Scilab Textbook Companion for Antenna & Wave Propagation by K. K. Sharma[1]

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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.

Contents

List of Scilab Codes

Chapter 1

Antenna Principles

Scilab code Exa 1.1 Calculate strength of magnetic field

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

Scilab code Exa 1.2 Calculate strength of Electric field

```
//Exa 1.2
clc;
clear;
close;
```

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

Scilab code Exa 1.3 Find Power radiated by Antenna

```
//Exa 1.3
clc;
clear;
close;
//given data :
I=20;//in A
Rr=100;//in Ohm
//Formula : Wr=I^2*R
Wr=I^2*Rr;//in W
disp(Wr/1000,"Radiated power in KW : ");
```

Scilab code Exa 1.4 Find Field Strength at 30 Km away

```
//Exa 1.4
clc;
clear;
close;
//given data :
W=625;//in KW
r=30;//in Km
Erms=sqrt(90*W*1000)/(r*1000);//in V/m
disp(Erms*1000,"Strength of Electric field at 30Km
    away in mV/m : ");
```

Scilab code Exa 1.5 Find out Efficiency of Antenna

```
//Exa 1.5
clc;
clear;
close;
//given data :
le=10;//in m
Irms=450;//in A
f=50;//in KHz
R=1.5;//in Ohm
lambda=300/(f/1000);//in m
Rr=160*(%pi)^2*(le/lambda)^2;//in Ohm
Wr=Irms^2*Rr;//in W
disp(Wr,"Radiated power in Watts : ");
Eta=(Rr/(Rr+R))*100;//efficiency in %
disp(Eta,"Efficiency of antenna in % : ");
```

Scilab code Exa 1.6 Determine Radiation Resistance

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

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

```
//Exa 1.7
clc;
clear;
close;
//given data :
l=30;//in m
Irms=20;//in A
f=1;//in MHz
r=10;//in Km
r=r*1000;//in m
le=2*l/%pi;//in m
lambda=300/(f);//in m
Erms=120*%pi*le*Irms/(lambda*r);//in V/m
disp(Erms,"Field strength at 10Km distace in V/m: ")
    ;
//Note : Answer in the book is wrong
```

Scilab code Exa 1.8 Calculate radiation resistance and efficiency of antenna

```
//Exa 1.8
clc;
clear;
close;
//given data :
Rl=1;//in ohm
//Formula : Rr=80*%pi^2*(l/lambda)^2
//Given l=lambda/10
//l/lambda=1/10
Rr=80*%pi^2*(1/10)^2;//in Ohm
```

```
disp(Rr,"Radiation resistance in Ohm: ");
Eta=Rr/(Rr+Rl);//Unitless
disp(Eta*100,"Antenna Efficiency in % : ");
```

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

```
//Exa 1.9
clc;
clear;
close;
//given data :
r=100;//in Km
W=100;//in KW
Erms=sqrt(90*W*1000)/(r*1000);//in V/m
disp(Erms,"Strength of Electric Field in V/m : ");
```

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

```
//Exa 1.10
clc;
clear;
close;
//given data :
le=200;//in m
Irms=200;//in A
f=300;//in KHz
r=10;//in Km
c=3*10^8;//speed of light i m/s
lambda=c/(f*1000);//in m
Erms=120*%pi*le*Irms/(lambda*r*10^3);//in V/m
```

```
disp(Erms,"Field strength at 10Km distace in V/m: ");
Rr=(160*(%pi)^2)*(le/lambda)^2;//in Ohm
W=Irms^2*Rr;//in Watts
disp(W/10^6,"Radiated Power in MWatts : ");
//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

```
//Exa 1.11
clc;
clear;
close;
//given data :
//Formula : Rr=80*%pi^2*(l/lambda)^2
//Given l=lambda/60
//l/lambda=1/60
Rr=80*%pi^2*(1/60)^2;//in Ohm
disp(Rr,"Radiation resistance in Ohm: ");
```

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

```
//Exa 1.12
clc;
clear;
close;
//given data :
r=10;//in Km
Erms=10;//in mV/m
r1=20;//in Km
//Formula : Erms=sqrt(90*W)/r;//in V/m
```

```
//Let swrt(90*W)=a
a=Erms*r;
Erms1=a/r1;//in mV/m
disp(Erms1,"Field strength at 20Km distace in mV/m: ");
```

Scilab code Exa 1.13 Determine field strength

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

Scilab code Exa 1.14 calculate Effective height of Antenna

```
//Exa 1.14
clc;
clear;
close;
```

```
//given data :
Irms=30;//in A
f=1;//in MHz
Erms=10;//in mV/m
Erms=Erms*10^-3;//in V/m
r=50;//in Km
r=r*10^3;//in m
c=3*10^8;//speed of light i m/s
lambda=c/(f*10^6);//in m
le=Erms*lambda*r/(120*%pi*Irms);//in m
disp(le,"Effetive height of Antenna in meter : ");
```

Scilab code Exa 1.15 Calculate radiation resistance

