

Scilab Textbook Companion for
Internal Combustion Engines
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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

INTRODUCTION

Scilab code Exa 1.1 MECHANICAL EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  BHP=51//Brake horse power in h.p
5  N=1000//Speed in r.p.m
6  FHP=17//Friction horse power in h.p
7
8  //Calculations
9  IHP=(BHP+FHP)//Indicated Horse power in h.p
10 mn=(BHP/IHP)*100//Mechanical efficiency in percent
11
12 //Output
13 printf('Mechanical efficiency of the engine is %i
    percent ',mn)
```

Scilab code Exa 1.2 MECHANICAL EFFICIENCY

```
1  clc
```

```

2 clear
3 //Data taken from Ex.No.1
4 BHP=51//Brake horse power in h.p
5 N=1000//Speed in r.p.m
6 FHP=17//Friction horse power in h.p
7 //Input data
8 O1=BHP/2//Half of b.h.p output in h.p
9 O2=10//Brake horse power in h.p
10
11 //Calculations
12 //Case(i)
13 IHP1=(O1+FHP)//Indicated Horse power in h.p
14 mn1=(O1/IHP1)*100//Mechanical efficiency in percent
15
16 //Case(ii)
17 IHP2=(O2+FHP)//Indicated Horse power in h.p
18 mn2=(O2/IHP2)*100//Mechanical efficiency in percent
19
20
21 //Output
22 printf('Mechanical efficiency of the engine when it
    delivers \n (a) Half the b.h.p output is %3.0f
    percent \n (b) 10 b.h.p is %3.0f percent ',mn1,mn2
    )

```

Scilab code Exa 1.3 BRAKE THERMAL EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 Fc=220//Fuel consumption in gm/(b.h.p*hr)
5 CV=10600//Calorific value in kcal/kg
6
7 //Calculations
8 hf=(Fc/1000)*CV//Heat supplied in kcal/hr

```

```

9  O=632//Output in terms of kcal/hr
10 bn=(O/hf)*100//Brake thermal efficiency in percent
11
12 //Output
13 printf('Brake thermal efficiency is %3.1f percent',
        bn)

```

Scilab code Exa 1.4 THERMAL EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  IHP=45//Indicated horse power in h.p
5  Fc=13//Fuel consumption in litres/hr
6  g=0.8//Specific gravity of oil
7  nm=80//Mechanical efficiency in percent
8  CV=10000//Calorific value of fuel in kcal/kg
9
10 //Calculations
11 BHP=(IHP*nm)/100//Brake horse power in h.p
12 hi=(Fc*g*CV)//Heat supplied in kcal/hour
13 In=((IHP*4500*60)/(427*hi))*100//Indicated thermal
    efficiency in percent
14 Bn=(In*(nm/100))//Brake thermal efficiency in
    percent
15
16 //Output
17 printf('Indicated thermal efficiency is %3.2f
    percent \n Brake thermal efficiency is %3.2f
    percent ',In,Bn)

```

Scilab code Exa 1.5 FUEL CONSUMPTION

```
1  clc
2  clear
3  //Input data
4  BHP=15//Brake horse power in h.p
5  In=28//Indicated thermal efficiency in percent
6  mn=75//Mechanical efficiency in percent
7  CV=10000//Calorific value of fuel in kcal/kg
8
9  //Calculations
10 Bn=((In/100)*(mn/100))*100//Brake thermal efficiency
    in percent
11 I=(BHP/(Bn/100))*((4500*60)/427)//Input in kcal/hr
12 Fc=(I/CV)//Fuel consumption in kg/hr
13
14 //Output
15 printf('Fuel consumption of the engine is %3.2f kg/
    hr ',Fc)
```

Chapter 3

AIR STANDARD CYCLES

Scilab code Exa 3.1 AIR STANDARD EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  p=[1,8] //Pressure at the beginning and end of
           compression in kg/m^3
5  g=1.4 //Ratio of specific heats
6
7  //Calculations
8  r=(p(2)/p(1))^(1/g) //Compression ratio
9  n=(1-(1/r)^(g-1))*100 //Air standard efficiency in
           percent
10
11 //Output
12 printf('Air standard efficiency of an engine working
           on the Otto cycle is %3.1f percent',n)
```

Scilab code Exa 3.2 THERMAL EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  D=0.25//Bore in m
5  L=0.45//Stroke in m
6  Cv=5//Clearance volume in litres
7  g=1.4//Ratio of specific heats
8  IHP=32//Indicated Horse power in h.p
9  m=14//Gas consumption in m^3/hr
10 CV=4000//Calorific value of gas in kcal/m^3
11
12 //Calculations
13 Vs=(3.14/4)*D^2*L//Stroke volume in m^3
14 Vc=Cv/1000//Clearance volume in m^3
15 r=(Vs+Vc)/Vc//Compression ratio
16 na=(1-(1/r)^(g-1))*100//Air standard efficiency in
    percent
17 q=(m*CV)/60//Heat supplied in kcal/min
18 aI=(IHP*4500)/427//Heat equivalent of I.H.P in kcal/
    min
19 itn=(aI/q)*100//Indicated thermal efficiency in
    percent
20 rn=(itn/na)*100//Relative efficiency in percent
21
22 //Output
23 printf('The air standard efficiency is %3.1f percent
    \n Indicated thermal efficiency is %3.1f percent
    \n Relative efficiency is %3.1f percent',na,itn,
    rn)

```

Scilab code Exa 3.3 FUEL CONSUMPTION

```

1  clc
2  clear
3  //Input data

```



```

4 r=6//Compression ratio
5 It=0.6//Indicated thermal efficiency ratio
6 CV=10000//Calorific value in kcal/kg
7 g=1.4//Ratio of specific heats
8
9 //Calculations
10 an=(1-(1/r)^(g-1))*100//Air standard efficiency in
    percent
11 In=(It*(an/100))//Indicated thermal efficiency
12 SFC=((4500*60)/(427*CV*In))//Specific fuel
    consumption in kg/I.H.P.hr
13
14 //Output
15 printf('Specific fuel consumption is %3.3f kg/I.H.P.
    hr ',SFC)

```

Scilab code Exa 3.4 RATIO

```

1 clc
2 clear
3 //Input data
4 T=[100+273,473+273]//Temperatures at the beginning
    and at the end of adiabatic compression in K
5 g=1.4//Ratio of specific heats
6
7 //Calculations
8 an=(1-(T(1)/T(2))) *100//Air standard efficiency in
    percent
9 r=(T(2)/T(1))^(1/(g-1))//Compression ratio
10
11 //Output
12 printf('The compression ratio is %3.2f \n Air
    standard efficiency is %i percent ',r,an)

```

Scilab code Exa 3.5 AIR STANDARD EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  T1=45+273//Temperature at the beginning of
    compression in K
5  p1=1//Pressure at the beginning of compression in kg
    /cm^2
6  T2=325+273//Temperature at the end of compression in
    K
7  T3=1500+273//Temperature at the end of constant
    volume heat addition in K
8  g=1.4//Ratio of specific heats
9
10 //Calculations
11 r=(T2/T1)^(1/(g-1))//Compression ratio
12 an=(1-(1/r)^(g-1))*100//Air standard efficiency in
    percent
13 p2=(p1*r^g)//Pressure at the end of compression in
    kg/cm^2
14 p3=(p2*(T3/T2))//Pressure at the end of constant
    volume heat addition in kg/cm^2
15 p4=p3/p2//Pressure at the end of adiabatic expansion
    in kg/cm^2
16 T4=T3/r^(g-1)//Temperature at the end of adiabatic
    expansion in K
17 t4=T4-273//Temperature at the end of adiabatic
    expansion in degree C
18
19 //Output
20 printf('The air standard efficiency is %3.1f percent
    \n Temperature at the end of adiabatic expansion
    is %i degree C \n Pressure at the end of
```

adiabatic expansion is %3.0f kg/cm²',an,t4,p4)

Scilab code Exa 3.6 HEAT AND WORK

```
1  clc
2  clear
3  //Input data
4  T1=40+273//Temperature at the beginning of
      compression in K
5  p1=1//Pressure at the beginning of compression in kg
      /cm2
6  p2=15//Pressure at the end of adabatic compression
      in kg/cm2
7  T3=2000+273//Maximum temperature during the cycle in
      K
8  Cv=0.17//Specific heat at constant volume in kJ/kg.K
9  g=1.4//Ratio of specific heats
10
11 //Calculations
12 T2=T1*(p2/p1)^((g-1)/g)//Temperature at the end of
      adabatic compression in K
13 na=(1-(T1/T2))*100//Air standard efficiency in
      percent
14 q=(Cv*(T3-T2))//Heat added in kcal/kg of air
15 W=((na/100)*q)//Workdone per kg of air in kcal
16 W1=(4.28*W)//Workdone per kg of air in kg.m
17 p3=(p2*(T3/T2))//Pressure at the end of constant
      volume heat addition in kg/cm2
18 p4=(p3*p1)/p2//Pressure at the end of adiabatic
      expansion in kg/cm2
19
20 //Output
21 printf('(a) The heat supplied is %3.0f kcal/kg of
      air \n (b) The workdone is %i kcal/kg of air \n (
      c) The pressure at the end of adiabatic expansion
```

is %3.2f kg/cm²',q,W,p4)

Scilab code Exa 3.7 AIR STANDARD EFFICIENCY

```
1 clc
2 clear
3 //Input data
4 r=16//Compression ratio
5 k=5//Cut off takes place at 5% of the stroke
6 g=1.4//Ratio of specific heats
7
8 //Calculations
9 c=((k/100)*(r-1))+1//Cut off ratio
10 na=(1-((1/r^(g-1))*((c^g-1)/(g*(c-1))))) *100 //Air
    standard efficiency in percent
11
12 //Output
13 printf('The air standard efficiency is %3.1f percent
    ',na)
```

Scilab code Exa 3.8 THERMAL EFFICIENCY

```
1 clc
2 clear
3 //Input data
4 p1=1.05//Inlet pressure in kg/cm2
5 T1=15+273//Inlet temperature in K
6 p2=33.4//Pressure at the end of adiabatic
    compression in kg/cm2
7 r=5//The ratio of expansion
8 Cp=0.238//Specific heat at constant pressure in kJ/
    kg.K
9 Cv=0.17//Specific heat at constant volume in kJ/kg.K
```

```

10 g=1.4//Ratio of specific heats
11
12 //Calculations
13 r1=(p2/p1)^(1/g)//Compression ratio
14 k=r1/r//Cutoff ratio
15 T2=(p2/p1)^((g-1)/g)*T1//Temperature at the end of
    adiabatic compression in K
16 T3=T2*k//Temperature at the end of constant pressure
    heat addition in K
17 T4=T3*(1/r)^(g-1)//Temperature at the end of
    adiabatic expansion in K
18 qa=(Cp*(T3-T2))//Heat added in kcal/kg of air
19 qre=(Cv*(T4-T1))//Heat rejected in kcal/kg of air
20 nt=((qa-qre)/qa)*100//Ideal thermal efficiency in
    percent
21
22 //Output
23 printf('The ideal thermal efficiency is %3.1f
    percent ',nt)

```

Scilab code Exa 3.9 TEMPERATURE AND EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 p1=1//Pressure at the end of suction stroke in kg/cm
    ^2
5 T1=30+273//Temperature at the end of suction stroke
    in kg/cm^2
6 T3=1500+273//Maximum temperature during the cycle in
    K
7 r=16//Compression ratio
8 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
9 Cv=0.17//Specific heat at constant volume in kJ/kg.K

```

```

10 g=1.41//Ratio of specific heats
11
12 //Calculations
13 T2=T1*r^(g-1)//Temperature at the end of adiabatic
    compression in K
14 s=((T3/T2)-1)/(r-1)*100//Percentage of the stroke
    at which cut off occurs
15 r1=(r/(T3/T2))//Expansion ratio
16 T4=T3/(r1)^(g-1)//Temperature at the end of
    adiabatic expansion in K
17 qa=(Cp*(T3-T2))//Heat added in kcal/kg of air
18 qre=(Cv*(T4-T1))//Heat rejected in kcal/kg of air
19 nt=((qa-qre)/qa)*100//Air standard efficiency in
    percent
20
21 //Output
22 printf('(a) The percentage of stroke at which cut
    off takes place is %3.2f percent \n (b) The
    temperature at the end of expansion stroke is %3
    .0f K \n (c) The theoretical efficiency is %3.0f
    percent ',s,T4,nt)

```

Scilab code Exa 3.10 PRESSURE AND HEAT

```

1 clc
2 clear
3 //Input data
4 p1=1//Pressure at the beginning of compression in kg
    /cm^2
5 T1=80+273//Temperature at the beginning of
    compression in K
6 r=14//Compression ratio
7 p4=2.7//Pressure at the end of expansion in kg/cm^2
8 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K

```

```

9 g=1.4//Ratio of specific heats
10
11 //Calculations
12 p2=p1*r^g//Pressure at the end of compression in kg/
    cm^2
13 s=((r*(p4/p2)^(1/g))-1)/(r-1))*100//Percentage of
    stroke when the fuel is cut off in percent
14 T2=(T1*(p2/p1))/r//Temperature at the end of
    compression in K
15 T3=(T2*r*(p4/p2)^(1/g))//Temperature at the end of
    adiabatic expansion in K
16 q=(Cp*(T3-T2))//Heat supplied in kcal/kg
17
18 //Output
19 printf('(a) The maximum pressure attained during the
    cycle is %3.1f kg/cm^2 \n (b) The percentage of
    working stroke at which the heat supply to the
    working fluid ceases is %3.2f percent \n (c) The
    heat received per kg of woring substance during
    the cycle is %3.0f kcal/kg',p2,s,q)

```

Scilab code Exa 3.11 AIR STANDARD EFFICIENCY

```

1 clc
2 clear
3 d=0.25//Diameter of the cylinder in m
4 L=0.35//Stroke in m
5 Cv=1500//Clearance volume in c.c
6 s=5//cut off ratio takes place at 5 percent of
    stroke
7 a=1.4//Explosion ratio
8 g=1.4//Ratio of specific heats for air
9
10 //Calculations
11 Vs=(3.14/4)*d^2*L//Stroke volume in m^3

```

```

12 r=(Vs*10^6+Cv)/Cv//Compression ratio
13 k=(Cv+((s/100)*Vs*10^6))/Cv//Cut off ratio
14 na=(1-((1/(r^(g-1)))*((a*k^g-1)/((a-1)+a*g*(k-1))))
    *100//Air standard efficiency in percent
15
16 //Output
17 printf('The air standard efficiency of the engine is
    %3.1f percent',na)

```

Scilab code Exa 3.12 AIR STANDARD EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 d=0.2//Diameter of the cylinder in m
5 L=0.4//Stroke in m
6 r=13.5//Compression ratio
7 a=1.42//Explosion ratio
8 s=5.1//Cut off occurs at 5.1 percent of the stroke
9 g=1.4//Ratio of specific heats for air
10
11 //Calculations
12 Vs=(3.14/4)*d^2*L*10^-6//Stroke volume in c.c
13 Vc=Vs/r//Clearance volume in c.c
14 k=((s/100)*Vs)+Vc//Cut off ratio
15 ASE=(1-((1/(r^(g-1)))*((a*k^g-1)/((a-1)+a*g*(k-1))))
    )*100//Air standard efficiency in percent
16
17 //Output
18 printf('The air standard efficiency of the engine is
    %3.1f percent',ASE)

```

Scilab code Exa 3.13 TEMPERATURE AND EFFICIENCY


```

1  clc
2  clear
3  //Input data
4  x=[2/3,1/3]//The dual cycle atkes two-thirds of its
      total heat supply at constant volume and one-
      third at constant pressure
5  r=13//Compression ratio
6  p3=43//Maximum pressure of the cycle in kg/cm^2
7  p1=1//Pressure at intake in kg/cm^2
8  T1=15+273//Intake temperature in K
9  Cp=0.24//Specific heat at constant pressure in kJ/kg
      .K
10 Cv=0.17//Specific heat at constant volume in kJ/kg.K
11 g=1.41//Ratio of specific heats
12
13 //Calculations
14 T2=T1*r^(g-1)//Temperature at the end of compression
      in K
15 p2=(p1*r^g)//Pressure at the end of compression in
      kg/cm^2
16 T3=T2*p3/p2//Temperature at the end of constant
      volume heat addition in K
17 q23=Cv*(T3-T2)//Heat added at constant volume in
      kcal/kg
18 q34=(1/2)*q23//Heat added at constant pressure in
      kcal/kg
19 T4=(q34/Cp)+T3//Temperature at the end of constant
      pressure heat supply in K
20 T5=(T4*((p1*(T4/T3))/r)^(g-1))//Temperature at the
      end of expansion in K
21 na=(1-((Cv*(T5-T1))/((Cv*(T3-T2))+(Cp*(T4-T3))))
      *100//Efficiency in percent
22 T=[T1-273,T2-273,T3-273,T4-273,T5-273]//Temperature
      at the five cardinal points in degree C
23
24 //Output
25 printf('(a) The temperature at the five cardinal
      points of the cycle are : \n point 1 is %3.0f

```

```

degree C \n point 2 is %3.0f degree C \n point 3
is %3.0f degree C \n point 4 is %3.1f degree C \n
point 5 is %3.0f degree C \n\n (b) The ideal
thermal efficiency of the cycle is %3.1f percent'
,T(1),T(2),T(3),T(4),T(5),na)

```

Scilab code Exa 3.14 AIR STANDARD EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  p1=1//Pressure at intake in kg/cm^2
5  T1=100+273//Intake temperature in K
6  r=10//Compression ratio
7  p3=70//Maximum pressure of the cycle in kg/cm^2
8  q=400//Amount of heat added in kcal/kg of air
9  Cp=0.24//Specific heat at constant pressure in kJ/kg
   .K
10 Cv=0.17//Specific heat at constant volume in kJ/kg.K
11 g=1.41//Ratio of specific heats
12
13 //Calculations
14 T2=(T1*r^(g-1))//Temperature at the end of
   compression in K
15 p2=(p1*r^g)//Pressure at the end of compression in
   kg/cm^2
16 T3=T2*(p3/p2)//Temperature at the end of constant
   volume heat addition in K
17 qv=(Cv*(T3-T2))//Heat added at constant volume in
   kcal/kg
18 qp=(q-qv)//Heat added at constant pressure in kcal/
   kg
19 T4=(qp/Cp)+T3//Temperature at the end of constant
   pressure heat supply in K
20 k=(T4/T3)//Cut off ratio

```

```

21 T5=T4/(r/k)^(g-1)//Temperature at the end of
    expansion in K
22 qv2=Cv*(T5-T1)//Heat added at constant volume in
    kcal/kg
23 W=q-qv2//Workdone in kcal/kg of air
24 na=(W/q)*100//Air standard efficiency in percent
25
26 //Output
27 printf('The temperature at the five cardinal points
    of the cycle are : \n point 1 is %3.0f K \n point
    2 is %3.0f K \n point 3 is %3.0f K \n point 4 is
    %3.0f K \n point 5 is %3.0f K \n\n The air
    standard efficiency of the engine is %3.1f
    percent ',T1,T2,T3,T4,T5,na)

```

Scilab code Exa 3.15 WORK DONE AND EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  r=12//Compression ratio
5  p1=0.955//Pressure at the start of compression in kg
    /cm^2
6  T1=85+273//Temperature at the start of compression
    in K
7  p3=55//Maximum pressure of the cycle in kg/cm^2
8  x=(1/30)//Constant pressure heat reception continues
    for 1/30 of the stroke
9  Cp=0.238//Specific heat at constant pressure in kJ/
    kg.K
10 Cv=0.17//Specific heat at constant volume in kJ/kg.K
11 g=1.4//Ratio of specific heats
12
13 //Calculations
14 T2=T1*r^(g-1)//Temperature at the end of compression

```

```

    in K
15 p2=(p1*r^g)//Pressure at the end of compression in
    kg/cm^2
16 T3=T2*(p3/p2)//Temperature at the end of constant
    volume heat addition in K
17 T4=(T3*((p1+x*(r-1))/p1))//Temperature at the end of
    constant pressure heat supply in K
18 T5=T4*((p1+x*(r-1))/r)^(g-1)//Temperature at the end
    of expansion in K
19 qs=(Cv*(T3-T2))+(Cp*(T4-T3))//Heat supplied in kcal/
    kg of air
20 qre=(Cv*(T5-T1))//Heat rejected in kcal/kg of air
21 W=(qs-qre)//Workdone in kcal/kg of air
22 an=((qs-qre)/qs)*100//Air standard efficiency in
    percent
23
24 //Ouptut
25 printf('The wordone per kg of air is %3.2f kcal \n
    The ideal thermal efficiency is %3.1f percent',W,
    an)

```

Scilab code Exa 3.16 TEMPERATURE AND EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  p1=1//Pressure of air intake in kg/cm^2
5  T1=50+273//Temperature of air intake in K
6  v=(1/14)//Volume compresses by it adiabatically of
    its original volume
7  x=2//During the first stage, the pressure increases
    at constant volume to twice the pressure of the
    adiabatic compression, and during the second stage
    the volume is increased twice the clearance
    volume at constant pressure

```

```

8  r=(1/v)//Compression ratio
9  Cp=0.237//Specific heat at constant pressure in kJ/
   kg.K
10 Cv=0.169//Specific heat at constant volume in kJ/kg.
   K
11 g=1.4//Ratio of specific heats for air
12
13 //Calculations
14 T2=T1*r^(g-1)//Temperature at the end of compression
   in K
15 p2=(p1*r^g)//Pressure at the end of compression in
   kg/cm^2
16 p3=x*p2//Pressure at the end of the heat addition at
   constant volume in kg/cm^2
17 T3=T2*(p3/p2)//Temperature at the end of constant
   volume heat addition in K
18 T4=(T3*x)//Temperature at the end of constant
   pressure heat supply in K
19 T5=T4/(r/x)^(g-1)//Temperature at the end of
   expansion in K
20 qs=(Cv*(T3-T2))+(Cp*(T4-T3))//Heat supplied in kcal/
   kg of air
21 qre=(Cv*(T5-T1))//Heat rejected in kcal/kg of air
22 na=((qs-qre)/qs)*100//Air standard efficiency in
   percent
23 T=[T1-273,T2-273,T3-273,T4-273,T5-273]//Temperature
   at the five key points in degree C
24
25 //Output
26 printf('(a) The temperature at the five key points
   of the cycle are : \n point 1 is %3.0f K = %3.0f
   degree C \n point 2 is %3.0f K = %3.0f degree C \
   n point 3 is %3.0f K = %3.0f degree C \n point 4
   is %3.0f K = %3.0f degree C \n point 5 is %3.0f K
   = %3.0f degree C \n\n (b) The ideal thermal
   efficiency of the cycle is %3.2f percent ',T1,T(1)
   ,T2,T(2),T3,T(3),T4,T(4),T5,T(5),na)

```

Scilab code Exa 3.18 MEAN EFFECTIVE PRESSURE

```
1  clc
2  clear
3  //Input data
4  n=6//Six cylinder engine
5  r=5//Compression ratio
6  Vc=110//Clearance volume in c.c
7  a=0.66//Efficiency ratio referred to the air
   standard cycle
8  N=2400//Speed in r.p.m
9  m=9.9//Mass of petrol in kg
10 CV=10600//Calorific value of fuel in kcal/kg
11 g=1.4//Ratio of specific heats
12
13 //Calculations
14 Vs=(r*Vc-Vc)//Swept Volume in c.c
15 na=(1-(1/r)^(g-1))*100//Air standard efficiency in
   percent
16 nt=(na/100)*a//Thermal efficiency
17 IHP=(nt*CV*m*427)/(4500*60)//Indicated Horse Power
   in h.p
18 pm((((IHP/n)*4500*100*2)/(Vs*N))//Average indicated
   mean effective pressure in kg/cm^2
19
20 //Output
21 printf('The average indicated mean effective
   pressure in each cylinder is %3.3f kg/cm^2',pm)
```

Scilab code Exa 3.19 CYLINDER SIZES

```
1  clc
```

```

2 clear
3 //Input data
4 n=4//Four cylinder engine
5 BHP=40//Brake horse power in h.p
6 N=3000//Speed in r.p.m
7 nm=70//Mechanical efficiency in percent
8 pm=13.5//Indicated mean effective pressure in kg/cm
   ^2
9 //Bore is equal to stroke
10
11 //Calculations
12 //case(i)
13 d1=((BHP*100*4500*n*2)/(n*(nm/100)*pm*N*3.14))^(1/3)
   //Cylinder bore or stroke length in cm
14
15 //Case(ii)
16 d2=((BHP*100*4500*n)/(n*(nm/100)*pm*N*3.14))^(1/3)
   *10//Cylinder bore or stroke length in cm
17
18 //Output
19 printf('The cylinder sizes for a bore equal to
   stroke of a four cylinder in case of \n (i)Four
   stroke engine is %3.1f cm \n (ii)Two stroke
   engine is %3.0f mm',d1,d2)

```

Scilab code Exa 3.20 THERMAL EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 T=[50+273,345+273]//Temperatures at the beginning
   and end of compression in K
5 g=1.4//ratio of specific heats
6 IHP=25//Indicated horse power in h.p
7 m=5.44//Mass of fuel consumed per hour in kg

```

```

8 CV=10300//Calorific value in kcal/kg
9
10 //Calculations
11 na=(1-(T(1)/T(2)))*100//Air standard efficiency in
    percent
12 r=(T(2)/T(1))^(1/(g-1))//Compression ratio
13 qIHP=(IHP*4500)/427//Heat equivalent of I.H.P in
    kcal/min
14 q=(m*CV)/60//Heat supplied per minute in kcal/min
15 Ith=(qIHP/q)*100//Indicated thermal efficiency in
    percent
16 nr=(Ith/na)*100//Efficiency ratio
17
18 //Output
19 printf('The air standard efficiency is %3.1f percent
    \n The compression ratio is %3.2f \n Indicated
    thermal efficiency is %3.1f percent \n Efficiency
    ratio is %3.1f percent ',na,r,Ith,nr)

```

Scilab code Exa 3.21 COMPRESSION RATIO

```

1 clc
2 clear
3 //Input data
4 CV=10000//Calorific value of petrol in kcal/kg
5 pe=[30,70]//Percentage of compression strokes in
    percent
6 p=[1.33,2.66]//Pressures in the cylinder
    corresponding to the compression strokes in kg/cm
    ^2
7 n=1.33//Polytropic constant
8 rn=50//Relative efficiency in percent
9 g=1.4//ratio of specific heats
10
11 //Calculations

