

Scilab Textbook Companion for  
Applied Thermodynamics and Engineering  
by T. D. Eastop and A. Mcconkey<sup>1</sup>

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# Book Description

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

**Exa** Example (Solved example)

**Eqn** Equation (Particular equation of the above book)

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

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

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# Chapter 1

## Introduction and the first law of thermodynamics

Scilab code Exa 1.1 chapter 1 example 1

```
1
2  clc;
3  p=3; //bar
4  v=0.18; //m^2/kg
5  p2=0.6; //bar
6
7  c=p*v^2;
8
9  v2=(c/p2)^0.5;
10
11 W=-c*(10^5)*[(1/v)-(1/v2)];
12 disp("Work done by the fluid is:");
13 disp("N m/kg",-W);
14 //Answers vary more than than +/-5 :
15 //Answers in the textbook is wrong
```

---

### Scilab code Exa 1.2 chapter 1 example 2

```
1  clc;
2  p1=20; //bar
3  v1=0.05; //m^3
4  v2=0.1; //m^3
5  p2=p1*[(v1/v2)^2]; //bar
6
7  W_12=-10^5*p1*(v1^2)*((1/v1)-(1/v2));
8
9  W_23=10^5*p2*(v2-v1);
10
11 //work done from 3-1 is zero as the piston is locked
    in position.
12
13 disp("The net work done by the fluid is:");
14 W=-(W_12+W_23)
15 disp("N m",W)
```

---

### Scilab code Exa 1.3 chapter 1 example 3

```
1  clc;
2
3  heat_supplied=2800; //kJ/kg
4  heat_rejected=2100; //kJ/kg
5  sigma_dQ=heat_supplied-heat_rejected;
6
7  work_done=1000;
8  work_reqr=5;
9  sigma_dW=work_reqr-work_done;
10
11 m=-sigma_dW/sigma_dQ
12 disp("steam mass flow rate required is:");
13 disp("kg/s",m)
```

---

**Scilab code Exa 1.4** chapter 1 example 4

```
1 clc ;
2 Q=-45; //kJ/kg
3 W=90; //kJ/kg
4
5 u2_u1=Q+W;
6 disp("gain in internal energy is:");
7 disp("kJ/kg",u2_u1);
```

---

**Scilab code Exa 1.5** chapter 1 example 5

```
1 clc ;
2 W=-100; //kJ/kg
3 u2=200; //kJ/kg
4 u1=420; //kJ/kg
5
6 Q=u2-u1-W;
7 disp("heat rejected by the air is:");
8 disp("kJ/kg",-Q);
```

---

**Scilab code Exa 1.6** chapter 1 example 6

```
1 clc ;
2 c1=60; //m/s
3 W=-14000; //kW
4 m=17; //kg/s
5 h1=1200; //kJ/kg
6 h2=360; //kJ/kg
```

```

7
8 KE_I=c1^2/2000; //kJ/kg
9 KE_0=(2.5^2)*KE_I;
10 //c2=2.5*c1;
11
12 Q=m*{[h2+(KE_I/1000)]-[h1+(KE_0/1000)]}-W;
13 disp("Heat rejected:");
14 disp("kW" , -Q);
15
16 v=0.5; //m^2
17 A=m*v/c1;
18 disp("inlet area is");
19 disp("m^2" , A)

```

---

#### Scilab code Exa 1.7 chapter 1 example 7

```

1 clc;
2 c1=6; //m/s
3 c2=4.5; //m^2
4 p1=10^5; //bar
5 p2=6.9*10^5; //bar
6 v1=0.85; //m^3/kg
7 v2=0.16; //m^3/kg
8 u2_u1=88; //kJ/kg
9 m=0.4; //kg/s
10 Q=-59; //kW
11
12 KI=c1^2/2000;
13 K0=c2^2/2000;
14
15 W=m*{(u2_u1)+(p2*v2-p1*v1)+(K0-KI)}-Q;
16 disp("powar input required is:");
17 disp("kW" , W/1000);
18
19 A1=m*(v1/c1);

```

```
20 disp("inlet pipe cross section area is:");
21 disp("m^2",A1);
22
23 A2=m*(v2/c2);
24 disp("outlet pipe cross section area is:");
25 disp("m^2",A2);
```

---

# Chapter 2

## The Working Fluid

Scilab code Exa 2.1 1

```
1  clc;
2
3  x=0.9;
4  vg=0.1104;
5  v=x*vg;
6  disp("specific volume is:");
7  disp("m^3/kg",v)
8
9  hf=885;
10 h_fg=1912;
11 h=hf+x*h_fg;
12 disp("specific enthalpy is:");
13 disp("kJ/kg",h);
14
15 uf=883;
16 ug=2598;
17 u=(1-x)*uf+x*ug;
18 disp("specific internal energy is:");
19 disp("kJ/kg",u);
```

---

### Scilab code Exa 2.2 2

```
1  clc;
2
3  p=7; //bar
4  h=2600; //kJ/kg
5  hf=697; //kJ/kg
6  h_fg=2067; //kJ/kg
7  x=(h-hf)/h_fg;
8  disp("dryness fraction is:");
9  disp(x);
10
11  vg=0.2728;
12  v=x*vg;
13  disp("specific volume is:");
14  disp("m^3/kg",v);
15
16  uf=696;
17  ug=2573;
18  u=(1-x)*uf+x*ug;
19  disp("specific internal energy is:");
20  disp("kJ/kg",u)
```

---

### Scilab code Exa 2.3 3

```
1  clc;
2
3  //at 110 bar, vg=0.01598m^3/kg which is less than
   the actual specific volume of 0.0196m^3/kg
4  //hence it is superheated
5
6  v=0.0196; //m^3/kg
```



```

7 p=110; //bar
8 //from tables
9 h=2889; //kJ/kg
10 t=350; //C
11 disp("temperature is:");
12 disp("C",t);
13 u=h-(p*10^5)*(v/1000);
14 disp("enthalpy is:");
15 disp("kJ/kg",u);
16 disp("specific internal energy is:");
17 disp("kJ/kg",u);

```

---

#### Scilab code Exa 2.4 4

```

1 clc;
2
3 p=150; //bar
4 h=3309; //kJ/kg
5
6 //from tables
7 hg=2611; //kJ/kg
8 //hence the steam is superheated.
9
10 //from table
11 t=500; //C
12 v=0.02078; //m^3/kg
13 disp("temperature is:");
14 disp("C",t);
15 disp("specific volume is:");
16 disp("m^3/kg",v);
17
18 u=h-(p*10^5)*(v/1000);
19 disp("specific internal energy is:")
20 disp("kJ/kg",u)

```

---

### Scilab code Exa 2.5 5

```
1  clc;
2
3  //from tables;
4  v_a=0.1115; //m^3/kg
5  p_b=20; //bar
6  v_d=0.4743; //m^3/kg
7
8  hf=763; //kJ/kg
9  h=2650; //kJ/kg
10 h_fg=2015; //kJ/kg
11 x=(h-hf)/h_fg;
12 vg=0.1944; //m^3/kg
13 v_c=x*vg;
14
15 clf();
16 x=linspace(0.05,0.5,1000);
17 y=(0.09957*20)*((x)^(-1));
18 plot2d(x,y,style=1);
19
20 y=20;
21 plot(x,y)
22
23 y=10;
24 plot(x,y);
25
26 y=(0.4743*6)*((x)^(-1));
27 plot2d(x,y,style=4);
28
29 y=(0.1115*20)*((x)^(-1));
30 plot2d(x,y,style=2);
31
32 y=6;
```

```
33 plot2d(x,y,style=4)
```

---

### Scilab code Exa 2.6 6

```
1  clc;
2  //from tables;
3
4
5  v_a=0.1115; //m^3/kg
6  u_a=2681; //kJ/kg
7  //steami s super heated
8  disp("internal energy of part a is:");
9  disp("kJ/kg",u_a);
10
11 p_b=20; //bar
12 u_b=2600; //kJ/kg
13 disp("internal energy of part b is:");
14 disp("kJ/kg",u_b);
15
16 v_d=0.4743; //m^3/kg
17 u_d=2881; //kJ/kg
18 disp("internal energy of part d is:");
19 disp("kJ/kg",u_d);
20
21 hf=763; //kJ/kg
22 h=2650; //kJ/kg
23 h_fg=2015; //kJ/kg
24 x=(h-hf)/h_fg;
25 ul=762; //kJ/kg
26 ug=2584; //kJ/kg
27 u=(1-x)*ul+x*ug;
28 disp("internal energy of part c is:");
29 disp("kJ/kg",u);
```

---

### Scilab code Exa 2.7 7

```
1  clc;
2
3  //for part (i)
4  hf=89.8; //kJ/kg
5  x=0.95;
6  h_fg=(1420-89.8); //kJ/kg
7  hi=hf+x*h_fg; //kJ/kg
8  disp("enthalpy of part (i)");
9  disp("kJ/kg",hi);
10
11 //for part (ii)
12 //ammonia heated by (60-20) K
13 x=40/50;
14 hf=1462.6; //kJ/kg
15 h_fg=(1597.2-1462.6); //kJ/kg
16 hii=hf+x*h_fg;
17 disp("enthalpy of part (ii)");
18 disp("kJ/kg",hii);
```

---

### Scilab code Exa 2.8 8

```
1  clc;
2  v1=0.2*10^5; //m^3
3  p1=1.013; //bar
4  T1=15+273; //C
5  w=0.2; //kg
6  m=28; //kg/k mole
7  R_=8314.5; //N m/K
8
9  R=R_/m;
```

```

10 m1=p1*v1/(R*T1);
11
12 m2=0.20+.237;
13 //T2=T1 & v2=v1
14 p2=m2*R*T1/v1
15 disp("the new pressure is:");
16 disp(" bar" ,p2)

```

---

### Scilab code Exa 2.9 9

```

1  clc;
2  p1=7*10^5; //bar
3  V1=0.003; //m^3/kg
4  m=0.01;
5  T1=131+273; //K
6  R_=8314.5;
7
8  R=p1*V1/(m*T1);
9
10 m_=R_/R;
11 disp("the molar mass of the gas is:");
12 disp(" kg/k mole" ,m_);
13
14 p2=1*10^5; //bar
15 V2=0.02; //m^3
16 m=0.01;
17 R=520;
18 T2=p2*V2/(m*R);
19 disp("final temperature is:");
20 disp("C" ,T2-273);

```

---

### Scilab code Exa 2.10 10

```

1  clc;
2  cp=0.846; //kJ/kg K
3  cv=0.657; //kJ/kg K
4
5  R=(cp-cv)*1000;
6  disp("the gas constant is:");
7  disp("N m/kg K",R);
8
9  R_=8314.5
10 m=R_/R;
11 disp("molar mass of the gas:");
12 disp("kg/k mole",m);

```

---

#### Scilab code Exa 2.11 11

```

1  clc;
2  R_=8314.5;
3  m_=26; //kg/k mole
4  y=1.26;
5
6  R=R_/m_;
7  cv=R/[(y-1)*1000];
8  cp=y*cv;
9
10 T1=315+273; //K
11 p2=1.5; //bar
12 p1=3; //bar
13 T2=T1*p2/p1;
14
15 Q=cv*(T2-T1);
16 disp("heat rejected in part a:");
17 disp("kJ/kg",-Q);
18
19 T2=20; //K
20 T1=280; //K

```

```
21 m_ = 1;  
22 Q = m_ * cp * (T2 - T1);  
23 disp("heat rejected in part b");  
24 disp("kW", -Q);
```

---

# Chapter 3

## Reversible and Irreversible processes

Scilab code Exa 3.1 1

```
1  clc
2  //at 2bar
3  h1=2707; //kJ/kg
4  hg=h1;
5  m1=0.05; //kg
6  v=0.0658; //m^3
7  v2=v/m1; //m^3/kg
8  h2=3072; //kJ/kg
9  p=2*10^5;
10 v1=0.8856
11
12 Q=m1*(h2-h1);
13 disp("heat supplied is:");
14 disp("kJ",Q);
15
16 W=-p*(v2-v1);
17 disp("work done is:");
18 disp("N m/kg",W);
19
```



```

20 //part (ii)
21 p2=p;
22 R=0.287;
23 T2=p2*v/(m1*R*1000);
24 cp=1.005;
25 T1=130+273;
26 Q=m1*cp*(T2-T1);
27 disp("heat supplied in part (ii)");
28 disp("kJ",Q);
29
30 W=-R*(T2-T1)*m1;
31 disp("work done by the mass of gas present:");
32 disp("kJ",W);

