Scilab Textbook Companion for Antenna and Wave Propagation by A. K. Gautam[1]

Created by
Nizamuddin
B Tech
Electronics Engineering
Uttarakhand Technical University Dehradun
College Teacher
None
Cross-Checked by
Chaya Ravindra

June 1, 2016

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Antenna and Wave Propagation

Author: A. K. Gautam

Publisher: S. K. Kataria & Sons, New Delhi

Edition: 3

Year: 2007

ISBN: 81-88458-04-X

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

Eletromagnetic Field Radiation

Scilab code Exa 1.1 What is the strength of a magnetic field H in free space

```
//Ex:1.1
clc;
clear;
close;
E=2;// electriv field strength in V/m
n=120*%pi;
H=E/n;// strength of a magnetic field H
printf("The strength of a magnetic field H = %f mA/
   meter", H*10^3);
```

Scilab code Exa 1.2 Find out the field strength

```
//Ex:1.2
clc;
```

```
clear;
close;
W=625*10^3;// power in W
r=30*10^3;// in m
Erms=(sqrt(90*W))/r;// the field strength in V/m
printf("The field strength = %d mV/meter", Erms*10^3);
```

Scilab code Exa 1.3 Calculate the radiation resistance

```
//Ex:1.3
clc;
clear;
close;
f=10;// frequency in MHz
le=60;// height of antenna in m
y=300/f;// wavelength in m
Rr=(160*%pi^2*le^2)/y^2;// radiation resistance in ohm
printf("The radiation resistance = %f K-ohm", Rr/1000);
```

Scilab code Exa 1.4 What is the power radiated and also what is the efficiency of the antenna

```
//Ex:1.4
clc;
clear;
close;
f=40000;// frequency in Hz
f1=0.040;// frequency in MHz
le=100;// height of antenna in m
Irms=450;// current in Amp
Rt=1.12;// total resistance in ohm
y=300/f1;// wavelength in m
Rr=(160*%pi^2*le^2)/y^2;// radiation resistance in ohm
W=Irms^2*Rr;// power radiated in Watts
n=Rr/Rt;// efficiency of the antenna
printf("The power radiated = %f KW", W/1000);
printf("\n The efficiency of the antenna = %f %%", n*100);
```

Scilab code Exa 1.5 How much power will an antenna having a radiation rasistance of fifty ohms

```
//Ex:1.5
clc;
clear;
close;
I=20;// current in amp
Rr=50;// radiation resistance in ohm
Wr=I^2*Rr;// radiated power in W
printf("The radiated power = %d W", Wr);
```

Scilab code Exa 1.6 What is the radiation resistance of an antenna

```
//Ex:1.6
clc;
clear;
close;
I=15;// current in amp
W=5000;// radiated power in W
Rr=W/I^2;// radiation resistance in ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.7 How much current flows into the antenna

```
//Ex:1.7
clc;
clear;
close;
W=10*1000;// radiated power in W
Rr=75;// radiation resistance in ohm
I=sqrt(W/Rr);// current in amp
printf("The current = %f Amp", I);
```

Scilab code Exa 1.8 Calculate the strength of electric field

```
//Ex:1.8
clc;
clear;
close;
W=100*1000;// radiated power in W
r=100*1000;// distance in m
Erms=(sqrt(90*W))/r;// strength of electric field in
    V/m
printf("The strength of electric field = %f V/m",
   Erms);
```

Scilab code Exa 1.9 Estimate the effective height of the antenna

```
//Ex:1.9
clc;
clear;
close;
Irms=25;// current in Amp
f=0.150;// frequency in MHz
y=2000;
Erms=1.5*10^-3;// strength of electric field in V/m
r=25*1000;// distance in m
```

```
le=(Erms*y*r)/(60*%pi*Irms);// effective height of
    antenna in m
printf("The effective height of antenna = %f m", le)
    ;
```

Scilab code Exa 1.10 Find the field strength and the power radiated

```
//Ex:1.10
clc;
clear;
close;
le=100;// effective height of antenna in m
Irms=100;// current in Amp
f=0.300;// frequency in MHz
r=10*1000;// distance in m
y=300/f;// in m
Erms=(120*%pi*Irms*le)/(y*r);// strength of electric
     field in V/m
Rr=160*(%pi^2)*(le/y)^2;// radiation resistance in
    ohm
W=Irms^2*Rr;// radiated power in Watt
printf("The strength of electric field = %f mV/m",
    Erms*1000);
printf("\n The radiated power = %f KW", W/1000);
```

Scilab code Exa 1.11 Calculate the power radiated

```
//Ex:1.11
clc;
clear;
close;
le=10;// effective height of antenna in m
Irms=50;// current in Amp
f=0.600;// frequency in MHz
y=300/f;// in m
Rr=160*(%pi^2)*(le/y)^2;// radiation resistance in
   ohm
W=Irms^2*Rr;// radiated power in Watt
printf("The radiated power = %f KW", W/1000);
```

Scilab code Exa 1.12 Calculate the radiation resistance of current elements

```
//Ex:1.12
clc;
clear;
close;
// dl=y/50
// then dl/y=((y/50)/y=1/50)
dl_y=1/50;// the value of dl/y
Rr=80*%pi^2*(dl_y^2);// Radiation resistance in ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.13 Calculate the power radiated and what is its radiation resistance

```
//Ex:1.13
clc;
clear;
close;
// Prad=n(pi/3)*(Io*dl/y)^2, where n=120pi & y is
    wavelength
// Prad=120*pi*(pi/3)*(100*y/16*y)
Prad=120*3.14*(3.14/3)*(100/16)^2;// power radiated
    in Watts
// Rr=80*pi*(y/16y)^2
Rr=80*3.14^2*(1/16)^2;// the radiation resistance in
    ohm
printf("The power radiated = %f watts", Prad);
printf("\n The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.14 what is the electric field

```
//Ex:1.14
clc;
clear;
close;
```

```
r=5*1000;// distance in m
r1=10*1000;// distance in m
W=1;
Erms=(sqrt(90*W))/r;// electric field strength at a
    distanve 5 km
Erms1=(sqrt(90*W))/r1;// electric field strength at
    a distanve 10 km
E_E1=Erms/Erms1;// the ratio of electric field
    strengths
Erms=10;// electric field strength in mV/m
Erms2=Erms/E_E1;// electric field strength in mV/m
    at a distance of 10 km
printf("The electric field strength in mV/m at a
    distance of 10 km = %d mV/m", Erms2);
```

Scilab code Exa 1.15 Calculate the antenna current at a distance of five eight wavelength away from the feed point

```
//Ex:1.15
clc;
clear;
close;
Irms=10;// rms value of current in amp
// Erms=(120*pi*Irms*le)/y*r, where y= wavelength
// Erms=(120*pi*10*(3y/2))/y*r=1200*pi*3/2*r=1800*pi
    /r V/m
// now, Erms1=120*pi*Irms1*5y/(8*y*r)=75*pi*Irms1/r
// now equate these two Erms, we have
// 1800*pi/r=75*pi*Irms1/r i.e., Irms1=1800/75
Irms1=1800/75;// antenna current in amp
printf("The antenna current = %d amp", Irms1);
```

Scilab code Exa 1.16 Determine the field strength of the radiated field produced

```
//Ex:1.16
clc;
clear;
close;
r=1000;// distance in m
l=1;// length in m
Irms=5;// current in Amp
f=1;// frequency in MHz
y=300/f;// Wavelength in m
le=(2/%pi)*l;// effective length in m
Erms=(120*%pi*le*Irms)/(y*r);// field strength in V/
    m
printf("The field strength = %d mV/m", Erms*1000);
```

Scilab code Exa 1.17 Calculate the effective height of the antenna in meters

```
//Ex:1.17
clc;
clear;
close;
```

```
r=100;// distance in m
Irms=32;// current in Amp
y=300*1000;// Wavelength in m
Erms=9*10^-3;// field strength in V/m
le=(Erms*y*r)/(120*3.14*Irms);// effective height of antenna in m
printf("The effective height of antenna = %f m", le);
```

Scilab code Exa 1.18 Calculate the radiation resistance

```
//Ex:1.18
clc;
clear;
close;
I=10;// current in Amp
Wt=(10*I)^2/30;// power in Watt
Rt=Wt/I^2;// Radiation resistance in ohm
printf("The Radiation resistance = %f ohm", Rt);
```

Scilab code Exa 1.19 Find the radiation resistance and power radiated and also antenna efficiency

```
//Ex:1.19
clc;
```

```
clear;
close;
le=61.4;// effective height in m
Irms=50;// current in amp
y=625;// wavelength in m
Rr=160*(%pi*le)^2/(y^2);// Radiation resistance of
    an antenna in ohm
W=(Irms^2)*Rr;// power radiated in Watt
Rt=50;// total antenna resistance in ohm
n=Rr/Rt;// efficiency
printf("The Radiation resistance of an antenna = %f
    ohm", Rr);
printf("\n The power radiated = %f KW", W/1000);
printf("\n The efficiency = %f %%", n*100);
```

Scilab code Exa 1.20 What is the power radiated

```
//Ex:1.20
clc;
clear;
close;
le=49.12;// effective height in m
Irms=220;// current in amp
f=37.5;// frequency in KHz
f1=f/1000;// frequency in MHz
y=300/f1;// wavelength in m
Rr=160*(%pi^2)*(le/y)^2;// Radiation resistance in
    ohm
W=Irms^2*Rr;//  power radiated in watts
printf("The power radiated = %f kW", W/1000);
```

Scilab code Exa 1.21 Find out the field strength

```
//Ex:1.21
clc;
clear;
close;
W=35*10^3;// power in Watts
r=60*10^3;// in m
Erms=(sqrt(90*W))/r;// field strength in mV/m
printf("The field strength = %f mV/m", Erms*1000);
```

Scilab code Exa 1.22 At what distance from a sixty cycle circuit is the radiation field approximately

```
//Ex:1.22
clc;
clear;
close;
f=60*10^-6;// frequency in MHz
y=300/f;// wavelength in m
r=y/(2*3.14);// distance in m
printf("The distance = %f*10^6 m", r/10^6);
```

Scilab code Exa 1.23 Find out the field strength

```
//Ex:1.23
clc;
clear;
close;
W=1*10^3;// power in Watts
r=10^3;// in m
Erms=(sqrt(30*W))/r;// field strength in mV/m
printf("The field strength = %f mV/m", Erms*1000);
```

Scilab code Exa 1.24 Find the velocity of a plane wave in a loss less medium

```
//Ex:1.24
clc;
clear;
close;
Er=15;// relative permittivity
ur=5;// relative mobility
B=1/sqrt(Er*ur);
A=3*10^8;// the value of 1/sqrt(Eo*uo)
V=A*B;// velocity of propagation in volt
printf("The field strength = %f*10^7 m/s", V/10^7);
```

Scilab code Exa 1.25 What is the strength of a magnetic field H in free space

```
//Ex:1.25
clc;
clear;
close;
E=6;// electric field strength in V/m
n=120*%pi;// efficiency
H=E/n;// magnetic field strength in Amp/m
printf("The magnetic field strength = %f mA/m", H
   *1000);
```

Scilab code Exa 1.26 Calculate the field strength at a distance of twenty five km

```
//Ex:1.26
clc;
clear;
close;
l=70;// antenna height in m
le=2*l/%pi;// effective length in m
Irms=25;// current in amp
```

```
f=10;// frequency in MHz
y=300/f;// wavelength in m
r=25*10^3;// distance in m
Erms=(120*%pi*le*Irms)/(y*r);// field strength in mV
    /m
printf("The field strength = %d mV/m", Erms*10^3);
```

Scilab code Exa 1.27 Calculate the radiation resistance

```
//Ex:1.27
clc;
clear;
close;
le=50;// effective height of antenna in m
f=10;// frequency in MHz
y=300/f;// wavelength in m
Rr=160*(%pi^2)*(le/y)^2;// Radiation resistance in
    ohm
printf("The Radiation resistance = %f k-ohm", Rr
    /1000);
```

Scilab code Exa 1.28 Derive an expression for the gain of a half wave antenna

```
//Ex:1.28
```

```
clc;
clear;
close;
// G=Pr/pi
// G=Pr/(Wi/4*%pi*r^2)
// G=4*%pi*r^2*Pr/Wi
// Pr=(30*Irms^2/%pi*r^2)*((cos(%pi/2*(cos(x))))^2/(
    sin(x)^2)
// this is max when x=90 degree
// then Pr=(30*Irms^2/(%pi*r^2))
// Wi=73.14*Irms^2
// then G=(4*%pi*r^2*30*Irms^2)/(73.14*Irms^2*%pi*r
    ^2)
// G=120/73.14
G=120/73.14;// Gain
g=10*log(G)/log(10);// Gain in dB
printf("The Gain = %f dB", g);
```

Scilab code Exa 1.29 Calculate the antenna current at a distance of seventh eighth wavelength away from the feed point

```
//Ex:1.29
clc;
clear;
close;
Irms=15;// current in Amp
// Erms=(120*%pi*Irms*le)/(y*r)
// here Irms=15 amp and le=3y/2
// then
// Erms=(120*%pi*15*3y/2)/(y*r)
// Erms=2700*%pi/r
```