```



```

12 v=(p(2)/p(1))^(1/n)//Ratio of specific volumes
13 r=((pe(2)/100)*v-(pe(1)/100))/((pe(2)/100)-(pe(1)
    /100)*v)//Compression ratio
14 na=(1-(1/r)^(g-1))*100//Air standard efficiency in
    percent
15 ith=(rn*na)/100//Indicated thermal efficiency in
    percent
16 q=(4500*60)/(427*(ith/100))//Heat supplied in kcal/i
    .h.p.hr
17 Sc=(q/CV)//Specific consumption in kg/i.h.p.hr
18
19 //Output
20 printf('Compression ratio is %3.2f \n Specific
    consumption is %3.3f kg/i.h.p.hr',r,Sc)

```

Scilab code Exa 3.22 EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 n=4//Four cylinder four stroke
5 d=7.5//Bore in cm
6 L=8.75//Stroke in cm
7 r=6//Compression ratio
8 n1=55//Efficiency in percent
9 g=1.4//ratio of specific heats
10 N=2400//Speed in r.p.m
11 pm=7//Brake mean effective pressure in kg/cm^2
12 m=9//Mass of fuel per hour in kg
13 CV=10500//Calorific Value in kcal/kg
14
15 //Calculations
16 an=(1-(1/r)^(g-1))*100//Air standard efficiency in
    percent
17 In=(an*n1)/100//Indicated thermal efficiency in

```

```

    percent. In textbook, answer is wrong
18 BHP=(pm*(3.14/4)*d^2*(L/100)*(N/2)*n)//Brake horse
    power in kg.m/min
19 Bth=((BHP*60)/(427*CV*m))*100//Brake thermal
    efficiency in percent
20 nm=(Bth/In)*100//Mechanical efficiency in percent
21 Sc=((4500*60)/(427*(Bth/100)*CV))//Specific
    consumption in g/i.h.p.hr
22
23 //Output
24 printf('Indicated thermal efficiency is %3.1f
    percent \n Brake thermal efficiency is %3.1f
    percent \n Mechanical efficiency is %3.1f percent
    \n Specific fuel consumption is %3.3f kg/i.h.p.
    hr ',In,Bth,nm,Sc)

```

Scilab code Exa 3.26 PERCENTAGE CHANGE IN EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  r=7//Compression ratio
5  v=1//Specific heat at constant volume increases by 1
    percent
6  g=1.4//Ratio of specific heats
7
8  //Calculations
9  e=(1-(1/r^(g-1)))//Air standard efficiency
10 dee=-(((1-e)*(g-1)*log(r)*(v/100))/e)*100//Change in
    efficiency to the original efficiency
11 x=-(dee)//For Output purpose
12
13 //Output
14 printf('Percentage change in efficiency is %3.2f
    percent i.e., a decrease of %3.2f percent ',dee,x)

```

Scilab code Exa 3.30 MAXIMUM HORSE POWER

```
1  clc
2  clear
3  //Input data
4  N=210//Speed in r.p.m
5  d=0.3//Diameter of the piston in m
6  L=0.4//Stroke in m
7  v=2.5//Clearance volume is 2.5% of the swept volume.
      But in textbook it is given wrong as 25%
8  C0=19.7//Percentage of CO gas
9  H2=28.8//Percentage of H2 gas
10 C02=14.4//Percentage of CO2 gas
11 N2=37.1//Percentage of N2 gas
12 x=0.875//Total mixture at N.T.P admitted per suction
      stroke is 0.875 of the total volume behind the
      piston at the end of the stroke
13 tn=35//Thermal efficiency in percent
14 CVH2=13200//Calorific value of H2 per kg in kcal
15 CVC=2540//Calorific value of carbon burning from CO
      to CO2 in kcal/kg
16 de=1.293//Density of air in kg/m^3
17 mC=12//Molecular weight of carbon
18 mO2=32//Molecular weight of O2
19 mH2=2//Molecular weight of H2
20 mCO=28//Molecular weight of CO
21
22 //Calculations
23 a=((100/21)*((C02/100)+((C0/2)/100)))//Air per cu.m
      of gas in cu.m
24 Vm=(a+1)//Volume of mixture per cu.m of gas in cu.m
25 Vs=((3.14/4)*d^2*L)//Swept volume in cu.m
26 Vc=(Vs*v)/100//Clearance volume in cu.m
27 V=Vc+Vs//Total volume in cu.m
```

```

28 VC=V*x//Volume of charge admitted per stroke in cu.m
29 VM=VC*(N/2)//Charge volume per minute in cu.m
30 VG=(VM/Vm)//cu.m of gas per minute
31 vH2=(VG*(H2/100))//Volume of H2 per minute in cu.m
32 vCO=(VG*(CO/100))//Volume of CO per minute in cu.m
33 CVH2cum=(mH2*CVH2)/(vH2*1000)//Calorific value of H2
    per cu.m in kcal
34 CVC0=(CVC*(2*mC)/(2*mCO))//Calorific value of CO per
    kg in kcal
35 CVC0cum=(mCO*CVC0)/(vH2*1000)//Calorific value of CO
    per cu.m in kcal
36 qH2=(16.09*CVH2cum)//Heat in charge due to H2 in
    kcal
37 qCO=(11*CVC0cum)//Heat in charge due to CO in kcal
38 qt=(qH2+qCO)//Heat supplied per minute in kcal
39 qu=(qt*(tn/100))//Heat utilised in kcal
40 hp=(qu*427)/4500//H.P developed
41
42 //Output
43 printf('Maximum horse power that can be developed is
    %3.1f H.P',hp)

```

Scilab code Exa 3.31 AIR FUEL RATIO

```

1 clc
2 clear
3 //Input data
4 vCH4=65//Composition by volume of CH4
5 vH2=2//Composition by volume of H2
6 vN2=2//Composition by volume of N2
7 vCO2=31//Composition by volume of CO2
8 O2=5.3//Composition of O2 in dry exhaust gases when
    analysed in orsat apparatus
9 N2=83//Composition of N2 in dry exhaust gases when
    analysed in orsat apparatus

```

```

10 C0=0.3//Composition of CO in dry exhaust gases when
    analysed in orsat apparatus
11 C02=11.4//Composition of CO2 in dry exhaust gases
    when analysed in orsat apparatus
12 an=79//Air contains 79% by volume of nitrogen
13
14 //Calculations
15 a=(100/(100-an))*(((vCH4/100)*2)+((vN2/100)*(1/2)))
    //Total air required for complete combustion of 1
    cu.m of gas in cu.m
16 xC0=(C0/2)//O2 required to burn the CO in cu.m
17 xC02=C0//CO2 formed in cu.m
18 t02=02-xC0//Total O2 in cu.m
19 tn2=N2//Total N2 in cu.m
20 tC02=C02+xC02//Total CO2 in cu.m
21 T=t02+tn2+tC02//Total mixture in cu.m
22 pC02=(tC02*100)/T//Percentage of CO2 in percent
23 mm=(a*100)//Minimum air supply required for complete
    combustion of 100 cu.m of the gas in cu.m
24 an2=(an/100)*mm//N2 for this air in cu.m
25 tn2=(an2+vN2)//Total N2 in cu.m
26 v=(((vCH4+vC02)*100)/pC02)-(vCH4+vC02+tn2)//Increase
    in air supply for reduction in percentage of CO2
    in cu.m
27 pea=(v*100)/mm//Percentage of excess air. In
    textbook it is given wrong as 26.7 percent
28
29 //Output
30 printf('(a) the air-fuel ratio by volume to give
    complete combustion is %3.3f \n (b) the
    percentage of excess air actually used in the
    test is %3.1f percent ',a,pea)

```

Scilab code Exa 3.32 AIR GAS RATIO

```

1  clc
2  clear
3  //Input data
4  Vs=9.45//Swept volume in litres
5  Vc=2.32//Clearance volume in litres
6  m=4.25//Consumption of gas per hour in cu.m
7  N=165//Speed in r.p.m
8  bhp=5.62//Brake horse power in h.p
9  nm=73.4//Mechanical efficiency in percent
10 CV=3500//Calorific value in kcal per cubic meter
11 vn=0.87//Volumetric efficiency
12 g=1.4//Ratio of specific heats
13
14 //Calculations
15 tV=(Vs+Vc)*1000//Total volume in c.c
16 rc=(tV/Vc)//Compression ratio
17 na=(1-(1/rc^(g-1)))*100//Air atandard efficiency in
    percent
18 W=(bhp*4500)/427//Workdone per minute in kcal
19 Iw=(W/(nm/100))//Indicated work in kcal/min
20 q=(m/60)*CV//Heat supplied in kcal/min
21 ith=(Iw/q)*100//Indicated thermal efficiency in
    percent
22 rn=(ith/na)*100//Relative efficiency in percent
23 Vm=(Vs*1000)*vn//Volume of mixture taken in per
    stroke in c.c
24 Vg=(m*2*10^6)/(60*N)//Volume of gas taken in per
    stroke in c.c
25 Va=(Vm-Vg)//Volume of air taken in per stroke in c.c
26 agr=(Va/Vg)//Air gas ratio
27 CVc=(CV/(agr+1))//Calorific value of charge in kcal
28
29 //Output
30 printf('Ratio of air to gas used is %3.2f \n
    Calorific value of 1 cu.m of the mixture in the
    cylinder is %3.1f kcal',agr, CVc)

```

Scilab code Exa 3.33 FRICTION HORSE POWER

```
1  clc
2  clear
3  //Input data
4  d=18//Bore in cm
5  l=37.5//Stroke in cm
6  N=220//Speed in r.p.m
7  //Mean effective pressure in kg/cm^2
8  //Firing
9  pp=5.9//Positive loop
10 pn=0.248//Negative loop
11 //Missing
12 nn=0.432//Negative loop
13 bhp=8.62//Brake horse power in h.p
14 ex=100//Explosions per minute
15 vg=0.101//Gas used in cu.m per minute
16
17 //Calculations
18 tc=(N/2)//The number of cycles
19 nw=ex//Number of working cycles
20 nm=(tc-nw)//Number of missing cycles
21 ihp=((1/100)*(3.14/4)*(d^2/4500))*((pp-pn)*(100-nn))
    //Net I.H.P in h.p
22 fhp=(ihp-bhp)//Friction horse power in h.p
23 W=((pp-pn)*(3.14/4)*(d^2*(1/100)))//Workdone per
    firing done in kg.m
24 Wp=(nn*(3.14/4)*d^2*(1/100))//Workdone per pumping
    stroke in kg.m
25 n=((fhp*4500)+(Wp*tc))/(W+Wp)//Number of strokes
26 gf=(vg/nw)//Gas per firing stroke in cu.m
27 gl=(n*gf)//Gas per minute at no load in cu.m
28
29 //Output
```

```
30 printf('Friction horse power of the engine is %3.2f
    \n Gas consumption at no load is %3.3f cu.m/min',
    fhp,g1)
```

Chapter 4

FUEL AIR CYCLES AND REAL CYCLES

Scilab code Exa 4.1 WORK DONE

```
1  clc
2  clear
3  //Input data
4  d=20//Bore in cm
5  l=38//Stroke in cm
6  Vc=900//Clearance volume in c.c
7  p1=1//Pressure at the start of compression stroke in
   kg/cm^2
8  T1=90+273//Temperature at the start of compression
   stroke in K
9  x=0.75//Piston travelled 0.75 of the compression
   stroke
10 n=1.32//Compression curve index
11 wa=0.0125//Weight of air in kg
12
13 //Calculations
14 Vs=(3.14/4)*d^2*l//Swept volume in c.c
15 V1=(Vs+Vc)//Volume in c.c
16 V2=(1-x)*Vs+Vc//Volume in c.c
```

```

17 p2=p1*(V1/V2)^n//Pressure in kg/cm^2
18 T2=(T1*(p2/p1)*(V2/V1))//Temperature in K
19 W=((p1*V1-p2*V2)/(n-1))*10^-2//Workdone in kg.m
20 dI=wa*0.17*(T2-T1)//Change in internal energy in
    kcal
21 q=(dI+(W/427))//Heat in kcal
22
23 //Output
24 printf('When the cylinder has travelled %3.2f of the
    compression stroke, \n The volume is %3.0f c.c \
n The pressure is %3.2f kg/cm^2 \n Temperature is
    %3.0f K \n\n The workdone on the gas is %3.2f kg
    .m \n\n Change in internal energy between the two
    points is %3.3f kcal',x,V2,p2,T2,W,dI)

```

Chapter 5

VARIABLE SPECIFIC HEAT

Scilab code Exa 5.2 CHANGE IN AIR STANDARD EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  r=8//Compression ratio
5  n=1.41//Adiabatic index of the medium
6  cv=0.17//Mean Specific heat at constant volume in
      kcal/kg/degree C
7  x=2//Percentage with which specific heat at constant
      volume increases
8  R=29.3//Characteristic gas constant in mkg/kg/degree
      C
9  J=427//Mechanical equivalent of heat in kg.m/kcal
10
11 //Calculations
12 e=(1-(1/r^(n-1)))//Air standard efficiency
      neglecting the variation in specific heat
13 debye=((x/100)*((1-e)/e)*(R/(J*cv))*log(r))*100//
      Ratio of de and e in percent
14
15 //Output
16 printf('The change in air standard efficiency of the
```

cycle is %3.3f percent ',debye)

Scilab code Exa 5.3 WORK DONE

```
1
2 clc
3 clear
4 //Input data
5 //Cv=0.125+0.000005T where Cv is Specific heat at
   constant volume and T is the temperature in K
6 R=28.9//Characteristic gas constant in mkg/kg/degree
   C
7 T=[100+273,50+273]//Temperature in K
8 J=427//Mechanical equivalent of heat in kg.m/kcal
9
10 //Calculations
11 function y=f(x),y=0.125+(0.00005*x),endfunction
12 I=J*intg(303,373,f)
13
14 //Output
15 printf('The work done is %i m.kg/kg of gas',I)
```

Scilab code Exa 5.4 PERCENTAGE OF STROKE

```
1 clc
2 clear
3 //Input data
4 af=25//Air fuel ratio
5 cv=[0.17,0.00004]//Cv=0.17+0.00004T where Cv is
   Specific heat at constant volume and T is the
   temperature in K
6 r=14//Compression ratio
```

```

7 p1=1//Pressure at the beginning of compression in kg
  /cm^2
8 T1=153+273//Temperature at the beginning of
  compression in K
9 CV=10000//Heating value of fuel in kcal/kg
10 n=1.35//Adiabatic constant
11 R=29//Characteristic gas constant in mkg/kg.K
12 J=427//Mechanical equivalent of heat in kg.m/kcal
13
14 //Calculations
15 T2=(T1*r^(n-1))//Temperature at the end of
  compression in K
16 a=(cv(2)/2)//For solving T3
17 b=cv(1)+(R/J)//For solving T3
18 c=(-T2*cv(1))-((cv(2)/2)*T2^2)-((R/J)*T2)-(CV/(af+1)
  )//Foe solving T3
19 T3=(-b+sqrt(b^2-(4*a*c)))/(2*a)//Soving for T3 in K
20 pc((((T3/T2)-1)/(r-1))*100//Percentage cut off
21
22 //Output
23 printf('The percentage of stroke at which the
  constant pressure combustion stops is %i percent'
  ,pc)

```

Scilab code Exa 5.5 PERCENTAGE OF STROKE

```

1 clc
2 clear
3 //Input data
4 af=25//Air fuel ratio
5 CV=10000//Calorific value in kcal/kg
6 cv=[0.17,0.00004]//Cv=0.17+0.00004T where Cv is
  Specific heat at constant volume and T is the
  temperature in K
7 r=14//Compression ratio

```

```

8 T2=800+273//Temperature at the end of compression in
  K
9 R=29//Characteristic gas constant in mkg/kg/degree C
10 J=427//Mechanical equivalent of heat in kg.m/kcal
11
12 //Calculations
13 CVm=(CV/(af+1))//Calorific value of mixture in kcal/
  kg
14 cpv=(R/J)//Difference in mean specific heats in kcal
  /kg mol.K
15 a=(cv(2)/2)//For solving T3
16 b=cpv+cv(1)//For solving T3
17 c=(-T2*(cpv+cv(1)))-((cv(2)/2)*T2^2)-CVm//Foe
  solving T3
18 T3=(-b+sqrt(b^2-(4*a*c)))/(2*a)//Soving for T3 in K
19 s=((T3/T2)/(r-1))*100//Percentage of the stroke
20
21 //Output
22 printf('The percentage of the stroke at which the
  combustion will be complete is %3.2f percent',s)

```

Scilab code Exa 5.6 CHANGE IN ENTHALPY

```

1 clc
2 clear
3 //Input data
4 T=[500,2000]//Change in temperature in K
5 x=[11.515,-172,1530]//Cp=11.515-172/sqrt(T)+1530/T
  in kcal/kg mole.K
6 mO2=32//Molecular weight of oxygen
7
8 //Calculations
9 function y=f(T),y=(x(1)+(x(2)/sqrt(T))+x(3)/T),
  endfunction
10 I=-intg(T(2),T(1),f)//Integration

```

```

11 dh=(I/m02)//Change in enthalpy in kcal/kg
12
13 //Output
14 printf('The change in enthalpy is %3.1f kcal/kg',dh)

```

Scilab code Exa 5.7 TEMPERATURE AND PRESSURE

```

1  clc
2  clear
3  //Input data
4  r=14//Compression ratio
5  s=5//Fuel injection stops at 5% stroke after inner
   head centre
6  pm=50//Maximum pressure in kg/cm^2
7  p4=1//Pressure at the end of suction stroke in kg/cm
   ^2
8  T4=90+273//Temperature at the end of suction stroke
   in K
9  R=29.3//Characteristic gas constant in mkg/kg/degree
   C
10 cv=[0.171,0.00003]//Cv=0.171+0.00003T where Cv is
   Specific heat at constant volume and T is the
   temperature in K
11 J=427//Mechanical equivalent of heat in kg.m/kcal
12
13 //Calculations
14 a=(R/J)+cv(1)//a value in kcal/kg.mole.K
15 g=(a+cv(2)*T4)/(cv(1)+cv(2)*T4)//Adiabatic index of
   compression
16 z=1.3//Rounding off 'z' value to one decimal.
17 T5=(T4*r^(z-1))//Temperature in K
18 p5=(p4*r^g)//Pressure in kg/cm^2
19 T1=T5*(pm/p5)//Tmperature in K
20 T2=(T1*(1+(s/100)*(r-1)))//Temperature in K
21 T3=(T2*((1+(s/100)*(r-1))/r)^(g-1))//Temperature in

```

```

K
22 p3=(p4*(T3/T4))//Pressure in kg/cm^2
23 function y=f1(T),y=cv(1)+(cv(2)*T),endfunction
24 I1=intg(T5,T1,f1)
25 function y=f2(T),y=(a+(cv(2)*T)),endfunction
26 I2=intg(T1,T2,f2)//I2 answer is given wrong in the
    textbook
27 qs=(I1+I2)//Heat supplied per kg of air in kcal/kg
28 function y=f3(T),y=a+(cv(2)*T),endfunction
29 qre=intg(T4,T3,f3)//Heat required per kg of air in
    kcal/kg
30 nth=((qs-qre)/qs)*100//Thermal efficiency in percent
31
32 //Output
33 printf('The tempertautes and pressures at salient
    points of the cycle are : \n T1 = %3.0f K  p1 =
    %3.1f kg/cm^2 \n T2 = %3.0f K  p2 = %3.1f kg/cm^2
    \n T3 = %3.0f K  p3 = %3.1f kg/cm^2 \n T4 = %3.0
    f K  p4 = %3.1f kg/cm^2 \n T5 = %3.0f K  p5 = %3
    .1f kg/cm^2 \n\n Heat supplied per kg of air is
    %3.1f kcal/kg \n\n The thermal efficiency of the
    cycle is %3.1f percent ',T1,pm,T2,pm,T3,p3,T4,p4,
    T5,p5,qs,nth)
34 //Textbook answers are given wrong

```

Scilab code Exa 5.8 TEMPERATURE AND HEAT

```

1  clc
2  clear
3  //Input data
4  r=14//Compression ratio
5  c=5//Cut off takes place at 5% of the stroke
6  p1=1//Pressure at the beginning of compression in kg
    /cm^2. In texbook, it is given wrong as 10
7  T1=90+273//Temperature at the beginning of

```



```

      compression in K
8  p3=50//Maximum pressure in kg/cm^2
9  R=29.3//Characteristic gas constant in mkg/kg/degree
    C
10 cv=[0.171,0.00003]//Cv=0.171+0.00003T where Cv is
    Specific heat at constant volume and T is the
    temperature in K
11 g1=1.4//Ratio of specific heats
12 J=427//Mechanical equivalent of heat in kg.m/kcal
13
14 //Calculations
15 T2x=(T1*r^(g1-1))//Temperature in K
16 function y=f1(T),y=cv(1)+(cv(2)*T),endfunction
17 I1=intg(T1,T2x,f1)
18 Cv=(1/(T2x-T1))*I1//Mean value of Cv in kJ/kg.K
19 Cp=(Cv+(R/J))//Mean value of Cp in kJ/kg.K
20 g=1.35//(Cp/Cv) value and rounded off to 2 decimal
    places for calculation purpose. Ratio of specific
    heats
21 T2=(T1*r^(g-1))//Temperature in K
22 I2=intg(T1,T2,f1)
23 CV=(1/(T2-T1))*I2//Maen value of Cv in kJ/kg.K
24 CP=(Cv+(R/J))//Mean value of Cp in kJ/kg.K
25 g2=1.36//(Cp/Cv) value and rounded off to 2 decimal
    places for calculation purpose. Ratio of specific
    heats
26 T2a=(T1*r^(g2-1))//Temperature in K
27 p2=(p1*r*(T2a/T1))//Pressure in kg/cm^2
28 T3=(T2a*(p3/p2))//Temperature in K
29 T4=((r-1)*(c/100))+1)*T3//Temperature in K
30 g3=1.3//Assuming gamma as 1.3 for process 4-5
31 T5=(T4/(r/(((r-1)*(c/100))+1)))^(g3-1)//Temperature
    in K
32 cV=cv(1)+(cv(2)/2)*(T5+T4)//Mean value of Cv in kJ/
    kg.K
33 cP=cV+(R/J)//Mean value of Cp in kJ/kg.K
34 g4=(cP/cV)//Ratio of specific heats
35 T5a=(T4/(r/(((r-1)*(c/100))+1)))^(g4-1))

```

```

36 I3=intg(T2a,T3,f1)
37 function y=f2(T),y=cv(1)+(R/J)+(cv(2)*T),endfunction
38 I4=intg(T3,T4,f2)//Textbook answer is wrong
39 q=I3+I4//Heat supplied per kg of working substance
    in kcal/kg
40
41 //Output
42 printf('(a) Temperatures at all the points of the
    cycle are: \n T1 = %i K \n T2 = %3.0f K \n T3 =
    %3.0f K \n T4 = %3.0f K \n T5 = %i K \n\n (b)
    heat supplied per kg of the working substance is
    %3.1f kcal/kg',T1,T2a,T3,T4,T5a,q)
43 //Textbook answer is wrong

```

Scilab code Exa 5.10 PERCENTAGE CHANGE IN EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  r=20//Compression ratio
5  c=5//Cut off at 5%
6  dc=1//Specific heat at constant volume increases by
    1%
7  Cv=0.171//pecific heat at constant volume in kJ/kg.K
8  R=29.3//Characteristic gas constant in mkg/kg/degree
    C
9  k=1.95//k can be obtained from relation  $de/e = -dc/cv$ 
     $*(1-e/e)*(g-1)*((1/g)+\ln(r)-(k^g*\ln k)/(k^g-1))$ 
10 J=427//Mechanical equivalent of heat in kg.m/kcal
11
12 //Calculations
13 g=(R/(J*Cv))+1//Ratio of specific heats
14 e=(1-((1/g)*(1/r^(g-1))*((k^g-1)/(k-1))))//Air
    standard efficiency of the cycle
15 dee=((-(dc/100)*((1-e)/e)*(g-1)*((1/g)+log(r)-((k^g*

```

```
    log(k)/(k^g-1))) * 100) //Change in efficiency due
    to 1% change in cv
16
17 //Output
18 printf('Percentage change in air standard efficiency
    is %3.3f percent \n This indicates that there is
    a decrease in efficiency ', dee)
```

Chapter 6

COMBUSTION CHARTS

Scilab code Exa 6.1 EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  r=7.5//Compression ratio
5  //Data from combustion chart
6  p=[1,15.1,26.95,1.95]//Pressure of air fuel mixture
   in kg/cm^2
7  T=[60,460,1150,435]//Temperature of air fuel mixture
   in K
8  V=[16.98,2.264,2.264,16.98]//Volume in m^3/kg
9  U=[17,78.8,212,80]//Internal energy in kcal/kg
10 S=[0.07,0.07,0.22,0.22]//Entropy in kcal/kg.degree C
11 g=1.4//Ratio of specific heats
12
13 //Calculations
14 n=((U(3)-U(4))-(U(2)-U(1)))/(U(3)-U(2))*100//
   Thermal efficiency in percent
15 na=(1-(1/r)^(g-1))*100//Air standard efficiency in
   percent
16
17 //Output
```

```
18 printf('Thermal efficiency is %3.1f percent \n Air
        standard efficiency is %3.1f percent ',n,na)
```

Scilab code Exa 6.2 EFFICIENCY

```
1 clc
2 clear
3 //Input data
4 //Data from combustion chart
5 p=[1,33,33,1]//Pressure of air fuel mixture in kg/cm
    ^2
6 T=[65,600,1450,725]//Temperature of air fuel mixture
    in K
7 V=[16,1.23,3.45,16]//Volume in m^3/kg
8 U=[11.8,110,295,140]//Internal energy in kcal/kg
9 H=[22.7,150,395,225]//Enthalpy in kcal/kg
10 S=[0.068,0.068,0.264,0.264]//Entropy in kcal/kg.
    degree C
11
12 //Calculations
13 r=(V(1)/V(2))//Compression ratio
14 q=(H(3)-H(2))//Heat supplied in kcal/kg
15 qre=(U(4)-U(1))//Heat rejected in kcal/kg
16 nt=((q-qre)/q)*100//Thermal efficiency in percent
17
18 //Output
19 printf('(a)Compression ratio is %3.0f \n (b) Heat
        supplied to the cycle is %3.0f kcal/kg \n (c)
        Heat rejected by the cycle is %3.2f kcal/kg \n (d
        ) Thermal efficiency is %3.2f percent ',r,q,qre,nt
        )
```

Scilab code Exa 6.3 EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  //Data from combustion chart
5  p=[1,51.5,77.25,77.25,3.75] //Pressure of air fuel
    mixture in kg/cm^2
6  T=[16,1,1,1.5,16] //Temperature of air fuel mixture
    in K
7  V=[65,745,1400,2200,1030] //Volume in m^3/kg
8  U=[14.7,135,275,475,197] //Internal energy in kcal/kg
9  H=[21.9,85,372,625,280] //Enthalpy in kcal/kg
10 S=[0.068,0.068,0.19,0.32,0.32] //Entropy in kcal/kg.
    degree C
11
12 //Calculations
13 nth=((U(3)-U(2))+H(4)-H(3))-(U(5)-U(1)))/((U(3)-U
    (2))+H(4)-H(3)))*100 //Thermal efficiency in
    percent
14
15 //Output
16 printf('Thermal efficiency is %3.2f percent',nth)