```

---

### Scilab code Exa 3.2 2

```

1 clc;
2 x=0.9;
3 uf=696;
4 ug=2573;
5 u1=(1-x)*uf+x*ug;
6 //similarly
7 u2=2602.8;
8
9 disp("change of internal energy is:");
10 disp("kJ/kg",u2-u1);
11
12 hf=697;
13 h_fg=2067;
14 h1=hf+x*h_fg;
15 h2=2803; //kJ/kg
16 disp("change in enthalpy:");
17 disp("kJ/kg",h2-h1);
18
19 Q=547;

```

```
20 W=(u2-u1)-Q;
21 disp("Work done is:");
22 disp("kJ/kg",W)
```

---

### Scilab code Exa 3.3 3

```
1 clc;
2 R_=8.3145;
3 m_=28;
4 R=R_/m_;
5 T=273+20;
6 p2=4.2; //bar
7 p1=1.01; //bar
8 W=R*T*log(p2/p1);
9 disp("work input:");
10 disp("kJ/kg",W);
11
12 disp("heat rejected:");
13 disp("kJ/kg",W); //Q+W=0
```

---

### Scilab code Exa 3.4 3

```
1 clc;
2 h1=3017; //kJ/kg
3 v1=0.02453; //m^3/kg
4 p1=100; //bar
5 u1=h1-p1*v1*10^5/1000;
6 ug=2602; //kJ/kg
7 u2=ug;
8 W=u2-u1;
9 disp("work done by system is :");
10 disp("kJ/kg",-W)
```

---

### Scilab code Exa 3.5 5

```
1  clc;
2  T1=295; //C
3  p1=1.02; //bar
4  p2=6.8; //bar
5  y=1.4;
6  v1=0.015; //m^3
7  cv=0.718;
8  R=0.287
9
10 T2=T1*(p2/p1)^((y-1)/y);
11 disp(" final temperature is:");
12 disp("k",T2);
13
14 v2=v1*{(p1/p2)^(1/y)};
15 disp(" final volume is:");
16 disp("m^3",v2);
17
18 w=cv*(T2-T1);
19 m=p1*v1*10^5/(10^3*R*T1);
20 W=w*m;
21 disp(" total work done is:");
22 disp("kJ",W)
```

---

### Scilab code Exa 3.6 6

```
1  clc;
2  p1=1; //bar
3  p2=10; //bar
4  n=1.1;
5  v1=0.16; //m^3
```

```

6
7 v2=v1*(p1/p2)^(1/n);
8
9 W=(p2*v2-p1*v1)*10^5/[10^3*(n-1)];
10 disp("work done by the refrigerant is:");
11 disp("kJ",W);
12
13 hg1=174.2;
14 u1=hg1-(p1*10^5*v1/10^3);
15
16 hg2=203.8; //kJ/kg
17 vg2=0.018; //m^3
18 v=0.02; //m^3
19 h=224; //kJ/kg
20 h2=hg2+(v2-vg2)*(h-hg2)/(v-vg2);
21 u2=h2-(p2*10^5*v2/10^3)
22
23 Q=-W+(u2-u1);
24 disp("heat transferred is:");
25 disp("kJ/kg",Q)

```

---

### Scilab code Exa 3.7 7

```

1 clc;
2 T1=300; //K
3 p2=6.6; //bar
4 p1=1.1; //bar
5 n=1.3;
6 T2=T1*[(p2/p1)^((n-1)/n)];
7
8 R_=8.3145;
9 m_=30;
10 R=R_/m_;
11
12 cp=2.10;

```

```

13 cv=cp-R;
14 y=cp/cv;
15 W=R*(T2-T1)/(n-1);
16 Q=(n-y)/(y-1)
17 disp("heat supplied is:");
18 disp("kJ/kg",Q);
19
20 m_=40;
21 R=R_/m_;
22 cp=0.520; //kJ/kg
23 cv=cp-R;
24 y=cp/cv;
25 W=R*(T1-T2)/(n-1);
26 Q=[(n-y)/(y-1)]*W
27 disp("heat rejected is:")
28 disp("kJ/kg",Q)

```

---

### Scilab code Exa 3.8 8

```

1 clc;
2 p1=7; //bar
3 p2=1; //bar
4 y=1.333;
5 T1=923; //K
6 T2=T1/[(p1/p2)^((y-1)/y)]
7
8 cp=1.11;
9 c2=45;
10 c1=9;
11 W=cp*(T2-T1)+[(c2^2-c1^2)/(2*10^3)];
12 disp("power output is");
13 disp("kW", -W)

```

---

### Scilab code Exa 3.9 9

```
1  clc ;
2  V1=1; //m^3
3  VA=1; //m^3
4  VB=1; //m^3
5  V2=VA+VB;
6  p1=20; //BAR
7  p2=p1*(V1/V2);
8  disp("final pressure is:");
9  disp("bar" ,p2);
```

---

### Scilab code Exa 3.10 10

```
1  clc ;
2  h3=2716.4; //kJ/kg
3  hf2=640;
4  h_fg2=2109;
5  x2=(h3-hf2)/(h_fg2);
6
7  flow_rate=9;
8  m_w2=(1-x2)*(flow_rate);
9  mass_water=0.5;
10 m_w1=m_w2+mass_water
11
12 flow_rate_dry=mass_water+flow_rate-m_w1;
13 x1=flow_rate_dry/(mass_water+flow_rate);
14 disp("fraction is:");
15 disp(x1)
```

---

### Scilab code Exa 3.11 11

1

```

2  clc;
3  x=0.9;
4  uf=511;
5  ug=2531;
6  u=uf*(1-x)+(ug*x);
7  V=10;
8  vg=0.8461;
9  v=x*vg;
10 m=V/v;
11 h=2944;
12 u2=2640;
13 v2=0.3522;
14 m2=V/v2;
15 Q=m2*u2-m*u-h*(m2-m);
16 disp("heat rejected is;");
17 disp("kJ", -Q)
18 //Answers vary more than than +/-5 :
19 //Answers in the textbook is wrong

```

---

### Scilab code Exa 3.12 12

```

1  clc;
2  p=15; //bar
3  V=6; //m^3;
4  R=0.287;
5  T=313.5;
6  y=1.4
7
8  m=p*V/(R*T);
9
10 p2=12; //bar
11 T2=T/[(p/p2)^((y-1)/y)];
12 m2=p2*V*10^5/(R*T2*10^3);
13
14 disp("mass of air left");

```

15 `disp(" kg" ,m2)`

---



# Chapter 4

## The Second Law

Scilab code Exa 4.1 1

```
1  clc ;
2  s1=6.5;
3  sf1=1.992;
4  sfg1=4.717;
5  x=(s1-sf1)/sfg1;
6
7  hf1=697; //kJ/kg
8  hfg1=2067; //kJ/kg
9  h1=hf1+x*hfg1;
10
11 h2=2995; //kJ/kg
12 Q=h2-h1;
13
14 disp("heat supplied:");
15 disp("kJ/kg",Q)
```

---

Scilab code Exa 4.2 2

```

1  clc;
2  v=0.025; //m^3
3  s=0.02994; //m^3/kg
4  m=v/s;
5
6  h1=2990; //
7  p1=s/10^3;
8  v1=80*10^5;
9  u1=h1-p1*v1;
10
11 v2=s;
12 vg1=0.03944;
13 x1=v2/vg1;
14
15 uf2=1149;
16 ug2=2597;
17 u2=(1-x1)*uf2+x1*ug2;
18
19 Q=m*(u2-u1);
20 disp("kJ", -Q, "rejected heat:")

```

---

### Scilab code Exa 4.3 3

```

1  clc;
2  p=1.05; //bar
3  V=0.02; //m^3
4  R=0.287; //m^3
5  T=15+273; //K
6  m=p*V*10^5/(R*T*10^3);
7
8  p2=4.2; //bar
9  T2=p2*T/p;
10
11 cv=0.714;
12 Q=m*cv*(T2-T);

```

```

13 Q_12=Q;
14
15 cp=1.005;
16 T3=288; //K
17 Q_23=m*cp*(T3-T2);
18
19 Q=Q_12+Q_23;
20 disp("heat rejected is:");
21 disp("kJ",-Q);
22
23 ch_entro=m*cp*log(T2/T3)-m*cv*log(T2/T3);
24 disp("decrease in entropy of air is:");
25 disp("kJ/K",ch_entro)

```

---

#### Scilab code Exa 4.4 4

```

1 clc;
2 s1=5.615; //kJ/kg K
3 t1=311; //C
4 t2=300; //C
5 t3=350; //C
6 s2=7.124+(t1-t2)/(t3-t2)*(7.301-7.124);
7
8 T=t1+273; //K
9 Q=T*(s2-s1);
10 disp("heat supplied is:");
11 disp("kJ/kg",Q)
12
13 u1=2545; //kJ/kg
14 u2=2794+(t1-t2)/(t3-t2)*(2875-2794);
15
16 W=(u2-u1)-Q
17 disp("work done by the steam is:");
18 disp("kJ/kg",-W)

```

---

### Scilab code Exa 4.5 5

```
1  clc ;
2  R_=8314.5;
3  m_=28;
4  R=R_/m_
5  p1=1.05; //bar
6  p2=4.2; //bar
7  s2=R*log(p1)/1000;
8  s1=R*log(p2)/1000;
9  disp("change of entropy is:");
10 disp("kJ/kg K",s2-s1);
11
12 T=15+273;
13 V=0.03;
14 m=p1*V*10^5/(R*T);
15 S1=m*s1;
16 S2=m*s2;
17 Q=T*(S1-S2);
18 disp("heat rejected is:");
19 disp("kJ/kg",Q);
20
21 W=-Q;
22 disp("work done is:");
23 disp("kJ",W)
```

---

### Scilab code Exa 4.6 6

```
1  clc ;
2  s1=6.091; //kJ/kg K
3  s2=s1;
4  sf=2.138; //kJ/kg K
```

```

5  sfg2=4.448;
6  x2=(s2-sf)/sfg2;
7
8  uf=762;
9  ug=2584;
10 u2=(1-x2)*uf+x2*ug;
11
12 h1=3017;
13 p1=100; //bar
14 v1=0.02453; //m^3
15 u1=h1-p1*v1*10^5/10^3;
16
17 W=u2-u1;
18 disp("Work done is;")
19 disp("kJ" , -W)

```

---

#### Scilab code Exa 4.7 7

```

1  clc;
2  s1=1.7189;
3  v1=0.0978; //m^3
4  p1=2.01; //bar
5  p2=10; //bar
6  lamda=1.1;
7
8  v2=v1*(p1/p2)^(1/lamda);
9
10 s_1=1.7564; //kJ/kg K
11 s_2=1.7847; //kJ/kg K
12 v_1=0.0228; //m^3
13 v_2=0.0222; //m^3
14 v_3=0.0233; //m^3
15 s2=s_1+[(v_1-v_2)/(v_3-v_2)]*(s_2-s_1)
16 disp("increase in entropy");
17 disp("kJ/kg K" , s2-s1)

```

---

### Scilab code Exa 4.8 8

```
1  clc;
2  p1=6.3; //bar
3  p2=1.05; //bar
4  n=1.3;
5  T1=823; //K
6  T2=T1/([p1/p2]^([n-1]/n))
7  R=0.287;
8  sA_s1=R*log(p1/p2); //sA_s1=sA-s1
9  cp=1.005;
10 sA_s2=cp*log(T1/T2);
11
12 disp("increase in entropy is:");
13 disp("kJ/kg",sA_s1-sA_s2)
```

---

### Scilab code Exa 4.9 9

```
1  clc;
2  R_=8314.5;
3  m_=44;
4  R=R_/m_;
5
6  p2=8.3; //bar
7  V2=0.004; //m^3
8  m=0.05;
9  T2=p2*V2*10^5/(m*R);
10
11 p2=8.3; //bar
12 pA=1; //bar
13 sA_s2=(R/1000)*log(p2/pA);
```

```
14
15 cp=0.88;
16 T2=351; //K
17 T1=288; //K
18 sA_s1=cp*log(T2/T1);
19
20 dec_ent=m*(sA_s2-sA_s1);
21 disp("decrease in entropy is:");
22 disp("kJ/K",dec_ent)
```

