

Scilab Textbook Companion for
Antenna & Wave Propagation
by K. K. Sharma¹

Created by
Nitin Kumar
B.Tech
Electronics Engineering
Uttarakhand Technical University
College Teacher
Arshad Khan
Cross-Checked by
Lavitha Pereira

July 31, 2019

¹Funded 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: Antenna & Wave Propagation

Author: K. K. Sharma

Publisher: Shubham Publications, Delhi

Edition: 1

Year: 2008

ISBN: 81-903721-5-7

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	4
1 Antenna Principles	5
3 Antenna Terminology	16
4 Antenna Arrays	27
5 Practical Antennas 1	35
6 Practical Antennas 2	40
7 Antenna Measurements	49
9 Ground wave Propagation	53
10 Sky Wave Propagation	58

List of Scilab Codes

Exa 1.1	Calculate strength of magnetic field	5
Exa 1.2	Calculate strength of Electric field	5
Exa 1.3	Find Power radiated by Antenna	6
Exa 1.4	Find Field Strength at 30 Km away	6
Exa 1.5	Find out Efficiency of Antenna	7
Exa 1.6	Determine Radiation Resistance	7
Exa 1.7	Determine field strength at a distance 10 Km	8
Exa 1.8	Calculate radiation resistance and efficiency of antenna	8
Exa 1.9	Calculate strength of electric field at a dis- tance 100 Km	9
Exa 1.10	Find Field Strength at 10 Km away and ra- diated power	9
Exa 1.11	Find Radiation Resistance	10
Exa 1.12	Value of Electric field at 20 Km away	10
Exa 1.13	Determine field strength	11
Exa 1.14	calculate Effective height of Antenna	11
Exa 1.15	Calculate radiation resistance	12
Exa 1.16	Find distance from 50 cycle circuit	12
Exa 1.17	Find Field Strength at 2 Km away	13
Exa 1.18	Calculate radiation resistance	13
Exa 1.19	Velocity impedance wavelength and Erms	14
Exa 1.20	Find Distance	15
Exa 3.1	Calculate strength of magnetic field	16
Exa 3.2	Calculate field strength at receiver	16
Exa 3.3	Calculate radiation resistance power radiated and antenna efficiency	17
Exa 3.4	Determine E and H field	17

Exa 3.5	Find Radiation Resistance	18
Exa 3.6	Directivity gain effective aperture beam solid angle	19
Exa 3.7	calculate Gain and Bandwidth	20
Exa 3.8	Calculate Directivity	21
Exa 3.9	Calculate Maximum effective aperture	21
Exa 3.10	Calculate front to back ratio	21
Exa 3.11	Determine Gain for received power	22
Exa 3.12	Find out Efficiency of Antenna and power gain	22
Exa 3.13	Determine Quality factor	23
Exa 3.14	Calculate Directivity of Isotropic Antenna	23
Exa 3.15	Calculate Maximum effective aperture	24
Exa 3.16	Find Effective Noise Temperature	24
Exa 3.19	Find Gain Beamwidth and Capture area	25
Exa 3.20	Find Beamwidth	25
Exa 4.3	Calculate HPBW of major lobes	27
Exa 4.4	Calculate Directivity and gain	28
Exa 4.5	HPBW Directivity Effective aperture and Beam solid angle	29
Exa 4.6	Determine Power radiated and HPBW	30
Exa 4.7	Find Directivity of end fire array	30
Exa 4.13	calculate the distance	31
Exa 4.14	Find Directivity of broad side array	31
Exa 4.15	Obtain Field pattern Maxima and Minima	32
Exa 4.17	design array to achieve optimum pattern	33
Exa 4.18	Design array 5 elements to achieve optimum pattern	33
Exa 5.1	Estima radiation resistance for single and 8 turn	35
Exa 5.2	Determine Peak Value of Magnetic Field Intensity	36
Exa 5.3	calculate maximum emf in the loop	36
Exa 5.4	Calculate Voltage across the capacitor	37
Exa 5.5	Calculate input voltage to the receiver	37
Exa 5.6	Derive input impedance of folded dipole antenna	38
Exa 6.1	Find HPBW Axial Ratio and Gain	40
Exa 6.2	Calculate Best spacing and directivity	41

Exa 6.3	Determine apex angle scale constant and no of elements	41
Exa 6.4	Estimate Power gain	42
Exa 6.5	Calculate 3 dB beamwidth and power gain .	42
Exa 6.6	Calculate HPBW BWFN and Gain	43
Exa 6.7	Specify diameter of parabolic reflector . . .	44
Exa 6.8	Find minimum distance between primary and secondary antenna	44
Exa 6.9	Calculate HPBW BWFN and diameter	45
Exa 6.10	Determine cut off frequencies and bandpass	46
Exa 6.11	Determine Length Width Flare Angle Theta and Fi	47
Exa 7.1	Find minimum distance between primary and secondary antenna	49
Exa 7.2	Determine gain of large Antenna	49
Exa 7.3	Find out Power gain in dB	50
Exa 7.4	Find minimum distance between primary and secondary antenna	50
Exa 7.5	Estimate diameter of paraboloidal reflector .	51
Exa 7.6	calculate gain og horn	51
Exa 9.1	Calculate Maximum line of sight and field strength	53
Exa 9.2	Find Field Strength at 20 Km away	54
Exa 9.3	Calculate field strength at receiver antenna .	54
Exa 9.4	Find height of receiving antenna	55
Exa 5.5	Find maximum possible distance along earth surface	55
Exa 9.6	Find Basic Path Loss	55
Exa 9.7	Calculate Basic transmission Loss	56
Exa 9.8	Find Range of LOS system	56
Exa 9.9	Find maximum power received by receiver .	57
Exa 10.1	Determine the range	58
Exa 10.2	Determine the ground range	59
Exa 10.3	Find critical frequency for reflection	59
Exa 10.4	Calculate MUF for given path	60
Exa 10.5	Calculate critical frequencies for F1 F2 and E	60
Exa 10.6	Find frequency for propagation in D region .	61
Exa 10.7	Find maximum distance and Radio Horizon	61

Exa 10.8	Calculate transmission path distance	62
Exa 10.9	Calculate maximum range obtainable in single hop transmission	62
Exa 10.10	Find frequency for propagation in E region .	63
Exa 10.11	Find frequency for propagation in D region .	63

Chapter 1

Antenna Principles

Scilab code Exa 1.1 Calculate strength of magnetic field

```
1 //Exa 1.1
2 clc;
3 clear;
4 close;
5 //given data :
6 E=4; //in V/m
7 Eta=120*%pi; //constant
8 //Formula : E/H=Eta
9 H=E/Eta; //in A/m
10 disp(H,"Strength of magnetic field in free space in
    A/m : ");
```

Scilab code Exa 1.2 Calculate strength of Electric field

```
1 //Exa 1.2
2 clc;
3 clear;
4 close;
```

```

5 //given data :
6 H=5.2;//in mA/m
7 Eta=120*%pi;//constant
8 //Formula : E/H=Eta
9 E=H*10^-3*Eta;//in V/m
10 disp(round(E),"Strength of Electric field in free
    space in V/m : ");

```

Scilab code Exa 1.3 Find Power radiated by Antenna

```

1 //Exa 1.3
2 clc;
3 clear;
4 close;
5 //given data :
6 I=20;//in A
7 Rr=100;//in Ohm
8 //Formula : Wr=I^2*R
9 Wr=I^2*Rr;//in W
10 disp(Wr/1000,"Radiated power in KW : ");

```

Scilab code Exa 1.4 Find Field Strength at 30 Km away

```

1 //Exa 1.4
2 clc;
3 clear;
4 close;
5 //given data :
6 W=625;//in KW
7 r=30;//in Km
8 Erms=sqrt(90*W*1000)/(r*1000);//in V/m
9 disp(Erms*1000,"Strength of Electric field at 30Km
    away in mV/m : ");

```

Scilab code Exa 1.5 Find out Efficiency of Antenna

```
1 //Exa 1.5
2 clc;
3 clear;
4 close;
5 //given data :
6 le=10;//in m
7 Irms=450;//in A
8 f=50;//in KHz
9 R=1.5;//in Ohm
10 lambda=300/(f/1000);//in m
11 Rr=160*(%pi)^2*(le/lambda)^2;//in Ohm
12 Wr=Irms^2*Rr;//in W
13 disp(Wr,"Radiated power in Watts : ");
14 Eta=(Rr/(Rr+R))*100;//efficiency in %
15 disp(Eta,"Efficiency of antenna in % : ");
```

Scilab code Exa 1.6 Determine Radiation Resistance

```
1 //Exa 1.6
2 clc;
3 clear;
4 close;
5 //given data :
6 le=50;//in m
7 f=100;//in MHz
8 lambda=300/(f);//in m
9 Rr=(160*(%pi)^2)*(le/lambda)^2;//in Ohm
10 disp(Rr/10^6,"Radiation Resistance in Mohm: ");
11 //Note : Answer in the book is wrong
```

