

Scilab Textbook Companion for
High Voltage Engineering Theory and Practice
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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

```
1 //Chapter 2, Example 5, page 65
2 //Calculate the maximum field at the sphere surface
3 clc
4 clear
5 //Calculating Field at surface E based on figure 2.31
  and table 2.3
6 Q1 = 0.25
7 e0 = 8.85418*10**-12 //Epselon nought
8 RV1= ((1/0.25**2)+(0.067/(0.25-0.067)**2)
  +(0.0048/(0.25-0.067)**2))
9 RV2= ((0.25+0.01795+0.00128)/(0.75-0.067)**2)
10 RV= RV1+RV2
11 E = (Q1*RV)/(4*%pi*e0)
12 printf("Maximum field = %e V/m per volt",E)
13
14 //Answers vary due to round off error
```

Scilab code Exa 2.6 Chapter 2 Example 6


```

1 //Chapter 2, Exmample 6, page 66
2 clc
3 clear
4 //calculation based on figure 2.32
5
6 //(a)Charge on each bundle
7 printf("Part a\n")
8 req = sqrt(0.0175*0.45)
9 printf("Equivalent radius = %e m \n", req)
10 V = 400*10**3 //Voltage
11 H = 12 //bundle height in m
12 d = 9 //pole to pole spacing in m
13 e0 = 8.85418*10**-12 //Epselon nought
14 Hd = sqrt((2*H)^2+d^2)//2*H^2 + d^2
15 Q = V*2*%pi*e0/(log((2*H/req))-log((Hd/d)))
16 q = Q/2
17 printf("Charge per bundle = %e uC/m \n",Q) //micro C
    /m
18 printf("Charge per sunconductor = %e uC/m \n",q) //
    micro C/m
19
20 //(b part i)Maximim & average surface feild
21 printf("\nPart b")
22 printf("\nSub part 1\n")
23 r = 0.0175 //subconductor radius
24 R = 0.45 //conductor to subconductor spacing
25 MF = (q/(2*%pi*e0))*((1/r)+(1/R)) // maximum feild
26 printf("Maximum feild = %e kV/m \n",MF)
27 MSF = (q/(2*%pi*e0))*((1/r)-(1/R)) // maximum
    surface feild
28 printf("Maximum feild = %e kV/m \n",MSF)
29 ASF = (q/(2*%pi*e0))*(1/r) // Average surface feild
30 printf("Maximum feild = %e kV/m \n",ASF)
31
32 //(b part ii) Considering the two sunconductors on
    the left
33 printf("\nSub part 2\n")
34 //field at the outer point of subconductor #1

```

```

35 dr01 = 1/(d+r)
36 dRr01 = 1/(d+R+r)
37 E01 = MF -((q/(2*pi*e0))*(dr01+dRr01))
38 printf("EO1 = %e kV/m \n",E01)
39 //field at the outer point of subconductor #2
40 dr02 = 1/(d-r)
41 dRr02 = 1/(d-R-r)
42 E02 = MF -((q/(2*pi*e0))*(dRr02+dr02))
43 printf("EO2 = %e kV/m \n",E02)
44
45 //field at the inner point of subconductor #1
46 drI1 = 1/(d-r)
47 dRrI1 = 1/(d+R-r)
48 EI1 = MSF -((q/(2*pi*e0))*(drI1+dRrI1))
49 printf("EI1 = %e kV/m \n",EI1)
50 //field at the inner point of subconductor #2
51 drI2 = 1/(d+r)
52 dRrI2 = 1/(d-R+r)
53 EI2 = MSF -((q/(2*pi*e0))*(dRrI2+drI2))
54 printf("EI2 = %e kV/m \n",EI2)
55
56 //(part c)Average of the maximim gradient
57 printf("\nPart c\n")
58 Eavg = (E01+E02)/2
59 printf("The average of the maximum gradient = %e kV/
    m \n",Eavg)
60
61
62 //Answers might vary due to round off error

```

Scilab code Exa 2.7 Chapter 2 Example 7

```

1 //Chapter 2, Exmample 7, page 69
2 //Electric feild induced at x
3 clc

```

```

4 clear
5 e0 = 8.85418*10**-12 //Epselon nought
6 q = 1 // C/m
7 C = (q/(2*pi*e0))
8 //Based on figure 2.33
9 E = C-(C*(1/3+1/7))+(C*(1+1/5+1/9))+(C*(1/5+1/9))-(C
    *(1/3+1/7))
10 printf(" Electric Feild = %e V/m \n",E)
11
12 //Answers might vary due to round off error

```

Scilab code Exa 2.8 Chapter 2 Example 8

```

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

```

```

20 t = 2*(%e^pow-1)
21 printf("Thickness of regular design = %e cm \n",t)
22 //Volume of regular design V2
23 V2 = %pi*((2+t)^2-4)
24 printf("V2 = %e cm^3 \n",V2)//unit not mentioned in
    textbook
25
26 //Answers may vary due to round off error

```

Scilab code Exa 2.11 Chapter 2 Example 11

```

1 //Chapter 2, Exmample 11, page 75
2 //Calculate the potential within the mesh
3 clc
4 clear
5 //Based on figure 2.38(b)
6 //equations are obtained using Eq.2.46
7 A1 = 1/2*(0.54+0.16)
8 A2 = 1/2*(0.91+0.14)
9 S = [0.5571 -0.4571 -0.1;-0.4751 0.828 0.3667;-0.1
    0.667 0.4667]
10 //By obtaining the elements of the global stiffness
    matrix(Sadiku,1994)
11 //and by emplying the Eq.2.49(a)
12 S1 = [1.25 -0.014;-0.014 0.8381]
13 S2 = [-0.7786 -0.4571;-0.4571 -0.3667]
14 Phi13 = [0 ;10]
15 val1 = S2*Phi13
16 Phi24 = S1\val1
17 disp(-Phi24,"The values of Phi2 and Phi4 are:")
18
19 //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

```
1 //Chapter 3, Exmample 1, page 103
2 //Movement of oxygen molecule
3 clc
4 clear
5 //using equation 3.3
6 R = 3814 // J/Kg.mol.K
7 T = 300 // K
8 M = 32 // mol-1
9 V2 = 3*R*(T/M)
10 V = sqrt(V2)
11 printf(" Velocity of Oxygen (O2)= %d m2/s2\n",V2)
12 //Since Oxygen is a diatomic gas
13 printf(" Velocity of Oxygen (O)= %d m/s",V)
14 //Velocity of oxygen is about 300 m/s
15
16 //Answer given in the textbook is wrong
```

Scilab code Exa 3.2 Chapter 3 Example 2

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

Scilab code Exa 3.3 Chapter 3 Example 3