---

#### Scilab code Exa 4.10 10

```
1 clc;
2 x1=0.96;
3 sf1=1.992;
4 sfg1=4.717;
5 s1=sf1+x1*sfg1;
6
7 hf1=697;
8 hfg1=2067;
9 h1=hf1+x1*hfg1;
10 h2=h1;
11
12 hf2=584;
13 hfg2=2148;
14 x2=(h2-hf2)/hfg2;
15
16 sf2=1.727;
17 sfg2=5.214;
18 s2=sf2+x2*sfg2;
19
20 disp("increasi in entropy is:");
21 disp("kJ/kg K",s2-s1)
```

---

### Scilab code Exa 4.11 11

```
1 clc;
2 R=0.287;
3 ch_ent=R*log(2); //V2=2*V1
4 disp("increase in entropy is:");
5 disp("kJ/kg K",ch_ent);
```

---

### Scilab code Exa 4.12 12

```
1 clc;
2 T1=703; //K
3 p1=6.8; //bar
4 p2=1.013; //bar
5 gama=1.4;
6 T2=T1/[(p1/p2)^( [gama-1]/gama)];
7
8 //from graph:
9 T2s=423; //K
10 cp=1.005;
11 inc_ent=cp*log(T2/T2s);
12 disp("increase in entropy is:");
13 disp("kJ/kg K",-inc_ent)
```

---

### Scilab code Exa 4.13 13

```
1 clc;
2 h1=3248; //kJ/kg
3 h2=2965; //kJ/kg
```



```

4 h2s=2753+[(7.126-6.929)/(7.172-6.929)]*(2862-2753);
5
6 eff=(h1-h2)/(h1-h2s);
7 disp("isentropic efficiency is:");
8 disp("%",eff*100);
9
10 s1=7.126; //kJ/kg K
11 s2=7.379; //kJ/kg K
12 T0=288; //K
13 loss=h1-h2+T0*(s2-s1);
14 disp("loss of energy is:");
15 disp("kJ/kg K",loss);
16
17 e=(h1-h2)/loss;
18 disp("effectiveness is:");
19 disp("%",e*100);

```

---

#### Scilab code Exa 4.14 14

```

1 clc;
2 T2=90; //K
3 T3=40; //K
4 T1=15; //K
5 y=(T3-T1)/(T2-T3);
6
7 cp=1.005;
8 h3=40;
9 h1=15;
10 h2=90;
11 T0=288; //K
12 T3=313; //K
13 T1=288; //K
14 T2=363; //K
15 s3_s1=cp*log(T3/T1);
16 inc=cp*(h3-h1)-T0*s3_s1;

```

```

17
18 s2_s3=cp*log(T2/T3)
19 loss=0.5*[cp*(h2-h3)-T0*(s2_s3)]
20 e=inc/loss;
21 disp("effectiveness is:");
22 disp("%",e*100); //ans diff due to difference in
    value of logarithmic values

```

---

#### Scilab code Exa 4.15 15

```

1  clc;
2  cp=6.3;
3  h2=70;
4  h1=15;
5  T0=283; //K
6  T1=343; //K
7  T2=288; //K
8  T3=1400+273; //K
9  s2_s1=cp*log(T1/T2);
10 b2_b1=cp*(h2-h1)-T0*(s2_s1);
11
12 loss=cp*(h2-h1)*(1-T0/T3)
13 eff=b2_b1/loss
14 disp("effectiveness is:")
15 disp("%",eff*100)

```

---

# Chapter 5

## The Heat Engine Cycle

Scilab code Exa 5.1 1

```
1 clc;
2 T2=10+273; //K
3 T1=2000+273; //K
4 eta=1-T2/T1;
5 disp(" highest possible efficiency is:");
6 disp("%", eta*100)
```

---

Scilab code Exa 5.2 2

```
1 clc;
2 T2=15+273;
3 T1=800+273;
4 eta=1-(T2/T1);
5 p4=210; //bar
6 p2=1; //bar
7 R=0.218;
8 sA_s4=R*log(p4/p2);
9
```

```

10 cp=1.005;
11 sA_s2=cp*log(T1/T2);
12
13 output=(T1-T2)*(sA_s4-sA_s2);
14
15 W41=T1*(sA_s4-sA_s2);
16 cv=0.718;
17 W21=cv*(T1-T2);
18
19 gross=W41+W21;
20 disp(W41)
21 work=output/gross;
22 disp("work ratio is");
23 disp(work)

```

---

### Scilab code Exa 5.3 3

```

1  clc;
2  p1=1.02; //nar
3  p2=6.12; //bar
4  y=1.4
5  eta=1-[(p1/p2)^[y-1]/y]
6
7  T1=288; //K
8  T2=[(p1/p2)^[-(y-1)/y]]*T1;
9  T3=800+273; //K
10 T4=T3*[(p1/p2)^[y-1]/y];
11
12 cp=1.005;
13 net_output=cp*(T3-T4)-cp*(T2-T1);
14 gross_output=cp*(T3-T4);
15
16 W=net_output/gross_output
17 disp("Work ratio is:");
18 disp(W)

```

---

#### Scilab code Exa 5.4 4

```
1 clc;
2 bore=5; //cm
3 stroke=7.5; //cm
4 V=(%pi/4)*5^2*7.5
5 V0=21.3;
6 tV=V+V0;
7
8 rv=tV/V0;
9
10 y=1.4;
11 eta=1-[rv^(1-y)];
12 disp(" efficiency is:");
13 disp("%",eta*100)
```

---

#### Scilab code Exa 5.5 5

```
1 clc;
2 T1=15+273; //K
3 T3=1100; //K
4 rv=12;
5 y=1.4;
6
7 T2=T1*rv^(y-1);
8 T3=1373;
9 T2=778;
10 T4=T3/[[rv*(T2/T3)]^(y-1)];
11
12 cp=1.005;
13 Q1=cp*(T3-T2);
```

```

14 cv=0.718;
15 Q=cv*(T4-T1);
16 eta=(Q1-Q)/Q1;
17 disp(" efficiency is: ");
18 disp("%",eta*100)

```

---

### Scilab code Exa 5.6 6

```

1  clc;
2  v1!v2=18;
3  y=1.4;
4  T1=293; //K
5  T2=v1!v2^(y-1)*T1;
6
7  p3=69; //bar
8  p1=1.01; //bar
9  p2=v1!v2^y*p1
10 T3=p3*T2/p2
11
12 cv=0.718;
13 cp=1.005;
14 T4=cv*(T3-T2)/cp+T3;
15
16 v5!v4=v1!v2*(T3/T4);
17 T5=T4/[(v5!v4)^(y-1)];
18 Q1=2*cv*(T3-T2);
19
20 eta=(Q1-[cv*(T5-T1)])/Q1
21 disp(" efficiency is")
22 disp("%",eta)

```

---

### Scilab code Exa 5.7 7

```
1  clc;
2  eta=0.682;
3  Q=260; //kJ/kg
4  W=-eta*Q;
5  R=287;
6  T1=293;
7  p1=1.01
8  v1_v2=(17/18)*(R*T1)/(p1*10^5);
9  pm=-W*10^3/(v1_v2*10^5);
10 disp("mean effective pressure is:");
11 disp(" bar" ,pm)
```

---

# Chapter 6

## Mixtures

Scilab code Exa 6.1 1

```
1  clc ;
2  M_O=23.3/100; //kg
3  M_N=76.7/100; //kg
4  M_C=45/100; //kg
5  R=8.3145;
6  T=288; //K
7  V=0.4; //m^3
8
9  m_o=32;
10 m_n=28;
11 pO=M_O*R*T*10^3/(m_o*V*10^5);
12 pN=M_N*R*T*10^3/(m_n*V*10^5);
13 m_c=28;
14 pC=M_C*R*T*10^3/(m_c*V*10^5);
15 p=pO+pN+pC;
16
17 disp(" bar",pO," partial pressure of Oxygen is:")
18 disp(" bar",pN," partial pressure of Nitrogen is:")
19 disp(" bar",pC," partial pressure of Carbon monoxide
    is:")
20 disp(" bar",p," total pressure is:")
```



---

### Scilab code Exa 6.2 2

```
1  clc;
2  R=8.3145;
3  m_o=31.999;
4  m_n=28.013;
5  m_a=39.948;
6  m_c=44.010;
7
8  R_O=R/m_o;
9  R_N=R/m_n;
10 R_A=R/m_a;
11 R_C=R/m_c;
12
13 miO=0.2314;
14 miN=0.7553;
15 miA=0.0128;
16 miC=0.0005;
17
18 R_=(miO*R_O)+(miN*R_N)+(miA*R_A)+(miC*R_C);
19
20 m_=R/R_
21 disp("specific gas constant of air is:")
22 disp(R_)
23 disp("molar mass of gas is:");
24 disp(m_)
```

---

### Scilab code Exa 6.3 3

```
1  clc;
2  miO=0.2314; //kg/kmole
```

```

3  miN=0.7553; //kg/kmole
4  miA=0.0128; //kg/kmole
5  miC=0.0005; //kg/kmole
6
7  m_O=31.999; //kg/kmole
8  m_N=28.013; //kg/kmole
9  m_A=39.948; //kg/kmole
10 m_C=44.010; //kg/kmole
11
12 niO=miO/m_O; //kmole
13 niN=miN/m_N; //kmole
14 niA=miA/m_A; //kmole
15 niC=miC/m_C; //kmole
16
17 n=niO+niN+niA+niC; //kmole
18
19 V_O=niO*100/n;
20 V_N=niN*100/n;
21 V_A=niA*100/n;
22 V_C=niC*100/n;
23
24 p=1;
25 piO=V_O*p/100;
26 piN=V_N*p/100;
27 piA=V_A*p/100;
28 piC=V_C*p/100;
29
30 disp("analysis of volume of Oxygen, Nitrogen, Argon
      and Carbon dioxide respectively are");
31 disp(V_C,V_A,V_N,V_O);
32
33 disp("partial pressure of Oxygen, Nitrogen, Argon
      and Carbon dioxide respectively are");
34 disp(piC,piA,piN,piO);

```

---

#### Scilab code Exa 6.4 4

```
1  clc ;
2  V0=0.21 ;
3  VN=0.79 ;
4  n=3.5 ;
5
6  nO=V0*n ;
7  nN=VN*n
8  nC=1 ;
9
10 m_0=32 ;
11 m_N=28 ;
12 m_C=44 ;
13
14 mO=m_0*nO ;
15 mN=m_N*nN ;
16 mC=m_C*nC ;
17
18 m=mO+mN+mC ;
19 disp(" total mass is:");
20 disp(" kg" ,m) ;
21
22 //percentage of carbon is
23 mc=12 ;
24 P=mc*100/m ;
25 disp(" percentage of carbon is:");
26 disp("%" ,P)
27
28
29 n=nO+nN+nC ;
30 m_=[nO*m_0/n]+[nN*m_N/n]+[nC*m_C/n]
31
32 R_=8.3145 ;
33 R=R_/m_ ;
34 disp(" specific gas constant for the mix is:");
35 disp(" kJ/kg K" ,R) ;
36
```

```

37 T=288; //K
38 p=1; //bar
39 v=R*T*10^3/(p*10^5);
40 disp("specific volume of the mix at 1 bar and 15 C
      is");
41 disp("m^3/kg",v)

```

---

#### Scilab code Exa 6.5 5

```

1  clc;
2  nH=0.5; //kmole
3  m_0=32;
4  VH!V0=2;
5  x=m_0*nH/VH!V0;
6  disp("mass of oxygen required is:");
7  disp("kg",x)
8  n0=x/m_0;
9  n=nH+n0;
10 R_=8.3145;
11 T=288; //K
12 p=1; //bar
13 V=n*R_*T*10^3/(p*10^5);
14 disp("Volume of container is:");
15 disp("m^3",V);

```

---

#### Scilab code Exa 6.6 6

```

1  clc;
2  m_H=2;
3  m_CO=28;
4  xH=0.8;
5  xCO=0.2;
6

```

```

7 m_ =xH*m_H+xCO*m_CO ;
8
9 x=(xH-0.5)*9;
10 disp("mass of mixture removed is:");
11 disp(" kg" ,x)
12
13 y=28/7.2*x;
14 disp("mass of CO added");
15 disp(" kg" ,y)

