Scilab Textbook Companion for Non Conventional Energy Resources by B. H. Khan[1]

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June 9, 2015

[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: Non Conventional Energy Resources

Author: B. H. Khan

Publisher: McGraw-Hill

Edition: 2

Year: 2014

ISBN: 9780070142763

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 of Energy Science and Technology

Scilab code Exa 1.1 heat rejected

```
// Given data:
clc
T1=500+273.0 //source temp in kelvin
T2=100+273.0 //sink temperature in kelvin
W=1 // output power in kW

nth=1-(T2/T1) // thermal efficiency

Q1=1/nth // heat supplied in kW

Q2=Q1-W // heat rejected in kW

printf("The heat rejected is %0.2f kW",Q2)

// the answer in book is wrong due to incorrect
   value of T1
```

Scilab code Exa 1.2 least power required

```
// Given data:
clc
T1=40+273.0 // ambient temp in kelvin
T2=-10+273.0 // freezer temp in kelvin
Q2=2 // heat loss rate for freezer in kJ/s

Q1=T1*(Q2/T2) // heat transfer rate in kJ/s

W=Q1-Q2 // work in kW

printf("The least power required is %0.2f kW",W)
```

Scilab code Exa 1.3 Heat abstracted

```
// Given data:
clc
Q1=3e4 // heat required in kJ/h
W=2e3 // work required in kJ/h

Q2=Q1-W // heat abstracted from outside in kJ/h

COP=Q1/(Q1-Q2) // COP of heat pump

printf("Heat abstracted from outside air is %0.2f kJ
    /h \n ",Q2)
printf("COP of heat pump is %d ",COP)
```

Scilab code Exa 1.4 work done

```
// Given data:
clc
```

```
T11=320+273.0 // temp at source 1 in kelvin
Q1=10000.0 // heat transfer rate at source 1 in kJ/
    min
T12=65+273.0 // temp at source 2 in kelvin
Q2=120000.0 //  heat transfer rate at source 2 in kJ
    /min
T2=35+273.0 // temp of surrounding in kelvin

n1=1-(T2/T11) // efficiency by source 1
n2=1-(T2/T12) // efficiency by source 2

W1=Q1*n1 // work at source 1 in kJ/min
W2=Q2*n2 // work at source 2 in kJ/min

printf("The work done at W1 is = %0.2f kJ/min \n ",
    W1)
printf("The work done at W2 is = %0.2f kJ/min \n ",
    W2)
printf("The larger power is provided by source 2")
```

Chapter 2

Energy Conservation

Scilab code Exa 2.1 overall efficiency

```
clc

// Given data:

Hcoal=20.0 // heating value of coal in MJ
W=200.0e3 // weight of coal in kg
E=1.2e6 // Electrical energy generated in MJ
delH=1.6e6 // Heat energy generated in MJ
ne=0.30 // electrical efficiency
nb=0.8 // thermal efficiency

QA=Hcoal*W // total thermal energy input to plant in
    MJ
nco=(E+delH)/QA // efficiency of cogeneration plant
e=E/(E+delH) // electrical fraction

nc=1/((e/ne)+(1-e)/nb) // overall efficiency

printf("The overall efficiency is %0.2f %%",nc*100)
```

Chapter 4

Solar Energy Basics

Scilab code Exa 4.1 radiation angle

```
// given data
clc
n=319 // 15th November
Gama=30 // angle in degree
Beta=45 // angle in degree
phi=18.9  // latitude in degree
solartime=13.5-4*(81.733-72.816)/60 +14.74/60 // in
   hours
delta=23.45*(sin(360.0*(284.0+n)/365.0)) // in
   degree
B=(360.0*(n-81)/364)
E=(9.87*sin(2*B)-7.53*cos(B)-15*sin(B))
w=(solartime-12)*15 // hour angle
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
   )

printf("the angle is %.2f degrees",theta)

```

```

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

Scilab code Exa 4.2 daylight hours

```
// given data
clc
n1=1 // 1st january
n2=182 // july 1

phi=34.083  //  latitude in degree

delta1=23.45*sin((%pi/180)*(360.0*(284.0+n1)/365.0)) // in degree
delta2=23.45*sin(((%pi/180)*360.0*(284.0+n2)/365.0)) // in degree

td1=(2.0/15)*(acos((tan(phi)/tan(delta1)))*180/%pi) // daylight hours for january 1
td2=(2.0/15)*(acos((tan(phi)/tan(delta2)))*180/%pi) // daylight hours for july 1

printf ("daylight hours for january 1 are %.2f hours",td1)
printf (" \n daylight hours for july 1 are %.2f hours",td2)

// the answers are slightly different in textbook due to approximation while here ansers are precise
```

Scilab code Exa 4.3 monthly average

```
// given data
clc

a=0.25 // constant for delhi from table 4.1
b=0.57 // constant for delhi from table 4.1
pi=27.166 // latitute in degrees
n=17 // day
nbar=7 // sunshine hours

dlta=23.45*(sind((360.0*(284.0+n)/365.0))) // in degree

wt=acosd((-tand(pi)*(tand(dlta)))) // hour angle at sunrise
Nbar=(2*(wt)/15.0)// day length