```
1 //Chapter 3, Exmample 3, page 104
2 //Maximum pressure in the chamber
3 clc
4 clear
5 //Making use of equation 3.10
6 N1 = (4*pi*1.7*1.7*0.10*10^-10*10^-10)
7 N = 1/N1
8 //Using equation 3.2
9 R = 8314 // J/Kg*mol*K
10 M = 28 // Mol^-1
11 N = 220*10**-8 // Kg
12 T = 300 // K
13 p = N/M*R*T
14 printf("\nN = %e ",N1) // answer mentioned in the
   tectbook is wrong
15 printf("\nPressure = %f N/m^2",p)
16
```

17 //Answer vary due to round off error

Scilab code Exa 3.4 Chapter 3 Example 4

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

Scilab code Exa 3.5 Chapter 3 Example 5

```
1 //Chapter 3, Exmample 5, page 105
2 //Volum of Helium
3 clc
4 clear
5 // Using equation 3.2
6 G = (1*8314*273)/(2.016*1.01*10**5)
7 printf("\nVolume of He = %f m^3",G)
8
9 //Answer may vary due to round off error.
```

Scilab code Exa 3.6 Chapter 3 Example 6

```

1 //Chapter 3, Exmample 6, page 105
2 //Determine mean free path
3 clc
4 clear
5 //(a) Mean free path
6 na = %e^-1
7 //(b) 5 times mean free path
8 nb = %e^-5
9 printf("\\n Mean free path = %f*n0 ",na)
10 printf("\\n 5 times mean free path = %f*n0 ",nb)
11
12 //Answer may vary due to round of error

```

Scilab code Exa 3.7 Chapter 3 Example 7

```

1 //Chapter 3, Exmample 7, page 105
2 //Mean square velocity of Helium
3 clc
4 clear
5 //based on equation 3.2 and 3.3 we derive the gas
  density
6 N = 178*10**-3 // kg/m^3
7 // calculating mean square velocity
8 v2 = (3*1.01*10**5)/N
9 printf("\\nV^2 = %e m^2/s^2",v2)
10 v = sqrt(v2)
11 printf("\\nMean square velocity = %f m/s",v)
12
13 //Answer may vary due to round off error

```

Scilab code Exa 3.8 Chapter 3 Example 8

```

1 //Chapter 3, Exmample 8, page 106

```



```

2 //Energy of free electron
3 clc
4 clear
5 //Using equation 3.3
6 mv2 = (3/2*1.38*10**-21*293) // 1/2*m*v2
7 E = mv2*10**38/1.6*10**-19
8 printf("\n1/2*m*v2 = %e J",mv2)
9 printf("\nEnergy of free electron = %f eV",E)
10
11 //Answers may vary due to round off error

```

Scilab code Exa 3.9 Chapter 3 Example 9

```

1 //Chapter 3, Exmample 9, page 106
2 //Average separation and volume occupied by one atom
3 clc
4 clear
5 NA = 6.0244*10**23
6 NoA = NA*0.075 // Number of atoms/cm3
7 V = 1/NoA // Average volume occupied by one atom
8 S = nthroot(V,3) // Average separation between
   atoms
9 printf("\nNumber od atoms per cm3 = %e ",NoA)
10 printf("\nAverage vloume occupied by one atom = %e
   cm3",V)
11 printf("\nAverage separation between atoms = %e cm",
   S)
12
13
14 //Answers may vary due to round off error

```

Scilab code Exa 3.10 Chapter 3 Example 10

```

1 //Chapter 3, Exmample 10, page 106
2 //KE and velocity of photoelectron
3 clc
4 clear
5 h = 4.15*10**-15
6 c = 3*10**8
7 l = 200*10**-10
8 BE = 13.6 // Binding energy
9 PE = h*c/l
10 KE = PE-BE // Kinetic energy of photoelectron
11 Ve = sqrt((2*KE*1.6*10**-19)/9.11*10**-31)*10**31
12 printf("\\nPhoton energy eV = %e ",PE)
13 printf("\\nKinetic energy eV = %e ",KE)
14 printf("\\nVelocity m/s = %e ",Ve)
15
16 //Answer may vary due to round off error

```

Scilab code Exa 3.11 Chapter 3 Example 11

```

1 //Chapter 3, Exmample 11, page 107
2 //Find the absorption coefficient
3 clc
4 clear
5 // Using equation 3.20
6 x = 20
7 I0 = 6
8 Mu = -1/x*log(1/I0)
9 printf("\\nLiquid photon absorption coefficient cm^-1
    = %e ",Mu)
10
11 //Answer may vary due to round off error

```

Scilab code Exa 3.12 Chapter 3 Example 12

```

1 //Chapter 3, Exmample 12, page 107
2 //Binding energy
3 clc
4 clear
5 h = 4.15*10**-15
6 c = 3*10**8
7 Imax = 1000*10**-10
8 We = h*c/Imax
9 printf("\nBinding Energy = %e eV ",We)
10
11 //Answer may vary due to round off errorS

```

Scilab code Exa 3.14 Chapter 3 Example 14

```

1 //Chapter 3, Exmample 14, page 108
2 //Diameter of argon atom
3 clc
4 clear
5 //As derived from example 13
6 N = (1.01*10**5/760)/(1.38*10**-23*273)
7 printf("\nN = %e atoms/m^3 ",N)
8 //Use equation 3.10
9 ra = sqrt((85*10^2/(%pi*3.527*10**22)))
10 printf("\nra = %e m ",ra)
11
12 //Answer may vary due to round off error

```

Scilab code Exa 3.15 Chapter 3 Example 15

```

1 //Chapter 3, Exmample 15, page 109
2 //Mobility of electrons
3 clc
4 clear

```

```

5 Ie = 3
6 d = 0.8
7 A = 8*10**-4
8 Vne = 20*10**17 //V*ne
9 e = 1.6*10**-19
10 ke = (Ie*d)/(A*Vne*e)
11 printf("\Mobility of electrons = %d m^2/s*V ",ke)
12
13 //Answer may vary from the text

```

Scilab code Exa 3.17 Chapter 3 Example 17

```

1 //Chapter 3, Exmample 17, page 110
2 //Determine the ion density
3 clc
4 clear
5 //Based on equation 3.50 and 3.52
6 nplus = 10**11*e
      **(-1.6*10**-19*5*0.02/(1.38*10**-23*293))
7 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
8 printf("\n+(0.02) = %e ions/m^3 ",nplus)
9 printf("\n+(-0.02) = %e ions/m^3 ",nminus)
10
11 //answers may vary due to round off error

```

Scilab code Exa 3.18 Chapter 3 Example 18