```

---

### Scilab code Exa 6.7 7

```

1  clc;
2  nC=0.120; //kmol
3  nO=0.115; //kmol
4  nN=0.765; //kmol
5
6  m_C=44; //kg/kmol
7  m_O=32; //kg/kmol
8  m_N=28; //kg/kmol
9
10 miC=m_C*nC; //kg
11 miO=m_O*nO; //kg
12 miN=m_N*nN; //kg
13
14 m=miC+miO+miN;
15
16 cpC=1.271; //kJ/kgK
17 cpO=1.110; //kJ/kgK
18 cpN=1.196; //kJ/kgK
19
20 cp=cpC*(miC/m)+cpO*(miO/m)+cpN*(miN/m);
21
22 R_=8.3145; //kJ/kg K
23

```

```

24 R=(miC/m)*(R_/m_C)+(miO/m)*(R_/m_O)+(miN/m)*(R_/m_N)
    ;
25
26 cv=cp-R;
27
28 T1=1000+273;
29 v1!v2=1/7;
30 n=1.25;
31 T2=T1*(v1!v2)^(n-1);
32
33 W=R*(T2-T1)/(n-1);
34 disp("Work done by th gas mixture is:");
35 disp("kJ/kg",-W,R,T2);
36
37 disp("heat supplied is:");
38 Q=[cv*(T2-T1)]-W;
39 disp("kJ/kg",Q);

```

---

### Scilab code Exa 6.8 8

```

1  clc;
2  R=0.274;
3  T1=1000+273;
4  v1!v2=1/7;
5  n=1.25;
6  T2=T1*(v1!v2)^(n-1);
7  sA_s1=R*log(1/v1!v2);
8
9  cv=0.925;
10 sA_s2=cv*log(T1/T2);
11 disp("change of entropy of mixture is:");
12 disp("kJ/kg K",sA_s1-sA_s2);

```

---

### Scilab code Exa 6.9 9

```
1  clc ;
2  cp_CO=29.27; //kJ/kmol K
3  cp_H=28.89; //kJ/kmol K
4  cp_CH4=35.80; //kJ/kmol K
5  cp_CO2=37.22; //kJ/kmol K
6  cp_N=29.14; //kJ/kmol K
7
8  niCO=0.29;
9  niH=0.12;
10 niCH4=0.03;
11 niCO2=0.04;
12 niN=0.52;
13
14 cp_=cp_CO*niCO+cp_H*niH+cp_CH4*niCH4+cp_CO2*niCO2+
    cp_N*niN;
15
16 R_=8.3145;
17 cv_=cp_-R_;
18
19 m_CO=28;
20 m_H=2;
21 m_CH4=16;
22 m_CO2=44;
23 m_N=28;
24
25 m_=niCO*m_CO+niH*m_H+niCH4*m_CH4+niCO2*m_CO2+niN*m_N
    ;
26
27 cp=cp_/m_ ;
28 cv=cv_/m_ ;
29
30 disp("the values of cp_ ,cv_ ,cp and cv respectively
    are:");
31 disp("kJ/kg K" ,cv_,"kJ/kg K" ,cp_,"kJ/kg K" ,cv_ ,"kJ/kg
    K" ,cp_)
```

---

### Scilab code Exa 6.10 10

```
1  clc;
2  p0=7; //bar
3  V0=1.5; //m^3
4  R_=8.3145;
5  T0=313; //K
6  n0=p0*V0*10^5/(R_*T0*10^3);
7
8  pC=1; //bar
9  VC=3; //m^3
10 TC=288; //K
11 nC=pC*VC*10^5/(R_*TC*10^3);
12
13 cv0=21.07;
14 cvC=20.86;
15 U1=n0*cv0*T0+nC*cvC*TC;
16 U2_T=n0*cv0+nC*cvC;
17
18 T=U1/U2_T;
19
20 p=(n0+nC)*R_*T*10^3/(V0+VC)/10^5;
21 disp(" final temperature and pressure of mixture is:"
      );
22 disp(" bar" ,p, "K" ,T)
23
24 //part ( II )
25 VA=4.5; //m^3
26 SA_S1_0=n0*R_*log(VA/V0);
27 SA_S2_0=n0*cv0*log(T0/T);
28 q1=SA_S1_0-SA_S2_0;
29
30 SA_S1_C=nC*R_*log(VA/VC);
31 SA_S2_C=nC*cvC*log(TC/T);
```



```
32 q2=SA_S1_C-SA_S2_C;
33
34 disp("change in entropy is:");
35 disp("kJ/k",q1+q2);
```

---

#### Scilab code Exa 6.11 11

```
1  clc;
2  V=0.3; //m^3
3  vg=4.133; //m^3/kg
4  m=V/vg;
5  disp("mass of water injected:");
6  disp("kg",m)
7
8  //part B
9  pa=0.7; //bar
10 pg=0.3855; //bar
11 v=0.001026;
12 ms=(V-[pa*v])/[vg-v];
13
14 mw=pa-ms;
15 V_d=ms*vg
16 pa2=pa*V/V_d;
17 disp("total pressure is:");
18 disp("bar",pa2+pg);
```

---

#### Scilab code Exa 6.12 12

```
1  clc;
2  ni!n=0.15;
3  p=1.4; //bar
4  x=ni!n*p;
```

```

5 //saturation temperature corresponding to 0.21 bar
   is 61.15 C
6 t=61.15; //C
7 disp("Temperature required is:");
8 disp("C",t)

```

---

### Scilab code Exa 6.13 13

```

1 clc;
2 ma=0.3/1000; //kg
3 Ra=0.287;
4 T=311; //K
5 V=21.63 //m^3
6
7 p=ma*Ra*T*10^3/(V*10^5);
8
9 T2=36+273; //K
10 p2=0.0594; //bar
11 vg=23.97; //m^3/kg
12 pt=0.6624; //bar
13 pa=pt-p2;
14 mf=20000*0.3/1000;
15
16 Vr=mf*Ra*T2*10^3/(pa*10^5);
17
18 ms=Vr/vg
19
20 T3=300; //K
21 P3=0.0306;
22 v=mf*(Ra)*T3*10^3/(P3*10^5)
23
24 vg1=38.81;
25 steam=v/vg1;
26 disp("steam removed is:");
27 disp("kg/H",steam)

```

---

Scilab code Exa 6.14 14

```
1  clc;
2  capacity_ac=778; //m^3/h
3  capacity=168.9; //m^3/h
4
5  red=(capacity_ac-capacity)*100/capacity_ac
6  disp("percentage reduction in air pump is:");
7  disp("%",red);
8
9  ms2=4.35; //kg/h
10 ms1=20000; //kg/h
11 ma1=6; //kg/h
12 ma2=ma1;
13 mc=20000; //apprx
14
15 hs2=2550.3;
16 hc=150.7;
17 hs1=2570.1;
18
19 cp=1.005;
20 T1=38;
21 T2=27;
22 ha1_ha2=cp*(T1-T2);
23
24 Q=ms2*hs2+{ma1*ha1_ha2}+mc*hc-ms1*hs1;
25
26 //mass of cooling water required
27 disp("mass of cooling water required");
28 t=5.5
29 M=-Q/(t*4.182);
30 disp(" kg/h",M)
```

---

# Chapter 7

## Combustion

Scilab code Exa 7.1 1

```
1  clc;
2  m_C=12;
3  m_O2=32;
4  x_C=0.9;
5  O_req_CO2=x_C*([m_O2*1]/[m_C*1]);
6  CO2_prod=x_C*([m_C*1]+[m_O2*1])/[m_C*1];
7  //HYDROGEN
8  m_H2=2;
9  x_H=0.03;
10
11  O_req_H2O=x_H*[m_O2/2/2];
12  steam_prod=x_H*{0.5*[(m_H2)+(m_O2)/2]};
13  //SULPHUR
14  m_S=32;
15  x_S=0.005;
16  O_req_SO2=x_S*(m_O2/32);
17  SO2_prod=2*x_S;
18
19  O_req=O_req_CO2+O_req_H2O+O_req_SO2;
20  %O=23.3;
21  A=O_req*100/%O;
```

```

22 disp("A/F ratio is:");
23 disp(A);
24
25 //part (ii)
26 actual_A=A*(1+0.2);
27 %N=076.7;
28 m_N2=28;
29 N_supp=actual_A*%N/100;
30 O_supp=actual_A*%O/100;
31 x_N=0.01;
32 N2=N_supp+x_N;
33 O2=O_supp-O_req;
34 disp(" actual A/F ratio is");
35 disp(actual_A);
36
37 m_CO2=m_C+m_O2;
38 m_H2O=m_H2+0.5*m_O2;
39 m_SO2=m_S+m_O2;
40
41 ni_CO2=CO2_prod/m_CO2;
42 ni_H2O=steam_prod/m_H2O;
43 ni_SO2=SO2_prod/m_SO2;
44 ni_O2=O2/m_O2;
45 ni_N2=N2/m_N2;
46
47 n_wet=ni_CO2+ni_H2O+ni_SO2+ni_O2+ni_N2;
48 n_dry=ni_CO2+ni_SO2+ni_O2+ni_N2;
49 disp(O_supp)
50 CO2_wet=ni_CO2/n_wet;
51 H2O_wet=ni_H2O/n_wet;
52 SO2_wet=ni_SO2/n_wet;
53 O2_wet=ni_O2/n_wet;
54 N2_wet=ni_N2/n_wet;
55
56 disp(" wet analysis of CO2,H2O,SO2,O2,N2");
57 disp(N2_wet*100,O2_wet*100,SO2_wet*100,H2O_wet*100,
      CO2_wet*100);

```

---

## Scilab code Exa 7.2 2

```
1  clc;
2  //part I
3  %H2=0.494;
4  %CO=0.18;
5  %CH4=0.2;
6  %C4H4=0.02;
7  %O2=0.004;
8  %N2=0.062;
9  %CO2=0.04;
10
11  O_H2=%H2/2;
12  O_CO=%CO/2;
13  O_CH4=%CH4*2;
14  O_C4H4=%C4H4*6;
15  O_O2=-%O2*1;
16
17  C_CO=%CO;
18  C_CH4=%CH4;
19  C_C4H8=4*%C4H4;
20  C_CO2=%CO2;
21
22  H_H2=%H2;
23  H_CH4=2*%CH4;
24  H_C4H8=4*%C4H4;
25
26  O_Tot=O_C4H4+O_CH4+O_CO+O_H2+O_O2;
27  C_Tot=C_CO+C_CH4+C_C4H8+C_CO2;
28  H_Tot=H_H2+H_CH4+H_C4H8;
29
30  AF=O_Tot/0.21;
31  disp(AF,"stoichiometric A/F ratio is:")
32
```

```

33 //partII
34
35 actual_AF=AF+0.2*AF;
36 Ass_N2=0.79*actual_AF;
37 Exs_O2=(0.21*actual_AF)-O_Tot;
38 N2_Tot=Ass_N2+%N2;
39
40 Tot_wet=H_Tot+C_Tot+Exs_O2+N2_Tot;
41 Tot_dry=C_Tot+Exs_O2+N2_Tot;
42
43 C_dry=(C_Tot)/Tot_dry*100;
44 O_dry=(Exs_O2)/Tot_dry*100;
45 N_dry=(N2_Tot)/Tot_dry*100;
46
47 C_wet=(C_Tot)/Tot_wet*100;
48 O_wet=(Exs_O2)/Tot_wet*100;
49 N_wet=(N2_Tot)/Tot_wet*100;
50 H_wet=(H_Tot)/Tot_wet*100;
51
52 disp("Analysis by volume of the wet product of CO2,
      H2O,O2,N2 respectively is:");
53 disp(N_wet,O_wet,H_wet,C_wet)
54
55 disp("Analysis by volume of the dry product of CO2,
      O2,N2 respectively is:");
56 disp(N_dry,O_dry,C_dry)

```

---

### Scilab code Exa 7.3 3

```

1 clc;
2 m_C2H6O=46;
3 m_O2=3*32;
4 O2_req=m_O2/m_C2H6O;
5 s_AF=O2_req/0.233;
6 disp(s_AF,"stoichiometric A/F ratio is:")

```

```

7
8 //part II
9 disp( "" )
10 AF=s_AF/0.9;
11 disp(AF," actual A/F ratio is:")
12 mC=2;
13 mH=3;
14 mO=0.333;
15 mN=12.540;
16 Tas=mC+mO+mH+mN;
17 disp(mN/Tas*100,mO/Tas*100,mH/Tas*100,mC/Tas*100,"
    wet analysis of CO2,H2O,O2,N2");
18
19 Tad=mC+mO+mN;
20 disp(mN/Tas*100,mO/Tas*100,mC/Tas*100," dry analysis
    of CO2,O2,N2");
21
22 //part III
23 disp( "" )
24 a_AF=s_AF/1.2;
25 disp(a_AF," actual A/F ratio is:")
26
27 mCO2=1;
28 mCO=1;
29 mH2=3;
30 mN2=9.405;
31 taw=mCO2+mCO+mH2+mN2;
32
33 disp(mN2/taw*100,mH2/taw*100,mCO/taw*100,mCO2/taw
    *100,"wet analysis of CO2,H2O,O2,N2");
34
35 tad=mCO2+mCO+mN2;
36 disp(mN2/tad*100,mCO/tad*100,mCO2/tad*100," dry
    analysis of CO2,H2O,O2,N2");

