

Scilab Textbook Companion for
Non Conventional Energy Resources
by B. H. Khan¹

Created by
Aviral Yadav
B.tech
Mechanical Engineering
ABES Engineering College
College Teacher
None
Cross-Checked by
Bhavani Jalkrish

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Fundamental of Energy Science and Technology

Scilab code Exa 1.1 heat rejected

```
1 // Given data:
2 clc
3 T1=500+273.0 //source temp in kelvin
4 T2=100+273.0 //sink temperature in kelvin
5 W=1 // output power in kW
6
7 nth=1-(T2/T1) // thermal efficiency
8
9 Q1=1/nth // heat supplied in kW
10
11 Q2=Q1-W // heat rejected in kW
12
13 printf("The heat rejected is %0.2f kW",Q2)
14
15 // the answer in book is wrong due to incorrect
    value of T1
```

Scilab code Exa 1.2 least power required

```
1 // Given data:
2 clc
3 T1=40+273.0 // ambient temp in kelvin
4 T2=-10+273.0 // freezer temp in kelvin
5 Q2=2 // heat loss rate for freezer in kJ/s
6
7 Q1=T1*(Q2/T2) // heat transfer rate in kJ/s
8
9 W=Q1-Q2 // work in kW
10
11 printf("The least power required is %0.2f kW",W)
```

Scilab code Exa 1.3 Heat abstracted

```
1 // Given data:
2 clc
3 Q1=3e4 // heat required in kJ/h
4 W=2e3 // work required in kJ/h
5
6 Q2=Q1-W // heat abstracted from outside in kJ/h
7
8 COP=Q1/(Q1-Q2) // COP of heat pump
9
10 printf("Heat abstracted from outside air is %0.2f kJ
11 /h \n ",Q2)
11 printf("COP of heat pump is %d ",COP)
```

Scilab code Exa 1.4 work done

```
1 // Given data:
2 clc
```



```

3 T11=320+273.0 // temp at source 1 in kelvin
4 Q1=10000.0 // heat transfer rate at source 1 in kJ/
  min
5 T12=65+273.0 // temp at source 2 in kelvin
6 Q2=120000.0 // heat transfer rate at source 2 in kJ
  /min
7 T2=35+273.0 // temp of surrounding in kelvin
8
9 n1=1-(T2/T11) // efficiency by source 1
10 n2=1-(T2/T12) // efficiency by source 2
11
12 W1=Q1*n1 // work at source 1 in kJ/min
13 W2=Q2*n2 // work at source 2 in kJ/min
14
15 printf("The work done at W1 is = %0.2f kJ/min \n ",
  W1)
16 printf("The work done at W2 is = %0.2f kJ/min \n ",
  W2)
17 printf("The larger power is provided by source 2")

```

Chapter 2

Energy Conservation

Scilab code Exa 2.1 overall efficiency

```
1  clc
2
3  // Given data:
4
5  Hcoal=20.0 // heating value of coal in MJ
6  W=200.0e3 // weight of coal in kg
7  E=1.2e6 // Electrical energy generated in MJ
8  delH=1.6e6 // Heat energy generated in MJ
9  ne=0.30 // electrical efficiency
10 nb=0.8 // thermal efficiency
11
12 QA=Hcoal*W // total thermal energy input to plant in
    MJ
13 nco=(E+delH)/QA // efficiency of cogeneration plant
14 e=E/(E+delH) // electrical fraction
15
16 nc=1/((e/ne)+(1-e)/nb) // overall efficiency
17
18 printf("The overall efficiency is %0.2f %%",nc*100)
```

Chapter 4

Solar Energy Basics

Scilab code Exa 4.1 radiation angle

```
1 // given data
2 clc
3 n=319 // 15th November
4 Gama=30 // angle in degree
5 Beta=45 // angle in degree
6 phi=18.9 // latitude in degree
7 solartime=13.5-4*(81.733-72.816)/60 +14.74/60 // in
  hours
8 delta=23.45*(sin(360.0*(284.0+n)/365.0)) // in
  degree
9 B=(360.0*(n-81)/364)
10 E=(9.87*sin(2*B)-7.53*cos(B)-15*sin(B))
11 w=(solartime-12)*15 // hour angle
12 theta=-%i*acos(((cos(phi)*cos(Beta)+sin(phi)*sin(
  Beta)*cos(Gama))*cos(delta)*cos(w) + cos(delta)*
  sin(w)*sin(Beta)*sin(Gama) + sin(delta)*(sin(phi)
  *cos(Beta)-cos(phi)*sin(Beta)*cos(Gama)))*180/%pi
  )
13
14 printf("the angle is %.2f degrees",theta)
15
```

```
16
17 // The answer in the textbook is slightly different
    due to approximations
```

Scilab code Exa 4.2 daylight hours

```
1 // given data
2 clc
3 n1=1 // 1st january
4 n2=182 // july 1
5
6 phi=34.083 // latitude in degree
7
8 delta1=23.45*sin((%pi/180)*(360.0*(284.0+n1)/365.0))
    // in degree
9 delta2=23.45*sin(((%pi/180)*360.0*(284.0+n2)/365.0))
    // in degree
10
11 td1=(2.0/15)*(acos((tan(phi)/tan(delta1)))*180/%pi)
    // daylight hours for january 1
12 td2=(2.0/15)*(acos((tan(phi)/tan(delta2)))*180/%pi)
    // daylight hours for july 1
13
14 printf ("daylight hours for january 1 are %.2f hours
    ",td1)
15 printf (" \n daylight hours for july 1 are %.2f
    hours",td2)
16
17 // the answers are slightly different in textbook
    due to approximation while here answers are
    precise
```

Scilab code Exa 4.3 monthly average

```

1 // given data
2 clc
3
4 a=0.25 // constant for delhi from table 4.1
5 b=0.57 // constant for delhi from table 4.1
6 pi=27.166 // latitude in degrees
7 n=17 // day
8 nbar=7 // sunshine hours
9
10 dlta=23.45*(sind((360.0*(284.0+n)/365.0))) // in
    degree
11
12 wt=acosd((-tand(pi)*(tand(dlta)))) // hour angle at
    sunrise
13 Nbar=(2*(wt)/15.0) // day length
14
15 Ho=3600*(24.0/%pi)*1.367*(1+0.033*cosd((360.0*n/365)
    ))*(cosd(pi)*cosd(dlta)*sind(wt)+1.3728*sind(dlta)
    )*sind(pi)) // in kj/m^2 per day
16
17 Hg=Ho*(a+b*(nbar/Nbar)) // in kj/m^2 per day
18 printf("The monthly average is %.2f in kj/m^2 per
    day" ,Hg)
19
20 // the answer in the book is slightly different due
    to approximations

