.3260	4048.5	4635.2	8.6391	0.2933	4048.0	4634.6	8.5901
1100	0.3958	4253.7	4887.0	8.8837	0.3518	4253.2	4886.4	8.8290	0.3166	4252.7	4885.9	8.7800
1200	0.4248	4464.2	5143.9	9.0643	0.3776	4463.7	5143.4	9.0096	0.3398	4463.3	5142.9	8.9607
1300	0.4538	4679.9	5406.0	9.2364	0.4034	4679.5	5405.6	9.1818	0.3631	4679.0	5405.1	9.1329

Figure 7.2: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 1

Scilab code Exa 7.2 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 2")
m=1;//mass of air in kg
Po=1*10^5;//atmospheric pressure in pa
To=(15+273);//temperature of atmosphere in K
```

```
Cv=0.717;//specific heat at constant volume in KJ/kg
   K
R=0.287;//gas constant in KJ/kg K
Cp=1.004;//specific heat at constant pressure in KJ/
   kg K
T=(50+273);//temperature of tanks A and B in K
disp("In these tanks the air stored is at same
   temperature of 50 degree celcius.Therefore,for
   air behaving as perfect gas the internal energy
   of air in tanks shall be same as it depends upon
   temperature alone.But the availability shall be
   different.")
disp("BOTH THE TANKS HAVE SAME INTERNAL ENERGY")
disp("availability of air in tank,A")
disp("A=(E-Uo)+Po*(V-Vo)-To*(S-So)")
disp("=m*{(e-uo)+Po(v-vo)-To(s-so)}")
disp("m*{Cv*(T-To)+Po*(R*T/P-R*To/Po)-To(Cp*log(T/To
   )-R*log(P/Po))}")
disp("so A=m*{Cv*(T-To)+R*(Po*T/P-To)-To*Cp*log(T/To
   )+To*R*log(P/Po)}")
disp("for tank A,P=1*10^5 pa,so availability_A in KJ
   ")
P=1*10^5;//pressure in tank A in pa
availability_A=m*{Cv*(T-To)+R*(Po*T/P-To)-To*Cp*log(
   T/To)+To*R*log(P/Po)}
disp("for tank B,P=3*10^5 pa,so availability_B in KJ
   ")
P=3*10^5;//pressure in tank B in pa
availability_B=m*{Cv*(T-To)+R*(Po*T/P-To)-To*Cp*log(
   T/To)+To*R*log(P/Po)}
disp("so availability of air in tank B is more than
   that of tank A")
disp("availability of air in tank A=1.98 KJ")
disp("availability of air in tank B=30.98 KJ")
```

Scilab code Exa 7.3 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 3")
m=15;//steam flow rate in kg/s
V2=160;//exit velocity of steam in m/s
To=(15+273);//pond water temperature in K
disp("inlet conditions,")
disp("from steam tables,,h1=3051.2 KJ/kg,s1=7.1229 KJ/kg K")
h1=3051.2;
s1=7.1229;
disp("outlet conditions,at 0.05 bar and 0.95 dryness fraction")
disp("from steam tables,sf=0.4764 KJ/kg K,s_fg=7.9187 KJ/kg K,x=0.95,hf=137.82 KJ/kg,h_fg=2423.7 KJ/kg")
sf=0.4764;
s_fg=7.9187;
x=0.95;
hf=137.82;
h_fg=2423.7;
disp("so s2=sf+x*s_fg in KJ/kg K")
s2=sf+x*s_fg
disp("and h2=hf+x*h_fg in KJ/kg")
h2=hf+x*h_fg
disp("neglecting the change in potential energy and velocity at inlet to turbine,the steady flow energy equation may be written as to give work output.")
disp("w=(h1-h2)-V2^2*10^-3/2 in KJ/kg")
```

```
w=(h1-h2)-V2^2*10^-3/2
disp("power output=m*w in KW")
m*w
disp("maximum work for given end states,")
disp("w_max=(h1-To*s1)-(h2+V2^2*10^-3/2-To*s2) in KJ
    /kg")
w_max=(h1-To*s1)-(h2+V2^2*10^-3/2-To*s2)
w_max=850.38;//approx.
disp("w_max in KW")
w_max=m*w_max
disp("so maximum power output=12755.7 KW")
disp("maximum power that could be obtained from
    exhaust steam shall depend upon availability with
     exhaust steam and the dead state.stream
    availability of exhaust steam,")
disp("A_exhaust=(h2+V^2/2-To*s2)-(ho-To*so)")
disp("=(h2-ho)+V2^2/2-To(s2-so)")
disp("approximately the enthalpy of water at dead
    state of 1 bar,15 degree celcius can be
    approximated to saturated liquid at 15 degree
    celcius")
disp("from steam tables,at 15 degree celcius,ho
    =62.99 KJ/kg,so=0.2245 KJ/kg K")
ho=62.99;
so=0.2245;
disp("maximum work available from exhaust steam,
    A_exhaust in KJ/kg")
disp("A_exhaust=(h2-ho)+V2^2*10^-3/2-To*(s2-so)")
A_exhaust=(h2-ho)+V2^2*10^-3/2-To*(s2-so)
A_exhaust=151.1;//approx.
disp("maximum power that could be obtained from
    exhaust steam=m*A_exhaust in KW")
m*A_exhaust
disp("so maximum power from exhaust steam=2266.5 KW"
    )
```

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.00 MPa (179.91 °C)			
Sat.	0.19444	2583.6	2778.1	6.5865
200	0.2060	2621.9	2827.9	6.6940
250	0.2327	2709.9	2942.6	6.9247
300	0.2579	2793.2	3051.2	7.1229
350	0.2825	2875.2	3157.7	7.3011
400	0.3066	2957.3	3263.9	7.4651
500	0.3541	3124.4	3478.5	7.7622
600	0.4011	3296.8	3697.9	8.0290
700	0.4478	3475.3	3923.1	8.2731
800	0.4943	3660.4	4154.7	8.4996
900	0.5407	3852.2	4392.9	8.7118
1000	0.5871	4050.5	4637.6	8.9119
1100	0.6335	4255.1	4888.6	9.1017
1200	0.6798	4465.6	5145.4	9.2822
1300	0.7261	4681.3	5407.4	9.4543

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.20 MPa (187.99 °C)			
Sat.	0.16333	2588.8	2784.8	6.5233
200	0.16930	2612.8	2815.9	6.5898
250	0.19234	2704.2	2935.0	6.8294
300	0.2138	2789.2	3045.8	7.0317
350	0.2345	2872.2	3153.6	7.2121
400	0.2548	2954.9	3260.7	7.3774
500	0.2946	3122.8	3476.3	7.6759
600	0.3339	3295.6	3696.3	7.9435
700	0.3729	3474.4	3922.0	8.1881
800	0.4118	3659.7	4153.8	8.4148
900	0.4505	3851.6	4392.2	8.6272
1000	0.4892	4050.0	4637.0	8.8274
1100	0.5278	4254.6	4888.0	9.0172
1200	0.5665	4465.1	5144.9	9.1977
1300	0.6051	4680.9	5407.0	9.3698

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 1.40 MPa (195.70 °C)			
Sat.	0.14084	2592.8	2790.0	6.4693
200	0.14302	2603.1	2803.3	6.4975
250	0.16350	2698.3	2927.2	6.7467
300	0.18228	2785.2	3040.4	6.9534
350	0.2003	2869.2	3149.5	7.1360
400	0.2178	2952.5	3257.5	7.3026
500	0.2521	3121.1	3474.1	7.6027
600	0.2860	3294.4	3694.8	7.8710
700	0.3195	3473.6	3920.8	8.1160
800	0.3528	3659.0	4153.0	8.3431
900	0.3861	3851.1	4391.5	8.5556
1000	0.4192	4049.5	4636.4	8.7559
1100	0.4524	4254.1	4887.5	8.9457
1200	0.4855	4464.7	5144.4	9.1262
1300	0.5186	4680.4	5406.5	9.2984

Figure 7.3: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 3

Scilab code Exa 7.4 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 4")
m=5;//mass of steam in kg
```

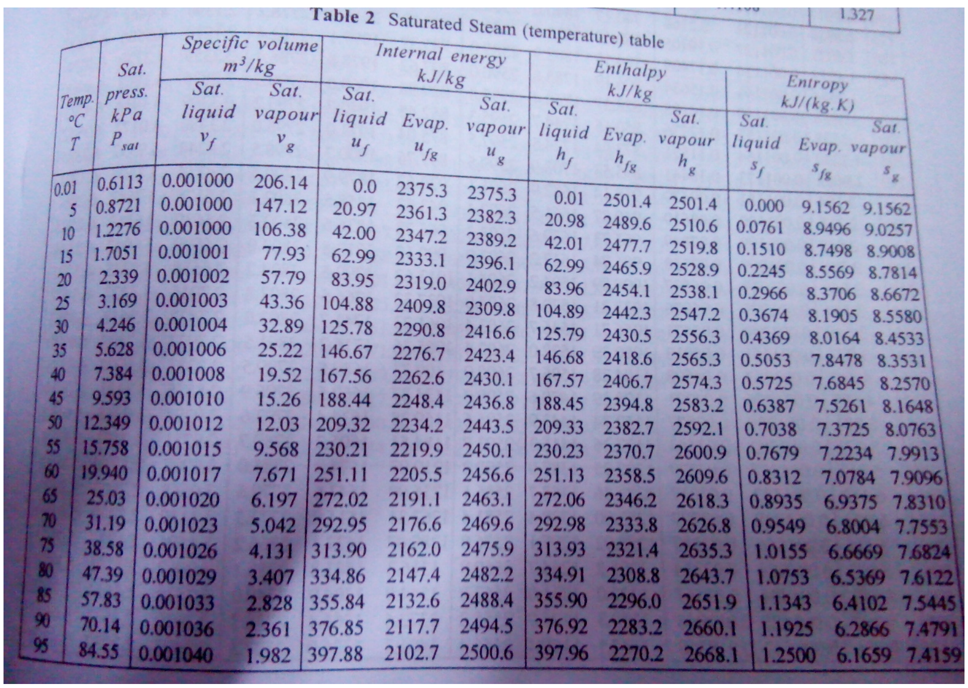

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.4	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2409.8	2309.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	7.6824
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	7.6122
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	7.5445
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	7.4791
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	7.4159

Figure 7.4: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 3

```
z1=10;//initial elevation in m
V1=25;//initial velocity of steam in m/s
z2=2;//final elevation in m
V2=10;//final velocity of steam in m/s
Po=100;//environmental pressure in Kpa
To=(25+273);//environmental temperature in K
g=9.81;//acceleration due to gravity in m/s^2
disp("for dead state of water,")
disp("from steam tables,uo=104.86 KJ/kg,vo
   =1.0029*10^-3 m^3/kg,so=0.3673 KJ/kg K")
uo=104.86;
vo=1.0029*10^-3;
so=0.3673;
disp("for initial state of water,")
disp("from steam tables,u1=2550 KJ/kg,v1=0.5089 m^3/
   kg,s1=6.93 KJ/kg K")
u1=2550;
v1=0.5089;
s1=6.93;
disp("for final state of water,")
disp("from steam tables,u2=83.94 KJ/kg,v2
   =1.0018*10^-3 m^3/kg,s2=0.2966 KJ/kg K")
u2=83.94;
v2=1.0018*10^-3;
s2=0.2966;
disp("availability at any state can be given by")
disp("A=m*((u-uo)+Po*(v-vo)-To*(s-so)+V^2/2+g*z)")
disp("so availability at initial state,A1 in KJ")
disp("A1=m*((u1-uo)+Po*(v1-vo)-To*(s1-so)+V1
   ^2*10^-3/2+g*z1*10^-3)")
A1=m*((u1-uo)+Po*(v1-vo)-To*(s1-so)+V1^2*10^-3/2+g*
   z1*10^-3)
disp("and availability at final state,A2 in KJ")
disp("A2=m*((u2-uo)+Po*(v2-vo)-To*(s2-so)+V2
   ^2*10^-3/2+g*z2*10^-3)")
A2=m*((u2-uo)+Po*(v2-vo)-To*(s2-so)+V2^2*10^-3/2+g*
   z2*10^-3)
disp("change in availability,A2-A1 in KJ")
```

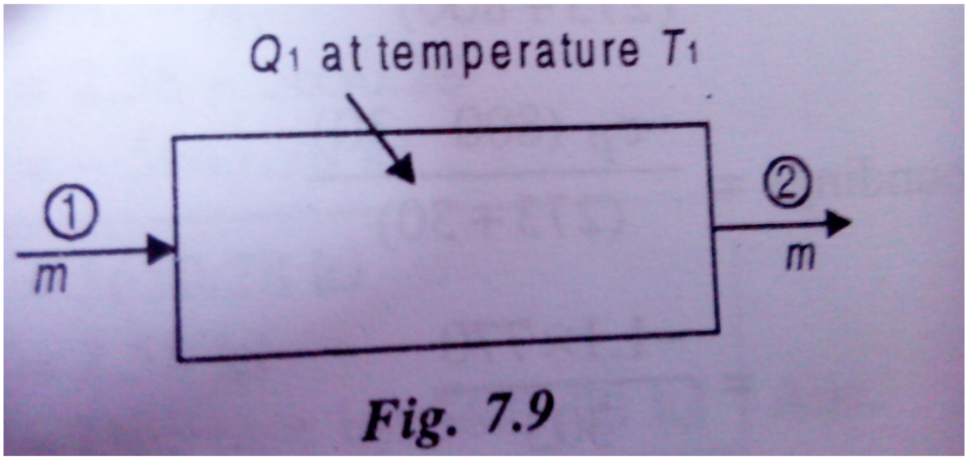

Figure 7.5: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 5

```
A2-A1
disp("hence availability decreases by 2702.188 KJ")
disp("NOTE=>In this question,due to large
    calculations,answers are approximately correct.")
```

Scilab code Exa 7.5 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 7 Example 5")
disp("In question no. 5 expression I=To*S_gen is
```

```
derived which cannot be solve using scilab
software.")
```

Scilab code Exa 7.6 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 6")
To=(30+273);//temperature of surrounding in K
W=1050;//work done in engine in KJ/kg
Cp=1.1;//specific heat at constant pressure in KJ/kg
    K
T=(800+273);//temperature of exhaust gas in K
disp("loss of available energy=irreversibility=To*
   deltaSc")
disp("deltaSc=deltaSs+deltaSe")
disp("change in enropy of system(deltaSs)=W/T in KJ/
   kg K")
deltaSs=W/T
disp("change in entropy of surrounding(deltaSe)=-Cp
   *(T-To)/To in KJ/kg K")
deltaSe=-Cp*(T-To)/To
disp("loss of available energy(E)=To*(deltaSs+
   deltaSe)in KJ/kg")
E=To*(deltaSs+deltaSe)
disp("loss of available energy(E)=")
E=-E
disp("ratio of lost available exhaust gas energy to
   engine work=E/W")
```

```
E/W
```

Scilab code Exa 7.7 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 7")
m=10;//mass of water in kg
C1=25;//initial velocity in m/s
C2=10;//final velocity in m/s
Po=0.1*1000;//environmental pressure in Kpa
To=(25+273.15);//environmental temperature in K
g=9.8;//acceleration due to gravity in m/s^2
z1=10;//initial elevation in m
z2=3;//final elevation in m
disp("let us consider velocities and elevations to be given in reference to environment.Availability is given by")
disp("A=m*((u-uo)+Po*(v-vo)-To(s-so)+C^2/2+g*z)")
disp("dead state of water,from steam tables,uo=104.88 KJ/kg,vo=1.003*10^-3 m^3/kg,so=0.3674 KJ/kg K")
uo=104.88;
vo=1.003*10^-3;
so=0.3674;
disp("for initial state of saturated vapour at 150 degree celcius")
disp("from steam tables,u1=2559.5 KJ/kg,v1=0.3928 m^3/kg,s1=6.8379 KJ/kg K")
```

```
u1=2559.5;
v1=0.3928;
s1=6.8379;
disp("for final state of saturated liquid at 20
   degree celcius")
disp("from steam tables ,u2=83.95 KJ/kg ,v2=0.001002 m
   ^3/kg ,s2=0.2966 KJ/kg K")
u2=83.95;
v2=0.001002;
s2=0.2966;
disp("substituting in the expression for
   availability")
disp("initial state availability ,A1 in KJ")
disp("A1=m*((u1-uo)+Po*(v1-vo)-To*(s1-so)+C1
   ^2*10^-3/2+g*z1*10^-3)")
A1=m*((u1-uo)+Po*(v1-vo)-To*(s1-so)+C1^2*10^-3/2+g*
   z1*10^-3)
disp("final state availability ,A2 in KJ")
disp("A2=m*((u2-uo)+Po*(v2-vo)-To*(s2-so)+C2
   ^2*10^-3/2+g*z2*10^-3)")
A2=m*((u2-uo)+Po*(v2-vo)-To*(s2-so)+C2^2*10^-3/2+g*
   z2*10^-3)
disp("change in availability ,deltaA=A2-A1 in KJ")
deltaA=A2-A1
disp("so initial availability =5650.28 KJ")
disp("final availability=2.58 KJ ")
disp("change in availability=decrease by 5647.70 KJ
   ")
```

Scilab code Exa 7.8 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 8")
m=5;//steam flow rate in kg/s
p1=5*1000;//initial pressure of steam in Kpa
T1=(500+273.15);//initial temperature of steam in K
p2=0.2*1000;//final pressure of steam in Kpa
T1=(140+273.15);//final temperature of steam in K
po=101.3;//pressure of steam at dead state in Kpa
To=(25+273.15);//temperature of steam at dead state in K
Q=600;//heat loss through turbine in KJ/s
disp("let inlet and exit states of turbine be denoted as 1 and 2")
disp("at inlet to turbine,")
disp("from steam tables,h1=3433.8 KJ/kg,s1=6.9759 KJ/kg K")
h1=3433.8;
s1=6.9759;
disp("at exit from turbine,")
disp("from steam tables,h2=2748 KJ/kg,s2=7.228 KJ/kg K")
h2=2748;
s2=7.228;
disp("at dead state,")
disp("from steam tables,ho=104.96 KJ/kg,so=0.3673 KJ/kg K")
ho=104.96;
so=0.3673;
disp("availability of steam at inlet,A1=m*((h1-ho)-To*(s1-so))in KJ")
A1=m*((h1-ho)-To*(s1-so))
disp("so availability of steam at inlet=6793.43 KJ")
disp("applying first law of thermodynamics,")
disp("Q+m*h1=m*h2+W")
disp("so W=m*(h1-h2)-Q in KJ/s")
```

```
W=m*(h1-h2)-Q
disp("so turbine output=2829 KW")
disp("maximum possible turbine output will be
   available when irreversibility is zero.")
disp("W_rev=W_max=A1-A2")
disp("W_max=m*((h1-h2)-To*(s1-s2))in KJ/s")
W_max=m*((h1-h2)-To*(s1-s2))
disp("so maximum output=3804.81 KW")
disp("irreversibility can be estimated by the
   difference between the maximum output and turbine
    output.")
disp("I=W_max-W in KW")
I=W_max-W
disp("so irreversibility=975.81807 KW")
disp("NOTE=>In book,W_max is calculated wrong,so
   irreversibility also comes wrong,which are
   corrected above.")
```

Scilab code Exa 7.9 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 9")
```

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 4.0 MPa (250.40 °C)				*P = 4.5 MPa (257.49 °C)*				*P = 5.0 MPa (263.99 °C)*			
Sat.	0.04978	2602.3	2801.4	6.0701	0.04406	2600.1	2798.3	6.0198	0.03944	2597.1	2794.3	5.9734
275	0.05457	2667.9	2886.2	6.2285	0.04730	2650.3	2863.2	6.1401	0.04141	2631.3	2838.3	6.0544
300	0.05884	2725.3	2960.7	6.3615	0.05135	2712.0	2943.1	6.2828	0.04532	2698.0	2924.5	6.2084
350	0.06645	2826.7	3092.5	6.5821	0.05840	2817.8	3080.6	6.5131	0.05194	2808.7	3068.4	6.4493
400	0.07341	2919.9	3213.6	6.7690	0.06475	2913.3	3204.7	6.7047	0.05781	2906.6	3195.7	6.6459
450	0.08002	3010.2	3330.3	6.9363	0.07074	3005.0	3323.3	6.8746	0.06330	2999.7	3316.2	6.8186
500	0.08643	3099.5	3445.3	7.0901	0.07651	3095.3	3439.6	7.0301	0.06857	3091.0	3433.8	6.9759
600	0.09885	3279.1	3674.4	7.3688	0.08765	3276.0	3670.5	7.3110	0.07869	3273.0	3666.5	7.2589
700	0.11095	3462.1	3905.9	7.6198	0.09847	3459.9	3903.0	7.5631	0.08849	3457.6	3900.1	7.5122
800	0.12287	3650.0	4141.5	7.8502	0.10911	3648.3	4139.3	7.7942	0.09811	3646.6	4137.1	7.7440
900	0.13469	3843.6	4382.3	8.0647	0.11965	3842.2	4380.6	8.0091	0.10762	3840.7	4378.8	7.9593
1000	0.14645	4042.9	4628.7	8.2662	0.13013	4041.6	4627.2	8.2108	0.11707	4040.4	4625.7	8.1612
1100	0.15817	4248.0	4880.6	8.4567	0.14056	4246.8	4879.3	8.4015	0.12648	4245.6	4878.0	8.3520
1200	0.16987	4458.6	5138.1	8.6376	0.15098	4457.5	5136.9	8.5825	0.13587	4456.3	5135.7	8.5331
1300	0.18156	4674.3	5400.5	8.8100	0.16139	4673.1	5399.4	8.7549	0.14526	4672.0	5398.2	8.7055

Figure 7.6: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 8

Table 4 Superheated steam table

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m³/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.20 MPa (120.23 °C)				*P = 0.30 MPa (133.55 °C)*				*P = 0.40 MPa (143.63 °C)*			
Sat.	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2312	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.5663	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780

Figure 7.7: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 8

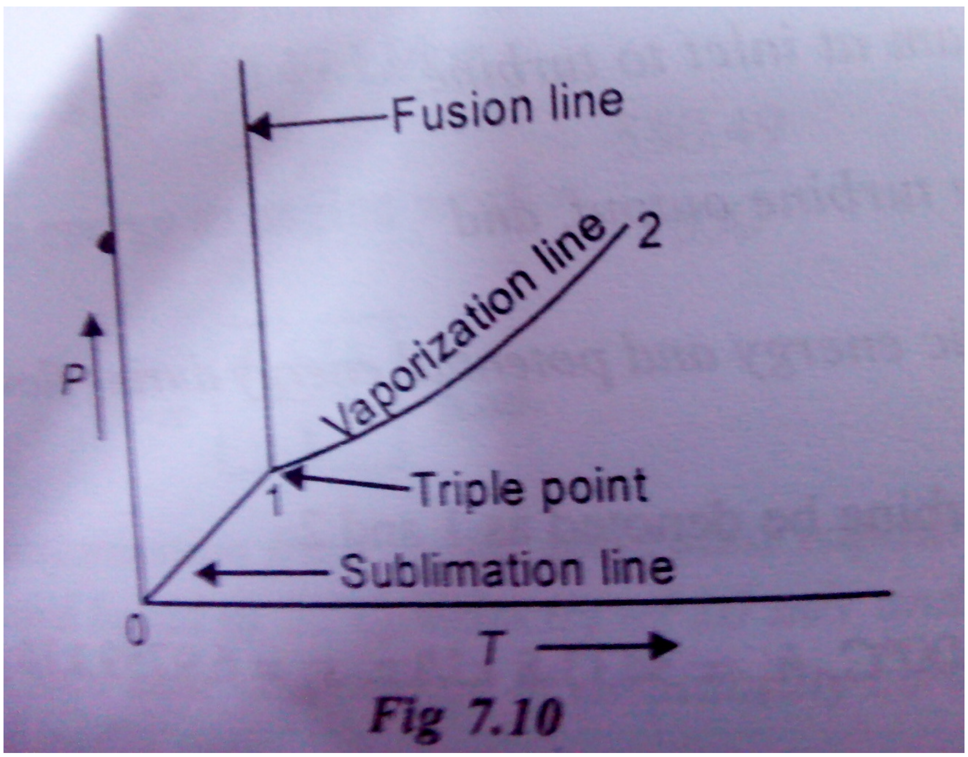

Figure 7.8: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 9

```
disp("In question no.9 comparision between
   sublimation and vaporisation line is made which
   cannot be solve using scilab software.")
```

Scilab code Exa 7.10 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 10")
disp("In question no. 10 expression for change in
   internal energy of gas is derive which cannot be
   solve using scilab software.")
```

Scilab code Exa 7.11 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 11

```
// Display modeK
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 11")
To=280;//surrounding temperature in K
Q=500;//heat removed in KJ
T1=835;//temperature of reservoir in K
```

```
T2=720;//temperature of system in K
disp("availability for heat reservoir(A_HR)=To*
    deltaS_reservoir in KJ/kg K")
A_HR=To*Q/T1
disp("now availability for system(A_system)=To*
    deltaS_syatem in KJ/kg K")
A_system=To*Q/T2
disp("net loss of available energy(A)=A_HR-A_system
    in KJ/kg K")
A=A_HR-A_system
disp("so loss of available energy=26.77 KJ/kg K")
```

Scilab code Exa 7.12 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 12

```
// Display modeK
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 7 Example 12")
h1=4142;//enthalpy at entrance in KJ/kg
h2=2585;//enthalpy at exit in KJ/kg
W1=1787;//availability of steam at entrance in KJ/kg
W2=140;//availability of steam at exit in KJ/kg
disp("here dead state is given as 300 K and maximum
    possible work for given change of state of steam
    can be estimated by the difference of flow
    availability as given under:")
disp("W_max=W1-W2 in KJ/kg")
W_max=W1-W2
disp("actual work from turbine,W_actual=h1-h2 in KJ/
    kg")
```

```
W_actual=h1-h2
disp("so actual work=1557 KJ/kg")
disp("maximum possible work=1647 KJ/kg")
```

Scilab code Exa 7.13 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 13

```
// Display modeK
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 7 Example 13")
T_min=(20+273);//minimum temperature reservoir
    temperature in K
T_max=(500+273);//maximum temperature reservoir
    temperature in K
n=0.25;//efficiency of heat engine
disp("reversible engine efficiency,n_rev=1-(T_min/
    T_max)")
n_rev=1-(T_min/T_max)
disp("second law efficiency=n/n_rev")
n/n_rev
disp("in %")
n*100/n_rev
```

Scilab code Exa 7.14 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 14

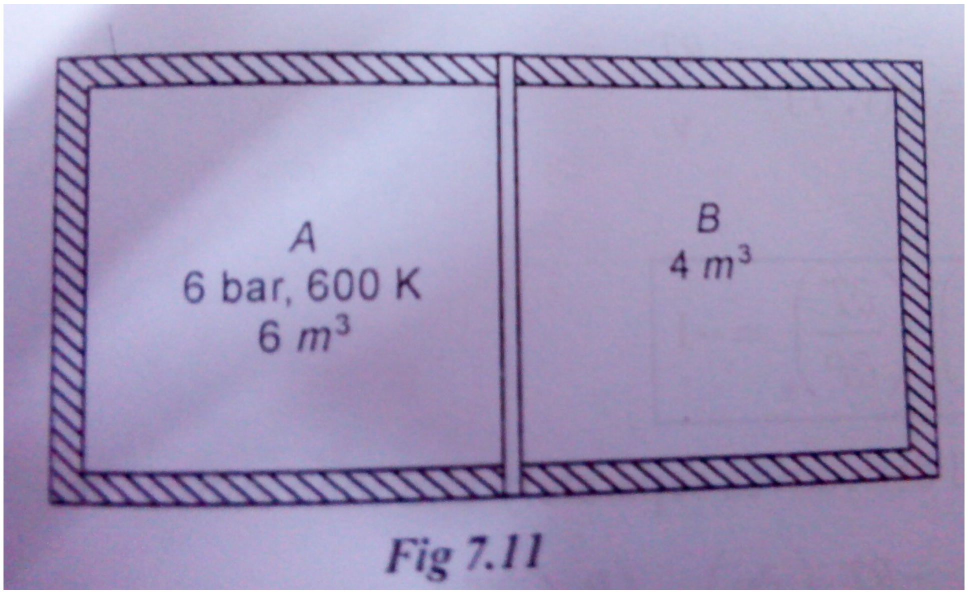

Figure 7.9: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 14")
V_A=6;//volume of compartment A in m^3
V_B=4;//volume of compartment B in m^3
To=300;//temperature of atmosphere in K
Po=1*10^5;//atmospheric pressure in pa
P1=6*10^5;//initial pressure in pa
T1=600;//initial temperature in K
V1=V_A;//initial volume in m^3
V2=(V_A+V_B);//final volume in m^3
y=1.4;//expansion constant
R=287;//gas constant in J/kg K
```

```
Cv=0.718;//specific heat at constant volume in KJ/kg
    K
disp("expansion occurs in adiabatic conditions.")
disp("temperature after expansion can be obtained by
    considering adiabatic expansion")
disp("T2/T1=(V1/V2)^(y-1)")
disp("so T2=T1*(V1/V2)^(y-1) in K")
T2=T1*(V1/V2)^(y-1)
T2=489.12;//approx.
disp("mass of air,m=(P1*V1)/(R*T1)in kg")
m=(P1*V1)/(R*T1)
m=20.91;//approx.
disp("change in entropy of control system,deltaSs=(
    S2-S1)=m*Cv*log(T2/T1)+m*R*10^-3*log(V2/V1)in KJ/
    K")
deltaSs=m*Cv*log(T2/T1)+m*R*10^-3*log(V2/V1)
disp("here,there is no change in entropy of
    environment,deltaSe=0")
deltaSe=0;
disp("total entropy change of combined system=
    deltaSc=deltaSs+deltaSe in KJ/K")
deltaSc=deltaSs+deltaSe
disp("loss of available energy(E)=irreversibility=To
    *deltaSc in KJ")
E=To*deltaSc
disp("so loss of available energy,E=0.603 KJ")
```

Scilab code Exa 7.15 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
```

```
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 15")
disp("In question no. 15 prove for ideal gas
   satisfies the cyclic relation is done which
   cannot be solve using scilab software.")
```

Scilab code Exa 7.16 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 16")
To=(17+273);//temperature of surrounding in K
T1=(700+273);//temperature of high temperature
   reservoir in K
T2=(30+273);//temperature of low temperature
   reservoir in K
Q1=2*10^4;//rate of heat receive in KJ/min
W_useful=0.13*10^3;//output of engine in KW
disp("availability or reversible work,W_rev=n_rev*Q1
    in KJ/min")
n_rev=(1-T2/T1);
W_rev=n_rev*Q1
W_rev=W_rev/60;//W_rev in KJ/s
disp("rate of irreversibility,I=W_rev-W_useful in KJ
   /sec")
I=W_rev-W_useful
disp("second law efficiency=W_useful/W_rev")
W_useful/W_rev
```

```
disp("in percentage")
W_useful*100/W_rev
disp("so availability=1.38*10^4 KJ/min")
disp("and rate of irreversibility=100 KW,second law
   efficiency=56.63 %")
disp("NOTE=>In this question,wrong values are put in
    expression for W_rev in book,however answer is
   calculated correctly.")
```

Scilab code Exa 7.17 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 17

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 17")
To=(27+273);//temperature of surrounding in K
T1=(60+273);//initial temperature of air in K
P1=1.5*10^5;//initial pressure of air in pa
P2=2.5*10^5;//final pressure of air in pa
T_reservoir=(400+273);//temperature of reservoir in
   K
Cp=1.005;//specific heat at constant pressure in KJ/
   kg K
disp("loss of available energy=irreversibility=To*
   deltaSc")
disp("deltaSc=deltaSs+deltaSe")
disp("change in entropy of system=deltaSs")
disp("change in entropy of environment/surroundings=
   deltaSe")
disp("here heat addition process causing rise in
```

```
   pressure from 1.5 bar to 2.5 bar occurs
   isochorically.let initial and final states be
   given by subscript 1 and 2")
disp("P1/T1=P2/T2")
disp("so T2=P2*T1/P1 in K")
T2=P2*T1/P1
disp("heat addition to air in tank")
disp("Q=m*Cp*deltaT in KJ/kg")
deltaT=T2-T1;
Q=Cp*deltaT
disp("deltaSs=Q/T1 in KJ/kg K")
deltaSs=Q/T1
disp("deltaSe=-Q/T_reservoir in KJ/kg K")
deltaSe=-Q/T_reservoir
disp("and deltaSc=deltaSs+deltaSe in KJ/kg K")
deltaSc=deltaSs+deltaSe
disp("so loss of available energy(E)in KJ/kg")
E=To*deltaSc
```

Scilab code Exa 7.18 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 18

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 18")
disp("In question no. 18,relation for T*ds using
   maxwell relation is derived which cannot be solve
    using scilab software.")
```

Scilab code Exa 7.19 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 19

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 19")
T=(200+273);//temperature of water in K
disp("clapeyron equation says,h_fg=T*v_fg*(dp/dT)_sat")
disp("from steam tables,vg=0.12736 m^3/kg,vf=0.001157 m^3/kg")
vg=0.12736;
vf=0.001157;
disp("v_fg=(vg-vf)_200oc in m^3/kg")
v_fg=(vg-vf)
disp("let us approximate,")
disp("(dp/dT)_sat_200oc=(deltaP/deltaT)_200oc=(P_205oc-P_195oc)/(205-195) in Mpa/oc")
disp("here from steam tables,P_205oc=1.7230 Mpa,P_195oc=1.3978 Mpa")
P_205oc=1.7230;//pressure at 205 degree celcius in Mpa
P_195oc=1.3978;//pressure at 195 degree celcius in Mpa
(P_205oc-P_195oc)/(205-195)
disp("substituting in clapeyron equation,")
disp("h_fg in KJ/kg")
```

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Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m³/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001157	0.12736	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001164	0.11521	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001173	0.10441	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001181	0.09479	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001190	0.08619	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001199	0.07849	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001209	0.07158	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001219	0.06537	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001229	0.05976	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001240	0.05471	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083
250	3.973	0.001251	0.05013	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001263	0.04598	1104.28	1596.7	2600.9	1109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001276	0.04221	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001289	0.03877	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001302	0.03564	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001317	0.03279	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001332	0.03017	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001348	0.02777	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001366	0.02557	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001384	0.02354	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001404	0.02167	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001425	0.019948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001447	0.018350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230

Figure 7.10: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 19

```
h_fg=T*v_fg*(P_205oc-P_195oc)*1000/(205-195)
disp("so calculated enthalpy of vaporisation=1941.25
    KJ/kg")
disp("and enthalpy of vaporisation from steam table
   =1940.7 KJ/kg")
```

Scilab code Exa 7.20 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 20

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 7 Example 20")
P2=260.96;//saturation pressure at -5 degree celcius
P1=182.60;//saturation pressure at -15 degree
   celcius
vg=0.07665;//specific volume of gas at -10 degree
   celcius in m^3/kg
vf=0.00070//specific volume at -10 degree celcius in
    m^3/kg
R=0.06876;//gas constant in KJ/kg K
h_fg=156.3;//enthalpy in KJ/kg K
T2=(-5+273);//temperature in K
T1=(-15+273);//temperature in K
disp("by clapeyron equation")
disp("h_fg=T2*v_fg*(do/dT)_sat ")
disp("h_fg=T2*(vg-vf)*(deltaP/deltaT)in KJ/kg")
h_fg=T2*(vg-vf)*(P1-P2)/(T1-T2)
disp("by clapeyron-clausius equation,")
disp("log(P2/P1)_sat=(h_fg/R)*((1/T1)-(1/T2))_sat")
disp("log(P2/P1)=(h_fg/R)*((1/T1)-(1/T2))")
```

Table 4 Superheated steam table

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 0.20 MPa (120.23 °C)				P = 0.30 MPa (133.55 °C)				P = 0.40 MPa (143.63 °C)			
Sat.	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662
400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2312	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.5663	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780

Figure 7.11: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 21

```
disp("so h_fg=log(P2/P1)*R/((1/T1)-(1/T2))in KJ/kg")
h_fg=log(P2/P1)*R/((1/T1)-(1/T2))
disp("% deviation from clapeyron equation in %")
(169.76-159.49)*100/159.49
disp("h_fg by clapeyron equation=159.49 KJ/kg")
disp("h_fg by clapeyron-clausius equation=169.76 KJ/
    kg")
disp("% deviation in h_fg value by clapeyron-
    clausius equation from the value from clapeyron
    equation=6.44%")
```

Scilab code Exa 7.21 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 21

```
// Display mode
```

```
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 21")
disp("volume expansion=(1/v)*(dv/dT)_P")
disp("isothermal compressibility=-(1/v)*(dv/dp)_T")
disp("let us write dv/dT=deltav/deltaT and dv/dP=deltav/deltaP.The difference may be taken for small pressure and temperature changes.")
disp("volume expansivity in K^-1,")
disp("=(1/v)*(dv/dT)_300Kpa")
disp("=(1/v_300Kpa_300oc)*((v_350oc-v_250oc)/(350-250))_300Kpa")
disp("from steam tables,v_300Kpa_300oc=0.8753 in m^3/kg,v_350oc=0.9534 in m^3/kg,v_250oc=0.7964 in m^3/kg")
v_300Kpa_300oc=0.8753;//specific volume at 300Kpa and 300 degree celcius
v_350oc=0.9534;//specific volume 350 degree celcius
v_250oc=0.7964;//specific volume 250 degree celcius
(1/v_300Kpa_300oc)*(v_350oc-v_250oc)/(350-250)
disp("volume expansivity=1.7937*10^-3 K^-1")
disp("isothermal compressibility in Kpa^-1")
disp("=(-1/v_300Kpa_300oc)*((v_350Kpa-v_250Kpa)/(350-250))_300oc")
disp("from steam tables,v_300Kpa_300oc=0.8753 in m^3/kg,v_350Kpa=0.76505 in m^3/kg,v_250Kpa=1.09575 in m^3/kg")
v_350Kpa=0.76505;//specific volume 350 Kpa
v_250Kpa=1.09575;//specific volume 250 Kpa
(-1/v_300Kpa_300oc)*(v_350Kpa-v_250Kpa)/(350-250)
disp("so isothermal compressibility=3.778*10^-3 Kpa^-1")
```

Scilab code Exa 7.22 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 22

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 7 Example 22")
Cp=1.005;//specific heat at constant pressure in KJ/
    kg K
Cv=0.718;//specific heat at constant volume in KJ/kg
    K
Ti=(25+273.15);//atmospheric temperature in K
disp("filling of the tank is a transient flow(
    unsteady)process.for the transient filling
    process,considering subscripts i and f for
    initial and final states,")
disp("hi=uf")
disp("Cp*Ti=Cv*Tf")
disp("so Tf=Cp*Ti/Cv in K")
Tf=Cp*Ti/Cv
disp("inside final temperature,Tf=417.33 K")
disp("change in entropy,deltaS_gen=(Sf-Si)+
    deltaS_surr in KJ/kg K")
disp("Cp*log(Tf/Ti)+0")
deltaS_gen=Cp*log(Tf/Ti)
disp("change in entropy,deltaS_gen=0.3379 KJ/kg K")
disp("irreversibility,I=To*deltaS_gen in KJ/kg")
To=Ti;
I=To*deltaS_gen
disp("irreversibility,I=100.74 KJ/kg")
```

Scilab code Exa 7.23 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 23

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 23")
m=75;//mass of hot water in kg
T1=(400+273);//temperature of hot water in K
T2=(27+273);//temperature of environment in K
Cp=4.18;//specific heat of water in KJ/kg K
disp("here the combined closed system consists of hot water and heat engine.here there is no thermal reservoir in the system under consideration.for the maximum work output, irreversibility=0")
disp("therefore,d(E-To-S)/dt=W_max")
disp("or W_max=(E-To-S)1-(E-To-S)2")
disp("here E1=U1=m*Cp*T1,E2=U2=m*Cp*T2")
disp("therefore,W_max=m*Cp*(T1-T2)-To*m*Cp*log(T1/T2)in KJ")
To=T2;
W_max=m*Cp*(T1-T2)-To*m*Cp*log(T1/T2)
disp("so maximum work in KJ=")
W_max
```

Scilab code Exa 7.24 Engineering Thermodynamics by Onkar Singh Chapter 7 Example 24

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 7 Example 24")
C1=150;//steam entering velocity in m/s
C2=50;//steam leaving velocity in m/s
To=(15+273);//dead state temperature in K
W=1000;//expansion work in KJ/kg
disp("from steam tables,h1=h_50bar_600oc=3666.5 KJ/kg,s1=s_50bar_600oc=7.2589 KJ/kg K,h2=hg=2584.7 KJ/kg,s2=sg=8.1502 KJ/kg K")
h1=3666.5;
s1=7.2589;
h2=2584.7;
s2=8.1502;
disp("inlet stream availability=(h1+C1^2*10^-3/2)-To*s1 in KJ/kg")
(h1+C1^2*10^-3/2)-To*s1
disp("input stream availability is equal to the input absolute availability.")
disp("exit stream availaability=(h2+C2^2*10^-3/2)-To*s2 in KJ/kg")
(h2+C2^2*10^-3/2)-To*s2
disp("exit stream availability is equal to the exit absolute availability.")
disp("W_rev in KJ/kg")
W_rev=1587.18-238.69
disp("irreversibility=W_rev-W in KJ/kg")
W_rev-W
disp("this irreversibility is in fact the availability loss.")
disp("inlet stream availability=1587.18 KJ/kg")
disp("exit stream availability=238.69 KJ/kg")
disp("irreversibility=348.49 KJ/kg")
```

Table 4 Superheated steam table

T °C	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)	v m^3/kg	u kJ/kg	h kJ/kg	s kJ/(kg·K)
	P = 4.0 MPa (250.40 °C)				P = 4.5 MPa (257.49 °C)				P = 5.0 MPa (263.99 °C)			
Sat.	0.04978	2602.3	2801.4	6.0701	0.04406	2600.1	2798.3	6.0198	0.03944	2597.1	2794.3	5.9734
275	0.05457	2667.9	2886.2	6.2285	0.04730	2650.3	2863.2	6.1401	0.04141	2631.3	2838.3	6.0544
300	0.05884	2725.3	2960.7	6.3615	0.05135	2712.0	2943.1	6.2828	0.04532	2698.0	2924.5	6.2084
350	0.06645	2826.7	3092.5	6.5821	0.05840	2817.8	3080.6	6.5131	0.05194	2808.7	3068.4	6.4493
400	0.07341	2919.9	3213.6	6.7690	0.06475	2913.3	3204.7	6.7047	0.05781	2906.6	3195.7	6.6459
450	0.08002	3010.2	3330.3	6.9363	0.07074	3005.0	3323.3	6.8746	0.06330	2999.7	3316.2	6.8186
500	0.08643	3099.5	3445.3	7.0901	0.07651	3095.3	3439.6	7.0301	0.06857	3091.0	3433.8	6.9759
600	0.09885	3279.1	3674.4	7.3688	0.08765	3276.0	3670.5	7.3110	0.07869	3273.0	3666.5	7.2589
700	0.11095	3462.1	3905.9	7.6198	0.09847	3459.9	3903.0	7.5631	0.08849	3457.6	3900.1	7.5122
800	0.12287	3650.0	4141.5	7.8502	0.10911	3648.3	4139.3	7.7942	0.09811	3646.6	4137.1	7.7440
900	0.13469	3843.6	4382.3	8.0647	0.11965	3842.2	4380.6	8.0091	0.10762	3840.7	4378.8	7.9593
1000	0.14645	4042.9	4628.7	8.2662	0.13013	4041.6	4627.2	8.2108	0.11707	4040.4	4625.7	8.1612
1100	0.15817	4248.0	4880.6	8.4567	0.14056	4246.8	4879.3	8.4015	0.12648	4245.6	4878.0	8.3520
1200	0.16987	4458.6	5138.1	8.6376	0.15098	4457.5	5136.9	8.5825	0.13587	4456.3	5135.7	8.5331
1300	0.18156	4674.3	5400.5	8.8100	0.16139	4673.1	5399.4	8.7549	0.14526	4672.0	5398.2	8.7055

Figure 7.12: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 24

```
disp("NOTE=>In book this question is solve using
   dead state temperature 25 degree celcius which is
    wrong as we have to take dead state temperature
   15 degree celcius ,now this question is correctly
   solve above taking dead state temperature 15
   degree celcius as mentioned in question. ")
```

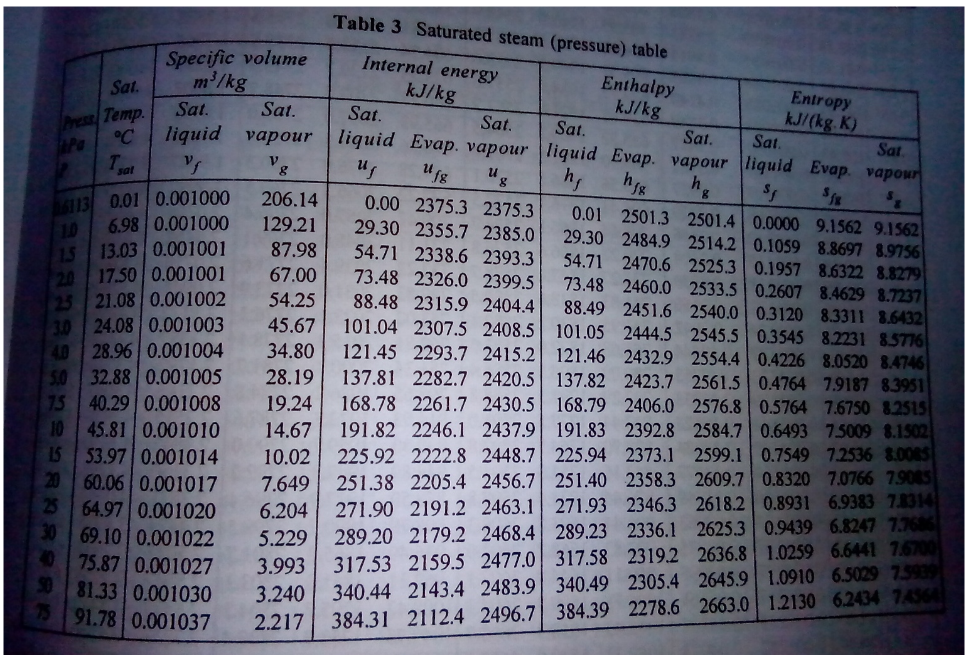


Table 3 Saturated steam (pressure) table

Press. kPa p	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.6113	0.01	0.001000	206.14	0.00	2375.3	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	9.1562
1.0	6.98	0.001000	129.21	29.30	2355.7	2385.0	29.30	2484.9	2514.2	0.1059	8.8697	8.9756
1.5	13.03	0.001001	87.98	54.71	2338.6	2393.3	54.71	2470.6	2525.3	0.1957	8.6322	8.8279
2.0	17.50	0.001001	67.00	73.48	2326.0	2399.5	73.48	2460.0	2533.5	0.2607	8.4629	8.7237
2.5	21.08	0.001002	54.25	88.48	2315.9	2404.4	88.49	2451.6	2540.0	0.3120	8.3311	8.6432
3.0	24.08	0.001003	45.67	101.04	2307.5	2408.5	101.05	2444.5	2545.5	0.3545	8.2231	8.5776
4.0	28.96	0.001004	34.80	121.45	2293.7	2415.2	121.46	2432.9	2554.4	0.4226	8.0520	8.4746
5.0	32.88	0.001005	28.19	137.81	2282.7	2420.5	137.82	2423.7	2561.5	0.4764	7.9187	8.3951
7.5	40.29	0.001008	19.24	168.78	2261.7	2430.5	168.79	2406.0	2576.8	0.5764	7.6750	8.2515
10	45.81	0.001010	14.67	191.82	2246.1	2437.9	191.83	2392.8	2584.7	0.6493	7.5009	8.1502
15	53.97	0.001014	10.02	225.92	2222.8	2448.7	225.94	2373.1	2599.1	0.7549	7.2536	8.0085
20	60.06	0.001017	7.649	251.38	2205.4	2456.7	251.40	2358.3	2609.7	0.8320	7.0766	7.9085
25	64.97	0.001020	6.204	271.90	2191.2	2463.1	271.93	2346.3	2618.2	0.8931	6.9383	7.8314
30	69.10	0.001022	5.229	289.20	2179.2	2468.4	289.23	2336.1	2625.3	0.9439	6.8247	7.7686
40	75.87	0.001027	3.993	317.53	2159.5	2477.0	317.58	2319.2	2636.8	1.0259	6.6441	7.6700
50	81.33	0.001030	3.240	340.44	2143.4	2483.9	340.49	2305.4	2645.9	1.0910	6.5029	7.5939
75	91.78	0.001037	2.217	384.31	2112.4	2496.7	384.39	2278.6	2663.0	1.2130	6.2434	7.4564

Figure 7.13: Engineering Thermodynamics by Onkar Singh Chapter 7 Example 24

Chapter 8

Vapour Power Cycles

Scilab code Exa 8.1 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 1")
disp("T-S representation for carnot cycle operating
   between pressure of 7 MPa and 7KPa is shown in
   fig.")
disp("enthalpy at state 2,h2= hg at 7 MPa")
disp("from steam table,h=2772.1 KJ/kg")
h2=2772.1;
disp("entropy at state 2,s2=sg at 7MPa")
disp("from steam table,s2=5.8133 KJ/kg K")
s2=5.8133;
disp("enthalpy and entropy at state 3,")
disp("from steam table,h3=hf at 7 MPa =1267 KJ/kg
   and s3=sf at 7 MPa=3.1211 KJ/kg K")
```

```
h3=1267;
s3=3.1211;
disp("for process 2-1,s1=s2.Let dryness fraction at state 1 be x1 ")
s1=s2;
disp("from steam table , sf at 7 KPa=0.5564 KJ/kg K, sfg at 7 KPa=7.7237 KJ/kg K")
sf=0.5564;
sfg=7.7237;
disp("s1=s2=sf+x1*sfg")
disp("so x1=(s2-sf)/sfg ")
x1=(s2-sf)/sfg
x1=0.6806;//approx.
disp("from steam table,hf at 7 KPa=162.60 KJ/kg,hfg at 7 KPa=2409.54 KJ/kg")
hf=162.60;
hfg=2409.54;
disp("enthalpy at state 1,h1=hf+x1*hfg in KJ/kg")
h1=hf+x1*hfg
disp("let dryness fraction at state 4 be x4")
disp("for process 4-3,s4=s3=sf+x4*sfg")
s4=s3;
disp("so x4=(s4-sf)/sfg")
x4=(s4-sf)/sfg
x4=0.3321;//approx.
disp("enthalpy at state 4,h4=hf+x4*hfg in KJ/kg")
h4=hf+x4*hfg
disp("thermal efficiency=net work/heat added")
disp("expansion work per kg=(h2-h1) in KJ/kg")
(h2-h1)
disp("compression work per kg=(h3-h4) in KJ/kg(+ve)")
(h3-h4)
disp("heat added per kg=(h2-h3) in KJ/kg(-ve)")
(h2-h3)
disp("net work per kg=(h2-h1)-(h3-h4) in KJ/kg")
(h2-h1)-(h3-h4)
disp("thermal efficiency")
```