```

---



#### Scilab code Exa 7.4 4

```
1  clc;
2  mC=1;
3  mO=3;
4  mN=(3*79/21);
5  Tar=mC+mO+mN;
6
7  p1=1.013*10^5;
8  R=8.3145*10^3;
9  T=338;
10 V=Tar*R*T/p1;
11
12 Vr=V/[(2*12)+6+16];
13 disp(Vr,"Volume of reactants per kilogram of fuel:")
14   ;
15 //part II
16 mCO2=2;
17 mH2O=3;
18 mN2=(3*79/21);
19 Tap=mCO2+mH2O+mN2;
20
21 T=393;
22 p=10^5;
23
24 V=Tap*R*T/p1;
25 Vr=V/[(2*12)+6+16];
26
27 disp(Vr,"Volume of products per kg of fuel is:");
```

---

#### Scilab code Exa 7.5 5

```
1  clc;
2  mCO2=2;
```

```

3  mH2O=3;
4  mN2=(3*79/21);
5  m_C2H6O=46;
6  Tadv=mCO2+mN2;
7  Tap=mCO2+mN2+mH2O;
8
9  n1=0.01704;
10 n=1;
11
12 n1=n1*Tadv/(1-n1)
13 m=[(mH2O-n1)*18/m_C2H6O]
14 disp(m)

```

---

#### Scilab code Exa 7.6 6

```

1  clc;
2  a=0.8/12;
3  b=0.12/2;
4  x=a+b/2;
5
6  s_AF=32*x/0.233;
7  disp(s_AF,"stoichiometric A/F ratio is:");
8
9  Twp=a+b+3.76*x;
10 C=a/Twp*100;
11 H=b/Twp*100;
12 N=.365/Twp*100;
13
14 disp(N,H,C,"wet analysis of C,H, and N respectively
    is:")

```

---

#### Scilab code Exa 7.7 7

```

1  clc;
2  a=1;
3  c={6.31-2-(2*1.95)}/2
4  d=0.03+(0.79*30)
5  tds=a+c+d;
6
7  C=a/tds*100
8  O=c/tds*100
9  N=d/tds*100
10
11 disp(N,O,C," analysis by volume is:");

```

---

#### Scilab code Exa 7.8 8

```

1  clc;
2  B=0.9/12/0.15;
3  b=0.1/2;
4  A=15.14;
5  a=0.02
6  AF=A;
7  disp(AF,"A/F ratio is:");
8
9  %C=.15;
10 %O=.20;
11 %N=.65;
12 twp=B*%C+B*%O+B*%N+b;
13
14 C=B*%C/twp*100;
15 O=B*%O/twp*100;
16 N=B*%N/twp*100;
17 H=b/twp*100;
18
19 disp(H,N,O,C," wet volumetric analysis is as follows:
    ");

```

---

### Scilab code Exa 7.9 9

```
1 clc;  
2 x=0.8805;  
3 B=3.41*(1-x);  
4 A=27.927*B;  
5 AF=A;  
6 disp(AF,"A/F ratio is:");
```

---

### Scilab code Exa 7.10 10

```
1 clc;  
2 b=0.228;  
3 a=1-b;  
4 c=[1+(2*0.455)-b-2*a]/2  
5  
6 n2=a+b+c+1.709;  
7  
8 p1=8.28;  
9 T2=555;  
10  
11 n1=1+0.455+1.709;  
12 T1=2968;  
13 p2=p1*(n2/n1)*(T1/T2);  
14 p=1;  
15  
16 K=a/b*[n2*p/(c*p2)]^0.5;  
17 disp(log(K),"log(K) is:");  
18 disp("2968","from tables it is proved that  
    temperatur is:");
```

---

### Scilab code Exa 7.12 12

```
1 clc ;
2 mH2O=3*18;
3 q=2441.8;
4 h0=-3301397+(mH2O*q)
5 disp(h0," h0 for H2O in the vapour phase:")
```

---

### Scilab code Exa 7.13 13

```
1 clc ;
2 h0=3169540
3 nR=1+7.5;
4 nP=6+3;
5 R=8.3145;
6 T=298;
7 U0=- (h0) -{(nP-nR)*R*T};
8 c=(6*12)+(6*1);
9 u0=U0/c
10 disp(u0,"specific internal energy of reaction for
    the combustion of benzene vapour is:")
```

---

### Scilab code Exa 7.14 14

```
1 clc ;
2 H0=282990;
3 HRo=(1*1018)+(0.5*1036);
4 HRr=(1*86115)+(0.5*90144);
5 HPo=1*1368;
```

```

6 HPr=1*140440;
7
8 HT=H0+(HRr-HR0)-(HPr-HP0);
9 disp(HT," h at 2800 K is:")

```

---

### Scilab code Exa 7.15 15

```

1 clc;
2 a=0.909;
3 b=0.091;
4 nR=1+0.5;
5 nP=1;
6 H0=-282990;
7 R=8.3145;
8 T0=298;
9
10 U0=H0-(nP-nR)*R*T0;
11
12 UR0=-7844;
13 UR1=9487;
14 UP0=-6716;
15 UP2=(a*281751)-(UR0-UR1)+UP0
16
17 UP2_=(a*138720)+(b*74391)+(1.709*73555);
18
19 disp(" which compares with the actual ,hence actual
      temperature of the products is slightly greater
      than 3200" ,UP2_," and UP2 at T=3200" ,UP2," actual
      UP2 is")

```

---

### Scilab code Exa 7.16 16

```

1 clc;

```

```

2 a=0.8;
3 T2=3000;
4 n2!p2=212.08/T2;
5 K=a/(1-a)*[n2!p2/(0.455-0.5*a)]^0.5;
6 disp("by such a method the value of T2 is found to
      be 2949 to the nerest degree")

```

---

#### Scilab code Exa 7.17 17

```

1 clc;
2 hR=-281102;
3 hP=2*-393520+3*-241830;
4 h=-hR+hP
5 disp(h,"molar enthalpY is")

```

---

#### Scilab code Exa 7.18 18

```

1 clc;
2 mw1=2*0.965*18;
3 mw2=3*0.005*18;
4 mw=mw1+mw2;
5
6 R=8314.5
7 T=288;
8 p=1.013*10^5;
9 v=R*T/p
10
11 mc=mw/v;
12
13 hfg=2441.8;
14 Qgt=38700;
15 Qn=Qgt-mc*hfg;
16

```

```

17 hs=3421;
18 hf=419.1;
19 Q=hs-hf;
20 s_o=31.6;
21 f_c=2.85;
22 nB=Q*s_o/(f_c*Qn);
23
24 disp(nB*100,"boiler efficiency is:");
25
26 g_o=25000;
27 n=g_o/(f_c*Qn)
28 disp(n*100,"overall thermal efficiency is:")

```

---

#### Scilab code Exa 7.19 19

```

1 clc;
2 n=5;
3 t0=25.740
4 tn=27.880
5 v=-[(t0-25.730)/5];
6 v1=(tn-27.870)/5;
7 t=25.735;
8 t1=27.875;
9 Et=110.9880;
10
11 corc=-5*v1+[(v1-v)/(t1-t)]*[Et+26.81-5*t];
12 temp_rise=tn-t0;
13 c_temp_rise=temp_rise+corc;
14
15 q=c_temp_rise*2500*4.187*10^-3;
16 Q=q/(.825*10^-3);
17 disp("kJ/kg",Q,"calorific value of fuel is:");

```

---



### Scilab code Exa 7.20 20

```
1 clc ;
2 mc=0.144*9;
3 Qgt=46900;
4 ufg=2304.4;
5
6 Qn=Qgt-mc*ufg;
7 disp("kJ/kg",Qn,"NCV is:")
```

---

### Scilab code Exa 7.21 21

```
1 clc ;
2 m_EtOH=46;
3 aof=1/m_EtOH;
4 m_a=28.96;
5 AF=8.957;
6 aoa=AF/m_a;
7
8 Total=aof+aoa;
9
10 R=8314.5;
11 T=288;
12 p=1.013*10^5;
13 V=Total*R*T/p;
14
15 NCVf=27.8;
16 NCVm=NCVf/V;
17
18 disp("MJ/m^3",NCVm,"calorific value of the
    combustion mixture is:");
```

---

### Scilab code Exa 7.22 22

```
1  clc;
2  m_EtOH=46;
3  aof=1/m_EtOH;
4  m_a=28.96;
5  AF=8.957;
6  aoa=AF/m_a;
7
8  Total=aof+aoa;
9  p0=aof/Total;
10
11 //from table
12 t1=20;
13 t2=30;
14 p1=0.0584;
15 p2=0.1049;
16
17 t=t1+[(p0-p1)/(p2-p1)]*(t2-t1);
18 disp("C",t,"minimum temperature of the mix is:");
```

---

# Chapter 8

## Steam Cycles

Scilab code Exa 8.1 1

```
1  clc;
2  T1=526.2;
3  T2=299.7;
4  nC=(T1-T2)/T1;
5  disp(nC,"carnot cycle efficiency is:")
6  Q=1698;
7  W=nC*Q;
8
9  h1=2800;
10 s1=6.049;
11 s2=s1;
12 sf2=0.391;
13 sfg2=8.13;
14 x2=(s2-sf2)/sfg2;
15
16 hf2=112;
17 hfg2=2438;
18 h2=hf2+(x2*hfg2);
19
20 W12=h1-h2;
21
```

```

22 Wr=W/W12;
23 disp(Wr,"work ratio is:")
24 ssc=1/W;
25 disp("kg/k W h",ssc,"ssc is:");
26
27 //part III
28 disp("");
29 h3=112;
30 vf=0.001
31 p4=42;
32 p3=0.035;
33
34 PW=vf*(p4-p3)*(10^5/10^3);
35 nR=[{(h1-h2)-(PW)}/{(h1-h3)-(PW)}]
36 disp(nR,"rankine cycle efficiency is:");
37
38 Wr=(W12-PW)/(W12)
39 disp(Wr,"Work ratio is");
40
41 ssc=1/(W12-PW)
42 disp("kg/k W h",ssc,"Work ratio is:");
43
44 //partIII
45 disp("");
46 W12_=0.8*W12;
47 Ceff=[(h1-h2)-PW]/[(h1-h3)-PW];
48 disp(Ceff,"rankine cycle of isentropic efficiency is
      :")
49
50 Wr=[W12_-PW]/W12_
51 disp(Wr,"Work ratio is:");
52
53 ssc=1/[(h1-h2)-PW]
54 disp("kg/kW s",ssc,"ssc is:")

```

---

### Scilab code Exa 8.2 2

```
1  clc;
2  h1=3442.6;
3  s1=7.066;
4  s2=s1;
5  sf2=0.391;
6  sfg2=8.13;
7  x2=(s2-sf2)/sfg2
8
9  hf2=112;
10 hfg2=2438;
11 h2=hf2+x2*hfg2;
12
13 h3=112;
14 W12_=h1-h2;
15
16 Q=h1-h3;
17
18 Ceff=(h1-h2)/(h1-h3);
19 disp(Ceff,"cycle efficiency is:");
20
21 ssc=1/(h1-h2);
22 disp("kg/kW h",ssc,"specific steam consumption is:");
    ;
23
24 disp("cycle efficiency has increased due to
    superheating and the improvement in specific
    steam consumption is even more marked:");
```

---

### Scilab code Exa 8.3 3

```
1  clc;
2  h1=3442.6;
3  h2=2713;
```

```

4 h6=3487;
5 h7=2535;
6 h3=112;
7
8 TW=(h1-h2)+(h6-h7);
9
10 Q=(h1-h3)+(h6-h2);
11
12 Ceff=TW/Q;
13 disp(Ceff," cycle efficiency is:");
14
15 ssc=1/TW;
16 disp(" kg/kW h",ssc," specific steam consumption is:")

