Scilab Textbook Companion for High Voltage Engineering Theory and Practice by M. Khalifa[1]

Created by
Divya Nayak
Project Associate
Civil Engineering
Indian Institute of Technology
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 2

Electric Fields

Scilab code Exa 2.5 Chapter 2 example 5

```
//Chapter 2, Example 5, page 65
//Calculate the maximum field at the sphere surface
clc
clear
//Calulating Field at surface E based on figure 2.31 and table 2.3
Q1 = 0.25
e0 = 8.85418*10**-12 //Epselon nought
RV1= ((1/0.25**2)+(0.067/(0.25-0.067)**2)+(0.0048/(0.25-0.067)**2))
RV2= ((0.25+0.01795+0.00128)/(0.75-0.067)**2)
RV= RV1+RV2
E = (Q1*RV)/(4*%pi*e0)
printf("Maximum field = %e V/m per volt",E)

//Answers vary due to round off error
```

Scilab code Exa 2.6 Chapter 2 Example 6

```
//Chapter 2, Exmaple 6, page 66
clc
clear
//calculation based on figure 2.32

//(a)Charge on each bundle
printf("Part a\n")
req = sqrt(0.0175*0.45)
printf("Equivalent radius = %e m \n", req)
V = 400*10**3 //Voltage
H = 12 //bundle height in m
d = 9 //pole to pole spacing in m
e0 = 8.85418*10**-12 //Epselon nought
Hd = sqrt((2*H)^2+d^2)//2*H^2 + d^2
Q = V*2*%pi*e0/(log((2*H/req))-log((Hd/d))
q = Q/2
printf("Charge per bundle = %e uC/m \n",Q) //micro C
    /m
printf("Charge per sunconducter = %e uC/m \n",q) //
    micro C/m

//(b part i)Maximim & average surface feild
printf("\nPart b")
printf("\nSub part 1\n")
r = 0.0175 //subconductor radius
R = 0.45 //conductor to subconductor spacing
MF = (q/(2*%pi*e0))*((1/r)+(1/R)) // maximum feild
printf("Maximum feild = %e kV/m \n",MF)
MSF = (q/(2*%pi*e0))*((1/r)-(1/R)) // maximum
    surface feild
printf("Maximum feild = %e kV/m \n",MSF)
ASF = (q/(2*%pi*e0))*(1/r) // Average surface feild
printf("Maximum feild = %e kV/m \n",ASF)

//(b part ii) Considering the two sunconductors on
    the left
printf("\nSub part 2\n")
//field at the outer point of subconductor #1
```

```
drO1 = 1/(d+r)
dRrO1 = 1/(d+R+r)
EO1 =  MF -((q/(2*%pi*e0))*(drO1+dRrO1))
printf("EO1 = %e kV/m \n",EO1)
//field at the outer point of subconductor #2
drO2 = 1/(d-r)
dRrO2 = 1/(d-R-r)
EO2 =  MF -((q/(2*%pi*e0))*(dRrO2+drO2))
printf("EO2 = %e kV/m \n",EO2)

//field at the inner point of subconductor #1
drI1 = 1/(d-r)
dRrI1 = 1/(d+R-r)
EI1 =  MSF -((q/(2*%pi*e0))*(drI1+dRrI1))
printf("EI1 = %e kV/m \n",EI1)
//field at the inner point of subconductor #2
drI2 = 1/(d+r)
dRrI2 = 1/(d-R+r)
EI2 =  MSF -((q/(2*%pi*e0))*(dRrI2+drI2))
printf("EI2 = %e kV/m \n",EI2)

//(part c)Average of the maximim gradient
printf("\nPart c\n")
Eavg = (EO1+EO2)/2
printf("The average of the maximum gradient = %e kV/m \n",Eavg)


//Answers might vary due to round off error
```

Scilab code Exa 2.7 Chapter 2 Example 7

```
//Chapter 2, Exmaple 7, page 69
//Electric feild induced at x
clc
```

```
clear
e0 = 8.85418*10**-12 //Epselon nought
q = 1 // C/m
C = (q/(2*%pi*e0))
//Based on figure 2.33
E = C-(C*(1/3+1/7))+(C*(1+1/5+1/9))+(C*(1/5+1/9))-(C
    *(1/3+1/7))
printf("Electric Feild = %e V/m \n",E)

//Answers might vary due to round off error
```

Scilab code Exa 2.8 Chapter 2 Example 8

```
//Chapter 2, Exmaple 8, page 70
//Calculate the volume of the insulator
clc
clear
//Thinkness of graded design
V = 150*sqrt(2)
Ebd = 50
T = V/Ebd
printf("\nThickness of graded design= %e cm \n",T)
//Based on figure 2.24
r = 2 // radius of the conductor
l = 10 //length of graded cylinder; The textbook
    uses 10 instead of 20
zr = l*(T+r)
printf("Curve = %e cm^2 \n",zr)
//Volume of graded design V1
V1 = 4*%pi*zr*(zr-r)
printf("V1 = %e cm^3 \n",V1) //Unit is wrong in the
    textbook
//Thickness of regular design as obtained form Eq
    .2.77
pow = V/(2*Ebd)
```

```
t = 2*(%e^pow-1)
printf("Thickness of regular design = %e cm \n",t)
//Volume of regular design V2
V2 = %pi*((2+t)^2-4)
printf("V2 = %e cm^3 \n",V2)//unit not mentioned in
    textbook

//Answers may vary due to round off error
```

Scilab code Exa 2.11 Chapter 2 Example 11

```
//Chapter 2, Exmaple 11, page 75
//Calculate the potential within the mesh
clc
clear
//Based on figure 2.38(b)
//equations are obtained using Eq.2.46
A1 = 1/2*(0.54+0.16)
A2 = 1/2*(0.91+0.14)
S = [0.5571 -0.4571 -0.1;-0.4751 0.828 0.3667;-0.1
    0.667 0.4667]
//By obtaining the elements of the global stiffness
    matrix(Sadiku,1994)
//and by emplying the Eq.2.49(a)
S1 = [1.25 -0.014;-0.014 0.8381]
S2 = [-0.7786 -0.4571;-0.4571 -0.3667]
Phi13 = [0 ;10]
val1 = S2*Phi13
Phi24 = S1\val1
disp(-Phi24,"The values of Phi2 and Phi4 are:")

//Answers may vary due to round of error
```

Chapter 3

Ionization and Deionization Process in Gasses

Scilab code Exa 3.1 Chapter 3 Example 1

```
//Chapter 3, Exmaple 1, page 103
//Movement of oxygen molecule
clc
clear
//using equation 3.3
R = 3814 // J/Kg.mol.K
T = 300 // K
M = 32 // mol^-1
V2 = 3*R*(T/M)
V = sqrt(V2)
printf("Velocity of Oxygen (O2)= %d m^2/s^2\n",V2)
//Since Oxygen is a diatomic gas
printf("Velocity of Oxygen (O)= %d m/s",V)
//Velocity of oxygen is about 300 m/s

//Answer given in the textbook is wrong
```