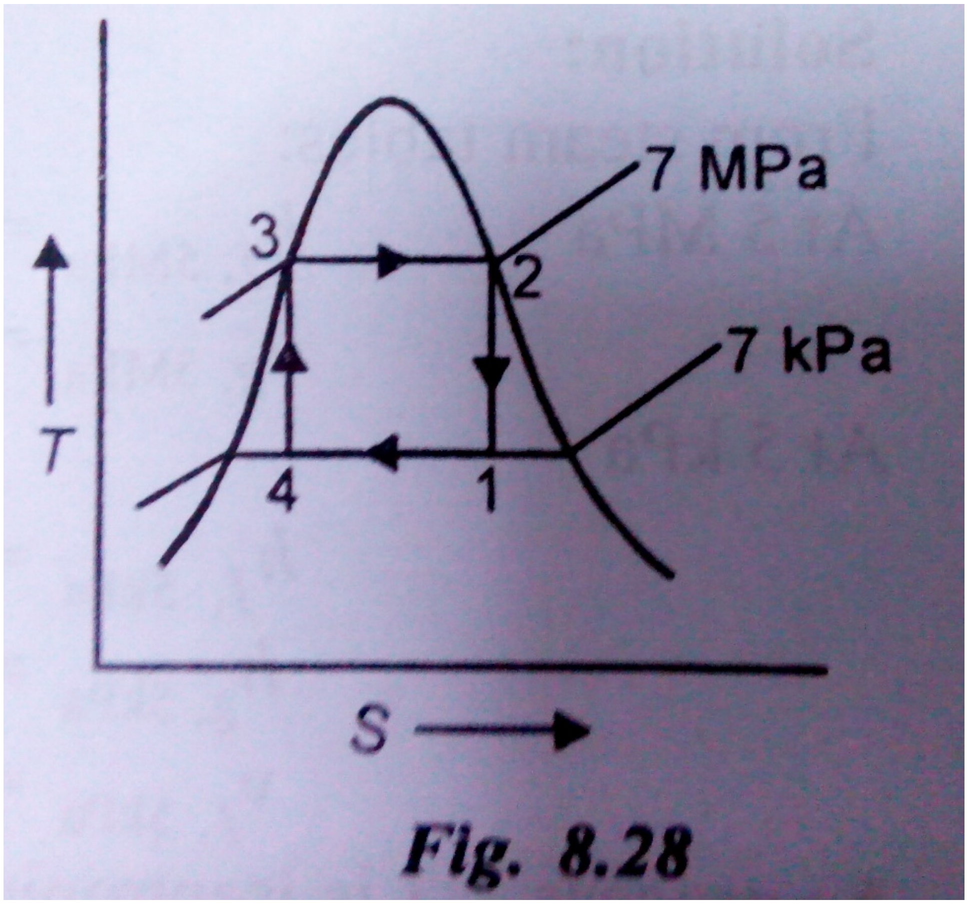


Figure 8.1: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 1

```
((h2-h1)-(h3-h4))/(h2-h3)
disp("in percentage")
(((h2-h1)-(h3-h4))/(h2-h3))*100
disp("so thermal efficiency=44.21%")
disp("turbine work=969.57 KJ/kg(+ve)")
disp("compression work=304.19 KJ/kg(-ve)")
```

Scilab code Exa 8.2 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 2")
disp("from steam tables,at 5 MPa,hf_5MPa=1154.23 KJ/
   kg,sf_5MPa=2.92 KJ/kg K")
disp("hg_5MPa=2794.3 KJ/kg,sg_5MPa=5.97 KJ/kg K")
hf_5MPa=1154.23;
sf_5MPa=2.92;
hg_5MPa=2794.3;
sg_5MPa=5.97;
disp("from steam tables,at 5 Kpa,hf_5KPa=137.82 KJ/
   kg,sf_5KPa=0.4764 KJ/kg K")
disp("hg_5KPa=2561.5 KJ/kg,sg_5KPa=8.3951 KJ/kg K,
   vf_5KPa=0.001005 m^3/kg")
hf_5KPa=137.82;
sf_5KPa=0.4764;
hg_5KPa=2561.5;
sg_5KPa=8.3951;
vf_5KPa=0.001005;
disp("as process 2-3 is isentropic,so s2=s3")
disp("and s3=sf_5KPa+x3*sfg_5KPa=s2=sg_5MPa")
s2=sg_5MPa;
s3=s2;
disp("so x3=(s3-sf_5KPa)/sfg_5KPa")
```

```
x3=(s3-sf_5KPa)/(sg_5KPa-sf_5KPa)
x3=0.694;//approx.
disp("hence enthalpy at 3,")
disp("h3=hf_5KPa+x3*hfg_5KPa in KJ/kg")
h3=hf_5KPa+x3*(hg_5KPa-hf_5KPa)
disp("enthalpy at 2,h2=hg_5KPa=2794.3 KJ/kg")
disp("process 1-4 is isentropic,so s1=s4")
s1=sf_5MPa;
disp("s1=sf_5KPa+x4*(sg_5KPa-sf_5KPa)")
disp("so x4=(s1-sf_5KPa)/(sg_5KPa-sf_5KPa)")
x4=(s1-sf_5KPa)/(sg_5KPa-sf_5KPa)
x4=0.308;//approx.
disp("enthalpy at 4,h4=hf_5KPa+x4*(hg_5KPa-hf_5KPa) in KJ/kg")
h4=hf_5KPa+x4*(hg_5KPa-hf_5KPa)
disp("enthalpy at 1,h1=hf_5MPa in KJ/kg")
h1=hf_5MPa
disp("carnot cycle(1-2-3-4-1) efficiency:")
disp("n_carnot=net work/heat added")
disp("n_carnot=((h2-h3)-(h1-h4))/(h2-h1)")
h2=hg_5MPa;
n_carnot=((h2-h3)-(h1-h4))/(h2-h1)
disp("in percentage")
n_carnot=n_carnot*100
disp("so n_carnot=42.95%")
disp("In rankine cycle,1-2-3-5-6-1,")
disp("pump work,h6-h5=vf_5KPa*(p6-p5)in KJ/kg")
p6=5000;//boiler pressure in KPa
p5=5;//condenser pressure in KPa
vf_5KPa*(p6-p5)
disp("h5=hf_5KPa=137.82 KJ/kg")
h5=hf_5KPa;
disp("hence h6 in KJ/kg")
h6=h5+(vf_5KPa*(p6-p5))
disp("net work in rankine cycle=(h2-h3)-(h6-h5)in KJ/kg")
(h2-h3)-(h6-h5)
disp("heat added=(h2-h6)in KJ/kg")
```

```
(h2-h6)
disp("rankine cycle efficiency(n_rankine)=")
n_rankine=((h2-h3)-(h6-h5))/(h2-h6)
disp("in percentage")
n_rankine=n_rankine*100
disp("so n_rankine=36.56%")
```

Scilab code Exa 8.3 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 3")
disp("from steam tables,h2=hg_40bar=3092.5 KJ/kg")
h2=3092.5;
disp("s2=sg_40bar=6.5821 KJ/kg K")
s2=6.5821;
disp("h4=hf_0.05bar=137.82 KJ/kg,hfg=2423.7 KJ/kg ")
h4=137.82;
hfg=2423.7;
disp("s4=sf_0.05bar=0.4764 KJ/kg K,sfg=7.9187 KJ/kg
   K")
s4=0.4764;
sfg=7.9187;
disp("v4=vf_0.05bar=0.001005 m^3/kg")
v4=0.001005;
```

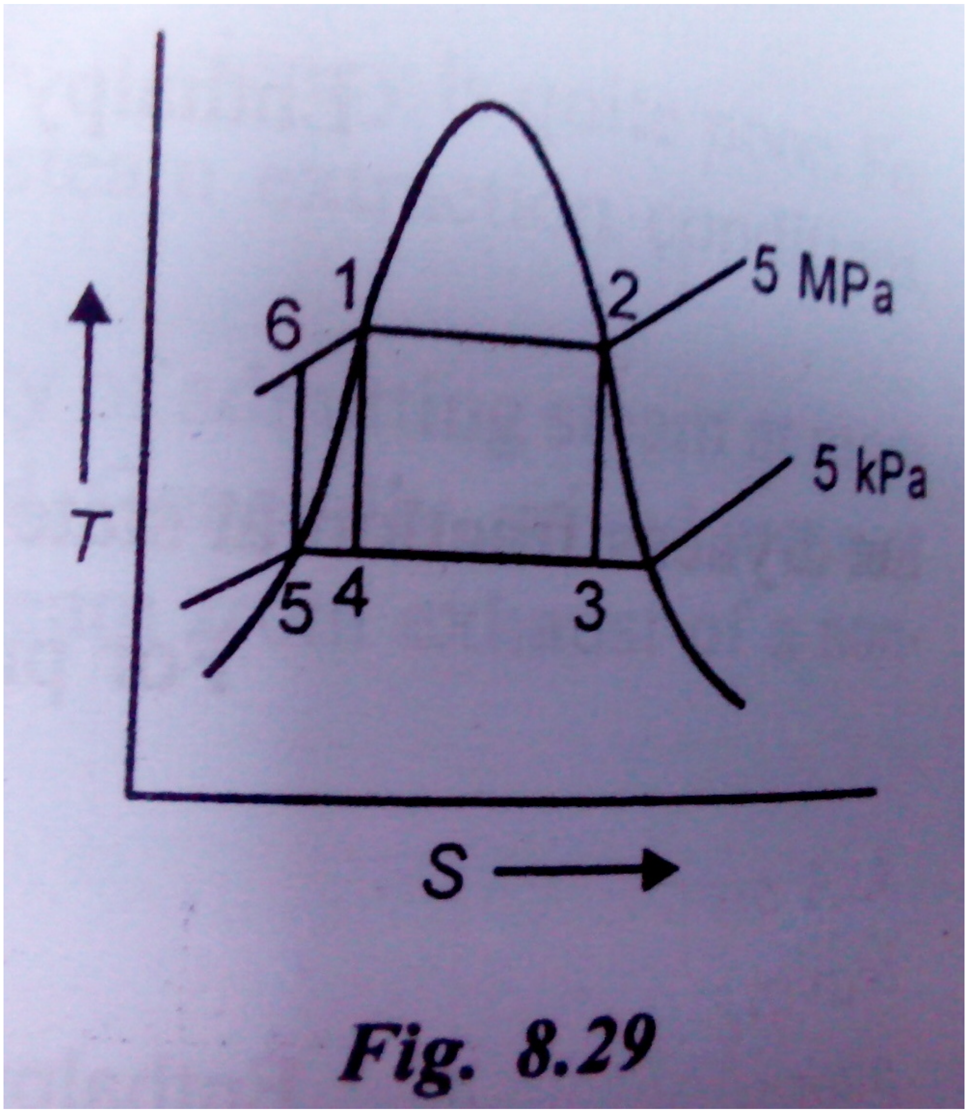


Figure 8.2: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 2

```
disp("let the dryness fraction at state 3 be x3,")
disp("for ideal process,2-3,s2=s3")
s3=s2;
disp("s2=s3=6.5821=sf_0.05bar+x3*sfg_0.05bar")
disp("so x3=(s2-s4)/(sfg)")
x3=(s2-s4)/(sfg)
x3=0.7711;//approx.
disp("h3=hf_0.05bar+x3*hfg_0.05bar in KJ/kg")
h3=h4+x3*hfg
disp("for pumping process,")
disp("h1-h4=v4*deltap=v4*(p1-p4)")
disp("so h1=h4+v4*(p1-p4) in KJ/kg")
p1=40*100;//pressure of steam enter in turbine in mPa
p4=0.05*100;//pressure of steam leave turbine in mPa
h1=h4+v4*(p1-p4)
disp("pump work per kg of steam=(h1-h4) in KJ/kg")
(h1-h4)
disp("net work per kg of steam =(expansion work-pump work)per kg of steam")
disp("=(h2-h3)-(h1-h4) in KJ/kg)")
(h2-h3)-(h1-h4)
disp("cycle efficiency=net work/heat added")
((h2-h3)-(h1-h4))/(h2-h1)
disp("in percentage")
((h2-h3)-(h1-h4))*100/(h2-h1)
disp("so net work per kg of steam=1081.74 KJ/kg")
disp("cycle efficiency=36.67%")
disp("pump work per kg of steam=4.02 KJ/kg")
```

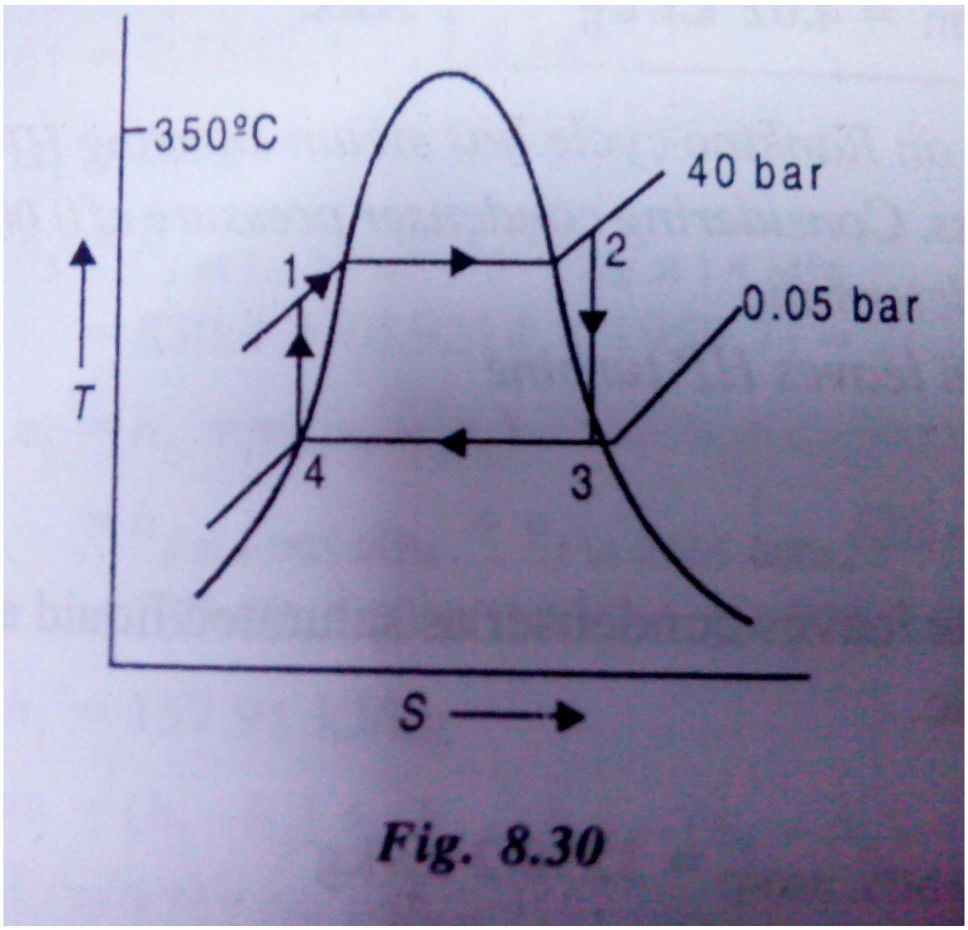


Figure 8.3: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 3

Scilab code Exa 8.4 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 4")
disp("Let us assume that the condensate leaves
   condenser as saturated liquid and the expansion
   in turbine and pumping processes are isentropic."
   )
disp("from steam tables,h2=h_20MPa=3238.2 KJ/kg")
h2=3238.2;
disp("s2=6.1401 KJ/kg K")
s2=6.1401;
disp("h5=h_0.005MPa in KJ/kg")
disp("from steam tables,at 0.005 MPa,hf=137.82 KJ/kg
   ,hfg=2423.7 KJ/kg,sf=0.4764 KJ/kg K,sfg=7.9187 KJ
   /kg K")
hf=137.82;
hfg=2423.7;
sf=0.4764;
sfg=7.9187;
disp("h5=hf+0.9*hfg in KJ/kg")
h5=hf+0.9*hfg
disp("s5=sf+0.9*sfg in KJ/kg K")
s5=sf+0.9*sfg
disp("h6=hf=137.82 KJ/kg")
h6=137.82;
disp("it is given that temperature at state 4 is 500
    degree celcius and due to isentropic processes
   s4=s5=7.6032 KJ/kg K.The state 4 can be
   conveniently located on mollier chart by the
   intersection of 500 degree celcius constant
```

```
    temperature line and entropy value of 7.6032 KJ/
    kg K and the pressure and enthalpy obtained.but
    these shall be approximate.")
disp("The state 4 can also be located by
    interpolation using steam table.The entropy value
     of 7.6032 KJ/kg K lies between the superheated
    steam states given under,p=1.20 MPa,s at 1.20 MPa
    =7.6027 KJ/kg K")
disp("p=1.40 MPa,s at 1.40 MPa=7.6027 KJ/kg K")
disp("by interpolation state 4 lies at pressure=")
1.20+((1.40-1.20)/(7.6027-7.6759))*(7.6032-7.6759)
disp("=1.399,approx.=1.40 MPa")
disp("thus,steam leaves HP turbine at 1.40 MPa")
disp("enthalpy at state 4,h4=3474.1 KJ/kg")
h4=3474.1;
disp("for process 2-33,s2=s3=6.1401 KJ/kg K.The
    state 3 thus lies in wet region as s3<sg at 1.40
    MPa.Let dryness fraction at state 3 be x3.")
s3=s2;
disp("s3=sf+x3*sfg")
disp("from staem tables,at 1.4 MPa,sf=2.2842 KJ/kg K
    ,sfg=4.1850 KJ/kg K")
sf=2.2842;
sfg=4.1850;
disp("so x3=(s3-sf)/sfg")
x3=(s3-sf)/sfg
disp("h3=hf+x3*hfg in KJ/kg")
disp("from steam tables,at 1.4 MPa,hf=830.3 KJ/kg,
    hfg=1959.7 KJ/kg")
hf=830.3;
hfg=1959.7;
h3=hf+x3*hfg
disp("enthalpy at 1,h1=h6+v6*(p1-p6) in KJ/kg")
disp("h1=hf at 0.005MPa+vf at 0.005MPa*(p1-p6)")
disp("from steam tables, at 0.005 MPa,h6=137.82 KJ/
    kg,v6=0.001005 m^3/kg")
h6=137.82;
v6=0.001005;
```

```
p1=20*1000;//steam entering HP turbine in KPa
p6=0.005*1000;//condensor pressure in KPa
h1=h6+v6*(p1-p6)
disp("net work per kg steam=(h2-h3)+(h4-h5)-(h1-h6)
   in KJ/kg")
(h2-h3)+(h4-h5)-(h1-h6)
disp("heat added per kg of steam=(h2-h1)in KJ/kg")
(h2-h1)
disp("thermal efficiency=net work/heat added")
((h2-h3)+(h4-h5)-(h1-h6))/(h2-h1)
disp("in percentage")
(((h2-h3)+(h4-h5)-(h1-h6))/(h2-h1))*100
disp("pressure of steam leaving HP turbine=1.40 MPa"
   )
disp("thermal efficiency=56.39%")
```

Scilab code Exa 8.5 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 5")
P=50*10^3;//output of plant in KW
Cpw=4.18;//specific heat of water in KJ/kg K
Tw_in=15;//cooling water entering condenser
   temperature in degree celcius
```

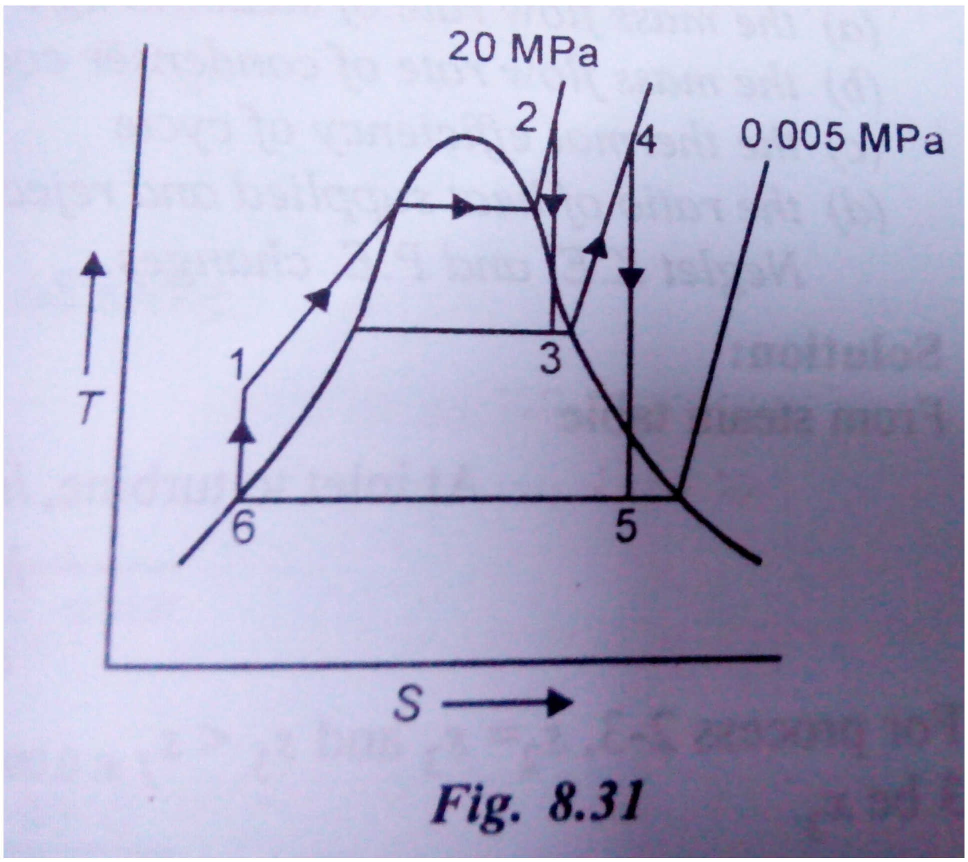


Fig. 8.31

Figure 8.4: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 4

```
Tw_out=30;//cooling water leaving condenser temperature in degree celcius
disp("from steam table,at inlet to turbine,")
disp("h2=h_10MPa,700 oc")
disp("h2=3870.5 KJ/kg,s2=7.1687 KJ/kg K")
h2=3870.5;
s2=7.1687;
s3=s2;
disp("for process 2-3,s2=s3 and s3<sf at 0.005 MPa so state 3 lies in wet region .Let dryness fraction at state 3 be x3.")
disp("s3=7.1687=sf at 0.005 MPa+x3*sfg at 0.005 MPa")
disp("from steam tables,at 0.005 MPa,sf=0.4764 KJ/kg K,sfg=7.9187 KJ/kg")
sf=0.4764;
sfg=7.9187;
disp("so x3=(s3-sf)/sfg")
x3=(s3-sf)/sfg
x3=0.845;//approx.
disp("h3=hf at 0.005 MPa+x3*hfg at 0.005 MPa")
disp("from steam tables,at 0.005 MPa,hf=137.82 KJ/kg,hfg=2423.7 KJ/kg")
hf=137.82;
hfg=2423.7;
disp("so h3=hf+x3*hfg in KJ/kg")
h3=hf+x3*hfg
disp("h4=hf at 0.005 MPa")
h4=hf;
disp("for pumping process,(h1-h4)=v4*(p1-p4)")
disp("from steam tables,v4=vf at 0.005 MPa=0.001005 m^3/kg")
v4=0.001005;
disp("h1=h4+v4*(p1-p4)in KJ/kg")
p1=10;//pressure of steam leave boiler in MPa
p4=0.005;//pressure of steam leave turbine in MPa
h1=h4+v4*(p1-p4)*100
disp("net output per kg of steam,w_net=(h2-h3)-(h1-
```

```
h4) in KJ/kg")
w_net=(h2-h3)-(h1-h4)
disp("mass flow rate of steam,ms=P/w_net in kg/s")
ms=P/w_net
ms=29.69;//approx.
disp("by heat balance on condenser,for mass flow rate of water being mw kg/s")
disp("(h3-h4)*ms=mw*Cpw*(Tw_out-Tw_in)")
disp("so mw=(h3-h4)*ms/(Cpw*(Tw_out-Tw_in)) in kg/s")
mw=(h3-h4)*ms/(Cpw*(Tw_out-Tw_in))
disp("the heat added per kg of steam (q_add)=(h2-h1) in KJ/kg")
q_add=(h2-h1)
disp("thermal efficiency=w_net/q_add")
w_net/q_add
disp("in percentage")
w_net*100/q_add
disp("ratio of heat supplied and rejected=(h2-h1)/(h3-h4)")
(h2-h1)/(h3-h4)
disp("mass of flow rate of steam=29.69 kg/s")
disp("mass flow rate of condenser cooling water=969.79 kg/s")
disp("thermal efficiency=45.12%")
disp("ratio of heat supplied and rejected=1.822")
```

Scilab code Exa 8.6 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 6

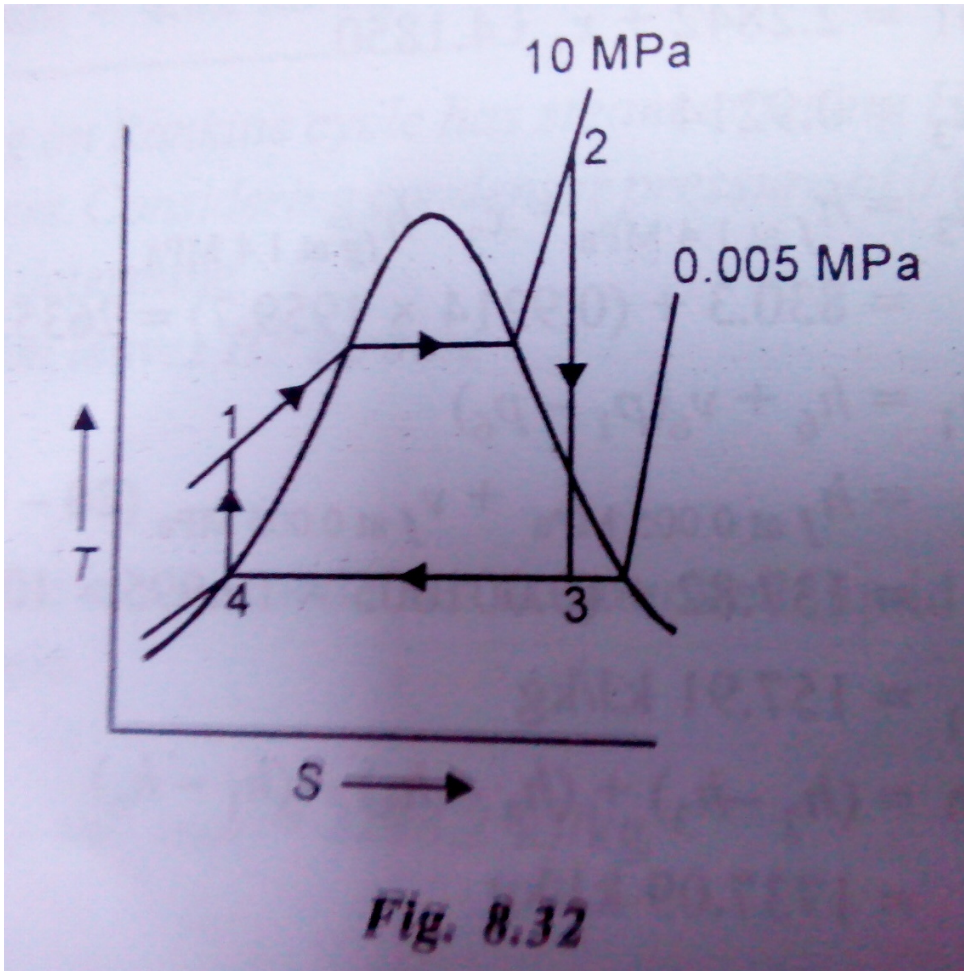


Figure 8.5: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 8 Example 6")
disp("case (a) When there is no feed water heater")
disp("Thermal efficiency of cycle=((h2-h3)-(h1-h4))/(h2-h1)")
disp("from steam tables,h2=h at 200 bar,650oc=3675.3 KJ/kg,s2=s at 200 bar,650oc=6.6582 KJ/kg K,h4=hf at 0.05 bar=137.82 KJ/kg,v4=vf at 0.05 bar=0.001005 m^3/kg")
h2=3675.3;
s2=6.6582;
h4=137.82;
v4=0.001005;
disp("hf at 0.05 bar=137.82 KJ/kg,hfg at 0.05 bar=2423.7 KJ/kg,sf at 0.05 bar=0.4764 KJ/kg K,sfg at 0.05 bar=7.9187 KJ/kg K")
hf=137.82;
hfg=2423.7;
sf=0.4764;
sfg=7.9187;
disp("For process 2-3,s2=s3.Let dryness fraction at 3 be x3.")
s3=s2;
disp("s3=6.6582=sf at 0.05 bar+x3*sfg at 0.05 bar")
disp("so x3=(s3-sf)/sfg")
x3=(s3-sf)/sfg
x3=0.781;//approx.
disp("h3=hf at 0.05 bar+x3*hfg at 0.05 bar in KJ/kg")
h3=hf+x3*hfg
disp("For pumping process 4-1,")
disp("h1-h4=v4*deltap")
```

```
disp("h1=h4+v4*(200-0.5)*10^2 in KJ/kg")
h1=h4+v4*(200-0.5)*10^2
disp("Thermal efficiency of cycle=")
((h2-h3)-(h1-h4))/(h2-h1)
disp("in percentage")
((h2-h3)-(h1-h4))*100/(h2-h1)
disp("case (b) When there is only one feed water
    heater working at 8 bar")
disp("here,let mass of steam bled for feed heating
    be m kg")
disp("For process 2-6,s2=s6=6.6582 KJ/kg K")
s6=s2;
disp("Let dryness fraction at state 6 be x6")
disp("s6=sf at 8 bar+x6*sfg at 8 bar")
disp("from steam tables,hf at 8 bar=721.11 KJ/kg,vf
    at 8 bar=0.001115 m^3/kg,hfg at 8 bar=2048 KJ/kg,
    sf at 8 bar=2.0462 KJ/kg K,sfg at 8 bar=4.6166 KJ
    /kg K")
hf=721.11;
vf=0.001115;
hfg=2048;
sf=2.0462;
sfg=4.6166;
disp("substituting entropy values,x6=(s6-sf)/sfg")
x6=(s6-sf)/sfg
x6=0.999;//approx.
disp("h6=hf at at 8 bar+x6*hfg at 8 bar in KJ/kg")
h6=hf+x6*hfg
disp("Assuming the state of fluid leaving open feed
    water heater to be saturated liquid at 8 bar.h7=
    hf at 8 bar=721.11 KJ/kg")
h7=721.11;
disp("For process 4-5,h5=h4+v4*(8-.05)*10^2 in KJ/kg
    ")
h5=h4+v4*(8-.05)*10^2
disp("Applying energy balance at open feed water
    heater,")
disp("m*h6+(1-m)*h5=1*h7")
```

```
disp("so m=(h7-h5)/(h6-h5) in kg")
m=(h7-h5)/(h6-h5)
disp("For process 7-1,h1=h7+v7*(200-8)*10^2 in KJ/kg")
disp("here h7=hf at 8 bar,v7=vf at 8 bar")
h7=hf;
v7=vf;
h1=h7+v7*(200-8)*10^2
disp("Thermal efficiency of cycle=((h2-h6)+(1-m)*(h6-h3)-{(1-m)*(h5-h4)+(h1-h7)})/(h2-h1)")
((h2-h6)+(1-m)*(h6-h3)-{(1-m)*(h5-h4)+(h1-h7)})/(h2-h1)
disp("in percentage")
((h2-h6)+(1-m)*(h6-h3)-{(1-m)*(h5-h4)+(h1-h7)})*100/(h2-h1)
disp("case (c) When there are two feed water heaters working at 40 bar and 4 bar")
disp("here, let us assume the mass of steam at 40 bar,4 bar to be m1 kg and m2 kg respectively.")
disp("2-10-9-3,s2=s10=s9=s3=6.6582 KJ/kg K")
s3=s2;
s9=s3;
s10=s9;
disp("At state 10.s10>sg at 40 bar(6.0701 KJ/kg K)so state 10 lies in superheated region at 40 bar pressure.")
disp("From steam table by interpolation,T10=370.6oc, so h10=3141.81 KJ/kg")
T10=370.6;
h10=3141.81;
disp("Let dryness fraction at state 9 be x9 so,")
disp("s9=6.6582=sf at 4 bar+x9*sfg at 4 bar")
disp("from steam tables,at 4 bar,sf=1.7766 KJ/kg K, sfg=5.1193 KJ/kg K")
sf=1.7766;
sfg=5.1193;
disp("x9=(s9-sf)/sfg")
x9=(s9-sf)/sfg
```

```
x9=0.9536;//approx.
disp("h9=hf at 4 bar+x9*hfg at 4 bar in KJ/kg")
disp("from steam tables,at 4 bar,hf=604.74 KJ/kg,hfg=2133.8 KJ/kg")
hf=604.74;
hfg=2133.8;
h9=hf+x9*hfg
disp("Assuming the state of fluid leaving open feed water heater to be saturated liquid at respective pressures i.e.")
disp("h11=hf at 4 bar=604.74 KJ/kg,v11=0.001084 m^3/kg=vf at 4 bar")
h11=604.74;
v11=0.001084;
disp("h13=hf at 40 bar=1087.31 KJ/kg,v13=0.001252 m^3/kg=vf at40 bar")
h13=1087.31;
v13=0.001252;
disp("For process 4-8,i.e in CEP.")
disp("h8=h4+v4*(4-0.05)*10^2 in KJ/kg")
h8=h4+v4*(4-0.05)*10^2
disp("For process 11-12,i.e in FP2,")
disp("h12=h11+v11*(40-4)*10^2 in KJ/kg")
h12=h11+v11*(40-4)*10^2
disp("For process 13-1_a i.e. in FP1,h1_a=h13+v13*(200-40)*10^2 in KJ/kg")
h1_a=h13+v13*(200-40)*10^2
disp("m1*3141.81+(1-m1)*608.64=1087.31")
disp("so m1=(1087.31-608.64)/(3141.81-608.64)in kg")
m1=(1087.31-608.64)/(3141.81-608.64)
disp("Applying energy balance  on open feed water heater 1 (OFWH1)")
disp("m1*h10+(1-m1)*h12)=1*h13")
disp("so m1=(h13-h12)/(h10-h12) in kg")
m1=(h13-h12)/(h10-h12)
disp("Applying energy balance on open feed water heater 2 (OFWH2)")
disp("m2*h9+(1-m1-m2)*h8=(1-m1)*h11")
```

```
disp("so m2=(1-m1)*(h11-h8)/(h9-h8) in kg")
m2=(1-m1)*(h11-h8)/(h9-h8)
disp("Thermal efficiency of cycle,n=[{(h2-h10)+(1-m1
    )*(h10-h9)+(1-m1-m2)*(h9-h3)}-{W_CEP+W_FP1+W_FP2
    }]/(h2-h1_a)")
disp("W_CEP=(1-m1-m2)*(h8-h4) in KJ/kg steam from
    boiler")
W_CEP=(1-m1-m2)*(h8-h4)
disp("W_FP1=(h1_a-h13)in KJ/kg of steam from boiler"
    )
W_FP1=(h1_a-h13)
disp("W_FP2=(1-m1)*(h12-h11)in KJ/kg of steam from
    boiler")
W_FP2=(1-m1)*(h12-h11)
disp("W_CEP+W_FP1+W_FP2 in KJ/kg of steam from
    boiler")
W_CEP+W_FP1+W_FP2
disp("n=[{(h2-h10)+(1-m1)*(h10-h9)+(1-m1-m2)*(h9-h3)
    }-{W_CEP+W_FP1+W_FP2}]/(h2-h1_a)")
n=[{(h2-h10)+(1-m1)*(h10-h9)+(1-m1-m2)*(h9-h3)}-{
    W_CEP+W_FP1+W_FP2}]/(h2-h1_a)
disp("in percentage")
n=n*100
disp("so cycle thermal efficiency,na=46.18%")
disp("nb=49.76%")
disp("nc=51.37%")
disp("hence it is obvious that efficiency increases
    with increase in number of feed heaters.")
```

Scilab code Exa 8.7 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 8 Example 7")
disp("from steam tables,")
disp("h2=h at 50 bar,500oc=3433.8 KJ/kg,s2=s at 50
    bar,500oc=6.9759 KJ/kg K")
h2=3433.8;
s2=6.9759;
disp("s3=s2=6.9759 KJ/kg K")
s3=s2;
disp("by interpolation from steam tables,")
disp("T3=183.14oc at 5 bar,h3=2818.03 KJ/kg,h4= h at
     5 bar,400oc=3271.9 KJ/kg,s4= s at 5 bar,400oc
    =7.7938 KJ/kg K")
T3=183.14;
h3=2818.03;
h4=3271.9;
s4=7.7938;
disp("for expansion process 4-5,s4=s5=7.7938 KJ/kg K
    ")
s5=s4;
disp("let dryness fraction at state 5 be x5")
disp("s5=sf at 0.05 bar+x5*sfg at 0.05 bar")
disp("from steam tables,at 0.05 bar,sf=0.4764 KJ/kg
    K,sfg=7.9187 KJ/kg K")
sf=0.4764;
sfg=7.9187;
disp("so x5=(s5-sf)/sfg")
x5=(s5-sf)/sfg
x5=0.924;//approx.
disp("h5=hf at 0.05 bar+x5*hfg at 0.05 bar in KJ/kg"
    )
disp("from steam tables,hf at 0.05 bar=137.82 KJ/kg,
    hfg at 0.05 bar=2423.7 KJ/kg")
hf=137.82;
hfg=2423.7;
```

```
h5=hf+x5*hfg
disp("h6=hf at 0.05 bar=137.82 KJ/kg")
h6=137.82;
disp("v6=vf at 0.05 bar=0.001005 m^3/kg")
v6=0.001005;
disp("for process 6-1 in feed pump,h1=h6+v6*(p1-p6)
    in KJ/kg")
p1=50;//steam generation pressure in bar
p6=0.05;//steam entering temperature in turbine in
    bar
h1=h6+v6*(p1-p6)*100
disp("cycle efficiency=W_net/Q_add")
disp("Wt=(h2-h3)+(h4-h5) in KJ/kg")
Wt=(h2-h3)+(h4-h5)
disp("W_pump=(h1-h6)in KJ/kg")
W_pump=(h1-h6)
disp("W_net=Wt-W_pump in KJ/kg")
W_net=Wt-W_pump
disp("Q_add=(h2-h1) in KJ/kg")
Q_add=(h2-h1)
disp("cycle efficiency=")
W_net/Q_add
disp("in percentage")
W_net*100/Q_add
disp("we know ,1 hp=0.7457 KW")
disp("specific steam consumption=0.7457*3600/W_net
    in kg/hp hr")
0.7457*3600/W_net
disp("work ratio=net work/positive work=W_net/Wt")
W_net/Wt
disp("so cycle efficiency=45.74%,specific steam
    consumption =1.78 kg/hp hr,work ratio=0.9967")
```

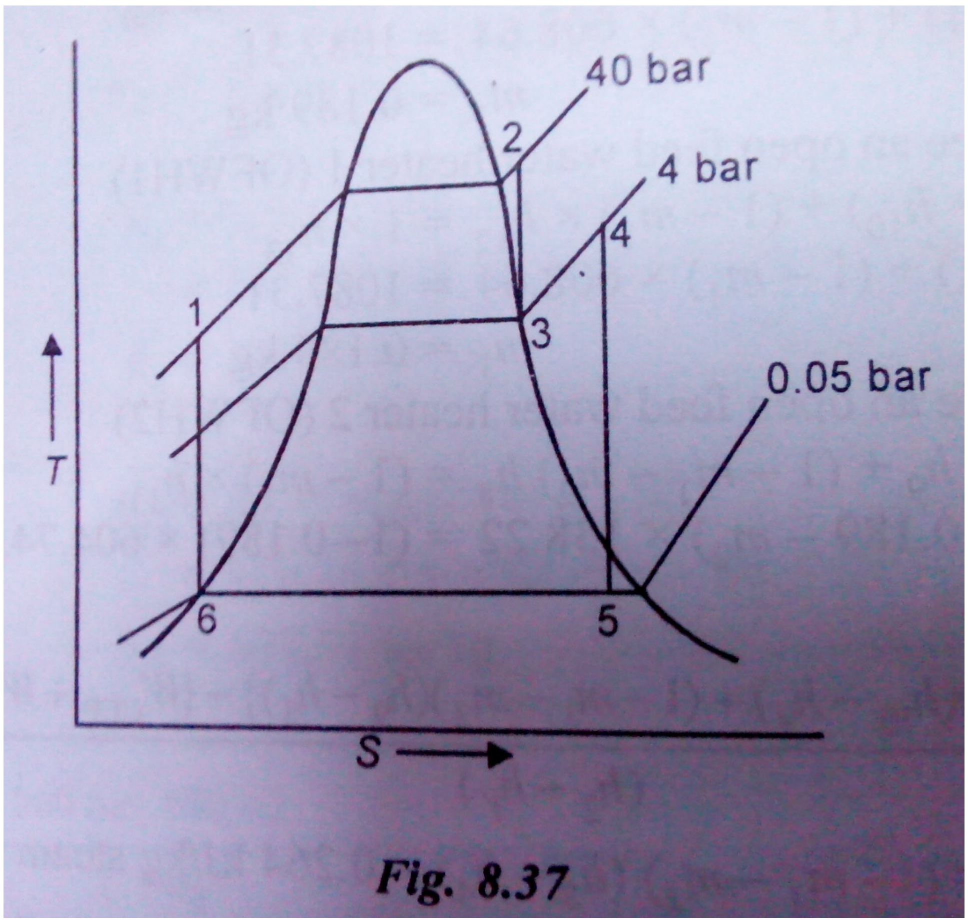


Figure 8.6: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 7

Scilab code Exa 8.8 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 8 Example 8")
T_cond=115;//condensate temperature in degree
    celcius
Cp=4.18;//specific heat at constant pressure in KJ/
    kg K
P=30*10^3;//actual alternator output in KW
n_boiler=0.9;//boiler efficiency
n_alternator=0.98;//alternator efficiency
disp("from steam tables,at state 2,h2=3301.8 KJ/kg,
    s2=6.7193 KJ/kg K")
h2=3301.8;
s2=6.7193;
disp("h5=hf at 0.05 bar=137.82 KJ/kg,v5= vf at 0.05
    bar=0.001005 m^3/kg")
h5=137.82;
v5=0.001005;
disp("Let mass of steam bled for feed heating be m
    kg/kg of steam generated in boiler.Let us also
    assume that condensate leaves closed feed water
    heater as saturated liquid i.e")
disp("h8=hf at 3 bar=561.47 KJ/kg")
h8=561.47;
```

```
disp("for process 2-3-4,s2=s3=s4=6.7193 KJ/kg K")
s3=s2;
s4=s3;
disp("Let dryness fraction at state 3 and state 4 be
    x3 and x4 respectively.")
disp("s3=6.7193=sf at 3 bar+x3* sfg at 3 bar")
disp("from steam tables, sf=1.6718 KJ/kg K, sfg=5.3201
    KJ/kg K")
sf_3bar=1.6718;
sfg_3bar=5.3201;
disp("so x3=(s3-sf_3bar)/sfg_3bar")
x3=(s3-sf_3bar)/sfg_3bar
x3=0.949;//approx.
disp("s4=6.7193=sf at 0.05 bar+x4* sfg at 0.05 bar")
disp("from steam tables,at 0.05 bar,sf=0.4764 KJ/kg
   K,sfg=7.9187 KJ/kg K")
sf=0.4764;
sfg=7.9187;
disp("so x4=(s4-sf)/sfg")
x4=(s4-sf)/sfg
x4=0.788;//approx.
disp("thus,h3=hf at 3 bar+x3* hfg at 3 bar in KJ/kg"
   )
disp("here from steam tables,at 3 bar,hf_3bar
   =561.47 KJ/kg,hfg_3bar=2163.8 KJ/kg K")
hf_3bar=561.47;
hfg_3bar=2163.8;
h3=hf_3bar+x3*hfg_3bar
disp("h4=hf at 0.05 bar+x4*hfg at 0.05 bar in KJ/kg"
   )
disp("from steam tables,at 0.05 bar,hf=137.82 KJ/kg,
   hfg=2423.7 KJ/kg")
hf=137.82;
hfg=2423.7;
h4=hf+x4*hfg
disp("assuming process across trap to be of
   throttling type so,h8=h9=561.47 KJ/kg.Assuming v5
   =v6,")
```

```
h9=h8;
v6=v5;
disp("pumping work=(h7-h6)=v5*(p1-p5)in KJ/kg")
p1=60;//pressure of steam in high pressure turbine in bar
p5=0.05;//pressure of steam in low pressure turbine in bar
v5*(p1-p5)*100
disp("for mixing process between condenser and feed pump,")
disp("(1-m)*h5+m*h9=1*h6")
disp("h6=m(h9-h5)+h5")
disp("we get,h6=137.82+m*423.65")
disp("therefore h7=h6+6.02=143.84+m*423.65")
disp("Applying energy balance at closed feed water heater;")
disp("m*h3+(1-m)*h7=m*h8+(Cp*T_cond)")
disp("so (m*2614.92)+(1-m)*(143.84+m*423.65)=m*561.47+480.7")
disp("so m=0.144 kg")
m=0.144;
h6=137.82+m*423.65;
h7=143.84+m*423.65;
disp("steam bled for feed heating=0.144 kg/kg steam generated")
disp("The net power output,W_net=(h2-h3)+(1-m)*(h3-h4)-(1-m)*(h7-h6) in KJ/kg steam generated")
W_net=(h2-h3)+(1-m)*(h3-h4)-(1-m)*(h7-h6)
disp("mass of steam required to be generated=in kg/s")
P/(n_alternator*W_net)
disp("or in kg/hr")
26.23*3600
disp("so capacity of boiler required=94428 kg/hr")
disp("overall thermal efficiency=W_net/Q_add")
disp("here Q_add=(h2-h1)/n_boiler in KJ/kg")
Q_add=(h2-Cp*T_cond)/n_boiler
disp("overall thermal efficiency=")
```

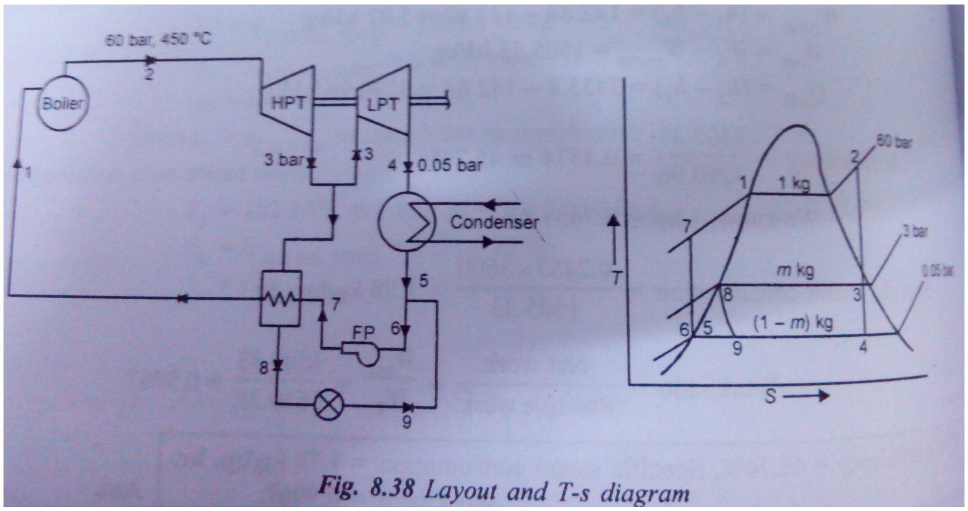


Figure 8.7: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 8

```
W_net/Q_add
disp("in percentage")
W_net*100/Q_add
disp("so overall thermal efficiency=37.24%")
```

Scilab code Exa 8.9 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

```
disp("Engineering Thermodynamics by Onkar Singh Chapter 8 Example 9")
P=15*10^3;//turbine output in KW
disp("At inlet to first turbine stage,h2=3230.9 KJ/kg,s2=6.9212 KJ/kg K")
h2=3230.9;
s2=6.9212;
disp("For ideal expansion process,s2=s3")
s3=s2;
disp("By interpolation,T3=190.97 degree celcius from superheated steam tables at 6 bar,h3=2829.63 KJ/kg")
T3=190.97;
h3=2829.63;
disp("actual stste at exit of first stage,h3_a=h2-0.8*(h2-h3) in KJ/kg")
h3_a=h2-0.8*(h2-h3)
disp("actual state 3_a shall be at 232.78 degree celcius,6 bar,so s3_a=7.1075 KJ/kg K")
s3_a=7.1075;
disp("for second stage,s3_a=s4;By interpolation,s4=7.1075=sf at 1 bar+x4*sfg at 1 bar")
s4=7.1075;
disp("from steam tables,at 1 bar,sf=1.3026 KJ/kg K,sfg=6.0568 KJ/kg K")
sf=1.3026;
sfg=6.0568;
disp("so x4=(s4-sf)/sfg")
x4=(s4-sf)/sfg
x4=0.958;//approx.
disp("h4=hf at 1 bar+x4*hfg at 1 bar in KJ/kg")
disp("from steam tables,at 1 bar,hf=417.46 KJ/kg,hfg=2258.0 KJ/kg")
hf=417.46;
hfg=2258.0;
h4=hf+x4*hfg
disp("actual enthalpy at exit from second stage,h4_a=h3_a-.8*(h3_a-h4) in KJ/kg")
```

```
h4_a=h3_a-.8*(h3_a-h4)
disp("actual dryness fraction,x4_a=>h4_a=hf at 1 bar
   +x4_a*hfg at 1 bar")
disp("so x4_a=(h4_a-hf)/hfg")
x4_a=(h4_a-hf)/hfg
disp("x4_a=0.987,actual entropy,s4_a=7.2806 KJ/kg K"
   )
s4_a=7.2806;
disp("for third stage,s4_a=7.2806=sf at 0.075 bar+x5
   *sfg at 0.075 bar")
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg
    K,sfg=7.6750 KJ/kg K")
sf=0.5764;
sfg=7.6750;
disp("so x5=(s4_a-sf)/sfg")
x5=(s4_a-sf)/sfg
x5=0.8735;//approx.
disp("h5=2270.43 KJ/kg")
h5=2270.43;
disp("actual enthalpy at exit from third stage,h5_a=
   h4_a -0.8*(h4_a-h5)in KJ/kg")
h5_a=h4_a-0.8*(h4_a-h5)
disp("Let mass of steam bled out be m1 and m2 kg at
   6 bar,1 bar respectively.")
disp("By heat balance on first closed feed water
   heater,(see schematic arrangement)")
disp("h11=hf at 6 bar=670.56 KJ")
h11=670.56;
disp("m1*h3_a+h10=m1*h11+4.18*150")
disp("(m1*2829.63)+h10=(m1*670.56)+627")
disp("h10+2159.07*m1=627")
disp("By heat balance on second closed feed water
   heater,(see schematic arrangement)")
disp("h7=hf at 1 bar=417.46 KJ/kg")
h7=417.46;
disp("m2*h4+(1-m1-m2)*4.18*38=(m1+m2)*h7+4.18*95*(1-
   m1-m2)")
disp("m2*2646.4+(1-m1-m2)*158.84=((m1+m2)*417.46)
```

```
+(397.1*(1-m1-m2))")
disp("m2*2467.27-m1*179.2-238.26=0")
disp("heat balance at point of mixing,")
disp("h10=(m1+m2)*h8+(1-m1-m2)*4.18*95")
disp("neglecting pump work,h7=h8")
disp("h10=m2*417.46+(1-m1-m2)*397.1")
disp("substituting h10 and solving we get,m1=0.1293
   kg and m2=0.1059 kg/kg of steam generated")
m1=0.1293;
m2=0.1059;
disp("Turbine output per kg of steam generated,Wt=(
   h2-h3_a)+(1-m1)*(h3_a-h4_a)+(1-m1-m2)*(h4_a-h5_a)
   in KJ/kg of steam generated")
Wt=(h2-h3_a)+(1-m1)*(h3_a-h4_a)+(1-m1-m2)*(h4_a-h5_a
   )
disp("Rate of steam generation required=P/Wt in kg/s
   ")
P/Wt
disp("in kg/hr")
P*3600/Wt
disp("capacity of drain pump i.e. FP shown in layout
   =(m1+m2)*69192 in kg/hr")
(m1+m2)*69192
disp("so capacity of drain pump=16273.96 kg/hr")
```

Scilab code Exa 8.10 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
```