```
// Now, le=7y, then
// Erms1=(120*%pi*Irms1*7y)/(y*r)
// Erms1=105*%pi/r
// and Erms=Erms1
// 2700*%pi/r=105*%pi*Irms1/r
// Irms1=2700/105
Irms1=2700/105;// current in Amp
printf("The current = %f Amp", Irms1);
```

Scilab code Exa 1.30 Find the average energy density

```
//Ex:1.30
clc;
clear;
close;
Pr=15;// poynting vector in W/m^2
v=3*10^8;// average velocity ( the speed of light)
dav=Pr/v;// average energy density in W S/m^3 or J/m
    ^3
dav1=dav*10^9;// average energy density in nJ/m^3
printf("The average energy density = %d nJ/m^3",
    dav1);
```

Scilab code Exa 1.31 Determine the radiation resistance

```
//Ex:1.31
clc;
clear;
close;
le_y=1/10;// the ratio of le to y
Rr=160*(%pi^2)*(le_y)^2;// radiation resistance in
    ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.32 What is the value of electric field strength at a point twenty five away in the same direction

```
//Ex:1.32
clc;
clear;
close;
r=15*10^3;// distance in m
r1=25*10^3;// distance in m
Erms_Erms1=r1/r;// the ratio of Erms to Erms1
Erms=25;// mV/m;// electric field strength in mV/m
Erms1=Erms/Erms_Erms1;// electric field strength in
    mV/m at a point 25 away in the same direction
printf("The electric field strength = %d mV/meter",
    Erms1);
```

Scilab code Exa 1.33 Find the velocity of propogation and the wavelength and the impedence of the medium and also the rms electric field E

```
//Ex:1.33
clc;
clear;
close;
f=20*10^6;// frequency in Hz
P=10;// poynting vector in W/m^2
u=4;// relative mobility
Er=5;// relative permeability
c=3*10^8;// the speed of light= 1/sqrt(uo*Eo)
V=c/sqrt(u*Er);// the velocity of propagation in m/s
y=V/f;// wavelength in m
E=sqrt(P*120*%pi*sqrt(4/5));// electric field in V/m
Erms=sqrt(E^2/sqrt(2));// rms electric field
E=sqrt(2)*Erms;// electric field
n=E^2/P;// impedance of the medium in ohm
printf("The velocity of propagation = %f*10^8 m/s",
   V/10^8);
printf("\n The wavelength = %f m", y);
printf("\n The impedance of the medium = %f ohm", n)
   ;
printf("\n The rms electric field = %f V/m", Erms);
```

Scilab code Exa 1.34 At what distance in wavelength is the radiation component of magnetic field three times the induction components

```
//Ex:1.34
clc;
clear;
```

```
close;
// 3*(1/r^2)=w/(r*c)
// 3/r=(2*%pi*f/c)
// r=(1/(2*%pi))*3
r=(1/(2*%pi))*3;// distance in terms of y(wavelength
    )
r1=(1/(2*%pi))*50;// distance in terms of y(
    wavelength)
printf("The distance when component of M-field three
     times the induction field = %f*y", r);
printf("\n The distance when component of M-field 50
     times the induction field= %f*y", r1);
```

Scilab code Exa 1.35 Find out the field strength

```
//Ex:1.35
clc;
clear;
close;
W=50*1000;// radiated power in W
r=90*1000;// distance in m
Erms=(sqrt(90*W))/r;// strength of electric field in
     V/m
printf("The strength of electric field = %f mV/m",
    Erms*1000);
```

Scilab code Exa 1.36 Find the velocity of a plane wave in a loss less medium

```
//Ex:1.36
clc;
clear;
close;
c=3*10^8;// the speed of light in m/s
ur=1;// relative permittivity
Er=4;// relative permeability
vp=c/sqrt(ur*Er);// velocity of a plane wave
printf("The velocity of a plane wave = %f*10^8 m/s",
    vp/10^8);
```

Scilab code Exa 1.37 Calculate the antenna current at a distance of seventh eighth wavelength away from the feed point

```
//Ex:1.37
clc;
clear;
close;
Irms=15;// current in Amp
// Erms=(120*%pi*Irms*le)/(y*r)
// here Irms=15 amp and le=7y/2
```

```
// then
// Erms=(120*%pi*15*7y/2)/(y*r)
// Erms=6300*%pi/r
// Now, le=7y, then
// Erms1=(120*%pi*Irms1*7y)/(y*r)
// Erms1=105*%pi/r
// and Erms=Erms1
// 6300*%pi/r=105*%pi*Irms1/r
// Irms1=6300/105
Irms1=6300/105;// current in Amp
printf("The current = %d Amp", Irms1);
```

Scilab code Exa 1.38 Determine the radiation resistance

```
//Ex:1.38
clc;
clear;
close;
le_y=1/150;// the ratio of le to y
Rr=16*(%pi^2)*(le_y)^2;// radiation resistance in ohm
printf("The radiation resistance = %f*10^-3 ohm", Rr*1000);
```

Scilab code Exa 1.39 What is the radiation resistance of an antenna

```
//Ex:1.39
clc;
clear;
close;
Pr=10*10^3;// power in Watts
I=18;// current in Amp
R=Pr/I^2;// radiation resistance of an antenna in
    ohm
printf("The radiation resistance of an antenna = %f
    ohm", R);
```

Scilab code Exa 1.40 What is the bandwidth

```
//Ex:1.40
clc;
clear;
close;
fo=25*10^6;// frequency in Hz
Q=40;
B_W=fo/Q;// bandwidth in Hz
printf("The bandwidth = %d KHz", B_W/1000);
```

Scilab code Exa 1.41 Define radiation resistance and also Calculate the radiation resistance and efficiency

```
//Ex:1.41
clc;
clear;
close;
Rl=1.5;// loss resistance in ohm
le_y=1/50;// the ratio of le to y
Rr=80*(%pi^2)*(le_y)^2;// radiation resistance in
    ohm
Rt=Rl+Rr;// total resistance in ohm
n=Rr/Rt;// effeciency
printf("The effeciency = %f %%", n*100);
```

Scilab code Exa 1.42 What is the significance of electrostatic field and induction field and also radiation field of the antenna and at what distance in wavelength the radiation component of magnetic field is hundred times of the induction component

```
//Ex:1.42
clc;
clear;
close;
// 100*(1/r^2)=w/(r*c)
// 100/r=(2*%pi*f/c)
// r=(1/(2*%pi))*100
r=(1/(2*%pi))*100;// distance in terms of y(
    wavelength)
printf("The distance when component of M-field three
     times the induction field = %f*y", r);
```

Scilab code Exa 1.43 Define retarded vector potential

```
//Ex:1.43
clc;
clear;
close;
printf("Retarded vector potential- The vector potential expression represents the super positions of various current elements I.dl, at a distant point P at a distance of r. If these are simply added up, it means an assumption is made that these field effects which are super imposed at time t, all started from the current elements of the same value of current and even though they have travelled different. Varying distances in other words finite time of propagation has been ignored which is not correct. This would have been correct provided the velocity of propagation would have been infinite which is actually not.");
printf("\n If the expression for vector potential in Integrated it follows thet potential due to various current element are added up let us suppose that current (I) is istantaneous current (I) in the element be Sinusoidal function of time as");
printf("\n I=Im.sin(wt), where Im= max current");
printf("\n I=Instantaneous current");
printf("\n w=2hf, angular frequency");
```

Scilab code Exa 1.44 What is the power radiated and what is the efficiency of the antenna

```
//Ex:1.44
clc;
clear;
close;
c=3*10^8;// the speed of light in m/s
Irms=450;// current in Amp
dl=100;// effective length in m
f=40*10^3;// frequency in Hz
y=c/f;// wavelength in m
w=80*%pi^2*Irms^2*(dl/y)^2;// power radiated in
    Watts
Rr=0.14;// radiation resistance in ohm
Rt=1.12;// total resistance in ohm
n=Rr/Rt;// effeciency
printf("The power radiated = %f kW", w/1000);
printf("\n The effeciency = %f %%", n*100);
```

Scilab code Exa 1.45 Calculate the radiation resistance power radiated and the efficiecy of an antenna

```
//Ex:1.45
```

```
clc;
clear;
close;
le=69.96;// effective length in m
Irms=50;// current in Amp
Rt=50;// total resistance in ohm
c=3*10^8;// the speed of light in m/s
f=0.480*10^6;// frequency in Hz
y=c/f;// wavelength in m
Rr=160*%pi^2*(le/y)^2;// radiation resistance in ohm
w=Irms^2*Rr;// power radiated in Watts
n=Rr/Rt;// effeciency
printf("The radiation resistance = %f ohm", Rr);
printf("\n The power radiated = %f kW", w/1000);
printf("\n The effeciency = %f %%", n*100);
```

Scilab code Exa 1.46 Find the radiation resistance and efficiency

```
//Ex:1.46
clc;
clear;
close;
Rl=1.5;// loss resistance in ohm
dl_y=1/15;// the ratio of dl to y(wavelength)
Rr=80*(%pi^2)*(dl_y)^2;// radiation resistance in
   ohm
Rt=Rl+Rr;// total resistance in ohm
n=Rr/Rt;// effeciency
printf("The radiation resistance = %f ohm", Rr);
printf("\n The effeciency = %d %%", n*100);
```

Scilab code Exa 1.47 What is the power radiated

```
//Ex:1.47
clc;
clear;
close;
I=10;// peak current in Amp
Irms=I/sqrt(2);// rms current in Amp
A=80*Irms^2;
printf("The the value of A = %f", A);
printf("\n power radiated=4000(pi*dl)^2/y^2");
printf("\n Where, y=wavelength & pi=3.14");
```

Scilab code Exa 1.48 What is the strength of magnetic field H in free space

```
//Ex:1.48
clc;
clear;
close;
E=60;// electric field strength in V/m
n=120*%pi;// efficiency
H=E/n;// magnetic field strength in Amp/m
printf("The magnetic field strength = %f A/m", H);
```

Scilab code Exa 1.49 Calculate the radiated field strength and the total power radiated and also the radiation resistance

```
//Ex:1.49
clc;
clear;
close;
c=3*10^8;// speed of the light in m/s
f=10*10^6;// frequency in Hz
y=c/f;// wavelength in m
I=1;// current in amp
l=1;// length in m
r=500*10^3;// distance in m
n=120*%pi;
Ex=(n*I*l*sin(%pi/2))/(2*r*y);// the magnitude of
    electric field in uV/m
Hx=(I*l*sin(%pi/2))/(2*r*y);// the magnitude of
    magnetic field in AT/m
Pm=(80*%pi^2*I^2*l^2)/(y^2);// the maximum power
    radiated in watts
Pav=(1/2)*Pm;// the average power radiated in watts
Rr=80*%pi^2*(l/y)^2;// the radiation resistance in
    ohm
printf("The magnitude of electric field = %f uV/m",
    Ex*10^6);
printf("\n The magnitude of magnetic field = %f
    *10^-8 AT/m", Hx*10^8);
printf("\n The maximum power radiated = %f watts",
    Pm);
printf("\n The average power radiated = %f watts",
```

```
    Pav);
printf("\n The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 1.50 Show the total far field electric field amplitude and also Calculate the power that could be fed into a dipole antenna

```
//Ex:1.50
clc;
clear;
close;
V=5*10^-3;// rms value in volt
r=3*10^3;// in meter
Rr=73;// the radiation resistance in ohm
// The electric field in the far region may be given
   by
// Ex=(60.pi.Im.sin(x)/y.r)*e^(-jko.r)*integrate('(
   cos(koz)*e^(jko.z.cos(x)))','z',-y/4,y/4)
// Ex=(60.pi.Im.sin(x)/y.r)*e^(-jko.r)*integrate
   ('(2.cos(ko)(cos(ko.z).cos(x)+j.sin(ko.z).cos(x))
   ','z',0,y/4)
// Ex=(60.pi.Im.sin(x)/y.r)*e^(-jko.r)*integrate
   ('(2.cos(ko.z).cos(ko.z.cos(x)))','z',0,y/4)
// on integrating, we get,
// Ex=(60*Im/r)*(cos(pi/2.cos(x))/sin(x))
Emax=V*sqrt(2);// the peak value of field in V/m
// on putting x=90 degree in Ex=(60*Im/r)*(cos(pi/2.
   cos(x))/sin(x)), we get
// Emax=60*Im/r, then
Im=Emax*r/60;// max current in amp
Pav=(Im^2/2)*(Rr);// the average power in watts
printf("The expression of total electric field
```

```
    amplidude,  Ex=(60*Im/r)*(cos(pi/2.cos(x))/sin(x))
    ")
printf("\n The value of the average power= %f watts"
    , Pav);
```

Scilab code Exa 1.51 Calculate the loss resistance and also Calculate the power radiated and the ohmic loss and loss resistance

```
//Ex:1.51
clc;
clear;
close;
I=4;// peak current in Amp
Irms=I/sqrt(2);// rms current in Amp
Rr=18;// radiation resistance in ohm
Pr=Irms^2*Rr;// power radiated in Watts
Rl=(0.1*Rr)/0.9;// loss resistance in ohm
Pl=Irms^2*Rl;// ohmic loss in Watt
printf("The power radiated = %f Watts", Pr);
printf("\n The loss resistance = %d ohm", Rl);
printf("\n The ohmic loss = %f watts", Pl);
```

Chapter 2

Antenna Terminology

Scilab code Exa 2.1 What is the wavelength