Scilab code Exa 1.7 Determine field strength at a distance 10 Km

```
1 //Exa 1.7
2 clc;
3 clear;
4 close;
5 //given data :
6 l=30;//in m
7 Irms=20;//in A
8 f=1;//in MHz
9 r=10;//in Km
10 r=r*1000;//in m
11 le=2*l/%pi;//in m
12 lambda=300/(f);//in m
13 Erms=120*%pi*le*Irms/(lambda*r);//in V/m
14 disp(Erms,"Field strength at 10Km distace in V/m: ")
15 ;
16 //Note : Answer in the book is wrong
```

Scilab code Exa 1.8 Calculate radiation resistance and efficiency of antenna

```
1 //Exa 1.8
2 clc;
3 clear;
4 close;
5 //given data :
6 Rl=1;//in ohm
7 //Formula :  $R_r=80*\pi^2*(l/\lambda)^2$ 
8 //Given  $l=\lambda/10$ 
9 // $l/\lambda=1/10$ 
10  $R_r=80*\pi^2*(1/10)^2$ ;//in Ohm
11 disp(Rr,"Radiation resistance in Ohm: ");
```

```

12 Eta=Rr/(Rr+Rl); // Unitless
13 disp(Eta*100,"Antenna Efficiency in % : ");

```

Scilab code Exa 1.9 Calculate strength of electric field at a distance 100 Km

```

1 //Exa 1.9
2 clc;
3 clear;
4 close;
5 //given data :
6 r=100; //in Km
7 W=100; //in KW
8 Erms=sqrt(90*W*1000)/(r*1000); //in V/m
9 disp(Erms,"Strength of Electric Field in V/m : ");

```

Scilab code Exa 1.10 Find Field Strength at 10 Km away and radiated power

```

1 //Exa 1.10
2 clc;
3 clear;
4 close;
5 //given data :
6 le=200; //in m
7 Irms=200; //in A
8 f=300; //in KHz
9 r=10; //in Km
10 c=3*10^8; //speed of light i m/s
11 lambda=c/(f*1000); //in m
12 Erms=120*%pi*le*Irms/(lambda*r*10^3); //in V/m
13 disp(Erms,"Field strength at 10Km distace in V/m: ")
    ;
14 Rr=(160*(%pi)^2)*(le/lambda)^2; //in Ohm
15 W=Irms^2*Rr; //in Watts

```

```
16 disp(W/10^6,"Radiated Power in MWatts : ");
17 //Note : Answer is wrong in the book. Unit of answer
    in the book is written mW instead of MW by
    mistake.
```

Scilab code Exa 1.11 Find Radiation Resistance

```
1 //Exa 1.11
2 clc;
3 clear;
4 close;
5 //given data :
6 //Formula :  $R_r=80*\pi^2*(1/\lambda)^2$ 
7 //Given  $l=\lambda/60$ 
8 // $1/\lambda=1/60$ 
9  $R_r=80*\pi^2*(1/60)^2$ ; //in Ohm
10 disp(Rr,"Radiation resistance in Ohm: ");
```

Scilab code Exa 1.12 Value of Electric field at 20 Km away

```
1 //Exa 1.12
2 clc;
3 clear;
4 close;
5 //given data :
6  $r=10$ ; //in Km
7  $E_{rms}=10$ ; //in mV/m
8  $r1=20$ ; //in Km
9 //Formula :  $E_{rms}=\sqrt{90*W}/r$ ; //in V/m
10 //Let  $\sqrt{90*W}=a$ 
11  $a=E_{rms}*r$ ;
12  $E_{rms1}=a/r1$ ; //in mV/m
```

```
13 disp(Erms1,"Field strength at 20Km distace in mV/m:
    ");
```

Scilab code Exa 1.13 Determine field strength

```
1 //Exa 1.13
2 clc;
3 clear;
4 close;
5 //given data :
6 r=1;//in Km
7 r=1*10^3;//in m
8 l=1;//in m
9 Irms=10;//in A
10 f=5;//in MHz
11 c=3*10^8;//speed of light i m/s
12 lambda=c/(f*10^6);//in m
13 le=2*l/%pi;//in m
14 Erms=120*%pi*le*Irms/(lambda*r);//in V/m
15 disp(Erms,"Field strength at 10Km distace in V/m: ")
    ;
16 //Note : Answer in the book is wrong. Mistake during
    value putting.
```

Scilab code Exa 1.14 calculate Effective height of Antenna

```
1 //Exa 1.14
2 clc;
3 clear;
4 close;
5 //given data :
6 Irms=30;//in A
7 f=1;//in MHz
```

```

8 Erms=10; //in mV/m
9 Erms=Erms*10^-3; //in V/m
10 r=50; //in Km
11 r=r*10^3; //in m
12 c=3*10^8; //speed of light i m/s
13 lambda=c/(f*10^6); //in m
14 le=Erms*lambda*r/(120*%pi*Irms); //in m
15 disp(le," Effetive height of Antenna in meter : ");

```

Scilab code Exa 1.15 Calculate radiation resistance

```

1 //Exa 1.15
2 clc;
3 clear;
4 close;
5 //given data :
6 disp(" Erms^2 = 30*Wt/r^2");
7 disp(" Wt = Erms^2*r^2/30");
8 disp(" Given : E = 10*I/r");
9 disp(" Wt = (10*I/r)^2*r^2/30");
10 disp(" Wt = 100*I^2/30");
11 disp(" Rr = Wt/I^2 = 100/30");
12 disp(100/30," Radiation resistance in Ohm : ");

```

Scilab code Exa 1.16 Find distance from 50 cycle circuit

```

1 //Exa 1.16
2 clc;
3 clear;
4 close;
5 //given data :
6 format('v',8);
7 lambda=300/(50*10^-6); //in m

```



```
8 r=round(lambda)/(2*%pi); //in m
9 disp(r,"Distance in meter : ");
10 //Note : Answer in the book is wrong.
```

Scilab code Exa 1.17 Find Field Strength at 2 Km away

```
1 //Exa 1.17
2 clc;
3 clear;
4 close;
5 //given data :
6 r=2; //in Km
7 r=r*10^3; //in m
8 Wt=1; //in KW
9 Wt=Wt*10^3; //in Watt
10 Erms=sqrt(30*Wt)/r; //in V/m
11 disp(Erms*10^3,"Field strength at 2Km distace in mV/
    m: ");
```

Scilab code Exa 1.18 Calculate radiation resistance

```
1 //Exa 1.18
2 clc;
3 clear;
4 close;
5 //given data :
6 f=20; //in MHz
7 f=f*10^6; //in Hz
8 le=100; //in m
9 c=3*10^8; //speed of light in m/s
10 lambda=c/f; //in m
11 Rr=160*(%pi*le/lambda)^2; //in ohm
12 disp(Rr/1000,"Radiation Resistance in KOhm : ");
```

Scilab code Exa 1.19 Velocity impedance wavelength and Erms

```
1 //Exa 1.19
2 clc;
3 clear;
4 close;
5 //given data :
6 P=10; //in W/m^2
7 f=40; //in MHz
8 f=f*10^6; //in Hz
9 mu_r=4; //constant
10 epsilon_r=5; //constant
11 //Velocity of propagation
12 //formula : v=(1/sqrt(mu_o*epsilon_o))*(1/sqrt(mu_r*
    epsilon_r)); //in m/s
13 //1/sqrt(mu_o*epsilon_o)=c=speed of light=3*10^8 m/s
14 c=3*10^8; //speed of light in m/s
15 v=c*(1/sqrt(mu_r*epsilon_r)); //in m/s
16 disp(v,"Velocity of propagation in m/s : ");
17 //Wavelength
18 lambda=v/f; //in meter
19 disp(lambda,"Wavelength in Meter : ");
20 //rms electric field
21 //Formula : E=P*sqrt(mu_o/epsilon_o)*sqrt(mu_r/
    epsilon_r); //in V/m
22 E=sqrt(1200*pi*sqrt(4/5)); //in V/m
23 Erms=sqrt(E^2/sqrt(2)); //in V/m
24 disp(Erms,"rms Electric Field in V/m: ");
25 //Impedence of medium
26 Eta=(sqrt(2)*Erms)^2/P; //in Ohm
27 disp(Eta,"Impedence of medium in ohm : ");
```

Scilab code Exa 1.20 Find Distance

```
1 //Exa 1.20
2 clc;
3 clear;
4 close;
5 //given data :
6 disp(" Hfi = (Im*dlsin(theta)/(4*%pi))*[cos(omega*t1)
      /r-omega*sin(omega*t1)/(c*r)]");
7 disp(" 200(Im*dlsin(theta)/(4*%pi))*(sin(omega*t1)/r
      ^2)=(Im*dlsin(theta)/(4*%pi))*(-omega*sin(omega*
      t1)/(c*r))");
8 disp(" 200*cos(omega*t1)/r^2 = -omega*sin(omega*t1)/(
      c*r)");
9 disp(" r=200*lambda/(2*%pi); // in Meter")
10 disp(" r = "+string(200/(2*%pi))+ "lambda");
```