```

1 //Chapter 3, Exmample 18, page 110
2 //Determine the diameter
3 clc

```

```

4 clear
5 //Based on the equation 3.40
6 k = 1.38*10**-23
7 T = 293
8 z2z1 = 0.05
9 e = 1.6*10**-19
10 E = 250
11 r1 = 0.09*10**-6
12 r1r2 = (6*k*T*z2z1)/(e*E)
13 r2 = sqrt(r1+r1r2)
14 printf("\n r1^2-r2^2 = %e ",r1r2)
15 printf("\n r2 = %e m ",r2)
16
17 //answers may vary due to round off error

```

Scilab code Exa 3.19 Chapter 3 Example 19

```

1 //Chapter 3, Exmample 19, page 111
2 //Determine mean free path and ionization
3 clc
4 clear
5 //(a)Mean free path
6 //Based on equation 3.14 and 3.15
7 lambda = 1/(9003*0.5)
8 //(b)Ionization potential
9 Vi = 256584/9003
10 printf("\n lambda = %e m ",lambda)
11 printf("\n Vi = %f V ",Vi)
12
13 //answers may vary due to round off error

```

Chapter 4

Electrical Breakdown of Gasses

Scilab code Exa 4.1 Chapter 4 Example 1

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

Scilab code Exa 4.2 Chapter 4 Example 2

```
1 //Chapter 4, Exmample 2, page 140
2 //Claculate electrode space
3 clc
4 clear
5 //based on the values of example 1
6 d2 = 0.01
7 d1 = 0.005
8 I2 = 2.7*10**-7
9 I1 = 2.7*10**-8
10 a = 1/(d2-d1)*log(I2/I1) // alpha
11 //10^9 = %e^a(a*d)
12 //multiplying log on bith sides log(10^9) = a*d
13 ad = log(10^9)
14 printf("\\n a*d = %f ",ad)
15 d = ad/a
16 printf("\\n electrode space = %f m",d)
17
18 //Answers may vary due to round off error
```

Scilab code Exa 4.3 Chapter 4 Example 3

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

```

10 As = exp(X) // Avalanche size
11 printf("\n Avalanche size = %f m",As)
12
13 //Answers may vary due to round of error

```

Scilab code Exa 4.4 Chapter 4 Example 4

```

1 //Chapter 4, Exmample 4, page 141
2 //Claculate distance to produce avalanche
3 clc
4 clear
5 //Rewrite equation 4.2
6 //using the values of a and b from previous example
7 //convert integartion to quaderatic equation form
8 x=poly(0,"x");
9 p=59.97-4*10**4*x+7.5*10**5*x^2 // making the
   polinomial equation
10 r= roots(p) //obtaining the roots
11 printf("\n %f m or %f m away from the cathode",r(1),
   r(2))
12
13 //Answer may vary due to round of error.

```

Scilab code Exa 4.5 Chapter 4 Example 5

```

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

```



```

7 p=43.75-4*10**4*x+7.5*10**5*x^2 // making the
  polinomial equation
8 r= roots(p) //obtaining the roots
9 printf("\n Minimum distance = %f m",r(2)) // other
  root is disregarded
10
11 //Answer may vary due to round of error.

```

Scilab code Exa 4.7 Chapter 4 Example 7

```

1 //Chapter 4, Exmample 7, page 142
2 //Claculate secondary coefficient
3 clc
4 clear
5 //Using equation 3.15
6 E = 9*10**3/0.002
7 T = 11253.7 // m^-7*kPa^-1
8 B = 273840 // V/mkPa
9 p = 101.3 // kPa or 1 atm
10 d = 0.002 // m
11 alpha = p*T*exp(-B*p/E)
12 Y = 1/(exp(alpha*d)-1)
13 printf("\n E = %e V/m",E)
14 printf("\n Alpha = %f m^-1",alpha)
15 printf("\n Total secondary coefficient of ionization
  = %f ",Y)
16
17 //Answer may vary due to round off error

```

Scilab code Exa 4.8 Chapter 4 Example 8

```

1 //Chapter 4, Exmample 8, page 143

```

```

2 //Claculate first and secondary ionization
   coefficient
3 clc
4 clear
5 //(a)first ionization coefficient
6 //Using equation 4.7a
7 d1 = 0.005
8 a1d1 = log(1.22)
9 a1 = a1d1/d1
10
11 d2 = 0.01504
12 a2d2 = log(1.82)
13 a2 = a2d2/d2
14
15 d3 = 0.019 // wrong value used in the text
16 a3d3 = log(2.22)
17 a3 = a3d3/d3
18
19 printf("\\n Alpha 1 = %f m-1",a1)
20 printf("\\n Alpha 2 = %f m-1",a2)
21 printf("\\n Alpha 3 = %f m-1",a3)
22 printf("\\n From the above results we can understand
   that ionization mechanism must be acting at d3 ")
23
24 //secondary ionization coefficient
25 I = 2.22
26 e = exp(a1*d3)
27 Y = (I-e)/(I*(e-1))
28 printf("\\n secondary ionization coefficient = %f ",Y
   )
29
30 //Answer may vary due to round off error.

```

Scilab code Exa 4.9 Chapter 4 Example 9

```

1 //Chapter 4, Exmample 9, page 144
2 //Claculate distance and voltage
3 clc
4 clear
5 a = 39.8 // alpha
6 Y = 0.0354 // corfficient
7 p = 0.133 // kPa
8 Ep = 12000 // E/P , unit : V/m*kPa
9
10 d = (1/a)*(log(1/Y + 1)) // distance
11 E = Ep*p
12 V = E*d
13
14 printf("\\n Distance = %f m",d)
15 printf("\\n E = %f V/m",E)
16 printf("\\n Volatge = %f V",V)
17
18 //Answers may vary due to round off error

```

Scilab code Exa 4.10 Chapter 4 Example 10

```

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

```

```

13 Ep = 58764.81 // E/p Unit:V/m*kPa
14
15 ad = 17.7 + log(d)
16 E = Ep*p
17 Vs = E*d*10^-3 // Voltage breakdown
18 printf("\n E = %e V/m",E)
19 printf("\n Voltage breakdown = %f kV",Vs)
20
21 //(b)Meek and Loeb's criterion
22 //Using equation 4.11 and based on 4.24 & 4,25
23 //+ we get Er = 468*10^4 V/m
24 Er = 468*10^4 // V/m
25 Vs2 = Er*0.001*10^-3
26 printf("\n Voltage breakdown = %f kV",Vs2)
27
28 // Answers may vary due to round of error

```

Scilab code Exa 4.11 Chapter 4 Example 11