```

Chapter 8

COMBUSTION

Scilab code Exa 8.1 COMPOSITION

```
1  clc
2  clear
3  //Input data
4  C=88.6//Composition of C in percent
5  H2=11.4//Composition of H2 in percent
6
7  //Calculations
8  w1=(C/100)//Weight per kg of fuel of C in kg
9  w2=(H2/100)//Weight per kg of fuel of H2 in kg
10 O1=(8/3)//Oxygen required per kg of constituent for
    C in kg
11 O2=8//Oxygen required per kg of constituent for H2
    in kg
12 O11=(w1*O1)//Oxygen required per kg of fuel for C in
    kg
13 O22=(w2*O2)//Oxygen required per kg of fuel for H2
    in kg
14 T=(O11+O22)//Total Oxygen required per kg of fuel in
    kg
15 P1=(w1+O11)//Composition of CO2 in kg
16 P2=(w2+O22)//Composition of H2O in kg
```

```

17 w=(T*(100/23))//Weight of air required in kg per kg
    of fuel
18
19 //Output
20 printf('The weight of air required for complete
    combustion of liquid fuel is %3.2f kg per kg of
    fuel \n \n The composition of CO2 is %3.3f kg \n
    The composition of H2O is %3.3f kg',w,P1,P2)

```

Scilab code Exa 8.2 WEIGHT OF AIR

```

1  clc
2  clear
3  //Input data
4  C=12//Molecular weight of carbon
5  H2=2//Molecular weight of H2
6  O2=32//Molecular weight of O2
7
8  //Calculations
9  C7H16=(7*C+8*H2)//Molecular weight of C7H16
10 O2x=(11*O2)//Molecular weight of 22O2
11 wt=(O2x/C7H16)*(100/23.2)//Weight of air in kg per
    kg of fuel
12 //Now in actual experiment, we have
13 //1[C7H16] +x[O2] +...[N2] = a[CO2] +8[H2O] +a[O2]
    +...[N2]
14 //This is the new equation written in volumes. The
    volumes of CO2 and O2 being equal, with no CO
    present, and the usual assumption that all the
    hydrogen is burnt to H2O
15 //Now, if all the carbon is burnt, we must have 7
    mols of CO2
16 x=(7+4+7)//Total number of mols from CO2,H2O and O2
    terms respectively
17 W=((x*O2)/100)*(100/23.2)//Weight of air in kg per

```



```

    kg of fuel
18
19 //Output
20 printf('The weight of air is %3.1f kg per kg of fuel
    which would just suffice for theoretically
    complete combustion \n The ratio of air to fuel
    by weight as actually supplied is %3.1f kg of air
    per kg of fuel ',wt,W)

```

Scilab code Exa 8.3 AIR AND VOLUME

```

1  clc
2  clear
3  //Input data
4  H=15//Percentage of Hydrogen by volume
5  CO=25//Percentage of carbon monoxide by volume
6  CH4=4//Percentage of methane by volume
7  CO2=4//Percentage of carbon dioxide by volume
8  O2=2//Percentage of oxygen by volume. In textbook it
    is given wrong as 25
9  N2=50//Percentage of nitrogen by volume
10
11 //Calculations
12 O21=(H/100)*(1/2)//Volume of oxygen required in m^3
    by 15 percent of H2
13 O22=(CO/100)*(1/2)//Volume of oxygen required in m^3
    by 25 percent of CO
14 CO21=(CO/100)*1//Volume of CO2 produced in m^3 by 25
    percent of CO
15 O23=(CH4/100)*2//Volume of oxygen required in m^3 by
    4 percent of CH4
16 CO22=(CH4/100)*1//Volume of CO2 produced in m^3 by 4
    percent of CH4
17 H2O1=(CO/100)*2//Volume of H2O produced in m^3 by 4
    percent of CH4

```

```

18 T02=(O21+O22+O23-(O2/100))//Total vol. of oxygen in
    m^3
19 wa=(T02*(100/21))//Theoretical volume of air
    required in m^3
20 vN2=(wa*(79/100))//Volume of N2 present in air in m
    ^3
21 TvN2=(vN2+(N2/100))//Total volume of N2 after
    combustion of 1 m^3 of fuel in m^3
22 xCO2=(CO21+CO22)//CO2 produced due to combustion of
    fuel in m^3
23 TCO2=(xCO2+(CO2/100))//Total volume of CO2 in the
    flue gas in m^3
24
25 //Output
26 printf('The air required for complete combustion of
    one m^3 of the fuel is %3.3f cu.m \n The dry flue
    gas contains %3.3f cu.m volume of N2 and %3.2f
    cu.m volume of CO2',wa,TvN2,TCO2)

```

Scilab code Exa 8.4 WEIGHT OF AIR

```

1  clc
2  clear
3  //Input data
4  C=88.1//Composition of C in percent
5  H2=10.7//Composition of H2 in percent
6  O2=1.2//Composition of O2 in percent
7
8  //Calculations
9  w1=(C/100)//Weight per kg of fuel of C in kg
10 w2=(H2/100)//Weight per kg of fuel of H2 in kg
11 w3=(O2/100)//Weight per kg of fuel of O2 in kg
12 O1=(8/3)//Oxygen required per kg of constituent for
    C in kg
13 O2=8//Oxygen required per kg of constituent for H2

```

```

    in kg
14  O11=(w1*01)//Oxygen required per kg of fuel for C in
    kg
15  O22=(w2*02)//Oxygen required per kg of fuel for H2
    in kg
16  T=(O11+O22-w3)//Total Oxygen required per kg of fuel
    in kg
17  P1=(w1+O11)//Composition of CO2 in kg
18  P2=(w2+O22)//Composition of H2O in kg
19  w=(T*(100/23))//Weight of air required in kg per kg
    of fuel
20  wN2=(w*(77/100))//Weight of N2 in 'w' kg of fuel in
    kg
21  T1=(P1+P2+wN2)//Total weight of all products of
    combustion in kg
22  pCO2=(P1/T1)*100//Percentage composition of CO2 by
    weight
23  pH2O=(P2/T1)*100//Percentage composition of H2O by
    weight
24  pN2=(wN2/T1)*100//Percentage composition of N2 by
    weight
25
26  //Output
27  printf('The weight of air required to burn one kg of
    the fuel is %3.1f kg \n The composition of
    products of combustion by weight is %3.2f percent
    of CO2, %3.2f percent of H2O and %3.2f percent
    of N2 ',w ,pCO2 ,pH2O ,pN2)

```

Scilab code Exa 8.5 MASS OF AIR

```

1  clc
2  clear
3  //Input data
4  C=85//Composition of C in percent

```

```

5 H2=15//Composition of H2 in percent
6 CV=10600//Calorific value in kcal/kg
7 eO2=60//Percentage of air in excess
8 bhp=240//Brake horse power in h.p
9 nth=30//Thermal efficiency in percent
10 O2=23//Percentage of oxygen contained in air by
    weight
11 wC=12//Molecular weight of carbon
12 wH2=2//Molecular weight of H2
13 wO2=32//Molecular weight of O2
14
15 //Calculations
16 mma=(100/23)*(((C/100)*(wO2/wC))+((H2/100)*(wO2/(wH2
    *2))))//Minimum air in kg per kg oil
17 aa=((100+eO2)/100)*mma//Actual air supplied in kg
    per kg oil
18 q=((bhp*(4500/427))/(nth/100))//Heat supplied in
    kcal/min
19 mf=(q/CV)//Mass of fuel supplied in kg/min
20 ma=(aa*mf)//Mass of air supplied in kg/min
21
22 //Output
23 printf('The weight of air is %3.2f kg/min',ma)

```

Scilab code Exa 8.6 VOLUMETRIC ANALYSIS

```

1 clc
2 clear
3 //Input data
4 //C + O2 -> CO2
5 // 12 + 32 -> 44
6 C=12//Molecular weight of carbon
7 O2=32//Molecular weight of O2
8 CO2=44//Molecular weight of CO2
9 N2=28//Molecular weight of N2

```

```

10
11 // Calculations
12 wair=(O2/C)*(100/23)//Air required per kg of C in kg
13 wN2=(O2/C)*(77/23)//N2 associated with the air in kg
14 pCO2=(CO2/C)/CO2//Parts by volume/k for CO2
15 pN2=(wN2/N2)//Parts by volume/k for N2
16 Tv=(pCO2+pN2)//Total parts by volume
17 ppCO2=(pCO2/Tv)*100//Percentage volume of CO2
18 ppN2=(pN2/Tv)*100//Percentage volume of N2
19
20 //Output
21 printf('The volumetric analysis of the flue gas when
    pure carbon is burnt with a minimum quantity of
    air is given by \n CO2 -> %3.1f percent \n N2 ->
    %3.1f percent ',ppCO2 ,ppN2)

```

Scilab code Exa 8.7 PERCENTAGE COMBUSTION

```

1  clc
2  clear
3  //Input data
4  C=90//Percentage composition of C
5  H2=3.3//Percentage composition of H2
6  O2=3//Percentage composition of O2
7  N2=0.8//Percentage composition of N2
8  S=0.9//Percentage composition of S
9  Ash=2//Percentage composition of Ash
10 eO2=50//Percentage of excess air
11 mC=12//Molecular weight of carbon
12 mS=32//Molecular weight of sulphur
13 mCO2=44//Molecular weight of CO2
14 mO2=32//Molecular weight of O2
15 mSO2=64//Molecular weight of SO2
16 mN2=28//Molecular weight of N2
17

```

```

18 //Calculations
19 w1=(C/100)//Weight per kg of fuel of C in kg
20 w2=(H2/100)//Weight per kg of fuel of H2 in kg
21 w3=(S/100)//Weight per kg of fuel of S in kg
22 O1=(8/3)//Oxygen required per kg of constituent for
    C in kg
23 O2=8//Oxygen required per kg of constituent for H2
    in kg
24 O3=1//Oxygen required per kg of constituent for S in
    kg
25 O11=(w1*O1)//Oxygen required per kg of fuel for C in
    kg
26 O22=(w2*O2)//Oxygen required per kg of fuel for H2
    in kg
27 O33=(w3*O3)//Oxygen required per kg of fuel for S in
    kg
28 T=(O11+O22+O33-(O2/100))//Total Oxygen required per
    kg of fuel in kg
29 ma=(T*(100/23))//Minimum air required in kg
30 aN2=(ma*((100+eO2)/100)*(77/100))//N2 in actual air
    supply in kg
31 TN2=(aN2+(N2/100))//Total N2 in kg
32 wt=(ma*(eO2/100)*(23/100))//Weight of air due to
    excess O2 in kg
33 TSO2=(w3*(mSO2/mS))//Total SO2 in kg
34 TCO2=(w1*(mCO2/mC))//Total CO2 in kg
35 pCO2=(TCO2/mCO2)//Parts by volume of CO2
36 pSO2=(TSO2/mSO2)//Parts by volume of SO2
37 pO2=(wt/mO2)//Parts by volume of O2
38 pN2=(TN2/mN2)//Parts by volume of N2
39 Tv=(pCO2+pSO2+pN2+pO2)//Total parts by volume
40 ppCO2=(pCO2/Tv)*100//Percentage volume of CO2
41 ppSO2=(pSO2/Tv)*100//Percentage volume of SO2
42 ppO2=(pO2/Tv)*100//Percentage volume of O2
43 ppN2=(pN2/Tv)*100//Percentage volume of N2
44
45 //Output
46 printf('Percentage combustion of the dry flue gases

```

by volume is \n CO2 %3.2f percent \n SO2 %3.2f
 percent \n O2 %3.1f percent \n N2 %3.2f percent ',
 ppCO2 , ppSO2 , ppO2 , ppN2)

Scilab code Exa 8.8 PARTIAL PRESSURE

```

1  clc
2  clear
3  //Input data
4  C=85//Composition of C in percent
5  H2=12.3//Composition of H2 in percent
6  i=2.7//Incombustible residue composition in percent
7  ma=25//Mass of air supplied in kg of air per kg of
   fuel
8  pO2=23//Percentage of oxygen in gemetric analysis of
   air
9  pN2=77//Percentage of nitrogen in gemetric analysis
   of air
10 p=1.03//Total pressure of the exhaust gases in kg/cm
   ^2
11 mC=12//Molecular weight of carbon
12 mO2=32//Molecular weight of O2
13 mCO2=44//Molecular weight of CO2
14 mH2=2//Molecular weght of H2
15 mH2O=18//Molecular weight of H2O
16 mN2=28//Molecular weight of N2
17
18 //Calculations
19 xCO2=((C/100)*(mCO2/mC))//per kg of fuel , the
   products formed in kg
20 xH2O=((H2/100)*((2*mH2O)/(2*mH2)))//per kg of fuel ,
   the products formed in kg
21 xO2=((C/100)*(mO2/mC))+((H2/100)*(mO2/(2*mH2)))//
   Oxygen used in kg
22 xN2=(pN2/pO2)*xO2//Associated nitrogen in kg

```

```

23 mma=(xO2+xN2)//Minimum air required in kg
24 ea=(ma-mma)//Excess air supplied in kg
25 XO2=((pO2/100)*ea)//Mass of O2 in excess air in kg
26 XN2=((pN2/100)*ea)//Mass of N2 in excess air in kg
27 wCO2=xCO2/mCO2//Parts by volume for CO2
28 wO2=XO2/mO2//Parts by volume for O2
29 wN2=((XN2+xN2)/mN2)//Parts by volume for N2
30 wH2O=(xH2O/mH2O)//Parts by volume for H2O
31 Tv=(wCO2+wO2+wN2+wH2O)//Total parts by volume
32 ppCO2=(wCO2/Tv)*100//Percentage volume of CO2
33 ppO2=(wO2/Tv)*100//Percentage volume of O2
34 ppN2=(wN2/Tv)*100//Percentage volume of N2
35 ppH2O=(wH2O/Tv)*100//Percentage volume of H2O
36 Tv1=(wCO2+wO2+wN2)//Total parts by volume for dry
    products
37 pp1CO2=(wCO2/Tv1)*100//Percentage volume of CO2 for
    dry analysis
38 pp1O2=(wO2/Tv1)*100//Percentage volume of O2 for dry
    analysis
39 pp1N2=(wN2/Tv1)*100//Percentage volume of N2 for dry
    analysis
40 papH2O=(ppH2O/100)*p//Partial pressure of H2O in kg/
    cm ^ 2
41
42 //Output
43 printf('The volumetric analysis for wet products
    gives (in percent) \n CO2 -> %3.1f \n O2 -> %3.1f
    \n N2 -> %3.1f \n H2O -> %3.1f \n\n The
    volumetric analysis for dry products gives (in
    percent) \n CO2 -> %3.1f \n O2 -> %3.1f \n N2 ->
    %3.1f \n\n The partial pressure of the vapour is
    %3.4f kg/cm^2 ',ppCO2 ,ppO2 ,ppN2 ,ppH2O ,pp1CO2 ,pp1O2
    ,pp1N2 ,papH2O)

```

Scilab code Exa 8.9 ANALYSIS BY WEIGHT


```

1  clc
2  clear
3  //Input data
4  C02=15//Volumetric analysis composition in percent
5  C0=2.2//Volumetric analysis composition in percent
6  O2=1.6//Volumetric analysis composition in percent
7  N2=81.2//Volumetric analysis composition in percent
8  mO2=32//Molecular weight of O2
9  mC02=44//Molecular weight of CO2
10 mC0=28//Molecular weight of CO
11 mN2=28//Molecular weight of N2
12
13 //Calculations
14 pC02=(C02/100)*mC02//Proportional weight for CO2
15 pC0=(C0/100)*mC0//Proportional weight for CO
16 pO2=(O2/100)*mO2//Proportional weight for O2
17 pN2=(N2/100)*mN2//Proportional weight for N2
18 T=(pC02+pC0+pO2+pN2)//Total proportional weight
19 ppC02=(pC02/T)*100//Weight per kg of exhaust gas for
   CO2
20 ppC0=(pC0/T)*100//Weight per kg of exhaust gas for
   CO
21 ppO2=(pO2/T)*100//Weight per kg of exhaust gas for
   O2
22 ppN2=(pN2/T)*100//Weight per kg of exhaust gas for
   N2
23
24 printf('The analysis by weight is given by (in
   percent) \n CO2 -> %3.1f \n CO -> %3.1f \n O2 ->
   %3.1f \n N2 -> %3.1f ', ppC02 , ppC0 , ppO2 , ppN2)

```

Scilab code Exa 8.10 GRAVIMETRIC ANALYSIS

```

1  clc
2  clear

```

```

3 C02=10.9//Volumetric analysis composition in percent
4 C0=1//Volumetric analysis composition in percent
5 O2=7.1//Volumetric analysis composition in percent
6 N2=81//Volumetric analysis composition in percent
7 m02=32//Molecular weight of O2
8 mC02=44//Molecular weight of CO2
9 mC0=28//Molecular weight of CO
10 mN2=28//Molecular weight of N2
11
12 //Calculations
13 pC02=(C02/100)*mC02//Proportional weight for CO2
14 pC0=(C0/100)*mC0//Proportional weight for CO
15 p02=(O2/100)*m02//Proportional weight for O2
16 pN2=(N2/100)*mN2//Proportional weight for N2
17 T=(pC02+pC0+p02+pN2)//Total proportional weight
18 ppC02=(pC02/T)*100//Weight per kg of exhaust gas for
   CO2
19 ppC0=(pC0/T)*100//Weight per kg of exhaust gas for
   CO
20 pp02=(p02/T)*100//Weight per kg of exhaust gas for
   O2
21 ppN2=(pN2/T)*100//Weight per kg of exhaust gas for
   N2
22
23 printf('The gravimetric analysis is given by (in
   percent) \n CO2 -> %3.2f \n CO -> %3.2f \n O2 ->
   %3.2f \n N2 -> %3.2f ',ppC02,ppC0,pp02,ppN2)

```

Scilab code Exa 8.11 WEIGHT OF AIR

```

1 clc
2 clear
3 //Input data
4 C02=10//Volumetric analysis composition in percent
5 N2=80//Volumetric analysis composition in percent

```

```

6 C=80//Carbon content of the fuel in percent
7 mO2=32//Molecular weight of O2
8 mCO2=44//Molecular weight of CO2
9 mN2=28//Molecular weight of N2
10 mC=12//Molecular weight of carbon
11
12 //Calculations
13 O2=100-(N2+C02)//Volumetric analysis composition in
    percent
14 pCO2=(C02/100)*mCO2//Proportional weight for CO2
15 pO2=(O2/100)*mO2//Proportional weight for O2
16 pN2=(N2/100)*mN2//Proportional weight for N2
17 T=(pCO2+pO2+pN2)//Total proportional weight
18 ppCO2=(pCO2/T)//Weight per kg of exhaust gas for CO2
19 ppO2=(pO2/T)//Weight per kg of exhaust gas for O2
20 ppN2=(pN2/T)//Weight per kg of exhaust gas for N2
21 wC=(ppCO2*(mC/mCO2))//Weight of carbon per kg of
    exhaust gases in kg
22 WC=((C/100)/wC)//Weight of exhaust gases per kg of
    fuel burned in kg
23 wa=(WC-(ppCO2+ppO2+ppN2))//Weight of air supplied
    per kg fuel in kg
24
25 //Output
26 printf('Weight of air supplied per kg of fuel is %i
    kg ',wa)

```

Scilab code Exa 8.12 AIR SUPPLIED

```

1 clc
2 clear
3 //Input data
4 C02=12//Volumetric analysis composition in percent
5 C0=4//Volumetric analysis composition in percent
6 N2=84//Volumetric analysis composition in percent

```

```

7  mO2=32//Molecular weight of O2
8  mCO2=44//Molecular weight of CO2
9  mCO=28//Molecular weight of CO
10 mN2=28//Molecular weight of N2
11 mC=12//Molecular weight of carbon
12 mH2=2//Molecular weight of H2
13
14 //Calculations
15 pCO2=(CO2/100)*mCO2//Proportional weight for CO2
16 pCO=(CO/100)*mCO//Proportional weight for CO
17 pN2=(N2/100)*mN2//Proportional weight for N2
18 T=(pCO2+pCO+pN2)//Total proportional weight
19 ppCO2=(pCO2/T)//Weight per kg of exhaust gas for CO2
20 ppCO=(pCO/T)//Weight per kg of exhaust gas for CO
21 ppN2=(pN2/T)//Weight per kg of exhaust gas for N2
22 wC=((ppCO2*(mC/mCO2))+ppCO*(mC/mCO))//Weight of
    carbon per kg of flue gases
23 pC=((6*mC)/(6*mC+7*mH2))//Percentage by weight of
    carbon in C6H14
24 we=(pC/wC)//Weight of exhaust gases per kg of fuel
    in kg
25 wa=(we-(ppCO2+ppCO+ppN2))//Weight of air supplied
    per kg of fuel in kg
26 tw=((100/23)*(((mO2/mC)*pC)+((mO2/(2*mH2))*0.163)))
    //Theoretical amount of air required for complete
    combustion of C6H14 in kg
27 exc=(wa-tw)//Excess air supplied per kg of fuel in
    kg
28
29 //Output
30 printf('Excess air supplied per kg of fuel is %3.1f
    kg(deficient)',exc)

```

Scilab code Exa 8.13 PERCENTAGE COMPOSITION

```

1  clc
2  clear
3  //Input data
4  C=84//Gravimetric analysis composition in percent
5  H2=12//Gravimetric analysis composition in percent
6  S=1.5//Gravimetric analysis composition in percent
7  O2=1.5//Gravimetric analysis composition in percent
8  ma=20//Mass of air in kg
9  pC=4//Percent of carbon in the fuel which is burnt
    to form CO
10 mO2=32//Molecular weight of O2
11 mCO2=44//Molecular weight of CO2
12 mCO=28//Molecular weight of CO
13 mN2=28//Molecular weight of N2
14 mC=12//Molecular weight of carbon
15 mH2=2//Molecular weight of H2
16 mS=32//Molecular weight of S
17 mSO2=64//Molecular weight of SO2
18
19 //Calculations
20 mm=((100/23)*((C/100)*(mO2/mC)+(H2/100)*(mO2/(2*mH2)
    )+(S/100)*(mO2/mS)-(O2/100)))//Minimum air in kg/
    kg of fuel
21 //When 20 kg of air is supplied
22 xCO2=((C/100)*(mCO2/mC))//Mass of CO2 in kg
23 xSO2=((S/100)*(mSO2/mS))//Mass of SO2 in kg
24 xO2=((23/100)*(ma-mm))//Mass of O2 in kg
25 xN2=((77/100)*ma)//Mass of N2 in kg
26 nCO2=(xCO2/mCO2)//Parts by volume of CO2
27 nSO2=(xSO2/mSO2)//Parts by volume of SO2
28 nO2=(xO2/mO2)//Parts by volume of O2
29 nN2=(xN2/mN2)//Parts by volume of N2
30 T=(nCO2+nSO2+nO2+nN2)//Total parts by volume
31 pCO2=(nCO2/T)*100//Percentage volume of CO2
32 pSO2=(nSO2/T)*100//Percentage volume of SO2
33 pO2=(nO2/T)*100//Percentage volume of O2
34 pN2=(nN2/T)*100//Percentage volume of N2
35 //4% of available carbon is burnt to CO then per kg

```

```

of fuel
36 yCO2=((C/100)/(1+(pC/100)))*(mCO2/mC)//Mass of CO2
in kg
37 yCO=((C/100)-((C/100)/(1+(pC/100)))*(mCO/mC))//
Mass of CO in kg
38 yO2=((C/100)*(mO2/mC))//Mass of O2 in kg
39 eO2=(yO2-(((C/100)/(1+(pC/100)))*(mO2/mC)+(((C/100)
-((C/100)/(1+(pC/100)))*(mO2/(2*mC))))))
40 nnCO2=(yCO2/mCO2)//Parts by volume of CO2
41 nnCO=(yCO/mCO)//Parts by volume of CO
42 nnSO2=(xSO2/mSO2)//Parts by volume of SO2
43 nnO2=((xO2+eO2)/mO2)//Parts by volume of O2
44 nnN2=(xN2/mN2)//Parts by volume of N2
45 TT=(nnCO2+nnCO+nnSO2+nnO2+nnN2)//Total parts by
volume
46 ppCO2=(nnCO2/TT)*100//Percentage volume of CO2
47
48 //Output
49 printf('Minimum weight of air required for complete
combustion of 1 kg of the fuel is %3.1f kg/kg of
fuel \n\n Percentage composition by volume when
%i kg of air is supplied (in percent) \n CO2 ->
%3.1f \n SO2 -> %3.1f \n O2 -> %3.1f \n N2 -> %3
.1f \n\n The percentage volume of CO2 when %i
percent of the carbon in the fuel is burnt to
form CO is %3.1f percent ',mm,ma,ppCO2,psO2,pO2,pN2
,pC,ppCO2)

```

Scilab code Exa 8.14 EXCESS AIR

```

1 clc
2 clear
3 //Input data
4 C=85//Composition by weight in percent
5 H2=14//Composition by weight in percent