Chapter 3

Antenna Terminology

Scilab code Exa 3.1 Calculate strength of magnetic field

```
1 //Exa 3.1
2 clc;
3 clear;
4 close;
5 //given data :
6 E=10; //in V/m
7 ETA_o=120*%pi; //Constant
8 H=E/ETA_o; //in A/m
9 disp(H,"The Magnetic Field Strength in A/m : ");
10 //Note : Answer is wrong in the book.
```

Scilab code Exa 3.2 Calculate field strength at receiver

```
1 //Exa 3.2
2 clc;
3 clear;
4 close;
5 //given data :
```

```

6 W=25; //in KW
7 W=W*10^3; //in W
8 r=3; //in Km
9 r=r*10^3; //in m
10 Erms=sqrt(90*W)/r; //in V/m
11 disp(Erms,"Field strength at reciever in V/m :");

```

Scilab code Exa 3.3 Calculate radiation resistance power radiated and antenna efficiency

```

1 //Exa 3.3
2 clc;
3 clear;
4 close;
5 //given data :
6 le=125; //in m
7 Irms=5; //in A
8 lambda=1.25; //in Km
9 lambda=lambda*10^3; //in m
10 Rl=10; //in Ohm
11 //radiation Resistance
12 Rr=(80*%pi^2)*(le/lambda)^2; //in Ohm
13 Rr=round(Rr); //in Ohm : approx
14 disp(Rr,"Radiation resistance in Ohm : ");
15 //Power radiated
16 W=(Irms^2)*Rr; //in
17 disp(W,"Power radiated in W : ")
18 //Antenna efficiency
19 ETA=Rr/(Rr+Rl)
20 disp(ETA*100,"Antenna efficiency in % : ");

```

Scilab code Exa 3.4 Determine E and H field

```

1 //Exa 3.4

```

```

2  clc;
3  clear;
4  close;
5  //given data :
6  r=1; //in Km
7  r=r*10^3; //in m
8  I=0.5; //in A
9  //For theta = 45 degree
10 theta=45 ; //in degree
11 E=(60*I/r)*((cos(%pi*cos(theta*%pi/180)/2))/sin(
    theta*%pi/180));
12 disp(E*10^3,"E-Field for 45 degree angle in mV/m :")
    ;
13 ETA_o=120*%pi; //constant
14 H=E/ETA_o; //in A/m
15 disp(H*10^3,"H-Field for 45 degree angle in mV/m :")
    ;
16
17 //For theta = 90 degree
18 theta=90 ; //in degree
19 E=(60*I/r)*((cos(%pi*cos(theta*%pi/180)/2))/sin(
    theta*%pi/180));
20 disp(E*10^3,"E-Field for 90 degree angle in mV/m :")
    ;
21 ETA_o=120*%pi; //constant
22 H=E/ETA_o; //in A/m
23 disp(H*10^3,"H-Field for 90 degree angle in mV/m :")
    ;

```

Scilab code Exa 3.5 Find Radiation Resistance

```

1  //Exa 3.5
2  clc;
3  clear;
4  close;

```

```

5 //given data :
6 //l=lambd/10 meter
7 //Assume %pi^2 = 10
8 Rl=2; //in Ohm
9 disp("Rr=80*%pi^2*(dl/lambd)^2");
10 disp("dl/lambd = 1/10 : as l=lambd/10 ");
11 Rr=80*10*(1/10)^2; //in Ohm
12 disp(Rr,"Radiation Resistance in Ohm : ");
13 ETA=Rr/(Rr+Rl); //in Ohm
14 disp(ETA*100,"Efficiency inn % : ");

```

Scilab code Exa 3.6 Directivity gain effective aperture beam solid angle

```

1 //Exa 3.6
2 clc;
3 clear;
4 close;
5 //given data :
6 //l=lambd/15 meter
7 //Assume %pi^2 = 10
8 Rl=2; //in Ohm
9 //Gain :
10 Gain=5.33/4; //Unitless
11 //Directivity
12 Rr=80*10*(1/15)^2; //in Ohm
13 ETA=Rr/(Rr+Rl); //Unitless
14 Directivity=Gain/ETA; //unitless
15 //Beam solid angle
16 BSA=4*%pi/Directivity; //in steradian
17 disp(Directivity,"Directivity : ");
18 disp(Gain,"Gain = Pt/Pr = ");
19 //Effective aperture
20 disp("Effective aperture = G*lambd^2/(4*%pi) ");
21 disp(string(Gain/(4*%pi))+ "lambd^2");
22 disp(BSA,"Beam Solid Angle in steradian : ");

```

```

23 disp(" Radiation Resistance :")
24 disp("Rr=80*%pi^2*(dl/lambda)^2 in Ohm");
25 disp(" dl/lambda = 1/15 : as l=lambda/10 ");
26 Rr=80*10*(1/15)^2; //in Ohm
27 disp(Rr," Radiation Resistance in Ohm : ");
28 disp("Pt = Area of sphere * (E^2/(120*%pi))");
29 disp("Pt = ((4*%pi^2)/(120*%pi))*((60*%pi*I/r)*(dl/
    lambda)^2)");
30 disp("Pt=120*%pi^2*(lambda*15/lambda)*I^2");
31 disp("Pt = "+string(120*10/225)+" I^2");
32 disp("Pr = I^2*Rr = 4*I^2");

```

Scilab code Exa 3.7 calculate Gain and Bandwidth

```

1 //Exa 3.7
2 clc;
3 clear;
4 close;
5 //given data :
6 D=30; //in m
7 k=0.55; //illumination efficiency
8 f=4; //in GHz
9 f=f*10^9; //in Hz
10 c=3*10^8; //speed of light in m/s
11 lambda=c/f; //in Meter
12 r=D/2; //in m
13 A=%pi*(r^2); //in m^2
14 G=(4*%pi/lambda^2)*k*A; //Unitless
15 disp(G," Gain : ");
16 HPBW=70*lambda/D; //in Degree
17 disp(HPBW,"HPBW in Degree : ");
18 BWFN=2*70*lambda/D; //in Degree
19 disp(BWFN,"BWFN in Degree : ");

```

Scilab code Exa 3.8 Calculate Directivity

```
1 //Exa 3.8
2 clc;
3 clear;
4 close;
5 //given data :
6 Rl=20; //in Ohm
7 Rr=100; //in Ohm
8 Gp=25; //power gain
9 ETA=Rr/(Rr+Rl); //Unitless
10 D=Gp/ETA; //unitless
11 disp(D," Directivity : ")
```

Scilab code Exa 3.9 Calculate Maximum effective aperture

```
1 //Exa 3.9
2 clc;
3 clear;
4 close;
5 //given data :
6 lambda=10; //in m
7 D=80; //unitless
8 Aem=D*lambda^2/(4*pi); //in m^2
9 disp(Aem,"Maximum effective aperture in m^2 : ")
```

Scilab code Exa 3.10 Calculate front to back ratio

```
1 //Exa 3.10
```

```

2  clc;
3  clear;
4  close;
5  //given data :
6  P1=30; //in KW
7  P1=P1*1000; //in W
8  P2=5000; //in W
9  Gdb=10*log10(P1/P2); //unitless
10 disp(Gdb,"Front to back ratio = Gdb = ");

```

Scilab code Exa 3.11 Determine Gain for received power

```

1  //Exa 3.11
2  clc;
3  clear;
4  close;
5  //given data :
6  f=10; //in GHz
7  f=f*10^9; //in Hz
8  Gt=40; //in dB
9  Gr=40; //in dB
10 disp(Gt,"Gain = Gt = Gr : ");

```

Scilab code Exa 3.12 Find out Efficiency of Antenna and power gain

```

1  //Exa 3.12
2  clc;
3  clear;
4  close;
5  //given data :
6  L=10; //in m
7  f=1.5; //in MHz
8  f=f*10^6; //in Hz

```

```

 9 X=350; //in Ohm
10 Q=100; //Coil parameter
11 c=3*10^8; //speed of light in m/s
12 lambda=c/f; //in Meter
13 l_eff=2*L/2; //in m
14 Re=2*X/Q; //in Ohm
15 Rr=40*%pi^2*(l_eff/lambda)^2; //in hm
16 Gd=(3/2)*(lambda^2/(4*%pi)); //unitless
17 ETA=Rr/(Rr+Re); //Efficiency unitless
18 Gp=Gd*ETA; //unitless
19 disp(ETA*100,"Antenna Efficiency in % : ");
20 disp(Gp,"Power gain : ");
21 //Note : Answer of Gp is wrong in the book.