```

---

#### Scilab code Exa 8.4 4

```

1 clc;
2 t1=253.2;
3 t2=26.7;
4 t6=(t1+t2)/2;
5
6 h7=584;
7 h3=112;
8 s1=6.049;
9 s6=s1;
10 s2=s1;
11
12 x6=(s1-1.727)/5.214;
13 x2=(s1-0.391)/8.130;
14
15 hf6=584;
16 hfg6=2148;
17 h6=hf6+x6*hfg6;
18
19 hf2=112;

```

```
20 hfg2=2438;
21 h2=hf2+x2*hfg2;
22
23 y=(h7-h3)/(h6-h3);
24
25 h1=2800;
26 Q=(h1-h7);
27
28 Tot=(h1-h6)+[(1-y)*(h6-h2)];
29
30 Ceff=Tot/Q;
31 disp("%",Ceff*100,"cycle efficiency is:");
32
33 ssc=1/Tot
34 disp("kg/kJ",ssc,"ssc is:");
```

---

# Chapter 9

## Gas Turbine Cycles

Scilab code Exa 9.1 1

```
1  clc;
2  T1=288;
3  p2!p1=10;
4  y=1.4;
5  T2s=T1*[(p2!p1)^(y-1)/y];
6
7  nc=0.82;
8  T2=(T2s-T1)/nc+T1;
9
10 T3=973;
11 y2=1.333;
12 T4s=T3/[(p2!p1)^(y2-1)/y2]
13
14 nt=0.85;
15 T4=T3-(T3-T4s)*nt
16
17 cp=1.005;
18 cp2=1.11;
19 Wi=cp*(T2-T1);
20 Wo=cp2*(T3-T4);
21
```



```
22 N=(Wo-Wi);
23 P=(N*15)
24 disp("W",P,"powar output is");
```

---

### Scilab code Exa 9.2 2

```
1  clc;
2
3  T1=288;
4  p2!p1=10;
5  y=1.4;
6  T2s=T1*[(p2!p1)^(y-1)/y];
7
8  nc=0.82;
9  T2=(T2s-T1)/nc+T1;
10
11 T3=973;
12 y2=1.333;
13 T4s=T3/[(p2!p1)^(y2-1)/y2]
14
15 nt=0.85;
16 T4=T3-(T3-T4s)*nt
17
18 cp=1.005;
19 cp2=1.11;
20 Wi=cp*(T2-T1);
21 Wo=cp2*(T3-T4);
22
23 N=(Wo-Wi);
24
25 Q=cp2*(T3-T2);
26 Ceff=N/Q
27 disp("$",Ceff*100,"cycle efficiency is:");
28
29 Wratio=N/Wo;
```

```
30 disp(Wratio*100,"Work ratio is:");
```

---

### Scilab code Exa 9.3 3

```
1  clc;
2  p2!p1=8;
3  T1=290;
4  y=1.4;
5  T2s=T1*({p2!p1}^[(y-1)/y]);
6  nc=0.8;
7  T2=[(T2s-T1)/nc]+T1;
8
9  cps=1.005;
10 T3=923;
11 Wi=cps*(T2-T1);
12 Wo=Wi;
13 cps2=1.15;
14 T4=T3-[Wo/cps2]
15
16 nt=0.85;
17 T4s=T3-[(T3-T4)/nt];
18
19 p3=8*1.01;
20 y2=1.333;
21 p4=p3/[(T3/T4s)^(y2/(y2-1))];
22 disp("bar",p4,"pressure at entry of the LP.");
23 disp("K",T4,"temperature at the entry of LP.");
24
25 p4!p5=p2!p1*(p4/p3);
26 T5s=T4/[(p4!p5)^{(y2-1)/y2}];
27
28 nT=0.83;
29 T5=T4-[nT*(T4-T5s)]
30 WoLP=cps2*(T4-T5);
31
```

```

32 N=WoLP*1;
33 Wr=WoLP/(WoLP+Wo);
34 disp("kW",Wr,"Work ratio is :");
35
36 Q=cps2*(T3-T2);
37 disp("kJ/kg",Q,"Heat supplied is:");
38
39 Ceff=N/Q;
40 disp("%",Ceff*100,"cycle efficiency is:");

```

---

#### Scilab code Exa 9.4 4

```

1  clc;
2  y=1.4;
3  p2!p1=3;
4  T1=288;
5  T2s=T1*[(p2!p1)^({y-1}/y)];
6
7  nc=0.8;
8  T2=T1+[T2s-T1]/nc
9
10 cps=1.005;
11 Wi=cps*(T2-T1);
12 Wo=2*(Wi)/0.98;
13
14 T6=923;
15 cps2=1.15;
16 T7=T6-Wo/cps2
17 nT=0.85;
18 T7s=T6-[(T6-T7)/nT]
19 y2=1.333;
20 p8!p9=[p2!p1^2]/[(T6/T7s)^{y2/(y2-1)}];
21
22 T8=T6;
23 T9s=T8/[(p8!p9)^({y2-1}/y2)];

```

```

24
25 T9=T8-nT*(T8-T9s)
26 N=cps2*(T8-T9)*0.98;
27
28 Tr=0.75;
29 T4=420.5;
30 T5=T4+Tr*(T9-T4)
31
32 Q=cps2*([T6-T5]+[T8-T7]);
33 Ceff=N/Q;
34 disp(Ceff,"cycle efficiency is:");
35
36 //part II
37 Gwo=Wo+N/0.98;
38 Wr=N/Gwo;
39 disp(Wr,"work ratio is:")
40
41 //part III
42 m=5000/N;
43 disp("kg/s",m,"rate of flow of air is:")

```

---

### Scilab code Exa 9.5 5

```

1  clc;
2  T1=288;
3  T2s=T1*[3^0.286];
4  T2=420.5
5  T4=T2;
6  p6=8.14;
7  p6!p7=4.19;
8  p7=p6/(p6!p7);
9  p8=(p7-0.2)
10 p1=1.01
11 p10=p1
12 p9=0.05+p10

```

```
13 y2=1.333;
14 T8=923;
15 T9s=T8/[(p8/p9)^({y2-1}/y2)];
16 T9=T8-[(T8-T9s)*0.85];
17 cps2=1.15;
18 N=cps2*(T8-T9);
19 T5=728.8;
20 T6=T8;
21 T7=686.5;
22 Q=cps2*(T6-T5+T8-T7)
23 disp("kJ/kg",Q,"Heat supplied is")
24
25 Ceff=105.2/Q;
26 disp("%",Ceff*100,"cycle efficiency is")
27 GW=(105.2/0.98)+277;
28
29 Wr=105.2/GW
30 disp(Wr,"work ratio is:")
```

---

# Chapter 10

## Nozzle and Jet Propulsion

Scilab code Exa 10.1 1

```
1  clc;
2  y=1.4;
3  p1=8.6;
4  pc=p1*[(2/(y+1))^{y/(y-1)}];
5
6  T1=190+273;
7  Tc=T1*[2/(y+1)];
8  R=287;
9  vc=R*Tc/(10^5*pc);
10 Cc=(y*R*Tc)^0.5;
11
12 m=4.5;
13 A=m*vc/Cc;
14 disp("mm^3",A*10^6,"Area of throat is:");
15
16 p2=1.03;
17 T1=463;
18 T2=T1/([p1/[p2]]^{[y-1]/y});
19
20 v2=R*T2/(10^5*p2);
21 cp=1.005
```

```

22 C2=[2*cp*10^3*(T1-T2)]^0.5;
23 A2=m*v2/C2
24 disp("mm^3",A2*10^6,"Exit area is:");

```

---

### Scilab code Exa 10.2 2

```

1  clc;
2  R_=8314.5;
3  R=R_/4;
4  cp=10^3*5.19;
5  y=1/[1-(R/cp)];
6  p1=6.9;
7  pc=( [2/(y+1)] ^ [y/(y-1)] ) * p1;
8
9  T1=93+273;
10 p2=3.6;
11 T2=T1/[(p1/p2)^( [y-1]/y )];
12
13 C2=[2*cp*(T1-T2)]^0.5;
14 v2=R*T2/(10^5*p2);
15
16 A2=1;
17 m=A2*C2/v2;
18 disp("kg/s",m,"mass flow per square meter of exit
    area:");
19
20 // partII
21 m_=30;
22 R=R_/m_;
23 cp=1880;
24 y=1/[1-(R/cp)]
25
26 p2=3.93;
27 T2=337;
28 pc=p1*[2/(y+1)]^[(y/(y-1))];

```

```

29 Tc=T1*[2/(y+1)];
30 Cc=[y*R*Tc]^0.5;
31 v2=R*T2/(10^5*p2);
32
33 m=A2*Cc/v2
34 disp("kg/s",m,"mass flow per square meter of exit
      area is:");

```

---

### Scilab code Exa 10.3 3

```

1  clc;
2  p1=3.5;
3  y=1.333;
4  pc=p1*[2/(y+1)]^[(y/(y-1))];
5
6  T1=425+273;
7  Tc=T1*[2/(y+1)];
8  T2=Tc;
9  cp=1.11*10^3;
10 Cc=[2*cp*(T1-T2)]^0.5;
11 C2=Cc;
12 R=cp*(y-1)/y;
13 vc=R*Tc/10^5/pc;
14
15 m=18/.99;
16 Ac=m*vc/Cc
17 disp("m^2",Ac,"throat area is:");
18 T1=698;
19 p1=3.5;
20 p2=0.97;
21 T2s=T1/[(p1/p2)^{(y-1)/y}];
22 Neff=0.94;
23 T2=T1-Neff*(T1-T2s);
24 v2=R*T2/10^5/p2;
25 C2=(2*cp*(T1-T2))^0.5;

```



```
26 m2=18;
27 A2=m2*v2/C2;
28 disp("m^2",A2," exit area is :");
```

---

#### Scilab code Exa 10.4 4

```
1 clc;
2 y=1.135;
3 p1=10;
4 pc=p1*[2/(y+1)]^[y/(y-1)];
5 h1=2778;
6 hc=2675;
7 xc=0.962;
8 vg=0.328;
9 vc=xc*vg;
10 Cc=(2*[h1-hc]*10^3)^0.5;
11 A_m=vc/Cc*10^6;
12 disp(A_m);
```

---

#### Scilab code Exa 10.5 5

```
1 clc;
2 h1=2846;
3 h2=2682;
4 x2=0.98;
5 vg=0.6057;
6 v2=x2*vg;
7 C2=[2*(h1-h2)*10^3]^0.5;
8 m=0.1;
9 A2=m*v2*10^6/C2;
10 disp("mm^2",A2,"Exit area is:");
11
12 //part II
```

```

13 p1=7;
14 p2=3;
15 k=1.3;
16 v1=0.3001;
17 vr=v1*[(p1/p2)^(1/k)];
18 y=1.3;
19 Cr=[2*(y*10^5)/(y-1)*{(p1*v1)-(p2*vr)}]^0.5;
20 A2=m*vr*10^6/Cr;
21 disp("mm^2",A2,"Exit area in supersaturated case is:")
    )

```

---

#### Scilab code Exa 10.6 6

```

1  clc;
2  KE=1/2*(800*1000/3600)^2/1000;
3
4  T0=-50+273;
5  cp=1.005;
6  T0_=T0+[24.7/cp];
7
8  Ieff=0.9;
9  T0_s=Ieff*(T0_-T0)+T0;
10
11 y=1.4;
12 pa=0.24;
13 p0_=[(T0_s/T0)^[y/(y-1)]]*pa;
14 p0_2!p0_=10;
15 T0_2s=T0_*[p0_2!p0_^[y-1]/y];
16
17 T0_2=T0_+(T0_2s-T0_)/Ieff;
18
19 p0_2=10*p0_;
20 p0_3=p0_2-(0.14);
21
22 T0_3=820+273;

```

```

23 meff=0.98;
24 cp2=1.15;
25 T0_4=T0_3-[cp*(T0_2-T0_)/(cp2*meff)];
26 T0_4s=T0_3-[cp*(T0_2-T0_)/(cp2*meff)]/0.92;
27 y2=1.333;
28 p0_4=3.24/[(T0_3/T0_4s)^(y2/(y2-1))]
29
30 pc=p0_4*([2/(y2+1)]^(y2/(y2-1)));
31 T0_5=[2/(y2+1)]*T0_4;
32 T0_5s=T0_4-((T0_4-T0_5)/0.92);
33
34 p5=p0_4/[(T0_4/T0_5s)^(y2/(y2-1))]
35
36 R=cp2*(y2-1)/y2;
37 v5=R*T0_5*1000/10^5/p5;
38
39 T5=741.3 //K
40 Cj=(y2*R*1000*T5)^0.5;
41
42 A=0.08;
43 m=A*Cj/v5;
44 Cg=222.2;
45 mt=m*(Cj-Cg)
46 pt=(p5-pa)*A*10^5;
47 Tt=pt+mt;
48
49 Q=m*cp2*(T0_3-T0_2)
50
51 C=43300;
52
53 mf=Q/meff/C;
54
55 SFC=mf*10^3/6453
56 disp("kg/kNs",SFC,"specific fuel consumption is")