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

Hg=Ho*(a+b*(nbar/Nbar))  // in kj/m^2 per day
printf("The monthly average is %.2f in kj/m^2 per day",Hg)

// the answer in the book is slightly different due to approximations
```

Scilab code Exa 4.4 beam radiation

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

```
KT=Hg/Ho // unitless
Hd=Hg*(1.354-1.570*KT) // in kj/m^2 per day
Hb= Hg-Hd // in kj/m^2 per day

printf("Monthly average of daily diffused is %.2f in
    kj/m^2 per day",Hd)
printf("\n beam radiation is %.2f in kj/m^2 per day"
   ,Hb)

// 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

```
// given data
clc
// most of the data is used is from previous example
   :
phi=27.166 // in degree
n=17 // day
ws=78.66 // degrees
dlta=-20.96 // in degrees
Ho=22926.408 // kj/m^2 per day
Hg=14450.418 // kj/m^2 per day
Hd=5266.2473 // kj/m^2 per day

w=(11.5-12)*15 // in degrees

Io=3600*1.367*(1+0.033*cosd(360*17/365.0))*(cosd((
   phi))*cosd((dlta))*cosd((w))+sind((dlta))*sind((
   phi))

a=0.409+0.5016*sind(ws-60)
b=0.6609-0.4767*sind(ws-60)
```

```
Ig=Hg*(a+b*cosd(w))*Io/Ho // in kJ/m^2-h

printf("The monthly average of hourly global
    radiation is %.2f kJ/m^2-h",Ig)

adash=0.4922+(0.27/(Hd/Hg))
bdash=2*(1-adash)*(sind(ws)-1.7328*cosd(78.66))
    /(1.7328-0.5*sind(2*78.66))


Id=5259.6*(1.2321-0.3983*cosd((w)))*Io/Ho // kJ/m^2-
    h



printf("\n The hourly diffuse radiations are %.2f kJ
    /m^2-h",Id)

// the solution in the textbook is wrong as the
    value of b and bdash are wrong
```

Scilab code Exa 4.6 total radiation

```
// given data
clc
phi=28.58 // in degree
n=135 // may 15
dlta=23.45*sind((360*(284+n)/365.0))

w=(13.5-12)*15 // in degrees
A=3981.6 // in W/m^2 from table 4.2
B=0.177// from table 4.2
C=0.130 // from table 4.2

```

```
costhetaz=cosd(phi)*cosd(dlta)*cosd(w)+sind(dlta)*
   sind(phi)

Ibn=A*exp(-B/0.922)// kJ/m^2-h


Id=C*Ibn // kJ/m^2-h

printf("The diffused radiation is %.2f kJ/m^2-h",Id)
Ib=Ibn*0.922 // in kJ/m^2-h

printf("\n The beam radiation is %.2f kJ/m^2-h",Ib)
Ig=Ib+Id // in kJ/m^2-h

printf("\n The global radiation is %.2f kJ/m^2-h",Ig
   )
```

Scilab code Exa 4.7 Monthly average

```
// given data
clc
phi=28.58 // in degree
B=30 // in degree
n=318 // november 14
Hg=16282.8 // in kJ/m^2-day from Table C1 appendix C
Hd=4107.6 // in kJ/m^2-day from Table C2 appendix C

dlta=23.45*(sind((360.0*(284.0+n)/365.0))) // in
   degrees

ws=acosd(tand(phi)*(atan(dlta))) // hour angle at
   sunrise

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))

Rd=(1+cosd((B)))/2

Rr=0.2*(1-cosd((B)))/2

Ht=((1-(Hd/Hg))*1.56+(Hd/Hg)*Rd + Rr)*Hg
printf("Monthly average total radiation is %.2f kJ/m^2-h",Ht)
```

Chapter 6

Solar Photovoltaic Systems

Scilab code Exa 6.1 fermi level

```
clc
// Given data

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

Scilab code Exa 6.2 optimum wavelength

```
// Given data :
clc
clear
```

```
E =2.42 // Band gap in eV
hc=1.24 // planck's constant * speed of light
// solution
Lambda=1.24/E // in micro-meter usinf eq 6.4

printf( "The optimum wavelength is %.3f micro meter"
   ,Lambda )
```

Scilab code Exa 6.3 number of modules

```
clc
clear
// Given data :

Pout=1*735 // motor power output in W
Peffi=0.85 // motor efficiency
cellarea=9*4*125*125e-6 // area in m^2
Rad=1000 //incident radiation in kW/m^2
celleffi=0.12 // cell efficiency

// soln.
Pin=Pout/Peffi // power req by motor in W
N=Pin/(Rad*cellarea*celleffi) // number of modules

printf("%.f number of modules are required",N)
```

Scilab code Exa 6.4 time required

```
clc
clear
// given:
noMPPTpower=10*8 // power without MPPT in W from fig
    6.25
```

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

Chapter 7

Wind Energy

Scilab code Exa 7.1 Maximum axial thrust

```
// given data
clear
clc
rho=1.226 // air density in kG/m^3
alpha =0.14
H=10.0 // height at which wind speed is given in m
uH=12.0 // speed in m/s
z=100.0 // tower height in m
D=80.0 // diameter  in m
effigen=0.85 // efficiency og generator