```
//Exa 1.15
clc;
clear;
close;
//given data :
disp("Erms^2 = 30*Wt/r^2");
disp("Wt = Erms^2*r^2/30");
disp("Given : E = 10*I/r");
disp("Wt = (10*I/r)^2*r^2/30")
disp("Wt = 100*I^2/30")
disp("Rr = Wt/I^2 = 100/30");
disp(100/30,"Radiation resistance in Ohm : ");
```

Scilab code Exa 1.16 Find distance from 50 cycle circuit

```
//Exa 1.16
clc;
clear;
close;
```

```
//given data :
format('v',8);
lambda=300/(50*10^-6);//in m
r=round(lambda)/(2*%pi);//in m
disp(r,"Distance in meter : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 1.17 Find Field Strength at 2 Km away

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

Scilab code Exa 1.18 Calculate radiation resistance

```
//Exa 1.18
clc;
clear;
close;
//given data :
f=20;//in MHz
f=f*10^6;//in Hz
le=100;//in m
c=3*10^8;//speed of light in m/s
```

```
lambda=c/f;//in m
Rr=160*(%pi*le/lambda)^2;//in ohm
disp(Rr/1000,"Radiation Resistance in KOhm : ");
```

Scilab code Exa 1.19 Velocity impedence wavelength and Erms

```
//Exa 1.19
clc;
clear;
close;
//given data :
P=10;//in W/m^2
f=40;//in MHz
f=f*10^6;//in Hz
mu_r=4;//constant
epsilon_r=5;//constant
//Velocity of propagation
//formula : v=(1/sqrt(mu_o*epsilon_o))*(1/sqrt(mu_r*epsilon_r));//in m/s
//1/sqrt(mu_o*epsilon_o)=c=speed of light=3*10^8 m/s
c=3*10^8;//speed of light in m/s
v=c*(1/sqrt(mu_r*epsilon_r));//in m/s
disp(v,"Velocity of propagation in m/s : ");
//Wavelength
lambda=v/f;//in meter
disp(lambda,"Wavelength in Meter : ");
//rms electric field
//Formula : E=P*sqrt(mu_o/epsilon_o)*sqrt(mu_r/epsilon_r);//in V/m
E=sqrt(1200*%pi*sqrt(4/5));//in V/m
Erms=sqrt(E^2/sqrt(2));//in V/m
disp(Erms,"rms Electric Field in V/m: ");
//Impedence of medium
Eta=(sqrt(2)*Erms)^2/P;//in Ohm
disp(Eta,"Impedence of medium in ohm : ");
```

Scilab code Exa 1.20 Find Distance

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

Chapter 3

Antenna Terminology

Scilab code Exa 3.1 Calculate strength of magnetic field

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

Scilab code Exa 3.2 Calculate field strength at receiver

```
//Exa 3.2
clc;
clear;
close;
//given data :
```

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

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

```
//Exa 3.3
clc;
clear;
close;
//given data :
le=125;//in m
Irms=5;//in A
lambda=1.25;//in Km
lambda=lambda*10^3;//in m
Rl=10;//in Ohm
//radiation Resistance
Rr=(80*%pi^2)*(le/lambda)^2;//in Ohm
Rr=round(Rr);//in Ohm : approx
disp(Rr,"Radiation resistance in Ohm : ");
//Power radiated
W=(Irms^2)*Rr;//in
disp(W,"Power radiated in W : ")
//Antenna efficiency
ETA=Rr/(Rr+Rl)
disp(ETA*100,"Antenna efficiency in % : ");
```

Scilab code Exa 3.4 Determine E and H field

```
//Exa 3.4
clc;
clear;
close;
//given data :
r=1;//in Km
r=r*10^3;//in m
I=0.5;//in A
//For theta = 45 degree
theta=45 ;//in degree
E=(60*I/r)*((cos(%pi*cos(theta*%pi/180)/2))/sin(
    theta*%pi/180));
disp(E*10^3,"E-Field for 45 degree angle in mV/m :")
    ;
ETA_o=120*%pi;//constant
H=E/ETA_o;//in A/m
disp(H*10^3,"H-Field for 45 degree angle in mV/m :")
    ;

//For theta = 90 degree
theta=90 ;//in degree
E=(60*I/r)*((cos(%pi*cos(theta*%pi/180)/2))/sin(
    theta*%pi/180));
disp(E*10^3,"E-Field for 90 degree angle in mV/m :")
    ;
ETA_o=120*%pi;//constant
H=E/ETA_o;//in A/m
disp(H*10^3,"H-Field for 90 degree angle in mV/m :")
    ;
```

Scilab code Exa 3.5 Find Radiation Resistance

```
//Exa 3.5
clc;
clear;
```

```
close;
//given data :
//l=lambda/10 meter
//Assume %pi^2 = 10
Rl=2;//in Ohm
disp("Rr=80*%pi^2*(dl/lambda)^2");
disp("dl/lambda = 1/10 : as l=lambda/10 ");
Rr=80*10*(1/10)^2;//in Ohm
disp(Rr,"Radiation Resistance in Ohm :  ");
ETA=Rr/(Rr+Rl);//in Ohm
disp(ETA*100," Efficiency inn % : ");
```