```

1 //Chapter 4, Exmample 11, page 146
2 //Claculate the first Townsend's ionization
  coefficient
3 clc
4 clear
5 t = 0.2*10**-6 // transit time of electrons in
  seconds
6 d = 0.05 // m
7 ve = d/t
8 TC = 35*10**-9 // Time constant
9 a = 1/(ve*TC)
10 printf("\n Electron drift velocity = %e m/s",ve)
11 printf("\n alpha = %e m^-1",a)
12
13 // Answers may vary due to round of error

```

Scilab code Exa 4.12 Chapter 4 Example 12

```
1 //Chapter 4, Exmample 12, page 146
2 //Travel time and maximum frequency
3 clc
4 clear
5 //(a)Determine the travel time
6 Ea = 200*sqrt(2)*10**3/0.1
7 x = 1.4*10**-4*2828.4*10**3/(2*%pi*50)
8 d = 0.1
9 printf("\n Ea = %e V/m",Ea)
10 printf("\n x = %f*sin(3.14*t)",x)
11 //obtaining t from x
12 t = asin(d/x)/3.14
13 printf("\n t = %f ms",t) // answer mentioned in the
    text is wrong
14 //(b)Determine the maximum frequency
15 k = 1.4*10**-4
16 fmax = k*Ea/(2*%pi*d)
17 printf("\n fmax = %f Hz",fmax)
18
19 //Answer may vary due to round off error
```

Chapter 5

The Corona discharge

Scilab code Exa 5.2 Chapter 5 Example 2

```
1 //Chapter 5, Exmample 2, page 173
2 //Calculate breakdown voltage
3 clc
4 clear
5 //(a)Based on equation 4.13
6 p = 101.3 // kPa
7 Ep = 2400.4/0.027
8 E = p*Ep
9 d = 1*10**-3 // 1 mm
10 Vs1 = E*d
11 printf("\n Part (a): based on equation 4.13")
12 printf("\n Breakdown voltage = %f V or %f kV",Vs1,
    Vs1*10^-3)
13
14 //(b)Corrsponding to an avelanche size of 10^8
15 p = 101.3 // kPa
16 Cp = Ep*0.027*p
17 Vs2 = (18.42 + (Cp*10**-3))/0.027
18 printf("\n Part (b):Corrsponding to an avelanche
    size of 10^8")
19 printf("\n Breakdown voltage = %f V or %f kV",Vs2,
```

```

        Vs2*10^-3)
20
21 //(b)According to criteria expressed by Equations
    5.4 and 5.5
22 p = 101.3 // kPa
23 Vs3a = 9.4
24 Vs3b = 9.2
25 printf("\n Part (c):According to criteria expressed
    by Equations 5.4 and 5.5")
26 printf("\n Breakdown voltage = %f kV or %f kV",Vs3a,
    Vs3b)
27
28 //Answer may vary due to round off error

```

Scilab code Exa 5.3 Chapter 5 Example 3

```

1 //Chapter 5, Exmample 3, page 174
2 //Calculate breakdown voltage at atm pressure 3 and
    5
3 clc
4 clear
5 //(a)Based on equation 5.14
6 p = 101.3 // kPa
7 Ep = 2400.4/0.027
8 E = p*Ep
9 d = 1*10**-3 // 1 mm
10 Vs13 = E*d*3 // at 3 atm
11 Vs15 = E*d*5 // at 5 atm
12 printf("\n Part (a): based on equation 5.14")
13 printf("\n Breakdown voltage = %f kV or %f kV",Vs13
    *10^-3,Vs15*10^-3)
14
15 //(b)According to equiton 5.13
16 p = 101.3 // kPa
17 Cp3 = Ep*0.027*p*3 // at 3 atm

```

```

18 Vs23 = (18.42 + (Cp3*10**-3))/0.027
19 Cp5 = Ep*0.027*p*5 // at 5 atm
20 Vs25 = (18.42 + (Cp5*10**-3))/0.027
21 printf("\n Part (b):According to equation 5.13")
22 printf("\n Breakdown voltage = %f V or %f kV",Vs23
    *10^-3,Vs25*10^-3)
23
24 //(b)According to criteria expressed by Equations
    5.4 and 5.5
25 p = 101.3 // kPa
26 Vs3a = 27.73 // at 3 atm
27 Vs3b = 45.5 // at 5 atm
28 printf("\n Part (c):According to criteria expressed
    by Equations 5.4 and 5.5")
29 printf("\n Breakdown voltage = %f kV or %f kV",Vs3a,
    Vs3b)
30
31 //Answer may vary due to round off error

```

Scilab code Exa 5.8 Chapter 5 Example 8

```

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

```



```

14 Vp1 = 6.2*E0
15 Vn1 = 6.2*En
16 printf("\n Part (a)")
17 printf("\n The postive corona = %f kVpeak",Vp1)
18 printf("\n The negative corona = %f kV",Vn1)
19 //part b
20 Vp2 = 8.32*E0
21 Vn2 = 8.32*En
22 printf("\n Part (b)")
23 printf("\n The postive corona = %f kVpeak",Vp2)
24 printf("\n The negative corona = %f kV",Vn2)
25 //part c
26 Vp3 = 9.97*E0
27 Vn3 = 9.97*En
28 printf("\n Part (c)")
29 printf("\n The postive corona = %f kVpeak",Vp3)
30 printf("\n The negative corona = %f kV",Vn3)
31 //part d
32 Vp4 = 11.39*E0
33 Vn4 = 11.39*En
34 printf("\n Part (d)")
35 printf("\n The postive corona = %f kVpeak",Vp4)
36 printf("\n The negative corona = %f kV",Vn4)
37
38 //Answer CONSIDERABLY vary due to round off error.

```

Scilab code Exa 5.9 Chapter 5 Example 9

```

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

```

```

    pressure
8  r = 1 //radius of the conductor
9  En = 27.501 // kVpeak/cm
10 E0 = 30*dt*(1 + 0.3*sqrt(dt*r))
11 V0peak = E0*log(Deq*10**2)
12 V0 = En*log(Deq*10**2)
13
14 printf("\n Mean geometric distance between the
    conductors %f m",Deq)
15 printf("\n E0 = %f kVpeak/cm",E0)
16 printf("\n V0peak = %f kVpeak",V0peak)
17 printf("\n V0 = %f kV",V0)
18
19 //Answers may vary due to round off error

```

Scilab code Exa 5.10 Chapter 5 Example 10

```

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

```

```

19 printf("\n Corona onset field = %f kVpeak/cm",E0)
20 printf("\n V0peak = %f kVpeak",V0peak)
21 printf("\n V0 = %f kV",V0)
22 printf("\n Ration of V0 = %f ",V0ratio)
23 K = 0.05 // K factor
24 Pc = (3.73*K*50*Vph^2)/(Deq*10**2)^2
25 Cc = Pc*10^3/Vph
26 printf("\n Corona power loss Pc = %f kW/km",Pc
        *10**-5)
27 printf("\n Corona current = %f mA/Km",Cc*10^-2)
28
29 //Answer vary due to round off error
30 //Some of the answers provided in the textbook are
    wrong

```

Scilab code Exa 5.11 Chapter 5 Example 11