```
//Ex:2.1
clc;
clear;
close;
c=3*10^8;// the speed of light in m/s
f=1000000;// frequency in Hz
y=c/f;// wavelength in m
printf("The wavelength = %d meter", y);
```

Scilab code Exa 2.2 What is the actual velocity of EM energy

```
//Ex:2.2
clc;
clear;
close;
```

```
c=3*10^8;// the speed of light in m/s
f=0.75;// propagation fector
v=c*f;// actual veloity in m/s
printf("The actual veloity = %f*10^8 meter/sec", v
   /10^8);
```

Scilab code Exa 2.3 What is the wavelength in vaccum and in air

```
//Ex:2.3
clc;
clear;
close;
c=3*10^8;// the speed of light in m/s
f=60*1000000;// frequency in Hz
y=c/f;// wavelength in vaccum in m
y1=y*0.98;// wavelength in air in m
printf("The wavelength in vaccum = %d meter", y);
printf("\n The wavelength in air = %f meter", y1);
```

Scilab code Exa 2.4 What is the directicity

```
//Ex:2.4
clc;
clear;
close;
```

```
Rr=80;// radiation resistance in ohm
Rl=10;// loss-resistance in ohm
n=Rr/(Rr+Rl);// effeciency
G=20;// Power Gain
D=G/n;// directivity
printf("The directivity = %f", D);
```

Scilab code Exa 2.5 Calculate the radiation resistance

```
//Ex:2.5
clc;
clear;
close;
dl_y=1/20;// the ratio of dl to y(wavelength)
Rr=80*(%pi^2)*(dl_y)^2;// radiation resistance in
   ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 2.6 Find the max directivity and compare it with its exact value

```
//Ex:2.6
clc;
clear;
close;
```

```
x1r=2*%pi/3;// in radian
x2r=2*%pi/3;// in radian
D=4*%pi/(x1r)^2;// the max directivity
// Now, let us find the exact value of the max directivity and compare the result
// y=Bo.cos(x)
// ymax=Bo
// Prad=integration of (Bo.cos(x).sin(x)) with limit 0 to 2*pi
P=integrate('sin(2*x)','x',0,2*3.14);
// Prad=%pi*Bo*integration of (Bo.cos(x).sin(x)) with limit 0 to 2*pi
// then we get Prad=%pi*Bo
// Do=(4*pi*ymax)/Prad=4*pi*Bo/%pi*Bo
Do=4;// exact value of the max directivity
printf("The max directivity = %f (dimensionless)", D);
printf("\n The exact value of the max directivity = %d (dimensionless)", Do);
printf("\n The exact max directivity is 4 and its approx. value is 2.84. Better approximations can be obtained if the patterns have much narrower beamwidths.");
```

Scilab code Exa 2.7 What is the bandwidth and also bandwidth ratio

```
//Ex:2.7
clc;
clear;
close;
fc=220;// center frequency in Hz
```

```
f3db=190;// 3 db frequency in Hz
f3db1=240;// 3 db frequency in Hz
Bl=(fc-f3db)/fc;// lower band width
Bu=(f3db1-fc)/fc;// upper band width
R=f3db1/f3db;// max to min ratio
printf("The lower band width = %f %%", Bl*100);
printf("\n The upper band width = %f %%", Bu*100);
printf("\n The max to min ratio = %f to 1 ", R);
```

Scilab code Exa 2.8 Calculate the max effective aperture of an antenna

```
//Ex:2.8
clc;
clear;
close;
y=2;// wavelength in m
D=100;// directivity
Aem=(D*y^2)/(4*%pi);// max efeective aperture in m^2
printf("The max efeective aperture = %f m^2", Aem);
```

Scilab code Exa 2.9 Find out the radiation resistance

```
//Ex:2.9
clc;
clear;
```

```
close;
dl_y=1/8;// the ratio of dl to y(wavelength)
Rr=80*(%pi^2)*(dl_y)^2;// radiation resistance in
   ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 2.10 How much power does a fifty ohms antenna radiate when fed a current five amp

```
//Ex:2.10
clc;
clear;
close;
Irms=5;// current in Amp
Rr=50;// radiation resistance in m
W=Irms^2*Rr;// power in Watts
printf("The power = %d Watts", W);
```

Scilab code Exa 2.11 Calculate the radiation resistance

```
//Ex:2.11
clc;
clear;
close;
G=20;// Power Gain
```

```
D=22;// directivity
n=G/D;// effeciency
Rl=10;// loss-resistance in ohm
Rr=(n*Rl)/(1-n);// radiation resistance in ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 2.12 Calculate the front to back ratio of an antenna in dB

```
//Ex:2.12
clc;
clear;
close;
P1=3000;// in Watts
P2=500;// in Watts
Gdb=10*log(P1/P2)/log(10);// front to back ratio of
    an antenna in dB
printf("The front to back ratio of an antenna = %f
    dB", Gdb);
```

Scilab code Exa 2.13 Find the received power

```
//Ex:2.13
clc;
clear;
```

```
close;
G=40;// power gain in dB
Gt=40;// power gain in dB
Gr=40;// power gain in dB
G1=10^(G/10);// power gain
Gt1=10^(Gt/10);// power gain
Gr1=10^(Gr/10);// power gain
f=10*10^3;// frequency in MHz
y=300/f;// wavelength in m
Wt=1;// Transmitter in Watts
r=30*10^3;// range of link in m
Wr=(Wt*G1^2*y^2)/(4*%pi*r)^2;// receive power in
    Watts
printf("The receive power = %f*10^-6 Watts", Wr
    *10^6);
```

Scilab code Exa 2.14 How much is the new signal picked up by the receiving station

```
//Ex:2.14
clc;
clear;
close;
V2=50;// in micro volt
G=5;// voltage gain in dB
G1=10^(G/20);// voltage gain
V1=V2*G1;// signal at receiving station in volt
printf("The signal at receiving station = %f micro
    volts", V1);
```

Scilab code Exa 2.15 Calculate the power gain

```
//Ex:2.15
clc;
clear;
close;
Pi=400*10^-3;// input power to reference Antenna
Pt=100*10^-3;// input power to test antenna
Gdb=10*log(Pi/Pt)/log(10);// power gain in dB
printf("The power gain = %f dB", Gdb);
```

Scilab code Exa 2.16 Calculate the approximate gain and beamwidth of a paraboloidal reflector antenna

```
//Ex:2.16
clc;
clear;
close;
D=20;// directivity
A=%pi*(D/2)^2;
f=4*10^3;// frequency in MHz
y=300/f;// wavelength in meter
n=0.55;// effeciency
G=(4*%pi*n*A)/y^2;// gain
```

```
Gdb=10*log(G)/log(10);// gain in dB
B_W=(70*y/D);// beamwidth of a paraboloidal
   reflector antenna
printf("The gain = %f dB", Gdb);
printf("\n The beamwidth of a paraboloidal reflector
    antenna = %f degree", B_W);
```

Scilab code Exa 2.17 Find out the quality factor Q of an antenna

```
//Ex:2.17
clc;
clear;
close;
df=0.600;// bandwidth in MHz
fr=30;// frequency in MHz
Q=fr/df;// quality factor
printf("The quality factor = %d", Q);
```

Scilab code Exa 2.18 Calculate the bandwidth of an antennas

```
//Ex:2.18
clc;
clear;
close;
fr=110*10^6;// frequency in Hz
```

```
Q=70;// quality factor
df=fr/Q;// bandwidth in MHz
printf("The bandwidth= %f MHz", df/10^6);
printf("\n The answer is wrong in the textbook");
```

Scilab code Exa 2.19 Calculate the directivity of isotropic antenna

```
//Ex:2.19
clc;
clear;
close;
A=4*%pi;// for isotropic antenna
D=4*%pi/A;// directivity
printf("The directivity= %d", D);
```

Scilab code Exa 2.20 Calculate the max effective aperture of a microwave antenna

```
//Ex:2.20
clc;
clear;
close;
D=900;// directivity
// Aem=(D.y^2)/(4*%pi), where y= Wavelength
Aem=(D/(4*%pi));// max effective aperture
```

```
printf("The max effective aperture= %f*y^2, where y=
    wavelength", Aem);
```

Scilab code Exa 2.21 Find the equivalent temperature

```
//Ex:2.21
clc;
clear;
close;
FdB=0.2;// noise figure in dB
F=10^(FdB/10);// noise figure
To=290;// temperature in k
Te=(F-1)*To;// equivalent temperature in k
printf("The equivalent temperature= %f k", Te);
printf("\n The answer is wrong in the textbook");
```

Scilab code Exa 2.22 Find the noise factor

```
//Ex:2.22
clc;
clear;
close;
Te=20;// equivalent temperature in k
To=290;// temperature in k
F=1+Te/To;// noise figure
```

```
printf("The noise figure = %f", F);
```

Scilab code Exa 2.23 what is the effective noise temperature

```
//Ex:2.23
clc;
clear;
close;
FdB=1.1;// noise figure in dB
F=10^(FdB/10);// noise figure
To=290;// temperature in k
Te=(F-1)*To;// equivalent temperature in k
printf("The equivalent temperature= %f k", Te);
```

Scilab code Exa 2.24 Calculate the available noise power per unit bandwidth and also Calculate the available noise power for a noise bandwidth

```
//Ex:2.24
clc;
clear;
close;
Ta=15;// effective temperature in k
Tn=20;// effective noise temperature in k
B=4*10^6;// noise bandwidth in Hz
k=1.38*10^-23;// boltzmann's constant
```

```
Ps_Bn=k*(Ta+Tn);// noise power per unit bandwidth in
     Watts/Hz
Ps=Ps_Bn*B;// the total available noise power in
    Watts
printf("The noise power per unit bandwidth= %f
    *10^-23 Watts/Hz", Ps_Bn*10^23);
printf("\n The total available noise power= %f
    *10^-17 Watts", Ps*10^17);
```

Scilab code Exa 2.25 How much is the new signal picked up by the receiving station

```
//Ex:2.25
clc;
clear;
close;
V2=50;// in u volt
G=5;// voltage gain in dB
G1=10^(G/20);// voltage gain
V1=V2*G1;// signal at receiving station in volt
printf("The signal at receiving station = %f u-volts
    ", V1);
```

Scilab code Exa 2.26 Calculate the max effective aperture of an antenna

```
//Ex:2.26
clc;
clear;
close;
y=5;// wavelength in m
D=75;// directivity
Aem=(D*y^2)/(4*%pi);// max efeective aperture in m^2
printf("The max efeective aperture = %f m^2", Aem);
```

Scilab code Exa 2.27 Find the equivalent temperature

```
//Ex:2.27
clc;
clear;
close;
FdB=0.5;// noise figure in dB
F=10^(FdB/10);// noise figure
To=290;// temperature in k
Te=(F-1)*To;// equivalent temperature in k
printf("The equivalent temperature= %f k", Te);
```

Scilab code Exa 2.28 Find the noise factor

```
//Ex:2.28
clc;
```

```
clear;
close;
Te=40;// equivalent temperature in k
To=290;// temperature in k
F=1+Te/To;// noise figure
printf("The noise figure = %f", F);
```

Scilab code Exa 2.29 What is the effective noise temperature

```
//Ex:2.29
clc;
clear;
close;
FdB=1.5;// noise figure in dB
F=10^(FdB/10);// noise figure
To=290;// temperature in k
Te=(F-1)*To;// equivalent temperature in k
printf("The equivalent temperature= %f k", Te);
```

Scilab code Exa 2.30 Calculate the available noise power per unit bandwidth and also Calculate the available noise power for a noise bandwidth

```
//Ex:2.30
clc;
clear;
```

```
close;
Ta=25;// effective temperature in k
Tn=45;// effective noise temperature in k
B=7*10^6;// noise bandwidth in Hz
k=1.38*10^-23;// boltzmann's constant
Ps_Bn=k*(Ta+Tn);// noise power per unit bandwidth in Watts/Hz
Ps=Ps_Bn*B;// the total available noise power in Watts
printf("The noise power per unit bandwidth= %f *10^-23 Watts/Hz", Ps_Bn*10^23);
printf("\n The total available noise power= %f *10^-17 Watts", Ps*10^17);
```

Scilab code Exa 2.31 Calculate the gain and beam width of the antenna

```
//Ex:2.31
clc;
clear;
close;
f=7.375*10^3;// frequency in MHz
y=300/f;// wavelength in m
D=2.7;// directivity
Ae=%pi*(D/2)^2*0.65;// effective aperture
G=(4*%pi/y^2)*Ae;// gain
BW=70*y/D;// Beamwidth in A
printf("The gain = %f ", G);
printf("\n The Beamwidth = %f A", BW);
```

Scilab code Exa 2.32 How much is the new signal picked up by the receiving station

```
//Ex:2.32
clc;
clear;
close;
V2=60;// in u volt
G=15;// voltage gain in dB
G1=10^(G/20);// voltage gain
V1=V2*G1;// signal at receiving station in volt
printf("The signal at receiving station = %f u-volts
    ", V1);
```