Scilab code Exa 3.2 Chapter 3 Example 2

```
//Chapter 3, Exmaple 2, page 104
//Kinetic energy of oxygen molecule
clc
clear
//from Eq.3.2
G = (2*10**-3/32)*(8314*298*1.01*10**5)*10**-10
printf("\nG = %e m^3\n",G) // Answer is is wrong in
    the text
//From equation 3.1
mv2 = 3/2*1.01*10**5 // 1/2*m0*v^2
KE = mv2*G//total transalational K.E
printf("K.E = %f J\n",KE)
//Answer may varry due to round off error
```

Scilab code Exa 3.3 Chapter 3 Example 3

```
//Chapter 3, Exmaple 3, page 104
//Maximum pressure in the chamber
clc
clear
//Making use of equation 3.10
N1 = (4*%pi*1.7*1.7*0.10*10^-10*10^-10)
N = 1/N1
//Using equation 3.2
R = 8314 // J/Kg*mol*K
M = 28 // Mol^-1
N = 220*10**-8 // Kg
T = 300 // K
p =  N/M*R*T
printf("\nN = %e ",N1) // answer mentioned in the
    tectbook is wrong
printf("\nPressure = %f N/m^2",p)

```

```
//Answer vary due to round off error
```

Scilab code Exa 3.4 Chapter 3 Example 4

```
//Chapter 3, Exmaple 4, page 105
//Temperature & Average K.E of He atom
clc
clear
m0 = 1
v2 = 1.6*10**-19 // V^2
KE = m0*v2
//Using equation 3.3
T = 2*KE/(3*1.38*10**-23)
printf("\nK.E = %e J",KE)
printf("\nTemperature = %e K",T)
```

Scilab code Exa 3.5 Chapter 3 Example 5

```
//Chapter 3, Exmaple 5, page 105
//Volume of Helium
clc
clear
// Using equation 3.2
G = (1*8314*273)/(2.016*1.01*10**5)
printf("\nVolume of He = %f m^3",G)

//Answer may vary due to round off error.
```

Scilab code Exa 3.6 Chapter 3 Example 6

```
//Chapter 3, Exmaple 6, page 105
//Determine mean free path
clc
clear
//(a) Mean free path
na = %e^-1
//(b) 5 times mean free path
nb = %e^-5
printf("\n Mean free path = %f*n0 ",na)
printf("\n 5 times mean free path = %f*n0 ",nb)

//Answer may vary due to round of error
```

Scilab code Exa 3.7 Chapter 3 Example 7

```
//Chapter 3, Exmaple 7, page 105
//Mean square velocity of Helium
clc
clear
//based on equation 3.2 and 3.3 we derive the gas
    density
N = 178*10**-3 // kg/m^3
// calculating mean square velocity
v2 = (3*1.01*10**5)/N
printf("\nV^2 = %e m^2/s^2",v2)
v = sqrt(v2)
printf("\nMean square velocity = %f m/s",v)

//Answer may vary due to round off error
```

Scilab code Exa 3.8 Chapter 3 Example 8

```
//Chapter 3, Exmaple 8, page 106
```

```
//Energy of free electron
clc
clear
//Using equation 3.3
mv2 = (3/2*1.38*10**-21*293) // 1/2*m*v^2
E = mv2*10**38/1.6*10**-19
printf("\n1/2*m*v^2 = %e J",mv2)
printf("\nEnergy of free electron = %f eV",E)

//Answers may vary due to round off error
```

Scilab code Exa 3.9 Chapter 3 Example 9

```
//Chapter 3, Exmaple 9, page 106
//Average separation and volume occupied by one atom
clc
clear
NA = 6.0244*10**23
NoA = NA*0.075 // Number of atoms/cm^3
V = 1/NoA // Average volume occupied by one atom
S = nthroot(V,3) //  Average separation between atoms
printf("\nNumber od atoms per cm^3 = %e ",NoA)
printf("\nAverage vloume occupied by one atom = %e cm^3",V)
printf("\nAverage separation between atoms = %e cm",S)


//Answers may vary due to round off error
```

Scilab code Exa 3.10 Chapter 3 Example 10

```
//Chapter 3, Exmaple 10, page 106
//KE and velocity of photoelectron
clc
clear
h = 4.15*10**-15
c = 3*10**8
l = 200*10**-10
BE = 13.6 // Binding energy
PE = h*c/l
KE = PE-BE // Kinetic energy of photoelectron
Ve = sqrt((2*KE*1.6*10**-19)/9.11*10**-31)*10**31
printf("\nPhoton energy eV = %e ",PE)
printf("\nKinetic energy eV = %e ",KE)
printf("\nVelocity m/s = %e ",Ve)

//Answer may vary due to round off error
```

Scilab code Exa 3.11 Chapter 3 Example 11

```
//Chapter 3, Exmaple 11, page 107
//Find the absorption coefficient
clc
clear
// Using equation 3.20
x = 20
I0 = 6
Mu = -1/x*log(1/I0)
printf("\nLiquid photon absorption coefficient cm^-1
    = %e ",Mu)

//Answer may vary due to round off error
```

Scilab code Exa 3.12 Chapter 3 Example 12

```
//Chapter 3, Exmaple 12, page 107
//Binding energy
clc
clear
h = 4.15*10**-15
c = 3*10**8
Imax = 1000*10**-10
We = h*c/Imax
printf("\nBinding Energy = %e eV ",We)

//Answer may vary due to round off errorS
```

Scilab code Exa 3.14 Chapter 3 Example 14

```
//Chapter 3, Exmaple 14, page 108
//Diameter of argon atom
clc
clear
//As derived from example 13
N = (1.01*10**5/760)/(1.38*10**-23*273)
printf("\nN = %e atoms/m^3 ",N)
//Use equation 3.10
ra = sqrt((85*10^2/(%pi*3.527*10**22)))
printf("\nra = %e m ",ra)

//Answer may vary due to round off error
```

Scilab code Exa 3.15 Chapter 3 Example 15

```
//Chapter 3, Exmaple 15, page 109
//Mobility of electrons
clc
clear
```

```
Ie = 3
d = 0.8
A = 8*10**-4
Vne = 20*10**17 //V*ne
e = 1.6*10**-19
ke = (Ie*d)/(A*Vne*e)
printf("\Mobility of electrons = %d m^2/s*V ",ke)

//Answer may vary from the text
```

Scilab code Exa 3.17 Chapter 3 Example 17

```
//Chapter 3, Exmaple 17, page 110
//Determine the ion density
clc
clear
//Based on equation 3.50 and 3.52
nplus = 10**11*%e
    **(-1.6*10**-19*5*0.02/(1.38*10**-23*293))
nminus = 10**11*%e
    **(-1.6*10**-19*5*-0.02/(1.38*10**-23*293)) //
    textbook uses 0.02 inseatead of -0.02. In the
    program I have used -0.02
printf("\n+(0.02) = %e ions/m^3 ",nplus)
printf("\n+(-0.02) = %e ions/m^3 ",nminus)

//answers may vary due to round off error
```

Scilab code Exa 3.18 Chapter 3 Example 18

```
//Chapter 3, Exmaple 18, page 110
//Determine the diameter
clc
```

```
clear
//Based on the equation 3.40
k = 1.38*10**-23
T = 293
z2z1 = 0.05
e = 1.6*10**-19
E = 250
r1 = 0.09*10**-6
r1r2 = (6*k*T*z2z1)/(e*E)
r2 = sqrt(r1+r1r2)
printf("\n r1^2-r2^2 = %e ",r1r2)
printf("\n r2 = %e m ",r2)

//answers may vary due to round off error
```