Scilab code Exa 3.6 Directivity gain effective aperture beam solid angle

```
//Exa 3.6
clc;
clear;
close;
//given data :
//l=lambda/15 meter
//Assume %pi^2 = 10
Rl=2;//in Ohm
//Gain :
Gain=5.33/4;//Unitless
//Directivity
Rr=80*10*(1/15)^2;//in Ohm
ETA=Rr/(Rr+Rl);//Unitless
Directivity=Gain/ETA;//unitless
//Beam solid angle
BSA=4*%pi/Directivity;//in steradian
disp(Directivity,"Directivity : ");
disp(Gain,"Gain = Pt/Pr = ");
//Effective aperture
disp("Effective aperture = G*lambda^2/(4*%pi) ");
disp(string(Gain/(4*%pi))+"lambda^2");
```

```
disp(BSA,"Beam Solid Angle in steradian : ");
disp("Radiation Resistance :")
disp("Rr=80*%pi^2*(dl/lambda)^2 in Ohm");
disp("dl/lambda = 1/15 : as l=lambda/10 ");
Rr=80*10*(1/15)^2;//in Ohm
disp(Rr,"Radiation Resistance in Ohm :  ");
disp("Pt = Area of sphere * (E^2/(120*%pi))");
disp("Pt = ((4*%pi^2)/(120*%pi))*((60*%pi*I/r)*(dl/lambda)^2)");
disp("Pt=120*%pi^2*(lambda*15/lambda)*I^2");
disp("Pt = "+string(120*10/225)+"I^2");
disp("Pr = I^2*Rr = 4*I^2");
```

Scilab code Exa 3.7 calculate Gain and Bandwidth

```
//Exa 3.7
clc;
clear;
close;
//given data :
D=30;//in m
k=0.55;//illumination efficiency
f=4;//in GHz
f=f*10^9;//in Hz
c=3*10^8;//speed of light in m/s
lambda=c/f;//in Meter
r=D/2;//in m
A=%pi*(r^2);//in m^2
G=(4*%pi/lambda^2)*k*A;//Unitless
disp(G,"Gain : ");
HPBW=70*lambda/D;//in Degree
disp(HPBW,"HPBW in Degree : ");
BWFN=2*70*lambda/D;//in Degree
disp(BWFN,"BWFN in Degree : ");
```

Scilab code Exa 3.8 Calculate Directivity

```
//Exa 3.8
clc;
clear;
close;
//given data :
Rl=20;//in Ohm
Rr=100;//in Ohm
Gp=25;//power gain
ETA=Rr/(Rr+Rl);//Unitless
D=Gp/ETA;//unitless
disp(D,"Directivity : ")
```

Scilab code Exa 3.9 Calculate Maximum effective aperture

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

Scilab code Exa 3.10 Calculate front to back ratio

```
//Exa 3.10
```

```
clc;
clear;
close;
//given data :
P1=30;//in KW
P1=P1*1000;//in W
P2=5000;//in W
Gdb=10*log10(P1/P2);//unitless
disp(Gdb,"Front to back ratio = Gdb = ");
```

Scilab code Exa 3.11 Determine Gain for received power

```
//Exa 3.11
clc;
clear;
close;
//given data :
f=10;//in GHz
f=f*10^9;//in Hz
Gt=40;//in dB
Gr=40;//in dB
disp(Gt,"Gain = Gt = Gr : ");
```

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

```
//Exa 3.12
clc;
clear;
close;
//given data :
L=10;//in m
f=1.5;//in MHz
f=f*10^6;//in Hz
```

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

Scilab code Exa 3.13 Determine Quality factor

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

Scilab code Exa 3.14 Calculate Directivity of Isotropic Antenna

```
//Exa 3.14
clc;
clear;
close;
//given data :
```

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

Scilab code Exa 3.15 Calculate Maximum effective aperture

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

Scilab code Exa 3.16 Find Effective Noise Temperature

```
//Exa 3.16
clc;
clear;
close;
//given data
Fn_dB=1.1;//in dB
Fn=10^(Fn_dB/10);//unitless
To=290;//in Kelvin
Te=To*(Fn-1);//in Kelvin
disp(Te,"Effective Noise Temperature in Kelvin : ");
```