```

Scilab code Exa 3.13 Determine Quality factor

```

1 //Exa 3.13
2 clc;
3 clear;
4 close;
5 //given data :
6 delf=600; //in KHz
7 fr=50; //in MHz
8 Q=(fr*10^6)/(delf*10^3); //unitless
9 disp(Q,"Quality Factor : ");

```

Scilab code Exa 3.14 Calculate Directivity of Isotropic Antenna

```

1 //Exa 3.14
2 clc;
3 clear;
4 close;
5 //given data :

```

```

6 OmegaA=4*%pi;//For isotropic Antenna
7 D=4*%pi/OmegaA;//Directivity : Unitless
8 disp(D,"Directivity of Isotropic Antenna : ");

```

Scilab code Exa 3.15 Calculate Maximum effective aperture

```

1 //Exa 3.15
2 clc;
3 clear;
4 close;
5 //given data :
6 D=500;//Directivity : Unitless
7 format('v',6)
8 disp("D = (4*%pi/lambda^2)*Aem");
9 disp("Aem = D*lambda^2/(4*%pi)");
10 disp("Aem =" +string(D/(4*%pi))+" lambda^2");

```

Scilab code Exa 3.16 Find Effective Noise Temperature

```

1 //Exa 3.16
2 clc;
3 clear;
4 close;
5 //given data
6 Fn_dB=1.1;//in dB
7 Fn=10^(Fn_dB/10);//unitless
8 To=290;//in Kelvin
9 Te=To*(Fn-1);//in Kelvin
10 disp(Te,"Effective Noise Temperature in Kelvin : ");

```

Scilab code Exa 3.19 Find Gain Beamwidth and Capture area

```
1 //Exa 3.19
2 clc;
3 clear;
4 close;
5 //given data
6 format('v',9);
7 D=6;//in meter
8 f=10;//in GHz
9 f=f*10^9;//in Hz
10 Aactual=%pi*D^2/4;//in m^2
11 Ae=0.6*Aactual;//in m^2
12 c=3*10^8;//speed of light in m/s
13 lambda=c/f;//in Meter
14 G=4*%pi*Ae/lambda^2;//Unitless
15 Gdb=10*log10(G);//gain in dB
16 BWFN=140*lambda/D;//in degree
17 disp(G,"Gain : ");
18 disp(Gdb,"Gain in dB : ");
19 disp(BWFN,"Beamwidth in degree : ");
20 disp(Ae,"Capture Area in m^2 : ");
21 //Note : Answer in the book is not accurate.
```

Scilab code Exa 3.20 Find Beamwidth

```
1 //Exa 3.20
2 clc;
3 clear;
4 close;
5 //given data
6 Gdb=44;//gain in dB
7 G=10^(Gdb/10);//gain unitless
8 OmegaB=4*%pi/G;//n steradian
9 THETA3db=sqrt(4*OmegaB/%pi);//in Radian
```

```
10 disp(THETA3db,"Beamwidth THETA3db in degree : ");  
11 //Note : Answer in the book is not accurate.
```

Chapter 4

Antenna Arrays

Scilab code Exa 4.3 Calculate HPBW of major lobes

```
1 //Exa 4.3
2 clc;
3 clear;
4 close;
5 //given data :
6 disp("For a two elements array the total field is
    given by : ");
7 disp("E=2*Eo*cos(psi/2)");
8 disp("(i) It is a case of broad side array : so,
    delta = 0");
9 disp("psi = Beta*d*cos(theta)+delta")
10 disp("d=3*lambda/2");
11 disp("Beta*d = (2*pi/lambda)*(3*lambda/2) = 3*pi")
12 disp("psi = 3*pi*cos(theta)");
13 disp("psi/2 = (3*pi/2)*cos(theta)");
14 disp("The maxima for broad side array occurs when
    theta = pi/2");
15 disp("Ep = 2*Eo*cos(3*(pi/2)*cos(pi/2))");
16 disp("Ep = 2*Eo as cos(pi/2) = 0 and cos(0)=1");
17 disp("At half power beamwidth the field becomes Ep/
    sqrt(2)");
```

```

18 disp("So,  $\cos(3*(\pi/2)*\cos(\theta)) = 1/\sqrt{2}$ ");
19 disp("  $3*(\pi/2)*\cos(\theta)=\pi/4$ ");
20 disp("  $\cos(\theta) = 1/6$ ");
21 disp("  $\theta = 80.5$  degree")
22 theta = 80.5; //in degree
23 HPBW=2*(90-theta); //in degree
24 disp(HPBW,"HPBW in degree : ");
25 disp("(ii) Equal amplitude and different phase(540
    degree) : (end fire array) ");
26 disp("In case of end fire array : ");
27 disp("  $\delta = -\text{Beta}*d$ ");
28 disp("  $\text{Beta}*d = 540$  degree =  $3*\pi$ ");
29 disp("  $\psi = 3*\pi*\cos(\theta)-3*\pi = 3*\pi*(\cos(\theta)-1)$ ");
30 disp("EHPBW =  $3*\pi*(\cos(\theta)-1) = \pi/4 = 1/\sqrt{2}$ 
    (2)");
31 disp("  $3*\pi*(\cos(\theta)-1) = \pi/4$ ");
32 disp("  $\cos(\theta) = 1+1/12 = 13/12$ ");
33 disp("  $\theta = 33.6$  degree");
34 theta=33.6; //in degree
35 HPBW=2*theta; //in degree
36 disp(HPBW,"HPBW in degree : ");

```

Scilab code Exa 4.4 Calculate Directivity and gain

```

1 //Exa 4.4
2 clc;
3 clear;
4 close;
5 //given data :
6 n=10; //no. of elements
7 //d=lambd/4 separation in meter
8 disp("For broad side array : ")
9 disp("  $D=2*n/(\lambda/d)$ ");
10 disp("Putting  $d=\lambda/4$  we get  $D=2*n/4$ ")

```



```

11 D=2*n/4;//directivity : unitless
12 Ddb=10*log10(D);//in db
13 disp(Ddb,"For broad side array D in db = ");
14 disp("For end fire array : ")
15 disp("D=4*n/(lambda/d)");
16 disp("Putting d=lambda/4 we get D=4*n/4")
17 D=4*n/4;//directivity : unitless
18 Ddb=10*log10(D);//in db
19 disp(Ddb,"For end fire array D in db = ");

```

Scilab code Exa 4.5 HPBW Directivity Effective aperture and Beam solid angle

```

1 //Exa 4.1
2 clc;
3 clear;
4 close;
5 //given data :
6 delta=-90;//in degree
7 //Formula : HPBW=57.3/(sqrt(L/(2*lambda))) in Degree
8 n=20;//no. of point sources
9 //d=lambda/4;//in meter
10 //L=(n-1)*d
11 //L=(n-1)*lambda/4
12 LBYlambda=(n-1)/4;//in meter
13 HPBW=57.3/(sqrt(LBYlambda/2));// in Degree
14 disp(HPBW,"HPBW in Degree : ");
15 D=4*LBYlambda;//Directivity
16 disp(D,"Directivity : ");
17 disp("Effective aperture : Ae="+string(D/(4*pi))+"*
    lambda^2");
18 Omega=4*pi/D;//in steradian
19 disp("Beam Solid Angle : Omega = "+string(Omega));
20 //Note : Answer of Ae and omega in the book is wrong

```

Scilab code Exa 4.6 Determine Power radiated and HPBW

```
1 //Exa 4.6
2 clc;
3 clear;
4 close;
5 //given data :
6 n=8;//no. of half wave dipoles
7 lambda=100;//in cm
8 lambda=lambda*10^-2;//in m
9 d=50;//in cm
10 d=d*10^-2;//in m
11 I=0.5;//in A
12 Rr=73;//in Ohm
13 Pr=n*I^2*Rr;//in Watts
14 disp(Pr,"Pr in Watts : ");
15 BWFN=2*lambda/(n*d);//in radian
16 HPBW=BWFN/2;//in radian
17 disp(HPBW,"HPBW in radian : ");
18 disp(HPBW*180/%pi,"HPBW in degree : ")
```

Scilab code Exa 4.7 Find Directivity of end fire array

```
1 //Exa 4.7
2 clc;
3 clear;
4 close;
5 //given data :
6 n=10;//no. of elements
7 //d=lambda/4 separation in meter
8 disp("Do=1.789*4*n*d/lambda");
9 disp("Putting d=lambda/4 we get D=1.789*n")
```

```

10 Do=1.789*n; //directivity : unitless
11 Dodb=10*log10(Do); //in db
12 disp(Dodb,"Do in db = ");

```

Scilab code Exa 4.13 calculate the distance

```

1 //Exa 4.13
2 clc;
3 clear;
4 close;
5 //given data :
6 n=8; //no. of elements
7 BWFN=45; //in degree
8 theta=45; //in degree
9 f=40; //in MHz
10 f=f*10^6; //in Hz
11 //Formula : theta=2*asin(2*%pi/(n*dr))
12 dr=(2*%pi/n)/sin((theta/2)*(%pi/180)); //
13 c=3*10^8; //speed of light in m/s
14 lambda=c/f; //in m
15 d=dr*lambda/(2*%pi); //in m
16 disp(d,"Distane in meter :");