```

1 //Chapter 5, Exmample 11, page 180
2 //Calculate corona onset voltage and effective
    corona envelope
3 clc
4 clear
5 //(a) corona onset voltage
6 r = 3.175 // cm
7 h = 13 // m
8 m= 0.9 // m1 and m2
9 dt = 1 // Relative air density
10 E0 = 30*dt*(1 + 0.3/sqrt(r))*m*m
11 V0 = 20*r*log(2*h*10^2/r)
12 printf("\n E0 = %f kVpeak/cm or 20 kV/cm",E0)
13 printf("\n V0 = %f kV",V0)
14 printf("\n V0 (line to line) = %f kV",V0*sqrt(3))
15
16 //(b)Corona envelope at 2.5 p.u
17 V = 2.5*525 // line to line voltage * 2.5

```

```
18 printf("\n Voltage (line to line) = %f kV",V)
19 //Solving the equations in trila and error method
20 printf("\n Envelope radius = 5 cm")
21
22 // Answers may vary due to round off error.
```

Chapter 12

High Voltage Cables

Scilab code Exa 12.1 Chapter 12 Example 1

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

```

22 printf("\n Inner radial thickness = %f cm ",inner)
23 printf("\n Outer radial thickness = %f cm",outer)
24 printf("\n Vpeak of outer dielectric = %f kV",
    V1peak)
25 printf("\n Vpeak of inner dielectric = %f kV",
    V2peak)
26 printf("\n Peak voltage of cable = %f kV", Vcab)
27 printf("\n Safe opearating voltage = %f kV", rms)
28
29 // Answers may vary due to round off error.

```

Scilab code Exa 12.2 Chapter 12 Example 2

```

1 //Chapter 12, Exmapple 2, page 404
2 //Calculate optimum value of r
3 clear
4 clc
5 //Based on equation 12.17
6 V1 = 100 // kV
7 V2 = 55 // kV
8 r = V1*sqrt(2)/V2
9 printf("\n Radius = %f cm ",r)
10
11 // Answers may vary due to round off error

```

Scilab code Exa 12.3 Chapter 12 Example 3

```

1 //Chapter 12, Exmapple 3, page 406
2 //Calculate resistivity
3 clear
4 clc
5 l = 10^4 // cable length in m
6 Rr = 3/1.5 // R/r ratio

```

```

7 ins = 0.5*10**6 // insulation in ohms
8 p = 2*pi*l*ins/log(Rr)
9 printf("\n Resistivity of insulation material = %e
    ohm/m ",p)
10
11 // Answers may vary due to round off error

```

Scilab code Exa 12.4 Chapter 12 Example 4

```

1 //Chapter 12, Exmample 4, page 406
2 //Calculate resistivity
3 clear
4 clc
5 // Baased on Equation 12.1*10**2
6 c4 = 0.5*10**2/10 // micro F
7 Ic = 2*10**4*2*pi*5*50*10**-6/sqrt(3)
8 C = (sqrt(3)*10000*Ic)*(10**-9*10**6)
9 printf("\n C4 = %f mircoF ",c4)
10 printf("\n Line charging current = %f A ",Ic)
11 printf("\n Charging = %f kVA ",C)
12
13 // Answers may vary due to round off error

```

Scilab code Exa 12.5 Chapter 12 Example 5

```

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

```

```

8 C4 = (C2+C3)/2 // microF/km
9 printf("\n C2 = %f mircoF/Km ",C2)
10 printf("\n C3 = %f mircoF/Km ",C3)
11 printf("\n C4 = %f mircoF/Km ",C4)
12 //(b)Capacitance of 10 km between 2 cores
13 V = 33*10**3
14 w = 2*%pi*50
15 C = 2*V^2*w*C4*10*10**-9
16 printf("\n Carging = %f kVAr ",C)
17
18 // Answers may vary due to round of errors.

```

Scilab code Exa 12.6 Chapter 12 Example 6

```

1 //Chapter 12,Example 6, page 409
2 //Determine the efective electrical parameters
3 clear
4 clc
5 rc = 0.0875*(1+0.004*50) // conductor resistance in
   ohm/km
6 Rc = 0.105*85 // ohm
7 w = 2*%pi*50
8 Rsh = 23.2*10**-6*85*10**5/(%pi*(3^2-2.5^2)) //
   Resistance of sheath
9 D = 8
10 rsh = 1/2*(2.5+3)
11 Xm = w*2*log(D/rsh)*10**-7*85000
12 Ref = Rc + Xm^2*Rsh/(Rsh^2+Xm^2) // Effective AC
   resistance
13 Xc = 11.1// reactance with sheaths open-circuit
14 Xef = Xc-(Xm^2/(Rsh^2+Xm^2)) //Effective reactance
   per cable
15 SlCl1 = Rsh*Xm^2/(Rc*(Rsh^2+Xm^2)) // Sheath loss/
   conductor loss
16 I = 400 // A

```



```

17 emf = Xm*I // emf induced per sheath
18 printf("\n Conductor resistance = %f ohm",rc)
19 printf("\n Conductor resistance for the whole
    leangth (Rc) = %f ohm",Rc)
20 printf("\n Resistance of sheath (Rsh) = %f ohm/Km ",
    Rsh)
21 printf("\n Conductor to sheath mutual inductive
    reactance (Xm)= %f ohm/m ",Xm)
22 printf("\n Effective AC resistance (Ref) = %f ohm ",
    Ref)
23 printf("\n Reactance with sheaths open-circuit(Xc) =
    %f ohm ",Xc)
24 printf("\n Effective reactance per cable(Xef) = %f
    ohm ",Xef)
25 printf("\n Sheath loss/conductor loss = %f ",S1C1)
26 printf("\n emf induced per sheath(emf) = %f V",emf)

```

Scilab code Exa 12.7 Chapter 12 Example 7

```

1 //Chapter 12,Example 7, page 410
2 //Determine the induced sheath voltage
3 clear
4 clc
5 D = 15 // cm
6 rsh = 5.5/2 // Sheath diameter converted to radius
    in cm
7 I = 250 // A
8 E = 2*10-7*314*I*log(D/rsh)*103
9 printf("\n Induced sheath voltage per Km = %f V/km",
    E)
10 printf("\n If the sheaths are bonded at one end, the
    voltage between them at the other end = = %f V/
    km",E*sqrt(3))
11
12 // Answers may vary due to round off errors.

```

Scilab code Exa 12.8 Chapter 12 Example 8