Scilab code Exa 2.33 Calculate the radiation resistance

```
//Ex:2.33
clc;
clear;
close;
G=30;// Power Gain
D=42;// directivity
n=G/D;// effeciency
Rl=25;// loss-resistance in ohm
```

```
Rr=(n*Rl)/(1-n);// radiation resistance in ohm
printf("The radiation resistance = %f ohm", Rr);
```

Scilab code Exa 2.34 Determine the total radited power

```
//Ex:2.34
clc;
clear;
close;
// For a closed surface, a sphere of radius r is
   choosen. To find the total radiated power, the
   radiated component of the power density is
   integrated over its surface. therefore,
// Wt=double integration of (ar.Ao.(sin(x)/r^2))*(ar
   .r^2.sin(x)) with limits from 0 to 2*pi and from
   0 to pi, and on integration we get , pi^2*Ao
   watts
printf("The total radiated power= pi^2*Ao watts");
```

Scilab code Exa 2.35 Find the max directivity of the antenna and write an expression for the directivity

```
//Ex:2.35
clc;
clear;
```

```
close;
// The max radiation is directed along x=pi/2. Therefore, Ymax=Ao
// radiation intensity in example 2.34 is , Wt=pi^2*Ao
// then, max directivity, Do=4*pi*Ymax/Wt=4*pi*Ao/pi^2*Ao=4/pi
Do=4/%pi;// the max directivity
// since the radiation intensity is only a function of angle x, the directivity as a function of the directional angles is represented by, D=Do*sin(x)
printf("The max directivity = %f", Do);
printf("\n The directivity as a function of the directional angles is represented by, D=Do*sin(x), where Do is the max value of directivity");
```

Scilab code Exa 2.36 Find the max directivity of the antenna and write an expression for the directivity

```
//Ex:2.36
clc;
clear;
close;
// The radiation intensity is given by, F=r^2*Wr=Ao*(sin(x))^2
// The max radiation is directed along x=pi/2. therefore, Ymax=Ao
// the total radiated power is given by,Wt= Ao(8*pi/3)
// then the max directivity is equal to
// Do=4*pi*Ymax/Wt=4*pi*Ao/(8*pi*Ao/3)=3/2
```

```
Do=3/2;// the max directivity
printf("The max directivity = %f", Do);
printf("\n The directivity as a function of the
    directional angles is represented by, D=1.5*(sin(
    x))^2");
```

Scilab code Exa 2.37 Show the max effective aperture of a short dipole antenna

```
//Ex:2.37
clc;
clear;
close;
// It is assume that
// 1. short dipole is coincide with x-axis
// 2. Plane polarized wave in travelling along y-
    axis and including current along the x-axis of
    antenna which constant throughout the length of
    the dipole and in the same phase
// 3. Length of the short dipole is small in
    comparison to wavelength i.e. dl<<y
// 4. Antenna losses are zero.
// i.e.,       RL=Rr+Rl
// or          RL=Rr,          Rl=0
// As we know max-effective aperture is given by
// (Ae)max=V^2/(4*pi*P*Rr)
// where, V=induced voltage, P=poynting vector, Rr=
    radiation resistance
// As we here, V=E*dl, P=E^2/n W/m^2, where, n=
    intrinsic impedence of free space and E=Electric
    field intensity
```

```
// the radiation Resistance of short dipole antenna
   is given by
// Rr=80*pi^2*(dl/y)^2 in ohm
// then (Ae)max=(E*dl)^2/(4*(E^2/n)*(80*pi^2)*(dl/y)
   ^2)
//        (Ae)max=(n*y^2)/(80*pi^2*4)=(120*pi*y^2)
   /(320*pi^2)
//                =(3*y^2)/(8*pi)=0.119*y^2
printf("The maximum effective aperture of a short
   dipole antenna, (Ae)max=0.119*y^2, where y is
   wavelength");
```

Scilab code Exa 2.38 Show the field strength at adistance r meters from an antenna of gain G and radiating power P

```
//Ex:2.38
clc;
clear;
close;
// Power at point P, i.e.,distance r meters
// w=wt/4*pi*r^2
// here, wt=PG
// now, w=EH and E/H=n then w=E^2/n where n=120*pi
// E^2=wn=(wt/4*pi*r^2)n=(PG/4*pi*r^2)n=120*pi*PG/4*
   pi*r^2=30*PG/r^2
printf("The field strength is, E=sqrt(30*P*G)/r^2 V/
   m");
```

Scilab code Exa 2.39 Define effective aperture and scattering aperture

```
//Ex:2.39
clc;
clear;
close;
printf("Effective aperture and scattering aperture-Resides effective aperture, there are other aperture also like scattering aperture (As) and loss aperture (Al). Corresponding to considerable losses in radiation or re-radiation Resistance (Rr) and antenna losses resistance (Rl) respectively and accordingly they are called as scattering apertures.");
// The scattering aperture, As=((Irms)^2*Rr)/P
printf("The scattering aperture, As=(V^2*Rr)/((RL+RA)^2+(XL+XA)^2)*P) ");
```

Scilab code Exa 2.40 Calculate the power density and magnetic and electric field strength

```
//Ex:2.40
clc;
clear;
```

```
close;
Irms=4;// rms current in Amp
Rr=70;// radiation resistance in ohm
Pmax=(sqrt(2)*Irms)^2*Rr;// max power in Watts
Pav=Pmax/2;// average power in Watts
d=60*10^3;// distance in m
Pd=(Pav*1.6)/(4*%pi*d^2);// power density
n=120*%pi;// efficiency
E=sqrt(n*Pd);// electric field in V/m
H=E/n;// magnetic field A/m
printf("The power density = %f micro Watt/m^2", Pd
    *10^6);
printf("\n The electric field = %f mV/m", E);
printf("\n The magnetic field = %f*10^-5 AT/m ", H
    *10^5);
```

Scilab code Exa 2.41 Calculate the antenna gain

```
//Ex:2.41
clc;
clear;
close;
Pt=120;// transmitting power in Watt
Pd=160*10^-6;// power density in W/cm^2
d=10*100;// distance in cm
Gt=(Pd*4*%pi*d^2)/Pt;// the antenna gain
printf("The antenna gain = %f ", Gt);
```

Scilab code Exa 2.42 Calculate the effective aperture and what will the power received

```
//Ex:2.42
clc;
clear;
close;
f=1.2*10^9;// freqyency in Hz
c=3*10^8;// the speed of light in m/s
y=c/f;// wavelength in m
D=1.5;// directivity
Ae=(D*y^2)/(4*%pi);// effective aperture area
Pd=2*10^-3;// power density in W/m^2
Pr=Pd*Ae;// power received in Watts
printf("The power received = %f*10^-6 Watts", Pr
    *10^6);
```

Scilab code Exa 2.43 Find the directivity and gain and effective aperture and beam solid angle and radiation resistance and also terminal resistance

```
//Ex:2.43
clc;
clear;
close;
```

```
Rl=1.5;// loss resistance in ohm
// Rr=80*pi^2*(l/y)^2=(80*pi^2*(y/15)^2)/y^2=80*pi^2/225
Rr=80*%pi^2/225;// the radiation resistance of the antenna in ohm
n=Rr/(Rr+Rl);// the efficiency factor
// the effective aperture of the antenna is given by
// Ae=V^2/4*S*Rr
// max emf induced, V=E*l volt
// Poynting vector, S=E^2/zo W/m^2, where zo=120*pi ohm
// Ae=(E*l)^2/(4*(E^2/zo)*Rr)=l^2*zo/(4*Rr), l=y/15
// Ae=((y/15)^2*120*pi)/(4*3.5)=0.1196*y^2
// the directivity, D=4*pi*Ae/y^2=(4*pi/y^2)*0.1196*y^2
D=4*%pi*0.1196;// the directivity
G=n*D;// the gain of the dipole
Rt=Rr+Rl;// the terminal resistance in ohm
x=4*%pi/D;// the beam solid angle in sreradian
printf("The radiation resistance of the anteenna = %f ohm", Rr);
printf("\n The effective aperture, Ae=0.1196*y^2, where y is wavelength");
printf("\n The directivity = %f", D);
printf("\n The gain of the dipole = %f", G);
printf("\n The terminal resistance = %d ohm", Rt);
printf("\n The beam solid angle = %f sreradian", x);
```

Scilab code Exa 2.44 Find the beam width

```
//Ex:2.44
```

```
clc;
clear;
close;
GdB=44;// gain in dB
G=10^(44/10);// gain
XB=(4*%pi)/G;// beam solid angle in sreradian
X3dB=sqrt(4/%pi)*sqrt(XB);// beam width in radian
X3dB1=X3dB*180/%pi;// beam width in degree
printf("The beam width = %f degree", X3dB1);
```

Scilab code Exa 2.45 what is the size of spot illuminated by the antenna

```
//Ex:2.45
clc;
clear;
close;
X3dB=0.1;// beam width in degree
X3dB1=X3dB*%pi/180;// beam width in radian
XB=(%pi/4)*(X3dB1^2);// beam solid angle
r=36000*1000;// distance from earth surface in m
A=XB*r^2;// area of spot in m^2
printf("The area of spot = %f*10^9 m^2", A/10^9);
```

Scilab code Exa 2.46 Find the power density

```
//Ex:2.46
clc;
clear;
close;
Gt=36;// the antenna gain in dB
Gt1=10^3.6;// the antenna gain
Pt=5*10^3;// transmitting power in Watt
R=25*10^3;// distance in m
Pd=(Pt*Gt1)/(4*%pi*R^2);// power density in W/cm^2
printf("The power density = %f*10^-3 W/m^2 ", Pd
    *1000);
```

Scilab code Exa 2.47 Find the max radiated electric field and what is the max power density

```
//Ex:2.47
clc;
clear;
close;
l=1.2/100;// length in m
Im=2.8;// peak current in Amp
f=1*10^9;// frequency in Hz
c=3*10^8;// the speed of light in m/s
y=c/f;// wavelength in m
x=90;// angle in degree
x1=x*%pi/180;// angle in radian
r=10;// in m
n=120*%pi;// efficiency
Emax=(n*Im*l*sin(x1))/(2*r*y);// max radiated
    electric field in V/m^2
Pmax=Emax^2/n;// max power density in W/m^2
```

```
printf("The max radiated electric field = %f V/m",
   Emax);
printf("\n The max power density = %f W/m", Pmax);
```

Scilab code Exa 2.48 Find the peak poynting vector and the average poynting vector and also the peak value of magnetic field H

```
//Ex:2.48
clc;
clear;
close;
E=10;// peak electric field in V/m
n=120*%pi;// efficiency
H=E/n;// peak magnetic field At/m
Ppeak=E*H;// peak poynting vector in W/m^2
Pav=(E^2)/(2*n);// average poynting vector in W/m^2
printf("The peak magnetic field = %f At/m", H);
printf("\n The peak poynting vector = %f W/m^2",
   Ppeak);
printf("\n The average poynting vector = %f W/m^2",
   Pav);
```

Scilab code Exa 2.49 Find the magnitude of magnetic and electric fields

```
//Ex:2.49
```

```
clc;
clear;
close;
Pav=100;// power density in W/m^2
E=8.85*10^-12;
V=3*10^8;// velocity in m/s
Eo=sqrt((2*Pav)/(E*V));// peak value of electric
    field in V/m
n=120*%pi;// efficiency
H=Eo/n;// magnetic field in AT/m
printf("The peak value of electric field = %f V/m",
    Eo);
printf("\n The magnetic field = %f AT/m", H);
```

Scilab code Exa 2.50 Find the rms electric and magnetic field and the average value of poynting vector and the average energy density and also the time it takes a signal to reach earth

```
//Ex:2.50
clc;
clear;
close;
R=3.8*10^5;// earth moon distance in km
R1=3.8*10^5*10^3;// earth moon distance in m
Pt=1;// transmitter power in Watts
Pd=Pt/(4*%pi*R^2);// power density at earth in W/m^2
n=120*%pi;// efficiency
pn=5.513*10^-13;// multiplication of P(poynting
    vector) and n(efficiency)
E=sqrt(2*Pd*n);// electric field in V/m
Erms=E/sqrt(2);// rms value of E
```

```
Hrms=Erms/n;// rms value of H
c=3*10^8;// the speed of light in m/s
t=R1/c;// time taken by the signal to reach earth
printf("The power density at earth = %f*10^-13 W/m^2
    ", Pd*10^13);
printf("\n The rms value of E = %f*10^-5 V/m", Erms
    *10^5);
printf("\n The rms value of H = %f*10^-8 AT/m", Hrms
    *10^8);
printf("\n The time taken by the signal to reach
    earth = %f sec", t);
```