Scilab code Exa 3.19 Find Gain Beamwidth and Capture area

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

Scilab code Exa 3.20 Find Beamwidth

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

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

Chapter 4

Antenna Arrays

Scilab code Exa 4.3 Calculate HPBW of major lobes

```
//Exa 4.3
clc;
clear;
close;
//given data :
disp("For a two elements arrayy the total field is
   given by : ");
disp("E=2*Eo*cos(psi/2)");
disp("(i) It is a case of braod side array : so,
   delta = 0");
disp("psi = Beta*d*cos(theta)+delta")
disp("d=3*lambda/2");
disp("Beta*d = (2*%pi/lambda)*(3*lambda/2) = 3*%pi")
disp("psi = 3*%pi*cos(theta)");
disp("psi/2 = (3*%pi/2)*cos(theta)");
disp("The maxima for broad side array occurs when
   theta = %pi/2");
disp("Ep = 2*Eo*cos(3*(%pi/2)*cos(%pi/2))");
disp("Ep = 2*Eo as cos(%pi/2) = 0 and cos(0)=1");
disp("At half power beamwidth the field becomes Ep/
   sqrt(2)");
```

```
disp("So, cos(3*(%pi/2)*cos(theta)) = 1/sqrt(2)");
disp("3*(%pi/2)*cos(theta)=%pi/4");
disp("cos(theta) = 1/6");
disp("theta = 80.5 degree")
theta = 80.5;//in degree
HPBW=2*(90-theta);//in degree
disp(HPBW,"HPBW in degree : ");
disp("(ii) Equal amplitude and different phase(540 degree) : (end fire array) ");
disp("In case of end fire array :  ");
disp("delta = -Beta*d");
disp("Beta*d = 540 degree = 3*%pi");
disp("psi = 3*%pi*cos(theta)-3*%pi = 3*%pi*(cos(theta)-1)");
disp("E_HPBW = 3*%pi*(cos(theta)-1) = %pi/4 = 1/sqrt(2)");
disp("3*%pi*(cos(theta)-1) = %pi/4");
disp("cos(theta) = 1+1/12 = 13/12");
disp("theta = 33.6 degree");
theta=33.6;//in degree
HPBW=2*theta;//in degree
disp(HPBW,"HPBW in degree : ");
```

Scilab code Exa 4.4 Calculate Directivity and gain

```
//Exa 4.4
clc;
clear;
close;
//given data :
n=10;//no. of elements
//d=lambda/4 separation in meter
disp("For broad side array : ")
disp("D=2*n/(lambda/d)");
disp("Putting d=lambda/4 we get D=2*n/4")
```

```
D=2*n/4;//directivity : unitless
Ddb=10*log10(D);//in db
disp(Ddb,"For broad side array D in db = ");
disp("For end fire array : ")
disp("D=4*n/(lambda/d)");
disp("Putting d=lambda/4 we get D=4*n/4")
D=4*n/4;//directivity : unitless
Ddb=10*log10(D);//in db
disp(Ddb,"For end fire array D in db = ");
```

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

```
//Exa 4.1
clc;
clear;
close;
//given data :
delta=-90;//in degree
//Formula : HPBW=57.3/(sqrt(L/(2*lambda))) in Degree
n=20;//no. of point sources
//d=lambda/4;//in meter
//L=(n-1)*d
//L=(n-1)*lambda/4
LBYlambda=(n-1)/4;//in meter
HPBW=57.3/(sqrt(LBYlambda/2));// in Degree
disp(HPBW,"HPBW in Degree : ");
D=4*LBYlambda;//Directivity
disp(D,"Directivity : ");
disp("Effective aperture : Ae="+string(D/(4*%pi))+"*
   lambda^2");
Omega=4*%pi/D;//in steradian
disp("Beam Solid Angle : Omega = "+string(Omega));
//Note : Answer of Ae and omega in the book is wrong
   .
```

Scilab code Exa 4.6 Determine Power radiated and HPBW

```
//Exa 4.6
clc;
clear;
close;
//given data :
n=8;//no. of half wave dipoles
lambda=100;//in cm
lambda=lambda*10^-2;//in m
d=50;//in cm
d=d*10^-2;//in m
I=0.5;//in A
Rr=73;//in Ohm
Pr=n*I^2*Rr;//in Watts
disp(Pr,"Pr in Watts : ");
BWFN=2*lambda/(n*d);//in radian
HPBW=BWFN/2;//in radian
disp(HPBW,"HPBW in radian : ");
disp(HPBW*180/%pi,"HPBW in degree : ")
```

Scilab code Exa 4.7 Find Directivity of end fire array

```
//Exa 4.7
clc;
clear;
close;
//given data :
n=10;//no. of elements
//d=lambda/4 separation in meter
disp("Do=1.789*4*n*d/lambda");
```

```
disp("Putting d=lambda/4 we get D=1.789*n")
Do=1.789*n;//directivity : unitless
Dodb=10*log10(Do);//in db
disp(Dodb,"Do in db = ");
```

Scilab code Exa 4.13 calculate the distance

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

Scilab code Exa 4.14 Find Directivity of broad side array

```
//Exa 4.14
clc;
clear;
close;
//given data :
n=10;//no. of elements
//given : d=lambda/4;//in m
```