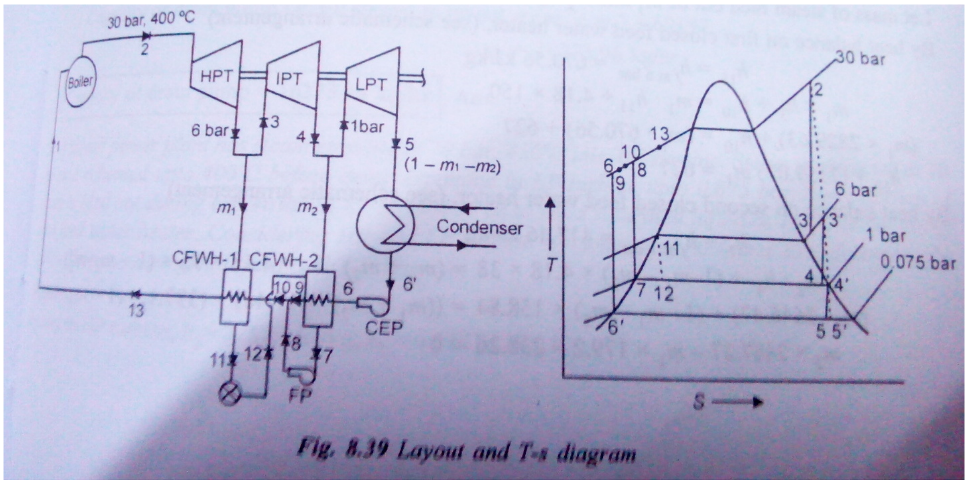


Figure 8.8: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 9

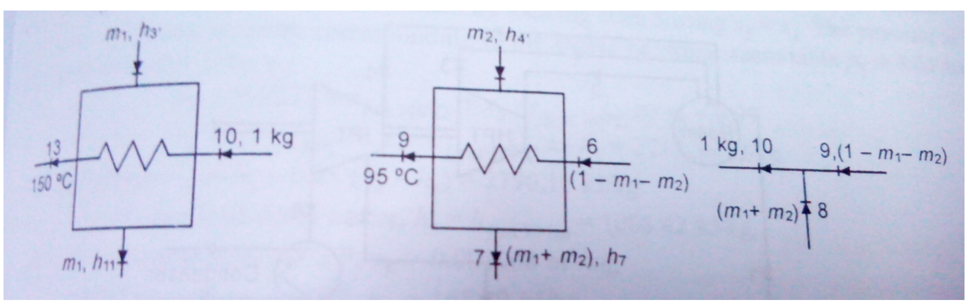


Figure 8.9: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 9

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 8 Example 10")
disp("at inlet to HP turbine,h2=3287.1 KJ/kg,s2=6.6327 KJ/kg K")
h2=3287.1;
s2=6.6327;
disp("By interpolation state 3 i.e. for isentropic expansion betweeen 2-3 lies at 328.98oc at 30 bar.h3=3049.48 KJ/kg")
h3=3049.48;
disp("actual enthapy at 3_a,h3_a=h2-0.80*(h2-h3)in KJ/kg")
h3_a=h2-0.80*(h2-h3)
disp("enthalpy at inlet to LP turbine,h4=3230.9 KJ/kg,s4=6.9212 KJ K")
h4=3230.9;
s4=6.9212;
disp("for ideal expansion from 4-6,s4=s6.Let dryness fraction at state 6 be x6.")
s6=s4;
disp("s6=6.9212=sf at 0.075 bar+x6* sfg at 0.075 bar in KJ/kg K")
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg K,sfg=7.6750 KJ/kg K")
sf=0.5764;
sfg=7.6750;
disp("so x6=(s6-sf)/sfg")
x6=(s6-sf)/sfg
x6=0.827;//approx.
disp("h6=hf at 0.075 bar+x6*hfg at 0.075 bar in KJ/kg K")
disp("from steam tables,at 0.075 bar,hf=168.79 KJ/kg,hfg=2406.0 KJ/kg")
hf=168.79;
hfg=2406.0;
```

```
h6=hf+x6*hfg
disp("for actual expansion process in LP turbine.")
disp("h6_a=h4-0.85*(h4-h6) in KJ/kg")
h6_a=h4-0.85*(h4-h6)
disp("Ideally ,enthalpy at bleed point can be
    obtained by locating state 5 using s5=s4.The
    pressure at bleed point shall be saturation
    pressure corresponding to the 140oc i.e from
    steam tables.Let dryness fraction at state 5 be
    x5.")
p5=3.61;
s5=s4;
disp("s5_a=6.9212=sf at 140oc+x5*sfg at 140oc")
disp("from steam tables,at 140oc,sf=1.7391 KJ/kg K,
    sfg=5.1908 KJ/kg K")
sf=1.7391;
sfg=5.1908;
disp("so x5=(s5-sf)/sfg")
x5=(s5-sf)/sfg
x5=0.99;//approx.
disp("h5=hf at 140oc+x5*hfg at 140oc in KJ/kg")
disp("from steam tables,at 140oc,hf=589.13 KJ/kg,hfg
    =2144.7 KJ/kg")
hf=589.13;
hfg=2144.7;
h5=hf+x5*hfg
disp("actual enthalpy,h5_a=h4-0.85*(h4-h5)in KJ/kg")
h5_a=h4-0.85*(h4-h5)
disp("enthalpy at exit of open feed water heater,h9=
    hf at 30 bar=1008.42 KJ/kg")
h9=1008.42;
disp("specific volume at inlet of CEP,v7=0.001008 m
    ^3/kg")
v7=0.001008;
disp("enthalpy at inlet of CEP,h7=168.79 KJ/kg")
h7=168.79;
disp("for pumping process 7-8,h8=h7+v7*(3.61-0.075)
    *10^2 in KJ/kg")
```

```
h8=h7+v7*(3.61-0.075)*10^2
disp("Applying energy balance at open feed water
    heater.Let mass of bled steam be m kg per kg of
    steam generated.")
disp("m*h5+(1-m)*h8=h9")
disp("so m=(h9-h8)/(h5-h8) in kg /kg of steam
    generated")
m=(h9-h8)/(h5-h8)
disp("For process on feed pump,9-1,v9=vf at 140oc
    =0.00108 m^3/kg")
v9=0.00108;
disp("h1=h9+v9*(70-3.61)*10^2 in KJ/kg")
h1=h9+v9*(70-3.61)*10^2
disp("Net work per kg of steam generated,W_net=(h2-
    h3_a)+(h4-h5_a)+(1-m)*(h5_a-h6_a)-{(1-m)*(h8-h7)
    +(h1-h9)}in KJ/kg steam generated")
W_net=(h2-h3_a)+(h4-h5_a)+(1-m)*(h5_a-h6_a)-{(1-m)*(
    h8-h7)+(h1-h9)}
disp("heat added per kg of steam generated,q_add=(h2
    -h1)+(h4-h3_a)in KJ/kg of steam generated")
q_add=(h2-h1)+(h4-h3_a)
disp("Thermal efficiency,n=W_net/q_add")
n=W_net/q_add
disp("in percentage")
n=n*100
disp("so thermal efficiency=39.03%%")
disp("NOTE=>In this question there is some
    calculation mistake while calculating W_net and
    q_add in book, which is corrected above and the
    answers may vary.")
```

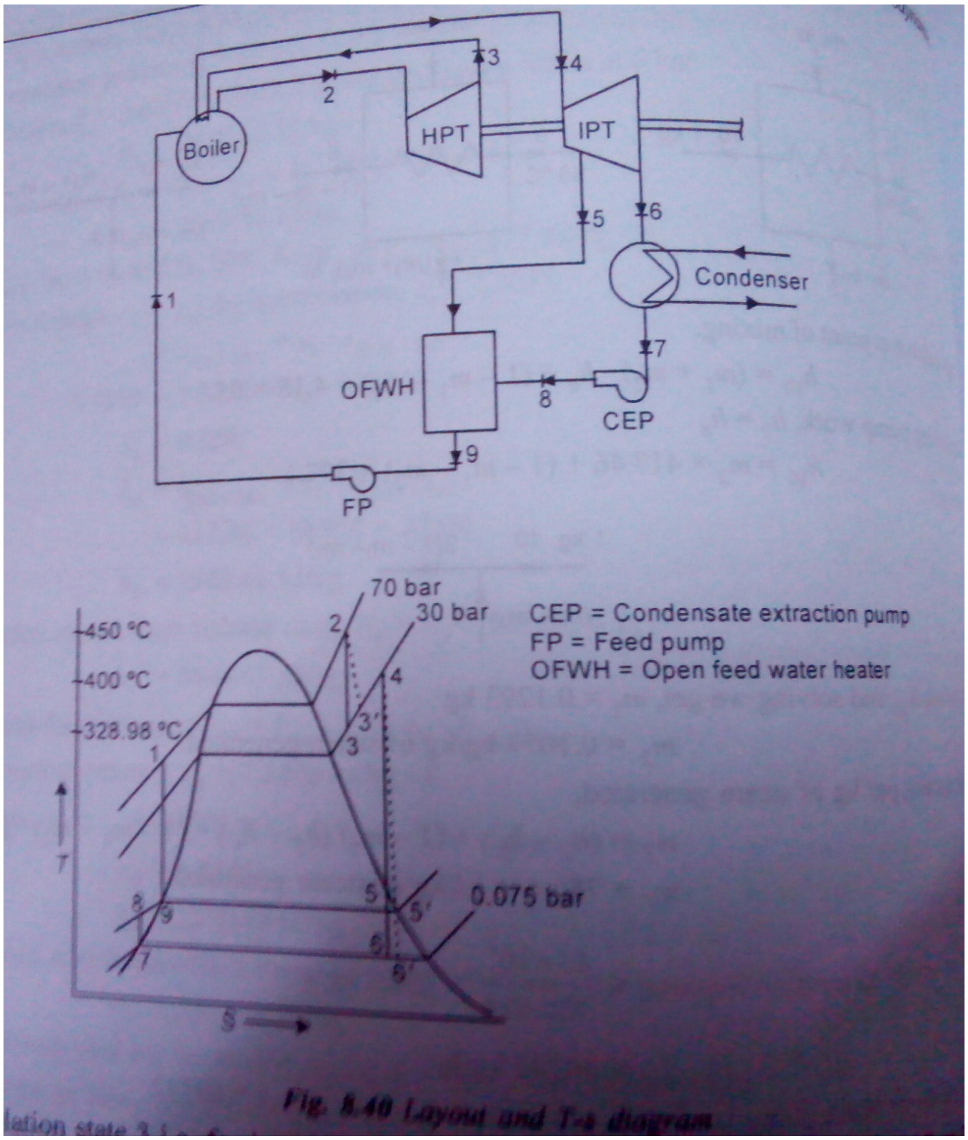


Figure 8.10: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 10

Scilab code Exa 8.11 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 8 Example 11")
disp("Enthalpy of steam entering ST1,h2=3308.6 KJ/kg,s2=6.3443 KJ/kg K")
h2=3308.6;
s2=6.3443;
disp("for isentropic expansion 2-3-4-5,s2=s3=s4=s5")
s3=s2;
s4=s3;
s5=s4;
disp("Let dryness fraction of states 3,4 and 5 be x3,x4 and x5")
disp("s3=6.3443=sf at 10 bar+x3*sfg at 10 bar")
disp("so x3=(s3-sf)/sfg")
disp("from steam tables,at 10 bar,sf=2.1387 KJ/kg K,sfg=4.4478 KJ/kg K")
sf=2.1387;
sfg=4.4478;
x3=(s3-sf)/sfg
x3=0.945;//approx.
disp("h3=hf+x3*hfg in KJ/kg")
disp("from steam tables,hf=762.81 KJ/kg,hfg=2015.3 KJ/kg")
hf=762.81;
hfg=2015.3;
h3=hf+x3*hfg
disp("s4=6.3443=sf at 1.5 bar+x4*sfg at 1.5 bar")
disp("so x4=(s4-sf)/sfg")
disp("from steam tables,at 1.5 bar,sf=1.4336 KJ/kg K
```

```
, sfg=5.7897 KJ/kg K")
sf=1.4336;
sfg=5.7897;
x4=(s4-sf)/sfg
x4=0.848;//approx.
disp("so h4=hf+x4*hfg in KJ/kg")
disp("from steam tables,at 1.5 bar,hf=467.11 KJ/kg,
   hfg=2226.5 KJ/kg")
hf=467.11;
hfg=2226.5;
h4=hf+x4*hfg
disp("s5=6.3443=sf at 0.05 bar+x5*sfg at 0.05 bar")
disp("so x5=(s5-sf)/sfg")
disp("from steam tables,at 0.05 bar,sf=0.4764 KJ/kg
   K,sfg=7.9187 KJ/kg K")
sf=0.4764;
sfg=7.9187;
x5=(s5-sf)/sfg
x5=0.739;//approx.
disp("h5=hf+x5*hfg in KJ/kg")
disp("from steam tables,at 0.05 bar,hf=137.82 KJ/kg,
   hfg=2423.7 KJ/kg")
hf=137.82;
hfg=2423.7;
h5=hf+x5*hfg
disp("h6=hf at 0.05 bar=137.82 KJ/kg")
h6=137.82;
disp("v6=vf at 0.05 bar=0.001005 m^3/kg")
v6=0.001005;
disp("h7=h6+v6*(1.5-0.05)*10^2 in KJ/kg")
h7=h6+v6*(1.5-0.05)*10^2
disp("h8=hf at 1.5 bar=467.11 KJ/kg")
h8=467.11;
disp("v8=0.001053 m^3/kg=vf at 1.5 bar")
v8=0.001053;
disp("h9=h8+v8*(150-1.5)*10^2 in KJ/kg")
h9=h8+v8*(150-1.5)*10^2
disp("h10=hf at 150 bar=1610.5 KJ/kg")
```

```
h10=1610.5;
disp("v10=0.001658 m^3/kg=vf at 150 bar")
v10=0.001658;
disp("h12=h10+v10*(150-10)*10^2 in KJ/kg")
h12=h10+v10*(150-10)*10^2
disp("Let mass of steam bled out at 10 bar,1.5 bar be m1 and m2 per kg of steam generated.")
disp("Heat balance on closed  feed water heater yields,")
disp("m1*h3+(1-m)*h9=m1*h10+(1-m1)*4.18*150")
disp("so m1=(4.18*150-h9)/(h3-h9-h10+4.18*150)in kg/kg of steam generated.")
m1=(4.18*150-h9)/(h3-h9-h10+4.18*150)
disp("heat balance on open feed water can be given as under,")
disp("m2*h4+(1-m1-m2)*h7=(1-m1)*h8")
disp("so m2=((1-m1)*(h8-h7))/(h4-h7)in kg/kg of steam")
m2=((1-m1)*(h8-h7))/(h4-h7)
disp("for mass flow rate of 300 kg/s=>m1=36 kg/s,m2=39 kg/s")
disp("For mixing after closed feed water heater,")
disp("h1=(4.18*150)*(1-m1)+m1*h12 in KJ/kg")
h1=(4.18*150)*(1-m1)+m1*h12
disp("Net work output per kg of steam generated=W_ST1+W_ST2+W_ST3-{W_CEP+W_FP+W_FP2}")
disp("W_net=(h2-h3)+(1-m1)*(h3-h4)+(1-m1-m2)*(h4-h5)-{(1-m1-m2)*(h7-h6)+(1-m1)*(h9-h8)+(m1*(h12-h10))}in KJ/kg of steam generated.")
W_net=(h2-h3)+(1-m1)*(h3-h4)+(1-m1-m2)*(h4-h5)-{(1-m1-m2)*(h7-h6)+(1-m1)*(h9-h8)+(m1*(h12-h10))}
disp("heat added per kg of steam generated,q_add=(h2-h1) in KJ/kg")
q_add=(h2-h1)
disp("cycle thermal efficiency,n=W_net/q_add")
n=W_net/q_add
disp("in percentage")
n=n*100
```

```
disp("Net power developed in KW=1219*300 in KW")
1219*300
disp("cycle thermal efficiency=47.6%")
disp("Net power developed=365700 KW")
```

Scilab code Exa 8.12 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 8 Example 12")
P=100*10^3;//net power output in KW
disp("At inlet to HPT,h2=3373.7 KJ/kg,s2=6.5966 KJ/
    kg K")
h2=3373.7;
s2=6.5966;
disp("For isentropic expansion between 2-3-4-5,s2=s3
    =s4=s5")
s3=s2;
s4=s3;
s5=s4;
disp("state 3 lies in superheated region as s3>sg at
     20 bar.By interpolation from superheated steam
    table,T3=261.6oc.Enthalpy at 3,h3=2930.57 KJ/kg")
```

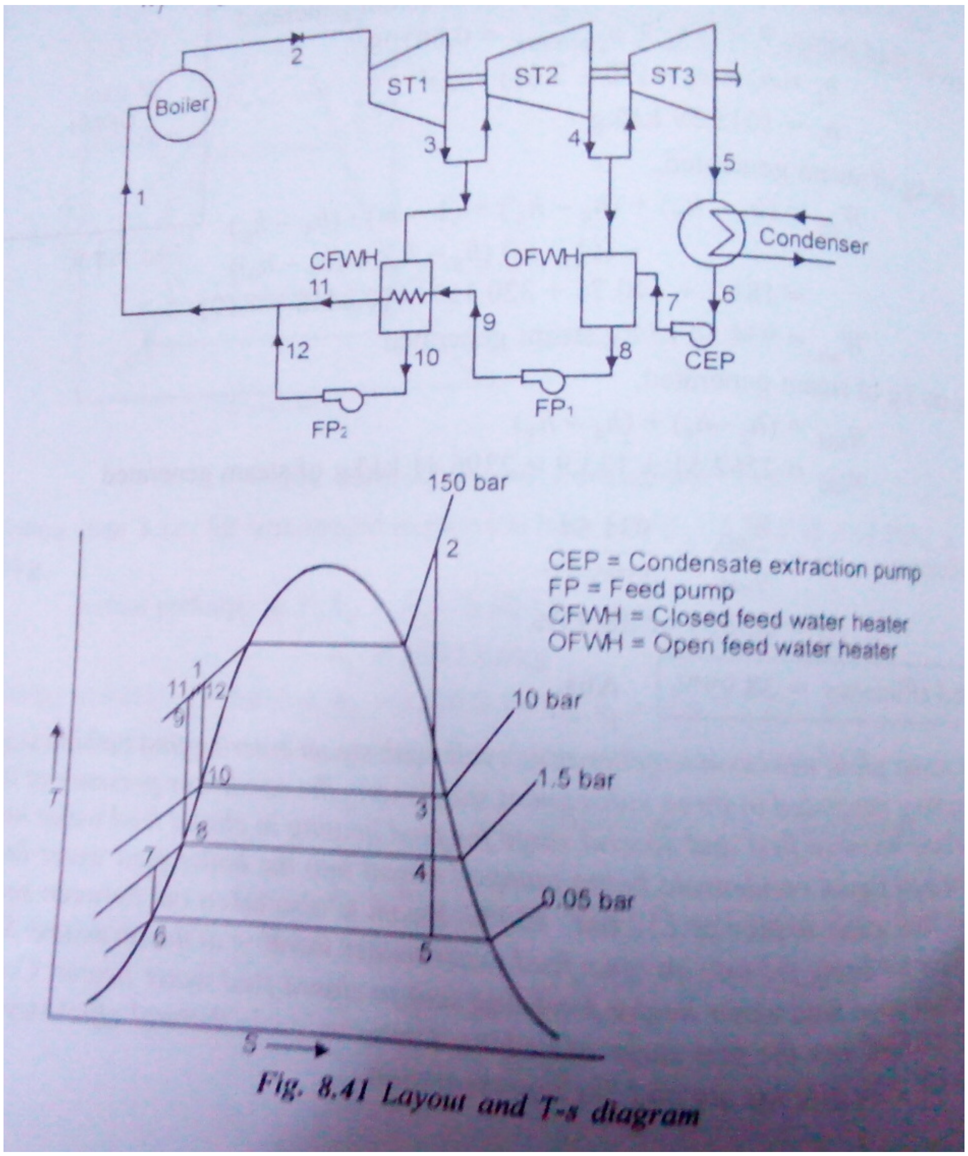


Figure 8.11: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 11

```
T3=261.6;
h3=2930.57;
disp("since s4<sg at 4 bar so state 4 and 5 lies in
    wet region.")
disp("Let dryness fraction at state 4 ans 5 be x4
    and x5.")
disp("s4=6.5966=sf at 4 bar+x4*sfg at 4 bar")
disp("from steam tables,at 4 bar,sf=1.7766 KJ/kg K,
    sfg=5.1193 KJ/kg K")
sf=1.7766;
sfg=5.1193;
disp("x4=(s4-sf)/sfg")
x4=(s4-sf)/sfg
x4=0.941;//approx.
disp("h4=hf at 4 bar+x4*hfg at 4 bar in KJ/kg")
disp("from steam tables,at 4 bar,hf=604.74 KJ/kg,hfg
    =2133.8 KJ/kg")
hf=604.74;
hfg=2133.8;
h4=hf+x4*hfg
disp("for state 5,")
disp("s5=6.5966=sf at 0.075 bar+x5*sfg at 0.075 bar"
    )
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg
     K,sfg=7.6750 KJ/kg K")
sf=0.5764;
sfg=7.6750;
disp("x5=(s5-sf)/sfg")
x5=(s5-sf)/sfg
x5=0.784;//approx.
disp("h5=hf at 0.075 bar+x5*hfg at 0.075 bar in KJ/
    kg")
disp("from steam tables,at 0.075 bar,hf=168.76 KJ/kg
    ,hfg=2406.0 KJ/kg")
hf=168.76;
hfg=2406.0;
h5=hf+x5*hfg
disp("Let mass of steam bled at 20 bar be m1 and m2
```

```
    per kg of steam generated.")
disp("h10=hf at 20 bar=908.76 KJ/kg,h8=hf at 4 bar=604.74 KJ/kg")
h10=908.76;
h8=604.74;
disp("At trap h10=h11=908.79 KJ/kg")
h11=h10;
disp("At condensate extraction pump,(CEP),h7-h6=v6*(4-0.075)*10^2 in KJ/kg")
disp("here v6=vf at 0.075 bar=0.001008 m^3/kg,h6=hf at 0.075 bar=168.79 KJ/kg")
v6=0.001008;
h6=168.79;
disp("so h7=h6+v6*(4-0.075)*10^2 in KJ/kg")
h7=h6+v6*(4-0.075)*10^2
disp("At feed pump,(FP),h9-h8=v8*(20-4)*10^2 in KJ/kg")
disp("here v8=vf at 4 bar=0.001084 m^3/kg,h8=hf at 4 bar=604.74 KJ/kg")
v8=0.001084;
h8=604.74;
disp("so h9=h8+v8*(20-4)*10^2 in KJ/kg")
h9=h8+v8*(20-4)*10^2
disp("Let us apply heat balance at closed feed water heater,")
disp("m1*h3+h9=m1*h10+4.18*200")
disp("so m1=(4.18*200-h9)/(h3-h10) in kg")
m1=(4.18*200-h9)/(h3-h10)
m1=0.114;//approx.
disp("Applying heat balance at open feed water,")
disp("m1*h11+m2*h4+(1-m1-m2)*h7=h8")
disp("so m2=(h8-m1*h11-h7+m1*h7)/(h4-h7) in kg")
m2=(h8-m1*h11-h7+m1*h7)/(h4-h7)
m2=0.144;//approx.
disp("Net work per kg steam generated,")
disp("w_net=(h2-h3)+(1-m1)*(h3-h4)+(1-m1-m2)*(h4-h5)-{(1-m1-m2)*(h7-h6)+(h9-h8)} in KJ/kg")
w_net=(h2-h3)+(1-m1)*(h3-h4)+(1-m1-m2)*(h4-h5)-{(1-
```

```
m1-m2)*(h7-h6)+(h9-h8)}
disp("Heat added per kg steam generated,q_add=(h2-h1) in KJ/kg")
h1=4.18*200;
q_add=(h2-h1)
disp("Thermal efficiency=w_net/q_add")
w_net/q_add
disp("in percentage")
w_net*100/q_add
disp("steam generation rate=P/w_net in kg/s")
P/w_net
disp("so thermal efficiency=44.78%")
disp("steam generation rate=87.99 kg/s")
disp("a> For the reheating introduced at 20 bar up to 400oc.The modified cycle representation is shown on T-S diagram by 1-2-3-3_a-4_a-5_a-6-7-8-9-10-11")
disp("At state 2,h2=3373.7 KJ/kg,s2=6.5966 KJ/kg K")
h2=3373.7;
s2=6.5966;
disp("At state 3,h3=2930.57 KJ/kg")
h3=2930.57;
disp("At state 3_a,h3_a=3247.6 KJ/kg,s3_a=7.1271 KJ/kg K")
h3_a=3247.6;
s3_a=7.1271;
disp("At state 4_a and 5_a,s3_a=s4_a=s5_a=7.1271 KJ/kg K")
s4_a=s3_a;
s5_a=s4_a;
disp("From steam tables by interpolation state 4_a is seen to be at 190.96oc at 4 bar,h4_a=2841.02 KJ/kg")
h4_a=2841.02;
disp("Let dryness fraction at state 5_a be x5,")
disp("s5_a=7.1271=sf at 0.075 bar+x5_a*sfg at 0.075 bar")
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg
```

```
K,sfg=7.6750 KJ/kg K")
disp("so x5_a=(s5_a-sf)/sfg")
x5_a=(s5_a-sf)/sfg
x5_a=0.853;//approx.
disp("h5_a=hf at 0.075 bar+x5_a*hfg at 0.075 bar in KJ/kg")
disp("from steam tables,at 0.075 bar,hf=168.76 KJ/kg,hfg=2406.0 KJ/kg")
h5_a=hf+x5_a*hfg
disp("Let mass of bled steam at 20 bar and 4 bar be m1_a,m2_a per kg of steam generated.Applying heat balance at closed feed water heater.")
disp("m1_a*h3+h9=m1*h10+4.18*200")
disp("so m1_a=(4.18*200-h9)/(h3-h10) in kg")
m1_a=(4.18*200-h9)/(h3-h10)
m1_a=0.114;//approx.
disp("Applying heat balance at open feed water heater,")
disp("m1_a*h11+m2_a*h4_a+(1-m1_a-m2_a)*h7=h8")
disp("so m2_a=(h8-m1_a*h11-h7+m1_a*h7)/(h4_a-h7) in kg")
m2_a=(h8-m1_a*h11-h7+m1_a*h7)/(h4_a-h7)
m2_a=0.131;//approx.
disp("Net work per kg steam generated")
disp("w_net=(h2-h3)+(1-m1_a)*(h3_a-h4_a)+(1-m1_a-m2_a)*(h4_a-h5_a)-{(1-m1_a-m2_a)*(h7-h6)+(h9-h8)} in KJ/kg")
w_net=(h2-h3)+(1-m1_a)*(h3_a-h4_a)+(1-m1_a-m2_a)*(h4_a-h5_a)-{(1-m1_a-m2_a)*(h7-h6)+(h9-h8)}
disp("Heat added per kg steam generated,q_add=(h2-h1)+(1-m1_a)*(h3_a-h3)in KJ/kg")
q_add=(h2-h1)+(1-m1_a)*(h3_a-h3)
disp("Thermal efficiency,n=w_net/q_add")
n=w_net/q_add
disp("in percentage")
n=n*100
disp("% increase in thermal efficiency due to reheating=(0.4503-0.4478)*100/0.4478")
```

```
(0.4503-0.4478)*100/0.4478
disp("so thermal efficiency of reheat cycle=45.03%")
disp("% increase in efficiency due to reheating=0.56
   %")
```

Scilab code Exa 8.13 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 13")
disp("For mercury cycle,")
disp("insentropic heat drop=349-234.5 in KJ/kg Hg")
349-234.5
disp("actual heat drop=0.85*114.5 in KJ/kg Hg")
0.85*114.5
disp("Heat rejected in condenser=(349-97.325-35)in
   KJ/kg")
(349-97.325-35)
disp("heat added in boiler=349-35 in KJ/kg")
349-35
disp("For steam cycle,")
disp("Enthalpy of steam generated=h at 40 bar,0.98
   dry=2767.13 KJ/kg")
h=2767.13;
disp("Enthalpy of inlet to steam turbine,h2=h at 40
   bar,450oc=3330.3 KJ/kg")
h2=3330.3;
```

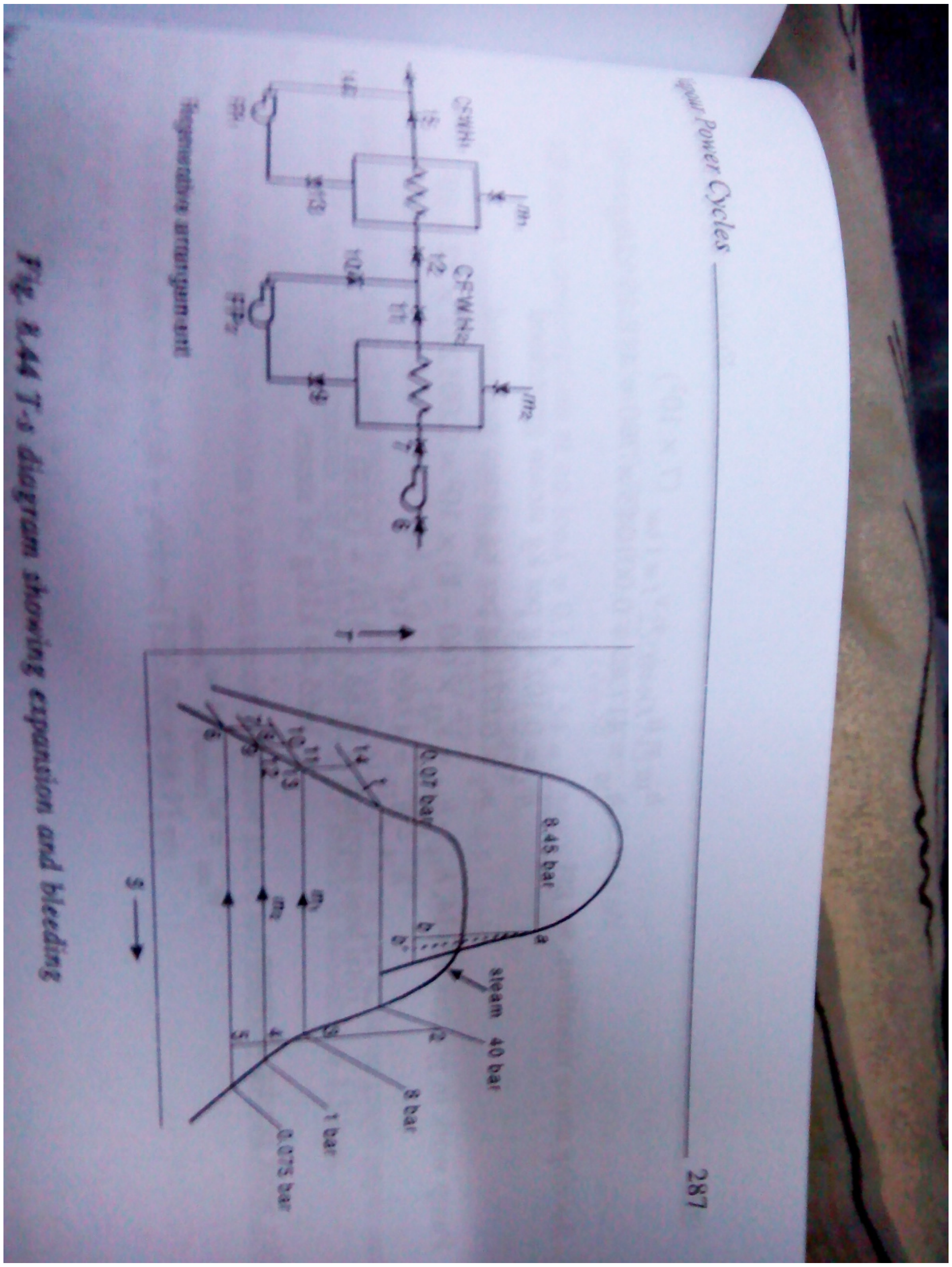


Figure 8.12: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 13

```
disp("Entropy of steam at inlet to steam turbine,s2
   =6.9363 KJ/kg K")
s2=6.9363;
disp("Therefore,heat added in condenser of mercury
   cycle=h at 40 bar,0.98 dry-h_feed at 40 bar in KJ
   /kg")
h-4.18*150
disp("Therefore,mercury required per kg of steam
   =2140.13/heat rejected in condenser in kg per kg
   of steam")
2140.13/216.675
disp("for isentropic expansion,s2=s3=s4=s5=6.9363 KJ
   /kg K")
s3=s2;
s4=s3;
s5=s4;
disp("state 3 lies in superheated region,by
   interpolation the state can be given by,
   temperature 227.07oc at 8 bar,h3=2899.23 KJ/kg")
h3=2899.23;
disp("state 4 lies in wet region,say with dryness
   fraction x4")
disp("s4=6.9363=sf at 1 bar+x4*sfg at 1 bar")
disp("so x4=(s4-sf)/sfg")
disp("from steam tables,at 1 bar,sf=1.3026 KJ/kg K,
   sfg=6.0568 KJ/kg K")
sf=1.3026;
sfg=6.0568;
x4=(s4-sf)/sfg
x4=0.93;//approx.
disp("h4=hf at 1 bar+x4*hfg at 1 bar in KJ/kg")
disp("from steam tables,at 1 bar,hf=417.46 KJ/kg,hfg
   =2258.0 KJ/kg")
hf=417.46;
hfg=2258.0;
h4=hf+x4*hfg
disp("Let state 5 lie in wet region with dryness
   fraction x5,")
```

```
disp("s5=6.9363=sf at 0.075 bar+x5*sfg at 0.075 bar")
disp("so x5=(s5-sf)/sfg")
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg K,sfg=7.6750 KJ/kg K")
sf=0.5764;
sfg=7.6750;
x5=(s5-sf)/sfg
x5=0.828;//approx.
disp("h5=hf+x5*hfg in KJ/kg")
disp("from steam tables,at 0.075 bar,hf=168.79 KJ/kg,hfg=2406.0 KJ/kg")
hf=168.79;
hfg=2406.0;
h5=hf+x5*hfg
disp("Let mass of steam bled at 8 bar and 1 bar be m1 and m2 per kg of steam generated.")
disp("h7=h6+v6*(1-0.075)*10^2 in KJ/kg")
disp("from steam tables,at 0.075 bar,h6=hf=168.79 KJ/kg,v6=vf=0.001008 m^3/kg")
h6=168.79;
v6=0.001008;
h7=h6+v6*(1-0.075)*10^2
disp("h9=hf at 1 bar=417.46 KJ/kg,h13=hf at 8 bar=721.11 KJ/kg")
h9=417.46;
h13=721.11;
disp("Applying heat balance on CFWH1,T1=150oc and also T15=150oc")
T1=150;
T15=150;
disp("m1*h3+(1-m1)*h12=m1*h13+(4.18*150)*(1-m1)")
disp("(m1-2899.23)+(1-m1)*h12=(m1*721.11)+627*(1-m1)")
disp("Applying heat balance on CFEH2,T11=90oc")
T11=90;
disp("m2*h4+(1-m1-m2)*h7=m2*h9+(1-m1-m2)*4.18*90")
disp("(m2*2517.4)+(1-m1-m2)*168.88=(m2*417.46)
```

```
    +376.2*(1-m1-m2)")
disp("Heat balance at mixing between CFWH1 and CFWH2
    ,")
disp("(1-m1-m2)*4.18*90+m2*h10=(1-m1)*h12")
disp("376.2*(1-m1-m2)+m2*h10=(1-m1)*h12")
disp("For pumping process,9-10,h10=h9+v9*(8-1)*10^2
    in KJ/kg")
disp("from steam tables,h9=hf at 1 bar=417.46 KJ/kg,
    v9=vf at 1 bar=0.001043 m^3/kg")
h9=417.46;
v9=0.001043;
h10=h9+v9*(8-1)*10^2
disp("solving above equations,we get")
disp("m1=0.102 kg per kg steam generated")
disp("m2=0.073 kg per kg steam generated")
m1=0.102;
m2=0.073;
disp("pump work in process 13-14,h14-h13=v13*(40-8)
    *10^2")
disp("so h14-h13 in KJ/kg")
v13=0.001252;
v13*(40-8)*10^2
disp("Total heat supplied(q_add)=(9.88*314)
    +(3330.3-2767.13) in KJ/kg of steam")
q_add=(9.88*314)+(3330.3-2767.13)
disp("net work per kg of steam,w_net=w_mercury+
    w_steam")
disp("w_net=(9.88*97.325)+{(h2-h3)+(1-m1)*(h3-h4)
    +(1-m1-m2)*(h4-h5)-(1-m1-m2)*(h4-h6)-m2*(h10-h9)-
    m1*(h14-h13)} in KJ/kg")
w_net=(9.88*97.325)+{(h2-h3)+(1-m1)*(h3-h4)+(1-m1-m2
    )*(h4-h5)-(1-m1-m2)*(h7-h6)-m2*(h10-h9)-m1*4.006}
disp("thermal efficiency of binary vapour cycle=
    w_net/q_add")
w_net/q_add
disp("in percentage")
w_net*100/q_add
disp("so thermal efficiency=55.36%")
```

```
disp("NOTE=>In this question there is some mistake
   in formula used for w_net which is corrected
   above.")
```

Scilab code Exa 8.14 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 14")
n=0.8;//efficiency of both HP and LP turbine
P=2500;//output in hp
disp("This is a mixed pressure turbine so the output
    of turbine shall be sum of the contributions by
   HP and LP steam streams.")
disp("For HP:at inlet of HP steam=>h1=3023.5 KJ/kg,
   s1=6.7664 KJ/kg K")
h1=3023.5;
s1=6.7664;
disp("ideally , s2=s1=6.7664 KJ/kg K")
s2=s1;
disp("s2=sf at 0.075 bar +x3* sfg at 0.075 bar")
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg
    K,sfg=7.6750 KJ/kg K")
sf=0.5764;
sfg=7.6750;
disp("so x3=(s2-sf)/sfg")
x3=(s2-sf)/sfg
```

```
x3=0.806;//approx.
disp("h_3HP=hf at 0.075 bar+x3*hfg at 0.075 bar in KJ/kg")
disp("from steam tables,at 0.075 bar,hf=168.79 KJ/kg,hfg=2406.0 KJ/kg")
hf=168.79;
hfg=2406.0;
h_3HP=hf+x3*hfg
disp("actual enthalpy drop in HP(h_HP)=(h1-h_3HP)*n in KJ/kg")
h_HP=(h1-h_3HP)*n
disp("for LP:at inlet of LP steam")
disp("h2=2706.7 KJ/kg,s2=7.1271 KJ/kg K")
h2=2706.7;
s2=7.1271;
disp("Enthalpy at exit,h_3LP=2222.34 KJ/kg")
h_3LP=2222.34;
disp("actual enthalpy drop in LP(h_LP)=(h2-h_3LP)*n in KJ/kg")
h_LP=(h2-h_3LP)*n
disp("HP steam consumption at full load=P*0.7457/h_HP in kg/s")
P*0.7457/h_HP
disp("HP steam consumption at no load=0.10*(P*0.7457/h_HP)in kg/s")
0.10*(P*0.7457/h_HP)
disp("LP steam consumption at full load=P*0.7457/h_LP in kg/s")
P*0.7457/h_LP
disp("LP steam consumption at no load=0.10*(P*0.7457/h_LP)in kg/s")
0.10*(P*0.7457/h_LP)
disp("The problem can be solved geometrically by drawing willans line as per scale on graph paper and finding out the HP stream requirement for getting 1000 hp if LP stream is available at 1.5 kg/s.")
disp("or,Analytically the equation for willans line
```

```
can be obtained for above full load and no load conditions for HP and LP seperately.")
disp("Willians line for HP:y=m*x+C,here y=steam consumption,kg/s")
disp("x=load,hp")
disp("y_HP=m_HP*x+C_HP")
disp("0.254=m_HP*0+C_HP")
disp("so C_HP=0.254")
C_HP=0.254;
disp("2.54=m_HP*2500+C_HP")
disp("so m_HP=(2.54-C_HP)/2500")
m_HP=(2.54-C_HP)/2500
disp("so y_HP=9.144*10^-4*x_HP+0.254")
disp("Willans line for LP:y_LP=m_LP*x_LP+C_LP")
disp("0.481=m_LP*0+C_LP")
disp("so C_LP=0.481")
C_LP=0.481;
disp("4.81=m_LP*2500+C_LP")
disp("so m_LP=(4.81-C_LP)/2500")
m_LP=(4.81-C_LP)/2500
disp("so y_LP=1.732*10^-3*x_LP+0.481")
disp("Total output(load) from mixed turbine,x=x_HP+x_LP")
disp("For load of 1000 hp to be met by mixed turbine,let us find out the load shared by LP for steam flow rate of 1.5 kg/s")
y_LP=1.5;
disp("from y_LP=1.732*10^-3*x_LP+0.481,")
disp("x_LP=(y_LP-0.481)/1.732*10^-3")
x_LP=(y_LP-0.481)/(1.732*10^-3)
disp("since by 1.5 kg/s of LP steam only 588.34 hp output contribution is made so remaining (1000-588.34)=411.66 hp,411.66 hp should be contributed by HP steam.By willans line for HP turbine,")
x_HP=411.66;
disp("from y_HP=9.144*10^-4*x_HP+C_HP in kg/s")
y_HP=9.144*10^-4*x_HP+C_HP
```

```
disp("so HP steam requirement=0.63 kg/s")
```

Scilab code Exa 8.15 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 15")
disp("Let us carry out analysis for 1 kg of steam
   generated in boiler.")
disp("Enthalpy at inlet to HPT,h2=2960.7 KJ/kg,s2
   =6.3615 KJ/kg K")
h2=2960.7;
s2=6.3615;
disp("state at 3  i.e. exit from HPT can be
   identified by s2=s3=6.3615 KJ/kg K")
s3=s2;
disp("Let dryness fraction be x3,s3=6.3615=sf at 2
   bar+x3*sfg at 2 bar")
disp("so x3=(s3-sf)/sfg")
disp("from stem tables,at 2 bar,sf=1.5301 KJ/kg K,
   sfg=5.5970 KJ/kg K")
sf=1.5301;
sfg=5.5970;
x3=(s3-sf)/sfg
x3=0.863;//approx.
disp("h3=2404.94 KJ/kg")
h3=2404.94;
disp("If one kg of steam is generated in bolier then
    at exit of HPT,0.5 kg goes into process heater
```

```
and 0.5 kg goes into separator")
disp("mass of moisture retained in separator(m)=(1-x3)*0.5 kg")
m=(1-x3)*0.5
disp("Therefore,mass of steam entering LPT(m_LP)=0.5-m kg")
m_LP=0.5-m
disp("Total mass of water entering hot well at 8(i.e. from process heater and drain from separator)=(0.5+0.685)=0.5685 kg")
disp("Let us assume the temperature of water leaving hotwell be T oc.Applying heat balance for mixing;")
disp("(0.5685*4.18*90)+(0.4315*4.18*40)=(1*4.18*T)")
disp("so T=((0.5685*4.18*90)+(0.4315*4.18*40))/4.18 in degree celcius")
T=((0.5685*4.18*90)+(0.4315*4.18*40))/4.18
disp("so temperature of water leaving hotwell=68.425 degree celcius")
disp("Applying heat balanced on trap")
disp("0.5*h7+0.0685*hf at 2 bar=(0.5685*4.18*90)")
disp("so h7=((0.5685*4.18*90)-(0.0685*hf))/0.5 in KJ/kg")
disp("from steam tables,at 2 bar,hf=504.70 KJ/kg")
hf=504.70;
h7=((0.5685*4.18*90)-(0.0685*hf))/0.5
disp("Therefore,heat transferred in process heater=0.5*(h3-h7)in KJ/kg steam generated")
0.5*(h3-h7)
disp("so heat transferred per kg steam generated=1023.175 KJ/kg steam generated")
disp("For state 10 at exit of LPT,s10=s3=s2=6.3615 KJ/kg K")
s10=s3;
disp("Let dryness fraction be x10")
disp("s10=6.3615=sf at 0.075 bar+x10*sfg at 0.075 bar")
disp("from steam tables,at 0.075 bar,sf=0.5764 KJ/kg
```

```
K, sfg=7.6750 KJ/kg K")
sf=0.5764;
sfg=7.6750;
disp("so x10=(s10-sf)/sfg")
x10=(s10-sf)/sfg
x10=0.754;//approx.
disp("h10=hf at 0.075 bar+x10*hfg at 0.075 bar")
disp("from steam tables,at 0.075 bar,hf=168.79 KJ/kg,hfg=2406.0 KJ/kg")
hf=168.79;
hfg=2406.0;
disp("so h10=hf+x10*hfg in KJ/kg ")
h10=hf+x10*hfg
disp("net work output,neglecting pump work per kg of steam generated,")
disp("w_net=(h2-h3)*1+0.4315*(h3-h10) in KJ/kg steam generated")
w_net=(h2-h3)*1+0.4315*(h3-h10)
disp("Heat added in boiler per kg steam generated,q_add=(h2-h1)in KJ/kg")
q_add=(h2-4.18*68.425)
disp("thermal efficiency=w_net/q_add")
w_net/q_add
disp("in percentage")
w_net*100/q_add
disp("so Thermal efficiency=27.58%")
```

Scilab code Exa 8.16 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 16

```
// Display mode
```

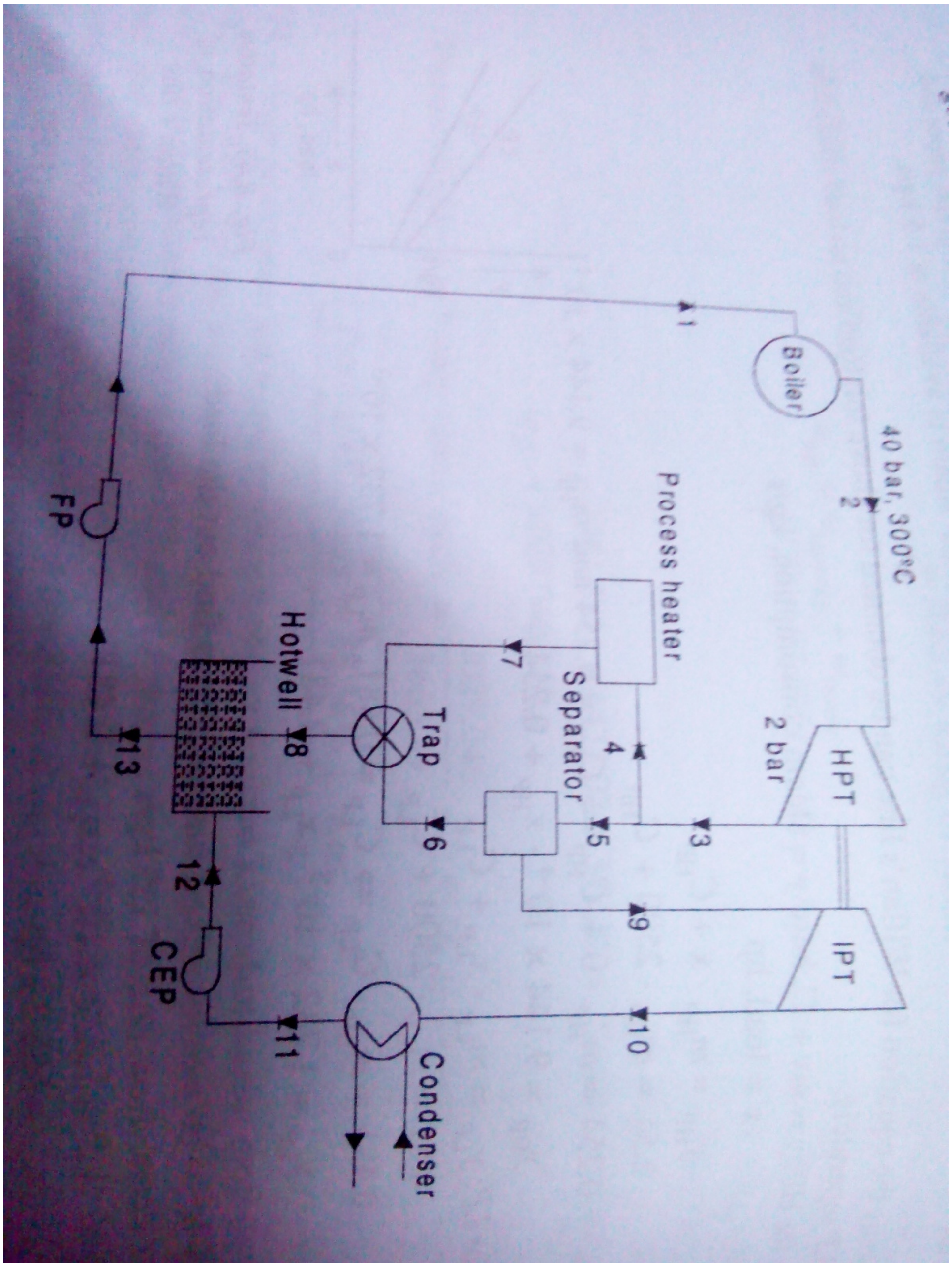


Figure 8.13: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 15

```
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 8 Example 16")
m=35;//mass flow rate in kg/s
disp("from steam tables,h1=3530.9 KJ/kg,s1=6.9486 KJ
    /kg K")
h1=3530.9;
s1=6.9486;
disp("Assuming isentropic expansion in nozzle,s1=s2
    =6.9486")
s2=s1;
disp("Letdryness fraction at state 2,x2=0.864")
disp("s2=sf at 0.2 bar+x2*sfg at 0.2 bar")
disp("from steam tables,sf=0.8320 KJ/kg K,sfg=7.0766
     KJ/kg K")
sf=0.8320;
sfg=7.0766;
disp("so x2=(s2-sf)/sfg")
x2=(s2-sf)/sfg
x2=0.864;//approx.
disp("hence,h2=hf at 0.2 bar+x2*hfg at 0.2 bar in KJ
    /kg")
disp("from steam tables,hf at 0.2 bar=251.4 KJ/kg,
    hfg at 0.2 bar=2358.3 KJ/kg")
hf=251.4;
hfg=2358.3;
h2=hf+x2*hfg
disp("considering pump work to be of isentropic type
    ,deltah_34=v3*deltap_34")
disp("from steam table,v3=vf at 0.2 bar=0.001017 m
    ^3/kg")
v3=0.001017;
disp("or deltah_34=v3*(p3-p4)in KJ/kg")
p3=70;//;pressure of steam entering turbine in bar
```

```
p4=0.20;//condenser pressure in bar
deltah_34=v3*(p3-p4)*100
disp("pump work,Wp=deltah_34 in KJ/kg")
Wp=deltah_34
disp("turbine work,Wt=deltah_12=(h1-h2)in KJ/kg")
Wt=(h1-h2)
disp("net work(W_net)=Wt-Wp in KJ/kg")
W_net=Wt-Wp
disp("power produced(P)=mass flow rate*W_net in KJ/s")
P=m*W_net
disp("so net power=43.22 MW")
disp("heat supplied in boiler(Q)=(h1-h4) in KJ/kg")
disp("enthalpy at state 4,h4=h3+deltah_34 in KJ/kg")
h3=hf;
h4=h3+deltah_34
disp("total heat supplied to boiler(Q)=m*(h1-h4)in KJ/s")
Q=m*(h1-h4)
disp("thermal efficiency=net work/heat supplied=W_net/Q")
P/Q
disp("in percentage")
P*100/Q
disp("so thermal efficiency=37.73%")
```

