Scilab Textbook Companion for Introduction To Mechanical Engineering by S. Chandra And O. Singh [1]

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June 2, 2016

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Introduction To Mechanical Engineering

Author: S. Chandra And O. Singh

Publisher: New Age International Pvt. Ltd, Delhi

Edition: 1

Year: 2001

ISBN: 81-224-1342-0

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Fundamental concepts and definitions

Scilab code Exa 1.1 Pressure Difference

```
//Part A Chapter 1 Example 1
clc;
clear;
close;
format('v',8);
rho=13550;//kg/m^3
g=9.78;//m/s^2
h=30*10^-2;//m
//Pressure Difference
P_diff=rho*g*h;//Pa
disp("Pressure difference = "+string(P_diff)+" pa");
```

Scilab code Exa 1.2 Effort required for lifting the lid

```
//Part A Chapter 1 Example 2
clc;
```

```
clear;
close;
format('v',8);
rho=13550;//kg/m^3
g=9.78;//m/s^2
h=76*10^-2;//m
d=30*10^-2;//m
//Effort required
Effort_req=rho*g*h*3.14*d^2/4;//N
disp("Effort required = "+string(Effort_req)+" N");
```

Scilab code Exa 1.3 Actual pressure of air

```
//Part A Chapter 1 Example 3
clc;
clear;
close;
format('v',7);
Patm=101;//kPa
rho=13550;//kg/m^3
g=9.78;//m/s^2
h=30*10^-2;//m
//Gauge pressure
Pgauge=rho*g*h/1000;//kPa
//Actual Pressure
Pactual=Pgauge+Patm;//kPa
disp("Actual pressure of air = "+string(Pactual)+"
  kPa");
```

Chapter 2

Ideal and real gases

Scilab code Exa 2.1 Determine molecular weight of gas

```
//Part A Chapter 2 Example 1
clc;
clear;
close;
format('v',6);
cp=2.286;//kJ/kgK
cv=1.768;//kJ/kgK
Rbar=8.3143;//universal gas constant
R=cp-cv;//kJ/kgK
M=Rbar/R;//kg/kg.mol.(Molecular weight)
disp("Molecular weight of gas = "+string(M)+" kg/kg.
    mol.");
```

Chapter 3

Zeroth law of thermodynamics

Scilab code Exa 3.1 Determine human body temperature

```
//Part A Chapter 3 Example 1
clc;
clear;
close;
format('v',6);
T_F=98.6;//degree F
T_C=(T_F-32)/1.8;//degree C
disp("Temperature in degree celsius = "+string(T_C)+
    " degree C");
```

Scilab code Exa 3.2 Determine Celsius temperature

```
//Part A Chapter 3 Example 2
clc;
clear;
close;
format('v',7);
t_ice=0;//degree C
```

```
p_ice=3;//thermometric property
t_steam=100;//degree C
p_steam=8;//thermometric property
//t=a*log(p)+b/2
//solving by matrix multiplication for a and b
A=[log(p_ice) 1/2;log(p_steam) 1/2];
B=[t_ice;t_steam];
X=A^-1*B;
a=X(1);//constant
b=abs(X(2));//constant
p=6.5;//thermometric property
t=a*log(p)+b/2;//degree C
disp("Celsius temperature corresponding to thermometric property = "+string(t)+" degree C");
```

Scilab code Exa 3.3 Temperature shown by thermometer

```
//Part A Chapter 3 Example 3
clc;
clear;
close;
format('v',6);
t_ice=0;//degree C
E0=0.003*t_ice-5*10^-7*t_ice^2+0.5*10^-3;//V
t_steam=100;//degree C
E100=0.003*t_steam-5*10^-7*t_steam^2+0.5*10^-3;//V
t=30;//degree C
E30=0.003*t-5*10^-7*t^2+0.5*10^-3;//V
t=((E30-E0)/(E100-E0))*(t_steam-t_ice);//degree C
disp("Temperature shown by thermometer = "+string(t)+" degree C");
//Answer given in the book is wrong.
```

Chapter 4

Torsion

Scilab code Exa 4.1 Work done by or on the system

```
//Part A Chapter 4 Example 1
clc;
clear;
close;
format('v',6);
P=689*1000;//Pa
V1=0.04;//m^3
V2=0.045;//m^3
Wpaddle=-4.88;//kJ
Wpiston=integrate('689*1000','P',V1,V2)/1000;//kJ
disp("Work done on piston = "+string(Wpiston)+" kJ");
Wnet=Wpiston+Wpaddle;//kJ
disp("Work done on system = "+string(abs(Wnet))+" kJ");
```

Scilab code Exa 4.2 Amount of heat required

```
//Part A Chapter 4 Example 2
clc;
clear;
close;
format('v',6);
m=0.5;//kg
u1=26.6;//kJ/kg
u2=37.8;//kJ/kg
W=0;//as vessel is rigid
U1=m*u1;//kJ
U2=m*u2;//kJ
//Heat required
Q=U2-U1+W;//kJ
disp("Heat required = "+string(Q)+" kJ");
```

Scilab code Exa 4.3 Rate of heat removal

```
//Part A Chapter 4 Example 3
clc;
clear;
close;
format('v',6);
m=50;//kg/hr
T1=800;//degree C
T2=50;//degree C
Cp=1.08;//kJ/kgK
Q=m*Cp*(T1-T2);//kJ/hr
disp("Heat should be removed at the rate of "+
    string(Q)+" kJ/hr");
```

Scilab code Exa 4.4 Work done by the air

```
//Part A Chapter 4 Example 4
```

```
clc;
clear;
close;
V=0.78;//m^3
Patm=101.325;//kPa
//W=work done by Patm
W=Patm*V;//kJ
disp("Work done by air = "+string(W)+" kJ");
```

Scilab code Exa 4.5 Heat and wok intraction

```
//Part A Chapter 4 Example 5
clc;
clear;
close;
m=5;//kg
p1=1;//MPa
V1=0.5;//m^3
p2=0.5;//MPa
//u=1.8*p*v+85;//kJ/kg
n=1.3;//constant
//p1*V1^n=p2*V2^n
V2=(p1/p2*V1^n)^(1/n);//m^3
W=(p2*V2-p1*V1)*10^3/(1-n);//kJ
delU=(p2*V2-p1*V1)*10^3;//kJ
delTheta=delU+W;//kJ
disp("Heat Interaction = "+string(delTheta)+" kJ");
disp("Work Interaction = "+string(W)+" kJ");
disp("Change in Internal Energy = "+string(delU)+"
   kJ");
```

Scilab code Exa 4.6 Heat Work and change in energy

```
//Part A Chapter 4 Example 6
clc;
clear;
close;
p1=1;//MPa
p2=2;//MPa
V1=0.05;//m^3
n=1.4;//constant
//U=7.5*p*v-425;//kJ/kg
delQ=180;//kJ
//p1*V1^n=p2*V2^n
V2=(p1/p2)^(1/n)*V1;//m^3
delU=7.5*10^3*(p2*V2-p1*V1);//kJ
W=(p2*V2-p1*V1)*10^3/(1-n);//kJ
delTheta=delU+W;//kJ
disp("Heat = "+string(delTheta)+" kJ");
disp("Work = "+string(W)+" kJ");
disp("Change in Internal Energy = "+string(delU)+"
    kJ");
//If heat transfer is 180 kJ
W=delQ-delU;//kJ
disp("Work = "+string(W)+" kJ");
```