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

Scilab code Exa 4.15 Obtain Field pattern Maxima and Minima

```
//Exa 4.15
clc;
clear;
close;
//given data :
n=2;//no. of elements
//given : d=lambda/3 in m
delta=%pi/3;//in phase difference
disp("dr=2*%pi*d/lambda");
disp("Putting d=lambda/3 we get dr=2*%pi/3");
dr=2*%pi/3;//
disp("psi=dr*cos(theta)+delta");
disp("psi=(2*%pi/3)*cos(theta)+%pi/3");
//Maxima :
disp("Maxima : cos((%pi/3)*cos(theta)+%pi/6)=1 .....
   Magnitude");
disp("(%pi/3)*cos(theta)+%pi/6=K*%pi");
disp("theta=acos(-1/2+3*k)");
disp("theta=+120,-120 degree");

//Minima :
disp("Minima : cos((%pi/3)*cos(theta)+%pi/6)=0");
disp("(%pi/3)*cos(theta)+%pi/6=(2*k+1)*%pi/2");
disp("theta=acos(-1/2+(3/2)*(2*k+1))");
disp("theta=0 degree");
```

Scilab code Exa 4.17 design array to achieve optimum pattern

```
//Exa 4.17
clc;
clear;
close;
//given data :
MainBeamwidth=45;//in degree
thetaN=MainBeamwidth/2;//in degree
thetaN=thetaN*%pi/180;//in radian
m=5;//no. of elements
//given : d=lambda/2 in meter
x=cos(%pi/(2*(m-1)));
xo=x/cos((%pi/2)*sin(thetaN));//unitless
disp("E5=ao*z+a1*(2*z^2-1)+a2*(8*z^4-8*z^2+1)");
disp("We Know that : z=x/xo, E5=T4*xo");
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");
disp("By comparing the term we have : ");
disp("a2=xo^4  a1=4*a2-4*xo^2  ao=1+a1-a2 ")
a2=xo^4;
a1=4*a2-4*xo^2;
ao=1+a1-a2;
disp("And therefore the 5 elements array is given by
     : ");
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

```
//Exa 4.18
clc;
```

```
clear;
close;
//given data :
//Side lobe level below main lobe
disp("Side lobe level below main lobe : ")
SideLobe=20;//in dB
r=10^(SideLobe/20);//
disp(r,"r=") ;
//No. of elements are 5, n=5
disp("No. of elements are 5, n=5 :");
disp("Tchebyscheff polynomials of degree (n-1) is");
disp("5-1=4");
disp("T4(xo)=r");
disp("8*xo^4-8*xo^2+1=10");
disp("By using alternate formula, we get");
m=4;
r=10;
xo=(1/2)*[{r+sqrt(r^2-1)}^(1/m)+{r-sqrt(r^2-1)}^(1/m)]
disp(xo,"xo=");
disp("E5=T4(xo)")
disp("E5=ao*z+a1*(2*z^2-1)+a2*(8*z^4-8*z^2+1)");
disp("We Know that : z=x/xo, E5=T4*xo");
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");
disp("By comparing the term we have : ");
disp("a2=xo^4  a1=4*a2-4*xo^2  ao=1+a1-a2 ")
a2=xo^4;
a1=4*a2-4*xo^2;
ao=1+a1-a2;
disp("And therefore the 5 elements array is given by : ");
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

```
//Exa 5.1
clc;
clear;
close;
//For Single Turn:
disp("A=%pi*a^2");
disp("Putting a=lambda/25 we get : A=%pi*lambda
    ^2/625");
disp("Radiation Resistance Rr=31171.2*[A/lambda^2]^2
    ");
disp("Putting A=%pi*lambda^2/625 ");
Rr_1=31171.2*[%pi/625]^2;//in Ohm
disp(Rr_1,"radiation Resistance(in Ohm) for single
    turn : ");

//For Eight Turn:
N=8;//no. of turns
Rr=Rr_1*N^2;//in Ohm
disp(Rr,"radiation Resistance(in Ohm) for Eight turn
    : ");
```

Scilab code Exa 5.2 Determine Peak Value of Magnetic Field Intensity

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

Scilab code Exa 5.3 calculate maximum emf in the loop

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

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

Scilab code Exa 5.4 Calculate Voltage across the capacitor

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

Scilab code Exa 5.5 Calculate input voltage to the receiver

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

Scilab code Exa 5.6 Derive input impedence of folded dipole antenna

```
//Exa 5.1
clc;
clear;
close;
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.");
disp("By nodal analysis : ");
disp("V/2=I1*Z11+I2*Z12        eq(1)");
disp("Where I1,I2 are currents flowing at terminals
   of dipole1 and dipole 2");
disp("Z11 and Z12 ares self impedences of dipole1
   and mutual impedence between dipole1 and dipole2
   respectively.");
```

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

Chapter 6

Practical Antennas 2

Scilab code Exa 6.1 Find HPBW Axial Ratio and Gain

```
//Exa 6.1
clc;
clear;
close;
n=20;//no. of turns
//Clambda=lambda
//Slambda=lambda/4
//HPBW :
disp("HPBW=52/(Clambda*sqrt(n*Slambda))");
//Putting values below :
Clambda=1;//in Meter
Slambda=1/4;//in Meter
HPBW=52/(Clambda*sqrt(n*Slambda));//in degree
disp(HPBW,"HPBW in degree : ");
//Axial Ratio
Aratio=(2*n+1)/2;//unitless
disp(Aratio,"Axial Ratio : ");
//Gain
D=12*Clambda^2*n*Slambda;//unitless
disp(D,"Gain : ");
```