Scilab code Exa 8.17 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 17

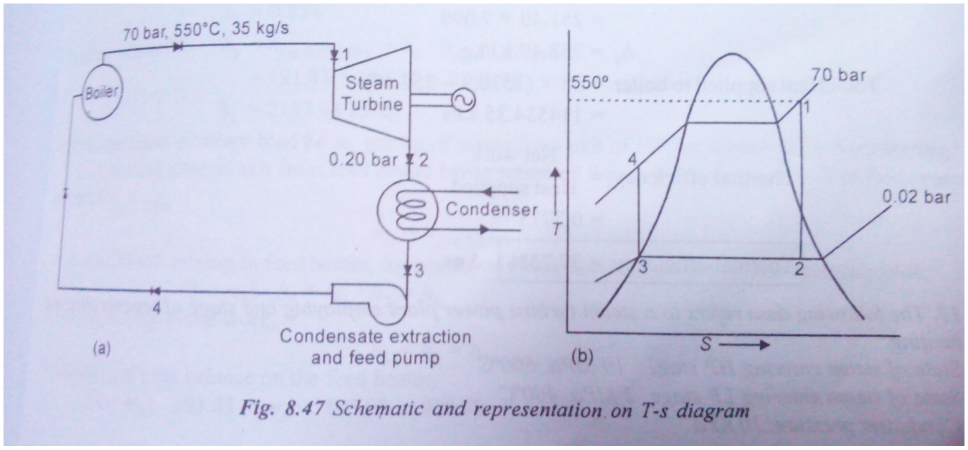
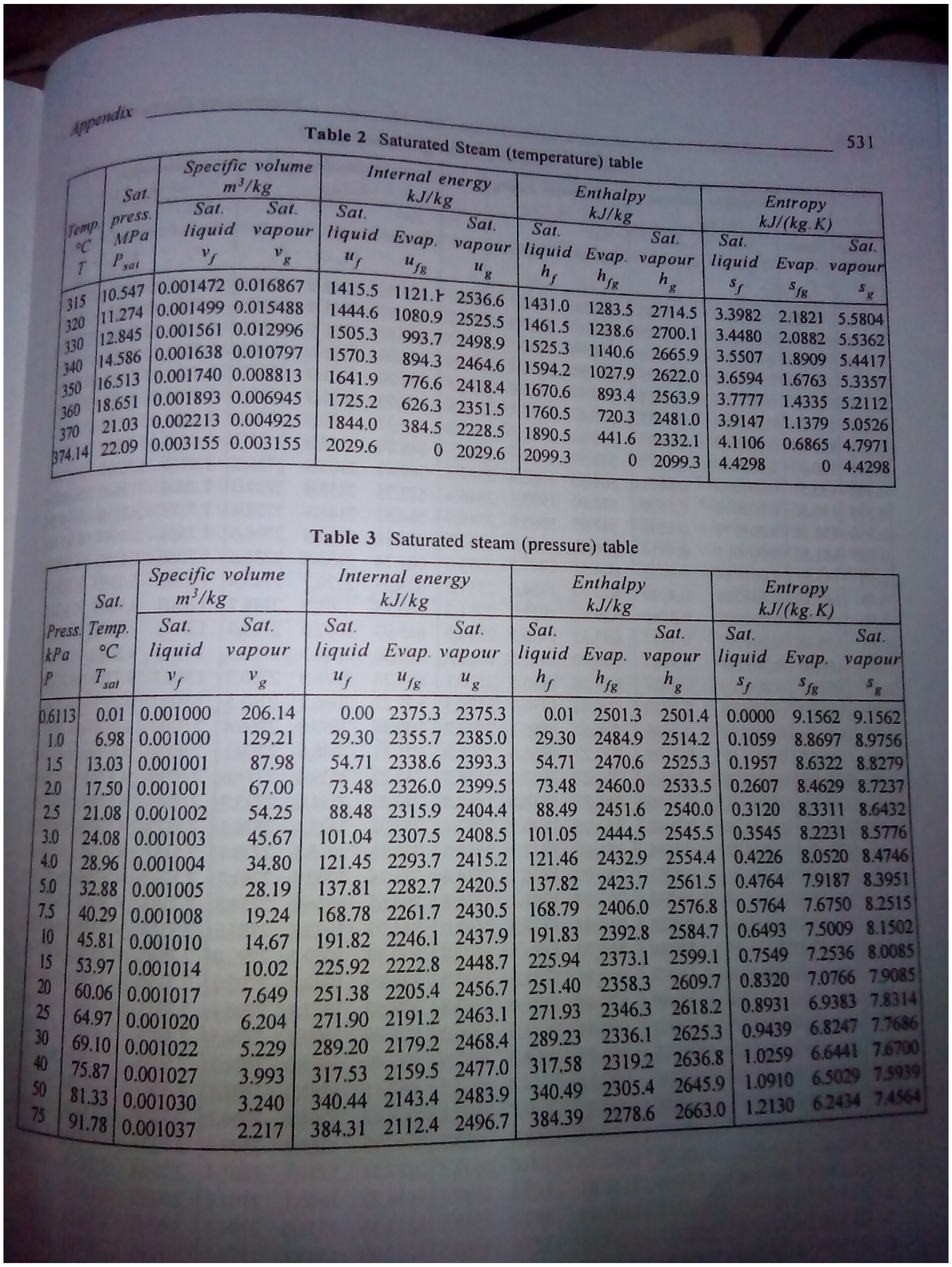


Figure 8.14: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 8 Example 17")
P=10*10^3;//output in KW
disp("from steam tables,h1=3625.3 KJ/s,s1=6.9029 KJ/kg K")
h1=3625.3;
s1=6.9029;
disp("due to isentropic expansion,s1=s2=s3=6.9029 KJ/kg K")
s2=s1;
s3=s2;
disp("at state 2,i.e at pressure of 2 MPa and entropy 6.9029 KJ/kg K")
disp("by interpolating state for s2 between 2 MPa,300 degree celcius and 2 MPa,350 degree celcius from steam tables,")
```



Appendix 531

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. MPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
315	10.547	0.001472	0.016867	1415.5	1121.1	2536.6	1431.0	1283.5	2714.5	3.3982	2.1821	5.5804
320	11.274	0.001499	0.015488	1444.6	1080.9	2525.5	1461.5	1238.6	2700.1	3.4480	2.0882	5.5362
330	12.845	0.001561	0.012996	1505.3	993.7	2498.9	1525.3	1140.6	2665.9	3.5507	1.8909	5.4417
340	14.586	0.001638	0.010797	1570.3	894.3	2464.6	1594.2	1027.9	2622.0	3.6594	1.6763	5.3357
350	16.513	0.001740	0.008813	1641.9	776.6	2418.4	1670.6	893.4	2563.9	3.7777	1.4335	5.2112
360	18.651	0.001893	0.006945	1725.2	626.3	2351.5	1760.5	720.3	2481.0	3.9147	1.1379	5.0526
370	21.03	0.002213	0.004925	1844.0	384.5	2228.5	1890.5	441.6	2332.1	4.1106	0.6865	4.7971
374.14	22.09	0.003155	0.003155	2029.6	0	2029.6	2099.3	0	2099.3	4.4298	0	4.4298

Table 3 Saturated steam (pressure) table

Press. kPa P	Sat. Temp. °C T_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.6113	0.01	0.001000	206.14	0.00	2375.3	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	9.1562
1.0	6.98	0.001000	129.21	29.30	2355.7	2385.0	29.30	2484.9	2514.2	0.1059	8.8697	8.9756
1.5	13.03	0.001001	87.98	54.71	2338.6	2393.3	54.71	2470.6	2525.3	0.1957	8.6322	8.8279
2.0	17.50	0.001001	67.00	73.48	2326.0	2399.5	73.48	2460.0	2533.5	0.2607	8.4629	8.7237
2.5	21.08	0.001002	54.25	88.48	2315.9	2404.4	88.49	2451.6	2540.0	0.3120	8.3311	8.6432
3.0	24.08	0.001003	45.67	101.04	2307.5	2408.5	101.05	2444.5	2545.5	0.3545	8.2231	8.5776
4.0	28.96	0.001004	34.80	121.45	2293.7	2415.2	121.46	2432.9	2554.4	0.4226	8.0520	8.4746
5.0	32.88	0.001005	28.19	137.81	2282.7	2420.5	137.82	2423.7	2561.5	0.4764	7.9187	8.3951
7.5	40.29	0.001008	19.24	168.78	2261.7	2430.5	168.79	2406.0	2576.8	0.5764	7.6750	8.2515
10	45.81	0.001010	14.67	191.82	2246.1	2437.9	191.83	2392.8	2584.7	0.6493	7.5009	8.1502
15	53.97	0.001014	10.02	225.92	2222.8	2448.7	225.94	2373.1	2599.1	0.7549	7.2536	8.0085
20	60.06	0.001017	7.649	251.38	2205.4	2456.7	251.40	2358.3	2609.7	0.8320	7.0766	7.9085
25	64.97	0.001020	6.204	271.90	2191.2	2463.1	271.93	2346.3	2618.2	0.8931	6.9383	7.8314
30	69.10	0.001022	5.229	289.20	2179.2	2468.4	289.23	2336.1	2625.3	0.9439	6.8247	7.7686
40	75.87	0.001027	3.993	317.53	2159.5	2477.0	317.58	2319.2	2636.8	1.0259	6.6441	7.6700
50	81.33	0.001030	3.240	340.44	2143.4	2483.9	340.49	2305.4	2645.9	1.0910	6.5029	7.5939
75	91.78	0.001037	2.217	384.31	2112.4	2496.7	384.39	2278.6	2663.0	1.2130	6.2434	7.4564

Figure 8.15: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 16

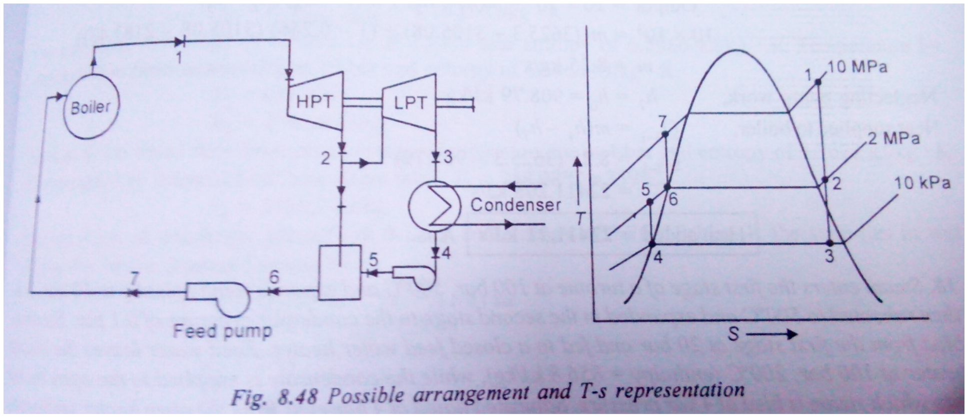


Figure 8.16: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 17

```
disp("h2=3105.08 KJ/kg ")
h2=3105.08;
disp("for state 3,i.e at pressure of 0.01 MPa
   entropy,s3 lies in wet region as s3<sg at 0.01
   MPa.Let dryness fraction be x3 at this state")
disp("s3=sf at 0.01 MPa+x3*sfg at 0.01 MPa")
disp("from steam tables,sf at 0.01 MPa=0.6493 KJ/kg
   K,sfg at 0.01 MPa=7.5009 KJ/kg K")
sf=0.6493;
sfg=7.5009;
disp("so x3=(s3-sf)/sfg")
x3=(s3-sf)/sfg
x3=0.834;//approx.
disp("enthalpy at state 3,h3= hf at 0.01 MPa+x3*hfg
   at 0.01 MPa in KJ/kg")
disp("from steam tables,at 0.01 MPa,hf=191.83 KJ/kg,
   hfg=2392.8 KJ/kg")
hf=191.83;
hfg=2392.8;
h3=hf+x3*hfg
disp("let the mass of steam bled be mb per kg of
   steam from exit of HP for regenerative feed
   heating.")
```

```
disp("Considering state at exit from feed heater being saturated liquid the enthalpy at exit of feed heater will be,hf at 2 MPa")
disp("h6=hf at 2 MPa=908.79 KJ/kg")
h6=908.79;
disp("for adiabatic mixing in feed heater,for one kg of steam leaving boiler,the heat balance yields,")
disp("(1-mb)*h5+mb*h2=h6")
disp("while neglecting pump work,")
disp("h5=h4=hf at 0.01MPa=191.83 KJ/kg")
h4=191.83;
h5=h4;
disp("substituting in heat balance on the feed heater,")
disp("(1-mb)*h5+mb*h2=h6")
disp("so mb=(h6-h5)/(h2-h5)in kg per kg of steam entering HP turbine")
mb=(h6-h5)/(h2-h5)
mb=0.246;//approx.
disp("steam bled per kg of steam passing through HP stage=0.246 kg")
disp("let mass of steam leaving boiler be m kg/s")
disp("output(P)=m*(h1-h2)+m*(1-mb)*(h2-h3)")
disp("so m=P/((h1-h2)+(1-mb)*(h2-h3))in kg/s")
m=P/((h1-h2)+(1-mb)*(h2-h3))
m=8.25;//approx.
disp("neglecting pump work,h7=h6=908.79 KJ/kg")
h7=h6;
disp("heat supplied to boiler,Q_71=m*(h1-h7) in KJ/s")
Q_71=m*(h1-h7)
disp("so heat added=22411.21 KJ/s")
```

Scilab code Exa 8.18 Engineering Thermodynamics by Onkar Singh Chapter 8 Example 18

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 8 Example 18")
W_net=50*10^3;//net output of turbine in KW
disp("from steam tables,at inlet to first stage of
   turbine,h1=h at 100 bar,500oc=3373.7 KJ/kg,s1=s
   at 100 bar,500oc=6.5966 KJ/kg")
h1=3373.7;
s1=6.5966;
disp("Due to isentropic expansion,s1=s6=s2 and s3=s8
   =s4")
s2=s1;
s6=s2;
disp("State at 6 i.e bleed state from HP turbine,
   temperature by interpolation from steam table
   =261.6oc.")
disp("At inlet to second stage of turbine,h6
   =2930.572 KJ/kg")
h6=2930.572;
disp("h3=h at 10 bar,500oc=3478.5 KJ/kg,s3=s at 10
   bar,500oc=7.7622 KJ/kg K")
h3=3478.5;
s3=7.7622;
s4=s3;
s8=s4;
disp("At exit from first stage of turbine i.e. at 10
    bar and entropy of 6.5966 KJ/kg K,Temperature by
    interpolation from steam table at 10 bar and
   entropy of 6.5966 KJ/kg K")
disp("T2=181.8oc,h2=2782.8 KJ/kg")
```

```
T2=181.8;
h2=2782.8;
disp("state at 8,i.e bleed state from second stage
    of expansion,i.e at 4 bar and entropy of 7.7622
    KJ/kg K,Temperature by interpolation from steam
    table,T8=358.98oc=359oc")
T8=359;
disp("h8=3188.7 KJ/kg")
h8=3188.7;
disp("state at 4 i.e. at condenser pressure of 0.1
    bar and entropy of 7.7622 KJ/kg K,the state lies
    in wet region.So let the dryness fraction be x4."
    )
disp("s4=sf at 0.1 bar+x4*sfg at 0.1 bar")
disp("from steam tables,at 0.1 bar,sf=0.6493 KJ/kg K
    ,sfg=7.5009 KJ/kg K")
sf=0.6493;
sfg=7.5009;
disp("so x4=(s4-sf)/sfg")
x4=(s4-sf)/sfg
x4=0.95;//approx.
disp("h4=hf at 0.1 bar+x4*hfg at 0.1 bar in KJ/kg ")
disp("from steam tables,at 0.1 bar,hf=191.83 KJ/kg,
    hfg=2392.8 KJ/kg")
hf=191.83;
hfg=2392.8;
h4=hf+x4*hfg
disp("given,h4=2464.99 KJ/kg,h11=856.8 KJ/kg,h9=hf
    at 4 bar=604.74 KJ/kg")
h4=2464.99;
h11=856.8;
h9=604.74;
disp("considering pump work,the net output can be
    given as,")
disp("W_net=W_HPT+W_LPT-(W_CEP+W_FP)")
disp("where,W_HPT={(h1-h6)+(1-m6)*(h6-h2)}per kg of
    steam from boiler.")
disp("W_LPT={(1-m6)+(h3-h8)*(1-m6-m8)*(h8-h4)}per kg
```

```
      of steam from boiler.")
disp("for closed feed water heater,energy balance
    yields;")
disp("m6*h6+h10=m6*h7+h11")
disp("assuming condensate leaving closed feed water
    heater to be saturated liquid,")
disp("h7=hf at 20 bar=908.79 KJ/kg")
h7=908.79;
disp("due to throttline,h7=h7_a=908.79 KJ/kg")
h7_a=h7;
disp("for open feed water heater,energy balance
    yields,")
disp("m6*h7_a+m8*h8+(1-m6-m8)*h5=h9")
disp("for condensate extraction pump,h5-h4_a=v4_a*
    deltap")
disp("h5-hf at 0.1 bar=vf at 0.1 bar*(4-0.1)*10^2 ")
disp("from steam tables,at 0.1 bar,hf=191.83 KJ/kg,
    vf=0.001010 m^3/kg")
hf=191.83;
vf=0.001010;
disp("so h5=hf+vf*(4-0.1)*10^2 in KJ/kg")
h5=hf+vf*(4-0.1)*10^2
disp("for feed pump,h10-h9=v9*deltap")
disp("h10=h9+vf at 4 bar*(100-4)*10^2 in KJ/kg")
disp("from steam tables,at 4 bar,hf=604.74 KJ/kg,vf
    =0.001084 m^3/kg ")
hf=604.74;
vf=0.001084;
h10=h9+vf*(100-4)*10^2
disp("substituting in energy balance upon closed
    feed water heater,")
disp("m6=(h11-h10)/(h6-h7)in kg per kg of steam from
      boiler")
m6=(h11-h10)/(h6-h7)
disp("substituting in energy balance upon feed water
      heater,")
disp("m8=(h9-m6*h7_a+m6*h5-h5)/(h8-h5)in kg per kg
    of steam from boiler")
```

```
m8=(h9-m6*h7_a+m6*h5-h5)/(h8-h5)
disp("Let the mass of steam entering first stage of
    turbine be m kg,then")
disp("W_HPT=m*{(h1-h6)+(1-m6)*(h6-h2)}")
disp("W_HPT/m=")
{(h1-h6)+(1-m6)*(h6-h2)}
disp("so W_HPT=m*573.24 KJ")
disp("also,W_LPT={(1-m6)*(h3-h8)+(1-m6-m8)*(h8-h4)}
    per kg of steam from boiler")
disp("W_LPT/m=")
{(1-m6)*(h3-h8)+(1-m6-m8)*(h8-h4)}
disp("so W_LPT=m*813.42 KJ")
disp("pump works(negative work)")
disp("W_CEP=m*(1-m6-m8)*(h5-h4_a)")
h4_a=191.83;//h4_a=hf at 0.1 bar
disp("W_CEP/m=")
(1-m6-m8)*(h5-h4_a)
disp("so W_CEP=m* 0.304")
disp("W_FP=m*(h10-h9)")
disp("W_FP/m=")
(h10-h9)
disp("so W_FP=m*10.41")
disp("net output,")
disp("W_net=W_HPT+W_LPT-W_CEP-W_FP ")
disp("so 50*10^3=(573.24*m+813.42*m-0.304*m-10.41*m)
    ")
disp("so m=W_net/(573.24+813.42-0.304-10.41)in kg/s"
    )
m=W_net/(573.24+813.42-0.304-10.41)
disp("heat supplied in boiler,Q_add=m*(h1-h11) in KJ
    /s")
Q_add=m*(h1-h11)
disp("Thermal efficenncy=W_net/Q_add")
W_net/Q_add
disp("in percentage")
W_net*100/Q_add
disp("so mass of steam bled at 20 bar=0.119 kg per
    kg of steam entering first stage")
```

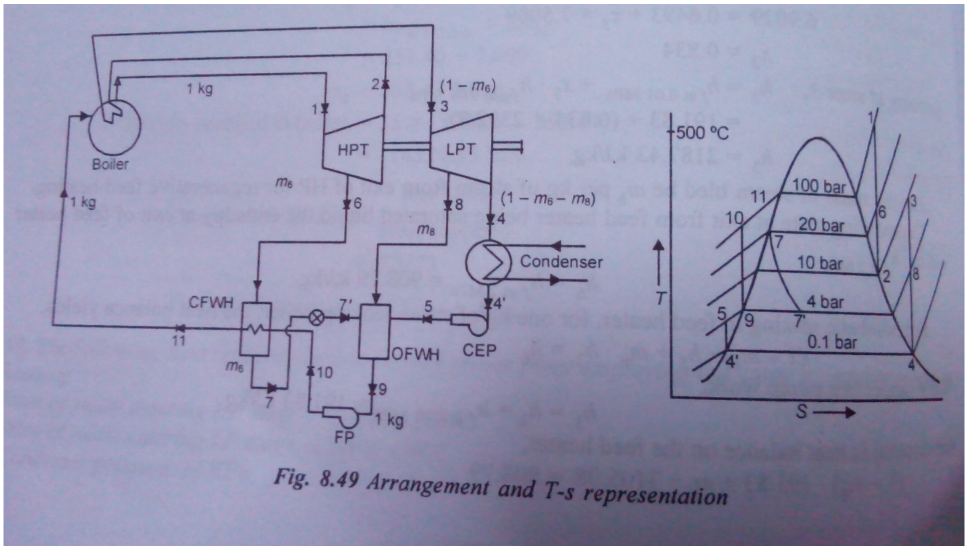


Figure 8.17: Engineering Thermodynamics by Onkar Singh Chapter 8 Example 18

```
disp("mass of steam bled at 4 bar=0.109 kg per kg of
    steam entering first stage")
disp("mass of steam entering first stage=36.33 kg/s"
   )
disp("thermal efficiency=54.66%")
disp("NOTE=>In this question there is some
   caclulation mistake while calculating m6 in book,
   which is corrected above so some answers may vary
   .")
```

Chapter 9

Gas Power Cycles

Scilab code Exa 9.1 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 1")
Cp=1;//specific heat at constant pressure in KJ/kg K
Cv=0.71;//specific heat at constant volume in KJ/kg
   K
P1=98;//pressure at begining of compression in KPa
T1=(60+273.15);//temperature at begining of
   compression in K
Q23=150;//heat supplied in KJ/kg
r=6;//compression ratio
R=0.287;//gas constant in KJ/kg K
disp("SI engine operate on otto cycle.consider
```

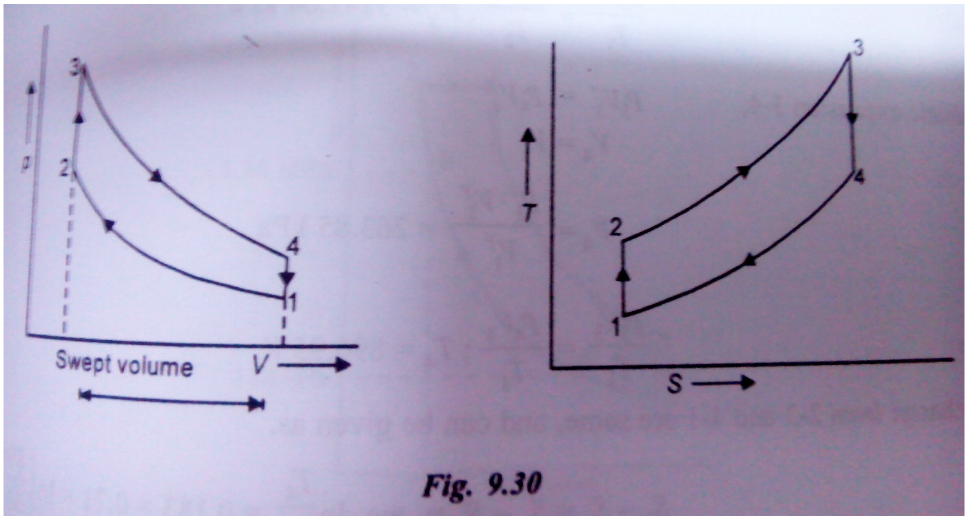


Figure 9.1: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 1

```
    working fluid to be perfect gas.")
disp("here,y=Cp/Cv")
y=Cp/Cv
y=1.4;//approx.
disp("Cp-Cv=R in KJ/kg K")
R=Cp-Cv
disp("compression ratio,r=V1/V2=(0.15+V2)/V2")
disp("so V2=0.15/(r-1) in m^3")
V2=0.15/(r-1)
disp("so V2=0.03 m^3")
disp("total cylinder volume=V1=r*V2 m^3")
V1=r*V2
disp("from perfect gas law,P*V=m*R*T")
disp("so m=P1*V1/(R*T1) in kg")
m=P1*V1/(R*T1)
m=0.183;//approx.
disp("from state 1 to 2 by P*V^y=P2*V2^y")
disp("so P2=P1*(V1/V2)^y in KPa")
P2=P1*(V1/V2)^y
disp("also,P1*V1/T1=P2*V2/T2")
```

```
disp("so T2=P2*V2*T1/(P1*V1)in K")
T2=P2*V2*T1/(P1*V1)
disp("from heat addition process 2-3")
disp("Q23=m*CV*(T3-T2)")
disp("T3=T2+(Q23/(m*Cv))in K")
T3=T2+(Q23/(m*Cv))
disp("also from,P3*V3/T3=P2*V2/T2")
disp("P3=P2*V2*T3/(V3*T2) in KPa")
V3=V2;//constant volume process
P3=P2*V2*T3/(V3*T2)
disp("for adiabatic expansion 3-4,")
disp("P3*V3^y=P4*V4^y")
disp("and V4=V1")
V4=V1;
disp("hence,P4=P3*V3^y/V1^y in KPa")
P4=P3*V3^y/V1^y
disp("and from P3*V3/T3=P4*V4/T4")
disp("T4=P4*V4*T3/(P3*V3) in K")
T4=P4*V4*T3/(P3*V3)
disp("entropy change from 2-3 and 4-1 are same,and
   can be given as,")
disp("S3-S2=S4-S1=m*Cv*log(T4/T1)")
disp("so entropy change,deltaS_32=deltaS_41 in KJ/K"
   )
deltaS_32=m*Cv*log(T4/T1)
deltaS_41=deltaS_32;
disp("heat rejected,Q41=m*Cv*(T4-T1) in KJ")
Q41=m*Cv*(T4-T1)
disp("net work(W)=Q23-Q41 in KJ")
W=Q23-Q41
disp("efficiency(n)=W/Q23")
n=W/Q23
disp("in percentage")
n=n*100
disp("mean effective pressure(mep)=work/volume
   change=W/0.15 in KPa")
mep=W/0.15
disp("so mep=511.67 KPa")
```

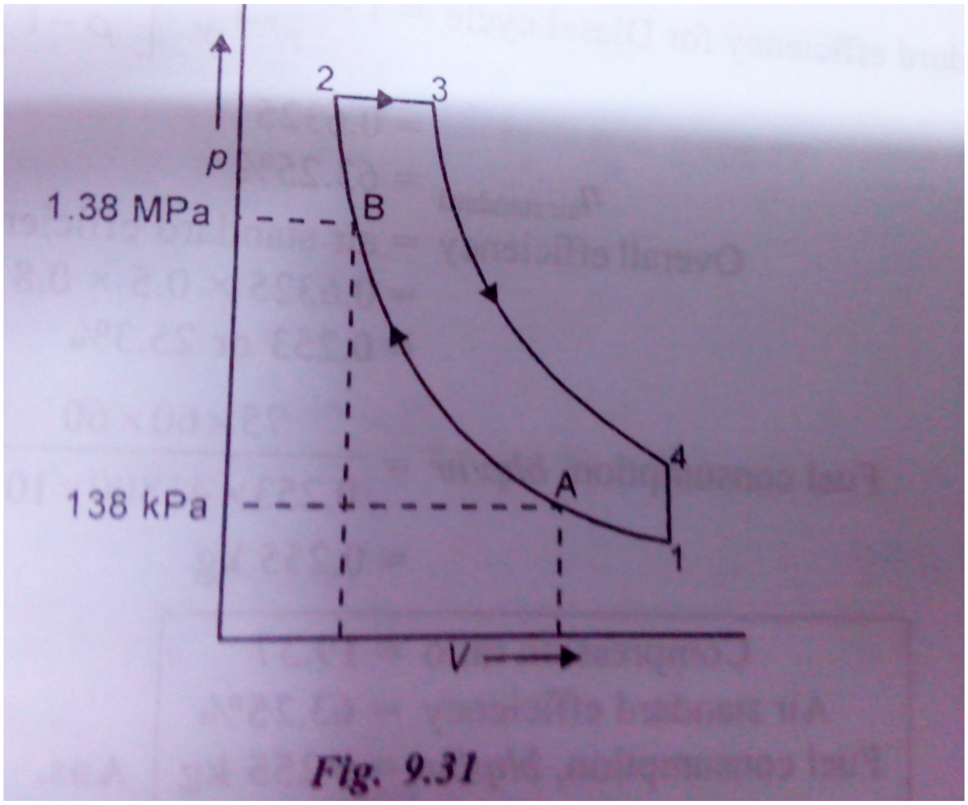


Figure 9.2: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 2

Scilab code Exa 9.2 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
```

```
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 9 Example 2")
Pa=138;//pressure during compression at 1/8 of stroke in KPa
Pb=1.38*10^3;//pressure during compression at 7/8 of stroke in KPa
n_ite=0.5;//indicated thermal efficiency
n_mech=0.8;//mechanical efficiency
C=41800;//calorific value in KJ/kg
y=1.4;//expansion constant
disp("as given")
disp("Va=V2+(7/8)*(V1-V2)")
disp("Vb=V2+(1/8)*(V1-V2)")
disp("and also")
disp("Pa*Va^y=Pb*Vb^y")
disp("so (Va/Vb)=(Pb/Pa)^(1/y)")
(Pb/Pa)^(1/y)
disp("also substituting for Va and Vb")
disp("(V2+(7/8)*(V1-V2))/(V2+(1/8)*(V1-V2))=5.18")
disp("so V1/V2=r=1+(4.18*8/1.82)")
r=1+(4.18*8/1.82)
disp("it gives r=19.37 or V1/V2=19.37,compression ratio=19.37")
disp("as given;cut off occurs at(V1-V2)/15 volume")
disp("V3=V2+(V1-V2)/15")
disp("cut off ratio,rho=V3/V2")
rho=1+(r-1)/15
disp("air standard efficiency for diesel cycle(n_airstandard)=1-(1/(r^(y-1)*y))*((rho^y-1)/(rho-1))")
n_airstandard=1-(1/(r^(y-1)*y))*((rho^y-1)/(rho-1))
disp("in percentage")
n_airstandard=n_airstandard*100
disp("overall efficiency(n_overall)=n_airstandard*n_ite*n_mech")
n_airstandard=0.6325;
```

```
n_overall=n_airstandard*n_ite*n_mech
disp("in percentage")
n_overall=n_overall*100
disp("fuel consumption,bhp/hr in kg=")
n_overall=0.253;
75*60*60/(n_overall*C*100)
disp("so compression ratio=19.37")
disp("air standard efficiency=63.25%")
disp("fuel consumption,bhp/hr=0.255 kg")
```

Scilab code Exa 9.3 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 3")
T1=(100+273.15);//temperature at beginning of
   compresssion in K
P1=103;//pressure at beginning of compresssion in
   KPa
Cp=1.003;//specific heat at constant pressure in KJ/
   kg K
Cv=0.71;//specific heat at constant volume in KJ/kg
   K
Q23=1700;//heat added during combustion in KJ/kg
P3=5000;//maximum pressure in cylinder in KPa
disp("1-2-3-4=cycle a")
disp("1-2_a-3_a-4_a-5=cycle b")
```

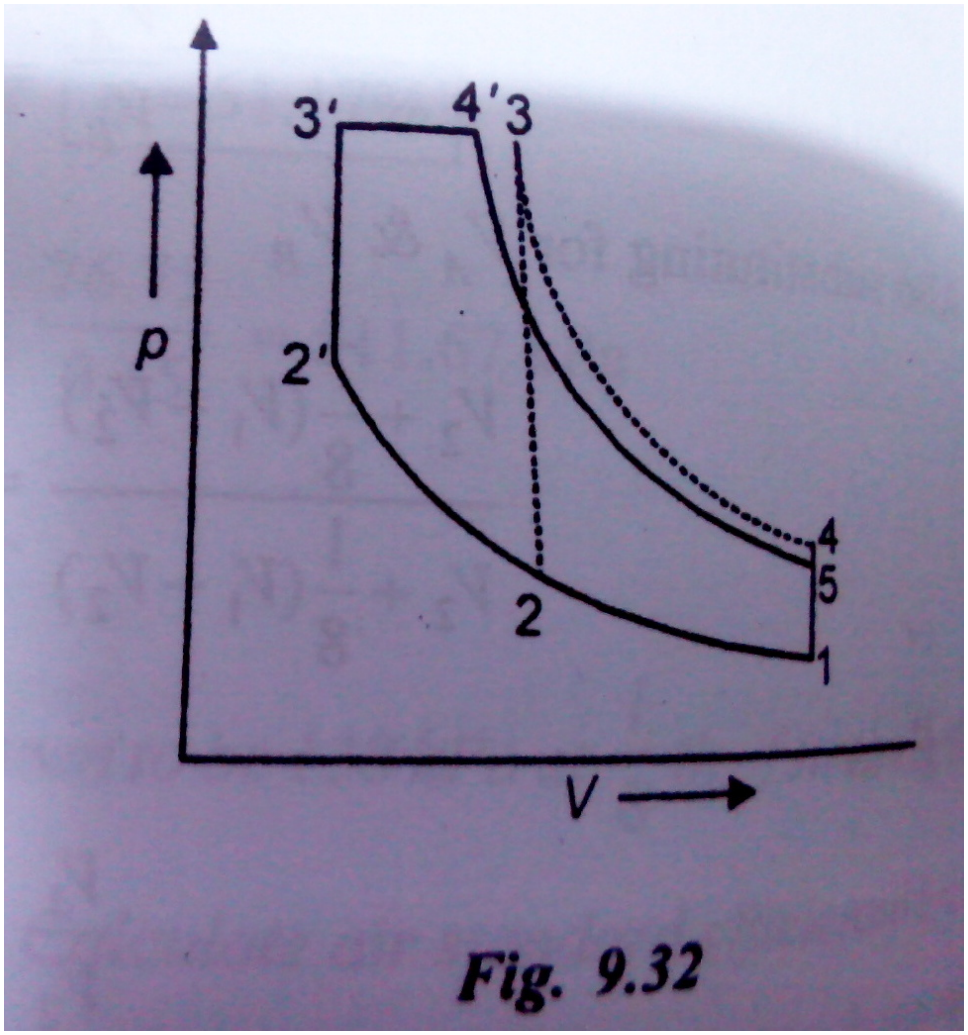


Figure 9.3: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 3

```
disp("here Cp/Cv=y")
y=Cp/Cv
y=1.4;//approx.
disp("and R=0.293 KJ/kg K")
R=0.293;
disp("let us consider 1 kg of air for perfect gas,")
m=1;//mass of air in kg
disp("P*V=m*R*T")
disp("so V1=m*R*T1/P1 in m^3")
V1=m*R*T1/P1
disp("at state 3,")
disp("P3*V3=m*R*T3")
disp("so T3/V2=P3/(m*R)")
P3/(m*R)
disp("so T3=17064.8*V2............eq1")
disp("for cycle a and also for cycle b")
disp("T3_a=17064.8*V2_a.............eq2")
disp("a> for otto cycle,")
disp("Q23=Cv*(T3-T2)")
disp("so T3-T2=Q23/Cv")
Q23/Cv
disp("and T2=T3-2394.36............eq3")
disp("from gas law,P2*V2/T2=P3*V3/T3")
disp("here V2=V3 and using eq 3,we get")
disp("so P2/(T3-2394.36)=5000/T3")
disp("substituting T3 as function of V2")
disp("P2/(17064.8*V2-2394.36)=5000/(17064.8*V2)")
disp("P2=5000*(17064.8*V2-2394.36)/(17064.8*V2)")
disp("also P1*V1^y=P2*V2^y")
disp("or 103*(1.06)^1.4=(5000*(17064.8*V2-2394.36)
    /(17064.8*V2))*V2^1.4")
disp("upon solving it yields")
disp("381.4*V2=17064.8*V2^2.4-2394.36*V2^1.4")
disp("or V2^1.4-0.140*V2^0.4-.022=0")
disp("by hit and trial it yields,V2=0.18 ")
V2=0.18;
disp("thus compression ratio,r=V1/V2")
r=V1/V2
```

```
disp("otto cycle efficiency,n_otto=1-(1/r)^(y-1)")
n_otto=1-(1/r)^(y-1)
disp("in percentage")
n_otto=n_otto*100
disp("b> for mixed or dual cycle")
disp("Cp*(T4_a-T3_a)=Cv*(T3_a-T2_a)=1700/2=850")
disp("or T3_a-T2_a=850/Cv")
850/Cv
disp("or T2_a=T3_a-1197.2 ..............eq4 ")
disp("also P2_a*V2_a/T2_a=P3_a*V3_a/T3_a")
disp("P2_a*V2_a/(T3_a-1197.2)=5000*V2_a/T3_a")
disp("or P2_a/(T3_a-1197.2)=5000/T3_a")
disp("also we had seen earlier that T3_a=17064.8*V2_a")
disp("so P2_a/(17064.8*V2_a-1197.2)=5000/(17064.8*V2_a)")
disp("so P2_a=5000*(17064.8*V2_a-1197.2)/(17064.8*V2_a).....................eq5")
disp("or for adiabatic process,1-2_a")
disp("P1*V1^y=P2*V2^y")
disp("so 1.3*(1.06)^1.4=V2_a^1.4*(5000-(359.78/V2_a))")
disp("or V2_a^1.4-0.07*V2_a^0.4-0.022=0")
disp("by hit and trial ")
disp("V2_a=0.122 m^3")
V2_a=0.122;
disp("therefore upon substituting V2_a,")
disp("by eq 5,P2_a in KPa")
P2_a=5000*(17064.8*V2_a-1197.2)/(17064.8*V2_a)
disp("by eq 2,T3_a in K")
T3_a=17064.8*V2_a
disp("by eq 4,T2_a in K")
T2_a=T3_a-1197.2
disp("from constant pressure heat addition")
disp("Cp*(T4_a-T3_a)=850")
disp("so T4_a=T3_a+(850/Cp) in K")
T4_a=T3_a+(850/Cp)
disp("also P4_a*V4_a/T4_a= P3_a*V3_a/T3_a")
```

```
disp("so V4_a=P3_a*V3_a*T4_a/(T3_a*P4_a) in m^3 ")
disp("here P3_a=P4_a and V2_a=V3_a")
V4_a=V2_a*T4_a/(T3_a)
disp("using adiabatic formulations V4_a=0.172 m^3")
disp("(V5/V4_a)^(y-1)=(T4_a/T5),here V5=V1")
V5=V1;
disp("so T5=T4_a/(V5/V4_a)^(y-1) in K")
T5=T4_a/(V5/V4_a)^(y-1)
disp("heat rejected in process 5-1,Q51=Cv*(T5-T1) in
    KJ")
Q51=Cv*(T5-T1)
disp("efficiency of mixed cycle(n_mixed)=(Q23-Q51)/
   Q23")
n_mixed=(Q23-Q51)/Q23
disp("in percentage")
n_mixed=n_mixed*100
("NOTE=>In this question temperature difference (T3-
   T2) for part a> in book is calculated wrong i.e
   2328.77,which is corrected above and comes to be
   2394.36,however it doesnt effect the efficiency
   of any part of this question.")
```

Scilab code Exa 9.4 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 4")
```

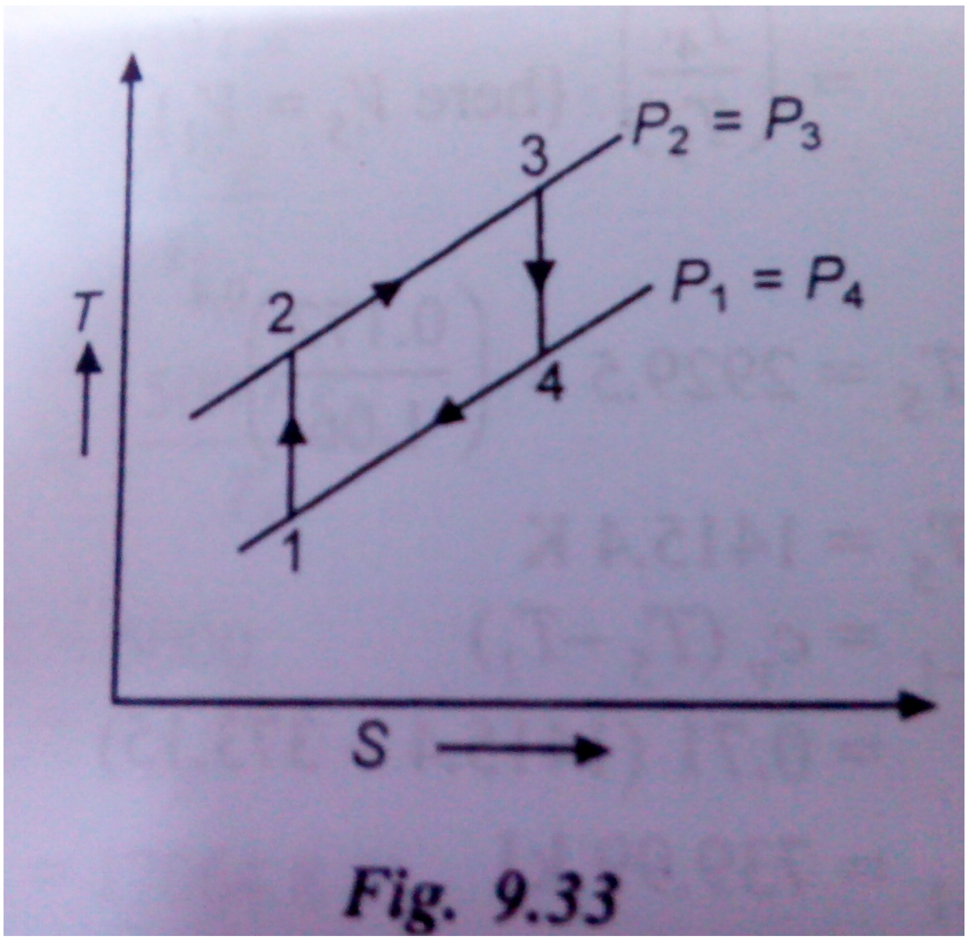


Figure 9.4: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 4

```
T3=1200;//maximum temperature in K
T1=300;//minimum temperature in K
y=1.4;//expansion constant
Cp=1.005;//specific heat at constant pressure in KJ/kg K
disp("optimum pressure ratio for maximum work output,")
disp("rp=(T_max/T_min)^((y)/(2*(y-1)))")
T_max=T3;
T_min=T1;
rp=(T_max/T_min)^((y)/(2*(y-1)))
disp("so p2/p1=11.3,For process 1-2, T2/T1=(p2/p1)^(y/(y-1))")
disp("so T2=T1*(p2/p1)^((y-1)/y)in K")
T2=T1*(rp)^((y-1)/y)
disp("For process 3-4,")
disp("T3/T4=(p3/p4)^((y-1)/y)=(p2/p1)^((y-1)/y)")
disp("so T4=T3/(rp)^((y-1)/y)in K")
T4=T3/(rp)^((y-1)/y)
disp("heat supplied,Q23=Cp*(T3-T2)in KJ/kg")
Q23=Cp*(T3-T2)
disp("compressor work,Wc=Cp*(T2-T1)in KJ/kg")
Wc=Cp*(T2-T1)
disp("turbine work,Wt=Cp*(T3-T4)in KJ/kg")
Wt=Cp*(T3-T4)
disp("thermal efficiency=net work/heat supplied=(Wt-Wc)/Q23")
(Wt-Wc)/Q23
disp("so compressor work=301.5 KJ/kg,turbine work=603 KJ/kg,thermal efficiency=50%")
```

Scilab code Exa 9.5 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 5

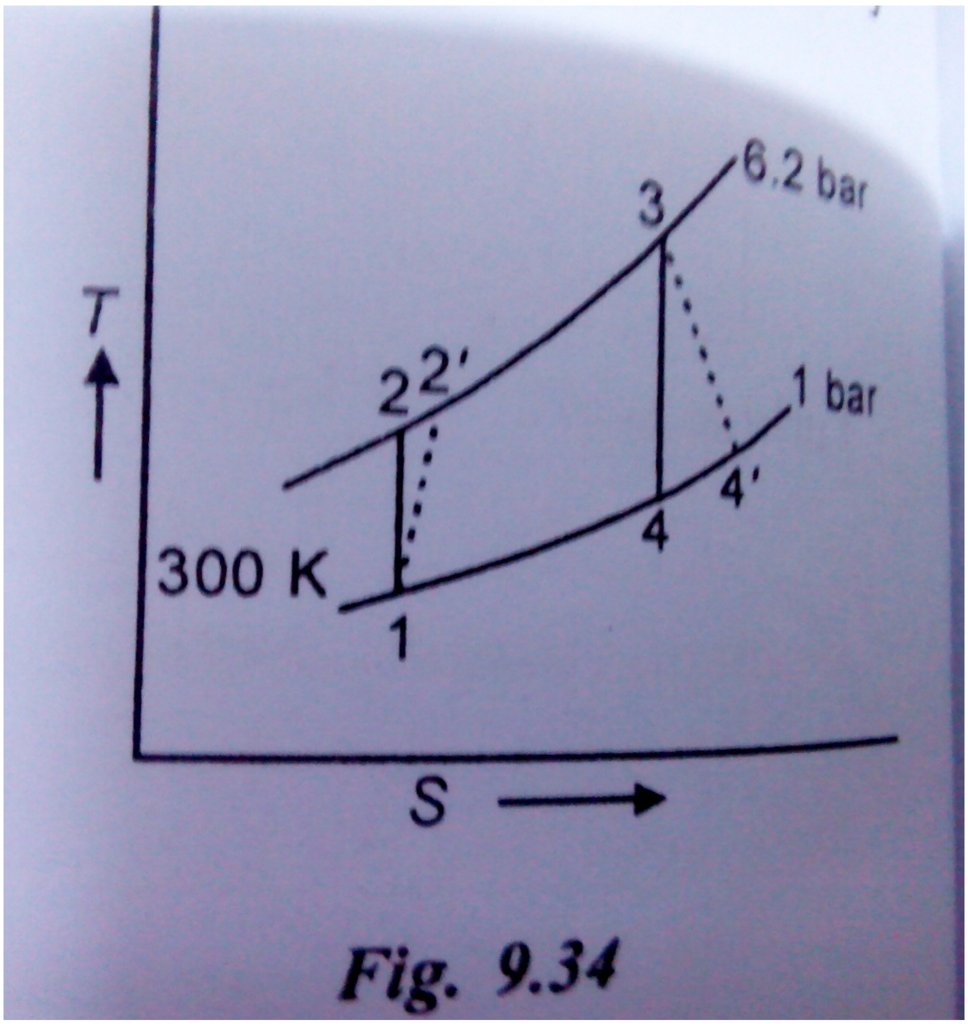


Figure 9.5: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 5")
P1=1*10^5;//initial pressure in Pa
P4=P1;//constant pressure process
T1=300;//initial temperature in K
P2=6.2*10^5;//pressure after compression in Pa
P3=P2;//constant pressure process
k=0.017;//fuel to air ratio
n_compr=0.88;//compressor efficiency
q=44186;//heating value of fuel in KJ/kg
n_turb=0.9;//turbine internal efficiency
Cp_comb=1.147;//specific heat of combustion at
   constant pressure in KJ/kg K
Cp_air=1.005;//specific heat of air at constant
   pressure in KJ/kg K
y=1.4;//expansion constant
n=1.33;//expansion constant for polytropic constant
disp("gas turbine cycle is shown by 1-2-3-4 on T-S
   diagram,")
disp("for process 1-2 being isentropic,")
disp("T2/T1=(P2/P1)^((y-1)/y)")
disp("so T2=T1*(P2/P1)^((y-1)/y) in K")
T2=T1*(P2/P1)^((y-1)/y)
disp("considering compressor efficiency,n_compr=(T2-
   T1)/(T2_a-T1)")
disp("so T2_a=T1+((T2-T1)/n_compr)in K")
T2_a=T1+((T2-T1)/n_compr)
disp("during process 2-3 due to combustion of unit
   mass of compressed the energy balance shall be as
    under,")
disp("heat added=mf*q")
disp("=((ma+mf)*Cp_comb*T3)-(ma*Cp_air*T2)")
```

```
disp("or (mf/ma)*q=((1+(mf/ma))*Cp_comb*T3)-(Cp_air*T2_a)")
disp("so T3=((mf/ma)*q+(Cp_air*T2_a))/((1+(mf/ma))*Cp_comb)in K")
T3=((k)*q+(Cp_air*T2_a))/((1+(k))*Cp_comb)
disp("for expansion 3-4 being")
disp("T4/T3=(P4/P3)^((n-1)/n)")
disp("so T4=T3*(P4/P3)^((n-1)/n) in K")
T4=T3*(P4/P3)^((n-1)/n)
disp("actaul temperature at turbine inlet considering internal efficiency of turbine,")
disp("n_turb=(T3-T4_a)/(T3-T4)")
disp("so T4_a=T3-(n_turb*(T3-T4)) in K")
T4_a=T3-(n_turb*(T3-T4))
disp("compressor work,per kg of air compressed(Wc)=Cp_air*(T2_a-T1) in KJ/kg of air")
Wc=Cp_air*(T2_a-T1)
disp("so compressor work=234.42 KJ/kg of air")
disp("turbine work,per kg of air compressed(Wt)=Cp_comb*(T3-T4_a) in KJ/kg of air")
Wt=Cp_comb*(T3-T4_a)
disp("so turbine work=414.71 KJ/kg of air")
disp("net work(W_net)=Wt-Wc in KJ/kg of air")
W_net=Wt-Wc
disp("heat supplied(Q)=k*q in KJ/kg of air")
Q=k*q
disp("thermal efficiency(n)=W_net/Q")
n=W_net/Q
disp("in percentage")
n=n*100
disp("so thermal efficiency=24%")
```

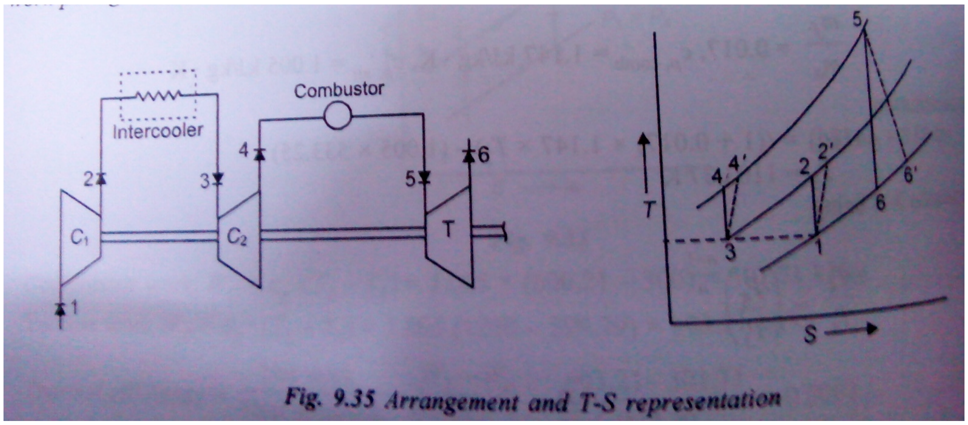


Figure 9.6: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 6

Scilab code Exa 9.6 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 6")
T1=300;//minimum temperature in brayton cycle in K
T5=1200;//maximum temperature in brayton cycle in K
n_isen_c=0.85;//isentropic efficiency of compressor
n_isen_t=0.9;//isentropic efficiency of turbine
y=1.4;//expansion constant
disp("NOTE=>In this question formula for overall
   pressure ratio is derived,which cannot be done
   using scilab,so using this formula we proceed
   further.")
disp("overall pressure ratio(rp)=(T1/(T5*n_isen_c*
   n_isen_t))^((2*y)/(3*(1-y)))")
```

```
rp=(T1/(T5*n_isen_c*n_isen_t))^((2*y)/(3*(1-y)))
disp("so overall optimum pressure ratio=13.6")
```