Scilab code Exa 4.7 Heat transfer and direction

```
//Part A Chapter 4 Example 7
clc;
clear;
close;
M=16;//molecular weight

p1=101.3;//KPa
p2=600;//MPa
T1=20+273;//K
n=1.3;//constant
```

```
Cp=1.7;//KJ/KgK
UGC=8.3143*10^3;//Universal Gas constant
R=UGC/M/1000;//KJ/KgK
Cv=Cp-R;//KJ/KgK
Gamma=Cp/Cv;//constant
T2=T1*(p2/p1)^((n-1)/n);//K
W=R*(T2-T1)/(n-1);//
Q=W*(Gamma-n)/(Gamma-1);//Kj/Kg
disp("Heat = "+string(Q)+" KJ");
```

Chapter 5

Second law of thermodynamics

Scilab code Exa 5.2 Determine heat supplied

```
//Part A Chapter 5 Example 2
clc;
clear;
close;
T1=400+273;//K
T2=15+273;//K
Q12=200;//kJ(Q1-Q2=200)
Q1BYQ2=T1/T2;
Q2=Q12/(Q1BYQ2-1);//kJ
Q1=Q1BYQ2*Q2;//kJ
disp("Heat to be supplied = "+string(Q1)+" kJ");
```

Scilab code Exa 5.3 Power required

```
//Part A Chapter 5 Example 3
clc;
clear;
close;
```

```
T1=42+273;//K
T2=4+273;//K
Q2=2;//kJ/s
Q1=T1/T2*Q2;//kJ/s
Pin=Q1-Q2;//kJ/s
disp("Power required = "+string(Pin)+" kJ/s");
```

Scilab code Exa 5.4 Heat transfered to refrigerant

```
//Part A Chapter 5 Example 4
clc;
clear;
close;
T1=827+273;//K
T2=27+273;//K
T3=-13+273;//K
Q1=2000;//kJ
Q2=545.45;//kJ
WE=Q1-Q2;//kJ
Q3BYQ4=T3/T2;
WE_sub_WR=300;//kJ
WR=WE-WE_sub_WR;//kJ
Q43=WR;//kJ(Q4-Q3=WR)
Q4=WR/(1-Q3BYQ4);//kJ
Q3=Q4-Q43;//kJ
Qt=Q2+Q4;//kJ
disp("Heat transfered to refrigerant = "+string(Q3)+
    " kJ");
disp("Total heat transfered to low
    temperaturereservoir = "+string(Qt)+" kJ");
//Answer is not accurate in the book.
```

Scilab code Exa 5.5 Estimate minimum power

```
//Part A Chapter 5 Example 5
clc;
clear;
close;
T1=25+273;//K
T2=-1+273;//K
Q2=125;//MJ/h
Q1BYQ2=T1/T2;
COP_HP=1/(Q1BYQ2-1);
W=Q2/COP_HP;//MJ/h
W=W*10^3/3600;//kW
disp("Minimum power required = "+string(W)+" kW");
```

Scilab code Exa 5.6 Power required

```
//Part A Chapter 5 Example 6
clc;
clear;
close;
T1=35+273;//K
T2=-15+273;//K
Q2=140.8;//kW
Q1BYQ2=T1/T2;
Carnot_COP=1/(Q1BYQ2-1);
Actual_COP=Carnot_COP/4;
W=Q2/Actual_COP;//kW
disp("Power required = "+string(W)+" kW");
//Answer is not accurate in the book.
```

Chapter 6

Entropy

Scilab code Exa 6.1 Change in entropy

```
//Part A Chapter 6 Example 1
clc;
clear;
close;
p1=5;//bar
T1=27+273;//K
p2=2;//bar
cp_air=1.004;//kJ/kgK
R=0.287;//kJ/kgK
T2=T1;//K(as cp*T1=cp*T2)
delta_s=cp_air*log(T2/T1)-R*log(p2/p1);//kJ/kgK
disp("Change in entropy = "+string(delta_s)+" kJ/kgK
   ");
```

Scilab code Exa 6.2 Change in entropy of steam

```
//Part A Chapter 6 Example 2
clc;
```

```
clear;
close;
T1=27+273;//K
T2=100+273;//K
T3=400+273;//K
m=5;//kg
cp=4.2;//kJ/kgK
cp2=2260;//kJ/kg
delta_T=100-27;//degree C
Q1=m*cp*delta_T;//kJ/K
delta_S1=Q1/T1//kJ/K
Q2=m*cp2;//kJ/K
delta_S2=Q2/T2//kJ/K
R=8.314/34;//kJ/kgK
//cp_steam=R*(3.5+1.2*T+0.14*T^2)*10^-3;//kJ/kgK
//delta_S3=m*cp_steam/T*dT
delta_S3=integrate('m*R*(3.5/T+1.2+0.14*T)*10^-3','T
    ',T2,T3);//kJ/K
delta_S=delta_S1+delta_S2+delta_S3;//kJ/K
disp("Total entropy change = "+string(delta_S)+" kJ/
    K");
//Answer in the book is not accurate.
```

Scilab code Exa 6.3 Change in entropy of gas

```
//Part A Chapter 6 Example 3
clc;
clear;
close;
R=8.314/32;//kJ/kgK
p1=125;//kPa
p2=375;//kPa
T1=27+273;//K
T2=T1;//K
delta_S=-R*log(p2/p1);//kJ/K;//kJ/kgK
```

```
disp("Change in entropy = "+string(delta_S)+" kJ/K")
    ;
```

Scilab code Exa 6.4 Change in entropy of universe

```
//Part A Chapter 6 Example 4
clc;
clear;
close;
T1=150+273;//K
T2=25+273;//K
m=1;//kg
cp=0.393;//kJ/kgK

deltaS_block=-m*cp*log(T1/T2);//kJ/kgK
HeatLost_block=-m*cp*(T1-T2);//kJ
deltaS_water=-HeatLost_block/T2;//kJ/K
deltaS_universe=deltaS_block+deltaS_water;//kJ/K
deltaS_universe=deltaS_universe*1000;//J/K
disp("Change in entropy of universe = "+string(
    deltaS_universe)+" J/K");
//unit of answer is wrong in the book.
```

Scilab code Exa 6.5 Change in entropy of universe

```
//Part A Chapter 6 Example 5
clc;
clear;
close;
m=1;//kg
g=9.81;//gravity constant
h=200;//m
T1=27+273;//K
```

```
cp=0.393;//kJ/kgK
deltaPE=m*g*h;//J
Q=deltaPE;//J
deltaS_SeaWater=Q/T1;//J/kgK
deltaS_universe=deltaS_SeaWater;//J/kgK(because of
    same temperature)
disp("Change in entropy of universe = "+string(
    deltaS_universe)+" J/kgK");
```

Scilab code Exa 6.6 Entropy change of universe

```
//Part A Chapter 6 Example 6
clc;
clear;
close;
m1=1;//kg
m2=0.5;//kg
T1=150+273;//K
T2=0+273;//K
cp1=0.393;//kJ/kgK
cp2=0.381;//kJ/kgK
//m1*cp1*(T1-Tf)=m2*cp2*(Tf-T2);
Tf=(m1*cp1*T1+m2*cp2*T2)/(m2*cp2+m1*cp1);//K
delta_S1=m1*cp1*log(Tf/T1);//kJ/K
delta_S2=m2*cp2*log(Tf/T2);//kJ/K
deltaS_universe=delta_S1+delta_S2;//kJ/K
disp("Change in entropy of universe = "+string(
    deltaS_universe)+" kJ/K");
```