```

```

6 x=50//Percentage of excess air
7 Ta=[70+273,500+273]//Temperature of air entering and
  leaving in K
8 Cp=0.24//Mean specific heat of air in kJ/kg.K
9 qC=8080//Heat liberated in kcal/kg
10 qH2=34250//Heat liberated in kcal/kg
11 a=23//Air contains 23% by weight of O2
12 mO2=32//Molecular weight of O2
13 mCO2=44//Molecular weight of CO2
14 mCO=28//Molecular weight of CO
15 mN2=28//Molecular weight of N2
16 mC=12//Molecular weight of carbon
17 mH2=2//Molecular weight of H2
18
19 //Calculations
20 mm=((100/a)*((C/100)*(mO2/mC)+(H2/100)*(mO2/(2*mH2)))
  )//Minimum air required in kg/kg of fuel
21 Q1=((C/100)*qC+(H2/100)*qH2)//Heat in kcal/kg fuel
22 ea=((x/100)*mm)//Excess air supplied in kg/kg fuel
23 Q2=((mm/2)*Cp*(Ta(2)-Ta(1)))//Heat in kcal/kg fuel
24
25 //Output
26 printf('(a) Minimum quantity of air necessary for
  the complete combustion of 1 kg of fuel is %3.2f
  kg/kg of fuel \n (b) Heat released per kg of fuel
  when the carbon is burnt to CO2 and hydrogen is
  burnt to H2O is %3.0f kcal/kg fuel \n (c) Heat
  carried away by the excess air is %3.0f kcal/kg
  fuel ',mm,Q1,Q2)

```

Scilab code Exa 8.15 VOLUME OF GAS

```

1 clc
2 clear
3 //Input data

```

```

4 C0=17//Percentage composition by volume
5 H2=53.4//Percentage composition by volume
6 CH2=28.8//Percentage composition by volume
7 O2=0.8//Percentage composition by volume
8 ea=30//Percentage of excess air
9 v=1//Volume in m^3
10
11 //Calculations
12 ta=((100/21)*((C0/100)/2+(H2/100)/2+(CH2/100)*2-(O2
    /100)))//Theoretical air in m^3/m^3 of gas
13 aa=((1+(ea/100))*ta)//Actual air in m^3/m^3 of gas
14 Vg=(v+aa)//Volume of gas air mixture in m^3/m^3 of
    gas
15
16 //Output
17 printf('Total quantity of air required is %3.2f m^3/
    m^3 of gas \n The volume of gas air mixture is %3
    .2f m^3/m^3 of gas ',ta,Vg)

```

Scilab code Exa 8.16 VOLUME OF AIR

```

1 clc
2 clear
3 //Input data
4 CH4=20//Percentage volumetric analysis
5 C2H4=2//Percentage volumetric analysis
6 H2=50//Percentage volumetric analysis
7 C0=16//Percentage volumetric analysis
8 C02=4//Percentage volumetric analysis
9 O2=1.5//Percentage volumetric analysis
10 N2=6.5//Percentage volumetric analysis
11 v=6.8//Volume of air supplied in m^3 per m^3 of coal
    gas
12
13 //Calculations

```



```

14 mmO2=((2*CH4)+(3*C2H4)+(H2/2)+(CO/2))-O2//Minimum
    moles of O2
15 mCO2=(CH4+(2*C2H4)+CO+CO2)//Moles of CO2
16 mH2O=((2*CH4)+(2*C2H4)+H2)//Moles of H2O
17 mN2=(N2+(79/21)*mmO2)//Moles of N2
18 ma=((100/21)*(mmO2/100))//Minimum air in m^3/m^3 of
    gas
19 ea=(v-ma)//Excess air in m^3/m^3 of gas
20 tm=(mCO2+mN2+ea)*2//Total moles of dry products per
    100 moles of gas
21 pCO2=(mCO2/tm)*100//Percentage of CO2 by volume in
    dry flue gases
22
23 //Output
24 printf('Minimum volume of air necessary for the
    complete combustion of 1 m^3 of coal gas is %3.2f
    m^3/m^3 of gas \n Percentage volume of CO2 in
    dry flue gases is %3.2f percent',ma,pCO2)

```

Scilab code Exa 8.17 VOLUMETRIC COMPOSITION

```

1  clc
2  clear
3  //Input data
4  C=86//Percentage of carbon
5  H2=14//Percentage of Hydrogen
6  ea=20//Percentage of excess air
7  O2=23//Weight of oxygen in air in percent
8  mO2=32//Molecular weight of O2
9  mCO2=44//Molecular weight of CO2
10 mCO=28//Molecular weight of CO
11 mN2=28//Molecular weight of N2
12 mC=12//Molecular weight of carbon
13 mH2=2//Molecular weight of H2
14 mH2O=18//Molecular weight of H2O

```

```

15
16 // Calculations
17 ma=((100/O2)*((C/100)*(mO2/mC)+(H2/100)*(mO2/(2*mH2)
    )))//Minimum weight of air required in kg/kg
    petrol
18 //Products of combustion by weight per kg- petrol
19 XC02=(C/100)*(mC02/mC)//CO2 in kg
20 XH20=(H2/100)*(mH20/mH2)//H2O in kg
21 X02=(XC02+XH20-1)*(ea/100)//O2 in kg
22 XN2=(ma*(1+(ea/100))*((100-O2)/100))//N2 in kg
23 XT=(XC02+XH20+X02+XN2)//Total weight in kg
24 //Percentage analysis by weight
25 xC02=(XC02/XT)*100//CO2
26 xH20=(XH20/XT)*100//H2O
27 x02=(X02/XT)*100//O2
28 xN2=(XN2/XT)*100//N2
29 //Percentage by weight to molecular weight
30 xxC02=(xC02/mC02)//CO2
31 xxH20=(xH20/mH20)//H2O
32 xx02=(x02/m02)//O2
33 xxN2=(xN2/mN2)//N2
34 xxt=(xxC02+xxH20+xx02+xxN2)//Total percentage by
    weight to molecular weight
35 //Percentage by volume
36 pC02=(xxC02/xxt)*100//CO2
37 pH20=(xxH20/xxt)*100//H2O
38 p02=(xx02/xxt)*100//O2
39 pN2=(xxN2/xxt)*100//N2
40
41 //Output
42 printf('Volumetric composition of the products of
    combustion (in percent) \n CO2 -> %3.1f \n H2O ->
    %3.1f \n O2 -> %3.2f \n N2 -> %3.2f ',pC02 ,pH20
    ,p02 ,pN2)

```

Scilab code Exa 8.18 WEIGHT

```
1  clc
2  clear
3  //Input data
4  bhp=20//Brake horse in h.p
5  N=320//Speed in r.p.m
6  C=84//Percentage of carbon
7  H2=16//Percentage of hydrogen
8  CV=10800//Calorific value in kcal/kg
9  bth=30//Brake thermal efficiency in percent
10 mO2=32//Molecular weight of O2
11 mCO2=44//Molecular weight of CO2
12 mCO=28//Molecular weight of CO
13 mN2=28//Molecular weight of N2
14 mC=12//Molecular weight of carbon
15 mH2=2//Molecular weight of H2
16 mH2O=18//Molecular weight of H2O
17
18 //Calculations
19 W=(bhp*4500)/427//Work done in kcal
20 Wc=(W*2)/N//Work done per cycle in kcal
21 qs=(Wc/(bth/100))//Heat supplied per cycle in kcal
22 wf=(qs/CV)//Weight of fuel used per cycle in kg
23 tO2=((C/100)*(mO2/mC)+(H2/100)*(mO2/(2*mH2)))//Total
    O2/kg fuel in kg
24 mw=(tO2/(23/100))//Minimum weight of air required in
    kg/kg fuel
25 aw=(mw*2)//Actual weight of air supplied in kg/kg
    fuel
26 wac=(aw*wf)//Wt. of air supplied/ cycle in kg. In
    textbook, it is given wrong as 0.1245 kg
27
28 //Output
29 printf('(a) the weight of fuel used per cycle is %3
    .6f kg \n (b) the actual weight of air taken in
    per cycle is %3.4f kg',wf,wac)
```

Scilab code Exa 8.19 WEIGHT OF AIR

```
1  clc
2  clear
3  //Input data
4  C02=8.85//Percentage composition by volume
5  C0=1.2//Percentage composition by volume
6  O2=6.8//Percentage composition by volume
7  N2=83.15//Percentage composition by volume
8  C=84//Percentage composition by weight
9  H2=14//Percentage composition by weight
10 aO2=2//Percentage composition by weight
11 mO2=32//Molecular weight of O2
12 mCO2=44//Molecular weight of CO2
13 mCO=28//Molecular weight of CO
14 mN2=28//Molecular weight of N2
15 mC=12//Molecular weight of carbon
16 mH2=2//Molecular weight of H2
17 mH2O=18//Molecular weight of H2O
18
19 //Calculations
20 //O2 required per kg of fuel
21 xC=((C/100)*(mO2/mC))//C
22 xH2=((H2/100)*(mO2/(2*mH2)))/H2
23 xO2=-(aO2/100)//O2
24 ttO2=(xC+xH2-xO2)//Theoretical total oxygen required
    in kg/kg fuel
25 twa=(ttO2/(23/100))//Theoretical weight of air in kg
    /kg fuel
26 //Conversion of volumetric analysis of the flue gas
    into a weight analysis
27 //Percentage by volume * mol. wt
28 xxCO2=(C02*mCO2)//CO2
29 xxCO=(C0*mCO)//CO
```

```

30 xxO2=(O2*mO2)//O2
31 xxN2=(N2*mN2)//N2
32 xxt=(xxCO2+xxCO+xxO2+xxN2)//Total
33 //Percentage by weight
34 yCO2=(xxCO2/xxt)*100//CO2
35 yCO=(xxCO/xxt)*100//CO
36 yO2=(xxO2/xxt)*100//O2
37 yN2=(xxN2/xxt)*100//N2
38 wcd=((yCO2/100)*(mC/mCO2))+((yCO/100)*(mC/mCO))//
    Weight of carbon/ kg of dry flue gas in kg
39 wdf=((C/100)/wcd)//Wt. of dry flue gas/kg fuel in kg
40 wxf=(wdf*(yO2/100))//Weight of excess O2/kg fuel in
    kg
41 weO2=(wxf/(23/100))//Weight of excess air in kg/kg
    fuel
42 was=(twa+weO2)//Weight of air supplied/kg fuel in kg
43
44 //Output
45 printf('Weight of air supplied per kg fuel burnt is
    %3.2f kg',was)

```

Chapter 9

SPARK IGNITION ENGINES

Scilab code Exa 9.1 WEIGHT

```
1  clc
2  clear
3  //Input data
4  d=0.001//Diameter of the jet in m
5  vd=104//Venturi depression in cm of water. In
   textbook, it is given as 10 cm
6  Cd=0.65//Coefficient of discharge
7  g=0.76//Specific gravity of petrol
8  w=1000//Weight of water per one cu.m in kg
9
10 //Calculations
11 pa=(vd/100)*w//Venturi depression in kg/m^2
12 dp=(g*w)//Density of petrol in kg/m^3
13 wf=((3.14*d^2)/4)*Cd*sqrt(2*9.81*dp*pa))/10^-3//
   Petrol discharge in gm/sec neglecting nozzle lip
14
15 //Output
16 printf('The weight of petrol discharged is %3.2f gm/
   sec ',wf)
```

Scilab code Exa 9.2 AIR FUEL RATIO

```
1  clc
2  clear
3  //Input data
4  d1=0.075//Throat diameter in m
5  Ca=0.93//Coefficient of air flow
6  d2=0.005//Orifice diameter in m
7  Cf=0.68//Coefficient of fuel discharge
8  ap=1//Approach factor
9  dp=0.15//Pressure drop in kg/cm^2
10 da=1.29//Density of air in kg/m^3
11 df=720//Density of fuel in kg/m^3
12
13 //Calculations
14 w=(((3.14/4)*d1^2)/((3.14/4)*d2^2))*(Ca/Cf)*sqrt(da/
    df)//The air-fuel ratio neglecting the nozzle lip
15
16 //Output
17 printf('The air-fuel ratio neglecting the nozzle lip
    is %3.1f',w)
```

Scilab code Exa 9.3 THEORETICAL RATIO OF DIAMETER

```
1  clc
2  clear
3  //Input data
4  af=15//Air fuel ratio
5  dp=753//Density of petrol in kg/m^3
6  da=1.28//Density of air in kg/m^3
7  C=[0.84,0.7]//Coefficient of discharge for air and
    fuel respectively
```

```

8
9 // Calculations
10 A=1/(af*(C(2)/C(1))*sqrt(dp/da))//Ratio of areas
11 d=sqrt(A)//Ratio of diamter of jet to diameter of
    venturi
12 x=(1/d)//Reverse of ratio
13
14 //Output
15 printf('The ratio of diameter of jet to diameter of
    venturi is 1 : %3.1f',x)

```

Scilab code Exa 9.4 SECTION AT THE THROAT

```

1 clc
2 clear
3 //Input data
4 D=[10,12]//Dimensions of four cylinder in 10 cm* 12
    cm
5 n=4//Four cylinder
6 N=2000//Speed in r.p.m
7 d=0.03//Venturi throat in m
8 nv=70//Volumetric efficiency of the engine in
    percent
9 Ca=0.8//Coefficient of air flow
10 da=1.29//Density of air in kg/m^3
11
12 //Calculations
13 Vs=(3.14/4)*(D(1)/100)^2*(D(2)/100)//Stroke volume
    of one cylinder in m^3
14 Va=(Vs*n*(nv/100)*(N/2))//Volume of air drawn per
    minute in m^3
15 w=(Va*da)/60//Weight of air drawn per sec
16 dp=((w/((3.14/4)*d^2*Ca))^2/(2*9.81*da))//Venturi
    depression in kg/cm^2
17

```



```

18 //Output
19 printf('The venturi depression is %3.1f kg/m^2',dp)

```

Scilab code Exa 9.5 SIZE OF THE VENTURI

```

1  clc
2  clear
3  //Input data
4  D=[8.25,11.5]//Dimensions of four cylinder in 8.25
      cm* 11.5 cm
5  n=4//Four cylinder
6  N=3000//Speed in r.p.m
7  v=150//Venturi depression in cm of water
8  nv=80//Volumetric efficiency of the engine in
      percent
9  af=14//Air fuel ratio
10 Ca=0.84//Coefficient of air flow
11 Cf=0.7//Coefficient of fuel orifice
12 da=1.29//Density of air in kg/m^3
13 df=700//Density of fuel in kg/m^3
14 dw=1000//Density of water in kg/m^3
15
16 //Calculations
17 Va=((3.14/4)*(D(1)/100)^2*(D(2)/100)*n*(nv/100)*(N
      /(2*60)))//Maximum amount of air passing through
      the venturi in m^3
18 vd=(v/100)*dw//Venturi depression in kg/m^2
19 va=(Ca*sqrt((2*9.81*vd)/da))//Velocity of air in m/s
20 d=sqrt((Va/va)*(4/3.14))//Throat diameter of venturi
      in m
21 Af=1/(af*(va/Va)*sqrt(df/da)*(Cf/Ca))//Area of
      orifice in m^2
22 df=sqrt((Af*4)/3.14)*1000//Diameter of orifice in mm
23
24 //Output

```

```
25 printf('The size of venturi is %i kg/m^2 \n The
    diameter of fuel orifice is %3.2 f mm',vd,df)
```

Scilab code Exa 9.6 FUEL CONSUMPTION

```
1 clc
2 clear
3 D=[7.5,10]//Dimensions of four cylinder in 7.5 cm
    diameter and 10 cm stroke
4 n=6//Six cylinder
5 pC=84//Percentage of carbon in volatile fuel
6 pH2=16//Percentage of hydrogen in volatile fuel
7 dc=(38.5/1000)//Diameter of the throat of the choke
    tube in m
8 N=3000//Speed in r.p.m
9 nv=0.8//Volumetric efficiency in ratio
10 p=0.914//Pressure at the throat of the choke tube in
    kg/cm^2
11 T=15.5+273//Temperature at the throat of the choke
    tube in K
12 Ts=273//Temperature of 0 degree C in K
13 ps=1.027//Atmospheric pressure in kg/cm^2
14 Ra=29.27//Universal gas constant for air in kg.m/kg.
    K
15 Rf=9.9//Gas constant for fuel in kg.m/kg.K
16 pO2=23//Composition by weight of oxygen in air in
    percent
17 pN2=77//Composition by weight of nitrogen in air in
    percent
18 mO2=32//Molecular weight of O2
19 mH2=2//Molecular weight oh H2
20 mC=12//Molecular weight of carbon
21
22 // Calculations
23 Vm=((3.14/4)*(D(1)/100)^2*(D(2)/100)*n*(N/2)*nv) //
```

```

    Volume of mixture supplied per sec in m^3
24 qa=((100/pO2)*(((pC/100)*(mO2/mC))+((pH2/100)*(mO2
    /(2*mH2))))))//Quantity of air required for
    complete combustion of fuel in kg
25 vf=(Rf*Ts)/(ps*10^4)//Specific volume of volatile
    fuel in m^3/kg
26 va=(Ra*Ts)/(ps*10^4)//Specific volume of air in m^3/
    kg
27 wf=(Vm/(qa*va+vf))//Flow rate of fuel in kg/min
28 Fc=(wf*60)//Fuel consumption in kg/hour
29 da=(p*10^4)/(Ra*T)//Density of air at the throat of
    the choke in kg/m^3
30 Va=((qa*wf)/((3.14/4)*dc^2*da*60))//Speed of air at
    throat in m/s
31
32 //Output
33 printf('(a) The fuel consumption is %3.1f kg/hr \n (
    b) The speed of the air through the choke is %3.1
    f m/s ',Fc,Va)

```

Scilab code Exa 9.7 DIAMETER OF JET

```

1  clc
2  clear
3  //Input data
4  mf=7.5//Consumption of petrol per hour
5  gf=0.75//Specific gravity of fuel
6  Tf=25+273//Temperature of fuel in K
7  af=15//Air fuel ratio
8  dc=22//diameter of choke tube in mm
9  l=4//Top of the jet is 4 mm above the petrol level
    in the float chamber
10 Ca=0.82//Coefficient of discharge for air
11 Cf=0.7//Coefficient of discharge for fuel
12 R=29.27//Characteristic gas constant for air in kg.m

```

```

    /kg.K
13 p=1.03//Atmospheric pressure in kg/cm^2
14
15 //Calculations
16 da=(p*10^4)/(R*Tf)//Density of air in kg/m^3
17 dp=(gf*1000)//Density of petrol in kg/cm^3
18 dpa=((af*mf*10^6)/(60*60*3.14*Ca*(dc/2)^2))
    ^2/(2*9.81*da)//Change in pressure in kg/m^2
19 df=sqrt((mf/(60*60*Cf*sqrt(2*9.81*dp*(dpa-((1/100)*
    dp))))*(4/3.14))*1000//Diameter of the fuel jet
    in mm
20
21 //Output
22 printf('Diameter of the jet of the carburettor is %3
    .2 f mm',df)

```

Scilab code Exa 9.8 AIR FUEL RATIO

```

1 clc
2 clear
3 //Input data
4 td=7.5//Throat diameter in cm
5 Ca=0.85//Coefficient of air flow
6 fd=0.5//Diameter of fuel orifice in cm
7 Cd=0.7//Coefficient of discharge
8 l=5//Nozzle lip in mm
9 x=1//Approach factor
10 dpa=0.15//Pressure drop in kg/cm^2
11 da=1.29//Density of air in kg/m^3
12 dp=720//Density of fuel in kg/m^3
13
14 //Calculations
15 afr1=((3.14*td^2)/(3.14*fd^2))*(Ca/Cd)*sqrt(da/dp))
    //Air fuel ratio
16 afr2=((3.14*td^2)/(3.14*fd^2))*(Ca/Cd)*sqrt((da*dpa)

```

```

    /(dp*(dpa-((1/100)*(dp/10^6))))//Air fuel ratio
17
18 //Output
19 printf('The air fuel ratio \n (a) neglecting nozzle
    lip is %3.2f \n (b) nozzle lip is taken into
    account is %3.2f',afr1,afr2)

```

Scilab code Exa 9.9 VELOCITY

```

1  clc
2  clear
3  //Input data
4  td=7.5//Throat diameter in cm
5  Ca=0.85//Coefficient of air flow
6  fd=0.5//Diameter of fuel orifice in cm
7  Cd=0.7//Coefficient of discharge
8  l=5//Nozzle lip in mm
9  x=1//Approach factor
10 dpa=0.15//Pressure drop in kg/cm^2
11 da=1.29//Density of air in kg/m^3
12 dp=720//Density of fuel in kg/m^3
13
14 //Calculations
15 v=sqrt(2*9.81*(1/1000)*(dp/da))//Velocity of air in
    m/s
16
17 //Output
18 printf('Velocity of air flow is %3.1f m/s',v)

```

Scilab code Exa 9.10 PETROL CONSUMPTION

```

1  clc
2  clear

```

```

3 //Input data
4 x=2.8//Height above the nozzle in mm
5 va=58//Velocity of air in m/s
6 da=1.28//Density of air in kg/m^3
7 dp=750//Density of petrol in kg/m^3
8 An=1.8//Area of cross section of nozzle in mm^2
9 Cd=0.6//Coefficient of discharge of nozzle
10 Ca=0.84//Coefficient of discharge of air
11
12 //Calculations
13 dpa=((va/Ca)^2*(da/(2*9.81)))/Change in pressure in
    kg/m^2
14 wf=((An*10^-6)*Cd*sqrt(2*9.81*dp*(dpa-((x/1000)*dp)))
    )//Petrol consumption in kg/sec
15
16 //Output
17 printf('Petrol consumption is %3.4f kg/sec',wf)

```

Scilab code Exa 9.11 AIR FUEL RATIO

```

1 clc
2 clear
3 //Input data
4 d=0.155//Diameter of orifice in mm
5 Cd=0.94//Coefficient of discharge
6 td=3.18//Throat diameter in cm
7 Ca=0.84//Coefficient of discharge
8 x=29//Venturi depression
9 dw=0.89//Minimum depression of water in cm
10 sa=1.1//Specific weight of air in kg/m^3
11 sg=0.72//Specific gravity of petrol
12 cyd=[7.75,10.75]//Cylinder dimensions in cm
13 fc=10.9//Fuel consumption in kg/hr
14 N=3200//Speed in r.p.m
15 n=4//Number of cylinders

```

```

16
17 // Calculations
18 w=((((3.14/4)*td^2)/((3.14/4)*d^2))*(Ca/Cd)*sqrt((sa
    /(sg*1000))*(x/(x-dw)))//Air fuel ratio
19 Va=(3.14/4)*(td/100)^2*Ca*sqrt(2*9.81*sa*x*6)//
    Volume of air drawn/sec
20 vn=(Va/(((3.14/4)*(cyd(1)/100)^2*(cyd(2)/100)*n*(N
    /(2*60))))*100//Volumetric efficiency in percent
21
22 //Output
23 printf('Air fue ratio is %3.1f \n Volumetric
    efficiency is %3.1f percent ',w,vn)

```

Scilab code Exa 9.12 THROAT PRESSURE

```

1 clc
2 clear
3 //Input data
4 af=0.066//Air fuel ratio
5 p=0.83//Pressure at the venturi throat in kg/cm^2
6 pd=0.04//Pressure drop in kg/cm^2
7 va=245//Air flow at sea level in kg per hour
8
9 //Calculations
10 dpa=1.03-p//Pressure at air cleaner in kg/cm^2
11 d=(1.03-pd-dpa)//Throat pressure when the air
    cleaner is fitted in kg/cm^2
12 naf=(af*sqrt((1.03-d)/dpa))//New air fuel ratio
13
14 //Output
15 printf('(a) Throat pressure when the air cleaner is
    fitted is %3.2f kg/cm^2 \n (b) New air fuel ratio
    is %3.4f ',d,naf)

```

Scilab code Exa 9.13 DROP IN PRESSURE

```
1  clc
2  clear
3  //Input data
4  x=3//Petrol stands 3 mm below
5  Ta=15.5+273//Temperature of air in K
6  pa=1.027//Pressure of air in kg/cm^2
7  R=29.27//Characteristic gas constant in kg.m/kg.K
8  sg=0.76//Specific gravity of fuel
9  fc=6.4//Consumption of fuel in kg/hour
10 jd=1.27//Jet diameter in mm
11 Cd=0.6//Nozzle discharge coefficient
12 Ca=0.8//Discharge coefficient of air
13 af=0.066//Air fuel ratio
14
15 //Calculations
16 df=(sg*1000)//Density of fuel in kg/m^3
17 da=(pa*10^4)/(R*Ta)//Density of air in kg/m^3
18 va=Ca*sqrt((2*9.81*x*df)/(da*1000))//Critical
    velocity of air in m/s
19 dpa=((fc/(60*60))/((3.14/4)*(jd/1000)^2*Cd))
    ^2/(2*9.81*df))+((x/1000)*df)//Drop in pressure
    in kg/m^3
20 dpaw=(dpa/1000)*100//Drop in pressure in cm of water
21 dj=sqrt(((fc/(3600*af))/(Ca*sqrt(2*9.81*da*dpa)))
    /(3.14/4))*1000//Effective throat diameter in mm
22
23 //Output
24 printf('Critical air velocity is %3.2f m/sec \n
    Effective throat diameter of the venturi is %3.1f
    mm \n The drop in pressure in the venturi is %3
    .2f cm of water ',va,dj,dpaw)
```

Scilab code Exa 9.14 ORIFICE DIAMETER

```
1  clc
2  clear
3  //Input data
4  ma=6.11//Flow rate of air in kg/min
5  mf=0.408//Flow rate of petrol in kg/min
6  dp=768//Density of petrol in kg/m^3
7  Ta=15.5+273//Temperature of air in K
8  pa=1.027//Pressure of air in kg/cm^2
9  R=29.27//Characteristic gas constant in kg.m/kg.K
10 va=97.5//Speed of air in m/sec
11 Cv=0.84//Velocity coefficient
12 g=1.4//Ratio of specific heats
13 x=0.8//pressure at the venturi is 0.8 of the
    pressure drop at the choke
14 Cd=0.66//Coefficient of discharge
15
16 //Calculations
17 rp=(1-((va/Cv)^2/(((2*9.81*g)/(g-1))*R*Ta)))^(g/(g
    -1))//Pressure ratio
18 p2=(pa*rp)//Pressure in kg/cm^2
19 T2=(Ta*rp^((g-1)/g))//Temperature in K
20 da=(p2/(R*T2))*10^4//Density in kg/m^3
21 daa=sqrt((ma/(60*va*da))/(3.14/4))*1000//Throat
    diameter in mm
22 df=sqrt((mf/(60*Cd*sqrt(2*9.81*dp*x*(pa-p2)*10^4)))/
    (3.14/4))*1000//Orifice diameter in mm
23
24 //Output
25 printf('Throat diameter of the choke is %i mm \n The
    orifice diameter is %3.2f mm',daa,df)
```