Scilab code Exa 3.19 Chapter 3 Example 19

```
//Chapter 3, Exmaple 19, page 111
//Determine mean free path and ionization
clc
clear
//(a)Mean free path
//Based on equation 3.14 and 3.15
lambda = 1/(9003*0.5)
//(b)Ionization potential
Vi = 256584/9003
printf("\n lambda = %e m ",lambda)
printf("\n Vi = %f V ",Vi)

//answers may vary due to round off error
```

Chapter 4

Electrical Breakdown of Gasses

Scilab code Exa 4.1 Chapter 4 Example 1

```
//Chapter 4, Exmaple 1, page 139
//Claculate alpha and No. of electrons emmited
clc
clear
//Claculate (a)alpha
d2 = 0.01
d1 = 0.005
I2 = 2.7*10**-7
I1 = 2.7*10**-8
alpha = 1/(d2-d1)*log(I2/I1)
//(b)number of electrons emmited from cathode per
    second
I0 = I1*%e**(-alpha*d1)
n0 = I0/(1.6*10**-19)
printf("\n Part (a)\n alpha = %f m^-1",alpha)
printf("\n Part (b)\n I0 = %e ",I0)
printf("\n No of electrons emitted = %e electrons/s"
    ,n0)
//Answer may vary due to round off error
```

Scilab code Exa 4.2 Chapter 4 Example 2

```
//Chapter 4, Exmaple 2, page 140
//Claculate electrode space
clc
clear
//based on the values of example 1
d2 = 0.01
d1 = 0.005
I2 = 2.7*10**-7
I1 = 2.7*10**-8
a = 1/(d2-d1)*log(I2/I1) // alpha
//10^9 = %e^a(a*d)
//multiplying log on bith sides log(10^9) = a*d
ad = log(10^9)
printf("\n a*d = %f ",ad)
d = ad/a
printf("\n electrode space = %f m",d)

//Answers may vary due to round off error
```

Scilab code Exa 4.3 Chapter 4 Example 3

```
//Chapter 4, Exmaple 3, page 140
//Claculate size of developed avalanche
clc
clear
a = 4*10**4
b = 15*10**5
//Rewriting equation 4.2
x0=0;x1=0.0005;
X=integrate('a-b*sqrt(x)','x',x0,x1);
```

```
As = exp(X) // Avelanche size
printf("\n Avalanche size = %f m",As)

//Answers may vary due to round of error
```

Scilab code Exa 4.4 Chapter 4 Example 4

```
//Chapter 4, Exmaple 4, page 141
//Claculate distance to produce avalanche
clc
clear
//Rewrite equation 4.2
//using the values of a and b from previous example
//convert integartion to quaderatic equation form
x=poly(0,"x");
p=59.97-4*10**4*x+7.5*10**5*x^2 // making the polinomial equation
r= roots(p) //obtaining the roots
printf("\n %f m or %f m away from the cathode",r(1),r(2))

//Answer may vary due to round of error.
```

Scilab code Exa 4.5 Chapter 4 Example 5

```
//Chapter 4, Exmaple 5, page 141
//Claculate minimum distance to produce avalanche of size 10^19
clc
clear
//Rewriting equation 4.2 and converting it into quadratic equation
x=poly(0,"x");
```

```
p=43.75-4*10**4*x+7.5*10**5*x^2 // making the polinomial equation
r= roots(p) //obtaining the roots
printf("\n Minimum distance = %f m",r(2)) // other root is disregarded

//Answer may vary due to round of error.
```

Scilab code Exa 4.7 Chapter 4 Example 7

```
//Chapter 4, Exmaple 7, page 142
//Claculate secondary coefficient
clc
clear
//Using equation 3.15
E = 9*10**3/0.002
T = 11253.7 // m^-7*kPa^-1
B = 273840 // V/mkPa
p = 101.3 // kPa or 1 atm
d = 0.002 // m
alpha = p*T*exp(-B*p/E)
Y = 1/(exp(alpha*d)-1)
printf("\n E = %e V/m",E)
printf("\n Alpha = %f m^-1",alpha)
printf("\n Total secondary coefficient of ionization = %f ",Y)

//Answer may vary due to round off error
```

Scilab code Exa 4.8 Chapter 4 Example 8

```
//Chapter 4, Exmaple 8, page 143
```

```
//Claculate first and secondary ionization coefficient
clc
clear
//(a)first ionization coefficient
//Using equation 4.7a
d1 = 0.005
a1d1 = log(1.22)
a1 = a1d1/d1

d2 = 0.01504
a2d2 = log(1.82)
a2 = a2d2/d2

d3 = 0.019 // wrong value used in the text
a3d3 = log(2.22)
a3 = a3d3/d3

printf("\n Alpha 1 = %f m^-1",a1)
printf("\n Alpha 2 = %f m^-1",a2)
printf("\n Alpha 3 = %f m^-1",a3)
printf("\n From the above results we can understand that ionization mechanism must be acting at d3 ")

//secondary ionization coefficient
I = 2.22
e = exp(a1*d3)
Y = (I-e)/(I*(e-1))
printf("\n secondary ionization coefficient = %f ",Y)

//Answer may vary due to round off error.
```

Scilab code Exa 4.9 Chapter 4 Example 9

```
//Chapter 4, Exmaple 9, page 144
//Claculate distance and voltage
clc
clear
a = 39.8 // alpha
Y = 0.0354 // corfficient
p = 0.133 // kPa
Ep = 12000 // E/P , unit : V/m*kPa

d = (1/a)*(log(1/Y + 1)) // distance
E = Ep*p
V = E*d

printf("\n Distance = %f m",d)
printf("\n E = %f V/m",E)
printf("\n Volatge  = %f V",V)

//Answers may vary due to round off error
```

Scilab code Exa 4.10 Chapter 4 Example 10

```
//Chapter 4, Exmaple 10, page 144
//Claculate (a)Raether's criterion (b)Meek and Lobe'
    s criterion
clc
clear
//(a)Raether's criterion
// as assumed by Raether and based equation 3.3,
    3.50, 4.22 and 4.23
d = 0.001 // m
alpha = 10792.2 // m^-1
p = 101.3 //kPa^-1
ap = 106.54 // alpha/p Unit: m^-1*kPa^-1
T = 11253.7 // m^-1*kPa^-1
B = 273840 // V/m*kPa
```

```
Ep = 58764.81 // E/p Unit:V/m*kPa

ad = 17.7 + log(d)
E = Ep*p
Vs = E*d*10^-3 //Voltage breakdown
printf("\n E = %e V/m",E)
printf("\n Voltage breakdown = %f kV",Vs)

//(b)Meek and Loeb's criterion
//Using equation 4.11 and based on 4.24 & 4,25
//+ we get Er = 468*10^4 V/m
Er = 468*10^4 // V/m
Vs2 = Er*0.001*10^-3
printf("\n Voltage breakdown = %f kV",Vs2)

// Answers may vary due to round of error
```