A=%pi*(D**2)/4 // area in m^3
u0=uH*(z/H)**alpha // velocity at 100 m in m/s
u1=0.8*u0 // exit velocity in m/s
Po=(A*rho*u0**3)/2 // Total Power in Wind
// Part 1
printf("Total Power in Wind is %0.2f MW \n",Po
    /1000000)

// Part 2
a=(u0-u1)/u0 // interference factor
```

```
Cp=4*a*(1-a)**2 // Power Coefficient
PT=Cp*Po/1000000 // power to turbine in MW

printf("The power extracted by turbine is %0.2f MW \n",PT)

// Part 3
Pelec=effigen*PT // electrical power generated in MW

printf("The Electrical power generated is %0.2f MW \n",Pelec)

// Part 4
FA=4*a*(1-a)*(A*rho*u0**2)/2 // axial thrust in N

printf("The axial thrust is %0.2f N \n",FA)

// Part 5

Fmax=(A*rho*u0**2)/2 // maximum thrust in N
printf("Maximum axial thrust is %0.2f N \n ",Fmax)
```

Scilab code Exa 7.2 maximum output

```
// given data
clear
clc

u0=20.0 // wind speed in m/s
T=273+27.0 // temp in kelvin
P=1.01325e5 // pressure in Pa
R=287.0 // gas constant
r=80/2.0 // radius of rotor in m
w=2*%pi*40/60.0 // rotor speed in rad/s
A=%pi*r**2 // area of rotor in m^2
```

```

// soln:
rho=P/(R*T) // density in Kg/m^3
a=1/3.0 // condition for maximum output
Cpmax=4*a*(1-a)**2 // Power Coefficient
Lambda=r*w/u0 //tip speed ratio

Po=(A*rho*u0**3)/2000000 // Total Power in Wind in W

Tm=Po*r/u0 // Torque in N

Ctmax=Cpmax/Lambda // torque coefficient

Tshmax=Tm*Ctmax // torque at shaft

printf("The torque at shaft for maximum output is %0.2f N",Tshmax)
```

Scilab code Exa 7.3 optimum energy

```
// Given Data
// given data
clear();
clc();
u0=15.0 // wind speed in m/s
R=80/2.0 // radius of rotor in m
n=3 // number of blades

Lambda=4*%pi/n // condition of tip ratio for maximum output

w=Lambda*u0/R // using Eq 7.21 rotor speed in rad/s

N=w*60/(2*%pi) // rotor speed in RPM

```

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

Chapter 8

Biomass Energy

Scilab code Exa 8.1 total volume of digester

```
clc
// given data
Gascook=5*0.227 // gas required for cooking in m^3/
    day
Gaslight=0.126*2*3 // gas required for lighting in m
    ^3/day
Totalgasreq=Gascook+Gaslight // in m^3/day
gasperday=0.34*0.18*7 // in m^3/day

n=1+Totalgasreq/gasperday // no. of cows
printf("The number of cows is %i",n)
cowfeed=7*n // in kg
slurry=cowfeed*2.0/1090 // in m^3
totalslurry=50.0*slurry // in m^3
reqvolume=totalslurry/0.9
printf("\n The total volume of digester is %.2f m^3"
    ,reqvolume)
```

Scilab code Exa 8.2 size of biogas plant

```
clc
// given data
Gaslight=10*0.227*4 // gas required for lighting in m^3/day
Eleccomp=10*250*6*60*60/1000000.0 // electrical energy required by computers in MJ
effith=0.25 // thermal efficieny
efficonv=0.80 // conversion efficiency
Heat=23.0 // heating value of biogas in MJ/m^3
rho=1090.0 // slurry density in kg/m^3
Engineinput=Eleccomp/(effith*efficonv)

energypump=746*2*2*60*60/1000000.0 // mechanical energy required for pumping in MJ
themalinput=energypump/effith  // required thermal input in MJ
totalinput=themalinput+Engineinput // total thermal input required by engine

Volreq=totalinput/Heat // volume required per day in m^3/day
Totalrq=Volreq+Gaslight // total gas required in m^3/day

n=Totalrq/(7*0.18*0.34) // solid mass is 18% and n is number of cows required
n=round(n)
printf("The number of cows is %i",n)
feed=7*n // daily feed in kg
slurry=2*feed // in kg
volslurry=slurry/rho // volume of slurry added per day in m^3
totalvol=50*volslurry/0.9 // total volume for 50 days in m^3 when 90 % is occupied by slurry

printf("\n The size of biogas plant is %.2f m^3", totalvol)
```

Scilab code Exa 8.3 gas holder capacity

```
clc
// given data
Voldaily=1200 // daily production in m^3/day
prodrate=Voldaily/24.0 // gas production rate per hour
consrate=Voldaily/6.0 //gas consumtion rate per hour
Vg1=(consrate-prodrate)*2 // gas holder size required for 2 hours in litres
Vg2=prodrate*9 // gas holder size for 9 hours without consumption in litres
if Vg1>Vg2
    Vgmax=Vg1
else
    Vgmax=Vg2
Vg=Vgmax*1.25 // required gas holder with 25 % safety margin in litres
printf("\n required gas holder size is %.2f litres", Vg)
Capacity=Vg/Voldaily // required gas holder capacity

printf("\n required gas holder capacity is %.2f %%", Capacity*100)
```

Scilab code Exa 8.4 total thermal power

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