Scilab code Exa 6.8 Rate of power loss

```
//Part A Chapter 6 Example 8
clc;
```

```
clear;
close;
T1=1800;//K
T2=300;//K
W=2;//MW
Q1=5;//MW
Q2=Q1-W;//MW
deltaS=(-Q1/T1+Q2/T2);//MW/K
W_lost=T2*deltaS;//MW
disp("Work lost = "+string(W_lost)+" MW");
```

Scilab code Exa 6.9 Estomate maximum work

```
//Part A Chapter 6 Example 9
clc;
clear;
close;
T1_HE=2000;//K
T2_HE=300;//K
T1=500;//K
T2=300;//K
Q1=integrate('0.05*T^2+0.10*T+0.085','T',T1,T2);//J
deltaS_system=integrate('0.05*T+0.10+0.085/T','T',T1
    ,T2);//J/K
//Putting deltaS_system+deltaS_reservoir>=0
//deltaS_reservoir=(Q1-W)/T2
W=deltaS_system*T2-Q1;//J
disp("Maximum Work = "+string(W/1000)+" kJ");
```

Scilab code Exa 6.10 Change in enthalpy and entropy

```
//Part A Chapter 6 Example 10
clc;
```

```
clear;
close;
p1=3;//MPa
V1=0.05;//m^3
V2=0.3;//m^3
p2=p1*V1^1.4/V2^1.4;//Mpa
deltaS=0;//for reversible process
deltaH=integrate('(p1*V1^1.4/P)^(1/1.4)','P',p2,p1);//MJ
disp("Enthalpy change = "+string(deltaH*1000)+" kJ");
disp("Entropy change = "+string(deltaS));
```

Scilab code Exa 6.11 Determine entropy change

```
//Part A Chapter 6 Example 11
clc;
clear;
close;
m=2;//kg
V1=1;//m^3
V2=10;//m^3
R=287;//consant
deltaS_air=m*R*log(V2/V1);//J/K
disp("Entropy change of air = "+string(deltaS_air)+" J/K");
deltaS_surr=0;//for free expansion
disp("Entropy change of surrounding = "+string(deltaS_surr));
deltaS_uni=deltaS_air+deltaS_surr;//J/K
disp("Entropy change of universe = "+string(deltaS_uni)+" J/K");
```

Chapter 7

Thermodynamic properties of pure substance

Scilab code Exa 7.2 Dryness fraction of steam

```
//Part A Chapter 7 Example 2
clc;
clear;
close;
h2=2682.5;//kJ/kg(For 0.05 MPa & 100 degree C)
h1=h2;//kJ/kg(for throttling)
hf=1407.56;//kJ/kg(For 10 MPa)
hfg=1317.1;//kJ/kg(For 10 MPa)
x1=(h1-hf)/hfg;//dryness fraction
disp("Dryness fraction = "+string(x1));
```

Scilab code Exa 7.3 Internal energy of steam

```
//Part A Chapter 7 Example 3
clc;
clear;
```

```
close;
m=5;//kg
cp_super_heat=2.1;//kJ/kgK
cp_water=4.18;//kJ/kgK
Tsuper_heat=300+273.15;//K
Tsat=212.42;//degreeC(at 2 MPa)
Tsat=Tsat+273.15;//K
hfg=1890.7;//kJ/kg(For 2 MPa & Tsat)\
S=cp_water*log(Tsat/273.15)+hfg/Tsat+cp_super_heat*
    log(Tsuper_heat/Tsat);//kJ/kgK
S_5kg=S*5;//kJ/K
disp("Entropy of 5 kg steam = "+string(S_5kg)+" kJ/K
    ");
```

Scilab code Exa 7.4 Boiling tempertaure

```
//Part A Chapter 7 Example 4
clc;
clear;
close;
T=110+273.15;//K
h=50;//cm
p=143.47;//kPa(at 110 degree C)
g=9.81;//ravity constant
p_dash=p-(1000*g*h/100)/1000;//kPa(pressure at 50 cm
     depth)
Tsat=108.866;//degree C(for pdash=138.365 kPa);
disp("Pressure at 50 cm depth is "+string(p_dash)+"
    kPa. From steam table, Boiling point = "+string(
    Tsat)+" degree C");
```

Scilab code Exa 7.5 Mass and volume of water

```
//Part A Chapter 7 Example 5
clc;
clear;
close;
V=0.5; //m^3
T=100+273.15; //K
v2=0.003155; //m^3/kg(at critical state)
v1=v2; //constant volume process
vf=0.001044; //m^3/kg(at 100 degree C)
vg=1.6729; //m^3/kg(at 100 degree C)
x1=(v1-vf)/vg; //dryness fraction
m=V/v2; //kg
mw=m*(1-x1); //kg
Vw=mw*vf; //m^3
disp("Mass of water is "+string(mw)+" kg.");
disp("Volume of water is "+string(Vw)+" m^3.");
```

Scilab code Exa 7.6 Slope of an isobar

```
//Part A Chapter 7 Example 6
clc;
clear;
close;
p=2; //MPa
T=500+273.15; //K
dh_by_ds=T; //for constant pressure
disp("Slope of an isobar is "+string(dh_by_ds));
```

Scilab code Exa 7.7 Enthalpy Entropy and specific volume

```
//Part A Chapter 7 Example 7
clc;
clear;
```

```
close;
p=0.15;//MPa
x=10/100;//quality
hf=467.11;//kJ/kg//at 0.15 MPa
hg=2693.6;//kJ/kg//at 0.15 MPa
vf=0.001053;//m^3/kg//at 0.15 MPa
vg=1.1593;//m^3/kg//at 0.15 MPa
sf=1.4336;//kJ/kg.K//at 0.15 MPa
sg=7.2233;//kJ/kg.K//at 0.15 MPa
hfg=hg-hf;//kJ/kg//
h=hf+x*hfg;//kJ/kg
disp("Enthalpy is "+string(h)+" kJ/kg");
vfg=vg-vf;//m^3/kg//
v=vf+x*vfg;//m^3/kg
disp("Specific volume is "+string(v)+" m^3/kg");
sfg=sg-sf;//kJ/kg.K
s=sf+x*sfg;//kJ/kg.K
disp("Entropy is "+string(s)+" kJ/kg.K");
```

Scilab code Exa 7.8 Heat added

```
//Part A Chapter 7 Example 8
clc;
clear;
close;
P1=1;//MPa
V1=0.05;//m^3
x1=80/100;//dryness fraction
P2=1;//MPa
V2=0.2;//m^3
W=P1*1000*(V2-V1);//kJ
vf=0.001127;//m^3/kg//at 1 MPa
vg=0.19444;//m^3/kg//at 1 MPa
uf=761.68;//kJ/kg//at 1 MPa
ufg=1822;//kJ/kg//at 1 MPa
```

```
vfg=vg-vf;//m^3/kg
v1=vf+x1*vfg;//m^3/kg
ms=V1/v1;//kg(mass of steam)
v2=V2/ms;//m^3/kg
T1=1000;T2=1100;//degree C(as v2>vg(1MPa))
T=T1+(T2-T1)*(v2-0.5871)/(0.6355-0.5871);//degree C
u2=4209.6;//kJ/kg(at 1MPa & T degree C)
u1=uf+x1*ufg;//kJ/kg
Q=W+ms*(u2-u1);//kJ
disp("Heat added is "+string(Q)+" kJ");
```