Chapter 3

Antenna Arrays

Scilab code Exa 3.1 Calculate the half power beam width of the major lobes of the array in horizontal plane

```
//Ex:3.1
clc;
clear;
close;
// the path difference , x=dcos(a)
// therefore , phase difference , w=(2*%pi/y)*dcos(a)
   =Bdcos(a)
// from the geometry of the figure in the far field
   r>>d
// r1=r+x=r+dcos(a)
// r2=r-x=r-dcos(a)
// Hence, Et=I1exp^(-jB(r+dcos(a)))+I2exp^(-jB(r-
   dcos(a)))
// Et=exp^(-jBr)(I1exp^(-jBdcos(a))+I2exp^(-jBdcos(a
   )))
// case (a): in case I, we have I1=I2=I
// Hence, Et=Iexp^(-jBr)*(exp^(-jBdcos(a))+exp^(-
   jBdcos(a)))=2exp^(-jBr)*cos(Bdcos(a))
// Et will be max when cos(Bdcos(a)) will be max.
   therefore
```

```
// cos(Bd*cos(a))=1
// Bd*cos(a)=0
// a_max=n*%pi/2, where n=1,2,3,........
// hence , for the half power point a_HPPD
// cos(Bd*cos(a))=1/(sqrt(2))
// Bd*cos(a)=%pi/4
// cos(a_HPPD)=%pi/4Bd= %pi/(4*2%pi*0.75y/y)=1/6
// a_HPPD=acos(1/6)
a_HPPD=(acos(1/6)*180/%pi);// the half power point
    in degree
a_m=2*a_HPPD;// the half power beam width in degree
// In case I1=I and I2=Iexp^(j540)=Iexp^(j180)=-I
// therefore , Et2=Iexp^(-jBr)*(exp^(-jBdcos(a))+exp
    ^(-jBdcos(a)))
// =2j*I*exp^(-jBd)*sin(Bdcos(a))
// The max value of sin(Bdcos(a)) is at a=%pi. When
// sin(Bd*cos(a))=sin(Bd*cos(%pi))=sin(-Bd)=sin(-2*
    %pi*3y/(y*4))=sin(-3%Pi/2)=1
// Hence at the half power point a_HPPD2
// sin(Bd*cos(a))=1/(sqrt(2))
// Bd*cos(a_HPPD2)=%pi/4
// cos(a_HPPD2)=%pi/(4*2%pi*0.75y/y)=1/6
a_HPPD2=(acos(1/6)*180/%pi);// the half power point
    in degree
a_m2=2*a_HPPD2;// the half power beam width in
    degree
printf("The half power beam width for broad side
    array = %f degree", a_m);
printf("\n The half power beam width for end fire
    array = %f degree", a_m2);
```

Scilab code Exa 3.2 Calculate the progressive phase shifts and also Calculate the angle at which the main beam is placed for this phase distribution

```
//Ex:3.2
clc;
clear;
close;
// The phase difference w=Bd*cos(a)=(2%pi/y)*(y/4)*cos(a)=(%pi/2)*cos(a)
// Therefore, Et=Io(exp^(-j(%pi/2*cos(a)+k))+1+exp^(j(%pi/2*cos(a)+infinite)))=Eo(1+2*cos(%pi/2*cos(a+k)))
// the null appear, when, 1+2*cos((%pi/2)*cos(a_n)+k), a_n is equal to 33.56
// therefore , 1+2*cos((%pi/2)*cos(33.56)+k)=0
// cos((%pi/2)*cos(33.56)+k)=-1/2
// (%pi/2)*cos(33.56)+k= 2%pi/3
// k=(2%pi/3)-((%pi/2)*cos(33.56))
k=(2*%pi/3)-((%pi/2)*cos(33.56*%pi/180));//progressive phase shift in radian
k1=k*180/%pi;// progressive phase shift in degree
// The position of main beam a_m occurs when
// ((%pi/2)*cos(a_m))+B=0
// cos(a_m)= -B*2/%pi=-(%pi/4)*(2/%pi)=-1/2
a_m=(acos(-1/2)*180/%pi);// the position of main beam width in degree
printf("The progressive phase shift = %d degree", k1);
printf("\n The position of main beam width in degree = %d degree", a_m);
```

Scilab code Exa 3.3 Discuss the radiation pattern of a linear array

```
//Ex:3.3
clc;
clear;
close;
// The phase difference , w=Bd*cos(a)+k
// In this case , d=y/2, k=0, therefore
// w= (2%pi/y)*(y/2)*cos(a)+0= %pi*cos(a)
// The total far field at distance point P is given
   by
// Et=Eo(exp^(-jw)+2+exp^(jw))=Eo*(2+2*cos(w))=2*Eo
   (1+cos(%pi*cos(a)))
// Maximum value mode of Et=4*Eo
// so the normal value Enor=Et/(mode of Et)=(1+cos(
   %pi*cos(a)))/2
// For the max value (1+cos(%pi*cos(a))) should be
   max , therefore
// 1+cos(%pi*cos(a))=1
// cos(%pi*cos(a))=0
// %pi*cos(a)=%pi/2( in both sign plus & minuse)
a_m1=(acos(1/2))*(180/%pi);// when take + sign ,
   angle will be in degree
a_m2=(acos(-1/2))*(180/%pi);//when take - sign ,
   angle will be in degree
// For the max value (1+cos(%pi*cos(a))) should be
   max , therefore
// 1+cos(%pi*cos(a))=0
// cos(%pi*cos(a))=-1
// %pi*cos(a)=%pi( in both sign plus & minuse)
a_m3=(acos(1))*(180/%pi);// when take + sign , angle
   will be in degree
a_m4=(acos(-1))*(180/%pi);//when take - sign , angle
   will be in degree
// for HPPD (1+cos(%pi*cos(a))) should be 1/sqrt(2)
// 1+cos(%pi*cos(a))=1/sqrt(2)
// cos(%pi*cos(a))=(1/sqrt(2))-1=-0.293
// %pi*cos(a)=107 degree  ( in both sign plus &
```

```
minuse)
// cos(a_HPPD)=0.595  ( in both sign plus & minuse)
a_HPPD1=(acos(0.595))*(180/%pi);// when take + sign , the value of a_HPPD in degree
a_HPPD2=(acos(-0.595))*(180/%pi);// when take - sign , the value of a_HPPD in degree
printf("when take + sign , angle for maxima = %d degree", a_m1);
printf("\n when take - sign , angle for maxima= %d degree", a_m2);
printf("\n when take + sign , angle for minima= %d degree", a_m3);
printf("\n when take - sign , angle for minima= %d degree", a_m4);
printf("\n when take + sign , the value of HPPD= %d degree", a_HPPD1);
printf("\n when take - sign , the value of HPPD= %d degree", a_HPPD2);
printf("\n The Radiation pattern of the 3-element is shown in figure in the given text book");
```

Scilab code Exa 3.4 Design a eight element broad side array

```
//Ex:3.4
clc;
clear;
close;
dB=26;
n=8;// eight element array
r1=10^(dB/20);// because dB=20log(r)
r=ceil(r1);// round off value of r1
```

```
// Tchebyscheff polynomial of degree (n-1)=8-1=7
// T7(xo)=r
// 64Xo^7-112xo^5+56xo^3-7xo=20
// then using ulternate formula, we get the value of xo
m=n-1;// degree of the equation
a=sqrt(r^2-1);
A=(r+a)^(1/m);
B=(r-a)^(1/m);
xo1=.5*(A+B);
xo=1.15;// approx. value of xo1
// eight element array is shown in figure in the given textbook
// Thus Et, i.e., E8 from the equation
// E8=aoz+a1(4z^3-3z)+a2(16z^5-20z^3+5z)+a3(64z^7-112z^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where z=(x/xo)
// Then on putting z=(x/xo), we get
// ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a^2(16(x/xo)^5-20(x/xo)^3+5(x/xo))+a^3(64(x/xo)^7-112(x/xo)^5+56(x/xo)^3-7(x/xo))=64x^7-112x^5+56x^3-7x
// Now equating terms, we have
a3=xo^7;
a2=(112*a3-112*xo^5)/16;
a1=14*xo^3+5*a2-14*a3;
ao=3*a1-5*a2+7*a3-7*xo;
// Therefore the relative amplitude of the array are
a33=a3/a3;// the ratio of the a3 to a3
a23=a2/a3;// the ratio of the a2 to a3
a13=a1/a3;// the ratio of the a1 to a3
ao3=ao/a3;// the ratio of the ao to a3
printf("The value of the parameter r= %d", r);
printf("\n The value of the parameter xo= %f", xo);
printf("\n The value of the current amplitude parameter ao= %f", ao);
printf("\n The value of the current amplitude parameter a1= %f", a1);
printf("\n The value of the current amplitude
```

```
parameter a2= %f", a2);
printf("\n The value of the current amplitude parameter a3= %f", a3);
printf("\n The value of the relative amplitude parameter a33= %f", a33);
printf("\n The value of the relative amplitude parameter a23= %f", a23);
printf("\n The value of the relative amplitude parameter a13= %f", a13);
printf("\n The value of the relative amplitude parameter ao3= %f", ao3);
printf("\n The five element array is shown in figure in the given textbook")
```

Scilab code Exa 3.5 Design a five element broad side array which has the optimum pattern

```
//Ex:3.5
clc;
clear;
close;
dB=20;
n=5;// five element array
r=10^(dB/20);// because dB=20log(r)
// Tchebyscheff polynomial of degree (n-1)=5-1=4
// T4(xo)=r
// 8xo^4-8xo^2+1=10
// then using ulternate formula, we get the value of xo
m=4;// degree of the equation
a=sqrt(r^2-1);
```

```
A=(r+a)^(1/m);
B=(r-a)^(1/m);
xo=.5*(A+B);
// five element array is shown in figure in the given textbook
// Thus Et, i.e., E5 from the equation
// E5=aoz+a1(2z^2-1)+a2(8z^4-8z^2+1), where z=(x/xo)
// E5=T4(xo)
// ao(x/xo)+a1(2(x/xo)^2-1)+a2(8(x/xo)^4-8(x/xo)^2+1)=8x^4-8x^2+1
// Now equating terms, we have
// a2(x/xo)^4=x^4
a2=xo^4;
// a1*2(x/xo)^2-a2*8(x/xo)^2=-8x^2
a1=4*a2-4*xo^2;
// ao-a1+a2=1
ao=1+a1-a2;
// Therefore the relative amplitude of the array are
a11=a1/a1;// the ratio of the a1 to a1
a12=a1/a2;// the ratio of the a1 to a2
a02=2*ao/a2;// the ratio of the 2ao to a2
printf("The value of the parameter r= %d", r);
printf("\n The value of the parameter xo= %f", xo);
printf("\n The value of the current amplitude parameter 2*ao= %f", 2*ao);
printf("\n The value of the current amplitude parameter a1= %f", a1);
printf("\n The value of the current amplitude parameter a2= %f", a2);
printf("\n The value of the relative amplitude parameter a11= %f", a11);
printf("\n The value of the relative amplitude parameter a12= %f", a12);
printf("\n The value of the relative amplitude parameter a02= %f", a02);
printf("\n The five element array is shown in figure in the given textbook")
```

Scilab code Exa 3.6 Design a four element broad side array

```
//Ex:3.6
clc;
clear;
close;
dB=18;
n=4;// five element array
r1=10^(dB/20);// because dB=20log(r1)
r=ceil(r1);
// Tchebyscheff polynomial of degree (n-1)=4-1=4
// T3(xo)=r
// 4xo^3-3xo=8
// then using ulternate formula, we get the value of xo
m=3;// degree of the equation
a=sqrt(r^2-1);
A=(r+a)^(1/m);
B=(r-a)^(1/m);
xo1=.5*(A+B);
xo=1.46;// approx. value of xo1 is 1.46 because xo1=1.456957
// four element array is shown in figure in the given textbook
// Thus Et, i.e., E4 from the equation
// E4=aoz+a1(4z^3-3z), where z=(x/xo)
// E4=T3(xo)
// ao(x/xo)+a1(4(x/xo)^3-3(x/xo))=4x^3-3x
// Now equating terms, we have
// 4a1(x/xo)=4x^3
```

```
a1=xo^3;
// ao-3a1=-3a1
ao=3*a1-3*xo;
// Therefore the relative amplitude of the array are
a11=a1/a1;// the ratio of the a1 to a1
ao1=ao/a1;// the ratio of the ao to a1
printf("The value of the parameter r= %d", r);
printf("\n The value of the parameter xo= %f", xo);
printf("\n The value of the current amplitude
    parameter ao= %f", ao);
printf("\n The value of the current amplitude
    parameter a1= %f", a1);
printf("\n The value of the relative amplitude
    parameter a11= %f", a11);
printf("\n The value of the relative amplitude
    parameter ao1= %f", ao1);
printf("\n The five element array is shown in figure
     in the given textbook")
```