```

Scilab code Exa 4.4 beam radiation

```

1 // given data
2 clc
3 Hg=14450.418 // in kj/m^2 per day from previous
    example
4 Ho=22926.408 // in kj/m^2 per day from previous
    example

```

```

5 KT=Hg/Ho // unitless
6 Hd=Hg*(1.354-1.570*KT) // in kj/m^2 per day
7 Hb= Hg-Hd // in kj/m^2 per day
8
9 printf("Monthly average of daily diffused is %.2f in
      kj/m^2 per day",Hd)
10 printf("\n beam radiation is %.2f in kj/m^2 per day"
      ,Hb)
11
12 // the solution inthe textbook is slighlty different
      as the values from previous examples are used
      which too are incorrect

```

Scilab code Exa 4.5 hourly diffuse

```

1 // given data
2 clc
3 // most of the data is used is from previous example
  :
4 phi=27.166 // in degree
5 n=17 // day
6 ws=78.66 // degrees
7 dlta=-20.96 // in degrees
8 Ho=22926.408 // kj/m^2 per day
9 Hg=14450.418 // kj/m^2 per day
10 Hd=5266.2473 // kj/m^2 per day
11
12 w=(11.5-12)*15 // in degrees
13
14 Io=3600*1.367*(1+0.033*cosd(360*17/365.0))*(cosd((
      phi))*cosd((dlta))*cosd((w)))+sind((dlta))*sind((
      phi))
15
16 a=0.409+0.5016*sind(ws-60)
17 b=0.6609-0.4767*sind(ws-60)

```

```

18
19 Ig=Hg*(a+b*cosd(w))*Io/Ho // in kJ/m^2-h
20
21 printf("The monthly average of hourly global
    radiation is %.2f kJ/m^2-h",Ig)
22
23 adash=0.4922+(0.27/(Hd/Hg))
24 bdash=2*(1-adash)*(sind(ws)-1.7328*cosd(78.66))
    /(1.7328-0.5*sind(2*78.66))
25
26
27 Id=5259.6*(1.2321-0.3983*cosd((w)))*Io/Ho // kJ/m^2-
    h
28
29
30
31 printf("\n The hourly diffuse radiations are %.2f kJ
    /m^2-h",Id)
32
33 // the solution in the textbook is wrong as the
    value of b and bdash are wrong

```

Scilab code Exa 4.6 total radiation

```

1 // given data
2 clc
3 phi=28.58 // in degree
4 n=135 // may 15
5 dltA=23.45*sind((360*(284+n)/365.0))
6
7 w=(13.5-12)*15 // in degrees
8 A=3981.6 // in W/m^2 from table 4.2
9 B=0.177 // from table 4.2
10 C=0.130 // from table 4.2
11

```

```

12 costhetaz=cosd(phi)*cosd(dlta)*cosd(w)+sind(dlta)*
    sind(phi)
13
14 Ibn=A*exp(-B/0.922) // kJ/m^2-h
15
16
17 Id=C*Ibn // kJ/m^2-h
18
19 printf("The diffused radiation is %.2f kJ/m^2-h",Id)
20 Ib=Ibn*0.922 // in kJ/m^2-h
21
22 printf("\n The beam radiation is %.2f kJ/m^2-h",Ib)
23 Ig=Ib+Id // in kJ/m^2-h
24
25 printf("\n The global radiation is %.2f kJ/m^2-h",Ig
    )

```

Scilab code Exa 4.7 Monthly average

```

1 // given data
2 clc
3 phi=28.58 // in degree
4 B=30 // in degree
5 n=318 // november 14
6 Hg=16282.8 // in kJ/m^2-day from Table C1 appendix C
7 Hd=4107.6 // in kJ/m^2-day from Table C2 appendix C
8
9 dlta=23.45*(sind((360.0*(284.0+n)/365.0))) // in
    degrees
10
11 ws=acosd(tand(phi)*(atan(dlta))) // hour angle at
    sunrise
12
13 Rb=(ws*sind(dlta)*sind(phi-B)+cosd((dlta))*sind(ws)*
    cosd(phi-B))/(ws*sind(dlta)*sind(phi)+cosd((dlta))

```



```
        )*sind(ws)*cosd((phi)))
14
15 Rd=(1+cosd((B)))/2
16
17 Rr=0.2*(1-cosd((B)))/2
18
19 Ht=((1-(Hd/Hg))*1.56+(Hd/Hg)*Rd + Rr)*Hg
20 printf("Monthly average total radiation is %.2f kJ/m
    ^2-h",Ht)
```

Chapter 6

Solar Photovoltaic Systems

Scilab code Exa 6.1 fermi level

```
1 clc
2 // Given data
3
4 T=27 +273 // temperature converted in kelvin\n",
5 NV=1e22 // effective density of states in valence
   band in cm(-3)\n",
6 NA=1e19 // acceptor density in cm(-3)\n",
7 k=8.629*10**(-5) // boltzmann constant in eV/K\n",
8 EFV=k*T*log(NV/NA) // closeness of fermi level i.e
   Ef-Ev\n",
9 printf("Closeness of fermi level with valence bond
   is %.4f eV",EFV)
```

Scilab code Exa 6.2 optimum wavelength

```
1 // Given data :
2 clc
3 clear
```

```

4 E =2.42 // Band gap in eV
5 hc=1.24 // planck's constant * speed of light
6 // solution
7 Lambda=1.24/E // in micro-meter usinf eq 6.4
8
9 printf( "The optimum wavelength is %.3f micro meter"
        ,Lambda )