Scilab code Exa 7.9 Determine pressure and temperature

```
//Part A Chapter 7 Example 9
clc;
clear;
close;
p=800;//kPa
T=200//degree C
Tsat=170.43;//degree C(at 800kPa)
v1=0.2404;//m^3/kg(at 800kPa)
v2=0.2404;//m^3/kg(at 800kPa)
vg=v2;//m^3/kg//(at 800kPa)
T1=175;T2=170;//degree C(vg=0.2404;//m^3/kg)
vg1=0.2168;//m^3/kg
vg2=0.2428;//m^3/kg
T2_begin=T1-(T1-T2)*(v1-vg1)/(vg2-vg1);//degree C
p1=892;p2=791.7;//kPa(vg=0.2404;//m^3/kg)
p2_begin=p1-(p1-p2)*(v1-vg1)/(vg2-vg1);//degree C
disp("Pressure and temperature at condensation is "+
   string(p2_begin)+" kPa & "+string(T2_begin)+"
   degree C");
```

Scilab code Exa 7.10 Change in enthalpy

```
//Part A Chapter 7 Example 10
clc;
clear;
close;
p2=200;//kPa
T=30//degree C
ds=0;//for isentropic process
//for saturated liquid at 30 degree C
p1=4.25;//kPa
vf=0.001004;//m^3/kg
v1=vf;//m^3/kg
h21=v1*(p2-p1);//kJ/kg(h21=h2-h1)
disp("Enthalpy change is "+string(h21)+" kJ/kg");
```

Scilab code Exa 7.11 Quality of water vapour mixture

```
//Part A Chapter 7 Example 11
clc;
clear;
close;
V=2;//m^3(Volume of vessel)
T=150//degree C
vf=0.001091;//m^3/kg//at 150 degree C
vg=0.3928;//m^3/kg//at 150 degree C
v_water=V*3/5//m^3
v_steam=V*2/5//m^3
mf=v_water/vf;//kg
mg=v_steam/vg;//kg
m=mf+mg;//kg//Total mass
x=mg/m;//dryness fraction
disp("Total mass is "+string(m)+" kg & Quality is "+
    string(x));
//Answer is wrong in the book.
```

Scilab code Exa 7.12 Determine work output

```
//Part A Chapter 7 Example 12
clc;
clear;
close;
p=4;//MPa
T1=300//degree C
T2=50//degree C
h1=2886.2;//kJ/kg(at 4 MPa & 300 degree C)
s1=6.2285;//kJ/kg.K(at 4 MPa & 300 degree C)
hf=209.33;//kJ/kg(at 50 degree C)
sf=0.7038;//kJ/kg.K(at 50 degree C)
hfg=2382.7;//kJ/kg(at 50 degree C)
sfg=7.3725;//kJ/kg.K(at 50 degree C)
x2=(s1-sf)/sfg;//dryness fraction
h2=hf+x2*hfg;//kJ/kg
W=h1-h2;//kJ/kg
disp("Steam turbine work is "+string(W)+" kJ/kg");
```

Scilab code Exa 7.13 Mass of dry saturated steam

```
//Part A Chapter 7 Example 13
clc;
clear;
close;
mg=100;//kg
pg=100;//kPa
x1=0.5;//dryness at 1000kPa
//At 100 kPa
hf=417.46;//kJ/kg
```

```
uf=417.46;//kJ/kg
vf=0.001043;//m^3/kg
hfg=2258;//kJ/kg
ufg=2088.7;//kJ/kg
vfg=1.6940;//m^3/kg

v1=vf+x1*vfg;//m^3/kg
h1=hf+x1*hfg;//kJ/kg
V=mg*x1*v1;//m^3
U1=mg*(hf+x1*ufg);//kJ

//At 2000 kPa
vg=0.09963;//m^3/kg
ug=2600.3;//m^3/kg
hg=2799.5;//kJ/kg
v2=1/(1/vg+1/v1);//m^3/kg

//At 1000 kPa
hf=762.81;//kJ/kg
hfg=2015.3;//kJ/kg
vf=0.001127;//m^3/kg
vg=0.19444;//m^3/kg

x2=(v2-vf)/(vg-vf);//dryness at 1000 ka
h2=hf+x2*hfg;//kJ/kg
m=(mg*h1-mg*h2)/(h2-hg);//kg
disp("Mass of dry steam at 2000 kPa to be added is "
   +string(m)+" kg");
disp("Quality of final mixture is "+string(x2));
```

Scilab code Exa 7.14 State of steam

```
//Part A Chapter 7 Example 14
clc;
clear;
```

```
close;
rcv=71.5;//cm of Hg(Recorded condenser vaccum)
br=76.8;//cm of Hg(Barometer reading)
Tc=35;//degree C(Temperature of condensation)
Tw=27.6;//degree C(Temperature of hot well)
mc=1930;//kg(Mass of condensate/hour)
mw=62000;//kg(Mass of cooling water/hour)
T1=8.51;//degree C(Inlet temperature)
T2=26.24;//degree C(Outlet temperature)
pc=(br-rcv)/73.55*101.325;//kPa(condenser pressure)
p_partial=5.628;//kPa(at 35 degree C)
hf=146.68;//kJ/kg
hfg=2418.6;//kJ/kg
x=(mw*(T2-T1)*4.18/mc+4.18*Tw-hf)/hfg;//dryness fraction
disp("State of steam(Dryness fraction) entering condenser is "+string(x));
```

Scilab code Exa 7.15 Dryness fraction and workdone

```
//Part A Chapter 7 Example 15
clc;
clear;
close;
d=20/100;//m
h=2;//cm
T=150;//degree C
F=10;//kN
Q=600;//kJ
Patm=101.3;//kPa
P=F/(%pi/4*d^2)+Patm;//kPa
V1=%pi/4*d^2*h/100;//m^3
m=V1*1000;//kg
hf=612.1;//kJ/kg(at Pressure P)
hfg=2128.7;//kJ/kg(at Pressure P)
```

```
h2=1582.8;//kJ/kg
x=(Q/m+4.18*T-hf)/hfg;//dryness factor
disp("Dryness fraction of steam produced is "+string
   (x));
U1=m*4.18*T-P*V1;//kJ
vg=0.4435;//m^3/kg at Pressure P
V2=m*x*vg;//m^3
U2=m*h2-P*V2;//kJ
U21=U2-U1;//kJ(U2-U1)
disp("Change in internal energy is "+string(U21)+"
   kJ.");
W=P*(V2-V1);//kJ
disp("Workdone is "+string(W)+" kJ.");
```

Scilab code Exa 7.16 Dryness fraction

```
//Part A Chapter 7 Example 16
clc;
clear;
close;
mg=40;//kg
mf=2.2;//kg
p1=1.47;//MPa
T=120;//degree C
p2=107.88;//kPa
cv=2.09;//kJ/kg.K
Td=T-101.8;//degree C(DegreeSuperHeat)
hf=2673.95;//kJ/kg
h=hf+Td*cv;//kJ/kg
hf2=918.926;//kJ/kg
hfg2=1864.28;//kJ/kg
x2=(h-hf2)/hfg2;//dryness fraction
x1=(mg-mf)/mg;//dryness fraction
x=x1*x2;//overall dryness fraction
disp("Dryness fraction is "+string(x));
```