```

Scilab code Exa 4.14 Find Directivity of broad side array

```

1 //Exa 4.14
2 clc;
3 clear;
4 close;
5 //given data :
6 n=10; //no. of elements
7 //given : d=lambda/4; //in m
8 disp("Llambda=n*d/lambda");

```

```

9 disp(" Putting d=;ambda/4 we get Llambda=n/4");
10 Llambda=n/4; // unitless
11 D=2*Llambda; //in unitless
12 disp(D," Directivity of broadside uniform array : ");

```

Scilab code Exa 4.15 Obtain Field pattern Maxima and Minima

```

1 //Exa 4.15
2 clc;
3 clear;
4 close;
5 //given data :
6 n=2; //no. of elements
7 //given : d=lambda/3 in m
8 delta=%pi/3; //in phase difference
9 disp(" dr=2*%pi*d/lambda");
10 disp(" Putting d=lambda/3 we get dr=2*%pi/3");
11 dr=2*%pi/3; //
12 disp(" psi=dr*cos(theta)+delta");
13 disp(" psi=(2*%pi/3)*cos(theta)+%pi/3");
14 //Maxima :
15 disp(" Maxima : cos((%pi/3)*cos(theta)+%pi/6)=1 .....
      Magnitude");
16 disp(" (%pi/3)*cos(theta)+%pi/6=K*%pi");
17 disp(" theta=acos(-1/2+3*k)");
18 disp(" theta=+120,-120 degree");
19
20 //Minima :
21 disp(" Minima : cos((%pi/3)*cos(theta)+%pi/6)=0");
22 disp(" (%pi/3)*cos(theta)+%pi/6=(2*k+1)*%pi/2");
23 disp(" theta=acos(-1/2+(3/2)*(2*k+1))");
24 disp(" theta=0 degree");

```

Scilab code Exa 4.17 design array to achieve optimum pattern

```
1 //Exa 4.17
2 clc;
3 clear;
4 close;
5 //given data :
6 MainBeamwidth=45;//in degree
7 thetaN=MainBeamwidth/2;//in degree
8 thetaN=thetaN*pi/180;//in radian
9 m=5;//no. of elements
10 //given : d=lambd/2 in meter
11 x=cos(%pi/(2*(m-1)));
12 xo=x/cos((%pi/2)*sin(thetaN));//unitless
13 disp("E5=ao*z+a1*(2*z^2-1)+a2*(8*z^4-8*z^2+1)");
14 disp("We Know that : z=x/xo, E5=T4*xo");
15 disp("ao=a1*(2*(x/xo)^2-1)+a2*[8*(x/xo)^4-8*(x/xo)
      ^2+1]=8*x^4-8*x^2+1");
16 disp("By comparing the term we have : ");
17 disp("a2=xo^4 a1=4*a2-4*xo^2 ao=1+a1-a2 ");
18 a2=xo^4;
19 a1=4*a2-4*xo^2;
20 ao=1+a1-a2;
21 disp("And therefore the 5 elements array is given by
      : ");
22 disp(string(a2)+" "+string(a1)+" "+string(2*ao)+"
      "+string(a1)+" "+string(a2));
```

Scilab code Exa 4.18 Design array 5 elements to achieve optimum pattern

```
1 //Exa 4.18
2 clc;
3 clear;
4 close;
5 //given data :
```

```

6 //Side lobe level below main lobe
7 disp("Side lobe level below main lobe : ")
8 SideLobe=20;//in dB
9 r=10^(SideLobe/20);//
10 disp(r,"r=") ;
11 //No. of elements are 5, n=5
12 disp("No. of elements are 5, n=5 :");
13 disp("Tchebyscheff polynomials of degree (n-1) is");
14 disp("5-1=4");
15 disp("T4(xo)=r");
16 disp("8*xo^4-8*xo^2+1=10");
17 disp("By using alternate formula , we get");
18 m=4;
19 r=10;
20 xo=(1/2)*[{r+sqrt(r^2-1)}^(1/m)+{r-sqrt(r^2-1)}^(1/m
    )]
21 disp(xo,"xo=");
22 disp("E5=T4(xo)")
23 disp("E5=ao*z+a1*(2*z^2-1)+a2*(8*z^4-8*z^2+1)");
24 disp("We Know that : z=x/xo, E5=T4*xo");
25 disp("ao=a1*(2*(x/xo)^2-1)+a2*[8*(x/xo)^4-8*(x/xo)
    ^2+1]=8*x^4-8*x^2+1");
26 disp("By comparing the term we have : ");
27 disp("a2=xo^4 a1=4*a2-4*xo^2 ao=1+a1-a2 ");
28 a2=xo^4;
29 a1=4*a2-4*xo^2;
30 ao=1+a1-a2;
31 disp("And therefore the 5 elements array is given by
    : ");
32 disp(string(a2)+" "+string(a1)+" "+string(2*ao)+"
    "+string(a1)+" "+string(a2));

```

Chapter 5

Practical Antennas 1

Scilab code Exa 5.1 Estima radiation resistance for single and 8 turn

```
1 //Exa 5.1
2 clc;
3 clear;
4 close;
5 //For Single Turn:
6 disp("A=%pi*a^2");
7 disp("Putting a=lambda/25 we get : A=%pi*lambda
      ^2/625");
8 disp("Radiation Resistance Rr=31171.2*[A/lambda^2]^2
      ");
9 disp("Putting A=%pi*lambda^2/625 ");
10 Rr_1=31171.2*[%pi/625]^2; //in Ohm
11 disp(Rr_1,"radiation Resistance(in Ohm) for single
      turn : ");
12
13 //For Eight Turn:
14 N=8; //no. of turns
15 Rr=Rr_1*N^2; //in Ohm
16 disp(Rr,"radiation Resistance(in Ohm) for Eight turn
      : ");
```

Scilab code Exa 5.2 Determine Peak Value of Magnetic Field Intensity

```
1 //Exa 5.2
2 clc;
3 clear;
4 close;
5 //Given data :
6 f=20; //in MHz
7 N=15; //No. of turns
8 A=2; //in m^2
9 Vrms=200; //in uV
10 theta=acos(1); //in radian
11 mu_o=4*pi*10^-7; //in H/m
12 //Formula : Vm=2*pi*f*mu_o*H*A*N
13 Vm=Vrms*sqrt(2); //in uV
14 H=(Vm*10^-6)/(2*pi*f*10^6*mu_o*A*N); //in A/m
15 disp(H*1000,"Peak Value of magnetic field intensity
    in mA/m : ");
16 //Note : Answer in the book is wrong.
```

Scilab code Exa 5.3 calculate maximum emf in the loop

```
1 //Exa 5.3
2 clc;
3 clear;
4 close;
5 //Given data :
6 f=20; //in MHz
7 f=f*10^6; //in Hz
8 Wmax=25; //in mW/m^2
9 A=10; //in m^2
10 c=3*10^8; //speed of light in m/s
```



```

11 lambda=c/f;//in meter
12 Rr=31171.2*[A/lambda^2]^2;//iin Ohm
13 //Formula : Wmax=V^2/(4*Rr)
14 V=sqrt(Wmax*10^-3*4*Rr);//in Volts
15 disp(V,"Maximum emf in the loop in Volts : ");
16 //Note : Answer in the book is wrong.

```

Scilab code Exa 5.4 Calculate Voltage across the capacitor

```

1 //Exa 5.4
2 clc;
3 clear;
4 close;
5 //Given data :
6 N=20;//turns
7 D=1;//in meter
8 r=D/2;//in meter
9 E=200*10^-6;//in V/m
10 L=50*10^-6;//in H
11 R=2;//in Ohm
12 f=1.5;//in MHz
13 f=f*10^6;//in Hz
14 c=3*10^8;//speed of light in m/s
15 lambda=c/f;//in meter
16 A=%pi*r^2;//in m^2
17 Vrms=2*%pi*E*A*N/lambda;//in Volts
18 Q=2*%pi*f*L/R;//unitless
19 Vc_rms=Vrms*Q;//in Volts
20 disp(Vc_rms*1000," Voltage across the capacitor in mV
   :");
21 //Note : Answer in the book is wrong.

```

Scilab code Exa 5.5 Calculate input voltage to the receiver

```

1 //Exa 5.5
2 clc;
3 clear;
4 close;
5 //Given data :
6 N=100;//No. of turns
7 A=2;//in m^2
8 f=10;//in MHz
9 f=f*10^6;//in Hz
10 Q=150;//Quality factor
11 c=3*10^8;//speed of light in m/s
12 lambda=c/f;//in meter
13 Erms=10*10^-6;//in V/m
14 theta=60;//in degree
15 Vrms=2*%pi*Erms*A*N*cos(theta*%pi/180)/lambda;
16 Vin=Vrms*Q;//in Volts
17 disp(Vin*1000," Voltage to the receiver in mV : ");
18 //Note : Answer in the book is wrong.