Scilab code Exa 6.2 Calculate Best spacing and diectivity

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

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

```
//Exa 6.3
clc;
clear;
```

```
close;
//from 7dBi gain graph the data obtained is given below :
K=1.2;//Scale constant
alfa=1.5;//Apex angle in degree
Slambda=0.15;
disp("K^n=F or n=logF/logK");
F=4;
n=log10(F)/log10(K);
n=ceil(n);
nplus1=n+1;
disp(alfa,"Apex Angle in degree : ");
disp(K,"Sale constant :");
disp(n,"No. of elements : ");
```

Scilab code Exa 6.4 Estimate Power gain

```
//Exa 6.4
clc;
clear;
close;
//Given data :
//d=10*lambda
disp("d=10*lambda");
disp("Power Gain : G=6*(d/lambda)^2");
disp("Putting value of d, we get G=6*10^2")
G=6*10^2;//unitless
disp(G,"Power gain : ");
G_dB=10*log10(G);//in dB
disp(G_dB,"Power Gain in dB : ");
```

Scilab code Exa 6.5 Calculate 3 dB beamwidth and power gain

```
//Exa 6.5
clc;
clear;
close;
//Given Data:
f=10;//in GHz
f=f*10^9;//in Hz
BWFN=10;//in degree
c=3*10^8;//Speed of light in m/s
lambda=c/f;//in meter
//Part (a):
d=140*lambda/BWFN;//in meter
disp(d,"Diameter of a parabolic Antenna in meter : "
    );
//Part (b):
HPBW=58*lambda/d;//in degree
disp(HPBW,"3-dB Beamwidth in degree :");
//Part (c):
Gp=6*(d/lambda)^2;//gain
Gp_dB=10*log10(Gp);//in dB
disp(Gp_dB,"Power Gain in dB : ");
```

Scilab code Exa 6.6 Calculate HPBW BWFN and Gain

```
//Exa 6.6
clc;
clear;
close;
//Given Data:
f=1430;//in MHz
f=f*10^6;//in Hz
d=64;//in meter
c=3*10^8;//Speed of light in m/s
lambda=c/f;//in meter
//Part (a):
```

```
HPBW=70*lambda/d;//in degree
disp(HPBW,"HPBW in degree :");
//Part (b):
BWFN=140*lambda/d;//in degree
disp(BWFN,"BWFN in degree :");
//Part (c):
Gp=6*(d/lambda)^2;//gain
Gp_dB=10*log10(Gp);//in dB
disp(Gp_dB,"Power Gain in dB : ");
```

Scilab code Exa 6.7 Specify diameter of parabolic reflector

```
//Exa 6.7
clc;
clear;
close;
//Given Data:
f=15;//in GHz
f=f*10^9;//in Hz
Gp_dB=75;//in dB
c=3*10^8;//Speed of light in m/s
lambda=c/f;//in meter
//Formula : Gp=9.87*(d/lambda)^2
//Formula : Gp_dB=10log10(Gp)
d=sqrt((10^(Gp_dB/10))*lambda^2/9.87);//in meter
disp(d,"Diameter of a parabolic reflector in meter :
   ");
```

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

```
//Exa 6.8
clc;
```

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

Scilab code Exa 6.9 Calculate HPBW BWFN and diameter

```
//Exa 6.9
clc;
clear;
close;
//Given Data:
K=55;//Aperture Efficiency in %
K=K/100;//Aperture Efficiency
f=15;//in GHz
f=f*10^9;//in Hz
c=3*10^8;//Speed of light in m/s
lambda=c/f;//in meter
G_dB=30;//in dB
G=10^(G_dB/10);//Gain unitless
//Formula : G=4*%pi*K*A/lambda^2
A=(G*lambda^2)/(4*%pi*K);//in m^2
disp(A,"Diameter of parabolic reflector in m^2 :");
//Part (b)
d=sqrt(4*A/%pi);//in meter
HPBW=70*lambda/d;//in degree
disp(HPBW,"HPBW in degree : ");
```

```
//Part (c)
BWFN=140*lambda/d;//in Degree
disp(BWFN,"BWFN in degree : ");
//Note : Answer in the book is not accurate.
```