Chapter 10

Compound stresses and strains

Scilab code Exa 2.1 Maximum shear stress

```
//Part B Chapter 2 Example 1
clc;
clear;
close;
format('v',6);
d=50;//mm(dimeter of bar)
F=120;//kN(Tensile force)
sigma_t=15;//MN/m^2(Tensile)
A=%pi*d^2/4;//mm^2
sigma_x=F/A*1000;//MN/m^2(tensile)
sigma_t_max=sigma_x/2;//MN/m^2
disp(sigma_t_max,"Maximum  shear stress in MN/m^2 :
   ");
two_theta=asind(sigma_t/(sigma_x/2));///degree
theta=[two_theta/2 (180-two_theta)/2];//degree
disp(theta,"Directions of plane in degree are : ");
sigma_n=sigma_x*cosd(theta)^2;//MN/m^2(Tensile)
disp(sigma_n,"Shear stress(tensile) in MN/m^2 for
   above angles are : ");
```

Scilab code Exa 2.2 Find the stresses

```
//Part B Chapter 2 Example 2
clc;
clear;
close;
format('v',6);
theta=25;//degree(angle with plane AB)
sigma_x=60;//N/mm^2
sigma_y=-90;//MN/m^2 or N/mm^2
sigma_n=(sigma_x+sigma_y)/2+(sigma_x-sigma_y)/2*cosd
    (2*theta);//N/mm^2
sigma_t=(sigma_x-sigma_y)/2*sind(2*theta);//N/mm^2
sigma=sqrt(sigma_n^2+sigma_t^2);//N/mm^2(Resultant
    stress)
fi=atand(sigma_n/sigma_t);//degree
disp(sigma_n,"Normal stress in N/mm^2 : ");
disp(sigma_t,"Tangential stress in N/mm^2 : ");
disp(fi,"Angle fi in degree : ");
disp(theta+fi,"Angle of resultant stress with plane
    AB will be theta+fi=");
```

Scilab code Exa 2.3 Principle stresses and max shear stress

```
//Part B Chapter 2 Example 3
clc;
clear;
close;
format('v',6);
sigma_x=150;//N/m^2
sigma_y=100;//N/m^2
tau=80;//N/m^2
```

```
two_theta=atand(2*tau/(sigma_x-sigma_y));//degree
theta=[two_theta/2 (two_theta+180)/2];//degree
disp(theta,"Direction of principle stresses in
   degree are : ");
sigma1=(sigma_x+sigma_y)/2+sqrt((sigma_x-sigma_y)
   ^2/4+tau^2);//N/mm^2
sigma2=(sigma_x+sigma_y)/2-sqrt((sigma_x-sigma_y)
   ^2/4+tau^2);//N/mm^2
disp(sigma2,sigma1,"Two principle stresses(tensile)
   in N/mm^2 are : ");
tau_max=sqrt((sigma_x-sigma_y)^2/4+tau^2);//N/mm^2
disp(tau_max,"Magnitude of maximum stresses(tensile)
    in N/mm^2 : ");
disp("Direction of maximum stress : 45 degree to
   principle plane");
```

Scilab code Exa 2.4 Value of shear stress

```
//Part B Chapter 2 Example 4
clc;
clear;
close;
format('v',6);
sigma_x=120;//N/mm^2(Tensile)
sigma_y=-90;//N/mm^2(Compressive)
sigma1=150;//N/mm^2(Principle stress: major)
tau=sqrt((sigma1-(sigma_x+sigma_y)/2)^2-(sigma_x-
   sigma_y)^2/4);//N/mm^2(Shear stress)
disp(tau,"Value of shear stress in N/mm^2 : ");
```

Scilab code Exa 2.5 Value of shear stress

```
//Part B Chapter 2 Example 5
```

```
clc;
clear;
close;
format('v',6);
sigma1=100;//N/m^2
sigma2=-50;//N/m^2
tau=0;//N/mm^2
theta=60;//degree
sigma_n=(sigma1+sigma2)/2+(sigma1-sigma2)/2*cosd(2*theta);//N/mm^2
sigma_t=(sigma1-sigma2)/2*sind(2*theta);//N/mm^2
sigma=sqrt(sigma_n^2+sigma_t^2);//N/mm^2
disp(sigma_n,"Value of sigma_n(compressive) in N/mm^2 : ");
disp(sigma_t,"Value of sigma_t in N/mm^2 : ");
disp(sigma,"Value of resultant stress in N/mm^2 : ");
alfa=1/2*asind(-(sigma1+sigma2)/2/sqrt((sigma1-sigma2)^2/4))-45;//degree
disp("Plane of whole shear is "+string(alfa)+" degree with plane AD");
sigma_t_alfa=(sigma1-sigma2)/2*sind(2*alfa)-tau*cosd(2*alfa);//N/mm^2
disp(sigma_t_alfa,"Value of shear stresses at this plane in N/mm^2 : ");
```

Scilab code Exa 2.7 Minimum principle stress

```
//Part B Chapter 2 Example 7
clc;
clear;
close;
format('v',6);
sigma1=600;//N/m^2(major)
sigma_x=450;//N/m^2
```

```
sigma_y=0;//N/m^2
tau=sqrt((sigma1-(sigma_x+sigma_y)/2)^2-(sigma_x-
    sigma_y)^2/4);//N/mm^2
disp(tau,"Maximum value of tau in N/mm^2 : ");
sigma2=(sigma_x+sigma_y)/2-sqrt((sigma_x-sigma_y)
    ^2/4+tau^2);//N/mm^2
disp(sigma2,"Minimum principle stress(compressive)
    in N/mm^2 : ");
```

Scilab code Exa 2.8 Principles stress and shear stress

```
//Part B Chapter 2 Example 8
clc;
clear;
close;
format('v',6);
sigma_x=-150;//N/m^2
sigma_y=-100;//N/m^2
tau=-60;//N/mm^2
sigma1=(sigma_x+sigma_y)/2+sqrt((sigma_x-sigma_y)
    ^2/4+tau^2);//N/mm^2
sigma2=(sigma_x+sigma_y)/2-sqrt((sigma_x-sigma_y)
    ^2/4+tau^2);//N/mm^2
disp(sigma2,sigma1,"Two principle stresses(
    compressive) in N/mm^2 are : ");
tau_max=sqrt((sigma_x-sigma_y)^2/4+tau^2);//N/mm^2
disp(tau_max,"Maximum shear stress in N/mm^2 : ");
two_theta=atand(2*tau/(sigma_x-sigma_y));//degree
theta=[two_theta/2 (two_theta+180)/2];//degree
disp(theta,"Direction of principle stresses in
    degree is : ");
disp("Direction of maximum stress : 45 degree to
    principle plane.");
```

Scilab code Exa 2.9 Find resultant stress

```
//Part B Chapter 2 Example 9
clc;
clear;
close;
format('v',6);
sigma1=200;//N/m^2
sigma2=-80;//N/m^2
theta_dash=60;//degree
theta=90-theta_dash;//degree
sigma_n=(sigma1+sigma2)/2+(sigma1-sigma2)/2*cosd(2*
    theta);//N/mm^2
sigma_t=(sigma1-sigma2)/2*sind(2*theta);//N/mm^2
sigmaR=sqrt(sigma_n^2+sigma_t^2);//N/mm^2
disp(sigmaR,"Resultant stress in N/mm^2 : ");
fi=atand(sigma_t/sigma_n);//degree
disp(fi,"Direction of resultant stress in degree : "
    );
tau_max=(sigma1-sigma2)/2;//N/mm^2
disp(tau_max,"Maximum shear stress in N/mm^2 : ");
```