```

Scilab code Exa 6.3 number of modules

```

1 clc
2 clear
3 // Given data :
4
5 Pout=1*735 // motor power output in W
6 Peffi=0.85 // motor efficiency
7 cellarea=9*4*125*125e-6 // area in m^2
8 Rad=1000 //incident radiation in kW/m^2
9 celleffi=0.12 // cell efficiency
10
11 // soln.
12 Pin=Pout/Peffi // power req by motor in W
13 N=Pin/(Rad*cellarea*celleffi) // number of modules
14
15 printf("%.f number of modules are required",N)

```

Scilab code Exa 6.4 time required

```

1 clc
2 clear
3 // given:
4 noMPPTpower=10*8 // power without MPPT in W from fig
    6.25

```

```
5 MaxP=25*5 // maximum power by PV module in W from
    fig 6.25
6 effi=0.95 // efficiency of MPPT
7 MPPTcost=4000 // Cost in rupees
8 // Soln
9 Pact=MaxP*effi // actual power produced in W
10 Psurplus=Pact-noMPPTpower // Surplus power in W
11 t=MPPTcost/(3*Psurplus/1000) // time required in
    hours
12 printf("time required is %.1f hours",t)
```

Chapter 7

Wind Energy

Scilab code Exa 7.1 Maximum axial thrust

```
1 // given data
2 clear
3 clc
4 rho=1.226 // air density in kG/m^3
5 alpha =0.14
6 H=10.0 // height at which wind speed is given in m
7 uH=12.0 // speed in m/s
8 z=100.0 // tower height in m
9 D=80.0 // diameter in m
10 effigen=0.85 // efficiency og generator
11
12 A=%pi*(D**2)/4 // area in m^3
13 u0=uH*(z/H)**alpha // velocity at 100 m in m/s
14 u1=0.8*u0 // exit velocity in m/s
15 Po=(A*rho*u0**3)/2 // Total Power in Wind
16 // Part 1
17 printf("Total Power in Wind is %0.2f MW \n",Po
18 /1000000)
19 // Part 2
20 a=(u0-u1)/u0 // interference factor
```

```

21 Cp=4*a*(1-a)**2 // Power Coefficient
22 PT=Cp*Po/1000000 // power to turbine in MW
23
24 printf("The power extracted by turbine is %0.2f MW \
n",PT)
25
26 // Part 3
27 Pelec=effigen*PT // electrical power generated in MW
28
29 printf("The Electrical power generated is %0.2f MW \
n",Pelec)
30
31 // Part 4
32 FA=4*a*(1-a)*(A*rho*u0**2)/2 // axial thrust in N
33
34 printf("The axial thrust is %0.2f N \n",FA)
35
36 // Part 5
37
38 Fmax=(A*rho*u0**2)/2 // maximum thrust in N
39 printf("Maximum axial thrust is %0.2f N \n ",Fmax)

```

Scilab code Exa 7.2 maximum output

```

1 // given data
2 clear
3 clc
4
5 u0=20.0 // wind speed in m/s
6 T=273+27.0 // temp in kelvin
7 P=1.01325e5 // pressure in Pa
8 R=287.0 // gas constant
9 r=80/2.0 // radius of rotor in m
10 w=2*pi*40/60.0 // rotor speed in rad/s
11 A=%pi*r**2 // area of rotor in m^2

```

```

12
13 // soln:
14 rho=P/(R*T) // density in Kg/m^3
15 a=1/3.0 // condition for maximum output
16 Cpmax=4*a*(1-a)**2 // Power Coefficient
17 Lambda=r*w/u0 //tip speed ratio
18
19 Po=(A*rho*u0**3)/2000000 // Total Power in Wind in W
20
21 Tm=Po*r/u0 // Torque in N
22
23 Ctmax=Cpmax/Lambda // torque coefficient
24
25 Tshmax=Tm*Ctmax // torque at shaft
26
27 printf("The torque at shaft for maximum output is %0
        .2 f N",Tshmax)

```

Scilab code Exa 7.3 optimum energy

```

1 // Given Data
2 // given data
3 clear();
4 clc();
5 u0=15.0 // wind speed in m/s
6 R=80/2.0 // radius of rotor in m
7 n=3 // number of blades
8
9 Lambda=4*%pi/n // condition of tip ratio for maximum
        output
10
11 w=Lambda*u0/R // using Eq 7.21 rotor speed in rad/s
12
13 N=w*60/(2*%pi) // rotor speed in RPM
14

```

```
15 printf( "For optimum energy the rotor speed should  
    be %.1 f rpm",N)
```

Chapter 8

Biomass Energy

Scilab code Exa 8.1 total volume of digester

```
1 clc
2 // given data
3 Gascook=5*0.227 // gas required for cooking in m3/
  day
4 Gaslight=0.126*2*3 // gas required for lighting in m
  3/day
5 Totalgasreq=Gascook+Gaslight // in m3/day
6 gasperday=0.34*0.18*7 // in m3/day
7
8 n=1+Totalgasreq/gasperday // no. of cows
9 printf("The number of cows is %i",n)
10 cowfeed=7*n // in kg
11 slurry=cowfeed*2.0/1090 // in m3
12 totalslurry=50.0*slurry // in m3
13 reqvolume=totalslurry/0.9
14 printf("\\n The total volume of digester is %.2f m3"
  ,reqvolume)
```

Scilab code Exa 8.2 size of biogas plant

```

1  clc
2  // given data
3  Gaslight=10*0.227*4 // gas required for lighting in
   m^3/day
4  Eleccomp=10*250*6*60*60/1000000.0 // electrical
   energy required by computers in MJ
5  effith=0.25 // thermal efficieny
6  efficonv=0.80 // conversion efficiency
7  Heat=23.0 // heating value of biogas in MJ/m^3
8  rho=1090.0 // slurry density in kg/m^3
9  Engineinput=Eleccomp/(effith*efficonv)
10
11 energypump=746*2*2*60*60/1000000.0 // mechanical
   energy required for pumping in MJ
12 themalinput=energypump/effith // required thermal
   input in MJ
13 totalinput=themalinput+Engineinput // total thermal
   input required by engine
14
15 Volreq=totalinput/Heat // volume required per day in
   m^3/day
16 Totalrq=Volreq+Gaslight // total gas required in m^3
   /day
17
18 n=Totalrq/(7*0.18*0.34) // solid mass is 18% and n
   is number of cows required
19 n=round(n)
20 printf("The number of cows is %i",n)
21 feed=7*n // daily feed in kg
22 slurry=2*feed // in kg
23 volslurry=slurry/rho // volume of slurry added per
   day in m^3
24 totalvol=50*volslurry/0.9 // total volume for 50
   days in m^3 when 90 % is occupied by slurry
25
26 printf("\\n The size of biogas plant is %.2f m^3",
   totalvol)