```

---

### Scilab code Exa 10.7 7

```
1  clc;
2  v=650*10^3/3600;
3  KE=(1/2*v^2);
4  T0=-18+273;
5  cp=1.005;
6  Ieff=0.9;
7  T01=KE/10^3/cp+T0;
8  T01s=T0+Ieff*(T01-T0)
9
10 p02!p01=9;
11 y=1.4;
12 T02s=T01*(p02!p01)^[(y-1)/y];
13
14 Ieff2=0.89;
15 T02=T01+(T02s-T01)/Ieff2
16
17 W=cp*(T02-T01);
18 p01!p0=1.215;
19 p03!p4=p02!p01*p01!p0;
20 T03=1123;
21 y2=1.333;
22 T4=T03/[(p03!p4)^{(y2-1)/y2}];
23 C4=180.5;
24 cps=1.15*10^3;
25 T04=T4+C4^2/(2*cps);
26 Ieff3=0.93;
27 Wo=cps*(T03-T04)*Ieff3/1000
28 Ieff4=0.98;
29 NW=(Wo-W)*Ieff4;
30 Q=cps*(T03-T02)/1000
31 Teff=NW/Q
32 disp("%",Teff*100,"Thermal efficiency");
```

---

# Chapter 11

## Rotodynamic Machinery

Scilab code Exa 11.1 1

```
1  clc;
2  Cai=900;
3  Cb=300;
4  alpha=20*%pi/180;
5  Cri=(Cai^2+Cb^2-2*Cb*Cai*cos(alpha))^0.5;
6  b=asin(Cai*sin(alpha)/Cri);
7  Beta=180*b/%pi
8  disp("the blade inlet angle is:");
9  disp("degree",Beta)
10
11 //part II
12 k=0.7;
13 Cre=k*Cri
14 AD=Cri*cos(b);
15 AE=Cre*cos(b);
16
17 Cw=AD+AE;
18 disp("driving force on wheel is:");
19 m=1;
20 Df=m*Cw
21 disp("N per kg/s",Df);
```

```

22
23
24 //part III
25 Cfi=Cri*sin(b);
26 Cfe=Cre*sin(b);
27 Cf=Cfi-Cfe;
28 At=m*Cf;
29 disp("axial thrust is:");
30 disp("N per kg/s",At)
31
32 //part IV
33 Dp=Cb*Cw;
34 disp("diagram power per unit mass flow rate:");
35 disp("kW",Dp/1000);
36
37 //part V
38 De=Cb*Cw/(Cai^2);
39 disp("Diagram efficiency is");
40 disp("%",De*100);

```

---

### Scilab code Exa 11.2 2

```

1 clc;
2 k=0.9;
3 Cri1=486; //m/s
4 Cri2=187.5; //m/s
5 Caei=327; //m/s
6 Cre1=k*Cri1;
7 Cre2=k*Cri2;
8 Cai2=k*Caei;
9 //from velocity diagram;
10 disp("inlet blade angle firls row of moving blades")
    ;
11 Bi1=20;
12 disp("degree",Bi1)

```

```

13
14 disp("inlet blade angle fixed blades");
15 alpha=20;
16 disp("degree",alpha)
17
18 disp("inlet blade angle second row of moving blades"
    );
19 Bi2=34.5;
20 disp("degree",Bi2);
21
22 //part II
23 m=1;
24 Cw1=874;
25 Cw2=292.5;
26 disp("N",m*Cw1,"driving force on first row:");
27 disp("N",m*Cw2,"driving force on second row:");
28
29 Cfi1=167;
30 Cfe1=135;
31 Cfi2=106;
32 Cfe2=97;
33 At1=m*(Cfi1-Cfe1);
34 At2=m*(Cfi2-Cfe2);
35 disp("N per kg/s",(At1+At2),"Total axial thrust:");
36
37 //part III
38 T_df=Cw1+Cw2
39 disp("N per kg/s",T_df,"total driving force");
40 bv=120
41 P=T_df*bv/10^3;
42 Cai1=600;
43 E=m*Cai1^2/(2*10^3);
44 De=P/E;
45 disp("%",De*100,"diagram efficiency is");
46
47 //partIV
48 alpha_i=16*%pi/180;
49 M=cos(alpha_i)^2;

```

```
50 disp("%",M*100,"Maximum diagram efficiency is:");
```

---

### Scilab code Exa 11.3 3

```
1  clc;
2  Cai=600;
3  alpha_i=16*%pi/180;
4  l=25/1000;
5  m=5;
6  vi=0.375;
7  n=m*vi/(Cai*sin(alpha_i)*l);
8  disp("m",n,"length of nozzle arc is:");
9
10 //part II
11 p=0.025;
12 Beta_1=18*%pi/180;
13 Cre=437;
14 t=0.0005;
15 l1=m*vi*p/n/(p*sin(Beta_1)-t)/Cre;
16 bhm=l1;
17
18 Beta_2=21*%pi/180;
19 Crf=294;
20 lf=m*vi*p/[n*(p*sin(Beta_2)-t)*Crf];
21 bhf=lf
22
23 Beta_3=35*%pi/180;
24 Crf2=169;
25 l2=m*vi*p/n/(p*sin(Beta_3)-t)/Crf2;
26
27 disp("Blade height at exit of first row, fixed and
      second row is respectively");
28 disp("mm",l2*1000,"mm",bhf*1000,"mm",bhm*1000);
```

---



#### Scilab code Exa 11.4 4

```
1  clc;
2  Cai=90;
3  alpha=20*%pi/180;
4  Cf=Cai*sin(alpha)
5
6  Cb=4*Cf/3;
7
8  v=0.6686; //m^3/kg
9  m=9000/3600;
10 A=m*v/Cf
11 h=0.04;
12 r=A/(2*%pi*h)
13 N=Cb/(A/h)
14 disp(" rev/s",N," Wheel speed is:")
15
16 //partII
17 Cw=2*Cai*cos(alpha)-Cb;
18 DP=m*Cb*Cw;
19 disp("kW",DP/1000," diagram power is:");
20
21 //part III
22 R=Cb*Cw
23 Cri=[(Cai^2)+(Cb^2)-(2*Cai*Cb*cos(alpha))]^0.5
24 Ei=Cai^2-(Cri^2/2)
25 DE=R/Ei
26 disp("%",DE*100," diagram efficiency is:");
27
28 //part IV
29 Ed=(Cai^2-Cri^2)/2;
30 Td=2*Ed;
31 disp(" kJ/kg",Td/1000," total enthalpy drop per stage:
    ")
```

---

### Scilab code Exa 11.5 5

```
1  clc;
2  Cw=115; //m/s
3  Cb=200; //m/s
4  wf=0.86;
5  P=(Cw*Cb*wf)/1000;
6  CP=12*P;
7  T=20+273;
8  y=1.4;
9  ET=T*6^[(y-1)/y];
10 cp=1.005;
11 sp=cp*(ET-T);
12 Ce=sp/CP;
13 disp("%",Ce*100,"compressor isentropic efficiency is
      :");
```

---

### Scilab code Exa 11.10 10

```
1  clc;
2  T=20+273;
3  y=1.4;
4  Ti=T*4^([y-1]/y)
5  ir=Ti-T;
6  actual_r=ir/0.8;
7  cp=1.005;
8  P=cp*actual_r;
9  Cai=150;
10 Cbi=15000*%pi*250/(60*10^3);
11 Cwi=Cai*sin(25*%pi/180);
12 Cbe=15000*%pi*590/(60*10^3);
13 Cwe=Cbe;
```

```
14 P=178.9*10^3;  
15 C_we=(P+Cbi*Cwi)/(Cbe);  
16 Sf=C_we/Cwe;  
17 disp(Sf,"Slip factor is:");
```

---

# Chapter 12

## Positive Displacement Machines

Scilab code Exa 12.4 4

```
1  clc;
2  Va_Vd=14/(300*2);
3  p2=7;
4  p1=1.013;
5  n=1.3;
6  Vs=Va_Vd/[(1.05) - (0.05*[(p2/p1)^(1/n)])];
7  disp("swept volume of compressor is:");
8  disp("m^3",Vs);
9
10 T1=288; //K
11 T2=T1*[(p2/p1)^([n-1]/n)];
12 disp("delivery temperature is:");
13 disp("K",T2);
14
15 V=14/60;
16 P=[n/(n-1)]*{[p1*V*10^5]/(10^3)}*{[(p2/p1)^[n-1]/n
    ]-1};
17 disp("indicated power is:");
18 disp("kW",P)
```

---

Scilab code Exa 12.7 7

```
1  clc;
2  p=1.013; //bar
3  V=2.83; //m^3
4  R=0.287;
5  T=288; //K
6
7  m_deliv=p*V*10^5/(T*R*10^3);
8
9  n=1.3;
10 z=3;
11 p2=70; //bar
12 p1=0.98; //bar
13 m=m_deliv/60;
14
15 T_P=z*[n/(n-1)]*m*R*T*{[(p2/p1)^[n/(3*n)]]-1};
16 disp("kW",T_P," Total indicated power is:");
```

---

Scilab code Exa 12.10 10

```
1  clc;
2  //part I
3  p1=6.3; //bar
4  V1!V2=0.55/1.05;
5  n=1.3;
6  p2=p1*[(V1!V2)^n];
7
8  T1=297;
9  T2=T1*[(V1!V2)^[n-1]];
10 disp(" Temperature after expansion is:");
```

```

11 disp("C",T2-273);
12
13
14 //part II
15 p4=1.013; //bar
16 V4!V5=0.1/0.05;
17 p5=p4*[(V4!V5)^n];
18
19 A=%pi*(63.5)^2;
20 sweptV=A*114/(4*10^9);
21
22 V1_V6=0.5;
23 V1=0.55;
24 V2=1.05;
25 p=1.013;
26 p3=p;
27 V3_V4=0.95
28 V5=0.05;
29 V4=0.1;
30 W_op=[10^5*0.361*10^-3]*[p1*(V1_V6)+[(p1*V1-p2*V2)
    /0.3]-p*V3_V4-[(p5*V5)-p*V4]/0.3]
31 disp("powar developed is:");
32 P=W_op*300/(60*010^3);
33 disp(P);
34
35 //part III
36 y=1.4;
37 T3=T2*(p3/p2)^((y-1)/y)
38
39 T4=T3
40 R=287
41 m4=p4*V4*[10^5*0.361*10^-3]/(R*T4);
42 m1=p1*V1*[10^5*0.361*10^-3]/(R*T1);
43 ind_mass=(m1-m4);
44 rate=ind_mass*300;
45 disp("mass flow rate of air supplied is;");
46 disp("kg/min",rate)

```

---

# Chapter 13

## Reciprocating Internal Combustion Engines

Scilab code Exa 13.1 1

```
1  clc;
2  W=155;
3  R=0.356;
4  T=W*R;
5  disp("N m",T,"Torque is:")
6
7  N=2800/60;
8  bp=2*pi*N*T/1000;
9  A=%pi*0.057^2;
10 L=0.09/4;
11 n=4;
12 bmep=bp*2*10^3/(A*L*N*n*10^5)
13 disp(" bar",bmep,"bmep is:")
14
15 spc_grv=0.735;
16 fc=6.74
17 m=(fc/3600)*spc_grv
18 Q=44200;
19 disp(m)
```

```
20 eff_BT=bp/(m*Q)
21 disp("%",eff_BT*100,"brake thermal efficiency is:");
22
23 sfc=m/(bp)*3600;
24 disp("specific fuel consumption is");
25 disp("kg/kW h",sfc);
```

---

### Scilab code Exa 13.2 2

```
1 clc;
2 spc_grv=0.735;
3 fc=6.74
4 m=(fc/3600)*spc_grv;
5 AMflow=14.5*m;
6 R=287;
7 T=288;//K
8 p=1.013;//bar
9 V_drawn=AMflow*R*T/(p*10^5)
10
11 N=2800/60;
12 A=%pi*0.057^2;
13 L=0.09/4;
14 n=4;
15 sweptV=A*L*N*n/2;//m^3/min
16
17 eff=V_drawn/sweptV;
18 disp("eff is:")
19 disp("%",eff*100)
```