Scilab code Exa 2.10 Find sigma and angle of obliquity

```
//Part B Chapter 2 Example 10
clc;
clear;
close;
format('v',6);
sigma_x=60;//N/mm^2
sigma_y=30;//N/mm^2
tau=25;//N/mm^2
```

```
theta=45;//degree(Oblique plane angle)
sigma_n=(sigma_x+sigma_y)/2+(sigma_x-sigma_y)/2*cosd
   (2*theta)+tau*sind(2*theta);//N/mm^2
disp(sigma_n,"Value of sigma_n in N/mm^2 : ");
sigma_t=(sigma_x-sigma_y)/2*sind(2*theta)-tau*cosd
   (2*theta);//N/mm^2
disp(sigma_t,"Value of sigma_t in N/mm^2 : ");
sigmaR=sqrt(sigma_n^2+sigma_t^2);//N/mm^2(Resultant
   stress)
disp(sigmaR,"Value of sigma_R in N/mm^2 : ");
fi=atand(sigma_t/sigma_n);//degree(Angle of
   obliquity)
disp(fi,"Angle of obliquity in degree : ");
```

Scilab code Exa 2.11 Find sigma and angle fi

```
//Part B Chapter 2 Example 11
clc;
clear;
close;
format('v',6);
sigma1=125;//N/mm^2(Tenslie)
sigma2=65;//N/mm^2(Tensile)
tau=0;//N/mm^2
theta=30;//degree
sigma_n=(sigma1+sigma2)/2+(sigma1-sigma2)/2*cosd(2*
   theta)+tau*sind(2*theta);//N/mm^2
disp(sigma_n,"Value of sigma_n in N/mm^2 : ");
sigma_t=(sigma1-sigma2)/2*sind(2*theta)-tau*cosd(2*
   theta);//N/mm^2
disp(sigma_t,"Value of sigma_t in N/mm^2 : ");
sigmaR=sqrt(sigma_n^2+sigma_t^2);//N/mm^2
disp(sigmaR,"Value of sigma_R in N/mm^2 : ");
fi=atand(sigma_t/sigma_n);//degree
disp(fi,"Angle, fi in degree : ");
```

Scilab code Exa 2.12 Find sigma and angle fi

```
//Part B Chapter 2 Example 12
clc;
clear;
close;
format('v',6);
sigma_y=0;//N/m^2
theta=30;//degree
A=450*10^-6;//m^2
F=-100;//kN
sigma_x=F/A/1000;//MN/m^2
sigma_n=(sigma_x+sigma_y)/2+(sigma_x-sigma_y)/2*cosd
    (2*theta);//MN/m^2
disp(sigma_n,"Value of sigma_n(compressive) in MN/m
    ^2 : ");
sigma_t=(-sigma_x-sigma_y)/2*sind(2*theta);//MN/m^2
disp(sigma_t,"Value of sigma_t in MN/m^2 : ");
sigmaR=sqrt(sigma_n^2+sigma_t^2);//N/mm^2
disp(sigmaR,"Value of sigma_R(compressive) in N/mm^2
     : ");
fi=atand(sigma_t/-sigma_n);//degree
disp(fi,"Angle, fi in degree : ");
tau_max=(-sigma_x-sigma_y)/2;//MN/m^2
disp(tau_max,"Maximum shear stress in MN/m^2 : ");
```

Scilab code Exa 2.13 Find sigma and angle fi

```
//Part B Chapter 2 Example 13
clc;
clear;
```

```
close;
format('v',6);
sigma1=70;//MN/m^2
sigma2=30;//MN/m^2
theta=20;//degree
sigma_n=(sigma1+sigma2)/2+(sigma1-sigma2)/2*cosd(2*theta);//MN/m^2
disp(sigma_n,"Value of sigma_n(tensile) in MN/m^2 : ");
sigma_t=(sigma1-sigma2)/2*sind(2*theta);//MN/m^2
disp(sigma_t,"Value of sigma_t(shear) in MN/m^2 : ");
sigmaR=sqrt(sigma_n^2+sigma_t^2);//MN/m^2
disp(sigmaR,"Value of sigma_R in MN/m^2 : ");
fi=atand(sigma_t/sigma_n);//degree
disp(fi,"Angle, fi in degree : ");
```

Chapter 11

Bending stresses and strains

Scilab code Exa 3.1 CG of T section

```
//Part B Chapter 3 Example 1
clc;
clear;
close;
format('v',6);
AB=160;//mm
AC=200;//mm
BF=25;//mm
CD=25;//mm
A=AB*BF+CD*(AC-BF);//mm^2
//Distance of G from AB
ybar=(AB*BF*CD/2+CD*(AC-BF)*((AC-BF)/2+CD))/A;//mm
disp(ybar,"Distance of G from AB(mm)");
//Distance of G from CD
CG=AC-ybar;//mm
disp(CG,"Distance of G from CD(mm) :   ");
```

Scilab code Exa 3.2 Centroid of angle section

```
//Part B Chapter 3 Example 2
clc;
clear;
close;
format('v',6);
BC=25;//mm
AB=125;//mm
AF=85;//mm
EF=25;//mm
A_GBCD=BC*(AB-EF);//mm^2
A_GEFA=AF*EF;//mm^2
//Distance of CG from AF
ybar=((A_GBCD*(AB-2*EF)+A_GEFA*EF/2)/(A_GBCD+A_GEFA)
    );//mm
//Distance of CG from AB
xbar=((A_GBCD*(BC/2)+A_GEFA*AF/2)/(A_GBCD+A_GEFA));
    //mm
disp(ybar,"From reference axes AF, centroid is(mm) :
    ");
disp(xbar,"From reference axes AB, centroid is(mm) :
    ");
```

Scilab code Exa 3.3 Centroid of area

```
//Part B Chapter 3 Example 3
clc;
clear;
close;
format('v',7);
AB=200;//mm
BC=300;//mm
CD=260;//mm
a1=1/2*AB*CD;//mm^2(Area of ABE)
a2=%pi*(BC/2)^2/2;//mm^2(Area of semicircle)
a3=BC*CD;//mm^2(Area of BECD)
```

```
x1bar=1/3*CD;//mm
y1bar=BC+1/3*AB;//mm
x2bar=4/3*(BC/2)/%pi;//mm
y2bar=BC/2;//mm
x3bar=1/2*CD;//mm
y3bar=BC/2;//mm
//Distance of CG from AC
xbar=(a1*x1bar-a2*x2bar+a3*x3bar)/(a1-a2+a3);//mm
//Distance of CG from CD
ybar=(a1*y1bar-a2*y2bar+a3*y3bar)/(a1-a2+a3);//mm
disp(ybar,"From reference axes CD, centroid ybar is(
    mm) :   ");
disp(xbar,"From reference axes AC, centroid xbar is(
    mm) :   ");
```

Scilab code Exa 3.4 Location of centroid

```
//Part B Chapter 3 Example 4
clc;
clear;
close;
format('v',6);
AB=160;//mm
BC=40;//mm
EF=100;//mm
FH=40;//mm
CH=120;//mm
a1=EF*FH;//mm^2
a2=20*CH;//mm^2
a3=AB*BC;//mm^2
y1bar=20+CH+FH;//mm
y2bar=CH/2+BC;//mm
y3bar=BC/2;//mm
//Distance of CG from AB
ybar=(a1*y1bar+a2*y2bar+a3*y3bar)/(a1+a2+a3);//mm
```

```
disp(ybar,"From reference axes AB, centroid ybar is(
    mm) :   ");
```