```

Scilab code Exa 8.3 gas holder capacity

```
1 clc
2 // given data
3 Voldaily=1200 // daily production in m3/day
4 prodrate=Voldaily/24.0 // gas production rate per
   hour
5 consrate=Voldaily/6.0 //gas consumption rate per hour
6 Vg1=(consrate-prodrate)*2 // gas holder size
   required for 2 hours in litres
7 Vg2=prodrate*9 // gas holder size for 9 hours
   without consumption in litres
8 if Vg1>Vg2
9     Vgmax=Vg1
10 else
11     Vgmax=Vg2
12 Vg=Vgmax*1.25 // required gas holder with 25 %
   safety margin in litres
13 printf("\n required gas holder size is %.2f litres",
   Vg)
14 Capacity=Vg/Voldaily // required gas holder capacity
15
16 printf("\n required gas holder capacity is %.2f %%",
   Capacity*100)
```

Scilab code Exa 8.4 total thermal power

```
1 clc
2 // given data
3 drymattrprd=2 // dry matter produced in kg/day/cow
4 gasyield=0.22 // biogas yield in m3 /kg
5 drymttr=18/100.0 // dry matter in cowdung
```

```

6 rho=1090 // slurry density in kg/m^3
7 effibrnr=0.6 // burner efficiency
8 Heat=23.0 // heating value of biogas in MJ/m^3
9
10 dungprd=drymatterprd*2/0.18 // dung produce in kg/day
    by 2 cows
11 slurry=2*dungprd // slurry produce in kg/day
12 volslurry=slurry/rho // volume of slurry in m^3
13 totalslurry=30*volslurry // for 30 days slurry in m
    ^3
14 digestersize=totalslurry/0.85 // in m^3
15 printf("the volume of digester is %.2f m^3",
    digestersize)
16
17 gasprd=drymatterprd*2*gasyield // gas produced in m
    ^3/day
18
19 Energytherm=gasprd*Heat*effibrnr // total thermal
    energy available in MJ/day
20
21
22 thermalpower=Energytherm*1000000/(24*60*60) // in
    watts
23
24 printf ("\n total thermal power is %.2f W",
    thermalpower)

```

Chapter 9

Geothermal Energy

Scilab code Exa 9.1.i Heat content

```
1 clc
2 // given data
3 G=39.0 // temperature gradient in K/km.
4 h2=10.0 // depth in km
5 rhor=2700.0 // kg/m^3
6 cr=820.0 // in J/kg-K
7
8 h1=120/G // T1-T0=120 K is given
9 h21=h2-h1 // in km
10 E0byA=(rhor*(1000**3)*G*cr*h21**2)/2 // in J/km^2
    Heat content per square km
11 printf("The Heat content per square km is %.3e J/km
    ^2",E0byA)
```

Scilab code Exa 9.1.ii average temp after 25 years

```
1 clc
2 // given data
```

```

3 G=39.0 // temperature gradient in K/km.
4 h2=10.0 // depth in km
5 rhor=2700.0 // kg/m^3
6 cr=820.0 // in J/kg-K
7 QbyA=0.5 //water flow rate in m^3/sec-km^2
8 rhow=1000.0 // density of water in kg/m^3
9 cw=4200.0 // specific heat of water in J/kg-K
10 h1=120.0/G // T1-T0=120 K is given
11 h21=h2-h1 // in km
12 t=25 // time in years
13
14 thtao=G*h21/2.0 // in degree K
15 printf( " Useful initial temp is %.2f degree K",
    thtao)
16 tau=rhor*cr*h21*(1000**3)/(QbyA*rhow*cw) // in
    seconds
17 tau=tau/(2*60*60*24*365) // in years
18 thta=thtao*exp(-t/tau) // in degree Kelvin
19 printf( " \n Useful average temp after 25 years is %
    .2f degree K",thta)

```

Scilab code Exa 9.1.iii Initial Heat extraction

```

1 clc
2 // given data
3 G=39.0 // temperature gradient in K/km.
4 h2=10.0 // depth in km
5 rhor=2700.0 // kg/m^3
6 cr=820.0 // in J/kg-K
7
8 h1=120/G // T1-T0=120 K is given
9 h21=h2-h1 // in km
10 E0byA=(rhor*(1000**3)*G*cr*h21**2)/2 // in J/km^2
    Heat content per square km
11

```

```

12 thetaso=G*h21/2.0 // in degree K
13 tau=rhor*cr*h21*(1000**3)/(QbyA*rhow*cw) // in
    seconds
14 tau=tau/(2*60*60*24*365) // in years
15 theta=thetaso*exp(-t/tau) // in degree Kelvin
16
17 Heatinitial=E0byA/(60*60*365*24*tau)/1000000 //
    intial heat extraction rate in MW /km^2
18
19 Heat25=Heatinitial*exp(-t/tau) // heat extraction
    rate after 25 years in MW /km^2
20
21 printf( " Initial Heat extraction rate is %.2f MW/km
    ^2",Heatinitial)
22
23 printf("\n Final Heat extraction rate is %.2f MW/km
    ^2",Heat25)

```

Scilab code Exa 9.2.i heat content

```

1 clc
2 // given data
3 w=0.6 // in km
4 h2=2.5 // in km
5 p=5/100.0 // porosity
6 rhor=3000.0 // density of sediment in kg/m^3
7 cr=750.0 // specific heat of sediment in J/kg-K
8 rhow=1000.0 // density of water in kg/m^3
9 cw=4200.0 // specific heat of water in J/kg-K
10 G=35.0 // temperature gradient in degree C/km
11 T1=45.0 // temp 1 in degree celsius
12 T0=12.0 // temp 2 in degree celsius
13 Q=0.75 // water extraction rate in m^3/sec-km^2
14
15 T2=T0+G*h2 // initial temp in degree celsius