```
1 //Chapter 12,Example 8, page 411
2 //Determine the maximum stress
3 clear
4 clc
5 ba = 5.3/2 // b/a
6 alpha = nthroot(ba,3)
7 r1 = 1.385 // cm
8 r2 = 1.92 // cm
9 r = 2.65 // cm
10 V = 66*sqrt(2)/sqrt(3)
11 V2 = V/(1+(1/alpha)+(1/alpha^2))
12 V1 = (1+1/alpha)*V2
13 //calculating maximim and minimum stress without
    sheaths
14 Emax0 = V/1*log(r/1)
15 Emin0 = V/(r*log(r))
16 //calculating max and min stress with the sheaths
17 Emax = Emax0*3/(1+(alpha)+(alpha^2))
18 Emin = Emax/alpha
19 printf("\n Peak voltage of the conductor V = %f kV",
    V)
20 printf("\n V1 = %f kV",V1)
21 printf("\n V2 = %f kV",V2)
22 printf("\n Maximum stress without sheaths = %f kV/cm
    ",Emax0)
23 printf("\n Minimum stress without sheaths = %f kV/cm
    ",Emin0)
24 printf("\n Maximum stress with sheaths = %f kV/cm",
    Emax)
25 printf("\n Minimum stress with sheaths = %f kV/cm",
    Emin)
26
```

27 // Answers vary due to round off errors.

Scilab code Exa 12.9 Chapter 12 Example 9

```
1 //Chapter 12,Example 9, page 412
2 //Determine the maximum stress
3 clear
4 clc
5 Emax = 47.5 // kV
6 b = 2.65 // cm
7 a = 1 // cm
8 ba = 0.55*3 // 1/3(b-a)
9 r1 = 1.55 // cm
10 r2 = 2.1 // cm2Vr = 2.65 // cm
11 V = 53.8 // kV
12 alpha = nthroot(ba,3)
13 // based on the example 12_8
14 //calculating VEmax1, Emax2, Emax3
15 x = 1/(a*log(r1/a))
16 y = 1/(r1*log(r2/r1))
17 z = 1/(r2*log(b/r2))
18 VV1 = Emax/x
19 V1V2 = Emax/y
20 V2 = Emax/z
21 V1 = V2+(Emax/y)
22 printf("\n Emax = %f kV/cm",Emax)
23 printf("\n V1 = %f kV/cm",V1)
24 printf("\n V2 = %f kV/cm",V2)
25
26 // Answers may vary due to round off error.
```

Scilab code Exa 12.10 Chapter 12 Example 10

```
1 //Chapter 12,Example 10, page 412
2 //Determine the maximum stress
3 clear
4 clc
5 a = 1 //cm
6 r1 = 2 // cm
7 b = 2.65 // cm
8 er1 = 4.5
9 er2 = 3.6
10 V = 53.8 // kV
11 ba = 5.3/2 // b/a
12 alpha = 1.325
13 E1max = V/(log(r1)+(er1/er2)*log(alpha))
14 E2max = V/((r1*(er2/er1)*log(r1))+log(alpha))
15 printf("\n E1max = %f kV/cm",E1max)
16 printf("\n E2max = %f kV/cm",E2max) // answer vary
    from the text
17
18 // Answer vary from the text due to round off
```

Chapter 14

Overvoltages on Power Systems

Scilab code Exa 14.4.2.1 Chapter 14 Example 1

```
1 //Chapter 14,Example 1, page 453
2 //Determine the time to crest
3 clear
4 clc
5 I = 400 // mH of inductance
6 L = 500*10^-3 // mH
7 C = 1.5*10^-6 // micro F
8
9 f = 1/(2*%pi*sqrt(L*C))
10 t = 10*6/(4*f) // calculation done in the text is
    wrong
11 printf("\n f1 = %f Hz",f)
12 printf("\n Time to crest = %f micro seconds",t)
13
14 // Answer may vary due to round off error.
```

Chapter 16

High Voltage Generation

Scilab code Exa 16.1 Chapter 16 Example 1

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

```

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

```

Scilab code Exa 16.2 Chapter 16 Example 2

```

1 //Chapter 16,Example 2, page 556
2 //Determine the (a)ripple voltage (b)voltage drop (c
   )Average output volatge (d)ripple factor
3 clear
4 clc
5 I1 = 5*10^-3 // A
6 C3 = 0.10*10^-6 // F
7 C2 = 0.05*10^-6 // F
8 C1 = 0.01*10^-6 // F
9 Vs = 100 // kV
10 f = 50 // Hz
11 // (a) Ripple voltage
12 printf("\n Part (a)")
13 delV = I1/f*((2/C1)+(1/C3))
14 printf("\n Ripple Voltage = %f kV", delV*10^-3)
15 // (b) Voltage drop
16 printf("\n Part (b)")
17 Vd = I1/f*((1/C2)+(1/C1)+(1/(2*C3)))
18 printf("\n Voltage drop = %f kV", Vd*10^-3)
19 // (c) Average output voltage
20 printf("\n Part (c)")
21 Vav = 3*Vs*sqrt(2)-Vd*10^-3
22 printf("\n Average output voltage = %f kV", Vav)
23 // (d) Ripple factor
24 printf("\n Part (d)")
25 RF = Vd*10^-3/(3*Vs*sqrt(2))

```

```

26 printf("\n Ripple Factor in percentage = %f", RF
    *100)
27
28 // Answers may vary due to round off error

```

Scilab code Exa 16.3 Chapter 16 Example 3

```

1 //Chapter 16,Example 3, page 557
2 //Determine the (a)ripple voltage (b)voltage drop (c
   )Average output volatge (d)ripple factor (e)
   optimum number of stages
3 clear
4 clc
5 I1 = 5*10^-3 // A
6 C = 0.15*10^-6 // F
7 Vs = 200 // kV
8 f = 50 // Hz
9 n = 12
10 // (a) Ripple voltage
11 printf("\n Part (a)")
12 delV = I1*n*(n+1)/(f*C*2)
13 printf("\n Ripple Voltage = %f kV", delV*10^-3)
14 // (b) Voltage drop
15 printf("\n Part (b)")
16 a = I1/(f*C)
17 Vd = a*((2/3*n^3)+(n^2/2)-(n/6)+(n*(n+1)/4))
18 printf("\n Voltage drop = %f kV", Vd*10^-3)
19 // (c) Average output voltage
20 printf("\n Part (c)")
21 Vav = 2*n*Vs*sqrt(2)-Vd*10^-3
22 printf("\n Average output voltage = %f kV", Vav)
23 // (d) Ripple factor
24 printf("\n Part (d)")
25 RF = Vd*10^-3/(2*n*Vs*sqrt(2))
26 printf("\n Ripple Factor in percentage = %f", RF

```