Scilab code Exa 9.7 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 7")
T1=313;//air entering temperature in K
P1=1*10^5;//air entering pressure in Pa
m=50;//flow rate through compressor in kg/s
R=0.287;//gas constant in KJ/kg K
disp("i> theoretically state of air at exit can be
   determined by the given stage pressure ratio of
   1.35.Let pressure at inlet to first stage P1 and
   subsequent intermediate pressure be P2,P3,P4,P5,
   P6,P7,P8 and exit pressure being P9.")
disp("therefore,P2/P1=P3/P2=P4/P3=P5/P4=P6/P5=P7/P6=
   P8/P7=P9/P8=r=1.35")
r=1.35;//compression ratio
disp("or P9/P1=k=(1.35)^8")
k=(1.35)^8
k=11.03;//approx.
disp("or theoretically,the temperature at exit of
   compressor can be predicted considering
   isentropic compression of air(y=1.4)")
y=1.4;//expansion constant
disp("T9/T1=(P9/P1)^((y-1)/y)")
disp("so T9=T1*(P9/P1)^((y-1)/y) in K")
```

```
T9=T1*(k)^((y-1)/y)
disp("considering overall efficiency of compression 82% the actual temperature at compressor exit can be obtained")
disp("(T9-T1)/(T9_actual-T1)=0.82")
disp("so T9_actual=T1+((T9-T1)/0.82) in K")
T9_actual=T1+((T9-T1)/0.82)
disp("let the actual index of compression be n, then")
disp("(T9_actual/T1)=(P9/P1)^((n-1)/n)")
disp("so n=log(P9/P1)/(log(P9/P1)-log(T9-actual/T1))")
n=log(k)/(log(k)-log(T9_actual/T1))
disp("so state of air at exit of compressor,pressure=11.03 bar and temperature=689.18 K")
disp("ii> let polytropic efficiency be n_polytropic for compressor then,")
disp("(n-1)/n=((y-1)/y)*(1/n_polytropic)")
disp("so n_polytropic=((y-1)/y)/((n-1)/n)")
n_polytropic=((y-1)/y)/((n-1)/n)
disp("in percentage")
n_polytropic=n_polytropic*100
disp("so ploytropic efficiency=86.88%")
disp("iii> stage efficiency can be estimated for any stage.say first stage.")
disp("ideal state at exit of compressor stage=T2/T1=(P2/P1)^((y-1)/y)")
disp("so T2=T1*(P2/P1)^((y-1)/y) in K")
T2=T1*(r)^((y-1)/y)
disp("actual temperature at exit of first stage can be estimated using polytropic index 1.49.")
disp("T2_actual/T1=(P2/P1)^((n-1)/n)")
disp("so T2_actual=T1*(P2/P1)^((n-1)/n) in K")
T2_actual=T1*(r)^((n-1)/n)
disp("stage efficiency for first stage,ns_1=(T2-T1)/(T2_actual-T1)")
ns_1=(T2-T1)/(T2_actual-T1)
disp("in percentage")
```

```
ns_=ns_1*100
disp("actual temperature at exit of second stage,")
disp("T3_actual/T2_actual=(P3/P2)^((n-1)/n)")
disp("so T3_actual=T2_actual*(P3/P2)^((n-1)/n) in K")
T3_actual=T2_actual*(r)^((n-1)/n)
disp("ideal temperature at exit of second stage")
disp("T3/T2_actual=(P3/P2)^((n-1)/n)")
disp("so T3=T2_actual*(P3/P2)^((y-1)/y) in K")
T3=T2_actual*(r)^((y-1)/y)
disp("stage efficiency for second stage,ns_2=(T3-T2_actual)/(T3_actual-T2_actual)")
ns_2=(T3-T2_actual)/(T3_actual-T2_actual)
disp("in percentage")
ns_2=ns_2*100
disp("actual rtemperature at exit of third stage,")
disp("T4_actual/T3_actual=(P4/P3)^((n-1)/n)")
disp("so T4_actual=T3_actual*(P4/P3)^((n-1)/n) in K")
T4_actual=T3_actual*(r)^((n-1)/n)
disp("ideal temperature at exit of third stage,")
disp("T4/T3_actual=(P4/P3)^((n-1)/n)")
disp("so T4=T3_actual*(P4/P3)^((y-1)/y) in K")
T4=T3_actual*(r)^((y-1)/y)
disp("stage efficiency for third stage,ns_3=(T4-T3_actual)/(T4_actual-T3_actual)")
ns_3=(T4-T3_actual)/(T4_actual-T3_actual)
disp("in percentage")
ns_3=ns_3*100
disp("so stage efficiency=86.4%")
disp("iv> from steady flow energy equation,")
disp("Wc=dw=dh and dh=du+p*dv+v*dp")
disp("dh=dq+v*dp")
disp("dq=0 in adiabatic process")
disp("dh=v*dp")
disp("Wc=v*dp")
disp("here for polytropic compression ")
disp("P*V^1.49=constant i.e n=1.49")
```

```
n=1.49;
disp("Wc=(n/(n-1))*m*R*T1*[((P9/P1)^((n-1)/n))-1] in
    KJ/s")
Wc=(n/(n-1))*m*R*T1*[((k)^((n-1)/n))-1]
disp("due to overall efficiency being 90% the actual
    compressor work(Wc_actual)=Wc*0.9 in KJ/s")
Wc_actual=Wc*0.9
disp("so power required to drive compressor
   =14777.89 KJ/s")
```

Scilab code Exa 9.8 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 8")
disp("In question no.8,expression for air standard
   cycle efficiency is derived which cannot be solve
    using scilab software.")
```

Scilab code Exa 9.9 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
```

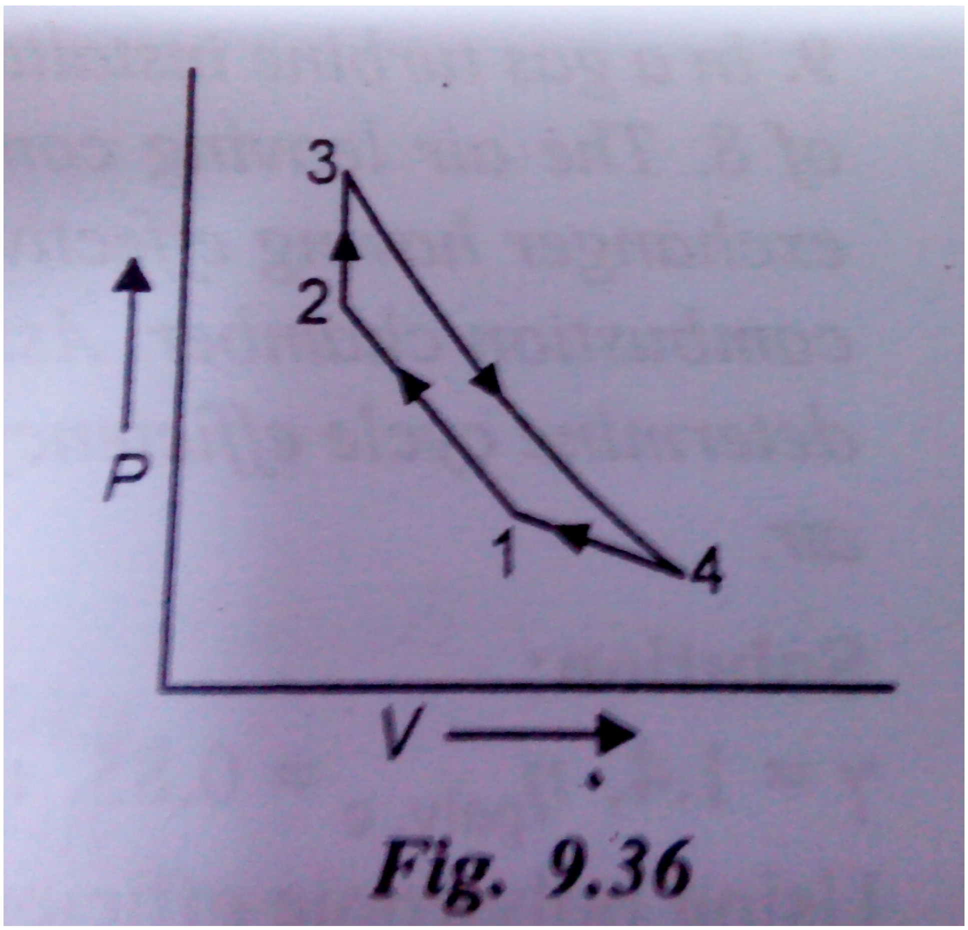


Figure 9.7: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 8

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 9 Example 9")
y=1.4;//expansion constant
n_poly_c=0.85;//ploytropic efficiency of compressor
n_poly_T=0.90;//ploytropic efficiency of Turbine
r=8;//compression ratio
T1=(27+273);//temperature of air in compressor in K
T3=1100;//temperature of air leaving combustion chamber in K
epsilon=0.8;//effectiveness of heat exchanger
Cp=1.0032;//specific heat at constant pressure in KJ/kg K
disp("using polytropic efficiency the index of compression and expansion can be obtained as under,")
disp("let compression index be nc,")
disp("(nc-1)/nc=(y-1)/(y*n_poly_c)")
disp("so nc=1/(1-((y-1)/(y*n_poly_c)))")
nc=1/(1-((y-1)/(y*n_poly_c)))
disp("let expansion index be nt,")
disp("(nt-1)/nt=(n_poly_T*(y-1))/y")
disp("so nt=1/(1-((n_poly_T*(y-1))/y))")
nt=1/(1-((n_poly_T*(y-1))/y))
disp("For process 1-2")
disp("T2/T1=(p2/p1)^((nc-1)/nc)")
disp("so T2=T1*(p2/p1)^((nc-1)/nc)in K")
T2=T1*(r)^((nc-1)/nc)
disp("also T4/T3=(p4/p3)^((nt-1)/nt)")
disp("so T4=T3*(p4/p3)^((nt-1)/nt)in K")
T4=T3*(1/r)^((nt-1)/nt)
disp("using heat exchanger effectivenesss,")
disp("epsilon=(T5-T2)/(T4-T2)")
disp("so T5=T2+(epsilon*(T4-T2))in K")
T5=T2+(epsilon*(T4-T2))
disp("heat added in combustion chamber,q_add=Cp*(T3-
```

```
T5)in KJ/kg")
q_add=Cp*(T3-T5)
disp("compressor work,Wc=Cp*(T2-T1)in ")
Wc=Cp*(T2-T1)
disp("turbine work,Wt=Cp*(T3-T4)in KJ/kg")
Wt=Cp*(T3-T4)
disp("cycle efficiency=(Wt-Wc)/q_add")
(Wt-Wc)/q_add
disp("in percentage")
(Wt-Wc)*100/q_add
disp("work ratio,(Wt-Wc)/Wt")
(Wt-Wc)/Wt
disp("specific work output=Wt-Wc in KJ/kg")
Wt-Wc
disp("so cycle efficiency=32.79%,work ratio=0.334,
    specific work output=152.56 KJ/kg")
```

Scilab code Exa 9.10 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 9 Example 10")
T1=(27+273);//temperature of air in compressor in K
```

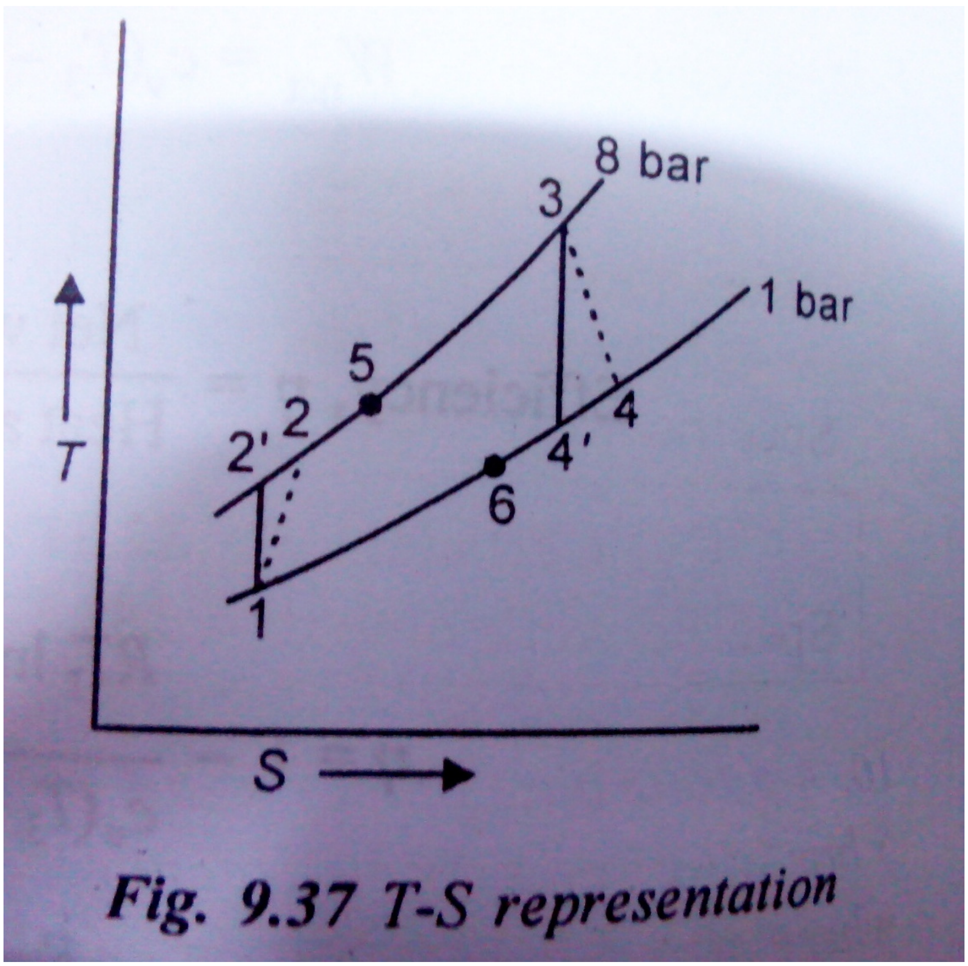


Figure 9.8: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 9

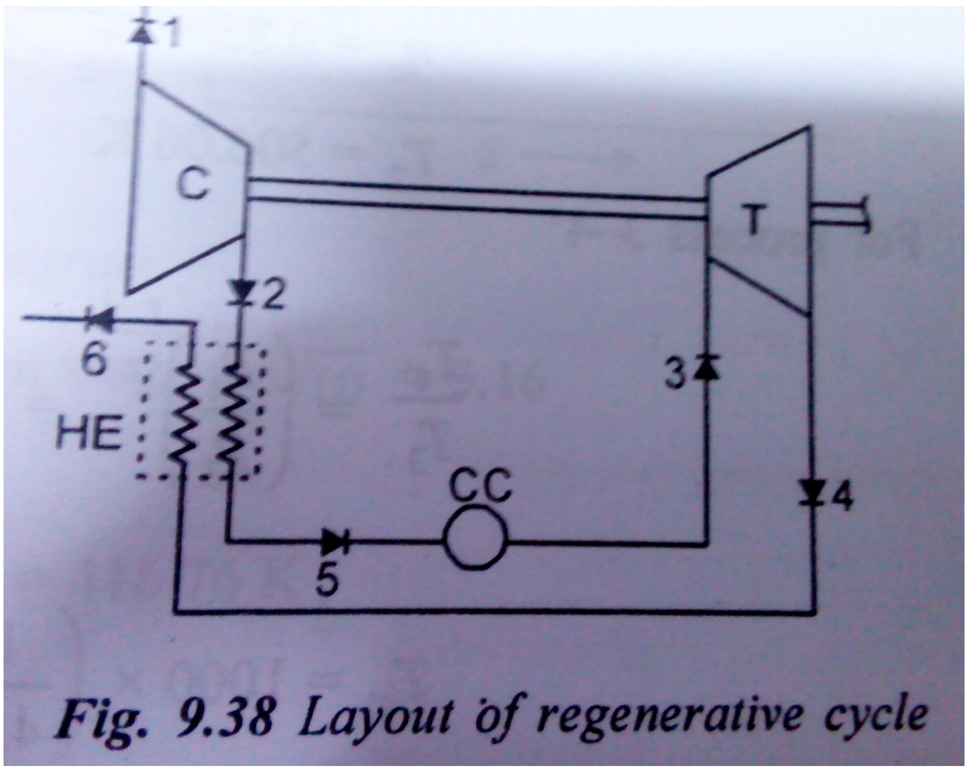


Fig. 9.38 Layout of regenerative cycle

Figure 9.9: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 9

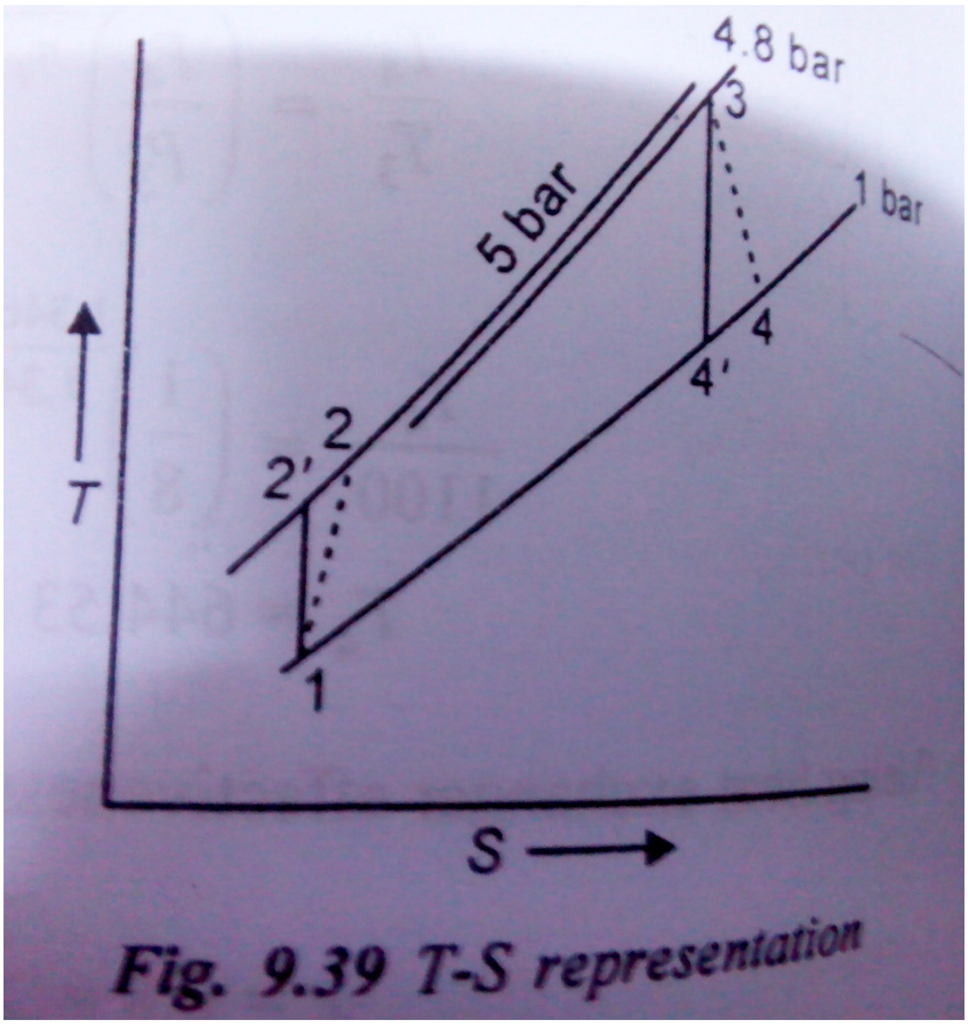


Figure 9.10: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 10

```
p1=1*10^5;//pressure of air in compressor in Pa
p2=5*10^5;//pressure of air after compression in Pa
p3=p2-0.2*10^5;//pressure drop in Pa
p4=1*10^5;//pressure to which expansion occur in turbine in Pa
nc=0.85;//isentropic efficiency
T3=1000;//temperature of air in combustion chamber in K
n=0.2;//thermal efficiency of plant
y=1.4;//expansion constant
Cp=1.0032;//specific heat at constant pressure in KJ/kg K
disp("for process 1-2_a")
disp("T2_a/T1=(p2_a/p1)^((y-1)/y)")
disp("so T2_a=T1*(p2_a/p1)^((y-1)/y) in K")
T2_a=T1*(p2/p1)^((y-1)/y)
disp("nc=(T2_a-T1)/(T2-T1)")
disp("so T2=T1+((T2_a-T1)/nc) in K")
T2=T1+((T2_a-T1)/nc)
disp("for process 3-4_a,")
disp("T4_a/T3=(p4/p3)^((y-1)/y)")
disp("so T4_a=T3*(p4/p3)^((y-1)/y)in K")
T4_a=T3*(p4/p3)^((y-1)/y)
disp("Compressor work per kg,Wc=Cp*(T2-T1) in KJ/kg")
Wc=Cp*(T2-T1)
disp("Turbine work per kg,Wt=Cp*(T3-T4)in KJ/kg")
disp("net output,W_net=Wt-Wc={Wc-(Cp*(T3-T4))} in KJ/kg")
disp("heat added,q_add=Cp*(T3-T2) in KJ/kg")
q_add=Cp*(T3-T2)
disp("thermal efficiency,n=W_net/q_add")
disp("n={Wc-(Cp*(T3-T4))}/q_add")
disp("so T4=T3-((Wc-(n*q_add))/Cp)in K")
T4=T3-((Wc-(n*q_add))/Cp)
disp("therefore,isentropic efficiency of turbine,nt=(T3-T4)/(T3-T4_a)")
nt=(T3-T4)/(T3-T4_a)
```

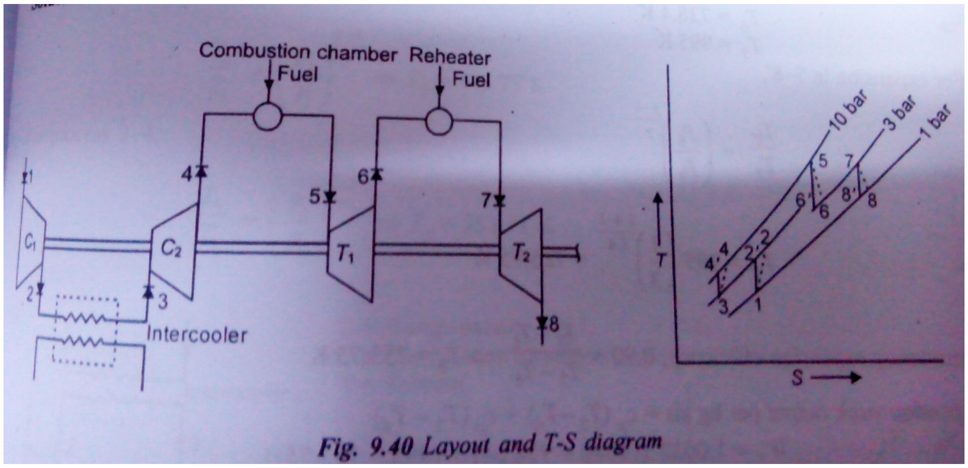


Figure 9.11: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 11

```
disp("in percentage")
nt=nt*100
disp("so turbine isentropic efficiency=29.69%")
```

Scilab code Exa 9.11 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 11")
P1=1*10^5;//initial pressure in Pa
T1=(27+273);//initial temperature in K
```

```
T3=T1;
r=10;//pressure ratio
T5=1000;//maximum temperature in cycle in K
P6=3*10^5;//first stage expansion pressure in Pa
T7=995;//first stage reheated temperature in K
C=42000;//calorific value of fuel in KJ/kg
Cp=1.0032;//specific heat at constant pressure in KJ
    /kg K
m=30;//air flow rate in kg/s
nc=0.85;//isentropic efficiency of compression
ne=0.9;//isentropic efficiency of expansion
y=1.4;//expansion constant
disp("for perfect intercooling the pressure ratio of
    each compression stage(k)")
disp("k=sqrt(r)")
k=sqrt(r)
k=3.16;//approx.
disp("for process 1-2_a,T2_a/T1=(P2/P1)^((y-1)/y)")
disp("so T2_a=T1*(k)^((y-1)/y)in K")
T2_a=T1*(k)^((y-1)/y)
disp("considering isentropic efficiency of
    compression,")
disp("nc=(T2_a-T1)/(T2-T1)")
disp("so T2=T1+((T2_a-T1)/nc)in K")
T2=T1+((T2_a-T1)/nc)
disp("for process 3-4,")
disp("T4_a/T3=(P4/P3)^((y-1)/y)")
disp("so T4_a=T3*(P4/P3)^((y-1)/y) in K")
T4_a=T3*(k)^((y-1)/y)
disp("again due to compression efficiency,nc=(T4_a-
    T3)/(T4-T3)")
disp("so T4=T3+((T4_a-T3)/nc)in K")
T4=T3+((T4_a-T3)/nc)
disp("total compressor work,Wc=2*Cp*(T4-T3) in KJ/kg
    ")
Wc=2*Cp*(T4-T3)
disp("for expansion process 5-6_a,")
disp("T6_a/T5=(P6/P5)^((y-1)/y)")
```

```
disp("so T6_a=T5*(P6/P5)^((y-1)/y) in K")
P5=10*10^5;//pressure in Pa
T6_a=T5*(P6/P5)^((y-1)/y)
disp("considering expansion efficiency,ne=(T5-T6)/(T5-T6_a)")
disp("T6=T5-(ne*(T5-T6_a)) in K")
T6=T5-(ne*(T5-T6_a))
disp("for expansion in 7-8_a")
disp("T8_a/T7=(P8/P7)^((y-1)/y)")
disp("so T8_a=T7*(P8/P7)^((y-1)/y) in K")
P8=P1;//constant pressure process
P7=P6;//constant pressure process
T8_a=T7*(P8/P7)^((y-1)/y)
disp("considering expansion efficiency,ne=(T7-T8)/(T7-T8_a)")
disp("so T8=T7-(ne*(T7-T8_a))in K")
T8=T7-(ne*(T7-T8_a))
disp("expansion work output per kg of air(Wt)=Cp*(T5-T6)+Cp*(T7-T8) in KJ/kg")
Wt=Cp*(T5-T6)+Cp*(T7-T8)
disp("heat added per kg air(q_add)=Cp*(T5-T4)+Cp*(T7-T6) in KJ/kg")
q_add=Cp*(T5-T4)+Cp*(T7-T6)
disp("fuel required per kg of air,mf=q_add/C")
mf=q_add/C
disp("air-fuel ratio=1/mf")
1/mf
disp("net output(W)=Wt-Wc in KJ/kg")
W=Wt-Wc
disp("output for air flowing at 30 kg/s,=W*m in KW")
W*m
disp("thermal efficiency=W/q_add")
W/q_add
disp("in percentage")
W*100/q_add
disp("so thermal efficiency=27.87%,net output=6876.05 KW,A/F ratio=51.07")
disp("NOTE=>In this question,expansion work is
```

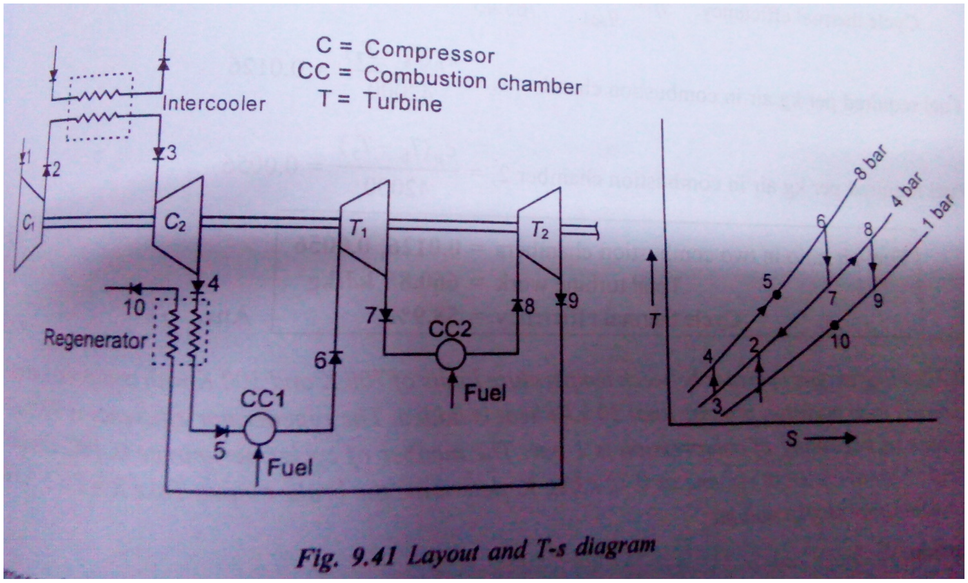


Figure 9.12: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 12

```
    calculated wrong in book,so it is corrected above
     and answers vary accordingly.")
```

Scilab code Exa 9.12 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 12")
```

```
P1=1*10^5;//initial pressure in Pa
P9=P1;
T1=300;//initial temperature in K
P2=4*10^5;//pressure of air in intercooler in Pa
P3=P2;
T3=290;//temperature of air in intercooler in K
T6=1300;//temperature of combustion chamber in K
P4=8*10^5;//pressure of air after compression in Pa
P6=P4;
T8=1300;//temperature after reheating in K
P8=4*10^5;//pressure after expansion in Pa
P7=P8;
C=42000;//heating value of fuel in KJ/kg
y=1.4;//expansion constant
ne=0.8;//effectiveness of regenerator
Cp=1.0032;//specific heat at constant pressure in KJ/kg K
disp("for process 1-2,")
disp("T2/T1=(P2/P1)^((y-1)/y)")
disp("so T2=T1*(P2/P1)^((y-1)/y) in K")
T2=T1*(P2/P1)^((y-1)/y)
disp("for process 3-4,")
disp("T4/T3=(P4/P3)^((y-1)/y)")
disp("so T4=T3*(P4/P3)^((y-1)/y) in K")
T4=T3*(P4/P3)^((y-1)/y)
disp("for process 6-7,")
disp("T7/T6=(P7/P6)^((y-1)/y)")
disp("so T7=T6*(P7/P6)^((y-1)/y) in K")
T7=T6*(P7/P6)^((y-1)/y)
disp("for process 8-9,")
disp("T9/T8=(P9/P8)^((y-1)/y)")
disp("T9=T8*(P9/P8)^((y-1)/y) in K")
T9=T8*(P9/P8)^((y-1)/y)
disp("in regenerator,effectiveness=(T5-T4)/(T9-T4)")
disp("T5=T4+(ne*(T9-T4))in K")
T5=T4+(ne*(T9-T4))
disp("compressor  work per kg air,Wc=Cp*(T2-T1)+Cp*(T4-T3) in KJ/kg")
```

```
Wc=Cp*(T2-T1)+Cp*(T4-T3)
disp("turbine work per kg air ,Wt=Cp*(T6-T7)+Cp*(T8-
   T9)in KJ/kg")
Wt=Cp*(T6-T7)+Cp*(T8-T9)
disp("heat added per kg air ,q_add=Cp*(T6-T5)+Cp*(T8-
   T7)in KJ/kg")
q_add=Cp*(T6-T5)+Cp*(T8-T7)
disp("total fuel required per kg of air=q_add/C")
q_add/C
disp("net work ,W_net=Wt-Wc in KJ/kg")
W_net=Wt-Wc
disp("cycle thermal efficiency ,n=W_net/q_add")
n=W_net/q_add
disp("in percentage")
n=n*100
disp("fuel required per kg air in combustion chamber
    1,Cp*(T8-T7)/C")
Cp*(T8-T7)/C
disp("fuel required per kg air in combustion
   chamber2,Cp*(T6-T5)/C")
Cp*(T6-T5)/C
disp("so fuel-air ratio in two combustion chambers
   =0.0126,0.0056")
disp("total turbine work=660.85 KJ/kg")
disp("cycle thermal efficiency=58.9%")
disp("NOTE=>In this question ,fuel required per kg
   air in combustion chamber 1 and 2 are calculated
   wrong in book,so it is corrected above and
   answers vary accordingly. ")
```

Scilab code Exa 9.13 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 13

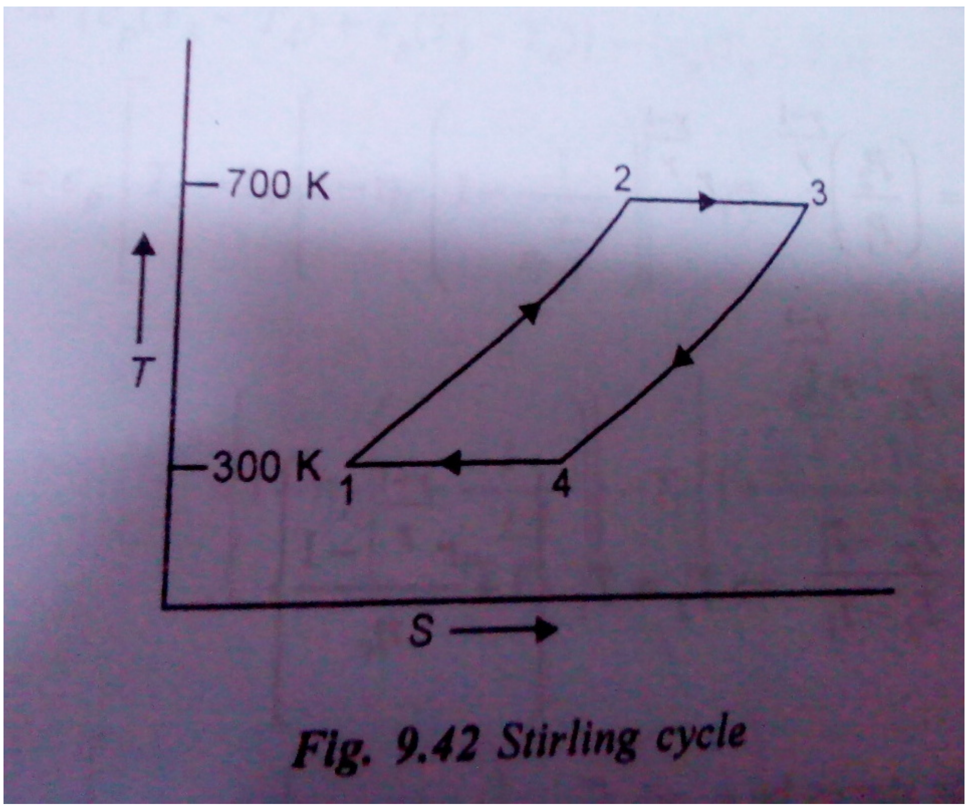


Figure 9.13: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 9 Example 13")
T2=700;//highest temperature of stirling engine in K
T1=300;//lowest temperature of stirling engine in K
r=3;//compression ratio
q_add=30;//heat addition in KJ/s
epsilon=0.9;//regenerator efficiency
P=1*10^5;//pressure at begining of compression in Pa
n=100;//number of cycle per minute
Cv=0.72;//specific heat at constant volume in KJ/kg K
R=29.27;//gas constant in KJ/kg K
disp("work done per kg of air,W=R*(T2-T1)*log(r) in KJ/kg")
W=R*(T2-T1)*log(r)
disp("heat added per kg of air,q=R*T2*log(r)+(1-epsilon)*Cv*(T2-T1) in KJ/kg")
q=R*T2*log(r)+(1-epsilon)*Cv*(T2-T1)
disp("for 30 KJ/s heat supplied,the mass of air/s(m)=q_add/q in kg/s")
m=q_add/q
disp("mass of air per cycle=m/n in kg/cycle")
m/n
disp("brake output=W*m in KW")
W*m
disp("stroke volume,V=m*R*T/P in m^3")
m=1.33*10^-4;//mass of air per cycle in kg/cycle
T=T1;
V=m*R*T*1000/P
disp("brake output=17.11 KW")
disp("stroke volume=0.0116 m^3")
```

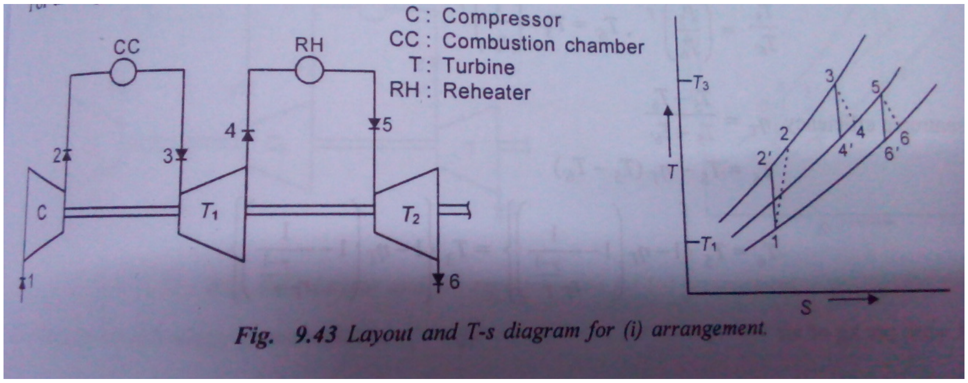


Figure 9.14: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 14

Scilab code Exa 9.14 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 9 Example 14")
disp("In question no.14,various expression is
    derived which cannot be solved using scilab
    software.")
```

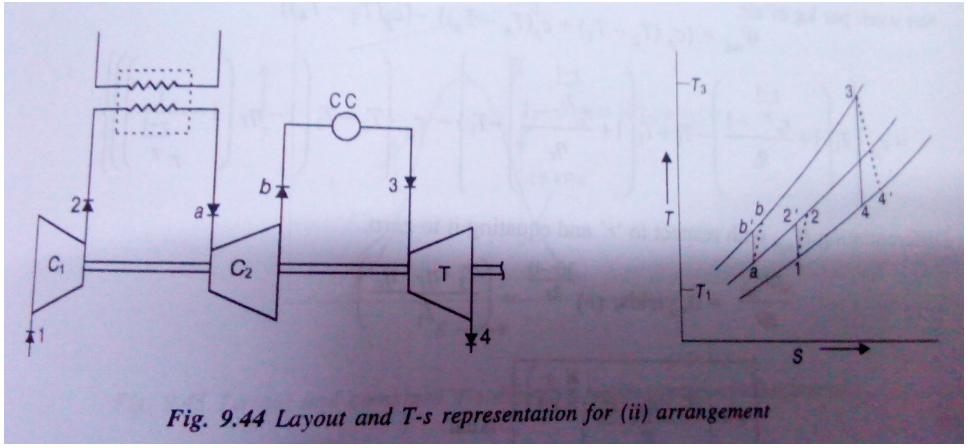


Figure 9.15: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 14

Scilab code Exa 9.15 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 9 Example 15")
r=10;//pressure ratio
Cp=1.0032;//specific heat of air in KJ/kg K
y=1.4;//expansion constant
T3=1400;//inlet temperature of gas turbine in K
T1=(17+273);//ambient temperature in K
P1=1*10^5;//ambient pressure in Pa
Pc=15;//condensor pressure in KPa
Pg=6*1000;//pressure of steam in generator in KPa
```

```
T5=420;//temperature of exhaust from gas turbine in
    K
disp("In gas turbine cycle,T2/T1=(P2/P1)^((y-1)/y)")
disp("so T2=T1*(P2/P1)^((y-1)/y)in K")
T2=T1*(r)^((y-1)/y)
disp("T4/T3=(P4/P3)^((y-1)/y)")
disp("so T4=T3*(P4/P3)^((y-1)/y) in K")
T4=T3*(1/r)^((y-1)/y)
disp("compressor work per kg,Wc=Cp*(T2-T1) in KJ/kg"
    )
Wc=Cp*(T2-T1)
disp("turbine work per kg,Wt=Cp*(T3-T4) in KJ/kg ")
Wt=Cp*(T3-T4)
disp("heat added in combustion chamber per kg,q_add=
    Cp*(T3-T2) in KJ/kg ")
q_add=Cp*(T3-T2)
disp("net gas turbine output,W_net_GT=Wt-Wc in KJ/kg
     air")
W_net_GT=Wt-Wc
disp("heat recovered in HRSG for steam generation
    per kg of air")
disp("q_HRGC=Cp*(T4-T5)in KJ/kg")
q_HRGC=Cp*(T4-T5)
disp("at inlet to steam in turbine,")
disp("from steam table,ha=3177.2 KJ/kg,sa=6.5408 KJ/
    kg K")
ha=3177.2;
sa=6.5408;
disp("for expansion in steam turbine,sa=sb")
sb=sa;
disp("let dryness fraction at state b be x")
disp("also from steam table,at 15KPa, sf=0.7549 KJ/
    kg K,sfg=7.2536 KJ/kg K,hf=225.94 KJ/kg,hfg
    =2373.1 KJ/kg")
sf=0.7549;
sfg=7.2536;
hf=225.94;
hfg=2373.1;
```

```
disp("sb=sf+x*sfg")
disp("so x=(sb-sf)/sfg ")
x=(sb-sf)/sfg
disp("so hb=hf+x*hfg in KJ/kg K")
hb=hf+x*hfg
disp("at exit of condenser,hc=hf ,vc=0.001014 m^3/kg from steam table")
hc=hf;
vc=0.001014;
disp("at exit of feed pump,hd=hd-hc")
disp("hd=vc*(Pg-Pc)*100 in KJ/kg")
hd=vc*(Pg-Pc)*100
disp("heat added per kg of steam =ha-hd in KJ/kg")
ha-hd
disp("mass of steam generated per kg of air=q_HRGC/(ha-hd)in kg steam per kg air")
q_HRGC/(ha-hd)
disp("net steam turbine cycle output,W_net_ST=(ha-hb)-(hd-hc)in KJ/kg")
W_net_ST=(ha-hb)-(hd-hc)
disp("steam cycle output per kg of air(W_net_ST)=W_net_ST*0.119 in KJ/kg air")
W_net_ST=W_net_ST*0.119
disp("total combined cycle output=(W_net_GT+W_net_ST) in KJ/kg air ")
(W_net_GT+W_net_ST)
disp("combined cycle efficiency ,n_cc=(W_net_GT+W_net_ST)/q_add")
n_cc=(W_net_GT+W_net_ST)/q_add
disp("in percentage")
n_cc=n_cc*100
disp("In absence of steam cycle,gas turbine cycle efficiency,n_GT=W_net_GT/q_add")
n_GT=W_net_GT/q_add
disp("in percentage")
n_GT=n_GT*100
disp("thus ,efficiency is seen to increase in combined cycle upto 57.77% as compared to gas
```

```
turbine offering 48.21% efficiency.")
disp("overall efficiency=57.77%")
disp("steam per kg of air=0.119 kg steam per/kg air")
```

Scilab code Exa 9.16 Engineering Thermodynamics by Onkar Singh Chapter 9 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 9 Example 16")
T1=(27+273);//temperature at begining of compression in K
k=70;//ration of maximum to minimum pressures
r=15;//compression ratio
y=1.4;//expansion constant
disp("here P4/P1=P3/P1=70............eq1")
disp("compression ratio,V1/V2=V1/V3=15.............eq2")
disp("heat added at constant volume= heat added at constant pressure")
disp("Q23=Q34")
disp("m*Cv*(T3-T2)=m*Cp*(T4-T3)")
disp("(T3-T2)=y*(T4-T3)")
```

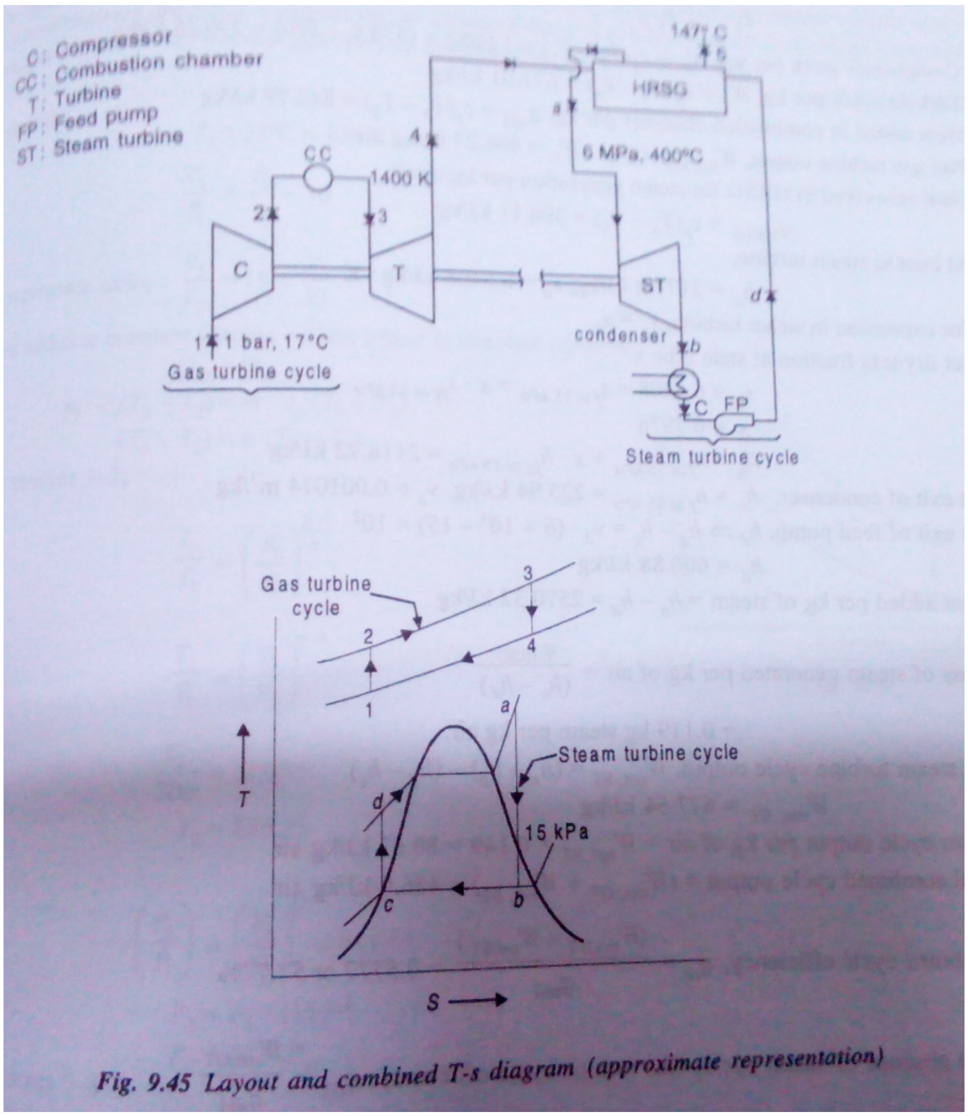


Figure 9.16: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 15

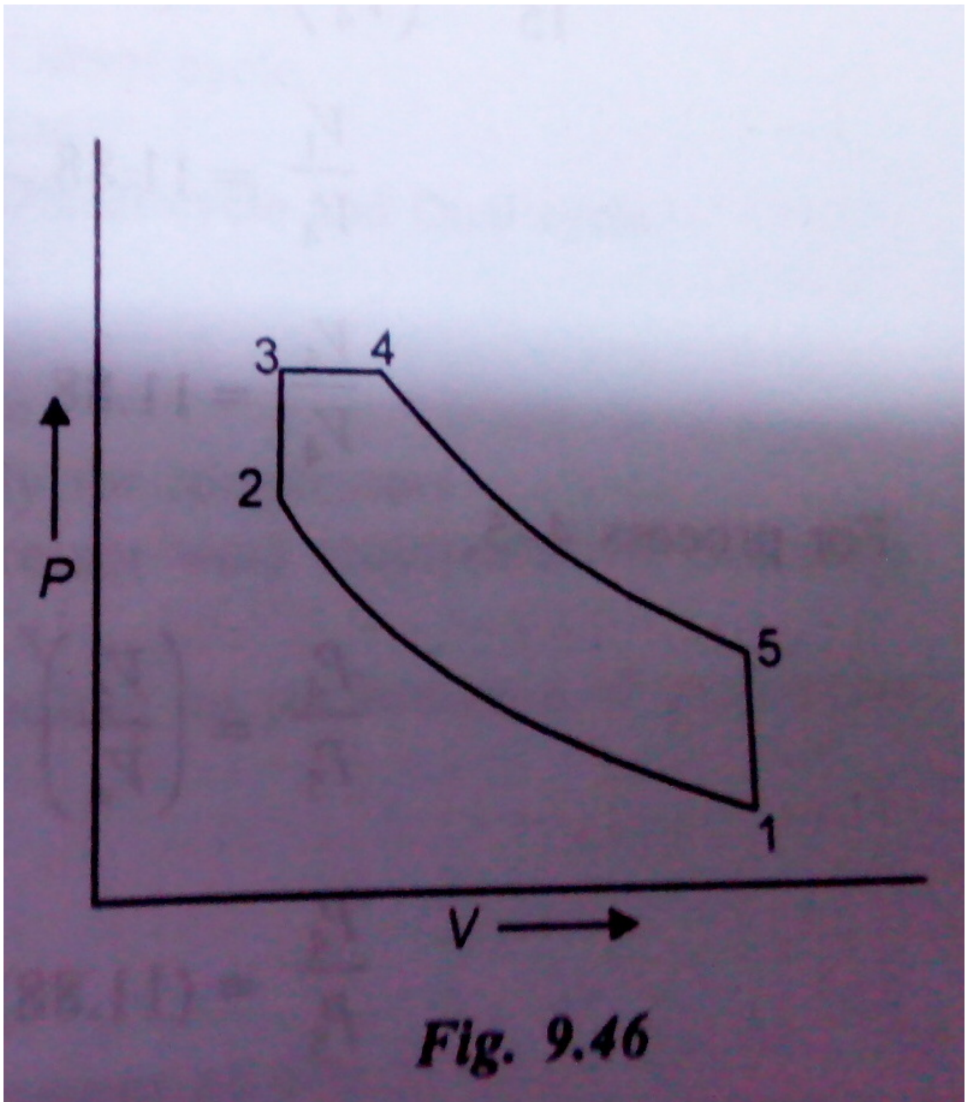


Figure 9.17: Engineering Thermodynamics by Onkar Singh Chapter 9 Example 16