```
rho=1090 // slurry density in kg/m^3
effibrnr=0.6 // burner efficiency
Heat=23.0 // heating value of biogas in MJ/m^3

dungprd=drymattrprd*2/0.18 // dung produce in kg/day by 2 cows
slurry=2*dungprd // slurry produce in kg/day
volslurry=slurry/rho // volume of slurry in m^3
totalslurry=30*volslurry // for 30 days slurry in m^3
digestersize=totalslurry/0.85 // in m^3
printf("the volume of digester is %.2f m^3",digestersize)

gasprd=drymattrprd*2*gasyield // gas produced in m^3/day

Energytherm=gasprd*Heat*effibrnr // total thermal energy available in MJ/day


thermalpower=Energytherm*1000000/(24*60*60) // in watts

printf (" \n total thermal power is %.2f W",thermalpower)
```

Chapter 9

Geothermal Energy

Scilab code Exa 9.1.i Heat content

```
clc
// given data
G=39.0 // temperature gradient in K/km.
h2=10.0 // depth in km
rhor=2700.0 // kg/m^3
cr=820.0 // in J/kg-K

h1=120/G // T1-T0=120 K is given
h21=h2-h1 // in km
E0byA=(rhor*(1000**3)*G*cr*h21**2)/2 // in J/km^2 Heat content per square km
printf("The Heat content per square km is %.3e J/km^2",E0byA)
```

Scilab code Exa 9.1.ii average temp after 25 years

```
clc
// given data
```

```
G=39.0 // temperature gradient in K/km.
h2=10.0 // depth in km
rhor=2700.0 // kg/m^3
cr=820.0 // in J/kg-K
QbyA=0.5 //water flow rate in  m^3/sec-km^2
rhow=1000.0 // density of water in kg/m^3
cw=4200.0 // specific heat of water in J/kg-K
h1=120.0/G // T1-T0=120 K is given
h21=h2-h1 // in km
t=25 // time in years

thtao=G*h21/2.0 // in degree K
printf("Useful initial temp  is %.2f degree K",
    thtao)
tau=rhor*cr*h21*(1000**3)/(QbyA*rhow*cw) // in
    seconds
tau=tau/(2*60*60*24*365) // in years
thta=thtao*exp(-t/tau) // in degree Kelvin
printf(" \n Useful average temp after 25 years is %
    .2f degree K",thta)
```

Scilab code Exa 9.1.iii Initial Heat extraction

```
clc
// given data
G=39.0 // temperature gradient in K/km.
h2=10.0 // depth in km
rhor=2700.0 // kg/m^3
cr=820.0 // in J/kg-K

h1=120/G // T1-T0=120 K is given
h21=h2-h1 // in km
E0byA=(rhor*(1000**3)*G*cr*h21**2)/2 // in J/km^2
    Heat content per square km

```

```
thetao=G*h21/2.0 // in degree K
tau=rhor*cr*h21*(1000**3)/(QbyA*rhow*cw) // in seconds
tau=tau/(2*60*60*24*365) // in years
theta=thetao*exp(-t/tau) // in degree Kelvin

Heatinitial=E0byA/(60*60*365*24*tau)/1000000 // intial heat extraction rate in MW /km^2

Heat25=Heatinitial*exp(-t/tau) // heat extraction rate after 25 years in MW /km^2

printf( "Initial Heat extraction rate is %.2f MW/km^2",Heatinitial)

printf(" \n Final Heat extraction rate is %.2f MW/km^2",Heat25)
```

Scilab code Exa 9.2.i heat content

```
clc
// given data
w=0.6 // in km
h2=2.5 // in km
p=5/100.0 // porosity
rhor=3000.0 // density of sediment in kg/m^3
cr=750.0 // specific heat of sediment in J/kg-K
rhow=1000.0 // density of water in kg/m^3
cw=4200.0 // specific heat of water in J/kg-K
G=35.0 // temperature gradient in degree C/km
T1=45.0 // temp 1 in degree celsius
T0=12.0 // temp 2 in degree celsius
Q=0.75 // water extraction rate in m^3/sec-km^2

T2=T0+G*h2 // initial temp in degree celsius
```

```

thetao=T2-T1 // in degree celsius

E0byA=(p*rhow*(1000**3)*cw+(1-p)*rhor*(1000**3)*cr)*
    w*thetao // in J/km^2

printf("The heat content is %.2e J/km^2",E0byA)

// the answer is different in textbook due to wrong
    thetao
```

Scilab code Exa 9.2.ii Time constant