Scilab code Exa 9.15 ORIFICE DIAMETER

```
1  clc
2  clear
3  //Input data
4  ma=6.8//Mass flow rate of air in kg/min
5  mf=0.45//Mass flow rate of petrol in kg/min
6  pa=1.033//Pressure of air in kg/cm^2
7  Ta=20+273//Temperature of air in K
8  va=97.5//Velocity of air in m/s
9  Cv=0.8//Velocity coefficient
10 g=1.4//Ratio of specific heats
11 R=29.27//Characteristic gas constant in kg.m/kg.K
12 x=0.75//pressure at the venturi is 0.8 of the
    pressure drop at the choke
13 Cd=0.65//Coefficient of discharge
14 pw=800//Weight of petrol in kg per cu.m
15
16 //Calculations
17 rp=(1-((va/Cv)^2/(((2*9.81*g)/(g-1))*R*Ta)))^(g/(g
    -1))//Pressure ratio
18 p2=(pa*rp)//Pressure in kg/cm^2
19 T2=(Ta*rp^((g-1)/g))//Temperature in K
20 da=(p2/(R*T2))*10^4//Density in kg/m^3
21 daa=sqrt((ma/(60*va*da))/(3.14/4))*100//Throat
    diameter in mm
22 df=sqrt((mf/(60*Cd*sqrt(2*9.81*pw*x*(pa-p2)*10^4)))/
    (3.14/4))//Orifice diameter in mm
23
24 //Output
25 printf('Throat diameter of the choke is %3.2f cm \n
    The orifice diameter is %3.5f m',daa,df)
```

Scilab code Exa 9.16 POWER DEVELOPED

```
1  clc
2  clear
3  //Input data
4  n=6//Number of cylinders
5  d=100//Diameter in mm
6  L=100//Stroke in mm
7  N=1500//Speed in r.p.m
8  ap=13.5//Air fuel ratio
9  Ta=80+273//Temperature of air in K
10 x=(7/8)//Ratio of volume drawn
11 nth=22//Thermal efficiency in percent
12 p=76//Pressure in cm of mercury
13 CV=9000//Calorific value of petrol in kcal/kg
14 l=1524//Altitude in m
15 dp=2.54//Drop in pressure in cm of barometric
    reading
16 lx=274//Altitude rise in m
17
18 //Calculations
19 Vs=(3.14/4)*(d/10)^2*(L/10)//Swept volume in c.c
20 Va=(x*Vs)//Volume of air drawn in per cylinder per
    stroke in c.c
21 wa=(Va*10^-6*(N/2)*n)//Weight of air supplied to the
    engine per minute in kg
22 wf=(wa/ap)//Weight of fuel consumed per minute in kg
23 q=(wf*CV)//Heat supplied to the engine per minute in
    kcal
24 P=(q*(nth/100)*427)/4500//Power developed at ground
    level in H.P
25 db=(l/lx)*dp//Drop in barometric reading at an
    altitude of 1524 m in cm
26 Pd=(P/p)*(p-db)//Power developed at 1524 m altitude
```

```
    in H.P
27
28 //Output
29 printf('Power developed at the ground level is %i H.
    P \n Power developed at an altitude of %i m is %i
    H.P',P,1,Pd)
```

Chapter 11

FOUR STROKE SPARK IGNITION ENGINE

Scilab code Exa 11.1 WEIGHT

```
1  clc
2  clear
3  //Input data
4  d=0.0625//Diameter in m
5  L=0.09//Stroke in m
6  nv=0.75//Volumetric efficiency
7  p=1.03//Pressure at N.T.P in kg/cm^2
8  T=273//Temperature at N.T.P in K
9  R=29.27//Characteristic gas constant in kg.m/kg.
    degree C
10
11 //Calculations
12 Vs=((3.14/4)*d^2*L)//Swept volume in cu.m
13 V=(nv*Vs)//Volume of charge at N.T.P in cu.m
14 w=(p*10^4*V)/(R*T)//Weight of the charge in kg/cycle
15
16 //Output
17 printf('The weight of the charge is %3.6f kg/cycle',
    w)
```

Scilab code Exa 11.2 INDICATED THERMAL EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  n=9//Number of cylinder
5  d=0.145//Bore in m
6  l=0.19//Stroke in m
7  r=5.9//Compression ratio
8  bhp=460//Brake horse power in B.H.P
9  N=2000//Speed in r.p.m
10 x=20//Percentage rich in mixture
11 CV=11200//Calorific value in kcal/kg
12 pC=85.3//Percentage of carbon
13 pH2=14.7//Percentage of Hydrogen
14 nv=70//Volumetric efficiency in percent
15 T=15+273//Temperature in K
16 nm=90//Mechanical efficiency in percent
17 wO2=23.3//Percentage of oxygen by weight in air
18 da=1.29//Density of air in kg/m^3
19 mC=12//Molecular weight of carbon
20 mO2=32//Molecular weight of O2
21 mH2=2//Molecular weight of H2
22
23 //Calculations
24 hihp=((bhp/(nm/100))*(4500/427))//Heat equivalent in
    kcal
25 Vs=((3.14/4)*d^2*l*(N/2)*n)//Swept volume in c.m per
    min
26 cw=(Vs/da)//Charge weight of air per minute in kg
27 ma=(100/wO2)*((pC/100)*(mO2/mC)+(pH2/100)*(mO2/(2*
    mH2)))/Wt. of air required per kg of fuel in kg
28 mf=(cw/ma)//Minimum fuel in kg
29 ith=(hihp/(mf*(100+x)/100*CV))*100//Indicated
```

```

        thermal efficiency in percent '
30
31 //Output
32 printf('Indicated thermal efficiency of the engine
        is %3.1f percent ',ith)

```

Scilab code Exa 11.3 PROPERTIES

```

1  clc
2  clear
3  //Input data
4  n=8//Number of cylinders
5  d=8.57//Bore in cm
6  l=8.25//Stroke in cm
7  r=7//Compression ratio
8  N=4000//Speed in r.p.m
9  la=53.35//Length of the arm in cm
10 t=10//Test duration in min
11 br=40.8//Beam reading in kg
12 gas=0.455//gasoline in kg. In textbook, it is given
    wrong as 4.55
13 CV=11400//Calorific value in kcal/kg
14 Ta=21+273//Temperature of air in K
15 pa=1.027//Pressure of air in kg/cm^2
16 wa=5.44//Rate of air in kg/min
17 J=427//Mechanical equivalent of heat in kg.m/kcal
18 R=29.27//Characteristic gas constant in kg.m/kg.K
19
20 //Calculations
21 bhp=(2*3.14*N*br*la)/(4500*100)//Brake horse power
    in B.H.P
22 pb=(bhp*4500)/((n/2)*(l/100)*(3.14/4)*d^2*N)//Brake
    mean effective pressure in kg/cm^2
23 bsfc=(gas*60)/bhp//Brake specific fuel consumption
    in kg/b.h.p.hr

```

```

24 bsac=((wa*60)/bhp)//Brake specific fuel consumption
    in kg/b.h.p.hr
25 nb=((bhp*4500)/(J*gas*CV))*100//Brake thermal
    efficiency in percent
26 Vd=((3.14/4)*d^2*1)//Piston displacement in c.c/
    cycle
27 Pd=(Vd/10^6)*(N/2)*n//Piston displacement in m^3/min
28 Va=((wa*R*Ta)/(pa*10^4))//Volume of air used in m^3/
    min
29 nv=(Va/Pd)*100//Volumetric efficiency in percent
30 af=(wa/gas)//Air fuel ratio
31
32 //Output
33 printf('(a) the B.H.P delivered is %3.0f h.p \n (b)
    the b.m.e.p is %3.1f kg/cm^2 \n (c) the b.s.f.c
    is %3.3f kg/b.h.p.hr \n (d) the brake specific
    air consumption is %3.3f kg/b.h.p.hr \n (e) the
    brake thermal efficiency is %3.1f percent \n (f)
    the volumetric efficiency is %3.0f percent \n (g)
    the air fuel ratio is %3.2f',bhp,pb,bsfc,bsac,nb
    ,nv,af)

```

Scilab code Exa 11.4 WEIGHT OF AIR

```

1 clc
2 clear
3 //Input data
4 n=4//Number of cylinders
5 N=2000//Speed in r.p.m
6 m=13.15//Mass of fuel in kg/hour
7 Vd=655.5//Displacement volume in c.c
8 da=1.2//Density of air in kg/m^3
9 d=12.7//Manometer depression in cm
10 //Qa=0.231*sqrt(ha); Qa is the flow rate in cu.m/min
    and ha is the pressure difference in metres

```



```

11
12 // Calculations
13 Qa=(0.231*sqrt(((d*1000)/da)/100))//Flow rate in cu.
    m/min
14 Wa=(Qa*da)//Weight of air in kg/min
15 Va=(Qa*(2/N)*(1/n))*10^6//Volume of air drawn in per
    cycle per cylinder in c.c
16 nv=(Va/Vd)*100//Volumetric efficiency in percent
17 af=(Wa/(m/60))//Air fuel ratio
18
19 //Output
20 printf('(a) the weight of air drawn is %3.3f kg/min
    \n (b) volumetric efficiency taking air into
    account is %3.1f percent \n (c) the air-fuel
    ratio is %i',Wa,nv,af)

```

Scilab code Exa 11.5 CLEARANCE VOLUME

```

1  clc
2  clear
3  //Input data
4  d=10//Diameter in cm
5  l=15//Stroke in cm
6  r=6//Compression ratio
7  ihp=20//Indicated horse power in h.p
8  N=1000//Speed in r.p.m
9  n=4//Number of cylinders
10 nt=30//Thermal efficiency in percent
11 CV=10000//Calorific value in kea/kg
12 g=1.4//Ratio of specific heats
13
14 //Output
15 Vs=((3.14/4)*d^2*l)//Swept volume in c.c
16 Vc=(Vs/(r-1))//Clearance volume in c.c
17 na=(1-(1/r)^(g-1))*100//Air standard efficiency in

```

```

    percent
18 pm=((ihp*4500)/((1/100)*(3.14/4)*(d/100)^2*(N/2)*n))
    //Pressure in kg/cm^2
19 pc=(ihp*4500*60)/(427*(nt/100)*CV)//Petrol
    consumption in kg/hr
20
21 //Output
22 printf('Clearance volume is %3.1f c.c \n The air
    standard efficiency is %3.1f percent \n Petrol
    consumption is %3.2f kg/hr ',Vc,na,pc)

```

Scilab code Exa 11.6 CYLINDER PROPERTIES

```

1  clc
2  clear
3  //Input data
4  n=6//Number of cylinders
5  P=62//Power in HP
6  N=3000//Speed in r.p.m
7  nv=85//Volumetric efficiency in percent
8  nt=25//Thermal efficiency in percent
9  CV=10500//Calorific value in kcal/kg
10 af=15//Air fuel ratio
11 T=273//Standard atmosphere temperature in K
12 p=1.03//Standard atmosphere pressure in kg/cm^2
13 R=29.27//Characteristic gas constant in kg.m/kg.K
14 J=427//Mechanical equivalent of heat in kg.m/kcal
15
16 //Calculations
17 q=(P*4500)/(J*(nt/100))//Heat supplied in kcal/min
18 F=(q/CV)//Fuel supplied per minute in kg
19 Fc=(F/N)*(2/n)//Fuel supplied per cycle per cylinder
    in kg
20 wt=(af*Fc)//Weight of air supplied per cycle in kg
21 d((((wt)*R*T)/(p*10^4*(3.14/4)*(nv/100)))^(1/3))

```

```
    *100//Diameter in cm
22
23 //Output
24 printf('Cylinder bore = stroke = %3.2f cm',d)
```

Chapter 14

THE DIESEL ENGINE

Scilab code Exa 14.1 WEIGHT OF OIL

```
1  clc
2  clear
3  //Input data
4  r=14.3//Compression ratio
5  c=5//Fuel cutoff in percent of stroke
6  w=0.006//Weight of charge in kg
7  T4=912//Final temperature in degree C abs
8  q=8300//Heat in kcal
9  x=[0.258,0.000048]//Temperature expression is  $0.258T$ 
    + $0.000048T^2$ , where T is in degree C abs
10
11 //Calculations
12 v4=1//Assuming clearance volume as unity
13 v1=1.665//v1 from fig. 14.2 on page no. 352
14 T1=(T4*v1)/v4//Temperature in degree C abs
15 qp1=(x(1)*T1+x(2)*T1^2)//Constant pressure heat of
    mixture at temperature T1 in kcal/kg
16 qp4=(x(1)*T4+x(2)*T4^2)//Constant pressure heat of
    mixture at temperature T4 in kcal/kg
17 qre=(qp1-qp4)//Heat required by the mixture in kcal/
    kg
```

```

18 wf=(w*qre)/q//Weight of oil in kg
19
20 //Output
21 printf('The weight of oil that must be injected is
        %3.6f kg',wf)

```

Scilab code Exa 14.2 RATIO OF MASS

```

1  clc
2  clear
3  //Input data
4  r=14//Compression ratio
5  p=1.2//Induction pipe pressure in kg/cm^2
6  bp=0.65//Exhaust back pressure in kg/cm^2
7  Tc=87+273//Charge temperature in K
8  Te=850+273//Exhaust temperature in K
9  T1=111+273//Temperature at the beginning of
    compression in K
10 g=1.2//Ratio of specific heats
11
12 //Calculations
13 Cw1=((bp*10^4)/Te)//specific heat in kJ/kg.K
14 Cw2=((p*10^4*(r-1))/Tc)//specific heat in kJ/kg.K
15 T3=((g*Te*Cw1+Cw2*Tc)/(Cw1*g+Cw2))//Temperature in K
16 t3=T3-273//Temperature in degree C
17 rw=(Cw1/Cw2)//Ratio of specific heats
18
19 //Output
20 printf('The ratio of the mass residuals to fresh
        charge is %3.4f',rw)

```

Chapter 15

FUEL INJECTION

Scilab code Exa 15.1 QUANTITY OF FUEL

```
1  clc
2  clear
3  //Input data
4  n=6//Number of cylinders
5  p=720//Horse power in h.p
6  N=180//Speed in r.p.m
7  f=250//Fuel rate in gm per horse power hour
8
9  //Calculations
10 w=(((f/1000)*p)/((N/2)*60*n))*1000//Weight of fuel
    per cycle in gm/cycle
11
12 //Output
13 printf('The quantity of fuel to be injected per
    cylinder is %3.2f gm/cycle ',w)
```

Scilab code Exa 15.2 QUANTITY OF FUEL

```

1  clc
2  clear
3  //Input data
4  n=4//Number of cylinders
5  fc=0.215//Brake specific fuel consumption in kg/B.H.
   P hour
6  BHP=400//Brake horse power in B.H.P
7  N=250//Speed in r.p.m
8  sg=0.9//Specific gravity
9
10 //Calculations
11 Fc=(fc*BHP)//Fuel consumption per hour in kg/hr
12 Fcy=(Fc/n)//Fuel consumption per cylinder in kg/hr
13 Fcyc=((Fcy/(60*(N/2)))/(sg*1000))*10^6//Fuel
   consumption per cycle in kg. In textbook it is
   given wrong as 0.0287 instead of 3.185
14
15 //Output
16 printf('The quantity of fuel to be injected per
   cycle per cylinder is %3.3f c.c',Fcyc)

```

Scilab code Exa 15.3 QUANTITY OF FUEL

```

1  clc
2  clear
3  //Input data
4  n=4//Number of cylinders
5  p=450//Brake Horse power in B.H.P
6  N=200//Speed in r.p.m
7  f=0.2//Fuel rate in kg per horse power hour
8  g=0.9//Specific gravity of fuel
9
10 //Output
11 Fc=(p*f)//Fuel consumption per hour in kg/hr
12 Fcy=(Fc/n)//Fuel consumption per cylinder in kg/hr

```

```

13 Fcyc=(Fcy/(60*(N/2)))//Fuel consumption per cycle in
    kg
14 q=(Fcyc/(g*1000))*10^6//Quantity of fuel injected
    per cylinder per cycle in c.c
15
16 //Output
17 printf('The quantity of fuel to be injected per
    cycle per cylinder is %3.3f c.c',q)

```

Scilab code Exa 15.4 SIZE OF PUMP

```

1  clc
2  clear
3  //Input data
4  //Data from problem 1
5  n=6//Number of cylinders
6  p=720//Horse power in h.p
7  N=180//Speed in r.p.m
8  f=250//Fuel rate in gm per horse power hour
9
10 Vo=20//Volume of oil in the suction chamber in c.c
11 dp=80//Discharge pressure in kg/cm^2
12 voi=6//Volume of oil in the injector in c.c
13 g=0.9//Specific gravity of oil
14 b=78.8*10^-6//Coefficient of compressibility in cm
    ^2/kg when pressure is taken as atmospheric
15
16 //Calculations
17 w=((f/1000)*p)/((N/2)*60*n)*1000//Weight of fuel
    per cycle in gm/cycle
18 Va=(w/g)//Volume of air per cycle in c.c
19 V1=(Vo+Va)//Initial volume in c.c
20 dV12=(b*V1*dp)//Change in volume in c.c
21 //Assuming in accordance with average practice that
    s=2d, nv=0.94 and full load in this pump type x

```



```

    =0.5
22 d=((voi+dV12)/((3.14/4)*2*0.94*0.5))^(1/3)//Diameter
    in cm
23 l=(2*d)//Stroke in cm
24
25 //Output
26 printf('The diameter of the pump is %3.2f cm \n The
    total stroke is %3.2f cm',d,l)

```

Scilab code Exa 15.5 VELOCITY

```

1 clc
2 clear
3 //Input data
4 p=110//Oil pressure in kg/cm^2
5 pc=25//Pressure in the combustion chamber in kg/cm^2
6 q=0.805//Velocity coefficient. In textbook it is
    given wrong as 9.805
7 d=0.906//Specific gravity
8
9 //Calculations
10 v=(37.1*q*sqrt((p-pc)/d))//Velocity in m/s
11
12 //Output
13 printf('The velocity of injection is %3.0f m/s',v)

```

Scilab code Exa 15.6 PUMP DISPLACEMENT

```

1 clc
2 clear
3 //Input data
4 Vf=6.2//Volume of fuel in c.c
5 l=65//Length of fuel line in cm

```

```

6 di=2.5//Inner diameter in mm
7 V=2.75//Volume of fuel in the injector valve in c.c
8 Vd=0.15//Volume of fuel to be delivered in c.c. In
   textbook it is given wrong as 0.047
9 p=140//Pressure in kg/cm^2
10 pp=1//Pump pressure in kg/cm^2
11 patm=1.03//Atmospheric pressure in kg/cm^2
12 b=78.8*10^-6//Coefficient of compressibility in cm
   ^2/kg when pressure is taken as atmospheric
13
14 //Calculations
15 V1=(Vf+(3.14/4)*(di/10)^2*l+V)//Initial volume in c.
   c
16 dV=((b*V1*(p-pp)/patm))//Change in volume in c.c
17 d=(dV+Vd)//Total displacement of the plunger in c.c
18
19 //Output
20 printf('The total displacement of the plunger is %3
   .3f c.c',d)

```

Scilab code Exa 15.7 PUMP DISPLACEMENT

```

1 clc
2 clear
3 //Input data
4 Vf=6.75//Volume of fuel in c.c
5 l=65//Length of fuel line in cm
6 di=2.5//Inner diameter in mm
7 V=2.45//Volume of fuel in the injector valve in c.c
8 Vd=0.15//Volume of fuel to be delivered in c.c.
9 p=150//Pressure in kg/cm^2
10 pp=1//Pump pressure in kg/cm^2
11 patm=1.03//Atmospheric pressure in kg/cm^2
12 b=78.8*10^-6//Coefficient of compressibility in cm
   ^2/kg when pressure is taken as atmospheric

```

```

13
14 // Calculations
15 V1=(Vf+(3.14/4)*(di/10)^2*l+V)//Initial volume in c.
    c
16 dV=((b*V1*(p-pp)/patm))//Change in volume in c.c
17 d=(dV+Vd)//Total displacement of the plunger in c.c
18
19 //Output
20 printf('The total displacement of the plunger is %3
    .3f c.c',d)

```

Scilab code Exa 15.8 PLUNGER STROKE

```

1  clc
2  clear
3  //Input data
4  Vf=6.75//Volume of fuel in c.c
5  l=65//Length of fuel line in cm
6  di=2.5//Inner diameter in mm
7  V=2.45//Volume of fuel in the injector valve in c.c
8  Vd=0.15//Volume of fuel to be delivered in c.c.
9  p=150//Pressure in kg/cm^2
10 pp=1//Pump pressure in kg/cm^2
11 patm=1.03//Atmospheric pressure in kg/cm^2
12 b=78.8*10^-6//Coefficient of compressibility in cm
    ^2/kg when pressure is taken as atmospheric
13 dp=0.75//Diameter of the plunger in cm
14
15 // Calculations
16 V1=(Vf+(3.14/4)*(di/10)^2*l+V)//Initial volume in c.
    c
17 dV=((b*V1*(p-pp)/patm))//Change in volume in c.c
18 d=(dV+Vd)//Total displacement of the plunger in c.c
19 s=((4/3.14)*(d/dp^2))*10//Stroke in mm
20

```

```

21 //Output
22 printf('The effective plunger stroke is %3.1f mm',s)

```

Scilab code Exa 15.9 DIAMETER

```

1  clc
2  clear
3  //Input data
4  n=6//Number of cylinders
5  p=300//Horse power in H.P
6  N=1200//Speed in r.p.m
7  f=0.2//Fuel rate in kg per B.H.P hour
8  ip=200//Injection pressure in kg/cm^2
9  cp=40//Pressure in the combustion chamber in kg/cm^2
10 pic=33//Period of injection of the crank angle in
    degrees
11 g=0.83//Specific gravity of fuel. In textbook, it is
    given wrong as 0.89
12 Cd=0.9//Coefficient of discharge
13
14 //Output
15 Fc=(p*f)//Fuel consumption per hour in kg/hr
16 Fcy=(Fc/n)//Fuel consumption per cylinder in kg/hr
17 Fcyc=(Fcy/(60*(N/2)))//Fuel consumption per cycle in
    kg
18 q=(Fcyc/(g*1000))*10^6//Quantity of fuel injected
    per cylinder per cycle in c.c
19 I=((pic/360)*(1/N)*60)//Injection period in sec
20 df=(g/1000)//Density of fuel in kg/m^3
21 v=sqrt(2*981*((ip-cp)/df))//Velocity of fuel through
    orifice in m/s
22 A=(q/(Cd*v*I))//Area of orifice in cm^2
23 d=sqrt(A/(3.14/4))*10//Diameter in mm
24
25 //Output

```

```
26 printf('The diameter of the single orifice injector
    is %3.2f mm',d)
```

Scilab code Exa 15.10 AMOUNT OF FUEL

```
1  clc
2  clear
3  //Input data
4  n=6//Number of cylinders
5  d=11.5//Bore in cm
6  l=14//Stroke in cm
7  af=16//Air fuel ratio
8  pa=1.03//Pressure of air intake in kg/cm^2
9  Ta=24+273//Temperature of air intake in K
10 nv=76.5//Volumetric efficiency in percent
11 R=29.27//Characteristic gas constant in kg.m/kg.K
12 N=1500//Speed in r.p.m
13 ip=125//Injection pressure in kg/cm^2
14 cp=40//Compression pressure in kg/cm^2
15 q=18.5//Fuel injection occupies 18.5 degrees of
    crenk travel
16 fsw=760//Fuel specific weight in kg/m^2
17 dc=0.94//Orifice discharge coefficient
18
19 //Calculations
20 Vs=((3.14/4)*d^2*l)//Stroke volume in c.c
21 Va=(Vs*(nv/100))//Volume of air supplied in c.c
22 wa=((pa*10^4*Va*10^-6)/(R*Ta))//Weight of air
    supplied per cylinder per cycle in kg
23 wf=(wa/af)//Weight of fuel injected per cylinder per
    cycle in kg
24 I=((60*q)/(N*360))//Injection time per cycle in sec
25 F=(wf/I)//Fuel injected per cylinder per sec in kg/
    sec
26 Af=(F/(dc*sqrt(2*9.81*fsw*(ip-cp)*10^4)))/Area of
```

```
    orifice in sq.m
27 df=sqrt(Af/(3.14/4))*1000//Diameter of orifice in mm
28
29 //Output
30 printf('Maximum amount of fuel injected per cylinder
    per sec is %3.2f kg/sec \n Diameter of orifice
    is %3.3f mm',F,df)
```

Chapter 16

COMBUSTION IN COMPRESSION IGNITION ENGINES

Scilab code Exa 16.1 DELAY TIME

```
1  clc
2  clear
3  //Input data
4  s=0.005//Delay in sec
5  d=30//Bore in cm
6  N=600//Speed in r.p.m
7  dx=[10,15,20]//Bore diameters in cm
8
9  //Calculations
10 t=(s/d)*dx//Time of delay in sec. In textbook, t(2)
    is given wrong as 0.00025 sec instead of 0.0025
    sec
11
12 //Output
13 printf('The delay time for %i cm diameter bore is %3
    .5f sec \n The delay time for %i cm diameter bore
    is %3.5f sec \n The delay time for %i cm
```

```
diameter bore is %3.5f sec ',dx(1),t(1),dx(2),t(2)
, dx(3),t(3))
```

Scilab code Exa 16.2 PRESSURE