```

    *100)
27 // (e) Optimum number of stages
28 printf("\n Part (e)")
29 nopt = sqrt(Vs*sqrt(2)*10^3*f*C/I1)
30 printf("\n Optimum number of stages = %d stages",
    nopt)
31
32 // Answers may vary due to round off error

```

Scilab code Exa 16.4 Chapter 16 Example 4

```

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

```

```

    *10^-3)
19 printf("\n Leakage reactance of the transformer = %f
    k ohm", XL*10^-3)
20 printf("\n Additional series reactance = %f k ohm",
    Radd*10^-3)
21 printf("\n Inductance of required series inductor =
    %f H", Ind*10^3)
22 printf("\n Total circuit resistance = %f k ohm", R
    *10^-3)
23 printf("\n maximum current that can be supplied by
    the transformer = %f A", Imax)
24 printf("\n Exciting voltage of transformer secondary
    = %f kV", Vex*10^-3)
25 printf("\n Input voltage of transformer primary = %f
    V", Vin*10^-3)
26 printf("\n Input power of the transformer = %f kW",
    P*10^-3)
27
28 // Answers may vary due to round off error

```

Scilab code Exa 16.5 Chapter 16 Example 5

```

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

```

13
14 // Answers may vary due to round off error

Scilab code Exa 16.6 Chapter 16 Example 6

```
1 //Chapter 16,Example 6,page 560
2 //Determine the wave generated
3 clear
4 clc
5 // With refrence to table 16.1
6 C1 = 0.125*10^-6 // F
7 C2 = 1*10^-9 // F
8 R1 = 360 // ohm
9 R2 = 544 // ohm
10 V0 = 100 // kV
11 theta = sqrt(C1*C2*R1*R2)
12 neta = 1/(1+(1+R1/R2)*C2/C1)
13 alpha = R2*C1/(2*theta*neta)
14 printf("\n Theta = %f micro S",theta*10^6)
15 printf("\n Neta = %f",neta)
16 printf("\n Alpha = %f ",alpha)
17 // Coresponding to alpha the following can be
    deduced from Fig 16.12
18 T2 = 10.1*theta*10^6
19 T1 = T2/45
20 imp = T1/T2 // generated lighting impulse
21 // From equations 16.41 and 16.42
22 a1 = (alpha-sqrt(alpha^2-1))*10^-6/(theta)
23 a2 = (alpha+sqrt(alpha^2-1))*10^-6/theta
24 printf("\n T1 = %f microS", T1)
25 printf("\n T2 = %f microS", T2)
26 printf("\n Generated lighting impulse = %e wave",
    imp)
27 printf("\n alpha1 = %f microS", a1)
28 printf("\n alpha2 = %f microS", a2)
```

```

29 // According to equation 16.40
30 et = neta*(alpha*V0)/sqrt(alpha^2-1)
31 printf("\n e(t) = %f * (e^%ft - f^%ft)",et,-a1,-a2)
    // Equation of the wave form generated by the
    impulese
32
33 //Answers may vary due to round off error

```

Scilab code Exa 16.7 Chapter 16 Example 7

```

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

```

```

24 printf("\n alpha1 = %f microS", a1)
25 printf("\n alpha2 = %f microS", a2)
26 // According to equation 16.40
27 et = neta*(alpha*V0)/sqrt(alpha^2-1)
28 printf("\n e(t) = %f * (e^%ft - f^%ft)", et, -a1, -a2)
    // Equation of the wave form generated by the
    impulose
29
30 //Answers may vary due to round off error

```

Scilab code Exa 16.8 Chapter 16 Example 8

```

1 //Chapter 16, Example 8, page 562
2 //Determine the circuit efficiency
3 clear
4 clc
5 C1 = 0.125*10^-6 // F
6 C2 = 1*10^-9 // F
7 T2 = 2500
8 T1 = 250
9 // Bsaed on Figure 16.12
10 T2T1 = T2/T1
11 a = 4 // alpha
12 theta = T2/6
13 // From table 16.1
14 X = (1/a^2)*(1+C2/C1)
15 R1 = (a*theta*10^-6/C2)*(1-sqrt(1-X))
16 R2 = (a*theta*10^-6/(C1+C2))*(1+sqrt(1-X))
17 neta = 1/(1+(1+R1/R2)*C2/C1)
18 printf("\n Theta = %f micro S", theta)
19 printf("\n X = %f ", X)
20 printf("\n R1 = %f k Ohm", R1*10^-3)
21 printf("\n R2 = %f k Ohm", R2*10^-3)
22 printf("\n neta = %f ", neta)
23

```

24 // Answers may vary due to round off error

Scilab code Exa 16.9 Chapter 16 Example 9

```
1 //Chapter 16,Example 9,page 563
2 //Determine the maximum output voltage and energy
  rating
3 clear
4 clc
5 n = 8
6 C1 = 0.16/n // micro F
7 C2 = 0.001 // micro F
8 T2 = 50
9 T1 = 1.2
10 // beased on figure 16.12
11 a = 6.4 // alpha
12 theta = T2/9.5
13 X = (1/a^2)*(1+C2/C1)
14 R1 = (a*theta*10^-6/C2)*(1-sqrt(1-X))
15 R2 = (a*theta*10^-6/(C1+C2))*(1+sqrt(1-X))
16 R1n = R1/n
17 R2n = R2/n
18 V0 = n*120
19 neta = 1/(1+(1+R1/R2)*C2/C1)
20 V = neta*V0
21 E = 1/2*C1*V0^2
22 printf("\n Theta = %f micro S", theta)
23 printf("\n X = %f ", X)
24 printf("\n V0 = %f ", V0)
25 printf("\n R1 = %f Ohm", R1*10^6)
26 printf("\n R2 = %f Ohm", R2*10^6)
27 printf("\n R1/n = %d Ohm", R1n*10^6)
28 printf("\n R2/n = %d Ohm", R2n*10^6)
29 printf("\n neta = %f ", neta)
30 printf("\n Maximum output voltage = %f kV", V)
```

```

31 printf("\n Energy rating = %f J", E)
32
33 // Answers greatly vary due to round off error

```

Scilab code Exa 16.10 Chapter 16 Example 10