```
disp("for process 1-2;")
disp("T2/T1=(P2/P1)^((y-1)/y)")
disp("T2/T1=(V1/V2)^(y-1)")
disp("so T2=T1*(V1/V2)^(y-1) in K")
T2=T1*(r)^(y-1)
disp("and (P2/P1)=(V1/V2)^y")
disp("so P2=P1*(V1/V2)^y in Pa...........eq3")
disp("for process 2-3,")
disp("P2/P3=T2/T3")
disp("so T3=T2*P3/P2")
disp("using eq 1 and 3,we get")
disp("T3=T2*k/r^y in K")
T3=T2*k/r^y
disp("using equal heat additions for processes 2-3 and 3-4,")
disp("(T3-T2)=y*(T4-T3)")
disp("so T4=T3+((T3-T2)/y) in K")
T4=T3+((T3-T2)/y)
disp("for process 3-4,")
disp("V3/V4=T3/T4")
disp("(V3/V1)*(V1/V4)=T3/T4")
disp("so (V1/V4)=(T3/T4)*r")
(T3/T4)*r
disp("so V1/V4=11.88 and V5/V4=11.88")
disp("for process 4-5,")
disp("P4/P5=(V5/V4)^y,or T4/T5=(V5/V4)^(y-1)")
disp("so T5=T4/((V5/V4)^(y-1))")
T5=T4/(11.88)^(y-1)
disp("air standard thermal efficiency(n)=1-(heat rejected/heat added)")
disp("n=1-(m*Cv*(T5-T1)/(m*Cp*(T4-T3)+m*Cv*(T3-T2)))")
disp("n=1-((T5-T1)/(y*(T4-T3)+(T3-T2)))")
n=1-((T5-T1)/(y*(T4-T3)+(T3-T2)))
disp("air standard thermal efficiency=0.6529")
disp("in percentage")
n=n*100
disp("so air standard thermal efficiency=65.29%")
```

```
disp("Actual thermal efficiency may be different from theoretical efficiency due to following reasons")
disp("a> Air standard cycle analysis considers air as the working fluid while in actual cycle it is not air throughtout the cycle.Actual working fluid which are combustion products do not behave as perfect gas.")
disp("b> Heat addition does not occur isochorically in actual process.Also combustion is accompanied by inefficiency such as incomplete combustion, dissociation of combustion products,etc.")
disp("c> Specific heat variation occurs in actual processes where as in air standard cycle analysis specific heat variation neglected.Also during adiabatic process theoretically no heat loss occur while actually these processes are accompanied by heat losses.")
```

Chapter 10

Introduction To Internal Combustion Engines

Scilab code Exa 10.1 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 1")
k=20*10^6;//spring constant in N/m^2
N=2000;//engine rpm
disp("from stroke to bore ratio i.e L/D=1.2 and
   cylinder diameter=bore,i.e D=12 cm")
D=12*10^-2;//cylinder diameter in m
disp("stroke(L)=1.2*D in m")
L=1.2*D
disp("Area of indicator diagram(A)=30*10^-4 m^2")
A=30*10^-4;
disp("length of indicator diagram(l)=(1/2)*L in m")
```

```
l=(1/2)*L
disp("mean effective pressure(mep)=A*k/l in N/m^2")
mep=A*k/l
disp("cross-section area of piston(Ap)=%pi*D^2/4 in
    m^2")
Ap=%pi*D^2/4
disp("for one cylinder indicated power(IP)=mep*Ap*L*
    N/(2*60) in W")
IP=mep*Ap*L*N/(2*60)
disp("for four cylinder total indicated power(IP)=4*
    IP in W")
IP=4*IP
disp("frictional power loss(FP)=0.10*IP in W")
FP=0.10*IP
disp("brake power available(BP)=indicated power-
    frictional power=IP-FP in W")
BP=IP-FP
disp("therefore,mechanical efficiency of engine(n)=
    brake power/indicated power=BP/IP")
n=BP/IP
disp("in percentage")
n=n*100
disp("so indicated power=90477.8 W")
disp("and mechanical efficiency=90%")
```

Scilab code Exa 10.2 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
```

```
   Chapter 10 Example 2")
A=40*10^-4;//area of indicator diagram in m^2
l=8*10^-2;//length of indicator diagram in m
D=15*10^-2;//bore of cylinder in m
L=20*10^-2;//stroke in m
k=1.5*10^8;//spring constant in pa/m
N=100;//pump motor rpm
disp("reciprocating pump is work absorbing machine
   having its mechanism similar to the piston-
   cylinder arrangement in IC engine.")
disp("mean effective pressure(mep)=A*k/l in pa")
mep=A*k/l
disp("indicator power(IP)=Ap*L*mep*N*1*2/60 in W")
disp("(it is double acting so let us assume total
   power to be double of that in single acting)")
Ap=%pi*D^2/4
IP=Ap*L*mep*N*2/60
disp("so power required to drive=88.36 KW")
```

Scilab code Exa 10.3 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 3")
n=0.9;//mechanical efficiency of engine
BP=38;//brake power in KW
disp("indicated power(IP)=brake power/mechanical
   efficiency=BP/n in KW")
IP=BP/n
```

```
disp("frictional power loss(FP)=IP-BP in KW")
FP=IP-BP
disp("brake power at quater load(BPq)=0.25*BP in KW"
  )
BPq=0.25*BP
disp("mechanical efficiency(n1)=BPq/IP")
IP=BPq+FP;
n1=BPq/IP
disp("in percentage")
n1=n1*100
disp("so indicated power=42.22 KW")
disp("frictional power loss=4.22 KW")
disp("mechanical efficiency=69.24%")
```

Scilab code Exa 10.4 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
  Chapter 10 Example 4")
m=0.25;//specific fuel consumption in kg/KWh
Pb_mep=1.5*1000;//brake mean effective pressure of
  each cylinder in Kpa
N=100;//engine rpm
D=85*10^-2;//bore of cylinder in m
L=220*10^-2;//stroke in m
C=43*10^3;//calorific value of diesel in KJ/kg
disp("brake power of engine(BP)=Pb_mep*L*A*N/60 in
  MW")
A=%pi*D^2/4;
```

```
BP=Pb_mep*L*A*N/60
disp("so brake power is 3.121 MW")
disp("The fuel consumption in kg/hr(m)=m*BP in kg/hr")
m=m*BP
disp("In order to find out brake thermal efficiency the heat input from fuel per second is required.")
disp("heat from fuel(Q)in KJ/s")
disp("Q=m*C/3600")
Q=m*C/3600
disp("energy to brake power=3120.97 KW")
disp("brake thermal efficiency(n)=BP/Q")
n=BP/Q
disp("in percentage")
n=n*100
disp("so fuel consumption=780.24 kg/hr,brake thermal efficiency=33.49%")
disp("NOTE=>In book,it is given that brake power in MW is 31.21 but in actual it is 3120.97 KW or 3.121 MW which is corrected above.")
```

Scilab code Exa 10.5 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 10 Example 5")
Pb_mep=6*10^5;//brake mean effective pressure in pa
N=600;//engine rpm
```

```
m=0.25;//specific fuel consumption in kg/KWh
D=20*10^-2;//bore of cylinder in m
L=30*10^-2;//stroke in m
k=26;//air to fuel ratio
C=43*10^3;//calorific value in KJ/kg
R=0.287;//gas constant in KJ/kg K
T=(27+273);//ambient temperature in K
P=1*10^2;//ambient pressure in Kpa
disp("brake thermal efficiency(n)=3600/(m*C)")
n=3600/(m*C)
disp("in percentage")
n=n*100
disp("brake power(BP)in KW")
disp("BP=4*Pb_mep*L*A*N/60000")
A=%pi*D^2/4;
BP=4*Pb_mep*L*A*N/60000
disp("brake specific fuel consumption,m=mf/BP")
disp("so mf=m*BP in kg/hr")
mf=m*BP
disp("air consumption(ma)from given air fuel ratio=k*mf in kg/hr")
ma=k*mf
disp("ma in kg/min")
ma=ma/60
disp("using perfect gas equation,")
disp("P*Va=ma*R*T")
disp("sa Va=ma*R*T/P in m^3/min")
Va=ma*R*T/P
disp("swept volume(Vs)=%pi*D^2*L/4 in m^3")
Vs=%pi*D^2*L/4
disp("volumetric efficiency,n_vol=Va/(Vs*(N/2)*no.of cylinder)")
n_vol=Va/(Vs*(N/2)*4)
disp("in percentage")
n_vol=n_vol*100
disp("NOTE=>In this question,while calculating swept volume in book,values of D=0.30 m and L=0.4 m is taken which is wrong.Hence above solution is
```

```
solve taking right values given in book which is
D=0.20 m and L=0.3 m, so the volumetric efficiency
 vary accordingly.")
```

Scilab code Exa 10.6 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 6")
N=3000;//engine rpm
m=5;//fuel consumption in litre/hr
r=19;//air-fuel ratio
sg=0.7;//specific gravity of fuel
V=500;//piston speed in m/min
P_imep=6*10^5;//indicated mean effective pressure in
    pa
P=1.013*10^5;//ambient pressure in pa
T=(15+273);//ambient temperature in K
n_vol=0.7;//volumetric efficiency
n_mech=0.8;//mechanical efficiency
R=0.287;//gas constant for gas in KJ/kg K
disp("let the bore diameter be (D) m")
disp("piston speed(V)=2*L*N")
disp("so L=V/(2*N) in m")
L=V/(2*N)
L=0.0833;//approx.
disp("volumetric efficiency,n_vol=air sucked/(swept
   volume * no. of cylinder)")
disp("so air sucked/D^2=n_vol*(%pi*L/4)*N*2 in m^3/
```

```
min")
n_vol*(%pi*L/4)*N*2
disp("so air sucked =274.78*D^2 m^3/min")
disp("air requirement(ma),kg/min=A/F ratio*fuel consumption per min")
disp("so ma=r*m in kg/min")
ma=r*m*sg/60
disp("using perfect gas equation,P*Va=ma*R*T")
disp("so Va=ma*R*T/P in m^3/min")
Va=ma*R*T*1000/P
disp("ideally,air sucked=Va")
disp("so 274.78*D^2=0.906")
disp("D=sqrt(0.906/274.78) in m")
D=sqrt(0.906/274.78)
disp("indicated power(IP)=P_imep*L*A*N*no.of cylinders in KW")
IP=P_imep*L*(%pi*D^2/4)*(N/60)*2/1000
disp("brake power=indicated power*mechanical efficiency")
disp("BP=IP*n_mech in KW")
BP=IP*n_mech
disp("so brake power=10.34 KW")
```

Scilab code Exa 10.7 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 10 Example 7")
M=20;//load on dynamometer in kg
```

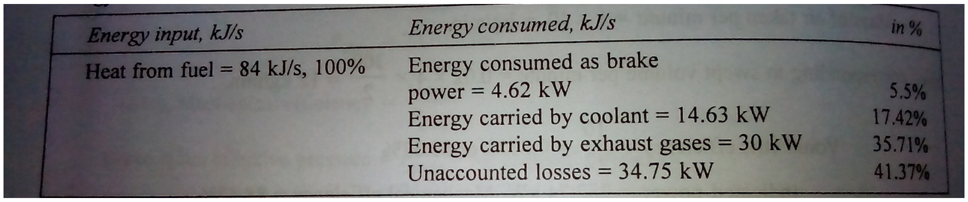
```
r=50*10^-2;//radius in m
N=3000;//speed of rotation in rpm
D=20*10^-2;//bore in m
L=30*10^-2;//stroke in m
m=0.15;//fuel supplying rate in kg/min
C=43;//calorific value of fuel in MJ/kg
FP=5;//friction power in KW
g=9.81;//acceleration due to gravity in m/s^2
disp("After switching off fuel supply the capacity of motor required to run engine will be the friction power required at this speed of engine.")
disp("friction power(FP)=5 KW")
disp("brake power(BP)=2*%pi*N*T in KW")
BP=2*%pi*N*(M*g*r)*10^-3/60
disp("indicated power(IP)=brake power(BP)+friction power(FP)in KW")
IP=BP+FP
disp("mechanical efficiency(n_mech)=BP/IP")
n_mech=BP/IP
disp("in percentage")
n_mech=n_mech*100
disp("brake specific fuel consumption(bsfc)=specific fuel consumption/brake power in kg/KW hr")
bsfc=m*60/BP
disp("brake thermal efficiency(n_bte)=3600/(brake specific fuel consumption*calorific value)")
n_bte=3600/(bsfc*C*1000)
disp("in percentage")
n_bte=n_bte*100
disp("also,mechanical efficiency(n_mech)=brake thermal efficiency/indicated thermal efficiency")
disp("indicated thermal efficiency(n_ite)=n_bte/n_mech")
n_ite=n_bte/n_mech
disp("in percentage")
n_ite=n_ite*100
disp("indicated power(IP)=P_imep*L*A*N")
```

```
disp("so P_imep=IP/(L*(%pi*D^2/4)*N)in Kpa")
P_imep=IP/(L*(%pi*D^2/4)*N/60)
disp("Also,mechanical efficiency=P_bmep/P_imep")
disp("so P_bmep=P_imep*n_mech in Kpa")
n_mech=0.8604;//mechanical efficiency
P_bmep=P_imep*n_mech
disp("brake power=30.82 KW")
disp("indicated power=35.82 KW")
disp("mechanical efficiency=86.04%")
disp("brake thermal efficiency=28.67%")
disp("indicated thermal efficiency=33.32%")
disp("brake mean effective pressure=65.39 Kpa")
disp("indicated mean effective pressure=76.01 Kpa")
```

Scilab code Exa 10.8 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 8")
N=300;//engine rpm
BP=250;//brake power in KW
D=30*10^-2;//bore in m
L=25*10^-2;//stroke in m
m=1;//fuel consumption in kg/min
r=10;//airfuel ratio
P_imep=0.8;//indicated mean effective pressure in pa
C=43*10^3;//calorific value of fuel in KJ/kg
P=1.013*10^5;//ambient pressure in K
R=0.287;//gas constant in KJ/kg K
```

```
T=(27+273);//ambient temperature in K
disp("indicated power(IP)=P_imep*L*A*N*4/60 in KW")
IP=P_imep*L*(%pi*D^2/4)*N*4*10^3/60
disp("mechanical efficiency(n_mech)=brake power/
    indicated power")
disp("so n_mech=BP/IP")
n_mech=BP/IP
disp("in percentage ")
n_mech=n_mech*100
disp("brake specific fuel consumption(bsfc)=m*60/BP
    in kg/KW hr")
bsfc=m*60/BP
disp("brake thermal efficiency(n_bte)=3600/(bsfc*C)"
    )
n_bte=3600/(bsfc*C)
disp("in percentage")
n_bte=n_bte*100
disp("swept volume(Vs)=%pi*D^2*L/4 in m^3")
Vs=%pi*D^2*L/4
disp("mass of air corresponding to above swept
    volume,using perfect gas equation")
disp("P*Vs=ma*R*T")
disp("so ma=(P*Vs)/(R*T) in kg")
ma=(P*Vs)/(R*T*1000)
ma=0.02;//approx.
disp("volumetric effeciency(n_vol)=mass of air taken
     per minute/mass corresponding to swept volume
    per minute")
disp("so mass of air taken per minute in kg/min ")
1*10
disp("mass corresponding to swept volume per minute
    in kg/min")
ma*4*N/2
disp("so volumetric efficiency ")
10/12
disp("in percentage")
(10/12)*100
disp("so indicated power =282.74 KW,mechanical
```



Energy input, kJ/s	Energy consumed, kJ/s	in %
Heat from fuel = 84 kJ/s, 100%	Energy consumed as brake power = 4.62 kW	5.5%
	Energy carried by coolant = 14.63 kW	17.42%
	Energy carried by exhaust gases = 30 kW	35.71%
	Unaccounted losses = 34.75 kW	41.37%

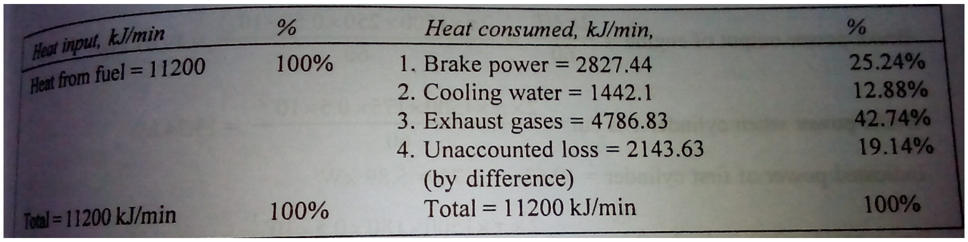
Figure 10.1: Engineering Thermodynamics by Onkar Singh Chapter 10 Example 9

```
   efficiency=88.42%")
disp("brake thermal efficiency=34.88%,volumetric
   efficiency=83.33%")
```

Scilab code Exa 10.9 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 9")
h=10;//height of indicator diagram in mm
k=25;//indicator constant in KN/m^2 per mm
N=300;//engine rpm
Vs=1.5*10^-2;//swept volume in m^3
M=60;//effective brake load upon dynamometer in kg
r=50*10^-2;//effective brake drum radius in m
m=0.12;//fuel consumption in kg/min
C=42*10^3;//calorific value in KJ/kg
mw=6;//circulating water rate in kg/min
```

```
T1=35;//cooling water entering temperature in degree celcius
T2=70;//cooling water leaving temperature in degree celcius
Eg=30;//exhaust gases leaving energy in KJ/s
Cw=4.18;//specific heat of water in KJ/kg K
g=9.81;//accelaration due to gravity in m/s^2
disp("indicated mean effective pressure(P_imeb)=h*k in Kpa")
P_imeb=h*k
disp("indicated power(IP)=P_imeb*L*A*N/2 in KW")
IP=P_imeb*Vs*N/(2*60)
disp("brake power(BP)=2*%pi*N*T in KW")
BP=2*%pi*N*(M*g*r*10^-3)/(2*60)
disp("mechanical efficiency(n_mech)=BP/IP")
n_mech=BP/IP
disp("in percentage")
n_mech=n_mech*100
disp("so indicated power=9.375 KW")
disp("brake power=4.62 KW")
disp("mechanical efficiency=49.28%")
disp("energy liberated from fuel(Ef)=C*m/60 in KJ/s")
Ef=C*m/60
disp("energy available as brake power(BP)=4.62 KW")
disp("energy to coolant(Ec)=(mw/M)*Cw*(T2-T1) in KW")
Ec=(mw/M)*Cw*(T2-T1)
disp("energy carried by exhaust gases(Eg)=30 KJ/s")
disp("unaccounted energy loss=Ef-BP-Ec-Eg in KW")
Ef-BP-Ec-Eg
disp("NOTE=>overall energy balance sheet is attached as jpg file with this code.")
```



Heat input, kJ/min	%	Heat consumed, kJ/min,	%
Heat from fuel = 11200	100%	1. Brake power = 2827.44	25.24%
		2. Cooling water = 1442.1	12.88%
		3. Exhaust gases = 4786.83	42.74%
		4. Unaccounted loss = 2143.63 (by difference)	19.14%
Total = 11200 kJ/min	100%	Total = 11200 kJ/min	100%

Figure 10.2: Engineering Thermodynamics by Onkar Singh Chapter 10 Example 10

Scilab code Exa 10.10 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 10")
m=4;//mass of fuel consumed in kg
N=1500;//engine rpm
mw=15;//water circulation rate in kg/min
T1=27;//cooling water inlet temperature in degree
   celcius
T2=50;//cooling water outlet temperature in degree
   celcius
ma=150;//mass of air consumed in kg
T_exhaust=400;//exhaust temperature in degree
   celcius
T_atm=27;//atmospheric temperature in degree celcius
Cg=1.25;//mean specific heat of exhaust gases in KJ/
   kg K
n_mech=0.9;//mechanical efficiency
T=300*10^-3;//brake torque in N
C=42*10^3;//calorific value in KJ/kg
```

```
Cw=4.18;//specific heat of water in KJ/kg K
disp("brake power(BP)=2*%pi*N*T in KW")
BP=2*%pi*N*T/60
disp("so brake power=47.124 KW")
disp("brake specific fuel consumption(bsfc)=m*60/(mw
   *BP) in kg/KW hr")
bsfc=m*60/(mw*BP)
disp("indicated power(IP)=BP/n_mech in Kw")
IP=BP/n_mech
disp("indicated  thermal efficiency(n_ite)=IP*mw
   *60/(m*C)")
n_ite=IP*mw*60/(m*C)
disp("in percentage")
n_ite=n_ite*100
disp("so indicated thermal efficiency=28.05%")
disp("heat available from fuel(Qf)=(m/mw)*C in KJ/
   min")
Qf=(m/mw)*C
disp("energy consumed as brake power(BP)=BP*60 in KJ
   /min")
BP=BP*60
disp("energy carried by cooling water(Qw)=mw*Cw*(T2-
   T1)in KJ/min")
Qw=mw*Cw*(T2-T1)
disp("energy carried by exhaust gases(Qg)=(ma+m)*Qg
   *(T_exhaust-T_atm)/mw in KJ/min")
Qg=(ma+m)*Cg*(T_exhaust-T_atm)/mw
disp("unaccounted energy loss in KJ/min")
Qf-(BP+Qw+Qg)
disp("NOTE=>Heat balance sheet on per minute basis
   is attached as jpg file with this code.")
```

No. of cylinders cut	Brake power, kW
1	40.1
2	39.5
3	39.1
4	39.6
5	39.8
6	40

Figure 10.3: Engineering Thermodynamics by Onkar Singh Chapter 10 Example 11

Scilab code Exa 10.11 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 10 Example 11")
BP=50;//brake power output at full load in KW
BP1=40.1;//brake power output of 1st cylinder in KW
BP2=39.5;//brake power output of 2nd cylinder in KW
BP3=39.1;//brake power output of 3rd cylinder in KW
BP4=39.6;//brake power output of 4th cylinder in KW
BP5=39.8;//brake power output of 5th cylinder in KW
BP6=40;//brake power output of 6th cylinder in KW
disp("indicated power of 1st cylinder=BP-BP1 in KW")
BP-BP1
disp("indicated power of 2nd cylinder=BP-BP2 in KW")
BP-BP2
disp("indicated power of 3rd cylinder=BP-BP3 in KW")
```

Heat balance sheet on per minute basis

Energy in, kJ/min	%	*Energy out, kJ/min,*	%
Heat released by fuel = 8127	100%	(a) Brake power = 1177.8 (b) Exhaust gases = 1436.02 (c) Cooling water = 1730.52 (d) Unaccounted = 3782.66 (by difference)	14.50 17.67 21.29 40.54
Total = 8127, kJ/min	100%	Total = 8127 kJ/min	100%

Figure 10.4: Engineering Thermodynamics by Onkar Singh Chapter 10 Example 12

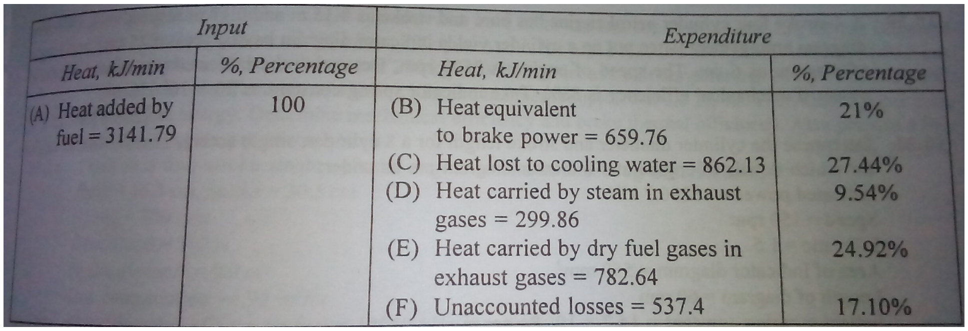
```
BP-BP3
disp("indicated power of 4th cylinder=BP-BP4 in KW")
BP-BP4
disp("indicated power of 5th cylinder=BP-BP5 in KW")
BP-BP5
disp("indicated power of 6th cylinder=BP-BP6 in KW")
BP-BP6
disp(" total indicated power(IP)in KW")
IP=9.9+10.5+10.9+10.4+10.2+10
disp("mechanical efficiency(n_mech)=BP/IP")
n_mech=BP/IP
disp("in percentage")
n_mech=n_mech*100
disp("so indicated power=61.9 KW")
disp("mechanical efficiency=80.77%")
```

Scilab code Exa 10.12 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 12")
N=1500;//engine rpm at full load
F=250;//brake load at full load in N
F1=175;//brake reading 1 in N
F2=180;//brake reading 2 in N
F3=182;//brake reading 3 in N
F4=170;//brake reading 4 in N
r=50*10^-2;//brake drum radius in m
m=0.189;//fuel consumption rate in kg/min
C=43*10^3;//fuel calorific value in KJ/kg
k=12;//air to fuel ratio
T_exhaust=600;//exhaust gas temperature in degree
   celcius
mw=18;//cooling water flow rate in kg/min
T1=27;//cooling water entering temperature in degree
    celcius
T2=50;//cooling water leaving temperature in degree
   celcius
T_atm=27;//atmospheric air temperature
Cg=1.02;//specific heat of exhaust gas in KJ/kg K
Cw=4.18;//specific heat of water in KJ/kg K
disp("brake power output of engine(BP)=2*%pi*N*T/60
   in KW")
BP=2*%pi*N*F*r*10^-3/60
disp("brake power when cylinder 1 is cut(BP1)=2*%pi*
   N*T/60 in KW")
BP1=2*%pi*N*F1*r*10^-3/60
disp("so indicated power of first cylinder(IP1)=BP-
   BP1 in KW")
IP1=BP-BP1
disp("brake power when cylinder 2 is cut(BP2)=2*%pi*
   N*T/60 in KW")
BP2=2*%pi*N*F2*r*10^-3/60
disp("so indicated power of second cylinder(IP2)=BP-
```

```
BP2 in KW")
IP2=BP-BP2
disp("brake power when cylinder 3 is cut(BP3)=2*%pi*N*T/60 in KW")
BP3=2*%pi*N*F3*r*10^-3/60
disp("so indicated power of third cylinder(IP3)=BP-BP3 in KW")
IP3=BP-BP3
disp("brake power when cylinder 4 is cut(BP4)=2*%pi*N*T/60 in KW")
BP4=2*%pi*N*F4*r*10^-3/60
disp("so indicated power of fourth cylinder(IP4)=BP-BP4 in KW")
IP4=BP-BP4
disp("now total indicated power(IP) in KW")
IP=IP1+IP2+IP3+IP4
disp("engine mechanical efficiency(n_mech)=BP/IP")
n_mech=BP/IP
disp("in percentage")
n_mech=n_mech*100
disp("so BP=19.63 KW,IP=23 KW,n_mech=83.35%")
disp("heat liberated by fuel(Qf)=m*C in KJ/min")
Qf=m*C
disp("heat carried by exhaust gases(Qg)=(k+1)*m*Cg*(T_exhaust-T_atm) in KJ/min")
Qg=(k+1)*m*Cg*(T_exhaust-T_atm)
disp("heat carried by cooling water(Qw)=mw*Cw*(T2-T1) in KJ/min")
Qw=mw*Cw*(T2-T1)
disp("energy to brake power(BP)=BP*60 in KJ/min")
BP=BP*60
disp("unaccounted losses in KJ/min")
Qf-(Qg+Qw+BP)
disp("NOTE=>Heat balance sheet on per minute basis is attached as jpg file with this code. ")
```



Input		Expenditure	
Heat, kJ/min	%, Percentage	Heat, kJ/min	%, Percentage
(A) Heat added by fuel = 3141.79	100	(B) Heat equivalent to brake power = 659.76	21%
		(C) Heat lost to cooling water = 862.13	27.44%
		(D) Heat carried by steam in exhaust gases = 299.86	9.54%
		(E) Heat carried by dry fuel gases in exhaust gases = 782.64	24.92%
		(F) Unaccounted losses = 537.4	17.10%

Figure 10.5: Engineering Thermodynamics by Onkar Singh Chapter 10 Example 13

Scilab code Exa 10.13 Engineering Thermodynamics by Onkar Singh Chapter 10 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 10 Example 13")
D=20*10^-2;//cylinder diameter in m
L=28*10^-2;//stroke in m
m=4.22;//mass of fuel used in kg
C=44670;//calorific value of fuel in KJ/kg
N=21000/60;//engine rpm
mep=2.74*10^5;//mean effective pressure in pa
F=600;//net brake load applied to a drum of 100 cm
   diameter in N
r=50*10^-2;//brake drum radius in m
```

```
mw=495;//total mass of cooling water in kg
T1=13;//cooling water inlet temperature in degree celcius
T2=38;//cooling water outlet temperature in degree celcius
ma=135;//mass of air used in kg
T_air=20;//temperature of air in test room in degree celcius
T_exhaust=370;//temperature of exhaust gases in degree celcius
Cp_gases=1.005;//specific heat of gases in KJ/kg K
Cp_steam=2.093;//specific heat of steam at atmospheric pressure in KJ/kg K
Cpw=4.18;//specific heat of water in KJ/kg K
disp("brake power(BP)=2*%pi*N*T in KW")
BP=2*%pi*N*F*r/60000
disp("indicated power(IP)=(mep*L*A*N)/60000 in KW")
IP=(mep*L*(%pi*D^2/4)*N)/60000
disp("A> heat added(Q)=m*C/3600 in KJ/s")
Q=m*C/3600
disp("or Q in KJ/min")
Q=Q*60
disp("thermal efficiency(n_th)=IP/Q ")
Q=52.36;//heat added in KJ/s
n_th=IP/Q
disp("in percentage")
n_th=n_th*100
disp("B> heat equivalent of brake power(BP)=BP*60 in KJ/min ")
BP=BP*60
disp("C> heat loss to cooling water(Qw)=mw*Cpw*(T2-T1) in KJ/min")
Qw=mw*Cpw*(T2-T1)/60
disp("heat carried by exhaust gases=heat carried by steam in exhaust gases+heat carried by fuel gases(dry gases) in exhaust gases")
disp("mass of exhaust gases(mg)=mass of air+mass of fuel in kg/min")
```

```
disp("mg=(ma+m)/60")
mg=(ma+m)/60
disp("mass of steam in exhaust gases in kg/min")
9*(0.15*m/60)
disp("mass of dry exhaust gases in kg/min")
mg-0.095
disp("D> heat carried by steam in exhaust in KJ/min"
    )
0.095*{Cpw*(100-T_air)+2256.9+Cp_steam*(T_exhaust
    -100)}
disp("E> heat carried by fuel gases(dry gases) in
    exhaust gases(Qg) in KJ/min")
Qg=2.225*Cp_gases*(T_exhaust-T_air)
disp("F> unaccounted loss=A-B-C-D-E in KJ/min")
3141.79-659.76-862.13-299.86-782.64
disp("NOTE>Heat balance sheet on per minute basis is
     attached as jpg file with this code.")
```

Chapter 11

Introduction To Refrigeration And Air Conditioning

Scilab code Exa 11.1 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 11 Example 1")
T1=(-16+273);//temperature of refrigerated space in
    K
T2=(27+273);//temperature of atmosphere in K
Q1=500;//heat extracted from refrigerated space in
    KJ/min
disp("for refrigerator working on reversed carnot
    cycle.")
disp("Q1/T1=Q2/T2")
```

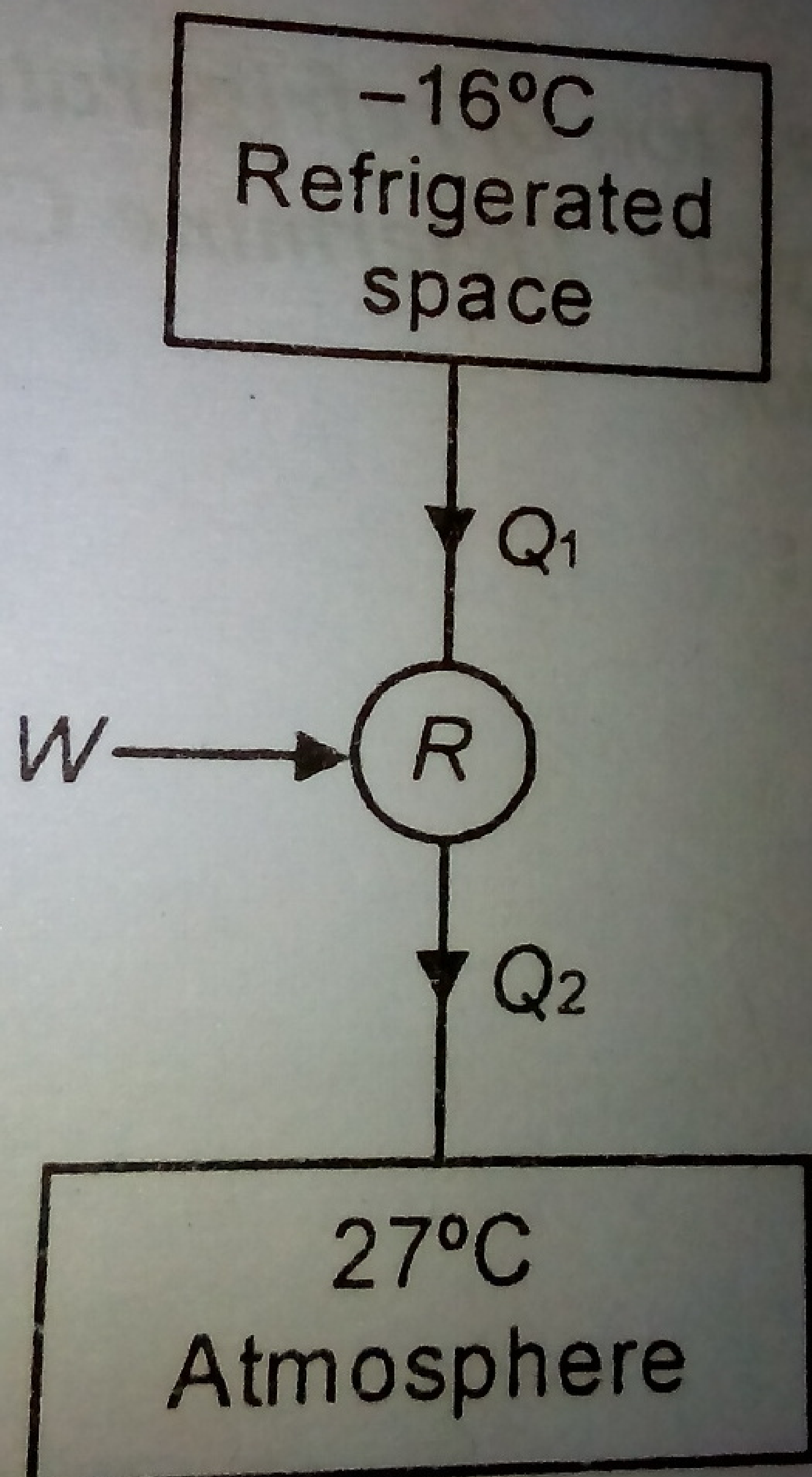


Fig 11.22

```
disp("so Q2=Q1*T2/T1 in KJ/min")
Q2=Q1*T2/T1
disp("and work input required ,W in KJ/min")
disp("W=Q2-Q1")
W=Q2-Q1
```

Scilab code Exa 11.2 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 11 Example 2")
Q=800;//refrigeration capacity in tons
Q_latent=335;//latent heat for ice formation from
    water in KJ/kg
T1=(-7+273);//temperature of reservoir 1 in K
T2=(27+273);//temperature of reservoir 2 in K
disp("refrigeration capacity or heat extraction rate
    (Q)in KJ/s")
Q=Q*3.5
disp("let the ice formation rate be m kg/s")
disp("heat to be removed from per kg of water for
    its transformation into ice(Q1)in KJ/kg.")
Q1=4.18*(27-0)+Q_latent
disp("ice formation rate(m)in kg=refrigeration
    capacity/heat removed for getting per kg of ice")
m=Q/Q1
disp("COP of refrigerator ,=T1/(T2-T1)=refrigeration
    capacity/work done")
COP=T1/(T2-T1)
```

```
disp("also COP=Q/W")
disp("so W=Q/COP in KJ/s")
W=Q/COP
disp("HP required")
W=W/0.7457
disp("NOTE=>In book,this question is solved by
   taking T1=-5 degree celcius,but according to
   question T1=-7 degree celcius so this question is
    correctly solved above by considering T1=-7
   degree celcius.")
```

Scilab code Exa 11.3 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 11 Example 3")
T1=(-27+273);//temperature of refrigerator in K
W=3*.7457;//work input in KJ/s
Q=1*3.5;//refrigeration effect in KJ/s
disp("COP=T1/(T2-T1)=Q/W")
COP=Q/W
COP=1.56;//approx.
disp("equating,COP=T1/(T2-T1)")
disp("so temperature of surrounding(T2)in K")
disp("T2=T1+(T1/COP)")
T2=T1+(T1/COP)
```

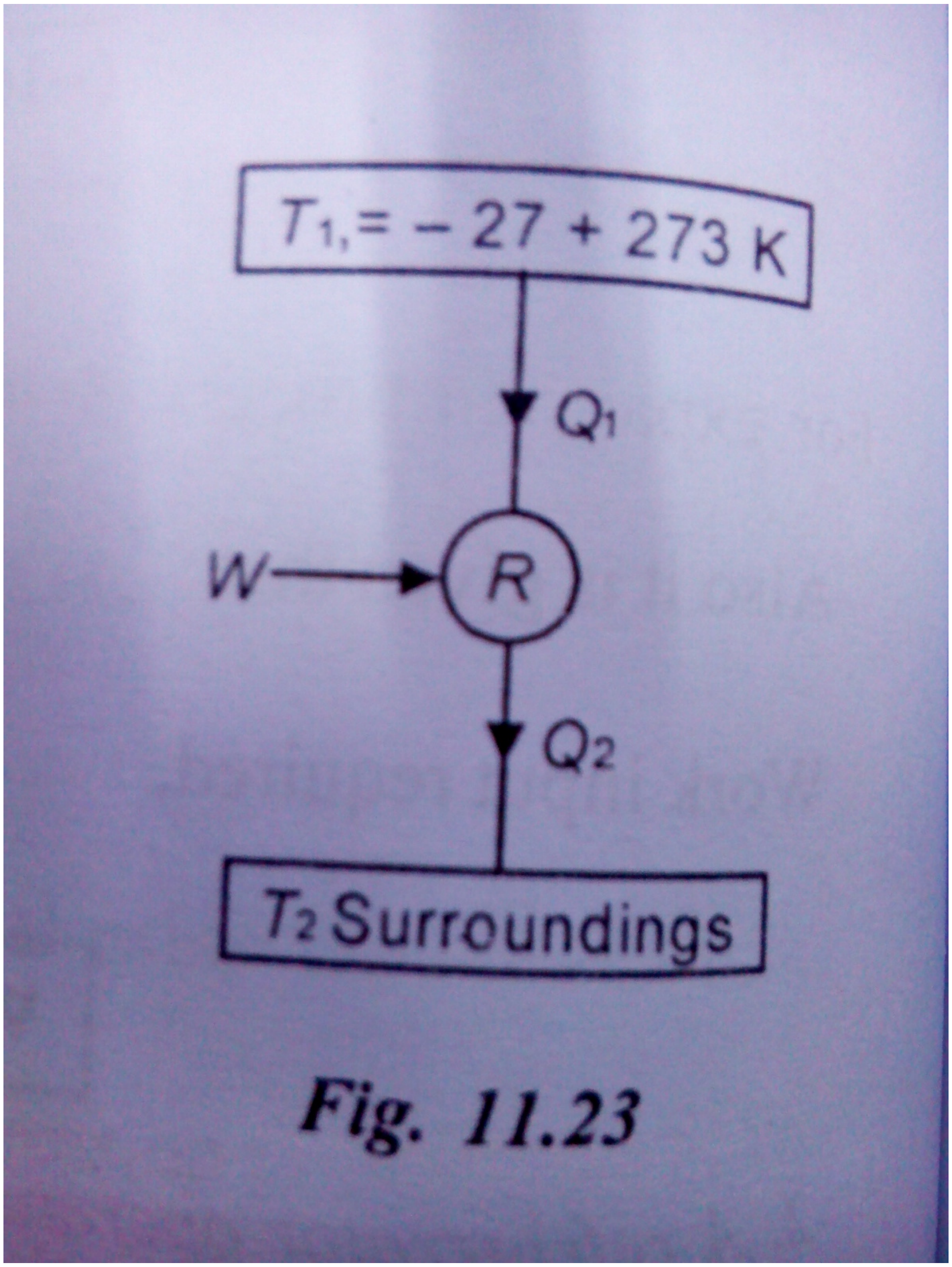


Figure 11.2: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 3

Scilab code Exa 11.4 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 11 Example 4")
T1=(-30+273);//temperature of air at beginning of
    compression in K
T3=(27+273);//temperature of air after cooling in K
r=8;//pressure ratio
Cp=1.005;//specific heat at constant pressure in KJ/
    kg K
y=1.4;//expansion constant
m=1;//air flow rate in kg/s
n1=0.85;//isentropic efficiency for compression
    process
n2=.9;//isentropic efficiency for expansion process
disp("during process 1-2_a")
disp("p2/p1=(T2_a/T1)^(y/(y-1))")
disp("so T2_a=T1*(p2/p1)^((y-1)/y)in K")
T2_a=T1*(r)^((y-1)/y)
disp("theoretical temperature after compression,T2_a
    =440.18 K")
disp("for compression  process,")
disp("n1=(T2_a-T1)/(T2-T1)")
disp("so T2=T1+(T2_a-T1)/n1 in K")
T2=T1+(T2_a-T1)/n1
```

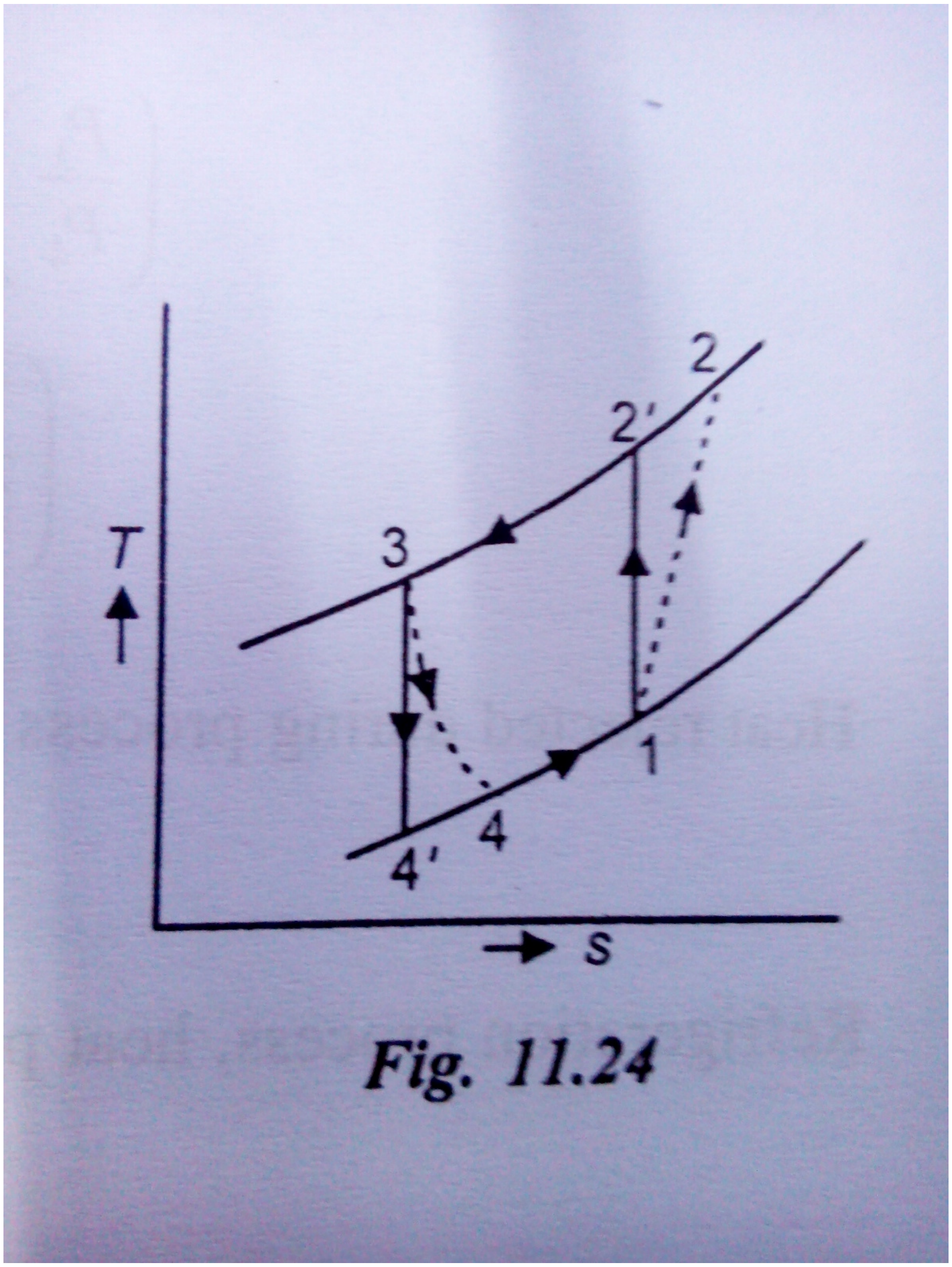


Figure 11.3: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 4

```
disp("for expansion process,3-4_a")
disp("T4_a/T3=(p1/p2)^((y-1)/y)")
disp("so T4_a=T3*(p1/p2)^((y-1)/y) in K")
T4_a=T3*(1/r)^((y-1)/y)
disp("n2=0.9=(T3-T4)/(T3-T4_a)")
disp("so T4=T3-(n2*(T3-T4_a))in K")
T4=T3-(n2*(T3-T4_a))
disp("so work during compression,W_C in KJ/s")
disp("W_C=m*Cp*(T2-T1)")
W_C=m*Cp*(T2-T1)
disp("work during expansion,W_T in KJ/s")
disp("W_T=m*Cp*(T3-T4)")
W_T=m*Cp*(T3-T4)
disp("refrigeration effect is realized during
   process,4-1.so refrigeration shall be,")
disp("Q_ref=m*Cp*(T1-T4) in KJ/s")
Q_ref=m*Cp*(T1-T4)
disp("Q_ref in ton")
Q_ref=Q_ref/3.5
disp("net work required(W)=W_C-W_T in KJ/s")
W=W_C-W_T
disp("COP=Q_ref/(W_C-W_T)")
Q_ref=64.26;
COP=Q_ref/(W_C-W_T)
disp("so refrigeration capacity=18.36 ton or 64.26
   KJ/s")
disp("and COP=0.57")
disp("NOTE=>In book this question is solve by taking
    T1=240 K which is incorrect,hence correction is
   made above according to question by taking T1=-30
    degree celcius or 243 K,so answer may vary
   slightly.")
```

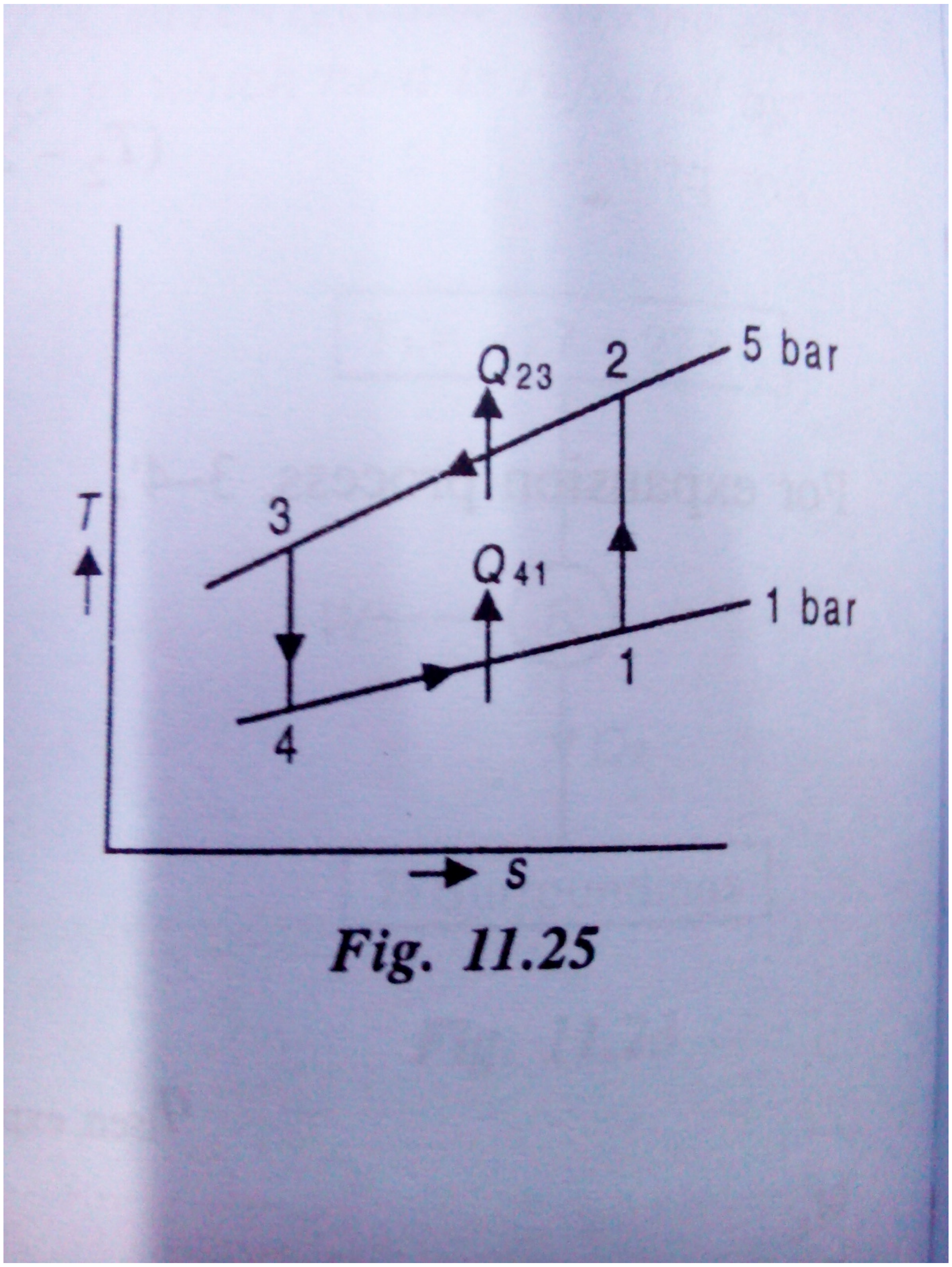


Figure 11.4: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 5

Scilab code Exa 11.5 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 11 Example 5")
T1=(7+273);//temperature of refrigerated space in K
T3=(27+273);//temperature after compression in K
p1=1*10^5;//pressure of refrigerated space in pa
p2=5*10^5;//pressure after compression in pa
y=1.4;//expansion constant
Cp=1.005;//specific heat at constant pressure in KJ/
   kg K
disp("for isentropic compression process:")
disp("(p2/p1)^((y-1)/y)=T2/T1")
disp("so T2=T1*(p2/p1)^((y-1)/y) in K")
T2=T1*(p2/p1)^((y-1)/y)
disp("for isenropic expansion process:")
disp("(p3/p4)^((y-1)/y)=(T3/T4)=(p2/p1)^((y-1)/y)")
disp("so T4=T3/(p2/p1)^((y-1)/y) in K")
T4=T3/(p2/p1)^((y-1)/y)
disp("heat rejected during process 2-3,Q23=Cp*(T2-T3
   )in KJ/kg")
Q23=Cp*(T2-T3)
disp("refrigeration process,heat picked during
   process 4-1,Q41=Cp*(T1-T4) in KJ/kg")
Q41=Cp*(T1-T4)
disp("so net work(W)=Q23-Q41 in KJ/kg")
W=Q23-Q41
disp("so COP=refrigeration effect/net work=Q41/W")
COP=Q41/W
```

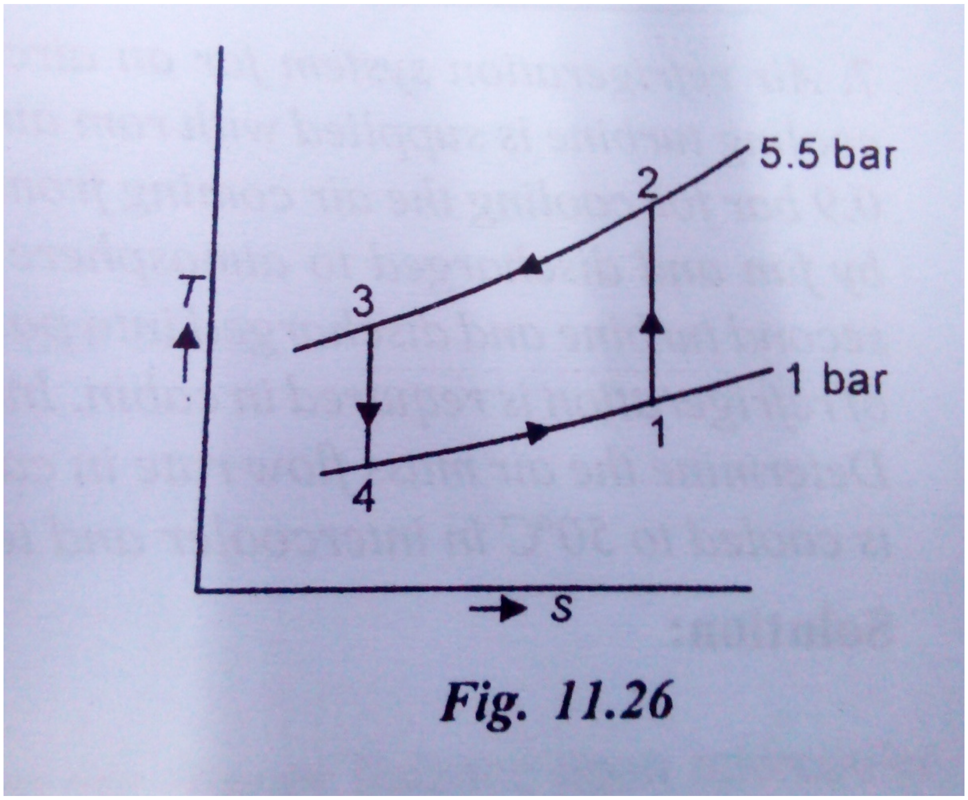


Fig. 11.26

Figure 11.5: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 6

Scilab code Exa 11.6 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
```

```
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 11 Example 6")
T1=(-10+273);//air entering temperature in K
p1=1*10^5;//air entering pressure in pa
T3=(27+273);//compressed air temperature after cooling in K
p2=5.5*10^5;//pressure after compression in pa
m=0.8;//air flow rate in kg/s
Cp=1.005;//specific heat capacity at constant pressure in KJ/kg K
y=1.4;//expansion constant
R=0.287;//gas constant in KJ/kg K
disp("for process 1-2")
disp("(p2/p1)^((y-1)/y)=T2/T1")
disp("so T2=T1*(p2/p1)^((y-1)/y) in K")
T2=T1*(p2/p1)^((y-1)/y)
disp("for process 3-4")
disp("(p3/p4)^((y-1)/y)=T3/T4")
disp("so T4=T3/(p3/p4)^((y-1)/y)=T3/(p2/p1)^((y-1)/y)in K")
T4=T3/(p2/p1)^((y-1)/y)
disp("refrigeration capacity(Q)=m*Cp*(T1-T4) in KJ/s")
Q=m*Cp*(T1-T4)
disp("Q in ton")
Q=Q/3.5
disp("work required to run compressor(w)=(m*n)*(p2*v2-p1*v1)/(n-1)")
disp("w=(m*n)*R*(T2-T1)/(n-1) in KJ/s")
n=y;
w=(m*n)*R*(T2-T1)/(n-1)
disp("HP required to run compressor")
w/0.7457
disp("so HP required to run compressor=177.86 hp")
disp("net work input(W)=m*Cp*{(T2-T3)-(T1-T4)}in KJ/s")
W=m*Cp*{(T2-T3)-(T1-T4)}
```