```

Scilab code Exa 5.6 Derive input impedance of folded dipole antenna

```

1 //Exa 5.1
2 clc;
3 clear;
4 close;
5 disp("The emf applied to the end terminals is V.
      This is being divided in two equal half in each
      dipole. Hence voltage in each dipole is V/2.");
6 disp("By nodal analysis : ");
7 disp("V/2=I1*Z11+I2*Z12          eq(1)");
8 disp("Where I1 ,I2 are currents flowing at terminals
      of dipole1 and dipole 2");
9 disp("Z11 and Z12 are self impedences of dipole1
      and mutual impedance between dipole1 and dipole2
      respectively.");

```

```
10 disp(" I1=I2");
11 disp("V/2=I*(Z11+Z12)          eq(2)");
12 disp("Both the dipoles are kept lambda/100 apart (i.
      e., they are very close to each other.)")
13 disp("So, Z11=Z12");
14 disp("From eq(1) and eq(2) : ");
15 disp("V/2=I1*(2*Z11)");
16 disp("Z=V/I1=4*Z11");
17 Z11=73 ;//Resistance for a dipole in Ohm
18 disp("Z=4*73 ohm");
19 disp("Z=292 ohm");
```

Chapter 6

Practical Antennas 2

Scilab code Exa 6.1 Find HPBW Axial Ratio and Gain

```
1 //Exa 6.1
2 clc;
3 clear;
4 close;
5 n=20; //no. of turns
6 //Clambda=lambda
7 //Slambda=lambda/4
8 //HPBW :
9 disp("HPBW=52/(Clambda*sqrt(n*Slambda))");
10 //Putting values below :
11 Clambda=1; //in Meter
12 Slambda=1/4; //in Meter
13 HPBW=52/(Clambda*sqrt(n*Slambda)); //in degree
14 disp(HPBW,"HPBW in degree : ");
15 //Axial Ratio
16 Aratio=(2*n+1)/2; // unitless
17 disp(Aratio,"Axial Ratio : ");
18 //Gain
19 D=12*Clambda^2*n*Slambda; // unitless
20 disp(D,"Gain : ");
```

Scilab code Exa 6.2 Calculate Best spacing and directivity

```
1 //Exa 6.2
2 clc;
3 clear;
4 close;
5 //Part (a): Given data :
6 disp("Part (a) : At the center frequency with a
      circumference of lambda, the directivity of an
      axial mode helix is , : D=12*n*Slambda");
7 n=20; //no. of turns
8 Slambda=0.472; //in meter
9 D=12*n*Slambda; //in meter
10 disp("Ae=(lambda^2/(4*pi))*D");
11 disp("Ae="+string(1/(4*pi*D))+ "lambda^2");
12 disp("Let this be the area of a square. The space
      between the elements is :")
13 disp("d=sqrt(Ae)");
14 disp("d="+string(sqrt(1/(4*pi*D)))+ "lambda");
15 disp("Part (b) : With a space of 3*lambda the total
      effective area : ");
16 disp("Ae=9.02*lambda^2*4");
17 disp("Ae="+string(9.02*4)+ "lambda^2");
18 disp("D=4*pi*Ae/lambda^2");
19 disp("D="+string(4*pi*36.08)); // unitless
```

Scilab code Exa 6.3 Determine apex angle scale constant and no of elements

```
1 //Exa 6.3
2 clc;
3 clear;
4 close;
```

```

5 //from 7dBi gain graph the data obtained is given
  below :
6 K=1.2;//Scale constant
7 alfa=1.5;//Apex angle in degree
8 Slambda=0.15;
9 disp("K^n=F or n=logF/logK");
10 F=4;
11 n=log10(F)/log10(K);
12 n=ceil(n);
13 nplus1=n+1;
14 disp(alfa,"Apex Angle in degree : ");
15 disp(K,"Sale constant :");
16 disp(n,"No. of elements : ");

```

Scilab code Exa 6.4 Estimate Power gain

```

1 //Exa 6.4
2 clc;
3 clear;
4 close;
5 //Given data :
6 //d=10*lambda
7 disp("d=10*lambda");
8 disp("Power Gain : G=6*(d/lambda)^2");
9 disp("Putting value of d, we get G=6*10^2")
10 G=6*10^2;// unitless
11 disp(G,"Power gain : ");
12 G_dB=10*log10(G);//in dB
13 disp(G_dB,"Power Gain in dB : ");

```

Scilab code Exa 6.5 Calculate 3 dB beamwidth and power gain

```

1 //Exa 6.5

```

```

2  clc;
3  clear;
4  close;
5  //Given Data:
6  f=10; //in GHz
7  f=f*109; //in Hz
8  BWFN=10; //in degree
9  c=3*108; //Speed of light in m/s
10 lambda=c/f; //in meter
11 //Part (a):
12 d=140*lambda/BWFN; //in meter
13 disp(d, "Diameter of a parabolic Antenna in meter : "
    );
14 //Part (b):
15 HPBW=58*lambda/d; //in degree
16 disp(HPBW, "3-dB Beamwidth in degree :");
17 //Part (c):
18 Gp=6*(d/lambda)2; //gain
19 Gp_dB=10*log10(Gp); //in dB
20 disp(Gp_dB, "Power Gain in dB : ");

```

Scilab code Exa 6.6 Calculate HPBW BWFN and Gain

```

1  //Exa 6.6
2  clc;
3  clear;
4  close;
5  //Given Data:
6  f=1430; //in MHz
7  f=f*106; //in Hz
8  d=64; //in meter
9  c=3*108; //Speed of light in m/s
10 lambda=c/f; //in meter
11 //Part (a):
12 HPBW=70*lambda/d; //in degree

```

```

13 disp(HPBW,"HPBW in degree :");
14 //Part (b):
15 BWFN=140*lambda/d;//in degree
16 disp(BWFN,"BWFN in degree :");
17 //Part (c):
18 Gp=6*(d/lambda)^2;//gain
19 Gp_dB=10*log10(Gp);//in dB
20 disp(Gp_dB,"Power Gain in dB : ");

```

Scilab code Exa 6.7 Specify diameter of parabolic reflector

```

1 //Exa 6.7
2 clc;
3 clear;
4 close;
5 //Given Data:
6 f=15;//in GHz
7 f=f*10^9;//in Hz
8 Gp_dB=75;//in dB
9 c=3*10^8;//Speed of light in m/s
10 lambda=c/f;//in meter
11 //Formula :  $G_p=9.87*(d/\lambda)^2$ 
12 //Formula :  $G_p_{dB}=10\log_{10}(G_p)$ 
13 d=sqrt((10^(Gp_dB/10))*lambda^2/9.87);//in meter
14 disp(d,"Diameter of a parabolic reflector in meter :
    ");

```

Scilab code Exa 6.8 Find minimum distance between primary and secondary antenna

```

1 //Exa 6.8
2 clc;
3 clear;
4 close;

```



```

5 //Given Data:
6 f=5000;//in MHz
7 f=f*10^6;//in Hz
8 d=10;//in feet
9 d=d*0.3048;//in meter
10 c=3*10^8;//Speed of light in m/s
11 lambda=c/f;//in meter
12 r=2*d^2/lambda;//in meter
13 disp(r,"Minimum distance between primary and
    secondary antenna in meter :");

```

Scilab code Exa 6.9 Calculate HPBW BWFN and diameter

```

1 //Exa 6.9
2 clc;
3 clear;
4 close;
5 //Given Data:
6 K=55;//Aperture Efficiency in %
7 K=K/100;//Aperture Efficiency
8 f=15;//in GHz
9 f=f*10^9;//in Hz
10 c=3*10^8;//Speed of light in m/s
11 lambda=c/f;//in meter
12 G_dB=30;//in dB
13 G=10^(G_dB/10);//Gain unitless
14 //Formula :  $G=4*\%pi*K*A/\lambda^2$ 
15  $A=(G*\lambda^2)/(4*\%pi*K)$ ;//in m^2
16 disp(A,"Diameter of parabolic reflector in m^2 :");
17 //Part (b)
18 d=sqrt(4*A/%pi);//in meter
19 HPBW=70*lambda/d;//in degree
20 disp(HPBW,"HPBW in degree : ");
21 //Part (c)
22 BWFN=140*lambda/d;//in Degree

```

```
23 disp(BWFN,"BWFN in degree : ");
24 //Note : Answer in the book is not accurate.
```