```

```

16
17 thetao=T2-T1 // in degree celsius
18
19 E0byA=(p*rhow*(1000**3)*cw+(1-p)*rhor*(1000**3)*cr)*
    w*thetao // in J/km^2
20
21 printf( "The heat content is %.2e J/km^2",E0byA)
22
23 // the answer is different in textbook due to wrong
    thetao

```

Scilab code Exa 9.2.ii Time constant

```

1 clc
2 // given data
3 w=0.6 // in km
4 h2=2.5 // in km
5 p=5/100.0 // porosity
6 rhor=3000.0 // density of sediment in kg/m^3
7 cr=750.0 // specific heat of sediment in J/kg-K
8 rhow=1000.0 // density of water in kg/m^3
9 cw=4200.0 // specific heat of water in J/kg-K
10 G=35.0 // temperature gradient in degree C/km
11 T1=45.0 // temp 1 in degree celsius
12 T0=12.0 // temp 2 in degree celsius
13 Q=0.75 // water extraction rate in m^3/sec-km^2
14
15 tau=((p*rhow*cw+(1-p)*rhor*cr)*w*1000**3/(Q*rhow*cw)
    )/(60*60*24*365) // in years
16
17 printf( "Time constant is %.1f years",tau)
18
19 // the answer is different in textbook due to wrong
    calculations

```

Scilab code Exa 9.2.iii power per square km

```
1  clc
2  // given data
3  w=0.6 // in km
4  h2=2.5 // in km
5  p=5/100.0 // porosity
6  rhor=3000.0 // density of sediment in kg/m^3
7  cr=750.0 // specific heat of sediment in J/kg-K
8  rhow=1000.0 // density of water in kg/m^3
9  cw=4200.0 // specific heat of water in J/kg-K
10 G=35.0 // temperature gradient in degree C/km
11 T1=45.0 // temp 1 in degree celsius
12 T0=12.0 // temp 2 in degree celsius
13 Q=0.75 // water extraction rate in m^3/sec-km^2
14 T2=T0+G*h2 // initial temp in degree celsius
15 t=25 // time in years
16 thetao=T2-T1 // in degree celsius
17
18 E0byA=(p*rhow*(1000**3)*cw+(1-p)*rhor*(1000**3)*cr)*
    w*thetao // in J/km^2
19
20 tau=((p*rhow*cw+(1-p)*rhor*cr)*w*1000**3/(Q*rhow*cw)
    ) // in seconds
21 Pperkm2=(E0byA)/(tau*1000000) // initial power per
    square km in MW/km^2
22 printf("initial power per square km is %.2f MW/km^2"
    ,Pperkm2)
23 Power20=Pperkm2*exp(-25*60*60*24*365/tau) // power
    per square km in MW/km^2 after 25 years
24 printf("\n power per square km in MW/km^2 after 25
    years is %.2f MW/km^2",Power20)
25
26 // The answers are slightly different due to error
```

in textbook

Chapter 10

Ocean Energy

Scilab code Exa 10.1 annual average energy generation

```
1  clc
2  // given data
3  R=13.0 // in m
4  r=3.0  // in m
5  A=2.0  // area in km^2
6  ebbcycle=12.42 // in hours
7  effi=0.7 // efficiency of turbine
8  g=9.8 // gravitational acceleration in m/sec^2
9  rho=1025 // density of sea in kg/m^3
10 Powerpotential=0.225*A*(10**6)*((R**2)-(r**2))/10**6
    // power potential in MW
11
12 Powergenerated=effi*Powerpotential // in MW
13
14 printf( "The average power generated by plant is %.2
    f kWh",Powergenerated)
15
16 Energysingle=rho*A*(10**6)*g*((R**2)-(r**2))
    /(2.0*10**6) // Energy in single emptying in MJ
17
18 ebbyear=364.0*24/ebbcycle
```

```

19
20 annualenergy=Energysingle*ebbyear*effi*1000/3600.0
    // in kWh
21
22 printf( "\n The annual average energy generation is
    %.2e kWh",annualenergy)

```

Scilab code Exa 10.2 phase velocity

```

1 clc
2 // given data
3 a=2.0/2 // in m
4 T=8.0 // in secs
5 rho=1025.0 // in kg/m^3
6 w=2*pi/T // angular frequency in radian/sec
7 g=9.8 // gravitational acceleration in m/sec^2
8
9 Lamda=2*(pi)*g/(w**2) // in m
10 printf( " wavelength is %.2f m",Lamda)
11 v=g/w // phase velocity in m/s
12 printf( " \n phase velocity is %.2f m/s",v)
13 P=rho*(g**2)*(a**2)*T/(8*pi*1000) // power in wave
    in kW/m
14 printf( " \n power in wave is %.2f kW/m",P)
15 E=P*8.76 // average annual wave energy in mWh/m
16
17 printf( "\n average annual wave energy is %.1f mWh/m
    ",E)

```

Chapter 11

Small Hydro Resources

Scilab code Exa 11.1 power available

```
1 clc
2 // given data
3 rho=996 // density in kg/m^3
4 effi=0.55 // overall efficiency
5 Q=100/1000.0 // discharge in m^3/sec
6 h=30 // gross head in m
7 g=9.81 // gravitational acceleration in m/sec^2
8
9
10 Pnet=effi*rho*Q*g*h/1000 // net power in watts
11 printf("Power available is %.2f kilowatts",Pnet)
```

Scilab code Exa 11.2 required flow rate

```
1 clc
2 // given data
3 pf=0.8 // power factor
4 Load=3 // load in kW
```

```

5 V=230 // voltage of kettle in V
6 P=500 // power of kettle in W
7 VA=pf*Load // VA load in kVA
8 C=4200 // specific heat of water in j/kg-K
9 T=45-20 // temperature difference in degree celsius
10
11 VAR=VA*1.6 // net required VAR rating thus 60% extra
    capacity
12
13 R=(V**2)/P // resistance by kettle in ohms
14
15 Po=7*(V**2)/R // power dissipation in W for 7
    elements
16
17 printf( "7 elements are connected in parallel")
18
19 Q=Load*1000.0/(C*T) // flow rate in kg/sec
20
21 printf("\n The required flow rate is %.4f litre/sec"
    ,Q)