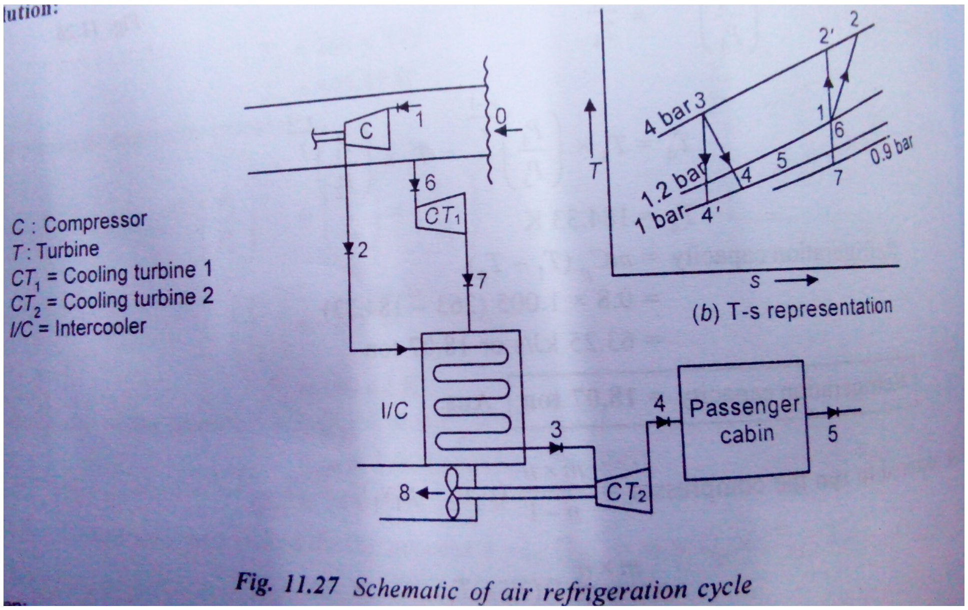


Figure 11.6: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 7

```
disp("COP=refrigeration capacity/work=Q/W")
Q=63.25;//refrigeration capacity in KJ/s
COP=Q/W
```

Scilab code Exa 11.7 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

```
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 11 Example 7")
p1=1.2*10^5;//pressure of ram air in pa
p6=p1;
T1=(15+273);//temperature of ram air in K
T6=T1;
p7=0.9*10^5;//pressure of ram air after expansion in
    pa
p3=4*10^5;//pressure of ram air after compression in
    pa
p2=p3;
p4=1*10^5;//pressure of ram air after expansion in
   second turbine in pa
T5=(25+273);//temperature of air when exhausted
   from cabin in K
T3=(50+273);//temperature of compressed air in K
T8=(30+273);//limited temperaure of ram air in K
Q=10*3.5;//refrigeration capacity in KJ/s
Cp=1.005;//specific heat capacity at constant
   pressure in KJ/kg K
disp("for process 1-2,n=1.45")
n=1.45;
disp("T2/T1=(p2/p1)^((n-1)/n)")
disp("so T2=T1*(p2/p1)^((n-1)/n) in K")
T2=T1*(p2/p1)^((n-1)/n)
disp("for process 3-4,n=1.3")
n=1.3;
disp("T4/T3=(p4/p3)^((n-1)/n)")
disp("so T4=T3*(p4/p3)^((n-1)/n)in K")
T4=T3*(p4/p3)^((n-1)/n)
disp("refrigeration effect in passenger cabin with m
    kg/s mass flow rate of air.")
disp("Q=m*Cp*(T5-T4)")
disp("m=Q/(Cp*(T5-T4))in kg/s")
m=Q/(Cp*(T5-T4))
disp("so air mass flow rate in cabin=0.55 kg/s")
disp("let the mass flow rate through intercooler be
   m1 kg/s then the energy balance upon intercooler
```

```
    yields,")
disp("m1*Cp*(T8-T7)=m*Cp*(T2-T3)")
disp("during process 6-7,T7/T6=(p7/p6)^((n-1)/n)")
disp("so T7=T6*(p7/p6)^((n-1)/n) in K")
T7=T6*(p7/p6)^((n-1)/n)
disp("substituting T2,T3,T7,T8 and m in energy
    balance on intercooler,")
disp("m1=m*(T2-T3)/(T8-T7)in kg/s")
m1=m*(T2-T3)/(T8-T7)
disp("total ram air mass flow rate=m+m1 in kg/s")
m+m1
disp("ram air mass flow rate=2.12 kg/s")
disp("work input to compressor(W)=m*Cp*(T2-T1)in KJ/
    s")
m=0.55;//approx.
W=m*Cp*(T2-T1)
disp("COP=refrigeration effect/work input=Q/W")
COP=Q/W
```

Scilab code Exa 11.8 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 11 Example 8")
po=0.9*10^5;//atmospheric air pressure in pa
To=(3+273);//temperature of atmospheric air in K
p1=1*10^5;//pressure due to ramming air in pa
```

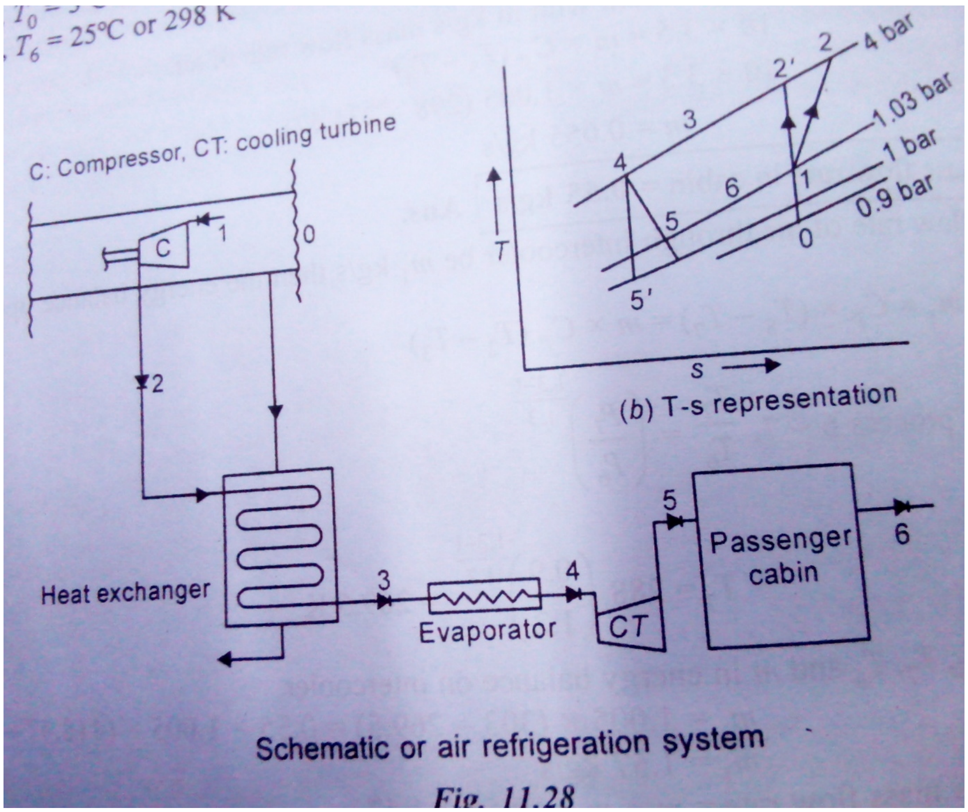


Figure 11.7: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 8

```
p2=4*10^5;//pressure when air leaves compressor in
    pa
p3=p2;
p4=p3;
p5=1.03*10^5;//pressure maintained in passenger
    cabin in pa
T6=(25+273);//temperature of air leaves cabin in K
Q=15*3.5;//refrigeration capacity of aeroplane in KJ
    /s
n1=0.9;//isentropic efficiency of compressor
n2=0.8;//isentropic efficiency of turbine
Cp=1.005;//specific heat at constant pressure in KJ/
    kg K
disp("considering index of compression and expansion
     as 1.4")
y=1.4;
disp("during ramming action,process 0-1,")
disp("T1/To=(p1/po)^((y-1)/y)")
disp("T1=To*(p1/po)^((y-1)/y)in K")
T1=To*(p1/po)^((y-1)/y)
disp("during compression process 1-2_a")
disp("T2_a/T1=(p2/p1)^((y-1)/y)")
disp("T2_a=T1*(p2/p1)^((y-1)/y)in K")
T2_a=T1*(p2/p1)^((y-1)/y)
disp("n1=(T2_a-T1)/(T2-T1)")
disp("so T2=T1+(T2_a-T1)/n1 in K")
T2=T1+(T2_a-T1)/n1
disp("In heat exchanger 66% of heat loss shall
    result in temperature at exit from heat exchanger
     to be,T3=0.34*T2 in K")
T3=0.34*T2
disp("subsequently for 10 degree celcius temperature
     drop in evaporator,")
disp("T4=T3-10 in K")
T4=T3-10
disp("expansion in cooling turbine during process
    4-5;")
disp("T5_a/T4=(p5/p4)^((y-1)/y)")
```

```
disp("T5_a=T4*(p5/p4)^((y-1)/y)in K")
T5_a=T4*(p5/p4)^((y-1)/y)
disp("n2=(T4-T5)/(T4-T5_a)")
disp("T5=T4-(T4-T5_a)*n2 in K")
T5=T4-(T4-T5_a)*n2
disp("let the mass flow rate of air through cabin be m kg/s.using refrigeration capacity heat balance yields.")
disp("Q=m*Cp*(T6-T5)")
disp("so m=Q/(Cp*(T6-T5))in kg/s")
m=Q/(Cp*(T6-T5))
disp("work input to compressor(W)=m*Cp*(T2-T1)in KJ/s")
W=m*Cp*(T2-T1)
disp("W in Hp")
W=W/.7457
disp("COP=refrigeration effect/work input=Q/W")
W=41.37;//work input to compressor in KJ/s
COP=Q/W
disp("so COP=1.27")
disp("and HP required=55.48 hp")
```

Scilab code Exa 11.9 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 9

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 11 Example 9")
```

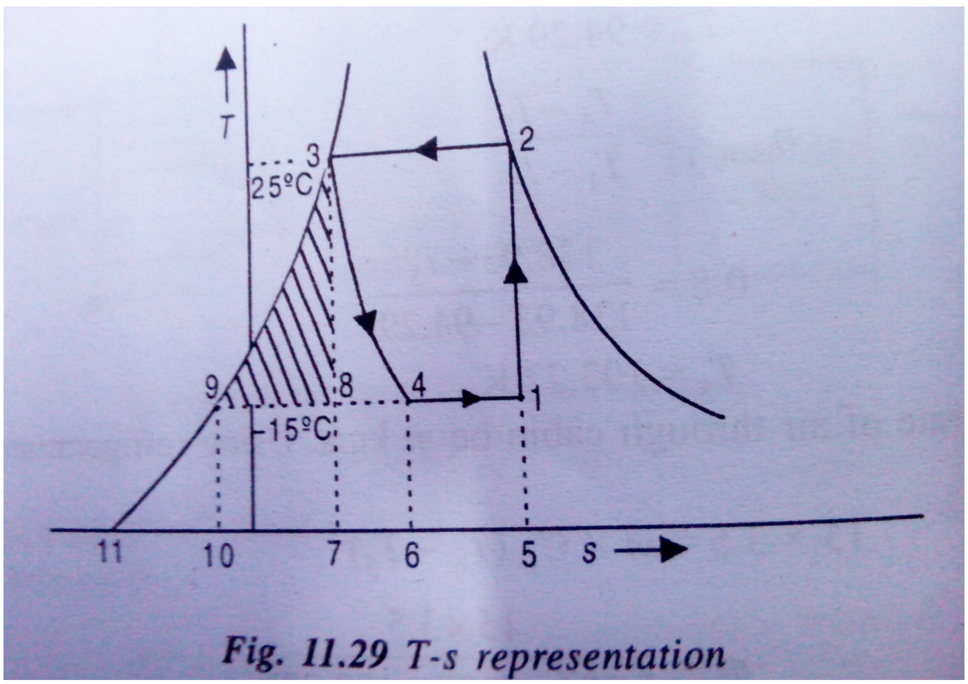


Fig. 11.29 T-s representation

Figure 11.8: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 9

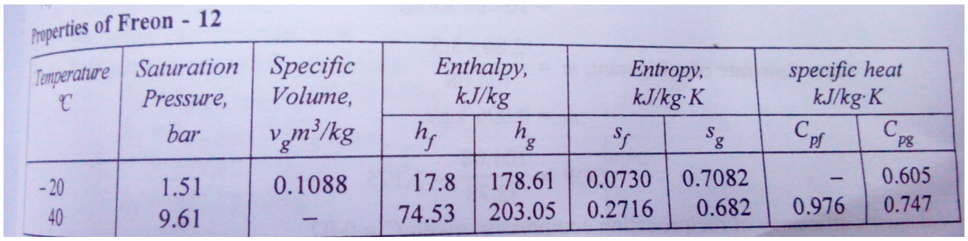
```
disp("properties of NH3,")
disp("at 15 degree celcius,h9=-54.51 KJ/kg,hg
    =1303.74 KJ/kg,s9=-0.2132 KJ/kg K,sg=5.0536 KJ/kg
    K")
T1=(-15+273);
h9=-54.51;
hg=1303.74;
s9=-0.2132;
sg=5.0536;
disp("and at 25 degree celcius,h3=99.94 KJ/kg,h2
    =1317.95 KJ/kg,s3=0.3386 KJ/kg K,s2=4.4809 KJ/kg
    K")
T2=(25+273);
h3=99.94;
h2=1317.95;
s3=0.3386;
s2=4.4809;
disp("here work done,W=Area 1-2-3-9-1")
disp("refrigeration effect=Area 1-5-6-4-1")
disp("Area 3-8-9 =(Area 3-11-7)-(Area 9-11-10)-(Area
    9-8-7-10)")
disp("so Area 3-8-9=h3-h9-T1*(s3-s9)in KJ/kg")
h3-h9-T1*(s3-s9)
disp("during throttling process between 3 and 4,h3=
    h4")
disp("(Area=3-11-7-3)=(Area 4-9-11-6-4)")
disp("(Area 3-8-9)+(Area 8-9-11-7-8)=(Area
    4-6-7-8-4)+(Area 8-9-11-7-8)")
disp("(Area 3-8-9)=(Area 4-6-7-8-4)")
disp("so (Area 4-6-7-8-4)=12.09 KJ/kg")
disp("also,(Area 4-6-7-8-4)=T1*(s4-s8)")
disp("so (s4-s8)in KJ/kg K=")
12.09/T1
disp("also s3=s8=0.3386 KJ/kg K")
s8=s3;
disp("so s4 in KJ/kg K=")
s4=s8+12.09/T1
disp("also s1=s2=4.4809 KJ/kg K")
```

```
s1=s2;
disp("refrigeration effect(Q)=Area (1-5-6-4-1)=T1*(s1-s4)in KJ/kg")
Q=T1*(s1-s4)
disp("work done(W)=Area (1-2-3-9-1)=(Area 3-8-9)+((T2-T1)*(s1-s8))in KJ/kg")
W=12.09+((T2-T1)*(s1-s8))
disp("so COP=refrigeration effect/work done=Q/W")
COP=Q/W
disp("so COP=5.94")
```

Scilab code Exa 11.10 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 11 Example 10")
Q=2.86*3.5;//refrigeration effect in KJ/s
N=1200;//compressor rpm
n=1.13;//compression index
disp("properties of Freon-12,")
disp("at -20 degree celcius,P1=1.51 bar,vg=0.1088 m^3/kg,hf=17.8 KJ/kg,h1=178.61 KJ/kg,sf=0.0730 KJ/kg K,s1=0.7082 KJ/kg K,Cpg=0.605 KJ/kg K")
P1=1.51;
T1=(-20+273);
vg=0.1088;
h1=178.61;
s1=0.7082;
s2=s1;
```

```
disp("at 40 degree celcius,P2=9.61 bar,h3=74.53 KJ/kg,hg=203.05 KJ/kg,sf=0.2716 KJ/kg K,sg=0.682 KJ/kg K,Cpf=0.976 KJ/kg K,Cpg=0.747 KJ/kg K")
P2=9.61;
h3=74.53;
h4=h3;
hg=203.05;
sf=0.2716;
sg=0.682;
Cpf=0.976;
Cpg=0.747;
disp("during expansion(throttling)between 3 and 4")
disp("h3=h4=hf_40oc=74.53 KJ/kg=h4")
disp("process 1-2 is adiabatic compression so,")
disp("s1=s2,s1=sg_-20oc=0.7082 KJ/kg K")
disp("at 40 degree celcius or 313 K,s1=sg+Cpg*log(T2/313)")
disp("T2=313*exp((s1-sg)/Cpg)in K")
T2=313*exp((s1-sg)/Cpg)
disp("so temperature after compression,T2=324.17 K")
disp("enthalpy after compression,h2=hg+Cpg*(T2-313) in KJ/kg")
h2=hg+Cpg*(T2-313)
disp("compression work required,per kg(Wc)=h2-h1 in KJ/kg")
Wc=h2-h1
disp("refrigeration effect during cycle,per kg(q)=h1-h4 in KJ/kg")
q=h1-h4
disp("mass flow rate of refrigerant,m=Q/q in kg/s")
m=Q/q
m=0.096;//approx.
disp("COP=q/Wc")
COP=q/Wc
disp("volumetric efficiency of reciprocating compressor,given C=0.02")
C=0.02;
disp("n_vol=1+C-C*(P2/P1)^(1/n)")
```



Properties of Freon - 12

Temperature °C	Saturation Pressure, bar	Specific Volume, $v_g m^3/kg$	Enthalpy, kJ/kg		Entropy, kJ/kg·K		specific heat kJ/kg·K	
			h_f	h_g	s_f	s_g	C_{pf}	C_{pg}
-20	1.51	0.1088	17.8	178.61	0.0730	0.7082	–	0.605
40	9.61	–	74.53	203.05	0.2716	0.682	0.976	0.747

Figure 11.9: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 10

```
n_vol=1+C-C*(P2/P1)^(1/n)
disp("let piston displacement by V,m^3")
disp("mass flow rate,m=(V*n_vol*N)/(60*vg_-20oc)")
disp("so V=(m*60*vg_-20oc)*10^6/(N*n_vol) in cm^3")
V=(m*60*vg)*10^6/(N*n_vol)
disp("so COP=3.175")
disp("and piston displacement=569.45 cm^3")
```

Scilab code Exa 11.11 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 11

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 11 Example 11")
Q=2;//refrigeration effect in KW
disp("properties of CO2,")
```

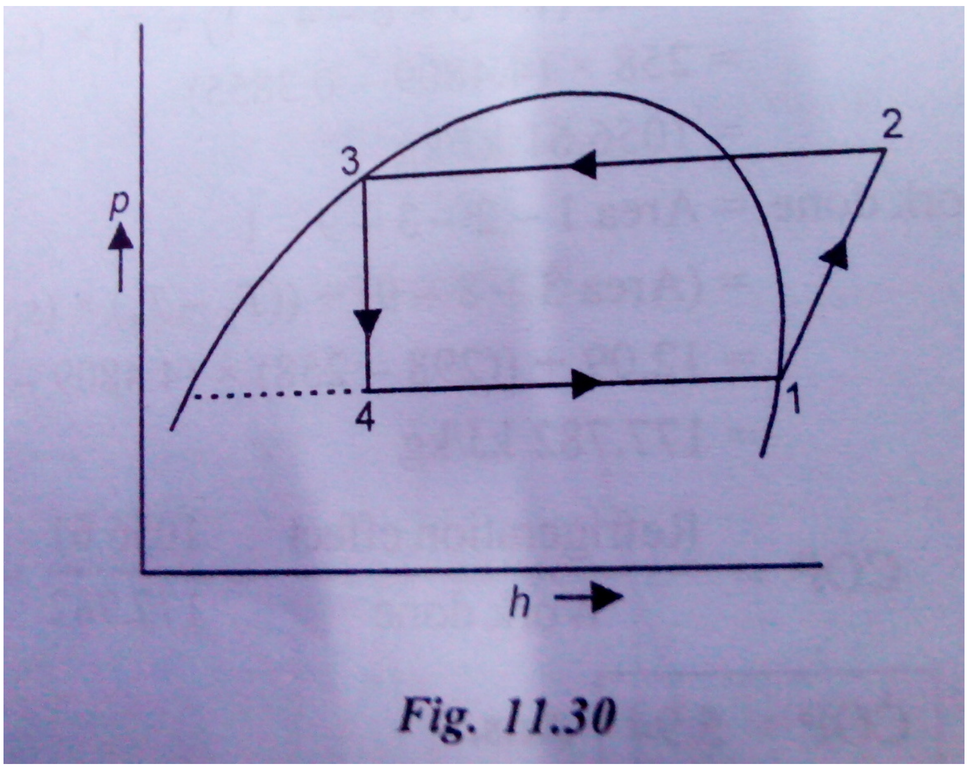


Figure 11.10: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 10

```
disp("at 20 degree celcius ,P1=57.27 bar ,hf=144.11 KJ
    /kg ,hg=299.62 KJ/kg ,sf=0.523 KJ/kg K,sg_20oc
    =1.0527 KJ/kg K,Cpf=2.889 KJ/kg K,Cpg=2.135 KJ/kg
     K")
T1=(20+273);//condensation temperature in K
P1=57.27;
h3=144.11;
hg=299.62;
sf=0.523;
sg_20oc=1.0527;
Cpf=2.889;
Cpg=2.135;
disp("at -10 degree celcius ,P2=26.49 bar ,vg=0.014 m
    ^3/kg ,hf=60.78 KJ/kg ,hg=322.28 KJ/kg ,sf=0.2381 KJ
    /kg K,sg=1.2324 KJ/kg K")
T2=(-10+273);//evaporator temperature in K
P2=26.49;
vg=0.014;
hf=60.78;
h1=322.28;
sf=0.2381;
sg=1.2324;
disp("processes of vapour compression cycle are
    shown on T-s diagram")
disp("1-2:isentropic compression process")
disp("2-3-4:condensation process")
disp("4-5:isenthalpic expansion process")
disp("5-1:refrigeration process in evaporator")
disp("h1=hg at -10oc=322.28 KJ/kg")
disp("at 20 degree celcius ,h2=hg+Cpg*(40-20)in KJ/kg
    ")
h2=hg+Cpg*(40-20)
disp("entropy at state 2,at 20 degree celcius ,s2=
    sg_20oc+Cpg*log((273+40)/(273+20))in KJ/kg K")
s2=sg_20oc+Cpg*log((273+40)/(273+20))
disp("entropy during isentropic process ,s1=s2")
disp("at -10 degree celcius ,s2=sf+x1*sfg")
disp("so x1=(s2-sf)/(sg-sf)")
```

```
x1=(s2-sf)/(sg-sf)
disp("enthalpy at state 1,at -10 degree celcius,h1=hf+x1*hfg in KJ/kg")
h1=hf+x1*(h1-hf)
disp("h3=hf at 20oc=144.11 KJ/kg")
disp("since undercooling occurs upto 10oc,so,h4=h3-Cpf*deltaT in KJ/kg")
h4=h3-Cpf*(20-10)
disp("also,h4=h5=115.22 KJ/kg")
h5=h4;
disp("refrigeration effect per kg of refrigerant(q)=(h1-h5)in KJ/kg")
q=(h1-h5)
disp("let refrigerant flow rate be m kg/s")
disp("refrigerant effect(Q)=m*q")
disp("m=Q/q in kg/s")
m=Q/q
disp("compressor work,Wc=h2-h1 in KJ/kg")
Wc=h2-h1
disp("COP=refrigeration effect per kg/compressor work per kg=q/Wc")
COP=q/Wc
disp("so COP=6.51,mass flow rate=0.01016 kg/s")
disp("NOTE=>In book,mass flow rate(m) which is 0.1016 kg/s is calculated wrong and it is correctly solve above and comes out to be m=0.01016 kg/s. ")
```

Properties of CO_2

Temperature °C	Saturation Pressure, bar	Specific Volume, v_g vm^3/kg	Enthalpy, kJ/kg		Entropy, kJ/kg·K		Specific heat kJ/kg·K	
			h_f	h_g	s_f	s_g	C_{pf}	C_{pg}
20	57.27	–	144.11	299.62	0.523	1.0527	2.889	2.135
–10	26.49	0.014	60.78	322.28	0.2381	1.2324	–	–

Figure 11.11: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 11

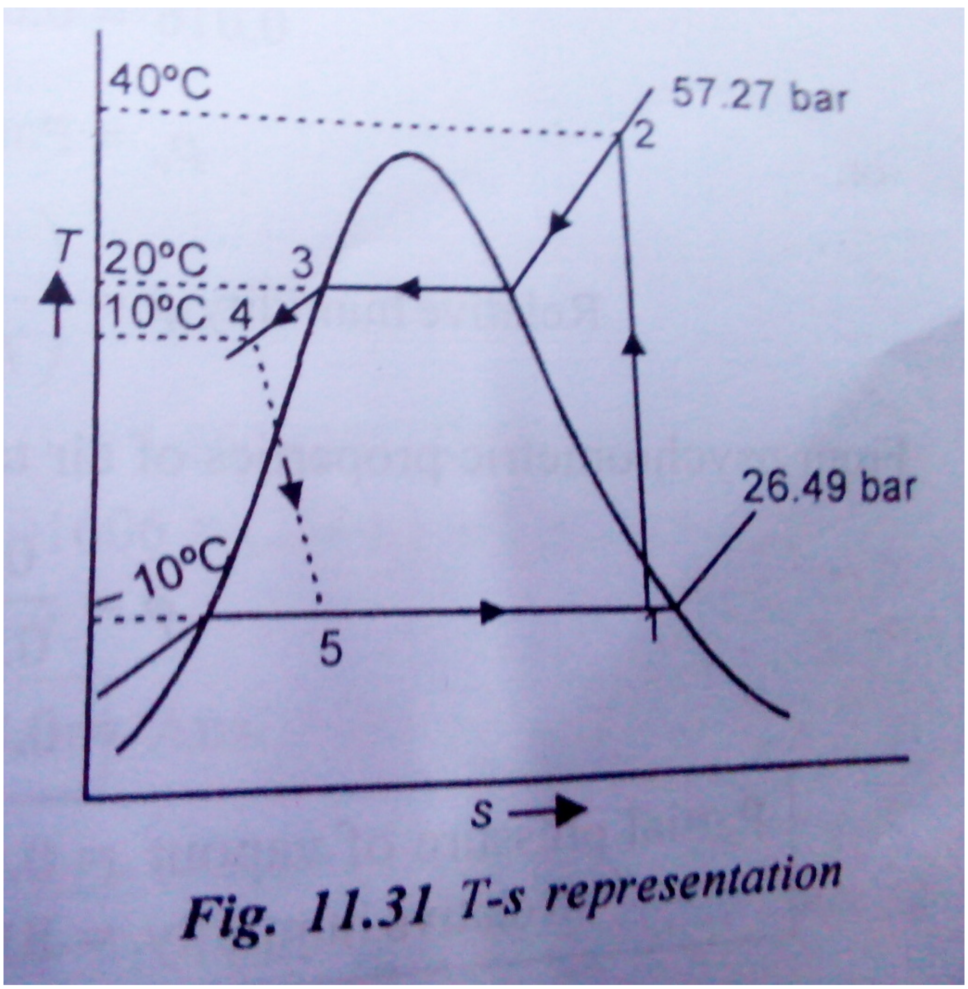


Fig. 11.31 T-s representation

Figure 11.12: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 11

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa p_{sat}	Specific volume m^3/kg: Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg: Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg: Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy $kJ/(kg\,K)$: Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.4	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2409.8	2309.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	[illegible]
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	[illegible]
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	[illegible]
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	[illegible]
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	[illegible]

Figure 11.13: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 12

Scilab code Exa 11.12 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 11 Example 12")
omega=0.016;//specific humidity in gm/gm of air
disp("here pressure of atmospheric air(P)may be
   taken as 1.013 bar")
P=1.013;//pressure of atmospheric air in bar
disp("specific humidity,omega=0.622*(Pv/(P-Pv))")
disp("so partial pressure of vapour(Pv)in bar")
disp("Pv=P/(1+(0.622/omega))in bar ")
Pv=P/(1+(0.622/omega))
Pv=0.0254;//approx.
disp("relative humidity(phi)=(Pv/Pv_sat)")
disp("from pychrometric properties of air Pv_sat at
   25 degree celcius=0.03098 bar")
Pv_sat=0.03098;
disp("so phi=Pv/Pv_sat")
phi=Pv/Pv_sat
disp("in percentage")
phi=phi*100
disp("so partial pressure of vapour=0.0254 bar")
disp("relative humidity=81.98 %")
```

Scilab code Exa 11.13 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 13

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.4	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2409.8	2309.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	[illegible]
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	[illegible]
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	[illegible]
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	[illegible]
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	[illegible]

Figure 11.14: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 13

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 11 Example 13")
r=0.6;//relative humidity
P=1.013;//total pressure of mixture in bar
R=0.287;//gas constant in KJ/kg K
Ta=(30+273);//room temperature in K
Cp=1.005;//specific heat at constant pressure in KJ/kg degree celcius
disp("at 30 degree celcius from steam table, saturation pressure,Pv_sat=0.0425 bar")
Pv_sat=0.0425;
disp("partial pressure of vapour(Pv)=relative humidity*Pv_sat in bar")
Pv=r*Pv_sat
disp("partial pressure of air(Pa)=total pressure of mixture-partial pressure of vapour")
Pa=P-Pv
disp("so partial pressure of air=0.9875 bar")
disp("humidity ratio,omega=0.622*Pv/(P-Pv)in kg/kg of dry air")
omega=0.622*Pv/(P-Pv)
disp("so humidity ratio=0.01606 kg/kg of air")
disp("Dew point temperature may be seen from the steam table.The saturation temperature corresponding to the partial pressure of vapour is 0.0255 bar.Dew point temperature can be approximated as 21.4oc by interpolation")
disp("so Dew point temperature=21.4 degree celcius")
disp("density of mixture(rho_m)=density of air(rho_a)+density of vapour(rho_v)")
disp("rho_m=(rho_a)+(rho_v)=rho_a*(1+omega)")
disp("rho_m=P*100*(1+omega)/(R*Ta)in kg/m^3")
```

```
rho_m=P*100*(1+omega)/(R*Ta)
disp("so density = 1.1835 kg/m^3")
disp("enthalpy of mixture,h=Cp*T+omega*(hg
   +1.860*(30-21.4))in KJ/kg of dry air")
T=30;//room temperature in degree celcius
hg=2540.1;//enthalpy at 30 degree celcius in KJ/kg
h=Cp*T+omega*(hg+1.860*(30-21.4))
disp("enthalpy of mixture =71.2 KJ/kg of dry air")
```

Scilab code Exa 11.14 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 14

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 11 Example 14")
disp("initial state at 15 degree celcius and 80%
   relative humidity is shown by point 1 and final
   state at 25 degree celcius and 50% relative
   humidity is shown by point 2 on psychrometric
   chart.")
disp("omega1=0.0086 kg/kg of air,h1=37 KJ/kg,omega2
   =0.01 kg/kg of air,h2=50 KJ/kg,v2=0.854 m^3/kg")
omega1=0.0086;
h1=37;
omega2=0.01;
h2=50;
v2=0.854;
disp("mass of water added between states 1 and 2
```

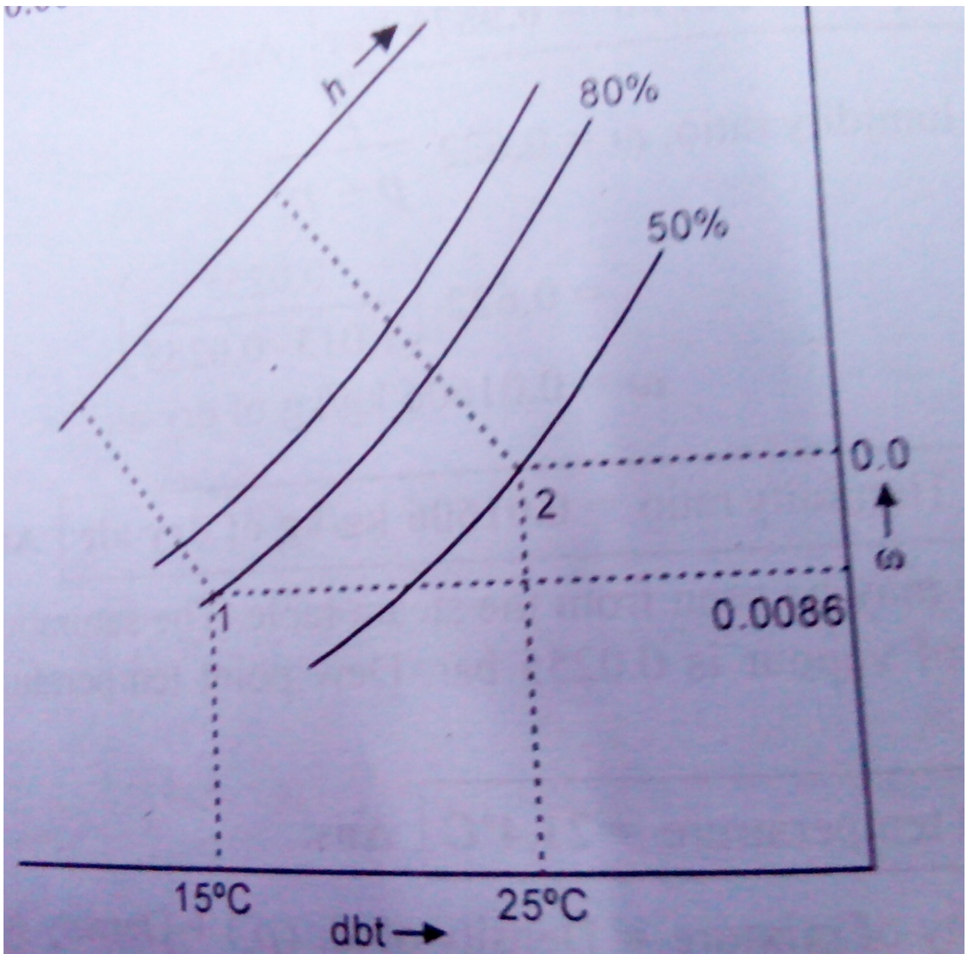


Fig. 11.32 Psychrometric chart

Figure 11.15: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 14

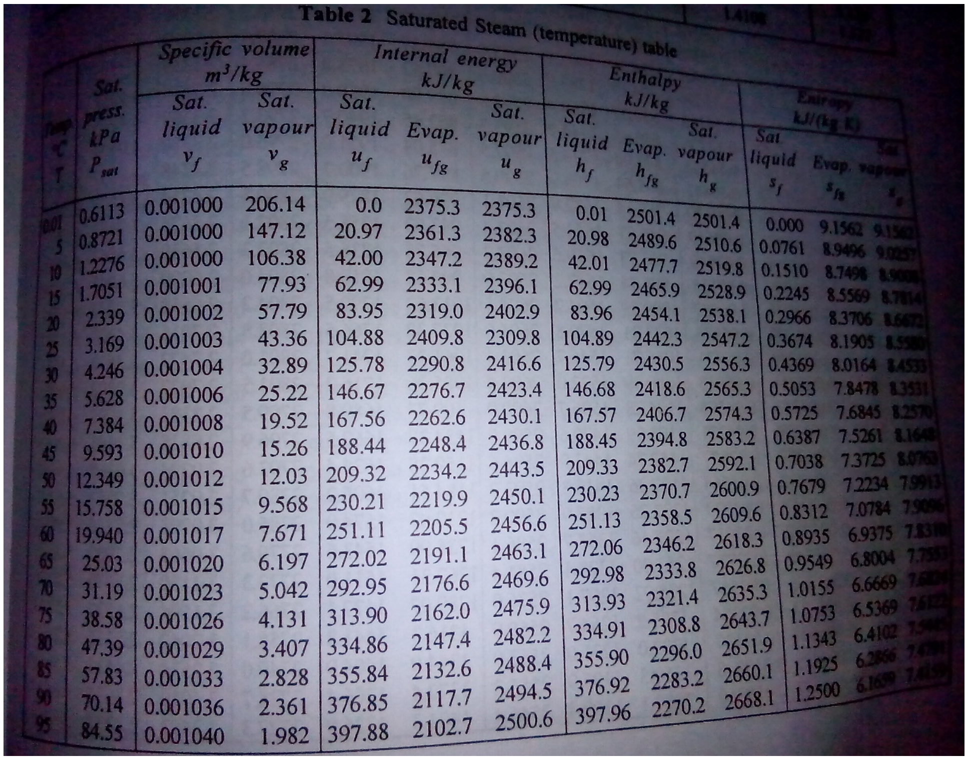


Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m^3/kg Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg K) Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
0.01	0.6113	0.001000	206.14	0.0	2375.3	2375.3	0.01	2501.4	2501.4	0.000	9.1562	9.1562
5	0.8721	0.001000	147.12	20.97	2361.3	2382.3	20.98	2489.6	2510.6	0.0761	8.9496	9.0257
10	1.2276	0.001000	106.38	42.00	2347.2	2389.2	42.01	2477.7	2519.8	0.1510	8.7498	8.9008
15	1.7051	0.001001	77.93	62.99	2333.1	2396.1	62.99	2465.9	2528.9	0.2245	8.5569	8.7814
20	2.339	0.001002	57.79	83.95	2319.0	2402.9	83.96	2454.1	2538.1	0.2966	8.3706	8.6672
25	3.169	0.001003	43.36	104.88	2409.8	2309.8	104.89	2442.3	2547.2	0.3674	8.1905	8.5580
30	4.246	0.001004	32.89	125.78	2290.8	2416.6	125.79	2430.5	2556.3	0.4369	8.0164	8.4533
35	5.628	0.001006	25.22	146.67	2276.7	2423.4	146.68	2418.6	2565.3	0.5053	7.8478	8.3531
40	7.384	0.001008	19.52	167.56	2262.6	2430.1	167.57	2406.7	2574.3	0.5725	7.6845	8.2570
45	9.593	0.001010	15.26	188.44	2248.4	2436.8	188.45	2394.8	2583.2	0.6387	7.5261	8.1648
50	12.349	0.001012	12.03	209.32	2234.2	2443.5	209.33	2382.7	2592.1	0.7038	7.3725	8.0763
55	15.758	0.001015	9.568	230.21	2219.9	2450.1	230.23	2370.7	2600.9	0.7679	7.2234	7.9913
60	19.940	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6	0.8312	7.0784	7.9096
65	25.03	0.001020	6.197	272.02	2191.1	2463.1	272.06	2346.2	2618.3	0.8935	6.9375	7.8310
70	31.19	0.001023	5.042	292.95	2176.6	2469.6	292.98	2333.8	2626.8	0.9549	6.8004	7.7553
75	38.58	0.001026	4.131	313.90	2162.0	2475.9	313.93	2321.4	2635.3	1.0155	6.6669	[illegible]
80	47.39	0.001029	3.407	334.86	2147.4	2482.2	334.91	2308.8	2643.7	1.0753	6.5369	[illegible]
85	57.83	0.001033	2.828	355.84	2132.6	2488.4	355.90	2296.0	2651.9	1.1343	6.4102	[illegible]
90	70.14	0.001036	2.361	376.85	2117.7	2494.5	376.92	2283.2	2660.1	1.1925	6.2866	[illegible]
95	84.55	0.001040	1.982	397.88	2102.7	2500.6	397.96	2270.2	2668.1	1.2500	6.1659	[illegible]

Figure 11.16: Engineering Thermodynamics by Onkar Singh Chapter 11 Example 15

```
    omega2−omega1 in kg/kg of air")
omega2-omega1
disp("mass flow rate of air(ma)=0.8/v2 in kg/s")
ma=0.8/v2
disp("total mass of water added=ma∗(omega2−omega1)in
    kg/s")
ma∗(omega2-omega1)
disp("heat transferred=ma∗(h2−h1) in KJ/s")
ma∗(h2-h1)
disp("so mass of water added=0.001312 kg/s,heat
    transferred=12.18 KW")
```

Scilab code Exa 11.15 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 15

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 11 Example 15")
P=1.013;//atmospheric pressure in bar
Cp_air=1.005;//specific heat of air at constant
   pressure in KJ/kg K
Cp_stream=1.86;//specific heat of stream at constant
    pressure in KJ/kg K
T1=30;//temperature of first stream of moist air in
   K
m1=3;//mass flow rate of first stream in kg/s
T2=35;//temperature of second stream of moist air in
    K
m2=2;//mass flow rate of second stream in kg/s
disp("Let temperature after mixing be Toc.For
   getting final enthalpy after adiabatic mixing the
    enthalpy of two streams are required.")
disp("For moist air stream at 30 degree celcius and
   30% relative humidity.")
phi1=0.3;
disp("phi1=Pv1/Pv_sat_30oc")
disp("here Pv_sat_30oc=0.04246 bar")
Pv_sat_30oc=0.04246;
disp("so Pv1=phi1*Pv_sat_30oc in bar")
Pv1=phi1*Pv_sat_30oc
disp("corresponding to vapour pressure of 0.01274
```

```
bar the dew point temperature shall be 10.5
   degree celcius")
Tdp1=10.5;
disp("specific humidity,omega1=0.622*Pv1/(P-Pv1)in
   kg/kg of air")
omega1=0.622*Pv1/(P-Pv1)
disp("at dew point temperature of 10.5 degree
   celcius,enthalpy,hg at 10.5oc=2520.7 KJ/kg")
hg=2520.7;//enthalpy at 10.5 degree celcius in KJ/kg
disp("h1=Cp_air*T1+omega1*{hg-Cp_stream*(T1-Tdp1)}in
    KJ/kg of dry air")
h1=Cp_air*T1+omega1*{hg-Cp_stream*(T1-Tdp1)}
disp("for second moist air stream at 35oc and 85%
   relative humidity")
phi2=0.85;
disp("phi2=Pv2/Pv_sat_35oc")
disp("here Pv_sat_35oc=0.005628 bar")
Pv_sat_35oc=0.005628;
disp("so Pv2=phi2*Pv_sat_35oc in bar")
Pv2=phi2*Pv_sat_35oc
disp("specific humidity,omega2=0.622*Pv2/(P-Pv2)in
   kg/kg of air")
omega2=0.622*Pv2/(P-Pv2)
disp("corresponding to vapour pressure of 0.004784
   bar the dew point temperature is 32 degree
   celcius")
Tdp2=32;
disp("so,enthalpy of second stream,")
disp("h2=Cp_air*T2+omega2*{hg+Cp_stream*(T2-Tdp2)}in
    KJ/kg of dry air")
hg=2559.9;//enthalpy at 32 degree celcius in KJ/kg
h2=Cp_air*T2+omega2*{hg+Cp_stream*(T2-Tdp2)}
disp("enthalpy of mixture after adiabatic mixing,")
disp("=(1/(m1+m2))*((h1*m1/(1+omega1))+(h2*m2/(1+
   omega2))) in KJ/kg of moist air")
(1/(m1+m2))*((h1*m1/(1+omega1))+(h2*m2/(1+omega2)))
disp("mass of vapour per kg of moist air=(1/5)*((
   omega1*m1/(1+omega1))+(omega2*m2/(1+omega2)))in
```

```
kg/kg of moist air")
(1/5)*((omega1*m1/(1+omega1))+(omega2*m2/(1+omega2)))
disp("specific humidity of mixture(omega)in kg/kg of dry air=")
omega=0.00589/(1-0.005893)
disp("omega=0.622*Pv/(P-Pv)")
disp("Pv=omega*P/(omega+0.622)in bar")
Pv=omega*P/(omega+0.622)
disp("partial pressure of water vapour=0.00957 bar")
disp("so specific humidity of mixture=0.00593 kg/kg dry air")
disp("and partial pressure of water vapour in mixture=0.00957 bar")
```

Scilab code Exa 11.16 Engineering Thermodynamics by Onkar Singh Chapter 11 Example 16

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 11 Example 16")
m1=3;//rate at which moist air enter in heating coil in m^3/s
disp("The type of heating involved is sensible heating.Locating satte 1 on psychrometric chart corresponding to 15 degree celcius dbt and 80% relative humidity the other property values shall be,")
disp("h1=36.4 KJ/kg,omega1=0.0086 kg/kg of air,v1=0.825 m^3/kg")
```

```
h1=36.4;
omega1=0.0086;
v1=0.825;
disp("final state 2 has,h2=52 KJ/kg")
h2=52;
disp("mass of air(m)=m1/v1 in kg/s")
m=m1/v1
m=3.64;//approx.
disp("amount of heat added(Q)in KJ/s")
disp("Q=m*(h2-h1)")
Q=m*(h2-h1)
```

Chapter 12

Introduction To Heat Transfer

Scilab code Exa 12.1 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 1")
h1=30;//heat transfer coefficient on side of 50 oc
   in W/m^2 K
h5=10;//heat transfer coefficient on side of 20 oc
   in W/m^2 K
k_brick=0.9;//conductivity of brick in W/m K
k_wood=0.15;//conductivity of wood in W/m K
T1=50;//temperature of air on one side of wall in
   degree celcius
T5=20;//temperature of air on other side of wall in
   degree celcius
```

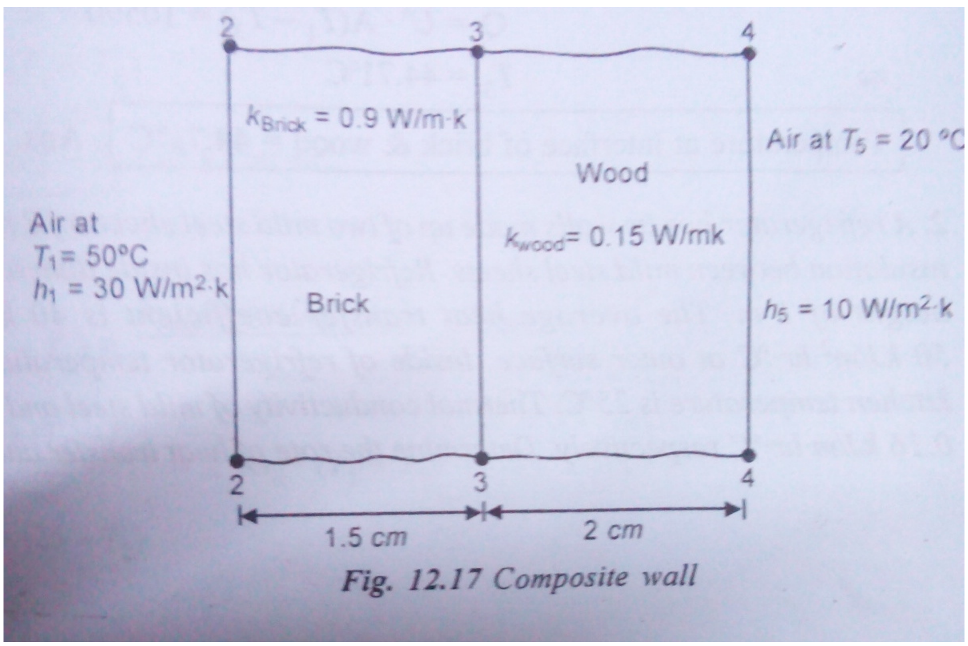


Figure 12.1: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 1

```
A=100;//surface area in m^2
deltax_brick=1.5*10^-2;//length of brick in m
deltax_wood=2*10^-2;//length of wood in m
disp("here for one dimentional heat transfer across the wall the heat transfer circuit shall comprises of thermal resistance due to convection between air & brick(R1),conduction in brick wall(R2),conduction in wood(R3),and convection between wood and air(R4).Let temperature at outer brick wall be T2 K,brick-wood interface be T3 K,outer wood wall be T4 K")
disp("overall heat transfer coefficient for steady state heat transfer(U)in W/m^2 K")
disp("(1/U)=(1/h1)+(deltax_brick/k_brick)+(deltax_wood/k_wood)+(1/h5)")
disp("so U=1/((1/h1)+(deltax_brick/k_brick)+(deltax_wood/k_wood)+(1/h5))")
U=1/((1/h1)+(deltax_brick/k_brick)+(deltax_wood/k_wood)+(1/h5))
U=3.53;//approx.
disp("rate of heat transfer,Q=U*A*(T1-T5)in W")
Q=U*A*(T1-T5)
disp("so rate of heat transfer=10590 W")
disp("heat transfer across states 1 and 3(at interface).")
disp("overall heat transfer coefficient between 1 and 3")
disp("(1/U1)=(1/h1)+(deltax_brick/k_brick)")
disp("so U1=1/((1/h1)+(deltax_brick/k_brick))in W/m^2 K")
U1=1/((1/h1)+(deltax_brick/k_brick))
disp("Q=U1*A*(T1-T3)")
disp("so T3=T1-(Q/(U1*A))in degree celcius")
T3=T1-(Q/(U1*A))
disp("so temperature at interface of brick and wood=44.71 degree celcius")
```