```
1  clc
2  clear
3  //Input data
4  d=[15,60]//Bore in cm
5  N=[1600,400]//Speed in r.p.m respectively
6  q=30//Injection of oil occupies 30 degrees of crank
   travel in each case
7  pc=30//Compression pressure in kg/cm^2
8  d=0.001//Delay time in sec
9  rp=5//Rapid combustion period is 5 degree of crank
   travel
10 pe=60//Compression pressure at the end of rapid
   compression in kg/cm^2
11
12 //Calculations
13 //For small engine
14 It1=(60/N(1))*(q/360)//Injection time in sec
15 pf1=((d/It1)+(rp/pc))*100//Percent fuel
16 //For large engine
17 It2=(60/N(2))*(q/360)//Injection time in sec
18 pf2=((d/It2)+(rp/pc))*100//Percent fuel
19 pr=(pc*(pf2/pf1))//Pressure rise in kg/cm^2
20 mp=(pc+pr)//Maximum pressure in kg/cm^2
21
22 //Output
23 printf('Pressure in the large engine is %3.1f kg/cm
   ^2 ',mp)
```

Scilab code Exa 16.3 BRAKE THERMAL EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  n=4//Number of cylinders
5  d=105//Bore in mm
6  l=127//Stroke in mm
7  BHP=63//Brake horse power in h.p
8  N=1800//Speed in r.p.m
9  t=15//Test time in min
10 mf=2.75//Mass of fuel in kg
11 CV=11000//Calorific value in kcal/kg
12 af=14.8//Air fuel ratio
13 v=0.805//Specific volume in m3/kg
14 nv=80//Volumetric efficiency in percent
15 J=427//Mechanical equivalent of heat in kg.m/kcal
16
17 //Calculations
18 bth=((BHP*4500)/(J*(mf/t)*CV))*100//Brake thermal
    efficiency in percent
19 Vs=((3.14/4)*(d/10)2*(l/10))//Stroke volume in c.c
20 Vsw=(Vs*n*(N/2)*t)//Swept volume in c.c
21 Va=(Vsw*10-6*(nv/100))//Volume of air sucked in m3
22 wa=(Va/v)//Weight of air sucked in kg
23 wr=(af*mf)//Weight of air required in kg
24 pei=(wr/wa)*100//Percentage of air available for
    combustion
25
26 //Output
27 printf('Brake thermal efficiency is %3.1f percent \n
    The percentage of air used for combustion is %i
    percent ',bth,pei)
```

Chapter 18

SUPERCHARGING

Scilab code Exa 18.1 PRESSURE AND AIR CONSUMPTION

```
1  clc
2  clear
3  //Input data
4  n=6//Number of cylinders
5  d=9//Bore in cm
6  l=10//Stroke in cm
7  N=2500//Speed in r.p.m
8  Ta=25+273//Temperature of air entering the
   compressor in K
9  q=16800//Heat rate in kcal/hour
10 T=60+273//Temperature of air leaving the cooler in K
11 p=1.6//Pressure of air leaving the cooler in kg/cm^2
12 t=14.5//Engine torque in kg.m
13 nv=75//Volumetric efficiency in percent
14 nm=74//Mechanical efficiency in percent
15 R=29.27//Characteristic gas constant in kg.m/kg.K
16 Cp=0.24//Specific heat at constant pressure n kcal/
   kg.K
17
18 //Calculations
19 BHP=(2*3.14*N*t)/4500//Brake horse power in B.H.P
```

```

20 IHP=(BHP/(nm/100))//Indicated horse power in I.H.P
21 pm=((IHP*4500)/((1/100)*(3.14/4)*d^2*(N/2)*n))//Mean
    effective pressure in kg/cm^2
22 Vs=(n*(3.14/4)*(d/100)^2*(1/100)*(N/2))//Swept
    volume in m^3/min
23 Va=(Vs*(nv/100))//Aspirated Volume of air into
    engine in m^3/min
24 ma=(p*10^4*Va)/(R*T)//Aspirated mass flow into the
    engine in kg/min
25 mcdT=((BHP*4500/427)/Cp)//Product of mass flow rate
    and change in temperature
26 msdT=((q/60)/Cp)//Product of mass flow rate and
    change in temperature
27 x=(mcdT/msdT)//Ratio
28 T2=((Ta-(x*T)))/(1-x)//Temperature in K
29 mc=(msdT/(T2-T))//Air flow in kg/min
30
31 //Output
32 printf('(a) the mean effective pressure is %3.2f kg/
    cm^2 \n (b) the air consumption is %3.3f kg/min \
    n (c) the air flow into the compressor is %3.2f
    kg/min',pm,ma,mc)

```

Scilab code Exa 18.2 PERCENTAGE INCREASE IN IMEP

```

1  clc
2  clear
3  //Input data
4  IMEP=10//Indicated mean effective pressure in kg/cm
    ^2
5  x=20//Mixture strength 20% richer than chemically
    correct
6  pIMEP=0.41//Pumping Indicated mean effective
    pressure in kg/cm^2
7  p1=0.97//Charge pressure at the beginning of

```

```

    compression in kg/cm^2
8  T1=100+273//Charge temperature at the beginning of
    compression in K
9  pm=0.91//Mean pressure during the conduction stroke
    in kg/cm^2
10 bn=70//Blower adiabatic efficiency in percent
11 T2=50//Temperature of the charge after delivery by
    the blower in degree C
12 dp=0.07//Pressure drop in kg/cm^2
13 pi=1.47//Charge pressure in the cylinder during the
    induction stroke in kg/cm^2
14 Ta=15+273//Atmospheric temperature in K
15 pa=1.03//Atmospheric pressure in kg/cm^2
16 g=1.4//Ratio of specific heats
17
18 //Calculations
19 T2x=(((pi/pa)^((g-1)/g)-1)/(bn/100))+1)*Ta+T2//
    Temperature in K
20 rIMEP=((pi/pa)*(T1/T2x))//Ratio of I.M.E.P
21 gIMEP=(rIMEP*IMEP)//Gross I.M.E.P in kg/cm^2
22 nsIMEP=(gIMEP+(pi-pa))//Net I.M.E.P supercharged in
    kg/cm^2
23 nuIMEP=(IMEP-pIMEP)//Net I.M.E.P unsupercharged in
    kg/cm^2
24 iIMEP=(nsIMEP-nuIMEP)//Increase in I.M.E.P in kg/cm
    ^2
25 pei=(iIMEP*100)/nuIMEP//Percentage increase
26
27 //Output
28 printf('Percentage increase in the net I.M.E.P due
    to supercharging is %3.1f percent',pei)

```

Scilab code Exa 18.3 PERCENTAGE INCREASE IN BHP

```
1  clc
```

```

2 clear
3 //Input data
4 l=4.5//Capacity in litres
5 P=20//Power in H.P per m3 of free air induced per
   minute
6 N=1700//Speed in r.p.m
7 nv=75//Volumetric efficiency in percent
8 Ta=27+273//Atmospheric temperature in K
9 pa=1.03//Atmospheric pressure in kg/cm2
10 pr=1.75//Pressure ratio
11 ie=70//Isentropic efficiency in percent
12 nm=75//Mechanical efficiency in percent
13 g=1.4//Ratio of specific heats
14 nb=80//Efficiency of blower in percent
15 R=29.27//Characteristic gas constant in kg.m/kg.K
16 Cp=0.24//Specific heat at constant pressure in kJ/kg
   .K
17 J=427//Mechanical equivalent of heat in kg.m/kcal
18
19 //Calculations
20 Vs=(l/1000*(N/2))//Swept volume in m3/min
21 uVs=((nm/100)*Vs)//Unsupercharged swept volume in m
   ^3/min
22 dp=(pr*pa)//Blower delivery pressure in kg/cm2
23 Tc=(Ta*pr((g-1)/g))//Temperature after isentropic
   compression in K
24 dT=(Ta+(Tc-Ta)/(ie/100))//Blow delivery temperature
   in K
25 Va=(Vs*(dp*Ta)/(pa*dT))//Equivalent volume at free
   air condition in m3/min
26 iiv=(Va-uVs)//Increase in the induced volume in m3/
   min
27 iIHP=(P*iiv)//Increase in I.H.P
28 iBHP=(iIHP*(nm/100))//Increase in B.H.P
29 ma=(dp*104*Vs)/(R*dT)//Mass of air delivered by
   blower in kg/min
30 HP=(ma*Cp*(dT-Ta)*J)/(4500*(80/100))//H.P required
   for blower

```

```
31 nibhp=(iBHP-HP)//Net increase in engine b.h.p
32 pei=(nibhp/(P*uVs))*100//Percentage increase
33
34 //Output
35 printf('Percentage net increase in B.H.P is %3.1f
    percent ',pei)
```

Chapter 19

TWO STROKE ENGINES

Scilab code Exa 19.3 PROPERTIES

```
1  clc
2  clear
3  //Input data
4  d=11.25//Bore in cm
5  l=15//Stroke in cm
6  r=7//Compression ratio
7  N=1800//Speed in r.p.m
8  a=4.5//Air supply in kg/min
9  Ta=72+273//Temperature of air in K
10 af=14.3//Air fuel ratio
11 ep=1//Exhaust pressure in kg/cm^2
12 R=29.27//Characteristic gas constant in kg.m/kg.
    degree C
13
14 //Calculations
15 Vc=((r/(r-1))*(3.14/4)*(d/100)^2*(l/100))//Swept
    volume in m^3
16 Wa=(Vc*N*ep*10^4)/(R*Ta)//Ideal air capacity in kg/
    min
17 sr=(a/Wa)//Scavenging ratio
18 sn=(1-exp(-sr))//Scavenging efficiency
```

```
19 nt=(sn/sr)//Trapping efficiency
20
21 //Output
22 printf('(a) Ideal air capacity is %3.2f kg/min \n (b
    ) Scavenging ratio is %3.2f \n (c) Scavenging
    efficiency is %3.3f \n (d) Trapping efficiency is
    %3.2f ',Wa,sr,sn,nt)
```

Chapter 23

TESTING OF ENGINES

Scilab code Exa 23.1 THERMAL EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  n=4//Four cylinder engine
5  N=1200//Speed in r.p.m
6  BHP1=26.3//Brake horse power in B.H.P
7  T=11.3//Average torque in kg
8  CV=10000//Calorific value of the fuel in kcal/kg
9  m=270//Flow rate in gm of petrol per B.H.P hour
10
11 //Calculations
12 BHP2=(T*2*3.14*N)/4500//Average B.H.P on 3 cylinders
13 IHP=BHP1-BHP2//Average I.H.P of one cylinder
14 TIHP=(n*IHP)//Total I.H.P
15 p=((m/1000)*BHP1)/TIHP//Petrol used in kg/I.H.P hr
16 nth=((4500*60)/(427*p*CV))*100//Indicated Thermal
    efficiency in percent
17
18 //Output
19 printf('Thermal efficiency is %3.1f percent ',nth)
```

Scilab code Exa 23.2 INDICATED HORSE POWER

```
1  clc
2  clear
3  n=4//Four cylinder engine
4  d=0.1//Diameter of piston in m
5  l=0.15//Stroke in m
6  RPM=1600//Speed in r.p.m
7  ap=(5.76*10^-4)//Area of positive loop of indicator
   diagram in sq.m
8  an=(0.26*10^-4)//Area of negative loop of indicator
   diagram in sq.m
9  L=0.055//Length of the indicator diagram in m
10 k=(3.5/10^-6)//Spring constant in kg/m^2 per m
11
12 //Calculations
13 NA=(ap-an)//Net area of the indicator diagram in sq.
   m
14 h=(NA/L)//Average height of diagram in m
15 Pm=(h*k)//Mean effective pressure in kg/m^2
16 IHP=(Pm*l*(3.14/4)*d^2*RPM*n)/4500//Indicated Horse
   Power
17
18 //Output
19 printf('Indicated horse power of a four cylinder two
   stroke petrol engine is %3.1f',IHP)
```

Scilab code Exa 23.3 CALORIFIC VALUE

```
1  clc
2  clear
3  //Input data
```

```

4 n=6//Number of cylinders
5 d=0.089//Bore in m
6 l=0.1016//Stroke in m
7 vc=3.183//Compression ratio
8 rn=55//Relative efficiency in percent
9 m=0.218//Petrol consumption in kg/hp.hr
10 Pm=(8.4/10^-4)//Indicated mean effective pressure in
    kg/m^2
11 N=2500//Speed in r.p.m
12
13 //Calculations
14 an=(1-(1/(vc-1)))*100//Air standard efficiency in
    percent
15 nth=(rn*an)/100//Thermal efficiency in percent
16 CV=((4500*60)/(m*(nth/100)*427))//Calorific value in
    kcal/kg
17 IHP=((Pm*(3.14/4)*d^2*l*N*n)/(4500*2))//Indicated
    horse power
18 p=(m*IHP)//Petrol consumption in kg/hour
19
20 //Output
21 printf('(1) The calorific value of petrol is %i kcal
    /kg \n (2) Corresponding petrol consumption is %3
    .1 f kg/hour',CV,p)

```

Scilab code Exa 23.4 BHP OF ENGINE

```

1 clc
2 clear
3 //Input data
4 n=4//Number of cylinders
5 d=0.2//Bore in m
6 l=0.3//Stroke in m
7 N=300//Speed in r.p.m
8 af=5//Air to fuel ratio by volume. In textbook it is

```

```

        given as 4 which is wrong
9  nv=78//Volumetric efficiency in percent
10 CV=2200//Calorific value in kcal/cu.m at N.T.P
11 bth=23//Brake thermal efficiency in percent
12
13 //Calculations
14 Vs=((3.14/4)*d^2*l)//Swept volume in cu.m
15 c=((nv/100)*Vs)//Total charge per stroke in cu.m
16 Vg=((c/af)*N)//Volume of gas used per min in cu.m at
    N.T.P
17 q=(CV*Vg)//Heat supplied in kcal/min
18 BHP=((bth/100)*q)/(4500/427)//Brake horse power
19
20 //Output
21 printf('The volume of gas used per min is %3.3f cu.m
    at N.T.P \n B.H.P of engine is %3.1f',Vg,BHP)

```

Scilab code Exa 23.5 THERMAL EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  d=20//Bore in cm
5  l=37.5//Stroke in cm
6  r=6//Compression ratio
7  IPm=5//Indicated Mean effective pressure in kg/cm^2
8  ag=6//Air to gas ratio
9  CV=3070//Calorific value of gas in kcal/cu.m
10 T=75+273//Temperature in K
11 p=0.975//Pressure in kg/cm^2
12 RPM=240//Speed in r.p.m
13 g=1.4//Ratio of specific heats
14
15 //Calculations
16 Vs=(3.14/4)*d^2*l//Stroke Volume in cu.m

```

```

17 Vg=(1/(r+1))*Vs//Volume of gas in cylinder in cu.m
    per cycle
18 x=(Vg*(p/1.03)*(273/T))//Volume at 'Vg' cu.m at 'p'
    kg/cm^2 and 'T' K are equivalent in cu.m
19 q=(CV*x)/10^6//Heat added in kcal per cycle
20 IHP=(IPm*(Vs/100)*(RPM/2))/4500//Indicated horse
    power
21 nth=((IHP*4500)/(427*q*(RPM/2)))*100//Thermal
    efficiency in percent
22 na=(1-(1/r^(g-1)))*100//Air standard efficiency in
    percent
23 rn=(nth/na)*100//Relative efficiency in percent
24
25 //Output
26 printf('The thermal efficiency is %3.1f percent \n
    The relative efficiency is %3.1f percent \n
    Indicated horse power is %3.1f H.P',nth,rn,IHP)

```

Scilab code Exa 23.6 FUEL CONSUMPTION

```

1  clc
2  clear
3  //Input data
4  n=4//Number of cylinders
5  d=6.25//Diametre in cm
6  l=9.5//Stroke in cm
7  t=678//Torque in kg.m
8  N=3000//Speed in r.p.m
9  Vc=60//Clearance volume in c.c
10 be=0.5//Brake efficiency ratio based on the air
    standard cycle
11 CV=10000//Calorific value in kcal/kg
12 g=1.4//Ratio of specific heats
13
14 //Calculations

```

```

15 Vs=(3.14/4)*d^2*l//Stroke volume in c.c per cylinder
16 r=((Vs+Vc)/Vc)//Compression ratio
17 na=(1-(1/r^(g-1)))//Air standard efficiency
18 bth=(be*na)*100//Brake thermal efficiency in percent
19 bhp=((t/100)*2*3.14*N)/4500//B.H.P in H.P
20 q=(bhp*(4500/427))/(bth/100)//Heat supplied in kcal/
    min
21 F=(q*60)/CV//Fuel consumption in kg/hour
22 P=(bhp*4500*2*100)/(n*Vs*N)//pressure in kg/cm^2
23
24 //Output
25 printf('The fuel consumption is %3.2f kg/hour \n The
    brake mean effective pressure is %3.2f kg/cm^2',
    F,P)

```

Scilab code Exa 23.7 PROPERTIES

```

1  clc
2  clear
3  //Input data
4  n=1//Number of cylinders
5  t=30//Trail time in min
6  m=5.6//Oil consumption in l
7  CV=9980//Calorific value of oil in kcal/kg
8  g=0.8//Specific gravity of oil
9  a=8.35//Average area of indicator diagram in sq.cm
10 l=8.4//Length of the indicator diagram in cm
11 is=5.5//Indicator spring scale
12 L=147.5//Brake load in kg
13 sp=20//Spring balance reading in kg
14 d=1.5//Effective brake wheel diameter in m
15 N=200//Speed in r.p.m
16 cyd=30//Cylinder diameter in cm
17 l1=45//Stroke in cm
18 mw=11//Jacket cooling water in kg/min

```

```

19 Tc=35+273//Temperature rise of cooling water in K
20
21 //Calculations
22 mp=(a/l)*is//Mean effective pressure
23 ihp=((mp*(l1/100)*(3.14/4)*cyd^2*(N/2))/4500)//
    Indicated horse power in h.p
24 bhp=(L*3.14*d*N)/4500//Brake horse power in h.p
25 nm=(bhp/ihp)*100//Mechanical efficiency in percent
26 F=(m*(60/t)*g)//Fuel consumption in kg/hour
27 Fc=(F/bhp)//Specific fuel consumption in kg/B.H.P/
    hour
28 ith=((ihp*(4500/427))/((F/60)*CV))*100//Indicated
    thermal efficiency in percent
29
30 //Output
31 printf('(a) I.H.P is %3.1f \n (b) B.H.P is %3.1f \n
    (c) Mechanical efficiency is %3.1f percent \n (d)
    Specific fuel consumption is %3.2f kg/B.H.P/hour
    \n (e) Indicated thermal efficiency is %3.1f
    percent ',ihp,bhp,nm,Fc,ith)

```

Scilab code Exa 23.8 HEAT BALANCE SHEET

```

1  clc
2  clear
3  //Input data
4  d=15//Diameter in cm. In textbook it is given wrong
    as 39
5  l=45//Stroke in cm
6  f=9.5//Total fuel used in litres
7  CV=10500//Calorific value in kcal/kg
8  n=12624//Total no. of revolutions
9  imep=7.24//Gross i.m.e.p in kg/cm^2
10 pimep=0.34//Pumping i.m.e.p in kg/cm^2
11 L=150//Net load on brake in kg

```

```

12 db=1.78//Diameter of the brake wheel drum in m
13 dr=4//Diameter of rope in cm
14 cw=545//Cooling water circulated in litres
15 Tc=45//Cooling water temperature rise in degree C
16 g=0.8//Specific gravity of oil
17
18 //Calculations
19 ihp=((imep-pimep)*(l/100)*3.14*d^2*n)/(4500*60)//I.H
    .P in h.p
20 q=(f*g*CV)/60//Heat supplied in kcal/min
21 bhp=(L*3.14*(db+(dr/100))*n)/(4500*60)//B.H.P in h.p
22 qbhp=(bhp*4500)/427//Heat equivalent of B.H.P in
    kcal/min
23 qw=(cw*Tc)/60//Heat lost to jacket cooling water in
    kcal/min
24 dq=(q-(qbhp+qw))//Heat unaccounted in kcal/min
25
26 //Output
27 printf('Heat supplied is %3.0f kcal/min \n Heat
    equivalent of B.H.P is %3.0f kcal/min \n Heat
    lost to jacket cooling water is %3.0f kcal/min \n
    Heat unaccounted is %3.0f kcal/min',q,qbhp,qw,dq
    )

```

Scilab code Exa 23.9 HEAT BALANCE SHEET

```

1 clc
2 clear
3 //Input data
4 d=27//Diameter in cm
5 l=45//Stroke in cm
6 db=1.62//Effective diameter of the brake in m
7 t=(38*60+30)//Test duration in sec
8 CV=4650//Calorific value in kcal/m^3 at N.T.P
9 n=8080//Total no. of revolutions

```



```

10 en=3230//Total number of explosions
11 p=5.75//Mean effective pressure in kg/cm^2
12 V=7.7//Gas used in m^3
13 T=15+273//Atmospheric temperature in K
14 pg=135//pressure of gas in mm of water above
    atmospheric pressure
15 hb=750//Height of barometer in mm of Hg
16 L=92//Net load on brake in kg
17 w=183//Weigh of jacket cooling water in kg
18 Tc=47//Cooling water temperature rise in degree C
19
20 //Calculations
21 ihp=(p*(1/100)*(3.14/4)*d^2*en)/(4500*(t/60))//I.H.P
    in h.p
22 bhp=(L*3.14*db*n)/(4500*(t/60))//B.H.P in h.p
23 pa=(hb+(pg/13))//Pressure of gas supplied in mm of
    Hg
24 Vg=(V*(273/T)*(pa/760))//Volume of gas used at N.T.P
    in m^3
25 q=(Vg*CV)/(t/60)//Heat supplied per minute in kcal
26 qbhp=(bhp*4500)/427//Heat equivalent of B.H.P in
    kcal/min
27 qc=(w/(t/60))*Tc//Heat lost to jacket cooling water
    in kcal/min
28 qra=(q-(qbhp+qc))//Heat lost to exhaust, etc in kcal
    /min
29
30 //Output
31 printf('Heat supplied is %3.1f kcal/min \n Heat
    equivalent of B.H.P is %3.0f kcal/min \n Heat
    lost to jacket cooling water is %3.1f kcal/min \n
    Heat lost to exhaust radiation etc. is %3.1f
    kcal/min ',q,qbhp,qc,qra)

```

Scilab code Exa 23.10 VOLUMETRIC EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  d=25//Bore in cm
5  l=50//Stroke in cm
6  N=240//Speed in r.p.m
7  n=100//Number of times fires per minute
8  qc=0.3//Quantity of coal gas used in cu.m per minute
9  h=100//Head in mm of water
10 bp=1.03//Barometric pressure in kg/cm^2
11 T=15+273//Temperature in K
12 ma=2.82//Mass of air used in kg per minute
13 R=29.45//Characteristic gas constant in kg.m/kg.K
14
15 //Calculations
16 gp=(bp+(100/13.6)*(bp/76))//Gas pressure in kg/cm^2
17 Vc=(qc*(gp/bp)*(273/T))//Volume of coal gas at N.T.P
    in cu.m per minute
18 Vce=(Vc/n)//Volume of coal gas per explosion in cu.m
    at N.T.P
19 va=(ma*R*273)/(bp*10^4)//Volume of air taken in at N
    .T.P in cu.m per min
20 V=((va-(((N/2)-n)*Vce))/(N/2))//Volume in cu.m
21 tV=(V+Vce)//Total volume of charge in cu.m at N.T.P
22 Vs=((3.14/4)*(d^2*l)*10^-6)//Swept volume in cu.m
23 nv=(tV/Vs)*100//Volumetric efficiency in percent
24
25 //Output
26 printf('(a) the charge of air per working cycle as
    measured at N.T.P is %3.5f cu.m \n (b) the
    volumetric efficiency is %3.1f percent',tV,nv)

```

Scilab code Exa 23.11 HEAT BALANCE SHEET

```

1  clc

```

```

2 clear
3 //Input data
4 d=18//Diameter in cm
5 l=24//Stroke in cm
6 t=30//Duration of trail in min
7 r=9000//Total number of revolutins
8 e=4445//Total number of explosions
9 mep=5.85//Mean effective pressure in kg/cm^2
10 Nl=40//Net load on brake wheel in kg
11 ed=1//Effective diameter of brake wheel in meter
12 tg=2.3//Total gas used at N.T.P in m^3
13 CV=4600//Calorific value of gas in kcal/m^3 at N.T.P
14 ta=36//Total air used in m^3
15 pa=720//Pressure of air in mm of Hg
16 Ta=18+273//Temperature of air in K
17 da=1.293//Density of air at N.T.P in kg/m^3
18 Te=350+273//Temperature of exhaust gases in K
19 Tr=18+273//Room temperature in K
20 Cp=0.24//Specific heat of exhaust gases in kJ/kg.K
21 twc=81.5//Total weight of cylinder jacket cooling
    water in kg
22 dT=33//Rise in temperature of jacket cooling water
    in degree C
23 R=29.45//Characteristic gas constant in kg.m/kg.
    degree C
24
25 //Calculations
26 ihp=(mep*(1/100)*(3.14/4)*d^2*(e/t))/4500//Indicated
    horse power in h.p
27 bhp=(Nl*3.14*r*ed)/(4500*t)//Brake horse power in h.
    p
28 qs=(tg/t)*CV//Heat supplied at N.T.P in kcal
29 qbhp=(bhp*4500)/427//Heat equivalent of B.H.P in
    kcal/min
30 ql=(twc/t)*dT//Heat lost to cylinder jacket cooling
    water in kcal/min
31 VA=(ta*(273/Ta)*(pa/760))//Volume of air used at N.T
    .P in m^3

```

```

32 WA=(VA*da)/t//Weight of air used per min in kg
33 WG=(1.03*tg*10^4)/(R*273)//Weight of gas in kg
34 Wg=(WG/t)//Weight of gas per minute in kg
35 We=(WA+Wg)//Total weight of exhaust gases in kg
36 qle=(We*(Te-Tr)*Cp)//Heat lost of exhaust gases in
    kcal/min
37 qra=(qs-(qbhp+ql+qle))//Heat lost by radiation in
    kcal/min
38 nm=(bhp/ihp)*100//Mechanical efficiency in percent
39 ith=((ihp*4500)/(427*qs))*100//Indicated thermal
    efficiency in percent
40
41 //Output
42 printf('          HEAT BALANCE SHEET\n
    _____ \n\n Heat supplied per minute
    is %3.1f kcal/min \n\n Heat expenditure
          (kcal per minute) \n 1.Heat
    equivalent of B.H.P is          %3.1f \n 2.Heat
    lost to jacket cooling water is %3.1f \n 3.Heat
    lost in exhaust gases is        %3.1f \n 4.Heat
    lost by radiation , etc., is    %3.1f \n
                                          _____\n
                                          %3.1f\n
                                          _____',qs
    ,qbhp,ql,qle,qra,qs)

```

Scilab code Exa 23.12 HEAT BALANCE SHEET

```

1  clc
2  clear
3  //Input data
4  gu=0.135//Gas used in m^3/min at N.T.P
5  CV=3990//Calorific value of gas in kcal/m^3 at N.T.P
6  dg=0.64//Density of gas in kg/m^3 at N.T.P
7  au=1.52//Air used in kg/min

```