```

Chapter 12

Emerging Technologies

Scilab code Exa 12.1 required heat removal rate

```
1  clc
2  // given data
3  delG=-39.59 // kJ/mol
4  delH=-56.83 // change in enthalpy in kJ/mol
5  mdotmethanol=32.0 // in g/s
6  mdotoxygen=48.0 // in g/s
7
8  Wmax=166.3 // -delG in kJ
9
10 flowmethanol=mdotmethanol*100*3600/(Wmax*1000) // in
    kg/h
11 flowoxygen=mdotoxygen*100*3600/(Wmax*1000) // in kg/
    h
12 printf( "The required flow rate of methanol is %.2f
    kg/h",flowmethanol)
13 printf( "\nThe required flow rate of oxygen is %.2f
    kg/h",flowoxygen)
14 delQ=delH-delG // using eq 12.7
15
16 fuelrate=-delQ*19.24/mdotmethanol // in kcal/s
17
```

```
18 printf( "\nThe required heat removal rate is %.2f
    kcal/s",fuelrate)
19
20 // The answer is wrong in textbook because of
    incorrect conversion from g/s to kg/h
```

Chapter 13

Miscellaneous Non conventional Technologies

Scilab code Exa 13.1 Maximum Power output

```
1 clc
2 // given data
3 A=0.25 // area in m^2
4 d=0.5 // distance between electrodes in m
5 B=1.8 // flux density in Wb/m^2
6 u=1200.0 // average gas velocity in m/s
7 sigma=10.0 // mho/m
8
9 Vo=B*u*d // in Volts
10 Pmax=1*sigma*(u**2)*(B**2)*A*d/(4.0*10**6) // in MW
11
12 printf("Maximum Power output %.3f MW",Pmax)
```

Chapter 14

Financial and Economic Evaluation

Scilab code Exa 14.1 Future value of investment

```
1 clc
2 // given data
3 P=2000 // in rs
4 i=12 // interest rate in %
5 n=6 // time in years
6
7 F=P*(1+i/100.0)**n // Future value of investment
8
9 printf("The amount will be Rs %.0f",F)
```

Scilab code Exa 14.2 number of years

```
1 clc
2
3 // given data
4
```

```

5 P=10.0 // in lakh rs
6 i=12.25 // interest rate in %
7 F=20 // final amount in lakh rs
8
9 n=log(F/P)/log(1+i/100.0) // time in years
10
11 printf("The number of years is %.2f years",n)

```

Scilab code Exa 14.3 initial value

```

1 clc
2 //given data
3 F=100000 // final amount in rs
4 i=6 // interest rate in %
5 n=10 // time in years
6
7 P=F*(1/(1+i/100.0)**n) // initial amount
8
9 printf("The initial value is Rs %.2f",P)

```

Scilab code Exa 14.4 Future amount

```

1 clc
2 //given data
3 A=500 // annual amount invested each year in rs
4 i=9 // interest rate in %
5 n=6 // time in years
6
7 F=A*(((1+i/100.0)**n)-1)/(i/100.0) // future amount
   in rs
8
9 printf("The Future amount will be Rs %.0f ",F)

```

Scilab code Exa 14.5 amount deposited each year

```
1 clc
2 //given data
3 F=12000 // Total amount in rs
4 i=9 // interest rate in %
5 n=4 // time in years
6
7 A=F*(i/100.0)/(((1+i/100.0)**n)-1) //
8
9 printf("The amount deposited each year should be Rs
    %i",A)
```

Scilab code Exa 14.6 Amount spent on replacement

```
1 clc
2 //given data
3 A=30000.0 // amount save each year in rs
4 i=10/100.0 // interest rate
5 n=8 // time in years
6
7 P=A*(((1+i)**n)-1)/(i*((1+i)**n)) // amount spent on
    replacement in rs
8 printf("Amount spent on replacement is Rs %i",P)
```

Scilab code Exa 14.7 final amount after 10 years

```
1 clc
2 //given data
```

```

3 i=12/100.0 // interest rate
4 n=10 // time in years
5
6 time=100.0 // days geyser is used in year
7 effi=0.9 // efficiency of geyser
8 w=100.0 // weight of water in kg
9 C=4.2 // heat capacity in kJ/kg-degree C
10 theta=60-15 // temperature difference in C
11 cost=4 // cost of electricity per kWh
12
13 Elec=(1/effi)*w*C*theta/3600.0 // electricity used
    in kWh/day
14
15
16
17 A=Elec*time*cost // annual saving in Rs
18
19 P=A*(((1+i)**n)-1)/(i*((1+i)**n)) // final amount in
    rs
20
21 printf("The final amount after 10 years is Rs %i",P)
22
23 // the answer is slightly different in textbook due
    to approximation while in scilab answers are
    precise
24 end

```

Scilab code Exa 14.8 unit cost of electricity production

```

1 clc
2 // given data
3
4 P=200000.0 //principal value in rs
5 i=10/100.0 // interest rate
6 n=25.0 // time in years

```

```

7 L=2.0 // power produced in kW
8
9 A=P*(i*(1+i)**n)/(-1+(1+i)**n) // annualised capital
    cost in rs
10
11 maintcost=P*0.05 // annual maintainence cost
12 Totalcost=A+maintcost // total annual cost
13
14 Elec=L*0.25*10*365 // annual electricity production
15
16 Cost=Totalcost/Elec // unit cost of electricity
    production
17
18 printf("unit cost of electricity production is Rs %
    .1f",Cost)

```

Scilab code Exa 14.9 present worth

```

1 clc
2 // given data
3
4 G=1 //gradient per period in lakh rs
5 i=12/100.0 // discount rate
6 n=5 // time in years
7 A1=10 // payment at end of 1st year in lakhs rs
8 loan=40 // load applied for in lakhs
9
10
11 AGin=(1/i)-5*1/(-1+(1+i)**n) // gradient to uniform
    series conversion factor
12
13 Ag=A1+G*AGin // in lakhs Rs
14
15 Pg=Ag*(-1+(1+i)**n)/(i*(1+i)**n) // present worth in
    lakhs rs