Scilab code Exa 3.5 Centroid of built up section

```
//Part B Chapter 3 Example 5
clc;
clear;
close;
format('v',6);
EF=150;//mm
GH=150;//mm
CD=150;//mm
AB=250;//mm
AE=10;//mm
DH=10;//mm
CH=120;//mm
CD_t=10;//mm(thickness of CD section)
a1=AB*AE;//mm^2
a2=180*AE;//mm^2
a4=180*AE;//mm^2
a3=450*10;//mm^2
a5=CD*AE;//mm^2
y1bar=5;y2bar=15;y3bar=225+20;y4bar=475;y5bar=485;//
    mm
//Distance of CG from AB
ybar=(a1*y1bar+a2*y2bar+a3*y3bar+a4*y4bar+a5*y5bar)
    /(a1+a2+a3+a4+a5);//mm
disp(ybar,"From reference axes AB, centroid ybar is(
    mm) : ");
```

Chapter 12

Torsion

Scilab code Exa 4.1 Angle of twist and shear

```
//Part B Chapter 4 Example 1
clc;
clear;
close;
R=75;//mm
G=75;//GN/m^2
L=3;//m
tau_s=75;//MN/m^2
theta=tau_s*L/R/G*180/%pi;//degree
disp("Angle of twist is "+string(theta)+" degree.");
r=50;//mm
tau=tau_s*r/R;//MN/m^2
disp("Shear stress at inside surface is "+string(tau
    )+" MN/m^2");
```

Scilab code Exa 4.2 Power and angle of twist

```
//Part B Chapter 4 Example 2
```

```
clc;
clear;
close;
R=125;//mm
D=250/1000;//m
d=160/1000;//m
tau_s=70;//MN/m^2
IP=%pi/32*(D^4-d^4);//m^4
Tmax=tau_s*10^6*IP/(R/1000);//Nm
Tmin=Tmax/1.40;//Nm
N=60;//RPM
P=2*%pi*N*Tmin/60;//W
disp("Power transmitted by the shaft is "+string(P
   /1000)+" kW");
L=5;//m
G=80;//GN/m^2
theta=tau_s*L/R/G*180/%pi;//degree
disp("Angle of twist is "+string(theta)+" degree.");
//Solution is not complete in the book.
```

Scilab code Exa 4.3 Internal diameter and bolt diameter

```
//Part B Chapter 4 Example 3
clc;
clear;
close;
n=12;//bolts
PCD=300;//mm
D=50;//mm
Ddash=90;//mm
tau_s=60;//MN/m^2
T=tau_s*10^6*%pi*(D/1000)^4/(D/2*10^-3*32);//Nm
R=Ddash/2;//mm
d=(Ddash^4-T*1000*R*32/60/%pi)^(1/4);//mm
disp("Internal diameter of hollow shaft is "+string(
```

```
   d)+" mm");
Tb=T/n;//Nm per bolt
PCrad=150;///mm
Fb=Tb/(PCrad/1000);//N(Force on bolt)
tau_sb=20;//MN/m^2
Ab=Fb/tau_sb/10^6;//m^2(Area of bolt)
db=sqrt(Ab/(%pi/4));//m
disp("Bolt diameter is "+string(db*1000)+" mm");
```

Scilab code Exa 4.4 Shear stress and twist angle

```
//Part B Chapter 4 Example 4
clc;
clear;
close;
D=50;//mm
l=3;//m
P=60;//hp
N=250;//rpm
G=90;//GN/m^2
Pl=20;//hp(assumed)
Tl=Pl*746/2/%pi/N;//Nm
Pr=Pl*2;//hp(Pr:Pl=1:2)
Tr=Pr*746/2/%pi/N;//Nm
tau_max=Tr*(D/2)*10^-3*32/(%pi*(D/1000)^4);//MN/m^2
disp("Maximum shear stress is "+string(tau_max/10^6)
   +" MN/m^2.");
theta_l=Tl*1.5*32/(G*10^9*%pi*(D/1000)^4);//radian
theta_r=Tr*1.5*32/(G*10^9*%pi*(D/1000)^4);//radian
theta=theta_r-theta_l;//radian
disp("Angle of twist is "+string(theta)+" radian.");
```

Scilab code Exa 4.5 Poisson Ratio and value of E G and K

```
//Part B Chapter 4 Example 5
clc;
clear;
close;
D=25;//mm
L=250;//mm
d=0.120;//mm(stretch)
F=60;//kN
theta=0.030;//radian
T=0.5;//kNm
epsilon=d/L;
sigma=F*1000*4/(%pi*(D/1000)^2);//GN/m^2
E=sigma/epsilon/10^9;//GN/m^2
disp("Value of E is "+string(E)+" GN/m^2");
G=T*1000*32*L/1000/(theta*%pi*(D/1000)^4)/10^9;//GN/
    m^2
disp("Value of G is "+string(G)+" GN/m^2");
m=2*G/E/(1-2*G/E);
disp("Poisson ratio is "+string(1/m));
K=m*E/3/(m-1);//GN/m^2
disp("Bulk Modulus, K is "+string(K)+" GN/m^2");
```

Scilab code Exa 4.6 Diameter of shaft

```
//Part B Chapter 4 Example 6
clc;
clear;
close;
L=2.5;//m
P=70*1000;//W
N=250;//rpm
tau_max=55*10^6;//N/m^2
theta=1;//degree
theta=theta*%pi/180;//radian
G=100;//GN/m^2
```

```
T=P*60/2/%pi/N;//Nm
d1=(T*16/%pi/(tau_max))^(1/3);//m
d2=(T*32/%pi/(G*10^9*theta/L))^(1/4);//m(Condidering
    twist 1 degree)
d=max(d1,d2)*1000;//mm
disp("Suitable diameter is "+string(d)+" mm");
```

Scilab code Exa 4.7 Diameter of shaft

```
//Part B Chapter 4 Example 7
clc;
clear;
close;
M=2.5*1000;//Nm
T=3.5*1000;//Nm
Te=sqrt(M^2+T^2)//Nm
Me=(M+sqrt(M^2+T^2))/2//Nm
tau_max=400*10^6;//N/m^2
d1=(Te*16/%pi/tau_max)^(1/3)*1000;//mm
sigma=750*10^6;//N/m^2
d2=(Me*32/%pi/sigma)^(1/3)*1000;//mm
d=max(d1,d2);//mm
disp("Suitable diameter is "+string(round(d))+" mm")
    ;
```

Scilab code Exa 4.8 Maximum torque and total rotation

```
//Part B Chapter 4 Example 8
clc;
clear;
close;
db=100;//m
ds=75;//mm
```

```
Lb=1.2*1000;//mm
Ls=1.2*1000;//mm
Gb=40;//kN/mm^2
Gs=80;//kN/mm^2
tau_s_AB=100;//N/m^2
T_AB=tau_s_AB*%pi*db^4/32/(db/2);//Nmm
tau_s_BC=120;//N/m^2
T_BC=tau_s_BC*%pi*ds^4/32/(ds/2);//Nmm
T=min(T_AB,T_BC);//Nmm(For safety minimum value choosen)
disp("Maximum torque can be applied is "+string(T)+" Nmm");
theta=T*(Lb/(Gb*1000)/(%pi/32*db^4)+Ls/(Gs*1000)/(%pi/32*ds^4));//radian
disp("Rotation of free end is "+string(theta)+" radian");
//ANSWER IN THE BOOK IS WRONG.
```

Scilab code Exa 4.9 Strength and weight ratio

```
//Part B Chapter 4 Example 9
clc;
clear;
close;
d=120;//mm
D1=120;//mm
D2=60;//mm
ThBYTs=(D1^4-D2^4)/d^4;
WhBYWs=%pi/4*((D1^2-D2^2)/(%pi/4)/d^2);
disp("Strength ratio, Th/Ts is "+string(ThBYTs));
disp("Weight ratio, Wh/Ws is "+string(WhBYWs));
```