```
clc
// given data
w=0.6 // in km
h2=2.5 // in km
p=5/100.0 // porosity
rhor=3000.0 // density of sediment in kg/m^3
cr=750.0 // specific heat of sediment in J/kg-K
rhow=1000.0 // density of water in kg/m^3
cw=4200.0 // specific heat of water in J/kg-K
G=35.0 // temperature gradient in degree C/km
T1=45.0 // temp 1 in degree celsius
T0=12.0 // temp 2 in degree celsius
Q=0.75 // water extraction rate in m^3/sec-km^2

tau=((p*rhow*cw+(1-p)*rhor*cr)*w*1000**3/(Q*rhow*cw)
    )/(60*60*24*365) // in years

printf("Time constant is %.1f years",tau)

// the answer is different in textbook due to wrong
    calculations
```

Scilab code Exa 9.2.iii power per square km

```
clc
// given data
w=0.6 // in km
h2=2.5 // in km
p=5/100.0 // porosity
rhor=3000.0 // density of sediment in kg/m^3
cr=750.0 // specific heat of sediment in J/kg-K
rhow=1000.0 // density of water in kg/m^3
cw=4200.0 // specific heat of water in J/kg-K
G=35.0 // temperature gradient in degree C/km
T1=45.0 // temp 1 in degree celsius
T0=12.0 // temp 2 in degree celsius
Q=0.75 // water extraction rate in m^3/sec-km^2
T2=T0+G*h2 // initial temp in degree celsius
t=25 // time in years
thetao=T2-T1 // in degree celsius

E0byA=(p*rhow*(1000**3)*cw+(1-p)*rhor*(1000**3)*cr)*
    w*thetao // in J/km^2

tau=((p*rhow*cw+(1-p)*rhor*cr)*w*1000**3/(Q*rhow*cw)
    ) // in seconds
Pperkm2=(E0byA)/(tau*1000000) // initial power per
    square km in MW/km^2
printf("initial power per square km is %.2f MW/km^2"
    ,Pperkm2)
Power20=Pperkm2*exp(-25*60*60*24*365/tau) //  power
    per square km in MW/km^2 after 25 years
printf("\n power per square km in MW/km^2 after 25
    years is %.2f MW/km^2",Power20)

// The answers are slightly different due to error
```

in textbook

Chapter 10

Ocean Energy

Scilab code Exa 10.1 annual average energy generation

```
clc
// given data
R=13.0 // in m
r=3.0 // in m
A=2.0 // area in km^2
ebbcycle=12.42 // in hours
effi=0.7 // efficiency of turbine
g=9.8 // gravitational acceleration in m/sec^2
rho=1025 // density of sea in kg/m^3
Powerpotential=0.225*A*(10**6)*((R**2)-(r**2))/10**6 // power potential in MW

Powergenerated=effi*Powerpotential // in MW

printf("The average power generated by plant is %.2f kWh",Powergenerated)

Energysingle=rho*A*(10**6)*g*((R**2)-(r**2))/(2.0*10**6) // Energy in single emptying in MJ

ebbyear=364.0*24/ebbcycle
```

```

annualenergy=Energysingle*ebbyear*effi*1000/3600.0 // in kWh

printf("\n The annual average energy generation is %.2e kWh",annualenergy)
```

Scilab code Exa 10.2 phase velocity

```
clc
// given data
a=2.0/2 // in m
T=8.0 // in secs
rho=1025.0 // in kg/m^3
w=2*%pi/T // angular frequency in radian/sec
g=9.8 // gravitational acceleration in m/sec^2

Lamda=2*(%pi)*g/(w**2) // in m
printf("wavelength is %.2f m",Lamda)
v=g/w // phase velocity in m/s
printf(" \n phase velocity is %.2f m/s",v)
P=rho*(g**2)*(a**2)*T/(8*%pi*1000) // power in wave in kW/m
printf(" \n power in wave is %.2f kW/m",P)
E=P*8.76  // average annual wave energy in mWh/m

printf("\n average annual wave energy is %.1f mWh/m ",E)
```

Chapter 11

Small Hydro Resources

Scilab code Exa 11.1 power available

```
clc
// given data
rho=996 // density in kg/m^3
effi=0.55 // oveall efficiency
Q=100/1000.0 // discharge in m^3/sec
h=30 // gross head in m
g=9.81 // gravitational acceleration in m/sec^2


Pnet=effi*rho*Q*g*h/1000 // net power in watts
printf("Power available is %.2f kilowatts",Pnet)
```

Scilab code Exa 11.2 required flow rate

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

```
V=230 // voltage of kettle in V
P=500 // power of kettle in W
VA=pf*Load // VA load in kVA
C=4200 // specific heat of water in j/kg-K
T=45-20 // temperature difference in degree celsius

VAR=VA*1.6 // net required VAR rating thus 60% extra capacity

R=(V**2)/P // resistance by kettle in ohms

Po=7*(V**2)/R // power dissipation in W for 7 elements

printf( "7 elements are connected in parallel")

Q=Load*1000.0/(C*T) // flow rate in kg/sec

printf("\n The required flow rate is %.4f litre/sec",Q)
```

Chapter 12

Emerging Technologies

Scilab code Exa 12.1 required heat removal rate

```
clc
// given data
delG=-39.59 // kJ/mol
delH=-56.83 // change in enthalpy in kJ/mol
mdotmethanol=32.0 // in g/s
mdotoxygen=48.0 // in g/s