Scilab code Exa 3.7 Determine Dolph Tchebyscheff current distribution and also determine the half power beam width

```
//Ex:3.7
clc;
clear;
close;
dB=21;
n=5;// five element array
r1=10^(dB/20);// because dB=20log(r1)
r=floor(r1);
// Tchebyscheff polynomial of degree (n-1)=5-1=4
```

```
// T4(xo)=r
// 8xo^4-8xo^2+1=20
// then using ulternate formula, we get the value of xo
m=4;// degree of the equation
a=sqrt(r^2-1);
A=(r+a)^(1/m);
B=(r-a)^(1/m);
xo1=.5*(A+B);
xo=1.3132;// approx. value of xo1 is 1.3132 because xo1=1.313295
// Thus Et, i.e., E5 from the equation
// E5=aoz+a1(2z^2-1)+a2(8z^4-8z^2+1), where z=(x/xo)
// E5=T4(xo)
// ao(x/xo)+a1(2(x/xo)^2-1)+a2(8(x/xo)^4-8(x/xo)^2+1)=8x^4-8x^2+1
// Now equating terms, we have
// a2(x/xo)^4=x^4
a2=xo^4;
// a1*2(x/xo)^2-8(x/xo)^2*a2=-8x^2
// a1-4a2=-4x^2
a1=4*a2-4*xo^2
// ao-a1+a2=1
ao=a1-a2+1;
a22=a2/a2;// the ratio of the a2 to a2
a12=a1/a2;// the ratio of the a1 to a2
ao2=2*ao/a2;// the ratio of the 2ao to a2
R=r/sqrt(2);
// Y=acos(R/sqrt(2))= log(R+sqrt(R^2-1))
Y=log(R+sqrt(R^2-1))/log(10);
// cosh(Y/4)=cosh(1.19/4)=cosh(0.2975)
// because cosh(x)= 1+(x^2/2)+(x^4/24)+.....
// cosh(0.2975)=1+(0.2975^2/2)+(0.2975^4/24)
A=1+(0.2975^2/2)+(0.2975^4/24);
// HPBW= 2*asin((y/180*d)*acos(1/x0*cosh(Y/4)))
// HPBW= 2*asin((y*2/180*y)*acos(1/x0*cosh(0.2975)))
// HPBW= 2*asin((2/180)*acos(1/x0*A))
HPBW=2*(asin((2/180)*(acos(A/xo))*(180/%pi)))*180/
```

```
%pi;// half power bandwidth in degree
printf("The value of the parameter r= %d", r);
printf("\n The value of the parameter xo= %f", xo);
printf("\n The value of the current amplitude parameter ao= %f", ao);
printf("\n The value of the current amplitude parameter a1= %f", a1);
printf("\n The value of the current amplitude parameter a2= %f", a2);
printf("\n The value of the relative amplitude parameter a22= %f", a22);
printf("\n The value of the relative amplitude parameter a12= %f", a12);
printf("\n The value of the relative amplitude parameter ao2= %f", ao2);
printf("\n The half power bandwidth= %f degree", HPBW);
printf("\n The five element array is shown in figure in the given textbook")
```

Scilab code Exa 3.8 Design an array to yield an optimum pattern

```
//Ex:3.8
clc;
clear;
close;
m=5;// number of elements
xn=45/2;// mean beamwidth in degree
xn1=xn*%pi/180;// mean beamwidth in radian
x=cos((180/(2*(m-1)))*(%pi/180));
a=sin(xn1);
```

```
p=cos(90*a*(%pi/180));
xo=x/p;
// E5=aoz+a1(2z^2-1)+a2(8z^4-8z^2+1), where z=(x/xo)
// E5=T4(xo)
// ao(x/xo)+a1(2(x/xo)^2-1)+a2(8(x/xo)^4-8(x/xo)
    ^2+1)=8x^4-8x^2+1
// Now equating terms, we have
// a2(x/xo)^4=x^4
a2=xo^4;
// a1*2(x/xo)^2-8(x/xo)^2*a2=-8x^2
// a1-4a2=-4x^2
a1=4*a2-4*xo^2
// ao-a1+a2=1
ao=a1-a2+1;
a22=a2/a2;// the ratio of the a2 to a2
a12=a1/a2;// the ratio of the a1 to a2
ao2=2*ao/a2;// the ratio of the 2ao to a2
printf("The value of the parameter xo = %f um", xo);
printf("\n The value of the current amplitude
    parameter ao= %f", ao);
printf("\n The value of the current amplitude
    parameter a1= %f", a1);
printf("\n The value of the current amplitude
    parameter a2= %f", a2);
printf("\n The value of the relative amplitude
    parameter a22= %f", a22);
printf("\n The value of the relative amplitude
    parameter a12= %f", a12);
printf("\n The value of the relative amplitude
    parameter ao2= %f", ao2);
printf("\n The five element array is shown in figure
     in the given textbook")
```

Scilab code Exa 3.9 Calculate the directivity of a given linear broad side

```
//Ex:3.9
clc;
clear;
close;
n=20;// number of isotropic array
// d=y/8, where y is wavelength
// then, D=2n(d/y)=2n((y/8)(1/y))=2n(1/8)
D=2*n*(1/8);// directivity of a linear broad-side
    array
printf("The directivity of a linear broad-side array
    = %d dimensionless", D);
```

Scilab code Exa 3.10 Calculate the Dolph Tchebysceff distribution which yield the optimum pattern

```
//Ex:3.10
clc;
clear;
close;
xnp=35;// beam width in degree
xnp1=(xnp/2)*(%pi/180);// half beam width in degree
// T(m-1)(x)=0 or T(8-1)(x)=0, or T(7)(x)=0
```

```
// cos((m-1)*acos(x))=0
// (8-1)*acos(x)=cos(2k-1)*(%pi/2)
// acos(x)=(2k-1)*pi/14
// for  first nulls , k=1
// acos(x)=pi/14;
x=cos(%pi/14);
// but z=x/xo=cos(p/2)
// p=Bd*sin(xnp1)
// p/2=Bd*sin(xnp1)/2
// x/xo=cos(Bd*sin(xnp1)/2)
// and Bd*sin(a)=(2*%pi/y)*(y/2)*(1/2)*sin(xnp1)
// and Bd*sin(xnp1)=90*sin(xnp1)
xo=x/(cos((90*sin(xnp1)*(%pi/180))));
// aoz+a1(4z^3-3z)+a2(16z^5-20z^3+5z)+a3(64z^7-112z^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where z=(x/xo)
// Then on putting z=(x/xo), we get
// ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a2(16(x/xo)^5-20(x/xo)^3+5(x/xo))+a3(64(x/xo)^7-112(x/xo)^5+56(x/xo)^3-7(x/xo))=64x^7-112x^5+56x^3-7x
// on comparing the terms, we get ao=3.339,a1=2.919,a2=2.191,a3=1.886
ao=3.339;
a1=2.919;
a2=2.191;
a3=1.886;
a33=a3/a3;// the ratio of the a3 to a3
a23=a2/a3;// the ratio of the a2 to a3
a13=a1/a3;// the ratio of the a1 to a3
ao3=ao/a3;// the ratio of the ao to a3
printf("The value of the parameter xo = %f", xo);
printf("\n The value of the amplitude parameter ao= %f", ao);
printf("\n The value of the amplitude parameter a1= %f", a1);
printf("\n The value of the amplitude parameter a2= %f", a2);
printf("\n The value of the amplitude parameter a3=
```

```
    %f", a3);
printf("\n The value of the relative amplitude
    parameter a33= %f", a33);
printf("\n The value of the relative amplitude
    parameter a23= %f", a23);
printf("\n The value of the relative amplitude
    parameter a13= %f", a13);
printf("\n The value of the relative amplitude
    parameter ao3= %f", ao3);
printf("\n The five element array is shown in figure
     in the given textbook")
```

Scilab code Exa 3.11 Design an array that will produce approximately a pattern of the given figure

```
//Ex:3.11
clc;
clear;
close;
// The given pattern is defined as
// f(x)=1,    0<x<pi/3
// f(x)=0,    pi/3<x<2*pi/3
// f(x)=1,    2*pi/3<x<pi
// It will , of course , by symmetrical about the line
     of the array x=0. If the spacing is closer to be
     y/2, then p=pi*cos(x)+a
// f(p)=1,       pi+a > p > pi/2+a
// f(p)=0,       pi/2+a > p > -pi/2+a
// f(p)=1,      -pi/2+a > p > -pi+a
// choosing a=-pi for an end fire array results in
    the function shown in figure in the given text
```

```
book. The fourier series expansion for this
   function is
// F(p)=(1/2)+((2/pi)*sigma(1/k*sin(k*pi/2)*cos(kp))
   ), k varies from 1 to infinite
// Therefore the coefficient
// ao=1/2
// ak=(1/pi*k)*(sin(pi*k/2))
// bk=0, k not equal to 0
// The pattern obtained using the value of m=4 is
   given as
// mode(E)= (1/pi)*(-(1/3)*z^-3)+z^-1+pi/2+z-(1/3)*z
   ^3
printf("The fire element array having the current
   ratios indicated and an overall length of three
   wavelength (the apparent spacing between elements
    is one half wavelength, but four of the elements
    are missing). The pattern produced by this array
    is shown in figure in the given textbook")
```

Scilab code Exa 3.12 Prove that the directivity of an end fire array

```
//Ex:3.12
clc;
clear;
close;
// D=4*%pi*E(x,y)max/(double integration of (f(x,y)*
   sin(x)) with limit from 0 to 2*pi & other from 0
   to pi)
// E(x)=Eo*(sin(n*si/2))/sin(si/2)=E(x)=(sin(2*si/2)
   )/sin(si/2)=E(x)=(sin(si))/sin(si/2),     for=Eo
   =1, n=2
```

```
// E(x)=2*cos(si/2)
// (E(x))^2=2*(1+cos(si))
// si=Bd*cos(x)+a, and a=-Bd
// then, si=Bd*cos(x)-Bd
A=2*(1+cos(0));// the value of (E(x))^2max
// Now on putting the value of (E(x))^2max and (E(x)
    )^2, we get
// D=4*pi*4/(2*pi)*integrate('2(1+cos(y)*sin(x))','x
    ',0,pi)
// then D=4/(integrate('(1+cos(y)*sin(x))','x',0,pi)
    )
// D=4/(integrate('sin(x)+cos(y)*sin(x)','x',0,pi))
// On solving this, we get,
// D=4/(2+sin(2Bd)/Bd)=2/(1+sin(2Bd)/2Bd)
printf("The directivity of an end fire array, D
    =2/(1+sin(2Bd)/2Bd)");
```

Scilab code Exa 3.13 Prove that directivity for a broadside array of two identical isotropic

```
//Ex:3.13
clc;
clear;
close;
// D=4*%pi*E(x,y)max/(double integration of (f(x,y)*
    sin(x)) with limit from 0 to 2*pi & other from 0
    to pi)
// E(x)=Eo*(sin(n*si/2))/sin(si/2)=E(x)=(sin(2*si/2)
    )/sin(si/2)=E(x)=(sin(si))/sin(si/2),     for=Eo
    =1, n=2
// E(x)=2*cos(si/2)
```

```
// (E(x))^2=2*(1+cos(si))
// si=Bd*cos(x)+a, and a=-Bd
// then, si=Bd*cos(x)-Bd
A=2*(1+cos(0));// the value of (E(x))^2max
// Now on putting the value of (E(x))^2max and (E(x)
    )^2, we get
// D=4*pi*4/(2*pi)*integrate('2(1+cos(y)*sin(x))','x
    ',0,pi)
// then D=4*pi*4/(integrate('(1+cos(y)*sin(x))','x
    ',0,pi))
// D=4*pi*4/(integrate('(1+cos(y)*sin(x))','x',0,pi)
    )
// D=4*pi*4/(integrate('sin(x)+cos(y)*sin(x)','x',0,
    pi))
// On solving this, we get, D=4*pi*4/(2*pi(2+2.sin(
   Bd)/Bd))=4/2*(1+sin(Bd)/Bd)
// and finally, D=2/(1+sin(Bd)/Bd)
printf("The directivity for a broadeside array, D
    =2/(1+sin(Bd)/Bd)");
```

Scilab code Exa 3.14 Calculate the Dolph Tchebyscheff distribution which yield the optimum pattern

```
//Ex:3.14
clc;
clear;
close;
xnp=45;// beam width in degree
xnp1=(xnp/2)*(%pi/180);// half beam width in degree
// T(n-1)(x)=0 or T(8-1)(x)=0, or T(7)(x)=0
// cos((m-1)*acos(x))=0
```

```
// (8-1)*acos(x)=cos(2k-1)*(%pi/2)
// acos(x)=(2k-1)*pi/14
// for first nulls , k=1
// acos(x)=pi/14;
x=cos(%pi/14);
// but z=x/xo=cos(p/2)
// p=Bd*sin(xnp1)
// p/2=Bd*sin(xnp1)/2
// x/xo=cos(Bd*sin(xnp1)/2)
// and Bd*sin(a)=(2*%pi/y)*(y/2)*(1/2)*sin(xnp1)
// and Bd*sin(xnp1)=90*sin(xnp1)
xo=x/(cos((90*sin(xnp1)*(%pi/180))));
// aoz+a1(4z^3-3z)+a^2(16z^5-20z^3+5z)+a^3(64z^7-112
   z^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where z=(x/
   xo)
// Then on putting z=(x/xo), we get
// ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a^2(16(x/xo)^5-20(
   x/xo)^3+5(x/xo))+a^3(64(x/xo)^7-112(x/xo)^5+56(x/
   xo)^3-7(x/xo))=64x^7-112x^5+56x^3-7x
// on comparing the terms, we get ao=12.3858,a1
   =10.0506,a2=6.4106,a3=3.223
ao=12.3858;
a1=10.0506;
a2=6.4106;
a3=3.223;
a33=a3/a3;// the ratio of the a3 to a3
a23=a2/a3;// the ratio of the a2 to a3
a13=a1/a3;// the ratio of the a1 to a3
ao3=ao/a3;// the ratio of the ao to a3
printf("The value of the parameter xo = %f", xo);
printf("\n The value of the current amplitude
   parameter ao= %f", ao);
printf("\n The value of the current amplitude
   parameter a1= %f", a1);
printf("\n The value of the current amplitude
   parameter a2= %f", a2);
printf("\n The value of the current amplitude
   parameter a2= %f", a3);
```

```
printf("\n The value of the relative amplitude
    parameter a33= %f", a33);
printf("\n The value of the relative amplitude
    parameter a23= %f", a23);
printf("\n The value of the relative amplitude
    parameter a13= %f", a13);
printf("\n The value of the relative amplitude
    parameter ao3= %f", ao3);
printf("\n The five element array is shown in figure
     in the given textbook")
```