```

```

16
17 printf( "The present worth is Rs %.2f Lakh",Pg)
18
19 if (Pg*0.85<loan)
20     printf( "\n Loan is not given as amount is less
                than applied for loan")
21
22 else
23 printf( "\n Loan is given" )
24 end

```

Scilab code Exa 14.10 present worth of saving

```

1 clc
2 // given data
3
4 g=0.2 // annual gas price increase rate
5 i=10/100.0 // discount rate
6 n=15 // time in years
7 A1=350*8 // payment at end of 1st year in lakhs rs
8
9 Pgg=(A1/(i-g))*(1-((1+g)/(1+i))**n) // present worth
    in Rs
10
11 printf("The present worth of saving is Rs %.0f",Pgg)

```

Scilab code Exa 14.11 simple payback period

```

1 clc
2 // given data
3 Co=10000 // initial investment in rs
4 B=900.0 // net annual savings per year
5

```

```

6 nsp=Co/B // simple payback period
7
8 printf( "The simple payback period is %0.2f",nsp)
9 if nsp<20
10     printf( "\n proposal may be accepted")
11 else
12     printf( "\n proposal may not be accepted")
13 end

```

Scilab code Exa 14.12 payback period for projects

```

1 clc
2
3 // given data
4
5
6
7 ProjectA=[-2400,600,600,600,600,600]
8 ProjectB=[-2400,800,800,800,800,800]
9 ProjectC=[-2400,500,700,900,1100,1300]
10
11 ProjAcu=zeros(6) // cumulative cash flow for
    project A
12 ProjAcu(1)=ProjectA(1)
13 for i =2:6
14
15     ProjAcu(i)=ProjectA(i)+ProjAcu(i-1)
16
17 end
18
19 ProjBcu=zeros(6) // cumulative cash flow for project
    B
20 ProjBcu(1)=ProjectB(1)
21 for i =2:6
22

```



```

23     ProjBcu(i)=ProjectB(i)+ProjBcu(i-1)
24
25 end
26
27 ProjCcu=zeros(6) // cumulative cash flow for project
    C
28 ProjCcu(1)=ProjectC(1)
29 for i =2:6
30
31     ProjCcu(i)=ProjectC(i)+ProjCcu(i-1)
32 end
33
34
35 printf( "\tProject A\t\tProject B\t\tProject C")
36 printf( "\nyear\tcurrent\tcumulative current
    cumulative current cumulative ")
37 for i =2:7
38
39     printf( "\n %i\t%i\t%.i\t\t %.i\t%.i \t \t%.i \t \
        t%.i",(i-2),ProjectA(i-1),ProjAcu(i-1),
        ProjectB(i-1),ProjBcu(i-1),ProjectC(i-1),
        ProjCcu(i-1))
40 end
41
42
43 for i =1:6
44
45     if ProjAcu(i)==0
46         PA=i-1
47     else
48     end
49 end
50
51 for i =1:6
52
53     if ProjBcu(i)==0
54         PB=i-1
55     else

```

```

56     end
57 end
58
59 for i =1:6
60     if (ProjCcu(i)<0 & ProjCcu(i+1)>0)
61         PC=i-ProjCcu(i)/ProjectC(i+1)-1
62     else
63     end
64 end
65 end
66
67 printf( " \n The payback period for project 1 is %.2
        f \n The payback period for project 2 is %.2f \n
        The payback period for project 3 is %.2f",PA,PB,
        PC)

```

Scilab code Exa 14.13 Net loss

```

1  clc
2  // given data
3
4
5
6  ProjAcu
   =[-2400.0,-1864.0,-1386.0,-959.0,-578.0,-238.0]
   // in Rs
7  ProjBcu=[-2400,-1686,-1048,-479.0,30,484] // in Rs
8  ProjCcu=[-2400,-1954,-1396,-755,-56.0,683] // in Rs
9
10 ProjAdis=[-2400,536,478,427,381,340] // in Rs
11 ProjBdis=[-2400,714,638,569,509.0,454] // in Rs
12 ProjCdis=[-2400,446,558,641,699,738.0] // in Rs
13
14 PA=0
15 PB=0

```

```

16 PC=0
17
18 for i =1:5
19     if ((ProjAcu(i)<0) & (ProjAcu(i+1)>0))
20         PA=(i+1)-ProjAcu(i)/ProjAdis(i+1)-1
21     end
22
23 end
24
25 printf( "\nFor project A")
26 if (PA==0)
27     printf( "\nNet loss , Thus should be rejected")
28 else:
29     printf( "\n%.2f years is payback period",PA)
30 end
31
32 for i =1:5
33
34     if ((ProjBcu(i)<0) & (ProjBcu(i+1)>0))
35         PB=(i)-ProjBcu(i)/ProjBdis(i+1)-1
36     else
37     end
38 end
39
40
41 printf( "\n\nFor project B" )
42
43 if (PB==0)
44     printf( "\nNet loss , Thus should be rejected")
45 else:
46     printf( "\n%.2f years is payback period",PB)
47 end
48 for i =1:5
49
50     if ((ProjCcu(i)<0) & (ProjCcu(i+1)>0))
51         PC=(i)-ProjCcu(i)/ProjCdis(i+1)-1
52     else
53         end

```

```

54 end
55
56 printf( "\n\nFor project C")
57
58 if (PC==0)
59     printf( "\nNet loss , Thus should be rejected")
60 else
61     printf( "\n%.2f years is payback period",PC )
62 end

```

Scilab code Exa 14.14 NPV of Projects

```

1  clc
2  // given data
3
4  i=12.0/100 // interest rate
5  n=5.0 // years
6
7  ProjectA=[-2400,600,600,600,600,600]
8  ProjectB=[-2400,800,800,800,800,800]
9  ProjectC=[-2400,500,700,900,1100,1300]
10
11
12 NPVA=ProjectA(1)+ProjectA(2)*(((1+i)**n) - 1)/(i*(1+
    i)**n)
13
14 printf( "\nNPV of Project A is %.i ",NPVA)
15
16 NPVB=ProjectB(1)+ProjectB(2)*(((1+i)**n) - 1)/(i*(1+
    i)**n)
17
18 printf( "\nNPV of Project B is %.0f ",NPVB)
19
20 ProjectNPVc=0 // cumulative cash flow for project A
21 for i =1:5