Wmax=166.3 // -delG in kJ

flowmethanol=mdotmethanol*100*3600/(Wmax*1000) // in
    kg/h
flowoxygen=mdotoxygen*100*3600/(Wmax*1000) // in kg/
   h
printf("The required flow rate of methanol is %.2f
   kg/h",flowmethanol)
printf("\nThe required flow rate of oxygen is %.2f
   kg/h",flowoxygen)
delQ=delH-delG // using eq 12.7

fuelrate=-delQ*19.24/mdotmethanol // in kcal/s

```

```
printf("\nThe required heat removal rate is %.2f
    kcal/s",fuelrate)

// 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

```
clc
// given data
A=0.25 // area in m^2
d=0.5 // distance between electrodes in m
B=1.8 // flux density in Wb/m^2
u=1200.0 // average gas velocity in m/s
sigma=10.0 // mho/m

Vo=B*u*d //  in Volts
Pmax=1*sigma*(u**2)*(B**2)*A*d/(4.0*10**6) //  in MW

printf("Maximum Power output %.3f MW",Pmax)
```

Chapter 14

Financial and Economic Evaluation

Scilab code Exa 14.1 Future value of investment

```
clc
// given data
P=2000 // in rs
i=12 // interest rate in %
n=6 // time in years

F=P*(1+i/100.0)**n // Future value of investment

printf("The amount will be Rs %.0f",F)
```

Scilab code Exa 14.2 number of years

```
clc

// given data

```

```
P=10.0 // in lakh rs
i=12.25 // interest rate in %
F=20 // final amount in lakh rs

n=log(F/P)/log(1+i/100.0) // time in years

printf("The number of years is %.2f years",n)
```

Scilab code Exa 14.3 initial value

```
clc
//given data
F=100000 // final amount in rs
i=6 // interest rate in %
n=10 // time in years

P=F*(1/(1+i/100.0)**n) // initial amount

printf("The initial value is Rs %.2f",P)
```

Scilab code Exa 14.4 Future amount

```
clc
//given data
A=500 // annual amount invested each year in rs
i=9 // interest rate in %
n=6 // time in years

F=A*(((1+i/100.0)**n)-1)/(i/100.0) // future amount
    in rs

printf("The Future amount will be Rs %.0f ",F)
```

Scilab code Exa 14.5 amount deposited each year

```
clc
//given data
F=12000 // Total amount in rs
i=9 // interest rate in %
n=4 // time in years

A=F*(i/100.0)/(((1+i/100.0)**n)-1) //

printf("The amount deposited each year should be Rs
    %i",A)
```

Scilab code Exa 14.6 Amount spent on replacement

```
clc
//given data
A=30000.0 // amount save each year in rs
i=10/100.0 // interest rate
n=8 // time in years

P=A*(((1+i)**n)-1)/(i*((1+i)**n)) // amount spent on
    replacement in rs
printf("Amount spent on replacement is Rs %i",P)
```

Scilab code Exa 14.7 final amount after 10 years

```
clc
//given data
```

```
i=12/100.0 // interest rate
n=10 // time in years

time=100.0 // days geyser is used in year
effi=0.9 // efficiency of geyser
w=100.0 // weight of water in kg
C=4.2 // heat capacity in kJ/kg-degree C
theta=60-15 // temperature difference in C
cost=4 // cost of electricity per kWh

Elec=(1/effi)*w*C*theta/3600.0 // electricity used
    in kWh/day



A=Elec*time*cost // annual saving in Rs

P=A*(((1+i)**n)-1)/(i*((1+i)**n)) // final amount in
     rs

printf("The final amount after 10 years is Rs %i",P)

// the answer is slightly different in textbook due
    to approximation while in scilab answers are
    precise
end
```

Scilab code Exa 14.8 unit cost of electricity production

```
clc
// given data

P=200000.0 //principal value in rs
i=10/100.0 // interest rate
n=25.0 // time in years
```

```
L=2.0 // power produced  in kW

A=P*(i*(1+i)**n)/(-1+(1+i)**n) // annualised capital cost in rs

maintcost=P*0.05 // annual maintainence cost
Totalcost=A+maintcost //  total annual cost

Elec=L*0.25*10*365 // annual electricity production

Cost=Totalcost/Elec // unit cost of electricity production

printf("unit cost of electricity production is Rs %.1f",Cost)
```

Scilab code Exa 14.9 present worth

```
clc
// given data

G=1 //gradient per period in lakh rs
i=12/100.0 // discount rate
n=5 // time in years
A1=10 // payment at end of 1st year in lakhs rs
loan=40 // load applied for in lakhs


AGin=(1/i)-5*1/(-1+(1+i)**n) // gradient to uniform series conversion factor

Ag=A1+G*AGin // in lakhs Rs

Pg=Ag*(-1+(1+i)**n)/(i*(1+i)**n) // present worth in lakhs rs
```

```
printf( "The present worth is Rs %.2f Lakh",Pg)

if (Pg*0.85<loan)
    printf( "\n Loan is not given as amount is less
        than applied for loan")

else
printf( "\n Loan is given" )
end
```