Scilab code Exa 3.15 Determine Dolph Tchebyscheff current distribution for the minimum beamwidth of a linear in phase broad side array of eight isotropic source

```
//Ex:3.15
clc;
clear;
close;
dB=40;
n=8;// five element array
r1=10^(dB/20);// because dB=20log(r1)
r=floor(r1);
// Tchebyscheff polynomial of degree (n-1)=8-1=4
// T7(xo)=r
// 64xo^7-112xo^5+56xo^3-7xo=r
// then using ulternate formula , we get the value of
    xo
m=7;// degree of the equation
a=sqrt(r^2-1);
A=(r+a)^(1/m);
```

```
B=(r-a)^(1/m);
xo1=.5*(A+B);
xo=1.3244;// approx. value of xo1
// Thus Et, i.e., E8 from the equation
// E8=aoz+a1(4z^3-3z)+a^2(16z^5-20z^3+5z)+a^3(64z^7-112z^5+56z^3-7z)=64x^7-112x^5+56x^3-7x, where z=(x/xo)
// Then on putting z=(x/xo), we get
// ao(x/xo)+a1(4(x/xo)^3-3(x/xo))+a^2(16(x/xo)^5-20(x/xo)^3+5(x/xo))+a^3(64(x/xo)^7-112(x/xo)^5+56(x/xo)^3-7(x/xo))=64x^7-112x^5+56x^3-7x
// Now equating terms, we have
a3=xo^7;
a2=7*a3-7*xo^5;
a1=14*xo^3+5*a2-14*a3;
ao=-7*xo+3*a1-5*a2+7*a3;
a33=a3/a3;// the ratio of the a3 to a3
a23=a2/a3;// the ratio of the a2 to a3
a13=a1/a3;// the ratio of the a1 to a3
ao3=ao/a3;// the ratio of the ao to a3
R=r/sqrt(2);
// Y=acos(R/sqrt(2))= log(R+sqrt(R^2-1))
Y=(1/7)*log(R+sqrt(R^2-1))/log(10);
// cosh(Y/4)=cosh(1.19/4)=cosh(0.2975)
// because cosh(x)= 1+(x^2/2)+(x^4/24) +.....
// cosh(0.3072)=1+(0.3072^2/2)+(0.3072^4/24)
K=1+(0.3072^2/2)+(0.3072^4/24);
// HPBW= 2*asin((y/180*d)*acos(1/x0*cosh(Y/4)))
// HPBW= 2*asin((y*4/180*3y)*acos(1/x0*cosh(0.3072)))
// HPBW= 2*asin((4/3*180)*acos(1/x0*K))
HPBW=2*(asin((4/540)*(acos(K/xo))*(180/%pi)))*180/%pi;// half power bandwidth in degree
printf("The value of the parameter r= %d", r);
printf("\n The value of the parameter xo= %f", xo);
printf("\n The value of the current amplitude parameter ao= %f", ao);
printf("\n The value of the current amplitude
```

```
    parameter a1= %f", a1);
printf("\n The value of the current amplitude
    parameter a2= %f", a2);
printf("\n The value of the current amplitude
    parameter a3= %f", a3);
printf("\n The value of the relative amplitude
    parameter a33= %f", a33);
printf("\n The value of the relative amplitude
    parameter a23= %f", a23);
printf("\n The value of the relative amplitude
    parameter a13= %f", a13);
printf("\n The value of the relative amplitude
    parameter ao3= %f", ao3);
printf("\n The half power bandwidth= %f degree",
    HPBW);
printf("\n The five element array is shown in figure
     in the given textbook")
```

Scilab code Exa 3.16 Find the directivity of linear broad side

```
//Ex:3.16
clc;
clear;
close;
n=10;// number of isotropic elements
// d=y/4
// Do=2n*(d/y)
// Do=2n*(y/4y)=2n(1/4)
Do=2*n*(1/4);
D0=10*log(Do)/log(10);// Directivity in db
printf("the Directivity = %f dB", D0);
```

Scilab code Exa 3.17 Find the directivity of linear end fire

```
//Ex:3.17
clc;
clear;
close;
n=10;// number of isotropic elements
// d=y/4
// Do=4n*(d/y)
// Do=4n*(y/4y)=2n(1/4)
Do=4*n*(1/4);
D0=10*log(Do)/log(10);// Directivity in db
printf("the Directivity = %d dB", D0);
```

Scilab code Exa 3.18 Find the directivity of a linear end fire

```
//Ex:3.18
clc;
clear;
close;
n=10;// number of isotropic elements
// d=y/4
// Do=1.789(4n*(d/y))
// Do=1.789(4n*(y/4y)=2n(1/4))
```

```
Do=1.789*(4*n*(1/4));
D0=10*log(Do)/log(10);// Directivity in db
printf("the Directivity = %f dB", D0);
```

Scilab code Exa 3.19 Define antenna gain and directivity

```
//Ex:3.19
clc;
clear;
close;
printf("Gain: gain is define as the ratio of max
   radiation. Intensity in a given direction  to the
    max radiation intensity from the reference
   antenna produced in the same direction with same
   power input.");
printf("\n Gain=max radiation intensity from test
   antenna/max radiation intensity from reference
   antenna with same power input ");
printf("\n Directivity: The max directivity gain is
   called as directivity of an antenna. We can
   defined directivity of antenna as follows. It is
   the ratio of max radiotion intensity to  its
   average raiotion intensity.");
printf("\n directivity= max radiation intensity from
    test antenna/average radiation intensity of test
    antenna");
```

Scilab code Exa 3.20 Find the array length and width and what will be these value for a broad side array

```
//Ex:3.20
clc;
clear;
close;
D=30;// directive gain
l=D/4;
// array length L=l*y, where y is wavelength
y=1.5;//
Bw=114.6*sqrt(2/(5*y));// beamwidth of the major
   lobe in degree
// for Broadside case
// L=(D/2)*y=(30/2)*y=15y=array length
y1=15/4;
BWFN=114.6/(4*y1);// beamwidth for a broadside array
    in degree
printf("The array length = %f*y, where y is
   wavelength", l);
printf("\n The beamwidth of the major lobe = %f
   degree", Bw);
printf("\n The beamwidth for a broadside array = %f
   degree", BWFN);
```

Scilab code Exa 3.21 Derive the expression for beam width

```
//Ex:3.21
clc;
clear;
close;
// For N array elements
// Etr/Eo=sin(ny/2)/sin(y/2), where y=Bdcos(x)+dl=
   Bdcos(x), because dl=0
// The null in the pattern occur when, ny/2=k*%pi
// (nBdcos(x))/2=%pi, for the first nulls
// or      cos(x)=2*%pi/(nBd)=2*%pi/(n*(2*%pi/L)*(L
   /4))=(4/n)
// In the broadeside array main beam is directed in
   x=90 degree. Therefore half beam width will be
// a=90-x1
// or x1=90-a
// Thus  cos(x1)=cos(90-a)=sin(a)
// or sin(a)=(4/n)
// Now the beam width for n elements array will be 2
   a=2.asin(4/n)
// Thus
BW1=2*(asin(4/5)*180/%pi);// Bandwidth for n=5
BW2=2*(asin(4/6)*180/%pi);// Bandwidth for n=6
BW3=2*(asin(4/7)*180/%pi);// Bandwidth for n=7
BW4=2*(asin(4/8)*180/%pi);// Bandwidth for n=8
BW5=2*(asin(4/9)*180/%pi);// Bandwidth for n=9
BW6=2*(asin(4/10)*180/%pi);// Bandwidth for n=10
printf("The Bandwidth for n=5 = %f degree", BW1);
printf("\n TheBandwidth for n=6 = %f degree", BW2);
```

```
printf("\n The Bandwidth for n=7 = %f degree", BW3);
printf("\n The Bandwidth for n=8 = %f degree", BW4);
printf("\n The Bandwidth for n=9 = %f degree", BW5);
printf("\n The Bandwidth for n=10 = %f degree", BW6)
    ;
```

Scilab code Exa 3.22 Find the FNBW and HPBW for a broad side linear array

```
//Ex:3.22
clc;
clear;
close;
n=20;
// d=y/2, where y is wavelength
// FNBW=2y/nd, then
// FNBW=2y/(n*y/2)=4/n radian
FNBW=4/n;// beam width for broad side array in
    radian
Fnbw=(180*FNBW)/%pi;// beam width for broad side
    array in degree
HPBW=Fnbw/2;// the half power beam width for broad
    side array in degree
// d1=y/4, for end fire array
// then FNBW1=2*sqrt(2y/nd1)
// FNBW1=2*sqrt(2y/(n*y/4))=2*sqrt(8/n)
FNBW1=2*sqrt(8/n);// beam width for end fire array
    in radian
Fnbw1=(180*FNBW1)/%pi;// beam width for end fire
    array in degree
HPBW1=(2/3)*Fnbw1;// the half power beam width for
```

```
end fire array in degree
printf("The beamwidth for a broad side array = %f degree", Fnbw);
printf("\n The half power beam width for broad side array = %f degree", HPBW);
printf("\n The beam width for end fire array = %f degree", Fnbw1);
printf("\n The half power beam width for end fire array = %f degree", HPBW1);
```

Scilab code Exa 3.23 Find the location of the first nulls on a either side of beam center

```
//Ex:3.23
clc;
clear;
close;
n=80;
// sinx=y/(nd)
// sinx=y/(n*y/2)=2/n
sinx=2/n;
x=asin(sinx)*(180/%pi);// in degree
dx=2*x;// the first nulls beam width in degree
printf("The first nulls beam width = %f degree",dx);
```

Scilab code Exa 3.24 Calculate the radiated power and also FNBW of the array

```
//Ex:3.24
clc;
clear;
close;
f=300*10^6;// frequency in Hz
c=3*10^10;// the speed of light in cm/sec
y=c/f;// wavelength in cm
d=y/2;// in cm
n=4;
I=0.5;// element current in amp
Rr=73;// resistence in ohm
Prad=n*Rr*I^2;// radiated power in watt
// sinx=y/(nd)
// sinx=y/(n*y/2)=2/n
sinx=2/n;
x=asin(sinx)*(180/%pi);// in degree
dx=2*x;// the FNBW of the array in degree
printf("The radiated power = %d watt",Prad);
printf("\n The FNBW of the array = %d degree",dx);
```

Scilab code Exa 3.25 Find the array length and width of the major lobe and what will be these values for broadside array

```
//Ex:3.25
clc;
clear;
close;
D=30;// directive gain
```

```
// D=4L/y=4Nd/y, where L=Nd
// then 30=4L/y
// L=7.5y
L=30/4;
// FNBW=2*sqrt(2y/Nd)=2*sqrt(2y/7.5y)
// =2*sqrt(2/7.5)
FNBW=2*sqrt(2/7.5);// FNBW for end fire array in radian
Fnbw=FNBW*180/%pi;// FNBW for end fire array in degree
// FNBW1=2y/Nd=2y/7.5y=2/7.5
FNBW1=2/7.5;// FNBW for broad side array in radian
Fnbw1=FNBW1*180/%pi;// FNBW for broad side array in degree
printf("The array length= %f*y, where y is wavelength", L);
printf("\n The FNBW for end fire array = %f degree", Fnbw);
printf("\n The FNBW for broad side array = %f degree", Fnbw1);
```

Chapter 4

Practical Antennas

Scilab code Exa 4.1 Design a log periodic antenna for a broadcast band

```
//Ex:4.1
clc;
clear;
close;
c=3*10^8;// the speed of light in m/s
f=88*10^6;// frequency in Hz
r=0.95;// in m
y=c/f;// wavelength in m
l1=y/2;
l2=r*l1;
l3=r*l2;
l4=r*l3;
l5=r*l4;
d1=0.08*y;
d2=r*d1;
d3=r*d2;
d4=r*d3;
d=d1+d2+d3+d4;// overall length of the antenna
   support boom in m
printf("The wavelength = %f meter", y);
printf("\n The overall length of the antenna support
```

```
boom = %f meter", d);
```

Scilab code Exa 4.2 Find the dimenssions of a three element

```
//Ex:4.2
clc;
clear;
close;
c=3*10^8;// the speed of light in m/s
f=100*10^6;// frequency in Hz
y=c/f;// wavelength in m
de=y/2;// drive element in m
Rf=de+(de*5/100);// reflector in m
Df=de-(de*5/100);// director in m
sp=0.2*y;// spacing between the elements in m
printf("The wavelength = %d meter", y);
printf("\n The drive element = %f meter", de);
printf("\n The reflector = %f meter", Rf);
printf("\n The director = %f meter", Df);
printf("\n The spacing between the elements = %f
    meter", sp);
```