```

8 C=0.24//Specific heat of exhaust gases in kJ/kg.K
9 Te=397+273//Temperature of exhaust gases in K
10 Tr=17+273//Room temperature in K
11 cw=6//Cooling water per minute in kg
12 rT=27.5//Rise in temperature in degree C
13 ihp=12.3//Indicated horse power in h.p
14 bhp=10.2//Brake horse power in h.p
15
16 //Calculations
17 qs=(gu*CV*60)//Heat supplied in kcal/hour
18 qbhp=((bhp*4500*60)/427)//Heat equivalent of B.H.P
    in kcal/hr
19 ql=(cw*60*rT)//Heat lost in jacket cooling water in
    kcal/hr
20 mg=(gu*dg)//Mass of gas used per minute in kg
21 me=(mg+au)//Mass of exhaust gases per minute in kg
22 qe=(me*C*(Te-Tr)*60)//Heat carried away by exhaust
    gases in kcal/hour
23 qun=(qs-(qbhp+ql+qe))//Heat unaccounted in kcal/hour
24
25 //Output
26 printf('Heat supplied is %3.0f kcal/hour \n Heat
    equivalent of B.H.P is %3.0f kcal/hr \n Heat lost
    in jacket cooling water is %3.0f kcal/hr \n Heat
    carried away by exhaust gases is %3.0f kcal/hour
    \n Heat unaccounted is %3.0f kcal/hour',qs,qbhp,
    ql,qe,qun)

```

Scilab code Exa 23.13 BRAKE MEAN EFFECTIVE PRESSURE

```

1 clc
2 clear
3 //Input data
4 n=4//Number of cylinders
5 r=1//Radius in metre

```

```

6 N=1400//Speed in r.p.m
7 bl=14.5//Net brake load in kg
8 P=[9.8,10.1,10.3,10]//Loads on the brake in kg
9 d=9//Bore in cm
10 l=12//Stroke in cm
11
12 //Calculations
13 bhp=(bl*2*3.14*r*N)/4500//Brake horse power in h.p
14 bhp1=(P(1)*2*3.14*r*N)/4500//Brake horse power in h.
    p
15 bhp2=(P(2)*2*3.14*r*N)/4500//Brake horse power in h.
    p
16 bhp3=(P(3)*2*3.14*r*N)/4500//Brake horse power in h.
    p
17 bhp4=(P(4)*2*3.14*r*N)/4500//Brake horse power in h.
    p
18 ihp1=bhp-bhp1//Indicated horse power in h.p
19 ihp2=bhp-bhp2//Indicated horse power in h.p
20 ihp3=bhp-bhp3//Indicated horse power in h.p
21 ihp4=bhp-bhp4//Indicated horse power in h.p
22 ihp=(ihp1+ihp2+ihp3+ihp4)//Indicated horse power in
    h.p
23 nm=(bhp/ihp)*100//Mechanical efficiency in percent
24 pm=((4500*bhp)/((1/100)*(3.14/4)*d^2*(N/2)))//Brake
    mean effective pressure in kg/cm^2
25
26 //Output
27 printf('I.H.P is %3.1f h.p \n Mechanical efficiency
    is %3.1f percent \n Brake mean effective pressure
    is %3.0f kg/cm^2 ',ihp,nm,pm)

```

Scilab code Exa 23.14 HEAT BALANCE SHEET

```

1 clc
2 clear

```

```

3 //Input data
4 N=350//Speed in r.p.m
5 L=60//Net brake load in kg
6 mep=2.75//Mean effective pressure in kg/cm^2
7 oc=4.25//Oil consumption in kg/hour
8 jcw=490//Jacket cooling water in kg/hour
9 Tw=[20+273,45+273]//Temperature of jacket water at
    inlet and outlet in K
10 au=31.5//Air used per kg of oil in kg
11 Ta=20+273//Temperature of air in the test room in K
12 Te=390+273//Temperature of exhaust gases in K
13 d=22//Cylinder diameter in cm
14 l=28//Stroke in cm
15 bd=1//Effective brake diameter in m
16 CV=10500//Calorific value of oil in kcal/kg
17 pH2=15//Proportion of hydrogen in fuel oil in
    percent
18 C=0.24//Mean specific heat of dry exhaust gases
19 Cs=9.5//Specific heat of steam in kJ/kg.K
20
21 //Calculations
22 ibp=(mep*(1/100)*(3.14/4)*d^2*N)/4500//Indicated
    brake power in h.p
23 bhp=(L*3.14*N*bd)/4500//Brake horse power in h.p
24 qs=(oc*CV)/60//Heat supplied per minute in kcal
25 qbhp=(bhp*4500)/427//Heat equivalent of B.H.P in
    kcal/min
26 pqbhp=(qbhp/qs)*100//Percentage of heat
27 ql=(jcw/60)*(Tw(2)-Tw(1))//Heat lost to cooling
    water in kcal/min
28 pql=(ql/qs)*100//Percentage of heat
29 wH2O=(9*(pH2/100)*(oc/60))//Weight of H2O produced
    per kg of fuel burnt in kg/min
30 twe=(oc*(au+1))/60//Total weight of wet exhaust
    gases per minute in kg
31 twd=(twe-wH2O)//Weight of dry exhaust gases per
    minute in kg
32 qle=(twd*C*(Te-Ta))//Heat lost to dry exhaust gases/

```

```

    min in kcal
33 pql = (ql / qs) * 100 // Percentatge of heat
34 qx = (100 + 538.9 + 0.5 * (Te - 373)) // Heat in kcal/kg
35 qst = (wH2O * qx) // Heat to steam in kcal/min
36 pqst = (qst / qs) * 100 // Percentatge of heat
37 qra = (qs - (qbhp + ql + qle + qst)) // Heat lost by radiation
    in kcal/min
38 pqra = (qra / qs) * 100 // Percentatge of heat
39
40 // Output
41 printf('
    HEAT BALANCE SHEET\n
    _____ \n\n Heat supplied per minute
    is          %3.0f kcal/min 100 percent \n\n Heat
    expenditure          (kcal per minute)      (
    percent) \n 1.Heat equivalent of B.H.P is
    %3.1f          %3.1f \n 2.Heat lost to
    cooling water is          %3.0f          %3.1f \n
    3.Heat lost to dry exhaust gases is          %3.1f
    %3.1f\n 4.Heat lost of steam in exhaust
    gases is %3.0f          %3.1f\n 5.Heat lost by
    radiation , etc. , is          %3.0f          %3.1f \n
    _____\n
    Total
    %3.0f          %3.0f
    \n
    _____', qs, qbhp, pqbhp, ql, pql, qle, pql,
    qst, pqst, qra, pqra, qs, (qbhp + pql + pql + pqst + pqra))

```

Scilab code Exa 23.15 HEAT BALANCE SHEET

```

1 clc
2 clear
3 //Input data
4 d=20 //Diameter in cm
5 l=40 //Stroke in cm

```



```

6 mep=5.95//Mean effective pressure in kg/cm^2
7 bt=41.5//Brake torque in kg.m
8 N=250//Speed in r.p.m
9 oc=4.2//Oil consumption in kg per hour
10 CV=11300//Calorific value of fuel in kcal/kg
11 jcw=4.5//Jacket cooling water in kg/min
12 rT=45//Rise in temperature in degree C
13 au=31//Air used in kg
14 Te=420//Temperature of exhaust gases in degree C
15 Tr=20//Room temperature in degree C
16 Cm=0.24//Mean specific heat of exhaust gases in kJ/
    kg.K
17
18 //Calculations
19 ihp=(mep*(1/100)*(3.14/4)*d^2*(N/2))/4500//Indicated
    horse power in h.p
20 bhp=(bt*2*3.14*N)/4500//Brake horse power in h.p
21 q=(oc*CV)//Heat supplied in kcal/hour
22 qbhp=(bhp*4500*60)/427//Heat equivalent of B.H.P in
    kcal/hour
23 qfhp=((ihp-bhp)*4500*60)/427//Heat equivalent F.H.P
    in kcal/hour
24 qc=(jcw*rT*60)//Heat lost in cooling water in kcal/
    hour
25 qe=(oc*32*Cm*(Te-Tr))//Heat lost in exhaust gases in
    kcal/hour
26 hu=(q-(qbhp+qfhp+qc+qe))//Heat unaccounted in kcal/
    hour
27
28 //Output
29 printf('Indicated horse power is %3.1f h.p \n Brake
    horse power is %3.2f h.p \n Heat supplied is %3.0
    f kcal/hour \n Heat equivalent of B.H.P is %3.0f
    kcal/hour \n Heat equivalent of F.H.P is %3.0f
    kcal/hour \n Heat lost in cooling water is %3.0f
    kcal/hour \n Heat lost in exhaust gases is %3.0f
    kcal/hour \n Heat unaccounted is %3.0f kcal/hour ',
    ,ihp,bhp,q,qbhp,qfhp,qc,qe,hu)

```

Scilab code Exa 23.16 HEAT BALANCE SHEET

```
1  clc
2  clear
3  //Input data
4  ihp=45//Indicated horse power in h.p
5  bhp=37//Brake horse power in h.p
6  fu=8.4//Fuel used in kg/hour
7  CV=10000//Calorific value in kcal/kg
8  Tc=[15,70]//Inlet and outlet temperatures of
   cylinders in degree C
9  cj=7//Rate of flow of cylinder jacket in kg/min
10 Tw=[15,55]//Inlet and outlet temperatures of water
    in degree C
11 rw=12.5//Rate of water flow in kg per minute
12 Te=82//Final temperature of exhaust gases in degree
   C
13 Tr=17//Room temperature in degree C
14 af=20//Air fuel ratio
15 Cm=0.24//Mean specific heat of exhaust gases in kJ/
   kg.K
16
17 //Calculations
18 q=(fu/60)*CV//Heat supplied in kcal/min
19 qbhp=(bhp*4500)/427//Heat equivalent of B.H.P in
   kcal/min
20 ql=(cj*(Tc(2)-Tc(1)))//Heat lost to cylinder jacket
   cooling water in kcal/min
21 qe=(rw*(Tw(2)-Tw(1)))//Heat lost by exhaust gases in
   kcal/min
22 qee=(Te-Tr)*Cm*(af+1)*fu/60//Heat of exhaust gas in
   kcal/min
23 te=(qe+qee)//Total heat lost to exhaust gases in
   kcal/min
```

```

24 hra=(q-(qbhp+ql+te))//Heat lost to radiation in kcal
    /min
25 ith=((ihp*4500)/(427*q))*100//Indicated thermal
    efficiency in percent
26 bth=((bhp*4500)/(427*q))*100//Brake thermal
    efficiency in percent
27 nm=(bhp/ihp)*100//Mechanical efficiency in percent
28
29 //Output
30 printf('Heat supplied is %3.0f kcal/min \n Heat
    equivalent of B.H.P is %3.0f kcal/min \n Heat
    lost to cylinder jacket cooling water is %3.0f
    kcal/min \n Total heat lost to exhaust gases is
    %3.1f kcal/min \n Heat lost to radiation is %3.1f
    kcal/min \n Indicated thermal efficiency is %3.1
    f percent \n Brake thermal efficiency is %3.1f
    percent \n Mechanical efficiency is %3.1f percent
    ',q,qbhp,ql,te,hra,ith,bth,nm)

```

Scilab code Exa 23.17 HEAT LOST

```

1  clc
2  clear
3  //Input data
4  Vs=0.0015//Stroke volume in cu.m
5  rc=5.5//Volume compression ratio
6  p2=8//Pressure at the end of compression stroke in
    kg/cm^2
7  T2=350+273//Temperature at the end of compression
    stroke in K
8  p3=25//Pressure in kg/cm^2
9  x=(1/30)//Fraction of distance travelled by piston
10 pa=1/16//Petrol air mixture ratio
11 R=29.45//Characteristic gas constant in kg.m/kg
    degree C

```

```

12 CV=10000//Calorific value of fuel in kcal per kg
13 Cv=0.23//Specific heat in kJ/kg.K
14
15 //Calculations
16 V2=(Vs*10^6)/(rc-1)//Volume in c.c
17 V3=(Vs*10^6)*x+V2//Volume in c.c
18 T3=(T2*p3*V3)/(p2*V2)//Temperature in K
19 W=((p3+p2)/2)*(V3-V2)//Workdone in kg.cm
20 mM=((p2*V2)/(T2*R*100))//Mass of mixture present in
    kg
21 dE=(mM*Cv*(T3-T2))//Change in energy in kcal
22 q=(dE+(W/(427*100)))//Heat in kcal
23 qc=(1/(1+(1/pa)))*mM*CV //Heat in kcal
24 q1=(qc-q)/mM//Heat lost in kcal per kg of charge
25
26 //Output
27 printf('Heat lost per kg of charge during explosion
    is %3.0f kcal',q1)

```

Chapter 25

GAS TURBINES

Scilab code Exa 25.2 OVERALL EFFICIENCY

```
1  clc
2  clear
3  //Input data
4  p=4//Pressure ratio
5  T3=1000//Turbine inlet temperature in K
6  T1=15+273//Inlet temperature in K
7  p1=1//Inlet pressure in kg/cm^2
8  m=11//Mass flow rate of air in kg/s
9  Cp=0.24//Specific heat at constant pressure in kJ/kg
   .K
10 R=29.27//haracteristic gas constant in kg.m/kg.K
11 g=1.4//Ratio of specific heats
12
13 //Calculations
14 Pc=(m*R*T1*(p^((g-1)/g)-1))/75//Power consumed by
   the compressor in H.P
15 Pt=(m*R*T3*(1-(1/p)^((g-1)/g)))/75//Power consumed
   by the turbine in H.P
16 N=(Pt-Pc)//Net output of the plant in H.P. In
   textbook answer is given wrong
17 T2=(T1*(p)^((g-1)/g))//Temperature at the end of
```

```

    compression in K
18 q=(Cp*(T3-T2))//Heat supplied in kcal/kg of air
19 n=((N*4500)/427)/(q*m*60)*100//Overall efficiency
    of the plant in percent
20
21 //Output
22 printf('Horse power developed is %3.0f H.P \n The
    overall efficiency of the plant is %3.2f percent'
    ,N,n)

```

Scilab code Exa 25.3 EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  T1=15+273//Temperature of air entering the
    compressor in K
5  rp=5//Pressure ratio
6  T3=700+273//Temperature of air after heating in K
7  g=1.4//Ratio of specific heats
8  Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
9
10 //Calculations
11 T2=(T1*rp^((g-1)/g))//Temperature of air after
    compression in K
12 T4=(T3/rp^((g-1)/g))//Temperature of air after
    expansion in K
13 Wc=(Cp*(T2-T1))//Workdone in the compressor in kcal/
    kg of air
14 Wt=(Cp*(T3-T4))//Workdone in the turbine in kcal/kg
    of air
15 N=(Wt-Wc)//Net workdone in kcal/kg of air
16 SHP=(N*427)/75//Shaft horse power in H.P per kg of
    air/sec

```

```

17 q=(Cp*(T3-T2))//Heat supplied in kcal/kg of air
18 n=(N/q)*100//Overall efficiency in percent
19
20 //Output
21 printf('Efficiency of plant is %3.1f percent \n The
        shaft horse-power per kg of air per second is %3
        .0f H.P',n,SHP)

```

Scilab code Exa 25.4 NET OUTPUT

```

1 clc
2 clear
3 //Input data
4 g=1.4//Ratio of specific heats
5 Cp=0.24//Specific heat at constant pressure in kJ/kg
   .K
6 m=20.5//Air flow rate in kg/sec
7 p=[5.85,1.03,1.03,5.85]//Inlet and outlet pressure
   of turbine and compressor respectively in kg/cm^2
8 T=[20+273,250+273,600+273,360+273]//Inlet and outlet
   temperatures of turbine and compressor
   respectively in degree C. In textbook instead of
   360 degree C, 375 degree C is given
9
10 //Calculations
11 T2=(T(1)*(p(4)/p(3))^((g-1)/g))//Temperature at the
   outlet of compressor in ideal cycle in K
12 T4=(T(3)/(p(1)/p(2))^((g-1)/g))//Temperature at the
   outlet of turbine in ideal cycle in K
13 ic=((T2-T(1))/(T(2)-T(1)))*100//Isentropic
   efficiency of compressor in percent
14 it=((T(3)-T(4))/(T(3)-T4))*100//Isentropic
   efficiency of turbine in percent
15 Wc=(Cp*(T(2)-T(1)))//Workdone in compressor in kcal/
   kg of air

```

```

16 Wt=(Cp*(T(3)-T(4)))//Workdone in turbine in kcal/kg
    of air
17 N=(Wt-Wc)//Net workdone in kcal/kg of air
18 P=(N*427*m)/75//Power output in H.P
19
20 //Output
21 printf('The net output is %3.0f H.P',P)

```

Scilab code Exa 25.5 TEMPERATURE

```

1  clc
2  clear
3  //Input data
4  rp=5//Pressure ratio
5  T1=15+273//Inlet temperature in K
6  nc=80//Adiabatic efficiency of the compressor in
    percent
7  n=1.4//Adiabatic index
8
9  //Calculations
10 T2=(T1*rp^((n-1)/n))//Temperature at the outlet of
    compressor in ideal cycle in K. The textbook
    answer is wrong. Instead of 456 K, it is given as
    452K
11 T2i=((nc/100)*T1)+T2-T1)/(nc/100)//Temperature at
    the outlet of the compressor in the actual cycle
    in K
12
13 //Output
14 printf('The temperature at the end of compression is
    %3.0f K',T2i)

```

Scilab code Exa 25.6 HP DEVELOPED


```

1  clc
2  clear
3  //Input data
4  p1=5.62//Pressure of gas entering the turbine in kg/
    cm^2
5  T1=1000+273//Temperature of gas entering the turbine
    in K
6  p2=1.124//Pressure of gas leaving the turbine in kg/
    cm^2. In textbook it is given as 1.24 instead of
    1.124
7  n1=0.8//Isotropic efficiency of the turbine in ratio
8  n=1.36//Adiabatic index
9  Cp=0.25//Specific heat at constant pressure in kJ/kg
    .K
10
11 //Calculations
12 T2=(T1/(p1/p2)^((n-1)/n))//Temperature at the end of
    adiabatic expansion in K
13 dt=(T1-T2)//Isentropic temperature drop in K
14 adt=(n1*dt)//Actual temperature drop in K
15 T2i=(T1-adt)//Temperature at the end of actual
    expansion in K
16 W=(Cp*(T1-T2i))//Workdone per kg of gas in kcal
17 q=(W*427)/4500//H.P developed per kg of gas per
    minute
18 t2i=(T2i-273)//Exhaust gas temperature in degree C
19
20 //Output
21 printf('(1) H.P developed per kg of gas per min is
    %3.2f \n (2) Exhaust gas temperature is %3.1f
    degree C',q,t2i)

```

Scilab code Exa 25.7 THERMAL EFFICIENCY

```

1  clc

```

```

2 clear
3 //Input data
4 pt1=[1,15+273]//Pressure and temperature at the
    inlet of compressor in kg/cm^2 and K respectively
5 pt3=[4,650+273]//Pressure and temperature at the
    inlet of turbine in kg/cm^2 and K respectively
6 n=[85,80]//Isentropic efficiencies of turbine and
    compressor respectively in percent
7 g=1.4//Ratio of specific heats
8 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
9
10 //Calculations
11 T2=(pt1(2)*(pt3(1)/pt1(1))^(g-1/g))//Temperature
    at the end of adiabatic compression in K
12 T2i=(pt1(2)+((T2-pt1(2))/(n(2)/100)))//Temperature
    at the end of actual compression in K
13 T4=(pt3(2)/(pt3(1)/pt1(1))^(g-1/g))//Temperature
    at the end of adiabatic expansion in K
14 T4i=(pt3(2)-((pt3(2)-T4)*(n(1)/100)))//Temperature
    at the end of actual expansion in K
15 Wt=(Cp*(pt3(2)-T4i))//Workdone in turbine in kcal/kg
    of air
16 Wc=(Cp*(T2i-pt1(2)))//Workdone in compressor in kcal
    /kg of air
17 N=(Wt-Wc)//Net workdone in kcal/kg of air
18 q=(Cp*(pt3(2)-T2i))//Heat supplied in kcal/kg of air
19 nt=(N/q)*100//Thermal efficiency in percent
20
21 //Output
22 printf('Thermal efficiency of the cycle is %3.2f
    percent ',nt)

```

Scilab code Exa 25.8 FLOW RATE

```

1  clc
2  clear
3  //Input data
4  p1=1.03//Inlet air pressure in kg/cm^2
5  T1=15.5+273//Inlet temperature of air in K
6  rp=5//Compression ratio
7  nc=85//Isentropic efficiency of the compressor in
   percent
8  T3=540+273//Temperature of the gas entering the
   turbine in K
9  p3=1.03//Pressure of gas entering the turbine in kg/
   cm^2
10 nt=80//Isentropic efficiency of the turbine in
   percent
11 O=2500//Net output in H.P
12 fp=0.07//Fall of pressure through the combustion
   chamber in kg/cm^2
13 g=1.4//Ratio of specific heats for both air and gas
14 Cp=0.24//Specific heat at constant pressure in kJ/kg
   .K for both air and gas
15
16 //Calculations
17 T2=(T1*rp^((g-1)/g))//Temperature of air at the end
   of adiabatic compression in K
18 T2i=(T1+((T2-T1)/(nc/100)))//Temperature of air at
   the end of actual compression in K
19 T4=(T3/((rp*p3-fp)/p3)^((g-1)/g))//Temperature of
   air at the end of adiabatic compression in K
20 T4i=(T3-((T3-T4)*(nt/100)))//Temperature of air at
   the end of actual compression in K
21 Wt=(Cp*(T3-T4i))//Workdone in turbine in kcal/kg of
   air
22 Wc=(Cp*(T2i-T1))//Workdone in compressor in kcal/kg
   of air
23 N=(Wt-Wc)//Net workdone in kcal/kg of air
24 Fl=(O*4500)/(427*N*60)//Flow rate for 2500 H.P in kg
   /sec
25

```

```

26 //Output
27 printf('Flow rate of air is %3.1f kg/sec for a net
        output of %i H.P',F1,0)

```

Scilab code Exa 25.9 FLOW RATE

```

1  clc
2  clear
3  //Input data
4  p1=1//Inlet air pressure in kg/cm^2
5  T1=16+273//Inlet temperature of air in K
6  rp=3.5//Pressure ratio
7  nc=85//Isentropic efficiency of the compressor in
        percent
8  T3=500+273//Temperature of the gas entering the
        turbine in K
9  nt=80//Isentropic efficiency of the turbine in
        percent
10 mc=4//Mass of air entering the compressor in tonnes/
        hour
11 g=1.4//Ratio of specific heats
12 Cp=0.24//Specific heat at constant pressure in kJ/kg
        .K
13
14 //Calculations
15 T2=(T1*rp^((g-1)/g))//Temperature of air at the end
        of adiabatic compression in K
16 dt=(T2-T1)//Isentropic temperature rise in K
17 act=(dt/(nc/100))//Actual temperature rise in K
18 T2i=(T1+((T2-T1)/(nc/100)))//Temperature of air at
        the end of actual compression in K
19 T4=(T3/rp^((g-1)/g))//Temperature of air at the end
        of adiabatic compression in K
20 T4i=(T3-((T3-T4)*(nt/100)))//Temperature of air at
        the end of actual compression in K

```

```

21 Wt=(Cp*(T3-T4i))//Workdone in turbine in kcal/kg of
    air
22 Wc=(Cp*(T2i-T1))//Workdone in compressor in kcal/kg
    of air
23 N=(Wt-Wc)//Net workdone in kcal/kg of air
24 q=(Cp*(T3-T2i))//Heat supplied in kcal/kg of air
25 NHP=(N*427*mc*1000)/(60*4500)//Net Horse Power
    available in H.P
26 nt=(N/q)*100//Thermal efficiency in percent
27
28 //Output
29 printf('(i) The net Horse power available from this
    unit is %3.1f H.P \n (ii) The thermal efficiency
    of the plant is %3.2f percent',NHP,nt)

```

Scilab code Exa 25.10 EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  p1=1.02//Inlet air pressure in kg/cm^2
5  T1=27+273//Inlet temperature of air in K
6  p2=4.08//Pressure after compression in kg/cm^2
7  nc=80//Isentropic efficiency of compressor in
    percent
8  mf=1//Mass of fuel in kg
9  ma=80//Mass of air in kg
10 nt=85//Isentropic efficiency of the turbine in
    percent
11 CV=10000//Calorific value of fuel n kcal per kg
12 g=1.4//Ratio of specific heats
13 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
14
15 //Calculations

```

```

16 rp=(p2/p1)//Pressure ratio
17 T2=(T1*rp^((g-1)/g))//Temperature of air at the end
    of adiabatic compression in K
18 dt=(T2-T1)//Isentropic temperature rise in K
19 adt=(dt/(nc/100))//Actual temperature rise in K
20 T2i=(T1+((T2-T1)/(nc/100)))//Temperature of air at
    the end of actual compression in K
21 q=(mf/ma)*CV//Heat supplied per kg of air in kcal
22 T3=(q/Cp)+T2i//Temperature of gas at the inlet of
    the turbine in K
23 T4=(T3/rp^((g-1)/g))//Temperature of air at the end
    of adiabatic expansion in K
24 T4i=(T3-((T3-T4)*(nt/100)))//Temperature of air at
    the end of actual expansion in K
25 Wt=(Cp*(T3-T4i)*((ma+mf)/ma))//Workdone in turbine
    in kcal/kg of air
26 Wc=(Cp*(T2i-T1))//Workdone in compressor in kcal/kg
    of air
27 N=(Wt-Wc)//Net workdone in kcal/kg of air
28 nt=(N/q)*100//Thermal efficiency in percent
29
30 //Output
31 printf('(a) The net work output of installation is
    %3.2f kcal/kg of air \n (b) Overall efficiency of
    the plant is %3.1f percent ',N,nt)

```

Scilab code Exa 25.11 EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  rp=5//Pressure ratio
5  T3=580+273//Temperature of gas at the inlet of the
    turbine in K
6  p1=1.03//Inlet air pressure in kg/cm^2