Scilab code Exa 6.10 Determine cut off frequencies and bandpass

```
1 //Exa 6.10
2 clc;
3 clear;
4 close;
5 //Given Data:
6 Tau=0.7; //Design Factor
7 L1=0.3*2; //in meter
8 c=3*10^8; //speednof light in m/s
9 f1=(c/(2*L1))/10^6; //in MHz
10 //Design factor : L1/L2=L2/L3=L3/L4 = ..... = 0.7
11 L2=0.7/L1; //in meter
12 f2=f1*0.7; //in MHz
13 f3=f2*0.7; //in MHz
14 f4=f3*0.7; //in MHz
15 f5=f4*0.7; //in MHz
16 f6=f5*0.7; //in MHz
17 f7=f6*0.7; //in MHz
18 f8=f7*0.7; //in MHz
19 f9=f8*0.7; //in MHz
20 f10=f9*0.7; //in MHz
21 disp("Cutoff frequencies in MHz :")
22 disp(f1,"f1 in MHz :");
23 disp(f2,"f2 in MHz :");
24 disp(f3,"f3 in MHz :");
25 disp(f4,"f4 in MHz :");
26 disp(f5,"f5 in MHz :");
27 disp(f6,"f6 in MHz :");
28 disp(f7,"f7 in MHz :");
29 disp(f8,"f8 in MHz :");
30 disp(f9,"f9 in MHz :");
```

```

31 disp(f10,"f10 in MHz :");
32 disp(f1-f10,"Passband=");

```

Scilab code Exa 6.11 Determine Length Width Flare Angle Theta and Fi

```

1 //Exa 6.11
2 clc;
3 clear;
4 close;
5 //Given Data:
6 disp("Assuming typical values for f as 0.2lamda in E
    -plane and 0.375lambda in H-plane");
7 //b=10*lambda ;mouth height
8 //delta=0.8*lambda
9 disp("Length :")
10 disp("L=b^2/(8*lambda)");
11 disp("L="+string(10^2/(8*0.2))+ "lambda");
12 disp("Flare Angle (Theta):")
13 disp("Theta=atan(b/(2*L))");
14 disp("Theta="+string(10/(2*(10^2/(8*0.2))))+" radian
    ");
15 Theta=(10/(2*(10^2/(8*0.2))))*180/%pi;//in Degree
16 disp(Theta,"Flare Angle Theta in degree : ");
17 disp("Flare Angle (fi):")
18 disp("fi=acos(L/(L+delta))=acos((10^2/(8*0.2))
    /((10^2/(8*0.2))+0.375))");
19 disp("fi="+string(acos((10^2/(8*0.2))/((10^2/(8*0.2)
    )+0.375)))+ " radian");
20 fi=(acos((10^2/(8*0.2))/((10^2/(8*0.2))+0.375)))
    *180/%pi;//in Degree
21 disp(fi,"Flare angle fi in degree : ");
22 disp("Width :");
23 disp("Width, a=2*L*tan(fi)");
24 disp("a="+string(2*62.5*tan((acos((10^2/(8*0.2))
    /((10^2/(8*0.2))+0.375))))+" lambda");

```


Chapter 7

Antenna Measurements

Scilab code Exa 7.1 Find minimum distance between primary and secondary antenna

```
1 //Exa 7.1
2 clc;
3 clear;
4 close;
5 //given data :
6 f=6;//in GHz
7 f=f*10^9;//in Hz
8 d=10;//in feet
9 d=3.048;//in meter
10 c=3*10^8;//in m/s
11 lambda=c/f;//in meters
12 rmin=2*d^2/lambda;//in meters
13 disp(rmin,"Minimumseparation distance in meters : ")
    ;
```

Scilab code Exa 7.2 Determine gain of large Antenna

```
1 //Exa 7.2
```

```

2  clc;
3  clear;
4  close;
5  //given data :
6  GP=12.5;//unitless
7  P_dB=23;//in dB
8  P=10^(P_dB/10);//unitless
9  G=GP*P;//unitless
10 GdB=GP+P_dB;//in dB
11 disp(GdB,"Gain of large antenna : ");
12 //Note : Answer in the book is wrong.

```

Scilab code Exa 7.3 Find out Power gain in dB

```

1  //Exa 7.3
2  clc;
3  clear;
4  close;
5  //given data :
6  disp("Open mouth aperture , D = 10*lambda");
7  disp("Power gain : GP = 6*(D/labda)^2");
8  GP=6*10^2;//unitless
9  GPdB=10*log10(GP)
10 disp(GPdB,"Power gain in dB : ");

```

Scilab code Exa 7.4 Find minimum distance between primary and secondary antenna

```

1  //Exa 7.4
2  clc;
3  clear;
4  close;
5  //given data :
6  f=3000;//in MHz

```

```

7 f=f*10^6; //in Hz
8 d=20; //in feet
9 d=20*0.3048; //in meter
10 c=3*10^8; //in m/s
11 lambda=c/f; //in meters
12 r=2*d^2/lambda; //in meters
13 disp(r,"Minimum distance between primary and
    secondary in meters : ");

```

Scilab code Exa 7.5 Estimate diameter of paraboloidal reflector

```

1 //Exa 7.5
2 clc;
3 clear;
4 close;
5 //given data :
6 f=1.2; //in GHz
7 f=f*10^9; //in Hz
8 BWFN=5; //in degree
9 c=3*10^8; //in m/s
10 lambda=c/f; //in meters
11 D=140*lambda/BWFN; //in meters
12 disp(D,"Diameter of a paraboloidal reflector in
    meters : ");

```

Scilab code Exa 7.6 calculate gain og horn

```

1 //Exa 7.6
2 clc;
3 clear;
4 close;
5 //given data :
6 f=9; //in GHz

```

```
7 f=f*10^9; //in Hz
8 c=3*10^8; //in m/s
9 lambda=c/f; //in meters
10 r=35; //in cm
11 r=r*10^-2; //in meters
12 Attenuation=9.8; //in dB
13 //Formula :  $10 \cdot \log_{10}(WT/Wr) = 9.8 \text{ dB}$ 
14 WTbyWr=10^(Attenuation/10); //unitless
15 D=(4*%pi*r/lambda)*(sqrt(1/WTbyWr)); //unitless
16 D_dB=10*log10(D);
17 disp(D_dB,"Gain of the horn in dB : ");
```

Chapter 9

Ground wave Propagation

Scilab code Exa 9.1 Calculate Maximum line of sight and field strength

```
1 //Exa 9.1
2 clc;
3 clear;
4 close;
5 //given data :
6 HT=50;//in meter
7 HR=10;//in meter
8 f=60;//in MHz
9 P=10;//in KW
10 D=10;//in Km
11 D=D*10^3;//in m
12 c=3*10^8;//speed of light in m/s
13 lambda=c/(f*10^6);//in meter
14 //Part (i)
15 d=3.55*(sqrt(HT)+sqrt(HR));//in Km
16 disp(d,"Maximum line of sight range in Km : ");
17 //Part (ii)
18 Et=88*sqrt(P*1000)*HT*HR/(lambda*D^2)
19 disp(Et,"The field strength at 10 Km in V/m: ");
20 //Part (iii)
21 //Formula : Et=88*sqrt(p)*HT*HR/(lambda*D^2)
```

```

22 Et=1; //in mV/m
23 D=sqrt(88*sqrt(P*1000)*HT*HR/(lambda*Et*10^-3)); //in
    m
24 disp(D/1000,"Distance in Km : ");

```

Scilab code Exa 9.2 Find Field Strength at 20 Km away

```

1 //Exa 9.2
2 clc;
3 clear;
4 close;
5 //given data :
6 P=200; //in KW
7 D=20; //in Km
8 D=D*10^3; //in m
9 E=300*sqrt(P)/D; //in V/m
10 disp(E*10^3,"Field Strength at 20 Km in mV/m:")

```

Scilab code Exa 9.3 Calculate field strength at receiver antenna

```

1 //Exa 9.3
2 clc;
3 clear;
4 close;
5 //given data :
6 HT=10; //in meter
7 HR=3; //in meter
8 P=200; //in W
9 D=50; //in Km
10 D=D*10^3; //in Km
11 f=150; //in MHz
12 c=3*10^8; //speed of light in m/s
13 lambda=c/(f*10^6); //in meter

```

```
14 E=88*sqrt(P)*HT*HR/(lambda*D^2); //in m
15 disp(E*10^6,"Field Strength at 20 Km in microV/m:");
```

Scilab code Exa 9.4 Find height of receiving antenna

```
1 //Exa 9.4
2 clc;
3 clear;
4 close;
5 //given data :
6 HT=100; //in meter
7 d=60; //in Km
8 //Formula : d=4.12*(sqrt(HT)+sqrt(HR)); //in Km
9 HR=(d/4.12-sqrt(HT))^2; //in meter
10 disp(HR,"Height of receiving antenna in meter : ");
```

Scilab code Exa 5.5 Find maximum possible distance along earth surface

```
1 //Exa 9.5
2 clc;
3 clear;
4 close;
5 //given data :
6 HT=3000; //in meter
7 HR=6000; //in meter
8 d=4.12*(sqrt(HT)+sqrt(HR)); //in Km
9 disp(d,"Maximum possible distance in Km : ");
```

Scilab code Exa 9.6 Find Basic Path Loss

```

1 //Exa 9.6
2 clc;
3 clear;
4 close;
5 //given data :
6 f_MHz=3000; //in MHz
7 d_Km=384000; //in Km
8 PathLoss=32.45+20*log10(f_MHz)+20*log10(d_Km); //in
   dB
9 disp(PathLoss,"Path loss in dB : ");

```

Scilab code Exa 9.7 Calculate Basic transmission Loss

```

1 //Exa 9.7
2 clc;
3 clear;
4 close;
5 //given data :
6 //Part (i)
7 D=10; //in Km
8 lambda=10000; //in meter
9 LP=(4*pi*D*1000/lambda)^2; //in dB
10 disp(LP,"Path loss in dB : ");
11 //Part (ii)
12 D=10^6; //in Km
13 lambda=0.3; //in cm
14 LP=(4*pi*D*1000/(lambda*10^-2))^2; //in dB
15 disp(LP,"Path loss in dB : ");
16 //Note : Answer in the book is wrong as value putted
   in the solution is differ from given in question
   .