Scilab code Exa 4.11 Chapter 4 Example 11

```
//Chapter 4, Exmaple 11, page 146
//Claculate the first Townsend's ionization
   coefficient
clc
clear
t = 0.2*10**-6 // transit time of electrons in
   seconds
d = 0.05 // m
ve = d/t
TC = 35*10**-9 // Time constant
a = 1/(ve*TC)
printf("\n Electron drift velocity = %e m/s",ve)
printf("\n alpha = %e m^-1",a)

// Answers may vary due to round of error
```

Scilab code Exa 4.12 Chapter 4 Example 12

```
//Chapter 4, Exmaple 12, page 146
//Travel time and maximum frequency
clc
clear
//(a)Determine the travel time
Ea = 200*sqrt(2)*10**3/0.1
x = 1.4*10**-4*2828.4*10**3/(2*%pi*50)
d = 0.1
printf("\n Ea = %e V/m",Ea)
printf("\n x = %f*sin(3.14*t)",x)
//obtaining t from x
t = asin(d/x)/3.14
printf("\n t = %f ms",t) // answer mentioned in the
    text is wrong
//(b)Determine the maximum frequency
k = 1.4*10**-4
fmax = k*Ea/(2*%pi*d)
printf("\n fmax = %f Hz",fmax)

//Answer may vary due to round off error
```

Chapter 5

The Corona discharge

Scilab code Exa 5.2 Chapter 5 Example 2

```
//Chapter 5, Exmaple 2, page 173
//Calculate breakdown voltage
clc
clear
//(a)Based on equation 4.13
p = 101.3 // kPa
Ep = 2400.4/0.027
E = p*Ep
d = 1*10**-3 // 1 mm
Vs1 = E*d
printf("\n Part (a): based on equation 4.13")
printf("\n Breakdown voltage = %f V or %f kV",Vs1,
   Vs1*10^-3)

//(b)Corrsponding to an avelanche size of 10^8
p = 101.3 // kPa
Cp = Ep*0.027*p
Vs2 = (18.42 + (Cp*10**-3))/0.027
printf("\n Part (b):Corrsponding to an avelanche
   size of 10^8")
printf("\n Breakdown voltage = %f V or %f kV",Vs2,
```

```
Vs2*10^-3)

//(b)According to criteria expressed by Equations 5.4 and 5.5
p = 101.3 // kPa
Vs3a = 9.4
Vs3b = 9.2
printf("\n Part (c):According to criteria expressed by Equations 5.4 and 5.5")
printf("\n Breakdown voltage = %f kV or %f kV",Vs3a,Vs3b)

//Answer may vary due to round off error
```

Scilab code Exa 5.3 Chapter 5 Example 3

```
//Chapter 5, Exmaple 3, page 174
//Calculate breakdown voltage at atm pressure 3 and 5
clc
clear
//(a)Based on equation 5.14
p = 101.3 // kPa
Ep = 2400.4/0.027
E = p*Ep
d = 1*10**-3 // 1 mm
Vs13 = E*d*3 // at 3 atm
Vs15 = E*d*5 // at 5 atm
printf("\n Part (a): based on equation 5.14")
printf("\n Breakdown voltage = %f kV or %f kV",Vs13*10^-3,Vs15*10^-3)

//(b)According to eqution 5.13
p = 101.3 // kPa
Cp3 = Ep*0.027*p*3 // at 3 atm
```

```
Vs23 = (18.42 + (Cp3*10**-3))/0.027
Cp5 = Ep*0.027*p*5 // at 5 atm
Vs25 = (18.42 + (Cp5*10**-3))/0.027
printf("\n Part (b):According to eqution 5.13")
printf("\n Breakdown voltage = %f V or %f kV",Vs23
    *10^-3,Vs25*10^-3)

//(b)According to criteria expressed by Equations
    5.4 and 5.5
p = 101.3 // kPa
Vs3a = 27.73 // at 3 atm
Vs3b = 45.5 // at 5 atm
printf("\n Part (c):According to criteria expressed
    by Equations 5.4 and 5.5")
printf("\n Breakdown voltage = %f kV or %f kV",Vs3a,
    Vs3b)

//Answer may vary due to round off error
```

Scilab code Exa 5.8 Chapter 5 Example 8

```
//Chapter 5, Exmaple 8, page 179
//Calculate corona onset voltage
clc
clear
s = 4 // cm
r = 1 // cm
D = 5*10^2 // cm
dt = 1
E0 = 30*dt*(1 + 0.3*sqrt(dt*r))
printf("\n E0 = %f kVpeak/cm",E0)
//using equations (5.18), the positive and negative
    corona
En = 27.501 // kVpeak/cm
//part a
```

```
Vp1 = 6.2*E0
Vn1 = 6.2*En
printf("\n Part (a)")
printf("\n The postive corona = %f kVpeak",Vp1)
printf("\n The negative corona = %f kV",Vn1)
//part b
Vp2 = 8.32*E0
Vn2 = 8.32*En
printf("\n Part (b)")
printf("\n The postive corona = %f kVpeak",Vp2)
printf("\n The negative corona = %f kV",Vn2)
//part c
Vp3 = 9.97*E0
Vn3 = 9.97*En
printf("\n Part (c)")
printf("\n The postive corona = %f kVpeak",Vp3)
printf("\n The negative corona = %f kV",Vn3)
//part d
Vp4 = 11.39*E0
Vn4 = 11.39*En
printf("\n Part (d)")
printf("\n The postive corona = %f kVpeak",Vp4)
printf("\n The negative corona = %f kV",Vn4)

//Answer CONSIDERABLY vary due to round off error.
```

Scilab code Exa 5.9 Chapter 5 Example 9

```
//Chapter 5, Exmaple 9, page 180
//Calculate corona onset voltage
clc
clear
t = 5*5*8.66 // the three side of the trangle in m
Deq = nthroot(t,3)
dt = 1 //delta = 1 at standard temperature and
```

```
    pressure
r = 1 //radius of the conductor
En = 27.501 // kVpeak/cm
E0 = 30*dt*(1 + 0.3*sqrt(dt*r))
V0peak = E0*log(Deq*10**2)
V0 = En*log(Deq*10**2)

printf("\n Mean geometric distance between the
    conductors %f m",Deq)
printf("\n E0 = %f kVpeak/cm",E0)
printf("\n V0peak = %f kVpeak",V0peak)
printf("\n V0 = %f kV",V0)

//Answers may vary due to round off error
```

Scilab code Exa 5.10 Chapter 5 Example 10

```
//Chapter 5, Exmaple 10, page 180
//Calculate corona power loss
clc
clear
p = 75 // pressure
t = 35 // temprature
m1 = 0.92
m2 = 0.95
t = 5*5*8.66 // the three side of the trangle in m
Deq = nthroot(t,3)
dt = (3.92*p)/(273+t) //Relative air density
E0 = 30*dt*(1 + 0.3*sqrt(dt))*m1*m2
En = 27.501 // kVpeak/cm
Vph = (275*10^3)/sqrt(3)
V0peak = E0*log(Deq*10**2)
V0 = En*log(Deq*10**2)
V0ratio = 275/V0
printf("\n Reative air density %f ",dt)
```

```
printf("\n Corona onset field = %f kVpeak/cm",E0)
printf("\n V0peak = %f kVpeak",V0peak)
printf("\n V0 = %f kV",V0)
printf("\n Ration of V0 = %f ",V0ratio)
K = 0.05 // K factor
Pc = (3.73*K*50*Vph^2)/(Deq*10**2)^2
Cc = Pc*10^3/Vph
printf("\n Corona power loss Pc = %f kW/km",Pc*10**-5)
printf("\n Corona current = %f mA/Km",Cc*10^-2)

//Answer vary due to round off error
//Some of the answers provided in the textbook are wrong
```