Scilab code Exa 6.10 Determine cut off frequencies and bandpass

```
//Exa 6.10
clc;
clear;
close;
//Given Data:
Tau=0.7;//Design Factor
L1=0.3*2;//in meter
c=3*10^8;//speednof light in m/s
f1=(c/(2*L1))/10^6;//in MHz
//Design factor : L1/L2=L2/L3=L3/L4=.......=0.7
L2=0.7/L1;//in meter
f2=f1*0.7;//in MHz
f3=f2*0.7;//in MHz
f4=f3*0.7;//in MHz
f5=f4*0.7;//in MHz
f6=f5*0.7;//in MHz
f7=f6*0.7;//in MHz
f8=f7*0.7;//in MHz
f9=f8*0.7;//in MHz
f10=f9*0.7;//in MHz
disp("Cutoff frequencies in MHz :")
disp(f1,"f1 in MHz :");
disp(f2,"f2 in MHz :");
disp(f3,"f3 in MHz :");
disp(f4,"f4 in MHz :");
disp(f5,"f5 in MHz :");
disp(f6,"f6 in MHz :");
disp(f7,"f7 in MHz :");
```

```
disp(f8,"f8 in MHz :");
disp(f9,"f9 in MHz :");
disp(f10,"f10 in MHz :");
disp(f1-f10,"Passband=");
```

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

```
//Exa 6.11
clc;
clear;
close;
//Given Data:
disp("Assuming typical values for f as 0.2lamda in E-plane and 0.375lambda in H-plane");
//b=10*lambda ;mouth height
//delta=0.8*lambda
disp("Length :")
disp("L=b^2/(8*lambda)");
disp("L="+string(10^2/(8*0.2))+"lambda");
disp("Flare Angle (Theta):")
disp("Theta=atan(b/(2*L))");
disp("Theta="+string(10/(2*(10^2/(8*0.2))))+" radian");
Theta=(10/(2*(10^2/(8*0.2))))*180/%pi;//in Degree
disp(Theta,"Flare Angle Theta in degree : ");
disp("Flare Angle (fi):")
disp("fi=acos(L/(L+delta))=acos((10^2/(8*0.2))/((10^2/(8*0.2))+0.375))");
disp("fi="+string(acos((10^2/(8*0.2))/((10^2/(8*0.2))+0.375)))+" radian");
fi=(acos((10^2/(8*0.2))/((10^2/(8*0.2))+0.375)))*180/%pi;//in Degree
disp(fi,"Flare angle fi in degree : ");
disp("Width :");
disp("Width, a=2*L*tan(fi)");
```

```
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

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

Scilab code Exa 7.2 Determine gain of large Antenna

```
//Exa 7.2
clc;
clear;
close;
//given data :
GP=12.5;//unitless
P_dB=23;//in dB
P=10^(P_dB/10);//unitless
G=GP*P;//unitless
GdB=GP+P_dB;//in dB
disp(GdB,"Gain of large antenna : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 7.3 Find out Power gain in dB

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

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

```
//Exa 7.4
clc;
clear;
close;
```

```
//given data :
f=3000;//in MHz
f=f*10^6;//in Hz
d=20;//in feet
d=20*0.3048;//in meter
c=3*10^8;//in m/s
lambda=c/f;//in meters
r=2*d^2/lambda;//in meters
disp(r,"Minimum distance between primary and
   secondary in meters : ");
```

Scilab code Exa 7.5 Estimate diameter of paraboloidal reflector

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

Scilab code Exa 7.6 calculate gain og horn

```
//Exa 7.6
clc;
clear;
close;
```

```
//given data :
f=9;//in GHz
f=f*10^9;//in Hz
c=3*10^8;//in m/s
lambda=c/f;//in meters
r=35;//in cm
r=r*10^-2;//in meters
Attenuation=9.8;//in dB
//Formula : 10*log10(WT/Wr) = 9.8dB
WTbyWr=10^(Attenuation/10);//unitless
D=(4*%pi*r/lambda)*(sqrt(1/WTbyWr));//unitless
D_dB=10*log10(D);
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

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

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

Scilab code Exa 9.2 Find Field Strength at 20 Km away

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

Scilab code Exa 9.3 Calculate field strength at receiver antenna

```
//Exa 9.3
clc;
clear;
close;
//given data :
HT=10;//in meter
HR=3;//in meter
P=200;//in W
D=50;//in Km
D=D*10^3;//in Km
f=150;//in MHz
c=3*10^8;//speed of light in m/s
lambda=c/(f*10^6);//in meter
```

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

Scilab code Exa 9.4 Find height of receiving antenna

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

Scilab code Exa 5.5 Find maximum possible distance along earth surface

```
//Exa 9.5
clc;
clear;
close;
//given data :
HT=3000;//in meter
HR=6000;//in meter
d=4.12*(sqrt(HT)+sqrt(HR));//in Km
disp(d,"Maximum possible distance in Km : ");
```

Scilab code Exa 9.6 Find Basic Path Loss

```
//Exa 9.6
clc;
clear;
close;
//given data :
f_MHz=3000;//in MHz
d_Km=384000;//in Km
PathLoss=32.45+20*log10(f_MHz)+20*log10(d_Km);//in
    dB
disp(PathLoss,"Path loss in dB : ");
```

Scilab code Exa 9.7 Calculate Basic transmission Loss