```

```

22
23     ProjectNPVc=ProjectNPVc+(-ProjectC(1)+ProjectC(i
        +1))/(1+i)**(i+1)
24 end
25
26
27 printf( "\nNPV of Project C is %.2f ",ProjectNPVc)
28
29 // The answer for project C is wrong in the book

```

Scilab code Exa 14.15 The IRR

```

1  clc
2  // given data
3  Co=20000.0 // cost in Rs
4  B=3000.0 // annual benefit in rs
5  n=15.0 // time in years
6  i=15.0/100 // initial guess for rate
7  NPV=zeros(4)
8
9  NPV(1)=B*((1+i)**n)-1/(i*(1+i)**n)-Co
10 x=1
11 printf( "Iteration no.\t\ti*\t\tNPV(i*)" )
12 while NPV(x)<0
13     x=x+1
14     i=i-0.01
15     NPV(x)=B*((1+i)**n)-1/(i*(1+i)**n)-Co
16 end
17 for z =1:4
18     printf( "\n %i\t\t\t\t %.2f\t\t\t %.0f\t\t ",z
        ,0.15-((z-1)/100.0) ,NPV(z))
19
20 end
21 IRR=i+(i+0.01-i)/(NPV(x)+NPV(x-1)) // using equation
    14.28

```

```

22
23 printf( "\nThe IRR is %.0f %%", IRR*100)
24
25 // the answer is slightly different in textbook due
    to approximation

```

Scilab code Exa 14.16 B minus C for projects

```

1  clc
2  // given data
3
4  i=12.0/100 // interest rate
5  ProjAdisB=[0,536.0,478,427,381,340] // discounted
    benefit for A
6  ProjAdisC=[2400.0,0,0,0,0,0] // discounted cost for
    A
7  ProjBdisB=[0,714.0,638,569,509,454] // discounted
    benefit for B
8  ProjBdisC=[2400.0,0,0,0,0,0] // discounted cost for
    B
9  ProjCdisB=[0,446.0,558,641,699,738] // discounted
    benefit for C
10 ProjCdisC=[2400.0,0,0,0,0,0] // discounted cost for
    C
11
12 BCforA=sum(ProjAdisB)/sum(ProjAdisC) // B minus C
    ratio
13 BCforB=sum(ProjBdisB)/sum(ProjBdisC) // B minus C
    ratio
14 BCforC=sum(ProjCdisB)/sum(ProjCdisC) // B minus C
    ratio
15 printf( "\nB - C for project A is %.1f", BCforA)
16 printf( "\nB - C for project B is %.1f", BCforB)
17 printf( "\nB - C for project C is %.2f", BCforC)

```

Scilab code Exa 14.17 Capital Recovery cost

```
1 clc
2 // given data
3 Co=12000.0 // cost in Rs
4 Ca=200.0 // annual maintainence in Rs
5 C12=3000.0 // replacement cost in 12th year
6 S=1000.0 // salvage value in rs
7 n=20.0 // time in years
8 i=11/100.0 // interest rate
9
10 Cnet=Co-S*(1/(1+i)**n)+Ca*(((1+i)**n)-1)/(i*(1+i)**
    n))+C12*(1/(1+i)**12)
11
12 CR=Cnet*(i*(1+i)**n)/(((1+i)**n)-1)
13
14 printf("The Capital Recovery cost is Rs %.0f",CR)
```

Scilab code Exa 14.18 AE for machines

```
1 clc
2 // given data
3 i=10/100.0 // rate
4 Acost=90000 // cost of A in Rs
5 Bcost=75000 // cost of B in Rs
6 Acashfl=26000 // annual cash flow of A in Rs
7 Bcashfl=26000 // annual cash flow of B in Rs
8 nA=5 // useful life of A in years
9 nB=4 // useful life of B in years
10
11 NPVA=Acashfl*(((1+i)**nA) - 1)/(i*(1+i)**nA) - Acost
    // NPV for A
```

```

12 NPVB=Bcashfl*((1+i)**nB) - 1)/(i*(1+i)**nB)- Bcost
    // NPV for B
13
14 printf( "\nThe NPV for A is Rs %.0f",NPVA)
15
16 printf( "\nThe NPV for B is Rs %.0f",NPVB)
17
18 AEA=i*NPVA/(1-(1+i)**(-nA))
19
20
21 AEB=i*NPVB/(1-(1+i)**(-nB))
22
23 printf( "\nThe AE for A is Rs %.0f",AEA)
24
25 printf( "\nThe AE for B is Rs %.0f",AEB)
26
27 printf( "\nThe machine B will have higher
    profitability")

```

Scilab code Exa 14.19 NPV of dryer

```

1  clc
2  // given data
3
4  Co=120000.0 // cost in Rs
5  N=5 // useful life
6  T=40/100.0 // tax rate
7  i=9/100.0 // interest rate
8  Earning=[33000.0,35000.0,37000.0,39000,41000.0]
9  Depreciate=Co/N // depreciation in Rs
10 pretax=zeros(5)
11 discshfl=zeros(5)
12 for x = 2:6
13     pretax=Earning(x-1)-Depreciate
14     tax=0.4*pretax

```



```

15     ernng=pretax-0.4*pretax
16     cashf=ernng+Depreciate
17     discshfl(x-1)=cashf/(1+i)**(x-1)
18 end
19 netdisctincm=sum(discshfl) // net discount income
    in Rs
20 NPV=netdisctincm-Co // NPV
21 printf( "NPV of dryer is Rs %.2f",NPV)
22
23 // The answer in the book is wrong as the value of
    discounted cashflow is incorrect

```

Scilab code Exa 14.20 The Book value

```

1  clc
2  // given data
3
4  Co=300000 // cost in Rs
5  S=20000.0 // salvage value in Rs
6  N=15 // useful life
7
8  D=(Co-S)/N // Depreciation
9  BV=Co // Book Value
10 for i =1:N
11     BV=BV-D;
12     printf(" The Book value at the end of %i th year
        is Rs %.2f\n",i,BV)
13 end

```