Scilab code Exa 5.11 Chapter 5 Example 11

```
//Chapter 5, Exmaple 11, page 180
//Calculate corona onset voltage and effective corona envelope
clc
clear
//(a) corona onset voltage
r = 3.175 // cm
h = 13 // m
m= 0.9 // m1 and m2
dt = 1 // Relative air density
E0 = 30*dt*(1 + 0.3/sqrt(r))*m*m
V0 = 20*r*log(2*h*10^2/r)
printf("\n E0 = %f kVpeak/cm or 20 kV/cm",E0)
printf("\n V0 = %f kV",V0)
printf("\n V0 (line to line) = %f kV",V0*sqrt(3))

//(b)Corona envelope at 2.5 p.u
V = 2.5*525 // line to line voltage * 2.5
```

```
printf("\n Voltage (line to line) = %f kV",V)
//Solving the equations in trila and error method
printf("\n Envelope radius = 5 cm")

// Answers may vary due to round off error.
```

Chapter 12

High Voltage Cables

Scilab code Exa 12.1 Chapter 12 Example 1

```
//Chapter 12, Exmaple 1, page 403
//Calculate radial thickness of insulating layer
clc
clear
//based on equation 12.15 and v1alues of E1 and E2
E1 = 40 // kV/cm
E2 = 25 // kV/cm
ep1 = 6 // permittives of the material
ep2 = 4 //permittives of the material
d1 = 4 // cm
d2 = 10 // cm
r1 = 2 // cm
r2 = (E1*ep1*2)/(E2*ep2)
inner = r2-(d1/2)
outer = (d2/2)-r2
//based on equation 12.16
V1peak = E1*r1*log(r2/r1) // inner dielectric
V2peak = E2*r2*log(d2/(2*r2)) // outter dielectric
Vcab = V1peak+V2peak // Peak volatge of cable
rms = Vcab/sqrt(2)
printf("\n Radius = %f cm ",r2)
```

```
printf("\n Inner radial thickness = %f cm ",inner)
printf("\n Outer radial thickness = %f cm",outer)
printf("\n Vpeak of outer dielectric = %f kV",
    V1peak)
printf("\n Vpeak of inner dielectric = %f kV",
    V2peak)
printf("\n Peak voltage of cable = %f kV", Vcab)
printf("\n Safe opearating voltage = %f kV", rms)

// Answers may vary due to round off error.
```

Scilab code Exa 12.2 Chapter 12 Example 2

```
//Chapter 12, Exmaple 2, page 404
//Calculate optimum value of r
clear
clc
//Based on equation 12.17
V1 = 100 // kV
V2 = 55 // kV
r = V1*sqrt(2)/V2
printf("\n Radius = %f cm ",r)

// Answers may vary due to round off error
```

Scilab code Exa 12.3 Chapter 12 Example 3

```
//Chapter 12, Exmaple 3, page 406
//Calculate resistivity
clear
clc
l = 10^4 // cable length in m
Rr = 3/1.5 // R/r ratio
```

```
ins = 0.5*10**6 // insulation in ohms
p = 2*%pi*l*ins/log(Rr)
printf("\n Resistivity of insulation material = %e
   ohm/m ",p)

// Answers may vary due to round off error
```

Scilab code Exa 12.4 Chapter 12 Example 4

```
//Chapter 12, Exmaple 4, page 406
//Calculate resistivity
clear
clc
// Baased on Equation 12.1*10**2
c4 = 0.5*10**2/10 // micro F
Ic = 2*10**4*2*%pi*5*50*10**-6/sqrt(3)
C = (sqrt(3)*10000*Ic)*(10**-9*10**6)
printf("\n C4 = %f mircoF ",c4)
printf("\n Line charging current = %f A ",Ic)
printf("\n Charging = %f kVA ",C)

// Answers may vary due to round off error
```

Scilab code Exa 12.5 Chapter 12 Example 5

```
//Chapter 12,Example 5, page 408
//Calculate capasitance and kVAr
clear
clc
//(a) Using the notations used in FiVgs. 12.15 and
    12.16
C2 = 0.75/3 // microF/km
C3 = (0.6*3-2*C2)/2 // microF/km
```

```
C4 = (C2+C3)/2 // microF/km
printf("\n C2 = %f mircoF/Km ",C2)
printf("\n C3 = %f mircoF/Km ",C3)
printf("\n C4 = %f mircoF/Km ",C4)
//(b)Capacitance of 10 km between 2 cores
V = 33*10**3
w = 2*%pi*50
C = 2*V^2*w*C4*10*10**-9
printf("\n Carging = %f kVAr ",C)

// Answers may vary due to round of errors.
```

Scilab code Exa 12.6 Chapter 12 Example 6

```
//Chapter 12,Example 6, page 409
//Determine the efective electrical parameters
clear
clc
rc = 0.0875*(1+0.004*50) // conductor resistance in
    ohm/km
Rc = 0.105*85 // ohm
w = 2*%pi*50
Rsh = 23.2*10**-6*85*10**5/(%pi*(3^2-2.5^2)) //
    Resistance of sheath
D = 8
rsh = 1/2*(2.5+3)
Xm = w*2*log(D/rsh)*10**-7*85000
Ref = Rc + Xm^2*Rsh/(Rsh^2+Xm^2) // Effective AC
    resistance
Xc = 11.1// reactance with sheaths open-circuit
Xef = Xc-(Xm^2/(Rsh^2+Xm^2)) //Effective reactance
    per cable
S1C1 = Rsh*Xm^2/(Rc*(Rsh^2+Xm^2)) // Sheath loss/
    conductor loss
I = 400 // A
```

```
emf = Xm*I // emf induced per sheath
printf("\n Conductor resistance = %f ohm",rc)
printf("\n Conductor resistance for the whole
    leangth (Rc) = %f ohm",Rc)
printf("\n Resistance of sheath (Rsh) = %f ohm/Km ",
    Rsh)
printf("\n Conductor to sheath mutual inductive
    reactance (Xm)= %f ohm/m ",Xm)
printf("\n Effective AC resistance(Ref) = %f ohm ",
    Ref)
printf("\n Reactance with sheaths open-circuit(Xc) =
     %f ohm ",Xc)
printf("\n Effective reactance per cable(Xef) = %f
    ohm ",Xef)
printf("\n Sheath loss/conductor loss = %f ",SlCl)
printf("\n emf induced per sheath(emf) = %f V",emf)
```

Scilab code Exa 12.7 Chapter 12 Example 7

```
//Chapter 12,Example 7, page 410
//Determine the induced sheath voltage
clear
clc
D = 15 // cm
rsh = 5.5/2 // Sheath diameter converted to radius
    in cm
I = 250 // A
E = 2*10^-7*314*I*log(D/rsh)*10^3
printf("\n Induced sheath voltage per Km = %f V/km",
    E)
printf("\n If the sheaths are bonded at one end, the
     voltage between them at the other end = = %f V/
    km",E*sqrt(3))

// Answers may vary due to round off errors.
```