```

Scilab code Exa 9.8 Find Range of LOS system

```

1 //Exa 9.8
2 clc;
3 clear;
4 close;
5 //given data :
6 HT=50;//in meter
7 HR=5;//in meter
8 d=4.12*(sqrt(HT)+sqrt(HR)); //in Km
9 disp(d,"Range of LOS system in Km : ");

```

Scilab code Exa 9.9 Find maximum power received by receiver

```

1 //Exa 9.9
2 clc;
3 clear;
4 close;
5 //given data :
6 PT=5;//in KW
7 PT=PT*1000;//in W
8 D=100;//in Km
9 D=D*10^3;//in m
10 f=300;//in MHz
11 GT=1.64;//Directivity of transmitter
12 GR=1.64;//Directivity of receiver
13 c=3*10^8;//speed of light in m/s
14 lambda=c/(f*10^6);//in meter
15 Pr=PT*GT*GR*[lambda/(4*pi*D)]^2
16 disp(Pr,"Maximum power received in Watt:");

```

Chapter 10

Sky Wave Propagation

Scilab code Exa 10.1 Determine the range

```
1 //Exa 10.1
2 clc;
3 clear;
4 close;
5 //given data :
6 H=500; //in km
7 n=0.8; //in m
8 f_muf=10; //in MHz
9 f_muf=f_muf*10^6; //in Hz
10 f=10; //in MHz
11 f=f*10^6; //in Hz
12 // Formula :  $n=\sqrt{1-81*N/f^2}$ 
13 Nmax=(1-n^2)*f^2/81; //in Hz;
14 fc=9*sqrt(Nmax); //in Hz
15 Dskip=2*H*sqrt((f_muf/fc)^2-1); //in Km
16 disp(Dskip,"Assuming the earth is flat the range in
    Km : ");
17 //Note : Answer in the book is wrong.
```

Scilab code Exa 10.2 Determine the ground range

```
1 //Exa 10.2
2 clc;
3 clear;
4 close;
5 //given data :
6 n=0.8; //in m
7 H=500; //in km
8 a=6370; //in km
9 D=1349.07; //in Km
10 f_muf=10; //in MHz
11 f_muf=f_muf*10^6; //in Hz
12 f=10; //in MHz
13 f=f*10^6; //in Hz
14 // Formula :  $n=\sqrt{1-81*N/f^2}$ 
15 Nmax=(1-n^2)*f^2/81; //in Hz;
16 fc=9*sqrt(Nmax); //in Hz
17 // Formula :  $f_{muf}/fc=\sqrt{D^2/(4*(H+D^2/(8*a)))}+1$ 
18 D1=2*[H+D^2/(8*a)]*sqrt((f_muf/fc)^2-1); //in Km
19 Dskip=2*H*sqrt((f_muf/fc)^2-1); //in Km
20 disp(D1,"Assuming the earth is curved the ground
    range in Km : ");
```

Scilab code Exa 10.3 Find critical frequency for reflection

```
1 //Exa 10.3
2 clc;
3 clear;
4 close;
5 //given data :
6 Nmax=2.48*10^6; //in cm^-3
7 Nmax=2.48*10^6*10^-6; //in m^-3
8 fc=9*sqrt(Nmax); //in MHz
9 disp(fc,"Critical frequency in MHz : ");
```

Scilab code Exa 10.4 Calculate MUF for given path

```
1 //Exa 10.4
2 clc;
3 clear;
4 close;
5 //given data :
6 H=200;//in Km
7 D=4000;//in Km
8 fc=5;//in MHz
9 f_muf=fc*sqrt(1+(D/(2*H))^2);//in MHz
10 disp(f_muf,"MUF for the given path in MHz : ");
11 //Note : Answer in the book is wrong.
```

Scilab code Exa 10.5 Calculate critical frequencies for F1 F2 and E

```
1 //Exa 10.5
2 clc;
3 clear;
4 close;
5 //given data :
6 //For F1 layer :
7 disp("For F1 layer :");
8 Nmax=2.3*10^6;//in cm^3
9 Nmax=2.3*10^6*10^-6;//in m^3
10 fc=9*sqrt(Nmax);//in MHz
11 disp(fc,"Critical frequency in MHz : ");
12
13 //For F2 layer :
14 disp("For F2 layer :");
15 Nmax=3.5*10^6;//in cm^3
```



```

16 Nmax=3.5*10^6*10^-6; //in m^3
17 fc=9*sqrt(Nmax); //in MHz
18 disp(fc," Critical frequency in MHz : ");
19
20 //For F3 layer :
21 disp("For F3 layer :");
22 Nmax=1.7*10^6; //in cm^3
23 Nmax=1.7*10^6*10^-6; //in m^3
24 fc=9*sqrt(Nmax); //in MHz
25 disp(fc," Critical frequency in MHz : ");
26 //Note : Answer in the book is wrong.

```

Scilab code Exa 10.6 Find frequency for propagation in D region

```

1 //Exa 10.6
2 clc;
3 clear;
4 close;
5 //given data :
6 n=0.7; //refractive index
7 N=400; //in cm^-3
8 //Formula : n=sqrt(1-81*N/f^2)
9 f=sqrt(81*N/(1-n^2)); //in KHz
10 disp(f,"Frequency of wave propagation in KHz : ");
11 //Note : Unit of Answer in the book is MHz. It is
    written by mistake. It is accurately calculated
    by scilab in KHz.

```

Scilab code Exa 10.7 Find maximum distance and Radio Horizon

```

1 //Exa 10.7
2 clc;
3 clear;

```

```

4 close;
5 //given data :
6 HT=169;//in meter
7 HR=20;//in meter
8 d=4.12*(sqrt(HT)+sqrt(HR));//in Km
9 disp(d,"Maximum distance in Km : ");
10 r_dash=(4/3)*6370/1000;//in Km
11 RadioHorizon=sqrt(2*r_dash*HT);//in Km
12 disp(RadioHorizon,"Radio Horizon in Km : ");

```

Scilab code Exa 10.8 Calculate transmission path distance

```

1 //Exa 10.8
2 clc;
3 clear;
4 close;
5 //given data :
6 H=200;//in Km
7 Beta=20;//in Degree
8 a=6370;//in Km
9 D_flat=2*H/tan(Beta*%pi/180);//in Km
10 disp(D_flat,"If earth assumed to be flat
    transmission path distance in Km : ");
11 D_curved=2*a*[(90*%pi/180-Beta*%pi/180)-asin(a*cos(
    Beta*%pi/180)/(a+H))]
12 disp(D_curved,"If earth assumed to be curved
    transmission path distance in Km : ");

```

Scilab code Exa 10.9 Calculate maximum range obtainable in single hop transmission

```

1 //Exa 10.9
2 clc;
3 clear;

```

```

4 close;
5 //given data :
6 R=6370; //in Km
7 hm=400; //in Km
8 //Formula :  $d=2*R*Q=2*R*\cos(R/(R+hm))$ 
9  $d=2*R*\cos(R/(R+hm));$  //in Km
10 disp(d,"Maximum Range in a single range transmission
      in Km : ");

```

Scilab code Exa 10.10 Find frequency for propagation in E region

```

1 //Exa 10.10
2 clc;
3 clear;
4 close;
5 //given data :
6 n=0.6; //refractive index
7 N=4.23*10^4; //in m^-3
8 //Formula :  $n=\sqrt{1-81*N/f^2}$ 
9  $f=\sqrt{81*N/(1-n^2)};$  //in Hz
10 disp(f/1000,"Frequency of wave propagation in KHz :
      ");

```

Scilab code Exa 10.11 Find frequency for propagation in D region

```

1 //Exa 10.11
2 clc;
3 clear;
4 close;
5 //given data :
6 n=0.8; //refractive index
7 N=500; //in cm^-3
8 //Formula :  $n=\sqrt{1-81*N/f^2}$ 

```

```
9 f=sqrt(81*N/(1-n^2)); //in KHz
10 disp(f,"Frequency of wave propagation in KHz : ");
```