```
//Exa 9.7
clc;
clear;
close;
//given data :
//Part (i)
D=10;//in Km
lambda=10000;//in meter
LP=(4*%pi*D*1000/lambda)^2;//in dB
disp(LP,"Path loss in dB : ");
//Part (ii)
D=10^6;//in Km
lambda=0.3;//in cm
LP=(4*%pi*D*1000/(lambda*10^-2))^2;//in dB
disp(LP,"Path loss in dB : ");
//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

```
//Exa 9.8
clc;
clear;
close;
//given data :
HT=50;//in meter
HR=5;//in meter
d=4.12*(sqrt(HT)+sqrt(HR));//in Km
disp(d,"Range of LOS system in Km : ");
```

Scilab code Exa 9.9 Find maximum power received by receiver

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

Chapter 10

Sky Wave Propagation

Scilab code Exa 10.1 Determine the range

```
//Exa 10.1
clc;
clear;
close;
//given data :
H=500;//in km
n=0.8;//in m
f_muf=10;//in MHz
f_muf=f_muf*10^6;//in Hz
f=10;//in MHz
f=f*10^6;//in Hz
// Formula : n=sqrt(1-81*N/f^2)
Nmax=(1-n^2)*f^2/81;//in Hz;
fc=9*sqrt(Nmax);//in Hz
Dskip=2*H*sqrt((f_muf/fc)^2-1);//in Km
disp(Dskip,"Assuming the earth is flat the range in Km : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 10.2 Determine the ground range

```
//Exa 10.2
clc;
clear;
close;
//given data :
n=0.8;//in m
H=500;//in km
a=6370;//in km
D=1349.07;//in Km
f_muf=10;//in MHz
f_muf=f_muf*10^6;//in Hz
f=10;//in MHz
f=f*10^6;//in Hz
// Formula : n=sqrt(1-81*N/f^2)
Nmax=(1-n^2)*f^2/81;//in Hz;
fc=9*sqrt(Nmax);//in Hz
// Formula : f_muf/fc=sqrt(D^2/(4*(H+D^2/(8*a))))+1
D1=2*[H+D^2/(8*a)]*sqrt((f_muf/fc)^2-1);//in Km
Dskip=2*H*sqrt((f_muf/fc)^2-1);//in Km
disp(D1,"Assuming the earth is curved the ground
    range in Km : ");
```

Scilab code Exa 10.3 Find critical frequency for reflection

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

Scilab code Exa 10.4 Calculate MUF for given path

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

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

```
//Exa 10.5
clc;
clear;
close;
//given data :
//For F1 layer :
disp("For F1 layer :");
Nmax=2.3*10^6;//in cm^3
Nmax=2.3*10^6*10^-6;//in m^3
fc=9*sqrt(Nmax);//in MHz
disp(fc,"Critical frequency in MHz : ");

//For F2 layer :
disp("For F2 layer :");
Nmax=3.5*10^6;//in cm^3
```

```
Nmax=3.5*10^6*10^-6;//in m^3
fc=9*sqrt(Nmax);//in MHz
disp(fc,"Critical frequency in MHz : ");

//For F3 layer :
disp("For F3 layer :");
Nmax=1.7*10^6;//in cm^3
Nmax=1.7*10^6*10^-6;//in m^3
fc=9*sqrt(Nmax);//in MHz
disp(fc,"Critical frequency in MHz : ");
//Note : Answer in the book is wrong.
```

Scilab code Exa 10.6 Find frequency for propagation in D region

```
//Exa 10.6
clc;
clear;
close;
//given data :
n=0.7;//refractive index
N=400;//in cm^-3
//Formula : n=sqrt(1-81*N/f^2)
f=sqrt(81*N/(1-n^2));//in KHz
disp(f,"Frequency of wave propagation in KHz : ");
//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

```
//Exa 10.7
clc;
clear;
```

```
close;
//given data :
HT=169;//in meter
HR=20;//in meter
d=4.12*(sqrt(HT)+sqrt(HR));//in Km
disp(d,"Maximum distance in Km : ");
r_dash=(4/3)*6370/1000;//in Km
RadioHorizon=sqrt(2*r_dash*HT);//in Km
disp(RadioHorizon,"Radio Horizon in Km : ");
```

Scilab code Exa 10.8 Calculate transmission path distance

```
//Exa 10.8
clc;
clear;
close;
//given data :
H=200;//in Km
Beta=20;//in Degree
a=6370;//in Km
D_flat=2*H/tan(Beta*%pi/180);//in Km
disp(D_flat,"If earth assumed to be flat transmission path distance in Km : ");
D_curved=2*a*[(90*%pi/180-Beta*%pi/180)-asin(a*cos(Beta*%pi/180)/(a+H))]
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

```
//Exa 10.9
clc;
```

```
clear;
close;
//given data :
R=6370;//in Km
hm=400;//in Km
//Formula : d=2*R*Q=2*R*acos(R/(R+hm))
d=2*R*acos(R/(R+hm));//in Km
disp(d,"Maximum Range in a single range transmission
    in Km : ");
```

Scilab code Exa 10.10 Find frequency for propagation in E region

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

Scilab code Exa 10.11 Find frequency for propagation in D region

```
//Exa 10.11
clc;
clear;
close;
//given data :
n=0.8;//refractive index
N=500;//in cm^-3
```

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