Scilab code Exa 12.8 Chapter 12 Example 8

```
//Chapter 12,Example 8, page 411
//Determine the maximum stress
clear
clc
ba = 5.3/2 // b/a
alpha = nthroot(ba,3)
r1 = 1.385 // cm
r2 = 1.92 // cm
r = 2.65 // cm
V = 66*sqrt(2)/sqrt(3)
V2 = V/(1+(1/alpha)+(1/alpha^2))
V1 = (1+1/alpha)*V2
//calculating maximim and minimum stress without
    sheaths
Emax0 = V/1*log(r/1)
Emin0 = V/(r*log(r))
//calculating max and min stress with the sheaths
Emax = Emax0*3/(1+(alpha)+(alpha^2))
Emin = Emax/alpha
printf("\n Peak voltage of the conductor V = %f kV",
    V)
printf("\n V1 = %f kV",V1)
printf("\n V2 = %f kV",V2)
printf("\n Maximum stress without sheaths = %f kV/cm
    ",Emax0)
printf("\n Minimum stress without sheaths = %f kV/cm
    ",Emin0)
printf("\n Maximum stress with sheaths = %f kV/cm",
    Emax)
printf("\n Minimum stress with sheaths = %f kV/cm",
    Emin)
```

```
// Answers vary due to round off errors.
```

Scilab code Exa 12.9 Chapter 12 Example 9

```
//Chapter 12,Example 9, page 412
//Determine the maximum stress
clear
clc
Emax = 47.5 // kV
b = 2.65 // cm
a = 1 // cm
ba = 0.55*3 // 1/3(b-a)
r1 = 1.55 // cm
r2 = 2.1 // cm2Vr = 2.65 // cm
V = 53.8 // kV
alpha = nthroot(ba,3)
// based on the example 12_8
//calculating VEmax1, Emax2, Emax3
x = 1/(a*log(r1/a))
y = 1/(r1*log(r2/r1))
z = 1/(r2*log(b/r2))
VV1 = Emax/x
V1V2 = Emax/y
V2 = Emax/z
V1 = V2+(Emax/y)
printf("\n Emax = %f kV/cm",Emax)
printf("\n V1 = %f kV/cm",V1)
printf("\n V2 = %f kV/cm",V2)

// Answers may vary due to round off error.
```

Scilab code Exa 12.10 Chapter 12 Example 10

```
//Chapter 12,Example 10, page 412
//Determine the maximum stress
clear
clc
a = 1 //cm
r1 = 2 // cm
b = 2.65 // cm
er1 = 4.5
er2 = 3.6
V = 53.8 // kV
ba = 5.3/2 // b/a
alpha = 1.325
E1max = V/(log(r1)+(er1/er2)*log(alpha))
E2max = V/((r1*(er2/er1)*log(r1))+log(alpha))
printf("\n E1max = %f kV/cm",E1max)
printf("\n E2max = %f kV/cm",E2max) // answer vary
    from the text

// Answer vary from the text due to round off
```

Chapter 14

Overvolatges on Power Systems

Scilab code Exa 14.4.2.1 Chapter 14 Example 1

```
//Chapter 14,Example 1, page 453
//Determine the time to crest
clear
clc
I = 400 // mH of inductance
L = 500*10^-3 // mH
C = 1.5*10^-6 // micro F

f = 1/(2*%pi*sqrt(L*C))
t = 10**6/(4*f) // calulation done in the text is
    wrong
printf("\n f1 = %f Hz",f)
printf("\n Time to crest = %f micro seconds",t)

// Answer may vary due to round off error.
```

Chapter 16

High Voltage Generation

Scilab code Exa 16.1 Chapter 16 Example 1

```
//Chapter 16,Example 1, page 556
//Determine the (a)ripple voltage (b)voltage drop (c
   )Average output volatge (d)ripple factor
clear
clc
I1 = 5*10^-3 // A
C2 = 0.05*10^-6 // F
C1 = 0.01*10^-6 // F
Vs = 100 // kV
f = 50 // Hz
// (a) Ripple voltage
printf("\n Part (a)")
delV = I1/(C2*f)
printf("\n Ripple Voltage = %f V", delV)
// (b) Voltage drop
printf("\n Part (b)")
Vd = I1/f*((1/C1)+(1/(2*C2)))
printf("\n Voltage drop = %f V", Vd)
// (c) Average output voltage
printf("\n Part (c)")
Vav = 2*Vs*sqrt(2)-Vd*10^-3
```

```
printf("\n Average output voltage = %f kV", Vav)
// (d) Ripple factor
printf("\n Part (d)")
RF = Vd*10^-3/(2*Vs*sqrt(2))
printf("\n Ripple Factor in percentage = %f", RF
    *100)
```

Scilab code Exa 16.2 Chapter 16 Example 2

```
//Chapter 16,Example 2, page 556
//Determine the (a)ripple voltage (b)voltage drop (c
    )Average output volatge (d)ripple factor
clear
clc
I1 = 5*10^-3 // A
C3 = 0.10*10^-6 // F
C2 = 0.05*10^-6 // F
C1 = 0.01*10^-6 // F
Vs = 100 // kV
f = 50 // Hz
// (a) Ripple voltage
printf("\n Part (a)")
delV = I1/f*((2/C1)+(1/C3))
printf("\n Ripple Voltage = %f kV", delV*10^-3)
// (b) Voltage drop
printf("\n Part (b)")
Vd = I1/f*((1/C2)+(1/C1)+(1/(2*C3)))
printf("\n Voltage drop = %f kV", Vd*10^-3)
// (c) Average output voltage
printf("\n Part (c)")
Vav = 3*Vs*sqrt(2)-Vd*10^-3
printf("\n Average output voltage = %f kV", Vav)
// (d) Ripple factor
printf("\n Part (d)")
RF = Vd*10^-3/(3*Vs*sqrt(2))
```

```
printf("\n Ripple Factor in percentage = %f", RF
    *100)

// Answers may vary due to round off error
```

Scilab code Exa 16.3 Chapter 16 Example 3

```
//Chapter 16,Example 3, page 557
//Determine the (a)ripple voltage (b)voltage drop (c
    )Average output volatge (d)ripple factor (e)
    optimum number of stages
clear
clc
I1 = 5*10^-3 // A
C = 0.15*10^-6 // F
Vs = 200 // kV
f = 50 // Hz
n = 12
// (a) Ripple voltage
printf("\n Part (a)")
delV = I1*n*(n+1)/(f*C*2)
printf("\n Ripple Voltage = %f kV", delV*10^-3)
// (b) Voltage drop
printf("\n Part (b)")
a = I1/(f*C)
Vd = a*((2/3*n^3)+(n^2/2)-(n/6)+(n*(n+1)/4))
printf("\n Voltage drop = %f kV", Vd*10^-3)
// (c) Average output voltage
printf("\n Part (c)")
Vav = 2*n*Vs*sqrt(2)-Vd*10^-3
printf("\n Average output voltage = %f kV", Vav)
// (d) Ripple factor
printf("\n Part (d)")
RF = Vd*10^-3/(2*n*Vs*sqrt(2))
printf("\n Ripple Factor in percentage = %f", RF
```

```
    *100)
// (e) Optimum number of stages
printf("\n Part (e)")
nopt = sqrt(Vs*sqrt(2)*10^3*f*C/I1)
printf("\n Optimum number of stages = %d stages",
    nopt)

// Answers may vary due to round off error
```