```

```

7 T1=15+273//Inlet temperature of air in K
8 nc=80//Isentropic efficiency of compressor in
  percent
9 no=18//Overall efficiency of the plant in percent
10 Cpa=0.239//Specific heat of air at constant pressure
  in kJ/kg.K
11 Cpg=0.261//Specific heat of gas at constant pressure
  in kJ/kg.K
12 R=29.27//haracteristic gas constant in kg.m/kg.K
13 g=1.4//Ratio of specific heats for air
14 g1=1.355//Ratio of specific heats for gas
15
16 //Calculations
17 T2=(T1*rp^((g-1)/g))//Temperature of air at the end
  of adiabatic compression in K
18 T2i=(T1+((T2-T1)/(nc/100)))//Temperature of air at
  the end of actual compression in K
19 q=(Cpg*(T3-T2i))//Heat supplied in kcal/kg of air
20 Wc=(Cpa*(T2i-T1))//Workdone in compressor in kcal/kg
  of air
21 Wt=((no/100)*q)+Wc//Turbine work output in kcal/kg
  of air
22 T4i=(T3-(Wt/Cpg))//Temperature of air at the end of
  actual expansion in K
23 T4=(T3/rp^((g1-1)/g1))//Temperature of air at the
  end of adiabatic expansion in K
24 nt=((T3-T4i)/(T3-T4))*100//Isentropic efficiency of
  turbine in percent
25
26 //Output
27 printf('Isentropic efficiency of turbine is %3.1f
  percent ',nt)

```

Scilab code Exa 25.12 FLOW OF AIR

```

1  clc
2  clear
3  //Input data
4  p1=1.03//Inlet air pressure in kg/cm^2
5  T1=15+273//Inlet temperature of air in K
6  rp=5//Pressure ratio
7  nc=85//Isentropic efficiency of the compressor in
   percent
8  T3=540+273//Temperature of the gas entering the
   turbine in K
9  nt=80//Isentropic efficiency of the turbine in
   percent
10 NHP=2000//Net horse power in H.P
11 fp=0.1//Fall of pressure through the combustion
   system in kg/cm^2
12 g=1.4//Ratio of specific heats for both air and gas
13 Cp=0.25//Specific heat at constant pressure in kJ/kg
   .K for both air and gas
14
15 //Calculations
16 T2i=(T1*rp^((g-1)/g))//Temperature of air at the end
   of adiabatic compression in K
17 dt=(T2i-T1)//Isentropic temperature rise in K
18 adt=(dt/(nc/100))//Actual temperature rise in K
19 Wc=(Cp*adt)//Workdone in compressor in kcal/kg of
   air
20 e=((rp*p1-fp)/p1)//Expansion ratio
21 T4i=(T3/e^((g-1)/g))//Temperature of air at the end
   of adiabatic expansion in K
22 dt1=(T3-T4i)//Isentropic temperature rise in K
23 adt1=(dt1/(nt/100))//Actual temperature rise in K
24 Wt=(Cp*adt1)//Workdone in turbine in kcal/kg of air
25 N=(Wt-Wc)//Net workdone in kcal/kg of air
26 w=(NHP*75)/(427*9.8)//Flow rate in kg of air per sec
27
28 //Output
29 printf('Flow rate is %3.2 f kg of air per sec',w)

```

Scilab code Exa 25.13 POWER OUTPUT

```
1  clc
2  clear
3  //Input data
4  nc=75//Isentropic efficiency of the compressor in
   percent
5  nt=85//Isentropic efficiency of the turbine in
   percent
6  nm=98//Mechanical efficiency in percent
7  rp=6//Pressure ratio
8  T3=727+273//Temperature of the gas entering the
   turbine in K
9  p1=1//Inlet air pressure in kg/cm^2
10 T1=15.5+273//Inlet temperature of air in K
11 m=2.2//Mass flow rate in kg/sec
12 Cpa=0.24//Specific heat of air at constant pressure
   in kJ/kg.K
13 Cpg=0.276//Specific heat of gas at constant pressure
   in kJ/kg.K
14 g=1.4//Ratio of specific heats for air
15 g1=1.33//Ratio of specific heats for gas
16
17 //Calculations
18 T2=(T1*rp^((g-1)/g))//Temperature of air at the end
   of adiabatic compression in K
19 T2i=(T1+((T2-T1)/(nc/100)))//Temperature of air at
   the end of actual compression in K
20 T4=(T3/rp^((g1-1)/g1))//Temperature of air at the
   end of adiabatic compression in K
21 T4i=(T3-((T3-T4)*(nt/100)))//Temperature of air at
   the end of actual compression in K
22 Wt=(Cpg*(T3-T4i))//Workdone in turbine in kcal/kg of
   air
```

```

23 Wc=(Cpa*(T2i-T1))//Workdone in compressor in kcal/kg
    of air
24 N=(Wt-Wc)//Net workdone in kcal/kg of air
25 P=(N*m*427)/(75*(nm/100))//Power output of the plant
    in H.P
26
27 //Output
28 printf('Power output of the plant is %3.0f H.P',P)

```

Scilab code Exa 25.14 EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  T1=15+273//Inlet temperature of air in K
5  rp=4//Pressure ratio
6  T4=560+273//Maximum temperature of the cycle in K
7  nc=83//Isentropic efficiency of the compressor in
    percent
8  nt=86//Isentropic efficiency of the turbine in
    percent
9  x=75//Heat exchanger making use of heat available in
    percent
10 g=1.4//Ratio of specific heats
11
12 //Calculations
13 T5i=(T4*(1/rp)^((g-1)/g))//Temperature in K
14 dt=(T4-T5i)//Isometric temperature drop through
    turbine in degree C
15 ta=((nt/100)*dt)//Actual temperature drop in degree
    C
16 T5=(T4-ta)//Temperature in K
17 T2i=(T1*rp^((g-1)/g))//Temperature in K
18 tc=(T2i-T1)//Temperature change in degree C
19 T2=(tc/(nc/100))+T1//Temperature in K

```

```

20 q=(T5-T2)//Available heat in exchanger in kcal per
    kg *Cp
21 T3=((q*(x/100))+T2)//Temperature in K
22 //Without heat exchanger
23 qw=(T4-T2)//Heat supplied *Cp in kcal/kg
24 tw=(T4-T5)//Turbine work *Cp in kcal/kg
25 cw=(T2-T1)//Compressor work *Cp in kcal/kg
26 nw=(tw-cw)//Net workdone *Cp in kcal/kg
27 no=(nw/qw)*100//Overall efficiency in percent
28 //With heat exchanger
29 qs=(T4-T3)//Heat supplied *Cp in kcal/kg
30 no1=(nw/qs)*100//Overall efficiency in percent
31
32 //Output
33 printf('The overall efficiency \n (a) without heat
    exchanger is %3.1f percent \n (b) with heat
    exchanger making use of %i percent of heat
    available is %3.1f percent ',no,x,no1)

```

Scilab code Exa 25.15 PRESSURE

```

1  clc
2  clear
3  //Input data
4  p1=1//Initial pressure in kg/cm^2
5  T1=15+273//Initial temperature in K
6  p2=5.5//Pressure after compression in kg/cm^2
7  T3=750+273//Temperature at the entrance of turbine
    in K
8  v=225//Speed in m/s
9  x=70//Percentage
10 in=75//Isentropic efficiency of compressor in
    percent
11 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K

```

```

12 g=1.4//Ratio of specific heats
13
14 //Calculations
15 T2=(T1*(p2/p1)^((g-1)/g))//Temperature in K
16 at=(T2-T1)/(in/100)//Actual temperature rise in the
    compressor in K
17 T2i=(T1+at)//Temperature in K
18 T4=(T3/(p2/p1)^((g-1)/g))//Temperature in K
19 to=(Cp*(T3-T4))//Theoretical turbine output in kcal/
    kg of air
20 ci=(Cp*(T2i-T1))//Actual compressor input in kcal/kg
    of air
21 ke=(v^2/(2*9.81*427))//Kinetic energy in gas leaving
    the exhaust annulus in kcal/kg
22 dT34=(ci+ke)/((x/100)*Cp)//Change in temperature in
    K
23 r=1/(1-(dT34/T3))^(g/(g-1))//Ratio of pressures
24 p4=(r/p2)//Pressure in kg/cm^2
25
26 //Output
27 printf('The pressure of the gases in the turbine
    exhaust annulus is %3.1f kg/cm^2',p4)

```

Scilab code Exa 25.16 EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 p=[1,5]//Pressures in atm
5 T1=288//Temperature in K
6 T3=650+273//Temperature in K
7 er=0.85//Efficiency ratio
8 x=0.72//Effectiveness of heat exchanger
9 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K

```

```

10 g=1.4//Ratio of specific heats
11
12 //Calculations
13 T2=(T1*(p(2)/p(1))^(g-1)/g)//Temperature in K
14 T2i=(T1+((T2-T1)/er))//Temperature in K
15 T4=(T3/(p(2)/p(1))^(g-1)/g)//Temperature in K
16 T4i=(T3-(er*(T3-T4))//Temperature in K
17 Tc=((x*(T4i-T2i))+T2i)//Temperature in K
18 W=((Cp*((T3-T4i)-(T2i-T1))))//Workdone in kcal/kg
19 q=(Cp*(T3-Tc))//Heat supplied in kcal/kg
20 n=(W/q)*100//Efficiency in percent
21
22 //Output
23 printf('The heat efficiency of the plant is %3.1f
    percent ',n)

```

Scilab code Exa 25.17 EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 T1=15+273//Inlet temperature of air in K
5 p1=1.03//Inlet pressure of air in kg/cm^2
6 rp=5//Pressure ratio
7 T3=815+273//Temperature of air entering the turbine
    in K
8 nc=0.83//Adiabatic efficiency of the compressor
9 nt=0.92//Internal engine efficiency of the turbine
10 nr=0.65//Effectiveness of regenerator
11 p2=2.45//Pressure in kg/cm^2
12 T6=T1//Temperature in K
13 T9=T3//Temperature in K
14 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
15 g=1.4//Ratio of specific heat

```

```

16
17 // Calculations
18 T2=(T1*rp^((g-1)/g))//Temperature in K
19 T4=(T3/rp^((g-1)/g))//Temperature in K
20 Wt=(Cp*(T3-T4))//Isentropic work done in the turbine
    in kcal/kg of air
21 Wc=(Cp*(T2-T1))//Isentropic work done in the
    compressor in kcal/kg of air
22 Wr=(Wt/Wc)//Work ratio
23 qa=(Cp*(T3-T2))//Heat added in kcal/kg of air
24 nth=((Wt-Wc)/qa)*100//Thermal efficiency in percent
25 T2i=(T1+((T2-T1)/nc))//Temperature in K
26 T4i=(T3-(nt*(T3-T4)))//Temperature in K
27 Wti=(Cp*(T3-T4i))//work done in the turbine in kcal/
    kg of air
28 Wci=(Cp*(T2i-T1))//work done in the compressor in
    kcal/kg of air
29 Wri=(Wti/Wci)//Work ratio
30 qai=(Cp*(T3-T2i))//Heat added in kcal/kg of air
31 nthi=((Wti-Wci)/qai)*100//Thermal efficiency in
    percent
32 T2ii=(T2i+((T4i-T2i)*nr))//Temperature in K
33 qaii=(Cp*(T3-T2ii))//Heat added in kcal/kg of air
34 nthii=((Wti-Wci)/qaii)*100//Thermal efficiency in
    percent
35 T5=(T1*(p2/p1)^((g-1)/g))//Temperature in K
36 T5i=(T1+((T5-T1)/nc))//Temperature in K
37 T7=(T1*((rp*p1)/p2)^((g-1)/g))//Temperature in K
38 T7i=(T6+((T7-T6)/nc))//Temperature in K
39 T7ii=(T7i+((T4i-T7i)*nr))//Temperature in K
40 Wcomp=(Cp*((T5i-T1)+(T7i-T6)))//Compressor work in
    kcal/kg of air
41 Wratio=(Wti/Wcomp)//Work ratio
42 qaa=(Cp*(T3-T7ii))//Heat added in kcal/kg of air
43 nth=((Wti-Wcomp)/qaa)*100//Thermal efficiency in
    percent
44 T8=(T3*(p2/(rp*p1))^((g-1)/g))//Temperature in K
45 T8i=(T3-((T3-T8)*nt))//Temperature in K

```

```

46 T10=(T9/(p2/p1)^((g-1)/g))//Temperature in K
47 T10i=(T9-((T9-T10)*nt))//Temperature in K
48 T2iii=(T2i+((T10i-T2i)*nr))//Temperature in K
49 Wturb=(Cp*((T3-T8i)+(T3-T10i))//Compressor work in
    kcal/kg of air
50 Wratioi=(Wturb/Wci)//Work ratio
51 qaai=(Cp*((T3-T2iii)+(T9-T8i))//Heat added in kcal/
    kg of air
52 nthei=((Wturb-Wci)/qaai)*100//Thermal efficiency in
    percent
53 T7iii=(T7i+((T10i-T7i)*nr))//Temperature in K
54 Wratioii=(Wturb/Wcomp)//Work ratio
55 qaaii=(Cp*((T3-T7iii)+(T9-T8i))//Heat added in kcal
    /kg of air
56 nthi=((Wturb-Wcomp)/qaaii)*100//Thermal efficiency
    in percent
57
58 //Output
59 printf('Condition      Work ratio      Thermal
    efficiency (in percent)\n      (a)          %3.3 f
    %3.1 f\n      (b)          %3.2 f
    %3.1 f\n      (c)          %3.2 f
    %3.1 f\n      (d)          %3.2 f
    %3.1 f\n      (e)          %3.3 f
    %3.1 f\n      (f)          %3.3 f
    %3.1 f',Wr,nth,Wri,nthi,Wri,nthii,
    Wratio,nthe,Wratioi,nthei,Wratioii,ntheii)

```

Scilab code Exa 25.18 EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 p=[1,9]//Pressures in ata
5 T=[25+273,1250+273]//Minimum and maximum

```

```

        temperatures in K
6  n=0.83//Compressor and turbine efficiencies
7  Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
8  g=1.4//Ratio of specific heats
9  x=0.65//Cycle with 65% regeneration
10
11 //Calculations
12 //(a)Without regeneration
13 ip=sqrt(p(1)*p(2))//Intermediate pressure in ata
14 T2=(T(1)*(ip/p(1))^((g-1)/g))//Temperature in K
15 T3=(T(1)+((T2-T(1))/n))//Temperature in K
16 T4=T(1)//Temperature in K
17 T5=T2//Temperature in K
18 T6=T3//Temperature in K
19 T7=T(2)//Temperature in K
20 T8=T7/(ip/p(1))^((g-1)/g)//Temperature in K
21 T9=(T7-((T7-T8)*n))//Temperature in K
22 T10=T7//Temperature in K
23 T11=T8//Temperature in K
24 T12=T9//Temperature in K
25 Wc=(2*Cp*(T3-T(1)))//Work of compression in kcal/kg
    of air
26 We=(2*Cp*(T7-T8))//Work of expansion in kcal/kg of
    air
27 NW=(We-Wc)//Net output in kcal/kg of air
28 qi=(Cp*((T7-T6)+(T10-T9)))//Heat input in kcal/kg of
    air
29 nth=(NW/qi)*100//Thermal efficiency in percent
30
31 //(b)Cycle efficiency with 65% regeneration
32 Tg=(T6+(x*(T12-T6)))//Temperature in K
33 q=(Cp*((T7-Tg)+(T10-T9)))//Heat input in kcal/kg of
    air
34 nthi=(NW/q)*100//Thermal efficiency in percent
35
36 //(c)Cycle efficiency with ideal regeneration
37 Eg=T12//Temperature in K

```



```

38 qa=(2*Cp*(T7-Eg))//Heat added in kcal/kg of air
39 nthii=(NW/qa)*100//Thermal efficiency in percent
40
41 //Output
42 printf('(a)Cycle efficiency without regeneration is
    %3.1f percent \n (b)Cycle efficiency with 65
    percent regeneration is %3.1f percent \n (c)Cycle
    efficiency with ideal regeneration is %3.0f
    percent ',nth,nthi,nthii)

```

Scilab code Exa 25.19 EFFICIENCY

```

1  clc
2  clear
3  //Input data
4  p1=1//Inlet pressure of compressor in atm
5  T1=27+273//Inle temperature of compressor in K
6  ic=0.8//Isentropic efficiency of compressor
7  ma=20.5//Mass flow rate of air in kg/sec
8  T3=650+273//Inlet temperatures of both turbines in K
9  p2=5//Inlet pressure of turbine in atm
10 it=0.92//Internal engine efficiency for both the
    turbines
11 CV=10000//Calorific value in kcal/kg
12 Cpa=0.24//Specific heat at constant pressure of air
    in kJ/kg.K
13 ga=1.4//Ratio of specific heats for air
14 Cpg=0.276//Specific heat at constant pressure of gas
    in kJ/kg.K
15 gs=1.33//Ratio of specific heats for gas
16
17 //Calculations
18 T2=(T1*(p2/p1)^((ga-1)/ga))//Temperature in K
19 T2i=(T1+((T2-T1)/ic))//Temperature in K
20 T4=(T3/(p2/p1)^((gs-1)/gs))//Temperature in K

```

```

21 T4i=(T3-((T3-T4)*it))//Temperature in K
22 Wc=(Cpa*(T2i-T1))//Work of compression in kcal/kg of
    air
23 We=(Cpg*(T3-T4i))//Work of expansion in kcal/kg of
    air
24 mx=(Wc/We)//Gas required per kg of air compressed in
    kg
25 F=((Cpa*T2i)-(Cpg*T3))/(Cpg*T3-CV)//Amount of fuel
    supplied per kg of air in kg
26 Wg=1+F//Weight of gases per kg of air in kg
27 Wt=(Wg-mx)//Gases supplied to turbine in kg
28 Ot=((Wt*ma*427*We)/75)//Output of turbine in H.P
29 nth=((Wt*We)/(CV*F))*100//Thermal efficiency in
    percent
30
31 //Output
32 printf('Output is %3.0f H.P \n Thermal efficiency is
    %3.2f percent ',Ot,nth)

```

Scilab code Exa 25.20 HP

```

1  clc
2  clear
3  //Input data
4  q=2250//Heat supplied per sec in kcal
5  //Input data from Fig. 25.34 from page no. 652
6  T1=200//Temperature in K
7  T2=100//Temperature in K
8  T3=625//Temperature in K
9  T4=550//Temperature in K
10 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
11 g=1.4//Ratio of specific heats
12
13 //Calculations

```

```

14 Wc=(2*Cp*(T1-T2))//Work of compression in kcal/kg of
    air
15 We=(2*Cp*(T3-T4))//Work of expansion in kcal/kg of
    air
16 NW=(Wc-We)//Net output in kcal/kg of air
17 qi=(2*Cp*(T3-T4))//Heat input in kcal/kg of air
18 nth=(NW/qi)*100//Thermal efficiency in percent
19 rf=(q/qi)//Rate of flow of working substance in kg/
    sec
20 O=(NW*rf*427)/75//Total output in H.P
21
22 //Output
23 printf('Output is %3.0f H.P \n Thermal efficiency is
    %3.1f percent ',O,nth)

```

Scilab code Exa 25.22 EFFICIENCY

```

1 clc
2 clear
3 //Input data
4 p=[5,20]//Pressure limits in atm
5 T3=650+273//Temperature in K
6 T1=60+273//Temperature in K
7 T2=T1//Temperature in K
8 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
9 g=1.4//Ratio of specific heats
10 R=29.27//Characteristic gas constant in kg.m/kg.K
11 J=427//Mechanical equivalent of heat in kg.m/kcal
12
13 //Calculations
14 T4=T3/(p(2)/p(1))((g-1)/g)//Temperature in K
15 Wc=((R*T1)/J)*log(p(2)/p(1))//Compression work in
    kcal/kg
16 qs=(Cp*(T3-T2))//Heat supplied at constant pressure

```

```

    in kcal/kg
17 qre=(Cp*(T4-T1))//Heat ejected during process 4-1 in
    kcal/kg
18 nth=((qs-Wc-qre)/(qs-qre))*100//Thermal efficiency
    in percent
19 nc=((T3-T1)/T3)*100//Carnot efficiency in percent
20 r=(nth/nc)*100//Ratio of air standard efficiency to
    carnot efficiency in percent
21
22 //Output
23 printf('(a) air standard efficiency of the cycle is
    %3.1f percent \n (b) carnot efficiency is %3.0f
    percent \n (c) Ratio of air standard efficiency
    to carnot efficiency is %3.1f percent ',nth,nc,r)

```

Chapter 26

JET PROPULSION

Scilab code Exa 26.1 PROPERTIES

```
1  clc
2  clear
3  //Input data
4  Ve=2700//Jet exit velocity in m/s
5  Vf=1350//Forward flight velocity in m/s
6  m=78.6//Propellant consumption in kg/s
7
8  //Calculations
9  T=((m/9.81)*(Ve-Vf))//Thrust in kg
10 TH=((T*Vf)/75)/10^5//Thrust horse power in HP*10^5
11 pn=(2/(1+(Ve/Vf)))*100//Propulsive efficiency in
    percent
12
13 //Output
14 printf('(i) Thrust is %3.0f kg \n (ii) Thrust horse
    power is %3.3f*10^5 H.P \n (iii) Propulsive
    efficiency is %3.1f percent ',T,TH,pn)
```

Scilab code Exa 26.2 AIR FUEL RATIO

```

1  clc
2  clear
3  //Input data
4  CV=10000//Calorific value in kcal/kg
5  F=1.4//Fuel consumption in kg per hour per kg of
    thrust
6  T=900//Thrust in kg
7  Va=425//Aircraft velocity in m/s
8  w=19.5//Weight of air in kg/sec
9
10 //Calculations
11 af=(w/((F*T)/3600))//Air fuel ratio
12 nv=((T*Va*3600)/(427*F*T*CV))*100//Overall
    efficiency in percent
13
14 //Output
15 printf('Air fuel ratio is %3.1f \n Overall
    efficiency is %3.1f percent ',af,nv)

```

Scilab code Exa 26.3 PROPERTIES

```

1  clc
2  clear
3  //Input data
4  a=11500//Altitude in m
5  n=123//Number of passengers
6  c=3//Cargo in tonnes
7  Va=650//Velocity of air craft in km/hour
8  d=640//Drag in kg
9  pe=50//Propulsion efficiency in percent
10 oe=18//Overall efficiency in percent
11 CV=10000//Calorific value in kcal/kg
12 da=0.0172//Density of air at 11500 m in kg/cm^2
13
14 //Calculations

```

```

15 Vp=((Va*1000)/3600)//Velocity of aeroplane in m/s
16 Vr=((2/(pe/100))-1)*Vp//Velocity of working medium
    in m/s
17 nhp=((d*Vp)/(75*(pe/100)))//Net horse power in H.P
18 wf=((nhp*75*3600)/((oe/100)*427*CV))//Mass flow rate
    in kg/hr
19 thp=((Va*Vp)/75)//Thrust horse power in H.P
20 F=(wf/thp)//Fuel consumption per thrust H.P hour in
    kg
21 W=((Va*9.81)/Vr)//Air flow in kg/sec
22 va=(W/da)//Volume of air in cu.m/sec
23 aa=(va/(3*Vr))//Area of jet in m^2
24 d=sqrt((4*aa)/3.14)*100//Diameter of jet in cm
25 af=((W*3600)/wf)//Air fuel ratio
26
27 //Output
28 printf('(a) Absolute velocity of the jet is %3.1f m/
    sec \n (b) Net horse power of the gas plant is %3
    .0f H.P \n (c) Fuel consumption per thrust H.P
    hour is %3.3f kg \n (d) Diameter of the jet is %3
    .1f cm \n (e) Air-fuel ratio of the engine is %3
    .1f ',Vr,nhp,F,d,af)

```

Scilab code Exa 26.4 AREA

```

1 clc
2 clear
3 //Input data
4 p1=7//Pressure of gas before expansion in kg/cm^2
5 p2=5//Pressure of gas after expansion in kg/cm^2
6 T1=250+273//Temperature of gas before expansion in K
7 Cp=0.24//Specific heat at constant pressure in kJ/kg
    .K
8 Cv=0.17//Specific heat at constant volume in kJ/kg.K
9 nv=0.8//Nozzle efficiency

```

```

10
11 // Calculations
12 R=427*(Cp-Cv) // Characteristic gas constant in kg.m/
    kg.K
13 g=(Cp/Cv) // Ratio of specific heats
14 V1=(R*T1)/(p1*10^4) // Volume in cu.m per kg
15 V2=(V1*(p1/p2)^(1/g)) // Volume in cu.m per kg
16 Wd=(g/(g-1))*(p1*V1-p2*V2)*10^4 // Work done in m.kg
    per kg
17 KE=(nv*Wd) // Kinetic energy at exit in m.kg per kg
18 v3=sqrt(2*9.81*nv*Wd) // Velocity in m/s
19 T2=(T1*(p2/p1)*(V2/V1)) // Temperature in K
20 T3=((1-nv)*Wd)/(427*Cp)+T2 // Temperature in K
21 V3=(V2*(T3/T2)) // Volume in cu.m per kg
22 qa=(V3/v3)*10^4 // Discharge area unit rate of mass
    flow in cm^2
23
24 // Output
25 printf('Area of discharge per unit rate of mass flow
    is %3.2f sq.cm', qa)

```

Scilab code Exa 26.5 POWER AND THRUST

```

1 clc
2 clear
3 // Input data
4 p=3.5 // Pressure at the delivery is 3.5 times that at
    entrance
5 T=1.15 // Temperature rise during compression is 1.15
    times that for frictionless adiabatic compression
    . In textbook it is given wrong as 1.5
6 T3=500+273 // Temperature of products of combustion in
    K
7 pa=1 // Atmospheric pressure in kg/cm^2
8 Ta=15+273 // Atmospheric temperature in K

```



```

9 Cp=0.24//Specific heat at constant pressure in kJ/kg
.K
10 g=1.4//Ratio of specific heats
11 J=427//Mechanical equivalent of heat in kg.m/kcal
12
13 //Calculations
14 p2=p*pa//Pressure in kg/cm^2
15 T2a=(Ta*(p2/pa)^((g-1)/g))//Temperature in K
16 T2=(T2a-Ta)*T+Ta//Temperature in K
17 wcomp=(Cp*(T2-Ta))//Work done by compressor in kcal/
kg
18 T5=T3/(p2/pa)^((g-1)/g)//Temperature in K
19 dh35=(Cp*(T3-T5))//Change in enthalpy in kcal/kg
20 dhnozzle=(dh35-wcomp)//Change in enthalpy of nozzle
in kcal/kg
21 v5=sqrt(2*9.81*J*dhnozzle)//Velocity at the nozzle
exit in m/sec
22 Th=(v5/9.81)//Thrust in kg per kg of air/sec
23
24 //Output
25 printf('(a) the power required to drive the
compressor per kg of air per second is %3.1f kcal
/kg \n (b) Static thrust developed per kg of air
per second is %3.1f kg',wcomp,Th)

```