```

1 //Chapter 16,Example 10,page 564
2 //Determine the from and tail times
3 clear
4 clc
5 n = 12
6 C1 = 0.125*10^-6/n // micro F
7 C2 = 0.001*10^-6 // micro F
8 R1 = 70*n // ohm
9 R2 = 400*n // ohm
10 // beased on figure 16.15
11 theta = sqrt(C1*C2*R1*R2)
12 neta = 1/(1+R1/R2+C2/C1)
13 a = R2*C1/(2*theta*neta) // alpha
14 T2 = 7*theta*10^6
15 T1 = T2/25
16 printf("\n R1 = %f Ohm", R1)
17 printf("\n R2 = %f Ohm", R2)
18 printf("\n Theta = %f microS",theta*10^6)
19 printf("\n Neta = %f",neta)
20 printf("\n Alpha = %f ",a)
21 printf("\n T1 = %f microS", T1)
22 printf("\n T2 = %f microS", T2)
23
24 // Answers greatly vary due to round off error

```

Scilab code Exa 16.11 Chapter 16 Example 11

```

1 //Chapter 16,Example 11,page 564
2 //Determine the equation generated by impulse
3 clear
4 clc
5 w = 0.02*10^6 // s^-1 obtained by solving eq 16.47
   iteratively
6 R = sqrt(4-(sqrt(8*8*4)*0.02)^2) // solved the
   simplified equation
7 L = 8*10^-6
8 V = 25*10^3
9 // In equation 16.46
10 y = R/(2*L)
11 // Deriving the equation
12 a = V/(w*L)
13 printf("\n R = %e ohm",R)
14 printf("\n y = %e s^-1",y)
15 printf("\n I(t) = %e * exp(%et) * sin(%et) A",a,-y,w
   )
16
17 // Answers may vary due to round off error

```

Chapter 19

Applications of High Voltage Engineering

Scilab code Exa 19.1 Chapter 19 Example 1

```
1 //Chapter 19,Example 1,page 665
2 //Determine the separation between the particles
3 clear
4 clc
5 // Based on the equations 19.6, 19.7, 19.8, 19.9 and
   19.10
6 E = 8*10^5 // V/m
7 qm = 10*10^-6 // C/kg, qm = q/m
8 y = -1 // m
9 t = (1*2/9.8)
10 x = 1/2*qm*E*t
11 printf("\n The separation between the particles = %f
   m",2*x)
12
13 // Answers may vary due to round off error
```

Scilab code Exa 19.2 Chapter 19 Example 2

```
1 //Chapter 19,Example 2,page 667
2 //Determine the pumping pressure
3 clear
4 clc
5 p0 = 30*10^-3 // C/m^3
6 V = 30*10^3 // V
7 P = p0*V
8 printf("\n The pumping pressure P = %f N/m^2",P)
9
10 // Answers may vary due to round off error
```

Scilab code Exa 19.4 Chapter 19 Example 4

```
1 //Chapter 19,Example 4,page 670
2 //Determine the vertical displacement of the drop
3 clear
4 clc
5 d = 0.03*10^-3 // m
6 p = 2000 // kg/m^3
7 q = 100*10^-15 // C
8 V0 = 3500 // V
9 d2 = 2*10^-3 // m
10 L1 = 15*10^-3 // m
11 L2 = 12*10^-3 // m
12 Vz = 25 // m/s
13
14 m = 4/3*%pi*(1/2*d)^3*p
15 t0 = L1/Vz
16 Vx0 = q*V0*t0/(m*d2)
17 x0 = 1/2*Vx0*t0
18 t1 = (L1+L2)/Vz
19 x1 = x0+Vx0*(t1-t0)
20
```

```

21 printf("\n The vertical displacement of the drop =
    %e m",x1)
22
23 // Answers may vary due to round off error

```

Scilab code Exa 19.5 Chapter 19 Example 5

```

1 //Chapter 19,Example 5,page 672
2 //Determine the electric stress and charge density
3 clear
4 clc
5 a = 25*10^-6 // m
6 b = 75*10^-6 // m
7 Er = 2.8
8 ps = 25*10^-6 // C/m^3
9 E0 = 8.84*10^-12
10
11 Ea = (b*ps)/(ps*E0+b*Er*E0)
12 Eb = (a*ps)/(ps*E0+b*Er*E0) // the negative noation
    is removed to obtain positive answer as in the
    book
13 psc = E0*Eb
14
15 printf("\n Ea = %e V/m",Ea)
16 printf("\n Eb = %e V/m",Eb)
17 printf("\n Charge density = %e C/m^2",psc)
18
19 // Answers may vary due to round off error

```

Scilab code Exa 19.6 Chapter 19 Example 6

```

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

```

```

3 clear
4 clc
5 E0 = 8.84*10^-12
6 Us = 1.5*10^-3*10^-4
7 V = 100
8 d3 = 10^-6 // d^3
9 J = 4*E0*Us*V^2/d3
10 printf("\n Current density = %e A/m^2",J)
11
12 // Answer may vary due to round off error

```

Scilab code Exa 19.7 Chapter 19 Example 7

```

1 //Chapter 19,Example 7,page 676
2 //Determine the thickness of dust layer
3 clear
4 clc
5 Edb = 3*10^6
6 E0 = 8.84*10^-12
7 p0 = 15*10^-3
8 d = Edb*E0/p0
9 printf("\n Thickness of the dust layer = %e m",d)
10
11 // Answers may vary due to round off errors

```

Scilab code Exa 19.8 Chapter 19 Example 8

```

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

```

```

6 qi = 1.6*10^-19 // C
7 Va = 3500 // V
8 I = 0.2 // A
9 vi = sqrt(2*qi*Va/mi)
10 F = vi*mi*I/qi
11 printf("\n Ion velocity = %e m/s",vi)
12 printf("\n Populsion force = %e N",F)
13
14 // Answers may vary due to round off errors

```

Scilab code Exa 19.9 Chapter 19 Example 9

```

1 //Chapter 19,Example 9,page 677
2 //Determine the position of the particle
3 clear
4 clc
5 V = 120*10^3 // applied voltage in V
6 d = 0.6 // space b/w the plates in m
7 vd = 1.2 // vertical dimation in m
8 qm = 10*10^-6 // charge to mass C/kg
9 y = 4.9
10
11 t0 = sqrt(vd/y)
12 // based on eq 19.51 and 19.52
13 dx2 = qm*V/d
14 x = t0^2
15 printf("\n Velocity = %d m/s2",dx2)
16 printf("\n Position of the particle = %f m",x)
17
18 // Answer may vary due to round off error

```

Scilab code Exa 19.10 Chapter 19 Example 10

```

1 //Chapter 19,Example 10,page 679
2 //Determine the minimum voltage required for
   generating drops witha charge of 50 pC per drop
3 clear
4 clc
5 q = 50*10^-12
6 a = 25*10^-6
7 b = 750*10^-6
8 E0 = 8.84*10^-12
9 r = 50*10^-6
10 V = (3*q*b^2*log(b/a))/(7*pi*E0*r^3)
11 printf("\n The minimum voltage required for
   generating drops witha charge of 50 pC per drop =
   %f kV",V*10^-6)
12
13 // Answers may vary due to round off error

```