Scilab code Exa 16.4 Chapter 16 Example 4

```
//Chapter 16,Example 4, page 558
//Determine the input voltage and power
clear
clc
Vc = 500*10^3 // V
A = 4 // A
Xl = 8/100 // in percentage
kV = 250
Xc = Vc/A // Reactance of the cable
XL = Xl*(kV**2/100)*10**3 // Leakage reactance of
    the transformer
Radd = Xc-XL // Additional series reactance
Ind = Radd/(2*%pi*XL) // Inductance of required
    series inductor
R = 3.5/100*(kV**2/100)*10**3  // Total circuit
    resistance
Imax = 100/250 // maximum current that can be
    supplied by the transformer
Vex = Imax*R // Exciting voltage of transformer
    secondary
Vin = Vex*220/kV // Input voltage of transformer
    primary
P = Vin*100/220 // Input power of the transformer
printf("\n Reactance of the cable = %f k ohm", Xc
```

```
*10^-3)
printf("\n Leakage reactance of the transformer = %f k ohm", XL*10^-3)
printf("\n Additional series reactance = %f k ohm", Radd*10^-3)
printf("\n Inductance of required series inductor = %f H", Ind*10^3)
printf("\n Total circuit resistance = %f k ohm", R*10^-3)
printf("\n maximum current that can be supplied by the transformer = %f A", Imax)
printf("\n Exciting voltage of transformer secondary = %f kV", Vex*10^-3)
printf("\n Input voltage of transformer primary = %f V", Vin*10^-3)
printf("\n Input power of the transformer = %f kW", P*10^-3)

// Answers may vary due to round off error
```

Scilab code Exa 16.5 Chapter 16 Example 5

```
//Chapter 16,Example 5,page 559
//Determine the charging current and potential difference
clear
clc
ps = 0.5*10**-6 // C/m^2
u = 10 // m/s
w = 0.1 // m
I = ps*u*w
Rl = 10^14 // ohm
V = I*Rl*10^-6
printf("\n Charging current= %f micro A", I*10^6)
printf("\n Potential difference = %f MV", V)
```

```
// Answers may vary due to round off error
```

Scilab code Exa 16.6 Chapter 16 Example 6

```
//Chapter 16,Example 6,page 560
//Determine the wave generated
clear
clc
// With refrence to table 16.1
C1 = 0.125*10^-6 // F
C2 = 1*10^-9 // F
R1 = 360 // ohm
R2 = 544 // ohm
V0 = 100 // kV
theta = sqrt(C1*C2*R1*R2)
neta = 1/(1+(1+R1/R2)*C2/C1)
alpha = R2*C1/(2*theta*neta)
printf("\n Theta = %f micro S",theta*10^6)
printf("\n Neta = %f",neta)
printf("\n Alpha = %f ",alpha)
// Coresponding to alpha the following can be deduced from Fig 16.12
T2 = 10.1*theta*10^6
T1 = T2/45
imp = T1/T2 // generated lighting impulse
// From equations 16.41 and 16.42
a1 = (alpha-sqrt(alpha^2-1))*10^-6/(theta)
a2 = (alpha+sqrt(alpha^2-1))*10^-6/theta
printf("\n T1 = %f microS", T1)
printf("\n T2 = %f microS", T2)
printf("\n Generated lighting impulse = %e wave", imp)
printf("\n alpha1 = %f microS", a1)
printf("\n alpha2 = %f microS", a2)
```

```
// According to equation 16.40
et = neta*(alpha*V0)/sqrt(alpha^2-1)
printf("\n e(t) = %f * (e^%ft - f^%ft)",et,-a1,-a2)
    // Equation of the wave form generated by the
    impulese

//Answers may vary due to round off error
```

Scilab code Exa 16.7 Chapter 16 Example 7

```
//Chapter 16,Example 6,page 561
//Determine the wave generated
clear
clc
C1 = 0.125*10^-6 // F
C2 = 1*10^-9 // F
R1 = 360 // ohm
R2 = 544 // ohm
V0 = 100 // kV
theta = sqrt(C1*C2*R1*R2)
neta = 1/(1+R1/R2+C2/C1)
alpha = R2*C1/(2*theta*neta)
printf("\n Theta = %f micro S",theta*10^6)
printf("\n Neta = %f",neta)
printf("\n Alpha = %f ",alpha)
// Coresponding to alpha the following can be
    deduced from Fig 16.12
T2 = 16.25*theta*10^6
T1 = T2/120
// From equations 16.41 and 16.42
a1 = (alpha-sqrt(alpha^2-1))*10^-6/(theta)
a2 = (alpha+sqrt(alpha^2-1))*10^-6/theta
printf("\n T1 = %f microS", T1) // Answer given in
    the text is wrong
printf("\n T2 = %f microS", T2)
```

```
printf("\n alpha1 = %f microS", a1)
printf("\n alpha2 = %f microS", a2)
// According to equation 16.40
et = neta*(alpha*V0)/sqrt(alpha^2-1)
printf("\n e(t) = %f * (e^%ft - f^%ft)",et,-a1,-a2)
    // Equation of the wave form generated by the
    impulese

//Answers may vary due to round off error
```

Scilab code Exa 16.8 Chapter 16 Example 8

```
//Chapter 16,Example 8,page 562
//Determine the circuit efficiency
clear
clc
C1 = 0.125*10^-6 // F
C2 = 1*10^-9 // F
T2 = 2500
T1 = 250
// Bsaed on Figure 16.12
T2T1 = T2/T1
a = 4 // alpha
theta = T2/6
// From table 16.1
X = (1/a^2)*(1+C2/C1)
R1 = (a*theta*10^-6/C2)*(1-sqrt(1-X))
R2 = (a*theta*10^-6/(C1+C2))*(1+sqrt(1-X))
neta = 1/(1+(1+R1/R2)*C2/C1)
printf("\n Theta = %f micro S", theta)
printf("\n X = %f ", X)
printf("\n R1 = %f k Ohm", R1*10^-3)
printf("\n R2 = %f k Ohm", R2*10^-3)
printf("\n neta = %f ", neta)

```

```
// Answers may vary due to round off error
```

Scilab code Exa 16.9 Chapter 16 Example 9

```
//Chapter 16,Example 9,page 563
//Determine the maximum output voltage and energy
   rating
clear
clc
n = 8
C1 = 0.16/n // micro F
C2 = 0.001 // micro F
T2 = 50
T1 = 1.2
// beased on figure 16.12
a = 6.4 // alpha
theta = T2/9.5
X = (1/a^2)*(1+C2/C1)
R1 = (a*theta*10^-6/C2)*(1-sqrt(1-X))
R2 = (a*theta*10^-6/(C1+C2))*(1+sqrt(1-X))
R1n = R1/n
R2n = R2/n
V0 = n*120
neta = 1/(1+(1+R1/R2)*C2/C1)
V = neta*V0
E = 1/2*C1*V0^2
printf("\n Theta = %f micro S", theta)
printf("\n X = %f ", X)
printf("\n V0 = %f ", V0)
printf("\n R1 = %f Ohm", R1*10^6)
printf("\n R2 = %f Ohm", R2*10^6)
printf("\n R1/n = %d Ohm", R1n*10^6)
printf("\n R2/n = %d Ohm", R2n*10^6)
printf("\n neta = %f ", neta)
printf("\n Maximum output voltage = %f kV", V)
```

```
printf("\n Energy rating = %f J", E)

// Answers greatly vary due to round off error
```