Scilab code Exa 14.10 present worth of saving

```
clc
// given data

g=0.2 // annual gas price increase rate
i=10/100.0 // discount rate
n=15 // time in years
A1=350*8 // payment at end of 1st year in lakhs rs

Pgg=(A1/(i-g))*(1-((1+g)/(1+i))**n) // present worth
    in Rs

printf("The present worth of saving is Rs %.0f",Pgg)
```

Scilab code Exa 14.11 simple payback period

```
clc
// given data
Co=10000 // initial investment in rs
B=900.0 // net annual savings per year

```

```
nsp=Co/B // simple payback period

printf( "The simple payback period is %0.2f",nsp)
if nsp<20
    printf( "\n proposal may be accepted")
else
    printf( "\n proposal may not be accepted")
end
```

Scilab code Exa 14.12 payback period for projects

```
clc

// given data



ProjectA=[-2400,600,600,600,600,600]
ProjectB=[-2400,800,800,800,800,800]
ProjectC=[-2400,500,700,900,1100,1300]

ProjAcu=zeros(6)  // cumulative cash flow for
    project A
ProjAcu(1)=ProjectA(1)
for i =2:6

    ProjAcu(i)=ProjectA(i)+ProjAcu(i-1)

end

ProjBcu=zeros(6) // cumulative cash flow for project
     B
ProjBcu(1)=ProjectB(1)
for i =2:6

```

```
    ProjBcu(i)=ProjectB(i)+ProjBcu(i-1)

end

ProjCcu=zeros(6) // cumulative cash flow for project C
ProjCcu(1)=ProjectC(1)
for i =2:6

    ProjCcu(i)=ProjectC(i)+ProjCcu(i-1)
end


printf("\tProject A\t\tProject B\t\tProject C")
printf("\nyear\tcurrent\tcummulative   current   cummulative   current   cummulative ")
for i =2:7

    printf("\n %i\t%i\t%.i\t\t %.i\t%.i \t \t%.i   \t%.i",(i-2),ProjectA(i-1),ProjAcu(i-1),ProjectB(i-1),ProjBcu(i-1),ProjectC(i-1),ProjCcu(i-1))
end


for i =1:6

    if ProjAcu(i)==0
        PA=i-1
    else
    end
end

for i =1:6

    if ProjBcu(i)==0
        PB=i-1
    else
```

```
    end
end

for i =1:6

    if (ProjCcu(i)<0 & ProjCcu(i+1)>0)
        PC=i-ProjCcu(i)/ProjectC(i+1)-1
    else
   end
end

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

```
clc
// given data



ProjAcu
   =[-2400.0,-1864.0,-1386.0,-959.0,-578.0,-238.0]
   // in Rs
ProjBcu=[-2400,-1686,-1048,-479.0,30,484] // in Rs
ProjCcu=[-2400,-1954,-1396,-755,-56.0,683] // in Rs

ProjAdis=[-2400,536,478,427,381,340] // in Rs
ProjBdis=[-2400,714,638,569,509.0,454] // in Rs
ProjCdis=[-2400,446,558,641,699,738.0] // in Rs

PA=0
PB=0
```

```
PC=0

for i =1:5
     if ((ProjAcu(i)<0) & (ProjAcu(i+1)>0))
        PA=(i+1)-ProjAcu(i)/ProjAdis(i+1)-1
    end

end

printf( "\nFor project A")
if (PA==0)
    printf( "\nNet loss , Thus should be rejected")
else:
    printf( "\n% .2f years is payback period",PA)
end

for i =1:5

    if ((ProjBcu(i)<0) & (ProjBcu(i+1)>0))
        PB=(i)-ProjBcu(i)/ProjBdis(i+1)-1
    else
    end
end


printf( "\n\nFor project B" )

if (PB==0)
    printf( "\nNet loss , Thus should be rejected"
else:
    printf( "\n%.2f years is payback period",PB)
end
for i =1:5

    if ((ProjCcu(i)<0) & (ProjCcu(i+1)>0))
        PC=(i)-ProjCcu(i)/ProjCdis(i+1)-1
    else
        end
```

```
end

printf("\n\nFor project C")

if (PC==0)
    printf("\nNet loss, Thus should be rejected")
else
    printf("\n%.2f years is payback period",PC )
end
```

Scilab code Exa 14.14 NPV of Projects

```
clc
// given data

i=12.0/100 // interest rate
n=5.0 // years

ProjectA=[-2400,600,600,600,600,600]
ProjectB=[-2400,800,800,800,800,800]
ProjectC=[-2400,500,700,900,1100,1300]


NPVA=ProjectA(1)+ProjectA(2)*(((1+i)**n) - 1)/(i*(1+
   i)**n)

printf("\nNPV of Project A is %.i ",NPVA)

NPVB=ProjectB(1)+ProjectB(2)*(((1+i)**n) - 1)/(i*(1+
   i)**n)

printf("\nNPV of Project B is %.0f ",NPVB)

ProjectNPVc=0  // cumulative cash flow for project A
for i =1:5
```

```
    ProjectNPVc=ProjectNPVc+(-ProjectC(1)+ProjectC(i+1))/(1+i)**(i+1)
end


printf("\nNPV of Project C is %.2f ",ProjectNPVc)