---

### Scilab code Exa 13.3 3

```
1 clc;
2 R=0.287
```



```

3  capct=0.003; //m^3
4  sweptV=3500/2*capct;
5  ind_V=0.8*sweptV;
6  p=1.013;
7  blow_p=1.7*p;
8  T=288; //K
9  y=1.4;
10 T_comp=T*1.7^[(y-1)/y];
11 blow_T=T+[T_comp-T]/0.75;
12
13 eq_V=sweptV*blow_p*T/(p*blow_T);
14 inc_ind_V=eq_V-ind_V;
15
16 inc_ip=[(blow_p-p)*10^5*sweptV]/(10^3*60);
17 Total=40.2+inc_ip;
18
19 inc_bp=0.8*Total;
20
21 mass_delv=blow_p*10^5*sweptV/(60*R*blow_T);
22 cp=1.005;
23 m=0.149;
24 W=m*cp*(blow_T-T);
25 P=W/0.8;
26 Net=inc_bp-P;
27
28 disp("kW",Net,"Net increase in bp")

```

---

# Chapter 14

## Refrigeration and Heat Pumps

Scilab code Exa 14.1 1

```
1  clc;
2  T1=-30+273; //K
3  T2=32+273; //K
4
5  COP=T1/(T2-T1);
6
7  eff=0.75;
8  acctual_COP=eff*(COP);
9
10 Q=5; //kW
11 W=Q/acctual_COP;
12
13 disp("required powar input is:");
14 disp("kW",W);
```

---

Scilab code Exa 14.6 6

```
1  clc;
```

```

2 h1=301; //K
3 h2=330; //K
4 h4=145.5; //K
5
6 COP=(h1-h4)/(h2-h1);
7 disp("COP is:");
8 disp(COP)

```

---

### Scilab code Exa 14.8 8

```

1 clc;
2 h3=162.93;
3 hf1=120.06;
4 hg1=303.38;
5 hfg1=hg1-hf1;
6 x=(h3-hf1)/hfg1;
7 disp("the amount of vapour bled off at the flash
      chamber:");
8 disp(x);
9
10 //part II
11 s1=1.7155; //kJ/kg K
12 s2=s1;
13 s3=1.7071;
14 s4=1.7463;
15 h2=hg1+[(s1-s3)/(s4-s3)]*(314.86-hg1);
16 h3={(1-x)*h2}+x*hg1;
17
18 disp(h3,"h3=")
19 disp("hence vapour at inlet to the second stage
      compressor is still superheated")
20
21 //part III
22 h1=291.77;
23 h4=120.06;

```

```

24 Refrigerating=(1-x)*(h1-h4);
25 disp("refrigerating effect is:");
26 disp("kJ/kg",Refrigerating);
27
28 //part IV
29 h5=305.26; //kJ/kg
30 s5=s3+[(h3-hg1)/(h2-hg1)]*(s1-s3);
31
32 h6=319.54+[(s5-1.7028)/(1.7440-1.7028)
    ]*(332.87-319.54);
33
34 W=(1-x)*(h2-h1)+(h6-h5);
35 disp("kJ/kg",W,"Work done per unit mass of
    refrigerant in the condenser is:");
36
37 //part V
38 Q=131.53; //W
39 COP=Q/W;
40 h2=319.54+[(s1-1.7028)/(1.7440-1.7028)
    ]*(332.87-319.54);
41
42 h4=162.93;
43 W=(h2-h1);
44 Q=(h1-h4);
45
46 disp("coefficient of performance is:");
47 disp(COP);

```

---

# Chapter 15

## Psychrometry And Air Conditioning

Scilab code Exa 15.5 5

```
1  clc;
2  sensible_heat=18000; //W
3  latent_heat=3600; //W
4  total_heat=sensible_heat+latent_heat;
5  w4=0.0089;
6  w1=0.0075;
7  wA=w4-(w4-w1)/0.8;
8
9  h1=33.9; //kJ/kg
10 h2=40.2; //kJ/kg
11
12 mn1=total_heat/(h2-h1);
13 mass_flow_rate=mn1*(1+w1);
14 disp("mass flow rate of supply air is:");
15 disp("kg/s",mass_flow_rate/1000);
16
17 //part II
18 humidity=0.00745;
19 h4=46.2; //kJ/kg
```

```
20 h5=31.1; //kJ/kg
21 cooling_load=mn1*(h4-h5);
22 disp("cooling load on washer is:");
23 disp("kW",cooling_load/1000);
24
25 //part III
26 h6=33.9; //kJ/kg
27 heat_load=mn1*(h6-h5);
28 disp("heating load is:");
29 disp("kw",heat_load/1000)
```

---

# Chapter 16

## Heat Transfer

Scilab code Exa 16.1 1

```
1 clc;  
2 lambda=10^3*0.52;  
3 x=250;  
4 t1=40;  
5 t2=20;  
6 q=lambda*(t1-t2)/x;  
7 disp("rate of heat transfer per unit area:");  
8 disp("W/m^2",q);
```

---

Scilab code Exa 16.2 2

```
1 clc;  
2 alpha_a=2800;  
3 lambda=10^3*50;  
4 x=10;  
5 alpha_b=11;  
6 U=1/[1/alpha_a+x/lambda+1/alpha_b];  
7
```

```

8 tA=90;
9 tB=15;
10 q=(tA-tB)*U;
11 disp("rate of heat lost per sq m of surface")
12 disp("kW",q)
13
14 //part b
15 t2=q/alpha_b+tB;
16 disp("temperature of outside surface:");
17 disp("C",t2)

```

---

#### Scilab code Exa 16.7 7

```

1 clc;
2 alpha=88.8;
3 L=0.05;
4 lambda=40;
5 Bi=alpha*L/lambda;
6 //p1L*[cos(p1L)/sin(p1L)]=1-Bi;
7 //from trial and error;
8 p1L=0.57;
9
10 tou=20*60;
11 rho=7600;
12 c=0.5*10^3;
13 R=0.05;
14 F0=lambda*tou/(rho*c*R^2);
15
16 tF=20;
17 ti=500;
18 a=(sin(p1L)-p1L*cos(p1L))*(2*%e^[-(p1L)^2*F0])/(p1L-
    sin(p1L)*cos(p1L));
19 tc=tF+a*(ti-tF);
20 disp("temperature of center is:")
21 disp("C",tc)

```



```
22
23 //part b
24 tc=tF+[%e^(-3*Bi*F0)]*(ti-tF)
25 disp("temperature of center by newtonian cooling is:
      ")
26 disp("C",tc)
```

---

#### Scilab code Exa 16.12 12

```
1 clc;
2 delta_p=0.0002;//bar
3 d=25;
4 rho=7600;//assumed to run program
5 c=1.13;
6 C=24;
7 tou=delta_p*10^5*d/(4*10^3);
8 f=tou/(rho*C^2/2);
9 alpha=0.125*rho*c*C/(rho*C^2);
10 disp("heat transfer coefficient is:");;
11 disp("kW/m^2 K",alpha);
```

---

#### Scilab code Exa 16.15 15

```
1 clc;
2 delta_t=277-17;
3 d=0.15;
4 alpha=1.32*(delta_t/d)^0.25;
5 disp("heat transfer coefficient=");
6 disp("W/m^2 K",alpha);
```

---

### Scilab code Exa 16.16 16

```
1  clc;
2  Beta=1/303;
3  g=9.81;
4  l=1;
5  delta_t=327-30;
6  v=(5.128*10^-5);
7  Gr=Beta*g*l^3*delta_t/v^2
8
9  alpha=1.31*delta_t^0.33333
10 A=1; //m^2
11 delta_t=627-27;
12 Q=alpha*A*delta_t
13 disp("rate of heat loss:");
14 disp("kW",Q/1000);
```

---

### Scilab code Exa 16.18 18

```
1  clc;
2  m=3;
3  rho=500;
4  v=m/rho;
5
6  l=4; //m
7  r=0.01;
8  A=%pi*r^2;
9  n=v*l/A;
10 disp("number of tubes is:");
11 disp(n)
12
13 alpha0=260;
14 A0=12.7;
15 alphai=580;
16 Ai=10;
```

```

17 U=1/[1/alpha0+A0/(alpha1*Ai)];
18 N=U*%pi*(A0/1000)*l*n/(3*1.5*1000);
19 R=3*1.5/(40*1.04);
20
21 eta=[1-%e^(-N*(1-R))]/[1-R*%e^(-N*(1-R))]
22 disp(eta,"eta is:");
23
24 t2=400;
25 t1=100;
26 tL=eta*(t2-t1)+t1
27 disp("exit temperature is :");
28 disp(tL);

```

---

#### Scilab code Exa 16.21 21

```

1 clc;
2 eta=0.4;
3 sigma=5.67;
4 T1=13.73;
5 T2=3.13;
6 q=eta*sigma*(T1^4-T2^4);
7 disp("heat loss by radiation is:");
8 disp("kW",q/1000);
9
10 eta2=0.9;
11 q1=eta*sigma*T1^4;
12 q2=eta2*sigma*T2^4
13 q_=q1-q2;
14 disp("grey body assumptions overestimates by:");
15 pct=(q-q_)/q_
16 disp("%",pct*100)

```

---

#### Scilab code Exa 16.25 25

```
1  clc;
2  eta=0.8;
3  F1_2=5.67*10^-8;
4  T1=533; //K
5  T2=293; //K
6  alpha=eta*F1_2*(T1^2+T2^2)*(T1+T2);
7
8  A=%pi*0.6*0.9;
9  Q1=alpha*A*(T1-T2);
10
11 alpha=8.8;
12 A=5;
13 Q2=alpha*A*(T1-T2);
14
15 Q=Q1+Q2;
16 disp("total heat loss is:");
17 disp("kW",Q/1000)
```

---

# Chapter 17

## The Source Use and Management of Energy

Scilab code Exa 17.1 1

```
1  clc;
2  T1=15+273; //K
3  p2!p1=8;
4  y1=1.4;
5  T2s=T1*([p2!p1]^[(y1-1)/y1]);
6
7  T2=T1+(T2s-T1)/0.8;
8
9  T3=800+273; //K
10 p3!p4=p2!p1
11 y2=1.333;
12 T4s=T3/[(p3!p4)^([y2-1]/y2)];
13
14 T4=T3-0.82*(T3-T4s)
15
16 cv=1.11;
17 cp=1.005;
18 W=[cv*(T3-T4)-cp*(T2-T1)];
19
```

```

20 heat_supp=cv*(T3-T2);
21
22 cycle_eff=W/heat_supp;
23 disp(" cycle efficiency is :")
24 disp("%",cycle_eff*100); //end of part I
25
26 //part II
27 h1=3248; //kJ/kg
28 h3=138; //kJ/kg
29 h4=h3;
30 h2s=2173; //kJ/kg
31 W=0.8*(h1-h2s);
32
33 steam_heat_supp=h1-h3;
34 steam_cycle_eff=W/steam_heat_supp;
35 disp(" steam cycle efficiency is:");
36 disp(steam_cycle_eff*100)

```

---

#### Scilab code Exa 17.4 4

```

1 clc;
2 boiler_eff=71; //%
3 slope=20; //GJ/D daly
4 space_heat=boiler_eff/100*slope;
5 base_load_zero=10000; //GJ/month
6 base_load=boiler_eff/100*base_load_zero;
7 consume=1000; //GJ
8 base_load_new=base_load+consume;
9
10 new_eff=75; //%
11 new_base_load=base_load_new*100/new_eff;
12 new_space_heat=space_heat/new_eff*100;
13
14 //part I
15 disp(new_space_heat)

```

```
16 annual_consum=12*new_base_load+2527*new_space_heat;
17 disp("annual consumption is:")
18 disp("GJ/annum",annual_consum);
19
20 //part II
21 max_consum=new_base_load+(379*new_space_heat);
22 disp("fuel consumption in january is:")
23 disp("GJ/month",max_consum);
24
25 //part III
26 enrgy_consume=12*base_load_new/boiler_eff*100;
27 original_space_heat=2527*20;
28 saving=enrgy_consume+original_space_heat -
    annual_consum;
29 disp("enegy saving is:");
30 disp("GJ/annum",saving);
```

---