Scilab code Exa 4.10 Shear stress and angle of twist

```
//Part B Chapter 4 Example 10
clc;
clear;
close;
d=50;//mm
D1=110;//mm
D2=70;//mm
L=1*1000;//mm
T=1.5*10^6;//kNmm
G=10^5;//MPa
tauH_BY_tauS=D1/2/(d/2);
//tauS=T/(tauH_BY_tauS*%pi*(D1^4-D2^4)/32/D1+%pi*d
    ^4/d/32);//N/mm^2
tauS=T/(tauH_BY_tauS*%pi*(D1^4-D2^4)/(D1*32)+%pi*d
    ^4/(32*d))
tauH=tauH_BY_tauS*tauS;//N/mm^2
disp("Shear Stress in Solid shaft is "+string(tauS)+
    " N/mm^2");
disp("Shear Stress in hollow shaft is "+string(tauH)
    +" N/mm^2");
thetaH=tauS/G/(d/2);//radian
thetaS=thetaH;//radian
disp("Angle of twist oh both shaft is equal and it
    is "+string(thetaS)+" radian.");
//ANSWER IN THE BOOK IS WRONG.
```

Scilab code Exa 4.11 Find shear stress

```
//Part B Chapter 4 Example 11
clc;
clear;
close;
b=25;//mm
L=120;//mm
d=60;//mm
```

```
P=100*1000;//W
N=120;//rpm
T=P*60/2/%pi/N;//Nm
tauS=(T*16/%pi/d^3)*1000;//N/mm^2
tauK=(T*2/b/d/L)*1000;//N/mm^2
disp("Shear Stress for shaft is "+string(tauS)+" N/
    mm^2");
disp("Shear Stress for key is "+string(tauK)+" N/mm
    ^2");
```

Scilab code Exa 4.12 Diameter of bolt

```
//Part B Chapter 4 Example 12
clc;
clear;
close;
n=8;//no. of bolts
d=160;//mm
F=450;//kN
T=20;//kNm
tau_t=120;//N/mm^2(For tensile load)
tau_s=60;//N/mm^2(For shear load)
db1=sqrt(F*1000/n/(%pi/4)/tau_t);//mm
db2=sqrt(T*10^6/(n*tau_s*%pi/4*(d/2)));//mm
db=max(db1,db2);//mm
disp("Suitable bolt diameter is "+string(db)+" mm");
```

Scilab code Exa 4.13 Max Power

```
//Part B Chapter 4 Example 13
clc;
clear;
close;
```

```
b=30; //mm(thickness)
l=8; //m
d=260; //mm
D=d+2*b; //mm
N=300; //rpm
tau_s=16; //N/mm^2
Gs=8.5*10^4; //N/mm^2
Gb=4.5*10^4; //N/mm^2
Ips=%pi/32*d^4; //mm^4
Ipb=%pi/32*(D^4-d^4); //mm^4
TsByTb=Ips/Ipb*Gs/Gb;
Ts=%pi/16*d^3*tau_s; //Nmm
Tb=Ts/TsByTb; //Nmm
T=Ts+Tb; //Nmm
P=2*%pi*N*T/60/1000; //W
disp("Maximum power is "+string(P/1000)+" kW");
```

Scilab code Exa 4.14 Safe diameter of shaft

```
//Part B Chapter 4 Example 14
clc;
clear;
close;
tau_s=60; //N/mm^2
//Forces on pulley A, B & C
A1=3000; //N
A2=1000; //N
B1=1200; //N
B2=2200; //N
C1=1000; //N
C2=2250; //N
dA=250; //mm
dB=250; //mm
dC=200; //mm
TA=(A1-A2)*dA/2; //Nmm
```

```
TB=(B2-B1)*dB/2;//Nmm
TC=(C2-C1)*dC/2;//Nmm
T=max(TA,TB,TC);//Nmm(Max. Torque)
d=(T/tau_s/(%pi/16))^(1/3);//mm
disp("Safe diameter of shaft is "+string(d)+" mm");
```

Scilab code Exa 4.15 Max bending and shear stress

```
//Part B Chapter 4 Example 15
clc;
clear;
close;
l=3;//m
d1=85;//mm
d2=65;//mm
A=1*0.5;//m^2
Pw=2200;//N/mm^2
LG=Pw*A//N(Total Wind load at G)
M=LG*(3+0.25)//Nm(Max BM on pipe)
T=LG*(0.5+0.5);//Nm
I=%pi/64*(d1^4-d2^4);//mm^4
Z=I/42.5;//mm^3
Zp=2*Z;//mm^3
sigma_b=M*1000/Z;//N/mm^2
tau_s=T*1000/Zp;//N/mm^2
disp("Maximum bending stress is "+string(sigma_b)+"
   N/mm^2");
disp("Maximum shear stress is "+string(tau_s)+" N/mm
   ^2");
```

Scilab code Exa 4.16 Estimate angular twist

```
//Part B Chapter 4 Example 16
```

```
clc;
clear;
close;
d1=80;//mm
b=1.75;//mm
l=1.6;//m
T=80;//Nm
G=82;//GN/m^2
d2=d1-2*b;//mm
Ip=%pi/32*(d1^4-d2^4)*10^-12;//m^4
theta=T*l/Ip/(G*10^9);//radian
disp("Angular twist is "+string(theta)+" radian.");
```

Scilab code Exa 4.17 Fnd torque required

```
//Part B Chapter 4 Example 17
clc;
clear;
close;
l=25;//m
d=0.5;//mm
n=10;//no. of rounds
G=82;//GN/m^2
Ip=%pi/32*d^4*10^-12;//m^4
theta=2*%pi*n;//radian
T=G*10^9*Ip*theta/l;//Nm
disp("Torque required is "+string(T)+" Nm.");
```

Scilab code Exa 4.18 Find maximum torque

```
//Part B Chapter 4 Example 18
clc;
clear;
```

```
close;
d=3.5/1000;//m
tau_s=240*10^6;//N/m^2
Ip=%pi/32*d^4;//m^4
T=tau_s*Ip/(d/2);//Nm
disp("Maximum torque transmitted is "+string(T)+" Nm
    .");
```

Scilab code Exa 4.19 Diameter of hollow shaft

```
//Part B Chapter 4 Example 19
clc;
clear;
close;
d=16;//cm
As=%pi/4*d^2;//cm
D1=poly(0,'D1');
D2=poly(0,'D2');
deltaD=As/(%pi/4);//(let deltaD=D1^2-D2^2)
//USS=1.2*USH
//USS=(D1^2+D2^2)/D1^2*USH
D2BYD1=sqrt(0.2);
D1=sqrt(deltaD/(1-D2BYD1^2));//cm
D2=D2BYD1*D1;//cm
disp("Outer diameter of hollow shaft is "+string(D1)
    +" cm.");
disp("Inner diameter of hollow shaft is "+string(D2)
    +" cm.");
```

Scilab code Exa 4.20 Max shear stress

```
//Part B Chapter 4 Example 20
clc;
```

```
clear;
close;
tau=82;//N/mm^2
M=3.5/1000;//Nm
T=4.5/1000;//Nm
DoBYDi=2;
Do=(16*sqrt(M^2+T^2)/%pi/tau*16/15)^(1/3);//mm
Di=Do/DoBYDi;//mm
disp("Outer diameter is "+string(Do*1000)+" m.");
disp("Inner diameter is "+string(Di*1000)+" m.");
```