Scilab code Exa 16.10 Chapter 16 Example 10

```
//Chapter 16,Example 10,page 564
//Determine the from and tail times
clear
clc
n = 12
C1 = 0.125*10^-6/n // micro F
C2 = 0.001*10^-6 // micro F
R1 = 70*n // ohm
R2 = 400*n // ohm
// beased on figure 16.15
theta = sqrt(C1*C2*R1*R2)
neta = 1/(1+R1/R2+C2/C1)
a = R2*C1/(2*theta*neta) // alpha
T2 = 7*theta*10^6
T1 = T2/25
printf("\n R1 = %f Ohm", R1)
printf("\n R2 = %f Ohm", R2)
printf("\n Theta = %f microS",theta*10^6)
printf("\n Neta = %f",neta)
printf("\n Alpha = %f ",a)
printf("\n T1 = %f microS", T1)
printf("\n T2 = %f microS", T2)

// Answers greatly vary due to round off error
```

Scilab code Exa 16.11 Chapter 16 Example 11

```
//Chapter 16,Example 11,page 564
//Determine the equation generated by impulse
clear
clc
w = 0.02*10^6 // s^-1 obtained by solving eq 16.47 iteratively
R = sqrt(4-(sqrt(8*8*4)*0.02)^2) // solved the simplified equation
L = 8*10^-6
V = 25*10^3
// In equation 16.46
y = R/(2*L)
// Deriving the equation
a = V/(w*L)
printf("\n R = %e ohm",R)
printf("\n y = %e s^-1",y)
printf("\n I(t) = %e * exp(%et) * sin(%et) A",a,-y,w)

// Answers may vary due to round off error
```

Chapter 19

Applications of High Voltage Engineering

Scilab code Exa 19.1 Chapter 19 Example 1

```
//Chapter 19,Example 1,page 665
//Determine the sepration between the particles
clear
clc
// Based on the equations 19.6, 19.7, 19.8, 19.9 and
    19.10
E = 8*10^5 // V/m
qm = 10*10^-6 // C/kg, qm = q/m
y = -1 // m
t = (1*2/9.8)
x = 1/2*qm*E*t
printf("\n The seperation between the particles = %f
    m",2*x)

// Answers may vary due to round off error
```

Scilab code Exa 19.2 Chapter 19 Example 2

```
//Chapter 19,Example 2,page 667
//Determine the pumping pressure
clear
clc
p0 = 30*10^-3 // C/m^3
V = 30*10^3 // V
P = p0*V
printf("\n The pumping pressure P = %f N/m^2",P)

// Answers may vary due to round off error
```

Scilab code Exa 19.4 Chapter 19 Example 4

```
//Chapter 19,Example 4,page 670
//Determine the vertical displacement of the drop
clear
clc
d = 0.03*10^-3 // m
p = 2000 // kg/m^3
q = 100*10^-15 // C
V0 = 3500 // V
d2 = 2*10^-3 // m
L1 = 15*10^-3 // m
L2 = 12*10^-3 // m
Vz = 25 // m/s

m = 4/3*%pi*(1/2*d)^3*p
t0 = L1/Vz
Vx0 = q*V0*t0/(m*d2)
x0 = 1/2*Vx0*t0
t1 = (L1+L2)/Vz
x1 = x0+Vx0*(t1-t0)

```

```
printf("\n The vertical displacement of the drop =
    %e m",x1)

// Answers may vary due to round off error
```

Scilab code Exa 19.5 Chapter 19 Example 5

```
//Chapter 19,Example 5,page 672
//Determine the electric stress and charge density
clear
clc
a = 25*10^-6 // m
b = 75*10^-6 // m
Er = 2.8
ps = 25*10^-6 // C/m^3
E0 = 8.84*10^-12

Ea = (b*ps)/(ps*E0+b*Er*E0)
Eb = (a*ps)/(ps*E0+b*Er*E0) // the negative noation
    is removed to obtain positive answer as in the
    book
psc = E0*Eb

printf("\n Ea = %e V/m",Ea)
printf("\n Eb = %e V/m",Eb)
printf("\n Charge density = %e C/m^2",psc)

// Answers may vary due to round off error
```

Scilab code Exa 19.6 Chapter 19 Example 6

```
//Chapter 19,Example 6,page 675
//Determine the current density
```

```
clear
clc
E0 = 8.84*10^-12
Us = 1.5*10^-3*10^-4
V = 100
d3 = 10^-6 // d^3
J = 4*E0*Us*V^2/d3
printf("\n Current density = %e A/m^2",J)

// Answer may vary due to round off error
```

Scilab code Exa 19.7 Chapter 19 Example 7

```
//Chapter 19,Example 7,page 676
//Determine the thickness of dust layer
clear
clc
Edb = 3*10^6
E0 = 8.84*10^-12
p0 = 15*10^-3
d = Edb*E0/p0
printf("\n Thickness of the dust layer = %e m",d)

// Answers may vary due to round off errors
```

Scilab code Exa 19.8 Chapter 19 Example 8

```
//Chapter 19,Example 8,page 676
//Determine the velocity of the ejected ions and
    propolsion force
clear
clc
mi = 133*1.67*10^-27 // kg
```

```
qi = 1.6*10^-19 // C
Va = 3500 // V
I = 0.2 // A
vi = sqrt(2*qi*Va/mi)
F = vi*mi*I/qi
printf("\n Ion velocity = %e m/s",vi)
printf("\n Populsion force = %e N",F)

// Answers may vary due to round off errors
```

Scilab code Exa 19.9 Chapter 19 Example 9

```
//Chapter 19,Example 9,page 677
//Determine the position of the particle
clear
clc
V = 120*10^3 // applied voltage in V
d = 0.6 //  space b/w the plates in m
vd = 1.2 // vertical dimention in m
qm = 10*10^-6 // charge to mass C/kg
y = 4.9

t0 = sqrt(vd/y)
// based on eq 19.51 and 19.52
dx2 = qm*V/d
x = t0^2
printf("\n Velocity = %d m/s2",dx2)
printf("\n Position of the particle = %f m",x)

// Answer may vary due to round off error
```

Scilab code Exa 19.10 Chapter 19 Example 10

```
//Chapter 19,Example 10,page 679
//Determine the minimum voltage required for
   gnerating drops witha charge of 50 pC per drop
clear
clc
q = 50*10^-12
a = 25*10^-6
b = 750*10^-6
E0 = 8.84*10^-12
r = 50*10^-6
V = (3*q*b^2*log(b/a))/(7*%pi*E0*r^3)
printf("\n The minimum voltage required for
   gnerating drops witha charge of 50 pC per drop =
   %f kV",V*10^-6)

// Answers may vary due to round off error
```