// The answer for project C is wrong in the book
```

Scilab code Exa 14.15 The IRR

```
clc
// given data
Co=20000.0 // cost in Rs
B=3000.0 // annual benefit in rs
n=15.0 // time in years
i=15.0/100 // initial guess for rate
NPV=zeros(4)

NPV(1)=B*(((1+i)**n)-1)/(i*(1+i)**n)-Co
x=1
printf("Iteration no.\t\ti*\t\tNPV(i*)")
while NPV(x)<0
    x=x+1
    i=i-0.01
    NPV(x)=B*(((1+i)**n)-1)/(i*(1+i)**n)-Co
end
for z =1:4
    printf("\n %i\t\t       %.2f\t      %.0f\t ",z,0.15-((z-1)/100.0),NPV(z))

end
IRR=i+(i+0.01-i)/(NPV(x)+NPV(x-1)) // using equation 14.28
```

```
printf( "\nThe IRR is %.0f %%",IRR*100)

// the answer is slightly different in textbook due to approximation
```

Scilab code Exa 14.16 B minus C for projects

```
clc
// given data

i=12.0/100 // interest rate
ProjAdisB=[0,536.0,478,427,381,340] // discounted benefit for A
ProjAdisC=[2400.0,0,0,0,0,0] // discounted cost for A
ProjBdisB=[0,714.0,638,569,509,454] // discounted benefit for B
ProjBdisC=[2400.0,0,0,0,0,0]  // discounted cost for B
ProjCdisB=[0,446.0,558,641,699,738] // discounted benefit for C
ProjCdisC=[2400.0,0,0,0,0,0] // discounted cost for C

BCforA=sum(ProjAdisB)/sum(ProjAdisC)  // B mius C ratio
BCforB=sum(ProjBdisB)/sum(ProjBdisC) // B mius C ratio
BCforC=sum(ProjCdisB)/sum(ProjCdisC) // B mius C ratio
printf( "\nB - C for project A is %.1f",BCforA)
printf( "\nB - C for project B is %.1f",BCforB)
printf( "\nB - C for project C is %.2f",BCforC)
```

Scilab code Exa 14.17 Capital Recovery cost

```
clc
// given data
Co=12000.0 // cost in Rs
Ca=200.0 // annual maintainence in Rs
C12=3000.0 // replacement cost in 12th year
S=1000.0 // salvage value in rs
n=20.0 // time in years
i=11/100.0 // interest rate

Cnet=Co-S*(1/(1+i)**n)+Ca*((((1+i)**n)-1)/(i*(i+1)**
   n))+C12*(1/(1+i)**12)

CR=Cnet*(i*(1+i)**n)/(((1+i)**n)-1)

printf("The Capital Recovery cost is Rs %.0f",CR)
```

Scilab code Exa 14.18 AE for machines

```
clc
// given data
i=10/100.0 // rate
Acost=90000 // cost of A in Rs
Bcost=75000 //  cost of B in Rs
Acashfl=26000 // annual cash flow of A in Rs
Bcashfl=26000 // annual cash flow of B in Rs
nA=5 // useful life of A in years
nB=4 // useful life of B in years

NPVA=Acashfl*(((1+i)**nA) - 1)/(i*(1+i)**nA) - Acost
     // NPV for A
```

```
NPVB=Bcashfl*(((1+i)**nB) - 1)/(i*(1+i)**nB)- Bcost
    // NPV for B

printf("\nThe NPV for A is Rs %.0f",NPVA)

printf("\nThe NPV for B is Rs %.0f",NPVB)

AEA=i*NPVA/(1-(1+i)**(-nA))


AEB=i*NPVB/(1-(1+i)**(-nB))

printf("\nThe AE for A is Rs %.0f",AEA)

printf("\nThe AE for B is Rs %.0f",AEB)

printf("\nThe machine B will have higher
    profitability")
```

Scilab code Exa 14.19 NPV of dryer

```
clc
// given data

Co=120000.0 // cost in Rs
N=5 // useful life
T=40/100.0 // tax rate
i=9/100.0 // interest rate
Earning=[33000.0,35000.0,37000.0,39000,41000.0]
Depreciate=Co/N // depreciation in  Rs
pretax=zeros(5)
discshfl=zeros(5)
for x = 2:6
    pretax=Earning(x-1)-Depreciate
    tax=0.4*pretax
```

```
    ernng=pretax-0.4*pretax
    cashf=ernng+Depreciate
    discshfl(x-1)=cashf/(1+i)**(x-1)
end
netdiscntincm=sum(discshfl) // net discount income
   in Rs
NPV=netdiscntincm-Co // NPV
printf( "NPV of dryer is Rs %.2f",NPV)

// The answer in the book is wrong as the value of
   discounted cashflow is incorrect
```

Scilab code Exa 14.20 The Book value

```
clc
// given data

Co=300000 // cost in Rs
S=20000.0 // salvage value in Rs
N=15 // useful life

D=(Co-S)/N // Depreciation
BV=Co // Book Value
for i =1:N
    BV=BV-D;
    printf(" The Book value at the end of %i th year
        is Rs %.2f\n",i,BV)
end
```