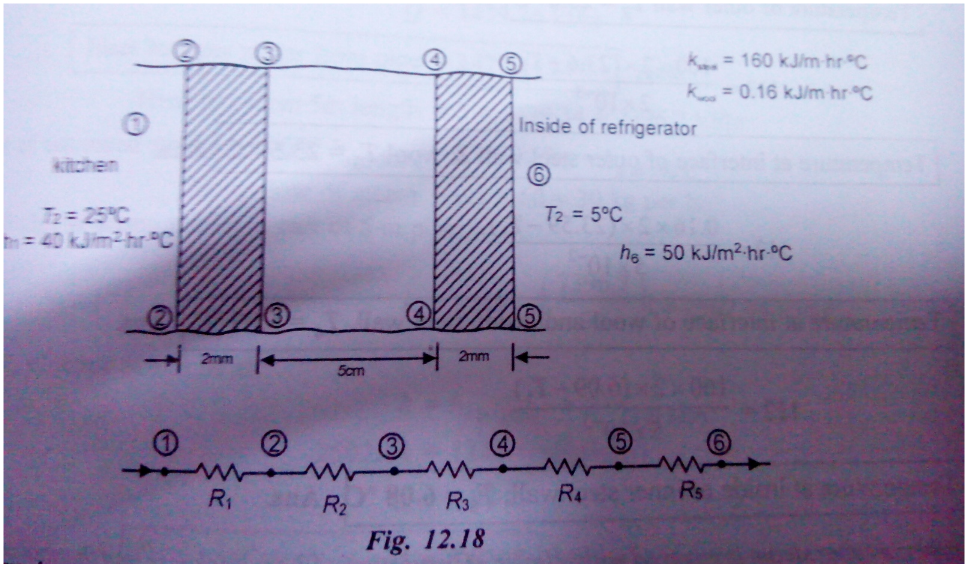


Figure 12.2: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 2

Scilab code Exa 12.2 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 2")
h1=40;//average heat transfer coefficient at inner
   surface in KJ/m^2 hr oc
h6=50;//average heat transfer coefficient at outer
```

```
surface in KJ/m^2 hr oc
deltax_steel=2*10^-3;//mild steel sheets thickness in m
deltax_wool=5*10^-2;//thickness of glass wool insulation in m
k_wool=0.16;//thermal conductivity of wool in KJ/m hr
k_steel=160;//thermal conductivity of steel in KJ/m hr
T1=25;//kitchen temperature in degree celcius
T6=5;//refrigerator temperature in degree celcius
disp("here thermal resistances are")
disp("R1=thermal resistance due to convection between kitchen air and outer surface of refrigerator wall(T1 & T2)")
disp("R2=thermal resistance due to conduction across mild steel wall between 2 & 3(T2 & T3)")
disp("R3=thermal resistance due to conduction across glass wool between 3 & 4(T3 & T4)")
disp("R4=thermal resistance due to conduction across mild steel wall between 4 & 5(T4 & T5)")
disp("R5=thermal resistance due to convection between inside refrigerator wall and inside of refrigerator between 5 & 6(T5 & T6)")
disp("overall heat transfer coefficient for one dimentional steady state heat transfer")
disp("(1/U)=(1/h1)+(deltax_steel/k_steel)+(deltax_wool/k_wool)+(deltax_steel/k_steel)+(1/h6)")
disp("so U=1/((1/h1)+(deltax_steel/k_steel)+(deltax_wool/k_wool)+(deltax_steel/k_steel)+(1/h6))in KJ/m^2hr oc")
U=1/((1/h1)+(deltax_steel/k_steel)+(deltax_wool/k_wool)+(deltax_steel/k_steel)+(1/h6))
U=2.8;//approx.
disp("rate of heat transfer(Q)=U*A*(T1-T6)in KJ/m^2 hr")
disp("wall surface area(A) in m^2")
```

```
A=4*(1*0.5)
Q=U*A*(T1-T6)
disp("so rate of heat transfer=112 KJ/m^2 hr ")
disp("Q=A*h1*(T1-T2)=k_steel*A*(T2-T3)/deltax_steel=k_wool*A*(T3-T4)/deltax_wool")
disp("Q=k_steel*A*(T4-T5)/deltax_steel=A*h6*(T5-T6)")
disp("substituting,T2=T1-(Q/(A*h1))in degree celcius")
T2=T1-(Q/(A*h1))
disp("so temperature of outer wall,T2=23.6 oc")
disp("T3=T2-(Q*deltax_steel/(k_steel*A))in degree ")
T3=T2-(Q*deltax_steel/(k_steel*A))
disp("so temperature at interface of outer steel wall and wool,T3=23.59 oc")
disp("T4=T3-(Q*deltax_wool/(k_wool*A))in degree celcius")
T4=T3-(Q*deltax_wool/(k_wool*A))
disp("so temperature at interface of wool and inside steel wall,T4=6.09 oc")
disp("T5=T4-(Q*deltax_steel/(k_steel*A))in degree celcius")
T5=T4-(Q*deltax_steel/(k_steel*A))
disp("so temperature at inside of inner steel wall,T5=6.08 oc")
```

Scilab code Exa 12.3 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 3

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```

```
disp("Engineering Thermodynamics by Onkar Singh Chapter 12 Example 3")
k_insulation=0.3;//thermal conductivity of insulation in KJ/m hr oc
k_pipe=209;//thermal conductivity of pipe in KJ/m hr oc
T1=300;//temperature of inner surface of steam pipe in degree celcius
T3=50;//temperature of outer surface of insulation layer in degree celcius
r1=15*10^-2/2;//steam pipe inner radius without insulation in m
r2=16*10^-2/2;//steam pipe outer radius without insulation in m
r3=22*10^-2/2;//radius with insulation in m
m=0.5;//steam entering rate in kg/min
disp("here,heat conduction is considered in pipe wall from 1 to 2 and conduction through insulation between 2 and 3 of one dimentional steady state type.")
disp("Q=(T1-T3)*2*%pi*L/((1/k_pipe)*log(r2/r1)+(1/k_insulation*log(r3/r2)))in KJ/hr")
L=1;
Q=(T1-T3)*2*%pi*L/((1/k_pipe)*log(r2/r1)+(1/k_insulation*log(r3/r2)))
disp("so heat loss per meter from pipe =1479.34 KJ/hr")
disp("heat loss from  5 m length(Q) in KJ/hr")
Q=5*Q
disp("enthalpy of saturated steam at 300 oc,h_sat=2749 KJ/kg=hg from steam table")
hg=2749;
disp("mass flow of steam(m)in kg/hr")
m=m*60
disp("final enthalpy of steam per kg at exit of 5 m pipe(h)in KJ/kg")
h=hg-(Q/m)
disp("let quality of steam at exit be x,")
```

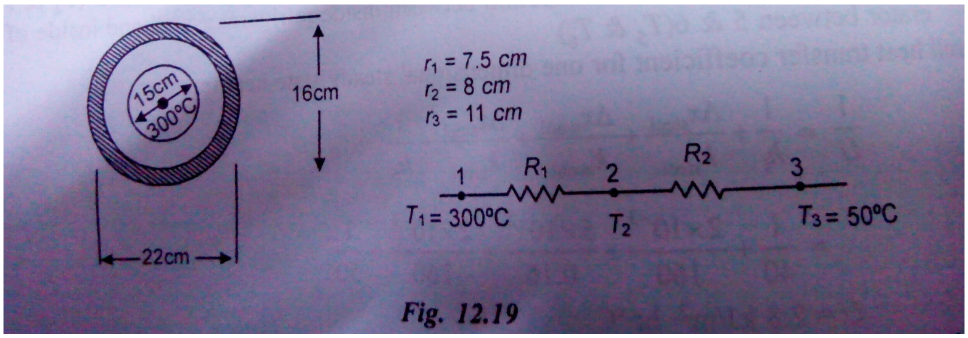
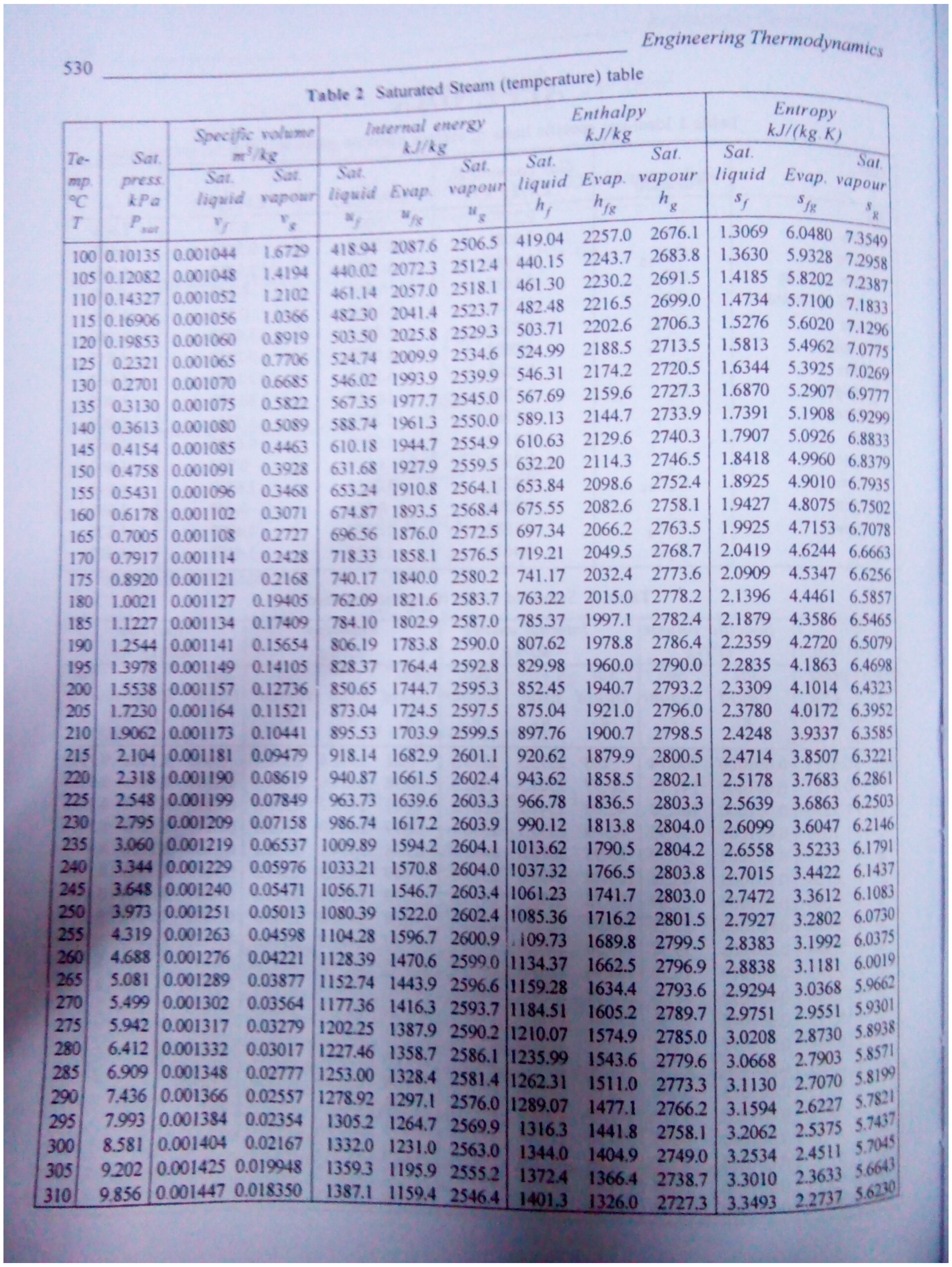


Figure 12.3: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 3

```
disp("also at 300oc,hf=1344 KJ/kg,hfg=1404.9 KJ/kg
   from steam table")
hf=1344;
hfg=1404.9;
disp("h=hf+x*hfg")
disp("so x=(h-hf)/hfg")
x=(h-hf)/hfg
disp("so quality of steam at exit=0.8245")
```

Scilab code Exa 12.4 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
```



530 Engineering Thermodynamics

Table 2 Saturated Steam (temperature) table

Temp. °C T	Sat. press. kPa P_{sat}	Specific volume m³/kg: Sat. liquid v_f	Sat. vapour v_g	Internal energy kJ/kg: Sat. liquid u_f	Evap. u_{fg}	Sat. vapour u_g	Enthalpy kJ/kg: Sat. liquid h_f	Evap. h_{fg}	Sat. vapour h_g	Entropy kJ/(kg.K): Sat. liquid s_f	Evap. s_{fg}	Sat. vapour s_g
100	0.10135	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1	1.3069	6.0480	7.3549
105	0.12082	0.001048	1.4194	440.02	2072.3	2512.4	440.15	2243.7	2683.8	1.3630	5.9328	7.2958
110	0.14327	0.001052	1.2102	461.14	2057.0	2518.1	461.30	2230.2	2691.5	1.4185	5.8202	7.2387
115	0.16906	0.001056	1.0366	482.30	2041.4	2523.7	482.48	2216.5	2699.0	1.4734	5.7100	7.1833
120	0.19853	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3	1.5276	5.6020	7.1296
125	0.2321	0.001065	0.7706	524.74	2009.9	2534.6	524.99	2188.5	2713.5	1.5813	5.4962	7.0775
130	0.2701	0.001070	0.6685	546.02	1993.9	2539.9	546.31	2174.2	2720.5	1.6344	5.3925	7.0269
135	0.3130	0.001075	0.5822	567.35	1977.7	2545.0	567.69	2159.6	2727.3	1.6870	5.2907	6.9777
140	0.3613	0.001080	0.5089	588.74	1961.3	2550.0	589.13	2144.7	2733.9	1.7391	5.1908	6.9299
145	0.4154	0.001085	0.4463	610.18	1944.7	2554.9	610.63	2129.6	2740.3	1.7907	5.0926	6.8833
150	0.4758	0.001091	0.3928	631.68	1927.9	2559.5	632.20	2114.3	2746.5	1.8418	4.9960	6.8379
155	0.5431	0.001096	0.3468	653.24	1910.8	2564.1	653.84	2098.6	2752.4	1.8925	4.9010	6.7935
160	0.6178	0.001102	0.3071	674.87	1893.5	2568.4	675.55	2082.6	2758.1	1.9427	4.8075	6.7502
165	0.7005	0.001108	0.2727	696.56	1876.0	2572.5	697.34	2066.2	2763.5	1.9925	4.7153	6.7078
170	0.7917	0.001114	0.2428	718.33	1858.1	2576.5	719.21	2049.5	2768.7	2.0419	4.6244	6.6663
175	0.8920	0.001121	0.2168	740.17	1840.0	2580.2	741.17	2032.4	2773.6	2.0909	4.5347	6.6256
180	1.0021	0.001127	0.19405	762.09	1821.6	2583.7	763.22	2015.0	2778.2	2.1396	4.4461	6.5857
185	1.1227	0.001134	0.17409	784.10	1802.9	2587.0	785.37	1997.1	2782.4	2.1879	4.3586	6.5465
190	1.2544	0.001141	0.15654	806.19	1783.8	2590.0	807.62	1978.8	2786.4	2.2359	4.2720	6.5079
195	1.3978	0.001149	0.14105	828.37	1764.4	2592.8	829.98	1960.0	2790.0	2.2835	4.1863	6.4698
200	1.5538	0.001157	0.12736	850.65	1744.7	2595.3	852.45	1940.7	2793.2	2.3309	4.1014	6.4323
205	1.7230	0.001164	0.11521	873.04	1724.5	2597.5	875.04	1921.0	2796.0	2.3780	4.0172	6.3952
210	1.9062	0.001173	0.10441	895.53	1703.9	2599.5	897.76	1900.7	2798.5	2.4248	3.9337	6.3585
215	2.104	0.001181	0.09479	918.14	1682.9	2601.1	920.62	1879.9	2800.5	2.4714	3.8507	6.3221
220	2.318	0.001190	0.08619	940.87	1661.5	2602.4	943.62	1858.5	2802.1	2.5178	3.7683	6.2861
225	2.548	0.001199	0.07849	963.73	1639.6	2603.3	966.78	1836.5	2803.3	2.5639	3.6863	6.2503
230	2.795	0.001209	0.07158	986.74	1617.2	2603.9	990.12	1813.8	2804.0	2.6099	3.6047	6.2146
235	3.060	0.001219	0.06537	1009.89	1594.2	2604.1	1013.62	1790.5	2804.2	2.6558	3.5233	6.1791
240	3.344	0.001229	0.05976	1033.21	1570.8	2604.0	1037.32	1766.5	2803.8	2.7015	3.4422	6.1437
245	3.648	0.001240	0.05471	1056.71	1546.7	2603.4	1061.23	1741.7	2803.0	2.7472	3.3612	6.1083
250	3.973	0.001251	0.05013	1080.39	1522.0	2602.4	1085.36	1716.2	2801.5	2.7927	3.2802	6.0730
255	4.319	0.001263	0.04598	1104.28	1596.7	2600.9	109.73	1689.8	2799.5	2.8383	3.1992	6.0375
260	4.688	0.001276	0.04221	1128.39	1470.6	2599.0	1134.37	1662.5	2796.9	2.8838	3.1181	6.0019
265	5.081	0.001289	0.03877	1152.74	1443.9	2596.6	1159.28	1634.4	2793.6	2.9294	3.0368	5.9662
270	5.499	0.001302	0.03564	1177.36	1416.3	2593.7	1184.51	1605.2	2789.7	2.9751	2.9551	5.9301
275	5.942	0.001317	0.03279	1202.25	1387.9	2590.2	1210.07	1574.9	2785.0	3.0208	2.8730	5.8938
280	6.412	0.001332	0.03017	1227.46	1358.7	2586.1	1235.99	1543.6	2779.6	3.0668	2.7903	5.8571
285	6.909	0.001348	0.02777	1253.00	1328.4	2581.4	1262.31	1511.0	2773.3	3.1130	2.7070	5.8199
290	7.436	0.001366	0.02557	1278.92	1297.1	2576.0	1289.07	1477.1	2766.2	3.1594	2.6227	5.7821
295	7.993	0.001384	0.02354	1305.2	1264.7	2569.9	1316.3	1441.8	2758.1	3.2062	2.5375	5.7437
300	8.581	0.001404	0.02167	1332.0	1231.0	2563.0	1344.0	1404.9	2749.0	3.2534	2.4511	5.7045
305	9.202	0.001425	0.019948	1359.3	1195.9	2555.2	1372.4	1366.4	2738.7	3.3010	2.3633	5.6643
310	9.856	0.001447	0.018350	1387.1	1159.4	2546.4	1401.3	1326.0	2727.3	3.3493	2.2737	5.6230

Figure 12.4: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 3

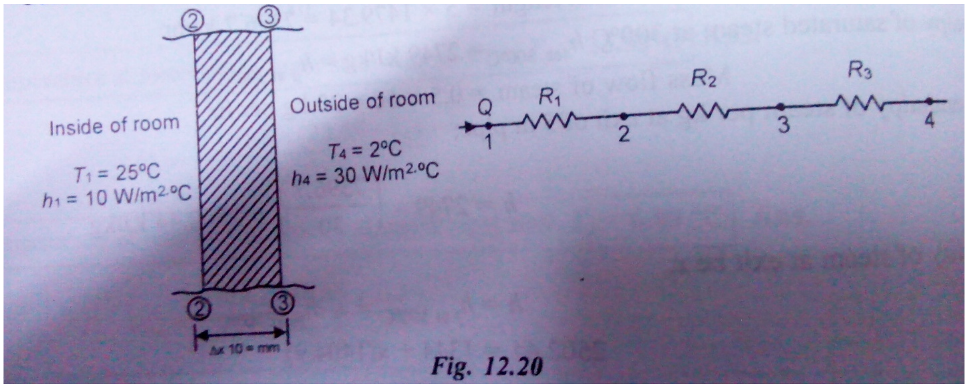


Figure 12.5: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 5

```
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 4")
r1=150*10^-2/2;//inner radius in m
r2=200*10^-2/2;//outer radius in m
k=28;//thermal conductivity in KJ m hr oc
T1=200;//inside surface temperature in degree
   celcius
T2=40;//outer surface temperature in degree celcius
disp("considering one dimensional heat transfer of
   steady state type")
disp("for sphere(Q)=(T1-T2)*4*%pi*k*r1*r2/(r2-r1) in
    KJ/hr")
Q=(T1-T2)*4*%pi*k*r1*r2/(r2-r1)
disp("so heat transfer rate=168892.02 KJ/hr")
disp("heat flux=Q/A in KJ/m^2 hr")
Q/(4*%pi*r1^2)
disp("so heat flux=23893.33 KJ/m^2 hr")
```

Scilab code Exa 12.5 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 5")
T1=25;//room temperature in degree celcius
T4=2;//winter outside temperature in degree celcius
h1=10;//heat transfer coefficient on inner window
   surfaces in W/m^2 oc
h4=30;//heat transfer coefficient on outer window
   surfaces in W/m^2 oc
k=0.78;//thermal conductivity of glass in W/m^2 oc
A=75*10^-2*100*10^-2;//area in m^2
deltax=10*10^-3;//glass thickness in m
disp("R1=thermal resistance for convection heat
   transfer between inside room (1)and inside
   surface of glass window(2)=1/(h1*A)")
disp("R2=thermal resistance for conduction through
   glass between inside of glass window(2)to outside
    surface of glass window(3)=deltax/(k*A)")
disp("R3=thermal resistance for convection heat
   transfer between outside surface of glass window
   (3)to outside atmosphere(4)=1/(h4*A)")
disp("total thermal resistance,R_total=R1+R2+R3 in
   oc/W")
R_total=1/(h1*A)+deltax/(k*A)+1/(h4*A)
disp("so rate of heat transfer,Q=(T1-T4)/R_total in
  W")
Q=(T1-T4)/R_total
disp("heat transfer rate from inside of room to
   inside surface of glass window.")
disp("Q=(T1-T2)/R1")
```

```
disp("so T2=T1-Q*R1 in degree celcius")
R1=(1/7.5);
T2=T1-Q*R1
disp("Thus,inside surface of glass window will be at temperature of 9.26 oc where as room inside temperature is 25 oc")
```

Scilab code Exa 12.6 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 6

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 12 Example 6")
D=4*10^-2;//inner diameter in m
L=3;//length in m
V=1;//velocity of water in m/s
T1=40;//mean temperature in degree celcius
T2=75;//pipe wall temperature in degree celcius
k=0.6;//conductivity of water in W/m
Pr=3;//prandtl no.
v=0.478*10^-6;//viscocity in m^2/s
disp("reynolds number,Re=V*D/v")
Re=V*D/v
disp("subsituting in Nu=0.023*(Re)^0.8*(Pr)^0.4")
disp("or (h*D/k)=0.023*(Re)^0.8*(Pr)^0.4")
disp("so h=(k/D)*0.023*(Re)^0.8*(Pr)^0.4 in W/m^2 K")
h=(k/D)*0.023*(Re)^0.8*(Pr)^0.4
disp("rate of heat transfer due to convection,Q in W")
```

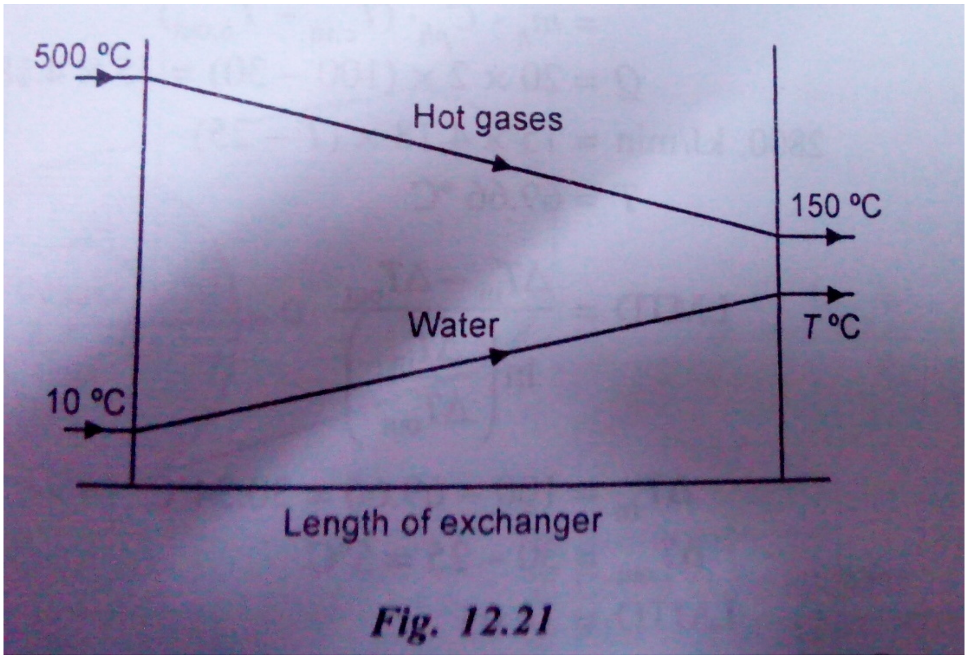


Figure 12.6: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 7

```
disp("Q=h*A*(T2-T1)")
Q=h*(%pi*D*L)*(T2-T1)
disp("so heat transfer rate=61259.38 W")
disp("Q in KW")
Q=Q/1000
```

Scilab code Exa 12.7 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 7

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 12 Example 7")
m=0.5;//hot gases flowing rate in kg/s
T1=500;//initial temperature of gas in degree
    celcius
T2=150;//final temperature of gas in degree celcius
Cg=1.2;//specific heat of gas in KJ/kg K
Cw=4.18;//specific heat of water in KJ/kg K
U=150;//overall heat transfer coefficient in W/m^2 K
mw=1;//mass of water in kg/s
T3=10;//water entering temperature in degree celcius
disp("Let the temperature of water at exit be T")
disp("Heat exchanger,Q=heat rejected by glasses=heat
     gained by water")
disp("Q=m*Cg*(T1-T2)=mw*Cw*(T-T3)")
disp("so T=T3+(m*Cg*(T1-T2)/(mw*Cw))in degree
    celcius")
T=T3+(m*Cg*(T1-T2)/(mw*Cw))
disp("and Q in KJ")
Q=m*Cg*(T1-T2)
disp("deltaT_in=T1-T3 in degree celcius")
deltaT_in=T1-T3
disp("deltaT_out=T2-T in degree celcius")
deltaT_out=T2-T
disp("for parallel flow heat exchanger,")
disp("LMTD=(deltaT_in-deltaT_out)/log(deltaT_in/
    deltaT_out)in degree celcius")
LMTD=(deltaT_in-deltaT_out)/log(deltaT_in/deltaT_out
    )
disp("also,Q=U*A*LMTD")
disp("so A=Q/(U*LMTD) in m^2")
A=Q*10^3/(U*LMTD)
disp("surface area,A=5.936 m^2")
```

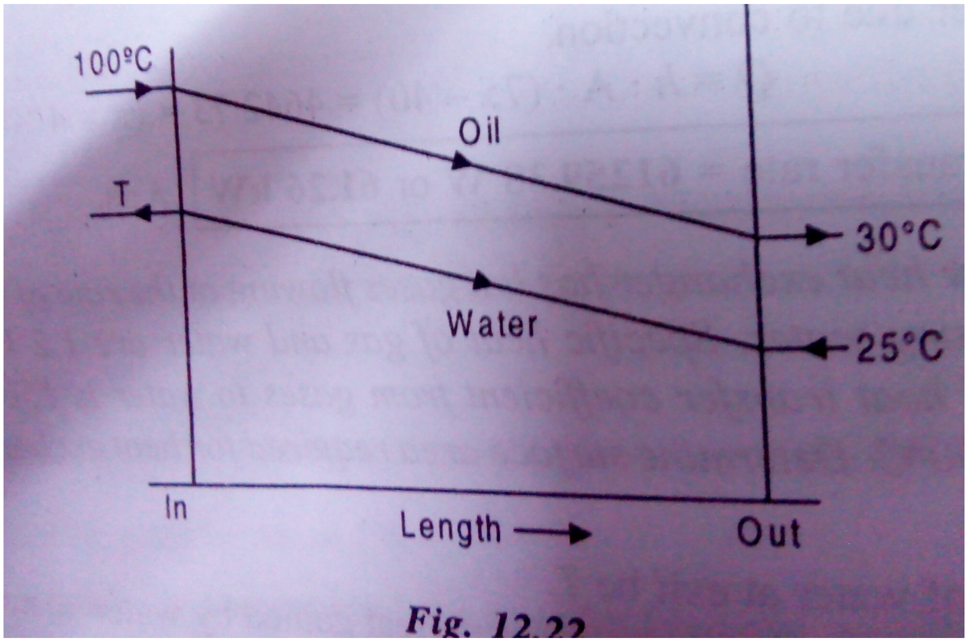


Figure 12.7: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 8

Scilab code Exa 12.8 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 8

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 8")
mc=20;//mass of oil in kg/min
```

```
Tc_out=100;//initial temperature of oil in degree
    celcius
Th_in=30;//final temperature of oil in degree
    celcius
Th_out=25;//temperature of water in degree celcius
Cpc=2;//specific heat of oil in KJ/kg K
Cph=4.18;//specific heat of water in KJ/kg K
mh=15;//water flow rate in kg/min
U=25;//overall heat transfer coefficient in W/m^2 K
disp("This oil cooler has arrangement similar to a
    counter flow heat exchanger.")
disp("by heat exchanger,Q=U*A*LMTD=mc*Cpc*(Tc_out-
    Th_in)=mh*Cph*(Tc_in-Th_out)")
disp("so Q in KJ/min")
Q=mc*Cpc*(Tc_out-Th_in)
disp("and T=Th_out+(Q/(mh*Cph))in degree celcius")
T=Th_out+(Q/(mh*Cph))
disp("LMTD=(deltaT_in-deltaT_out)/log(deltaT_in/
    deltaT_out)in degree ")
disp("here deltaT_in=Tc_out-T in degree celcius")
deltaT_in=Tc_out-T
disp("deltaT_out=Th_in-Th_out in degree celcius")
deltaT_out=Th_in-Th_out
disp("so LMTD in degree celcius")
LMTD=(deltaT_in-deltaT_out)/log(deltaT_in/deltaT_out
    )
disp("substituting in,Q=U*A*LMTD")
disp("A=(Q*10^3/60)/(U*LMTD)in m^2")
A=(Q*10^3/60)/(U*LMTD)
disp("so surface area=132.85 m^2")
```

Scilab code Exa 12.9 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 9

```
// Display mode
```

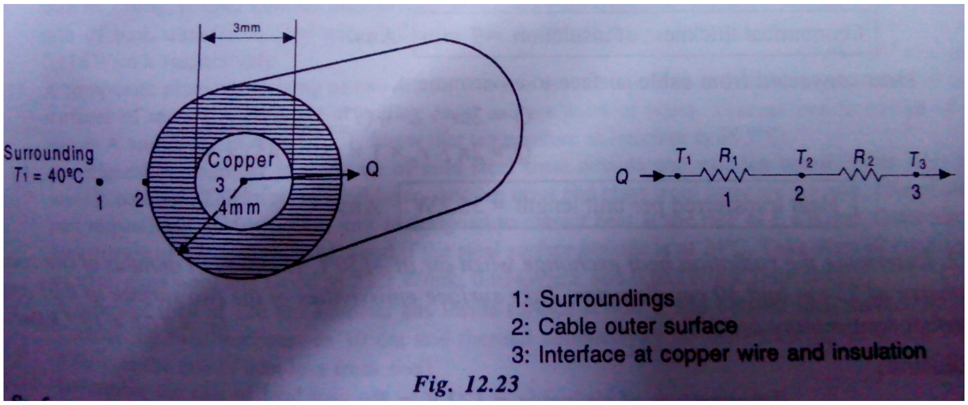


Figure 12.8: Engineering Thermodynamics by Onkar Singh Chapter 12 Example 10

```
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 9")
T1=(1200+273);//temperature of body in K
T2=(600+273);//temperature of black surrounding in K
epsilon=0.4;//emissivity of body at 1200 degree
   celcius
sigma=5.67*10^-8;//stephen boltzman constant in W/m
   ^2 K^4
disp("rate of heat loss by radiation(Q)=wpsilon*
   sigma*A*(T1^4-T2^4)")
disp("heat loss per unit area by radiation(Q)in W")
disp("Q=epsilon*sigma*(T1^4-T2^4)")
Q=epsilon*sigma*(T1^4-T2^4)
disp("Q in KW")
Q=Q/1000
```

Scilab code Exa 12.10 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 10

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 12 Example 10")
V=16;//voltage drop in V
I=5;//current in cable in A
r2=8*10^-3/2;//outer cable radius in m
r3=3*10^-3/2;//copper wire radius in m
k=0.16;//thermal conductivity of copper wire in W/m
   oc
L=5;//length of cable in m
h1=15;//heat transfer coefficient of cable in W/m^2
   oc
T1=40;//temperature of surrounding in degree celcius
disp("Let us carry out one dimentional analysis for
   steady state.Due to flow of electricity the heat
   generated can be given as:")
disp("Q=V*I in W")
Q=V*I
disp("For steady state which means there should be
   no change in temperature of cable due to
   electricity flow,the heat generated should be
   transferred out to surroundings.Therefore,heat
   transfer across table should be 80 W")
disp("surface area for heat transfer,A2=2*%pi*r*L in
   m^2")
A2=2*%pi*r2*L
```

```
A2=0.125;//approx.
disp("R1=thermal resistance due to convection
   between surroundings and cable outer surface
   ,(1-2)=1/(h1*A2)")
disp("R2=thermal resistance due to conduction across
    plastic insulation(2-3)=log(r2/r3)/(2*%pi*k*L)")
disp("Total resistance,R_total=R1+R2 in oc/W")
R_total=(1/(h1*A2))+(log(r2/r3)/(2*%pi*k*L))
disp("Q=(T3-T1)/R_total")
disp("so T3=T1+Q*R_total in degree celcius")
T3=T1+Q*R_total
disp("so temperature at interface=125.12 degree
   celcius")
disp("critical radius of insulation,rc=k/h in m")
rc=k/h1
disp("rc in mm")
rc=rc*1000
disp("This rc is more than outer radius of cable so
   the increase in thickness of insulation upon rc
   =110.66 mmwould increase rate of heat transfer.
   Doubling insulation thickness means new outer
   radius would be r1=1.5+5=6.5 mm.Hence doubling(
   increase) of insulation thickness would increase
   heat transfer and thus temperature at interface
   would decrease if other parameters reamins
   constant.")
disp("NOTE=>In this question value of R_total is
   calculated wrong in book,hence it is correctly
   solve above,so the values of R_total and T3 may
   vary.")
```

Scilab code Exa 12.11 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 11

```
// Display mode
```

```
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 12 Example 11")
r_wire=3;//radius of electric wire in mm
k=0.16;//thermal conductivity in W/m oc
T_surrounding=45;//temperature of surrounding in
    degree celcius
T_surface=80;//temperature of surface in degree
    celcius
h=16;//heat transfer cooefficient in W/m^2 oc
disp("for maximum heat transfer the critical radius
    of insulation should be used.")
disp("critical radius of insulation(rc)=k/h in mm")
rc=k*1000/h
disp("economical thickness of insulation(t)=rc-
    r_wire in mm")
t=rc-r_wire
disp("so economical thickness of insulation=7 mm")
disp("heat convected from cable surface to
    environment,Q in W")
disp("Q=2*%pi*rc*L*h*(T_surface-T_surrounding)")
L=1;//length in mm
Q=2*%pi*rc*L*h*(T_surface-T_surrounding)*10^-3
disp("so heat transferred per unit length=35.2 W")
```

Scilab code Exa 12.12 Engineering Thermodynamics by Onkar Singh Chapter 12 Example 12

```
// Display mode
mode(0);
// Display warning for floating point exception
```

```
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 12 Example 12")
T1=(-150+273);//temperature of air inside in K
T2=(35+273);//temperature of outer surface in K
epsilon1=0.03;//emissivity
epsilon2=epsilon1;
D1=25*10^-2;//diameter of inner sphere in m
D2=30*10^-2;//diameter of outer sphere in m
sigma=2.04*10^-4;//stephen boltzmann constant in KJ/m^2 hr K^4
disp("heat transfer through concentric sphere,Q in KJ/hr ")
disp("Q=(A1*sigma*(T1^4-T2^4))/((1/epsilon1)+((A1/A2)*((1/epsilon2)-1)))")
A1=4*%pi*D1^2/4;
A2=4*%pi*D2^2/4;
Q=(A1*sigma*(T1^4-T2^4))/((1/epsilon1)+((A1/A2)*((1/epsilon2)-1)))
disp("so heat exchange=6297.1 KJ/hr")
```

Chapter 13

One Dimensional Compressible Fluid Flow

Scilab code Exa 13.1 Engineering Thermodynamics by Onkar Singh Chapter 13 Example 1

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
    Chapter 13 Example 1")
To=(27+273);//stagnation temperature in K
P=0.4*10^5;//static pressure in pa
m=3000/3600;//air flowing rate in kg/s
d=80*10^-3;//diameter of duct in m
R=287;//gas constant in J/kg K
y=1.4;//expansion constant
disp("mass flow rate(m)=rho*A*C")
disp("so rho*C=4*m/(%pi*d^2)")
4*m/(%pi*d^2)
disp("so rho=165.79/C")
```

```
disp("now using perfect gas equation,p=rho*R*T")
disp("T=P/(rho*R)=P/((165.79/C)*R)")
disp("C/T=165.79*R/P")
165.79*R/P
disp("so C=1.19*T")
disp("we know,C^2=((2*y*R)/(y-1))*(To-T)")
disp("C^2=(2*1.4*287)*(300-T)/(1.4-1)")
disp("C^2=602.7*10^3-2009*T")
disp("C^2+1688.23*C-602.7*10^3=0")
disp("solving we get,C=302.72 m/s and T=254.39 K")
C=302.72;
T=254.39;
disp("using stagnation property relation,")
disp("To/T=1+(y-1)*M^2/2")
disp("so M=sqrt(((To/T)-1)/((y-1)/2))")
M=sqrt(((To/T)-1)/((y-1)/2))
M=0.947;//approx.
disp("stagnation pressure,Po=P*(1+(y-1)*M^2/2)in bar")
Po=P*(1+(y-1)*M^2/2)/10^5
disp("so mach number=0.947,stagnation pressure=0.472 bar,velocity=302.72 m/s")
```

Scilab code Exa 13.2 Engineering Thermodynamics by Onkar Singh Chapter 13 Example 2

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
```

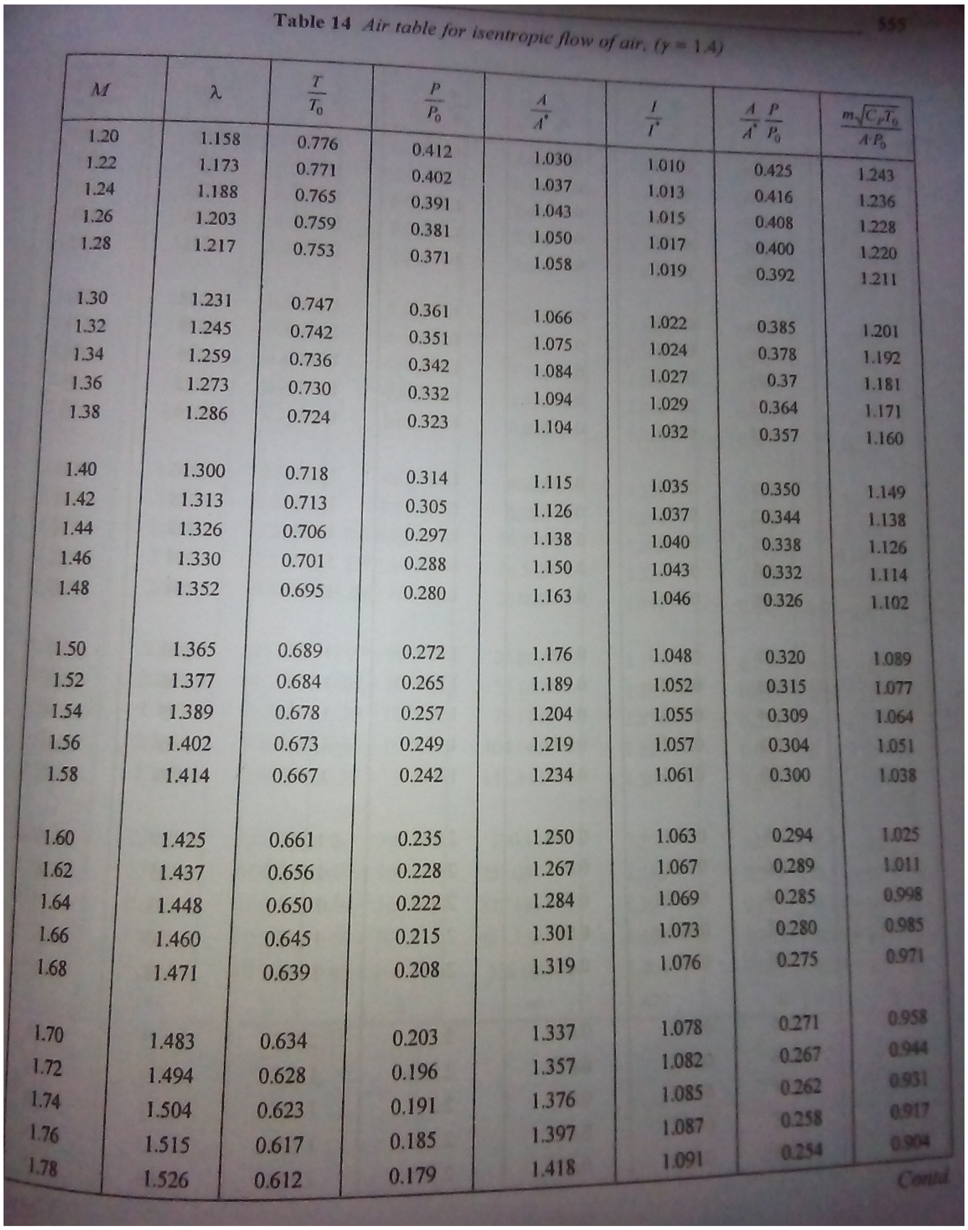


Table 14 *Air table for isentropic flow of air, (γ = 1.4)* 555

M	λ	$\frac{T}{T_0}$	$\frac{P}{P_0}$	$\frac{A}{A^*}$	$\frac{I}{I^*}$	$\frac{A}{A^*} \cdot \frac{P}{P_0}$	$\frac{m\sqrt{C_p T_0}}{A \cdot P_0}$
1.20	1.158	0.776	0.412	1.030	1.010	0.425	1.243
1.22	1.173	0.771	0.402	1.037	1.013	0.416	1.236
1.24	1.188	0.765	0.391	1.043	1.015	0.408	1.228
1.26	1.203	0.759	0.381	1.050	1.017	0.400	1.220
1.28	1.217	0.753	0.371	1.058	1.019	0.392	1.211
1.30	1.231	0.747	0.361	1.066	1.022	0.385	1.201
1.32	1.245	0.742	0.351	1.075	1.024	0.378	1.192
1.34	1.259	0.736	0.342	1.084	1.027	0.37	1.181
1.36	1.273	0.730	0.332	1.094	1.029	0.364	1.171
1.38	1.286	0.724	0.323	1.104	1.032	0.357	1.160
1.40	1.300	0.718	0.314	1.115	1.035	0.350	1.149
1.42	1.313	0.713	0.305	1.126	1.037	0.344	1.138
1.44	1.326	0.706	0.297	1.138	1.040	0.338	1.126
1.46	1.330	0.701	0.288	1.150	1.043	0.332	1.114
1.48	1.352	0.695	0.280	1.163	1.046	0.326	1.102
1.50	1.365	0.689	0.272	1.176	1.048	0.320	1.089
1.52	1.377	0.684	0.265	1.189	1.052	0.315	1.077
1.54	1.389	0.678	0.257	1.204	1.055	0.309	1.064
1.56	1.402	0.673	0.249	1.219	1.057	0.304	1.051
1.58	1.414	0.667	0.242	1.234	1.061	0.300	1.038
1.60	1.425	0.661	0.235	1.250	1.063	0.294	1.025
1.62	1.437	0.656	0.228	1.267	1.067	0.289	1.011
1.64	1.448	0.650	0.222	1.284	1.069	0.285	0.998
1.66	1.460	0.645	0.215	1.301	1.073	0.280	0.985
1.68	1.471	0.639	0.208	1.319	1.076	0.275	0.971
1.70	1.483	0.634	0.203	1.337	1.078	0.271	0.958
1.72	1.494	0.628	0.196	1.357	1.082	0.267	0.944
1.74	1.504	0.623	0.191	1.376	1.085	0.262	0.931
1.76	1.515	0.617	0.185	1.397	1.087	0.258	0.917
1.78	1.526	0.612	0.179	1.418	1.091	0.254	0.904

Contd

Figure 13.1: Engineering Thermodynamics by Onkar Singh Chapter 13 Example 2

```
    Chapter 13 Example 2")
To=(273+1100);//stagnation temperature in K
a=45;//mach angle over exit cross-section in degree
Po=1.01;//pressure at upstream side of nozzle in bar
P=0.25;//ststic pressure in bar
y=1.4;//expansion constant
R=287;//gas constant in J/kg K
disp("mach number,M_a=(1/sin(a))=sqrt(2)")
M_a=sqrt(2)
M_a=1.414;//approx.
disp("here,P/Po=0.25/1.01=0.2475.Corresponding to
    this P/Po ratio the mach number and T/To can be
    seen from air table as M=1.564 and T/To=0.6717")
M=1.564;
disp("T=To*0.6717 in K")
T=To*0.6717
disp("and C_max=M*sqrt(y*R*T) in m/s")
C_max=M*sqrt(y*R*T)
disp("corresponding to mach number(M_a=1.414)as
    obtained from experimental observation,the T/To
    can be seen from air table and it comes out as (T
    /To)=0.7145")
disp("so T=0.7145*To in K")
T=0.7145*To
disp("and C_av=M_a*sqrt(y*R*T) in m/s")
C_av=M_a*sqrt(y*R*T)
disp("ratio of kinetic energy=((1/2)*C_av^2)/((1/2)*
    C_max^2)")
((1/2)*C_av^2)/((1/2)*C_max^2)
disp("so ratio of kinetic energy=0.869")
```

Scilab code Exa 13.3 Engineering Thermodynamics by Onkar Singh Chapter 13 Example 3

```
// Display mode
```

```
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh Chapter 13 Example 3")
C=300;//aircraft flying speed in m/s
P=0.472*10^5;//altitude pressure in Pa
rho=0.659;//density in kg/m^3
y=1.4;//expansion constant
R=287;//gas constant in J/kg K
disp("From bernoulli equation,Po-P=(1/2)*rho*C^2")
disp("so Po=P+(1/2)*rho*C^2 in N/m^2")
Po=P+(1/2)*rho*C^2
disp("speed indicator reading shall be given by mach no.s")
disp("mach no.,M=C/a=C/sqrt(y*R*T)")
disp("using perfect gas equation,P=rho*R*T")
disp("so T=P/(rho*R)in K")
T=P/(rho*R)
disp("so mach no.,M")
M=C/sqrt(y*R*T)
M=0.947;//approx.
disp("considering compressibility effect,Po/P=(1+(y-1)*M^2/2)^(y/(y-1))")
disp("so stagnation pressure,Po=P*((1+(y-1)*M^2/2)^(y/(y-1)))in N/m^2")
Po=P*((1+(y-1)*M^2/2)^(y/(y-1)))
disp("also Po-P=(1+k)*(1/2)*rho*C^2")
disp("substitution yields,k=")
k=((Po-P)/((1/2)*rho*C^2))-1
disp("so compressibility correction factor,k=0.2437")
```

Scilab code Exa 13.4 Engineering Thermodynamics by Onkar Singh Chapter 13 Example 4

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 13 Example 4")
Po=2;//total pressure in bar
P=0.3;//static pressure in bar
y=1.4;//expansion constant
disp("we know that,Po/P=(1+(y-1)*M^2/2)^((y)/(y-1))"
   )
disp("so M=sqrt((exp(log(Po/P)/(y/(y-1)))-1)/((y-1)
   /2))")
M=sqrt((exp(log(Po/P)/(y/(y-1)))-1)/((y-1)/2))
disp("so mach number,M=1.89")
```

Scilab code Exa 13.5 Engineering Thermodynamics by Onkar Singh Chapter 13 Example 5

```
// Display mode
mode(0);
// Display warning for floating point exception
ieee(1);
clear;
clc;
disp("Engineering Thermodynamics by Onkar Singh
   Chapter 13 Example 5")
To=305;//stagnation temperature of air stream in K
y=1.4;//expansion constant
R=287;//gas constant in J/kg K
```

```
disp("actual static pressure(P)=1+0.3 in bar")
P=1+0.3
disp("It is also given that,Po-P=0.6,")
disp("so Po=P+0.6 in bar")
Po=P+0.6
disp("air velocity,ao=sqrt(y*R*To)in m/s")
ao=sqrt(y*R*To)
disp("density of air,rho_o=Po/(R*To)in ")
rho_o=Po*10^5/(R*To)
disp("considering air to be in-compressible,")
disp("Po=P+rho_o*C^2/2")
disp("so C=sqrt((Po-P)*2/rho_o)in m/s")
C=sqrt((Po-P)*10^5*2/rho_o)
disp("for compressible fluid,Po/P=(1+(y-1)*M^2/2)^(y/(y-1))")
disp("so M=sqrt((exp(log(Po/P)/(y/(y-1)))-1)/((y-1)/2))")
M=sqrt((exp(log(Po/P)/(y/(y-1)))-1)/((y-1)/2))
M=0.7567;//approx.
disp("compressibility correction factor,k")
disp("k=(M^2/4)+((2-y)/24)*M^4")
k=(M^2/4)+((2-y)/24)*M^4
disp("stagnation temperature,To/T=1+((y-1)/2)*M^2")
disp("so T=To/(1+((y-1)/2)*M^2) in K")
T=To/(1+((y-1)/2)*M^2)
disp("density,rho=P/(R*T) in kg/m^3")
rho=P*10^5/(R*T)
disp("substituting Po-P=(1/2)*rho*C^2(1+k)")
disp("C=sqrt((Po-P)/((1/2)*rho*(1+k)))in m/s")
C=sqrt((Po-P)*10^5/((1/2)*rho*(1+k)))
disp("so C=250.95 m/s")
```