Scilab code Exa 4.3 What is the gain in dB and the beam width of a helical antenna

```
//Ex:4.3
clc;
clear;
close;
y=3;// wavelength in m
d=1;// in m
N=10;// no. of turns
s=0.75;// in m
Gp=15*(%pi^2*(1/y)^2*(10*(s/y)));// power gain
GdB=10*log(Gp)/log(10);// power gain in dB
Bw=52/(%pi*(1/y)*sqrt(10*(s/y)));// beamwidth in
   degree
BW=70/20;// beamwidth when d=20*y(wavelength)
printf("The power gain = %f dB", GdB);
printf("\n The beamwidth = %f degree", Bw);
printf("\n The beamwidth when d is 20*y = %f degree"
   , BW);
```

Scilab code Exa 4.4 How large is the dish diameter

```
//Ex:4.4
clc;
clear;
close;
f=300*10^6;// frequency in Hz
c=3*10^8;// the speed of light in m/s
y=c/f;// wavelength in m
GdB=60;// gain in dB
G=10^(GdB/10);// gain
D=sqrt(G/6)*y;// diameter in m
D1=3.28*D;// diameter in m
```

```
printf("The dish diameter = %d meter", D);
printf("\n The dish diameter = %d ft.", D1);
```

Scilab code Exa 4.5 What is the change in gain and beam width

```
//Ex:4.5
clc;
clear;
close;
printf("By the formula, gain increases with the
   square of D, so new diameter =2D will have gain
   2*2=4 compared to diameter D. The increase in
   gain is 4 times or 6dB.");
printf("\n Similarly, the beamwidth varies with the
   inverse of D, so the new D causes beamwidth to
   one half its previous value ");
```

Scilab code Exa 4.6 what is the change in gain

```
//Ex:4.6
clc;
clear;
close;
printf("The formula for the gain shows that it is
   proportional to 1/y^3, a new y(wavelength) is
```

```
half of the previous value will therefore
increase the gain by");
printf("\n 1/(1/2)^3=8 times ")
```

Scilab code Exa 4.7 Calculate the beamwidth and gain as a power ratio and in dB

```
//Ex:4.7
clc;
clear;
close;
Vc=3*10^10;// the speed of light in m/cm
f=5*10^9;// frequency in Hz
y=Vc/f;// wavelength in cm
hw=9*8;// aperture dimensions in cm
D=(7.5*hw)/y^2;// beamwidth in degree
Ap=(4.5*hw)/y^2;
G=10*log(Ap)/log(10);// gain as a power ratio and in
    dB
printf("The beamwidth = %d degree", D);
printf("\n The gain as a power ratio and in dB = %f
    dB", G);
```

Scilab code Exa 4.8 What are the dimensions of the elements

```
//Ex:4.8
clc;
clear;
close;
Vc=3*10^8;// the speed of light in m/cm
f=100*10^6;// frequency in Hz
y=Vc/f;// wavelength in cm
de=(y/2)+(y/2)*(5/100);// driven element length in m
l1=(y/2)-(y/2)*(5/100);// first director length in m
l2=l1-(l1*5/100);// second director length in m
l3=l2-(l2*5/100);// third director length in m
l_s=0.2*y*4;// support boom length in m
L_s=l_s*3.28;// support boom length in ft.
printf("The first director length = %f meter", l1);
printf("\n The second director length = %f meter",
   l2);
printf("\n The third director length = %f meter", l3
   );
printf("\n The support boom length in m = %f meter",
    l_s);
printf("\n The support boom length in ft. = %d ft.",
    L_s)
```

Scilab code Exa 4.9 Calculate the power gain of an optimum horn antenna

```
//Ex:4.9
clc;
clear;
close;
printf("Aperture=10y*10y");
```

```
printf("\n then , G=(4.5*10y*10y)/(y^2)");
printf("\n and finally , G=4.5*100");
G=4.5*100;// power gain of optimum horn antenna
printf("\n The power gain of optimum horn antenna =
   %d", G);
```

Scilab code Exa 4.10 Calculate the peak value of the magnetic field intensity H of the RF wave

```
//Ex:4.10
clc;
clear;
close;
N=10;// number of turns
A=1;// area in m^2
f=1*10^6;// frequency in Hz
V=100*10^-6;// in volt
x=1;// the value of cos(Angle)
u=4*%pi*10^-7;
H=(sqrt(2)*V)/(2*%pi*f*u*A*N);// peak value of the
   magnetic field intensity H
printf("The peak value of the magnetic field
   intensity H = %f uA/m", H*10^6);
```

Scilab code Exa 4.11 Calculate the radiation resistance

```
//Ex:4.11
clc;
clear;
close;
printf("A=pi*a^2=pi(y/25)^2=pi*y^2/625");
printf("\n Rr=31171.2*(A/y^2)^2");
printf("\n and finally , Rr=(31171.2*pi^2)/(625^2)");
Rr=(31171.2*%pi^2)/(625^2);// radiation resistance
    for single turn
N2=82;
Rr1=Rr*N2;// radiation resistance for turn loop
printf("\n The radiation resistance for single turn
    = %f ohm", Rr);
printf("\n The radiation resistance for turn loop =
    %f ohm", Rr1);
printf("\n The answer is wronge in the given
    textbook");
```

Scilab code Exa 4.12 Estimate the diameter of the mouth and the half power beam width of the antenna

```
//Ex:4.12
clc;
clear;
close;
y=0.1;// wavelength in m
GP=1000;// power gain
D=y*(sqrt(GP/6));// diameter of the mouth in m
printf("The diameter of the mouth = %f meter", D);
```

Scilab code Exa 4.13 Find the terminal resistance of complementary slot

```
//Ex:4.13
clc;
clear;
close;
Zs=35476/710;// terminal resistance in ohm
L_D=28;// the ratio of L to D
L=0.925;// length in m in terms of wavelength y
D=L/L_D;// diameter in m in terms of wavelength y
W=2*D;// width in m in terms of wavelength y
printf("The terminal resistance = %f ohm", Zs);
printf("\n The diameter in m in terms of wavelength
   = %f*y meter", D);
printf("\n The width in m in terms of wavelength =
   %f*y meter", W);
```

Scilab code Exa 4.14 Estimate the diameter and the effective aperture of a paraboloidal reflector antenna

```
//Ex:4.14
clc;
clear;
close;
```

```
f=3*10^3;// frequency in MHz
y=300/f;// wavelength in m
BW=10;// beamwidth in degree
D=140*y/BW;// diameter of a paraboidal reflector
    antenna in m
printf("The diameter of a paraboidal reflector
    antenna = %f meter", D);
```

Scilab code Exa 4.15 Calculate the antenna gain in dB

```
//Ex:4.15
clc;
clear;
close;
D=20;// diameter in m
r=10;// radius in m
f=6*10^3;// frequency in MHz
y=300/f;// wavelength in m
K=0.54;// illumination efficiency
A=%pi*r^2;// area in m^2
G=(4*%pi*K*A)/y^2;// antenna gain
G1=10*log(G)/log(10);// antenna gain in dB
printf("The antenna gain = %f dB", G1);
```

Scilab code Exa 4.16 Determine the gain beamwidth and capture area for a parabolic antenna

```
//Ex:4.16
clc;
clear;
close;
f=10*10^3;// frequency in MHz
y=300/f;// wavelength in m
D=10;// diameter in m
Gp=6*(D/y)^2;// gain of a parabolic antenna
BW=140*y/D;// beamwidth in degree
Dr=6*Gp;// directivity
A=(Dr*y^2)/(4*%pi);// capture area in m^2
printf("The gain of a parabolic antenna = %f", Gp);
printf("\n The beamwidth = %f degree", BW);
printf("\n The capture area in m^2 of a parabolic
    antenna = %f meter^2", A);
```

Scilab code Exa 4.17 Calculate the gain of the horn antenna

```
//Ex:4.17
clc;
clear;
close;
r=0.45;// distance in m
f=10*10^3;// frequenc in MHz
y=300/f;// wavelength in m
Wtr=8.9;
wtr=10^(Wtr/10);
wrt=1/wtr;
```

```
D=(4*%pi*r/y)*(sqrt(wrt));// gain of the horn antenna
d=10*log(D)/log(10);// gain of the horn antenna in dB
printf("The gain of the horn antenna = %f dB", d);
```

Scilab code Exa 4.18 Estimate the diameter of the paraboloidal reflector

```
//Ex:4.18
clc;
clear;
close;
BW=15;// beamwidth in degree
f=1.5*10^3;// frequenc in MHz
y=300/f;// wavelength in m
D=(140*y)/(BW);// diameter of the paraboloidal reflector in m
printf("The diameter of the paraboloidal reflector = %f meter", D);
```

Scilab code Exa 4.19 Estimate the diameter and effective aperture

```
//Ex:4.19
clc;
clear;
```

```
close;
BW=15;// beamwidth in degree
f=3*10^3;// frequenc in MHz
y=300/f;// wavelength in m
D=(140*y)/(BW);// diameter of the paraboloidal
   reflector in m
printf("The diameter of the paraboloidal reflector =
    %f meter", D);
```

Scilab code Exa 4.20 Estimate the diameter of the mouth and the half power beamwidth

```
//Ex:4.20
clc;
clear;
close;
y=0.1;// wavelength in m
GP=1000;// power gain
D=y*(sqrt(GP/6));// diameter of the mouth in m
HPBW=(70*y)/D;// half power beamwidth in degree
printf("The diameter of the mouth = %f meter", D);
printf("\n The half power beamwidth of the antenna =
    %f degree", HPBW);
```

Scilab code Exa 4.21 What is the directivities of these two antennas

```
//Ex:4.21
clc;
clear;
close;
r=5000;// in m
F=1.9;// propagation factor
f=150;// frequenc in MHz
y=300/f;// wavelength in m
wr=2*10^-3;// receiving power in watt
wt=25;// transmitting power in watt
D=(4*%pi*r/(2*F))*(sqrt(wr/wt));// directivities of
    these antenna
printf("The directivity of antenna = %f", D);
```

Scilab code Exa 4.22 Calculate the directivity in dB

```
//Ex:4.22
clc;
clear;
close;
a=15*%pi/180;// angle in radian
N=35;// number of turns
s_c=tan(a);// the ratio of s to c and c=y
D=(15*N*s_c);// directivity of 35 turn helix
d=10*log(D)/log(10);// directivities of 35 turn
    helix in dB
printf("The directivity of 35 turn helix = %f dB", d
    );
```

Scilab code Exa 4.23 Find out the length and width and half flare angles

```
//Ex:4.23
clc;
clear;
close;
// dl=0.23y, value of dl in E-plane
// dL=0.375y, value of dl in H-plane
// h=15y, height in terms of wavelength y
// L=h^2/8*dl in  E-plane
// L=(15*y)^2/8*0.2y=225y^2/1.6y;=140.625y
printf("The value of length L in terms of wavelength y=140.625y");
// OE=atan(h/2L)=atan(15y/2*140.625y)=atan(15/2*140.625)
OE=(atan(15/(2*140.625))*180/%pi);// half flare angle in E-plane in degree
// OH=acos(L/(L+dL))=acos(140.625y/(140.625y+0.375y))=acos(140.625/(140.625+.375))
OH=(acos(140.625/(140.625+0.375))*(180/%pi));// half flare angle in H-plane in degree
//w=2*L*tan(OH)=2*140.625y*tan(4.18)=20.56y, width interms of wavelength y
printf("\n The half flare angle in E-plane = %f degree", OE);
printf("\n The half flare angle in H-plane = %f degree", OH);
printf("\n The width interms of wavelength y= 20.56y");
```

Scilab code Exa 4.24 Calculate the angular aperture for paraboloidal reflector antenna

```
//Ex:4.24
clc;
clear;
close;
D=20;// diameter of the reflector mouth in m
// As we know, f=(D/4)*cot(x/2)
// f/D=0.25*cot(x/2)
f_d1=0.30;// ratio of f to D or aperture number
f_d2=0.55;// aperture number
f_d3=0.80;// aperture number
// 0.30=0.25*cot(x/2)
// tan(x/2)=0.25/0.30
x1=2*(atan(0.25/f_d1))*(180/%pi);
x2=2*(atan(0.25/f_d2))*(180/%pi);
x3=2*(atan(0.25/f_d3))*(180/%pi);
Aa1=2*x1;// angular aperture in degree
Aa2=2*x2;// angular aperture in degree
Aa3=2*x3;// angular aperture in degree
f1=f_d1*D;// position of focal point for aperture
    number 0.30
f2=f_d2*D;// position of focal point for aperture
    number 0.30
f3=f_d3*D;// position of focal point for aperture
    number 0.30
printf("The angular aperture for aperture number
    0.30 = %f degree", Aa1);
printf("\n The angular aperture for aperture number
```

```
    0.55 = %f degree", Aa2);
printf("\n The angular aperture for aperture number
    0.80 = %f degree", Aa3);
printf("\n The position of focal point for aperture
    number 0.30 = %f meter", f1);
printf("\n The position of focal point for aperture
    number 0.55 = %f meter", f2);
printf("\n The position of focal point for aperture
    number 0.80 = %f meter", f3);
```

Scilab code Exa 4.25 Calculate the peak value of the magnetic field intensity H of the radio wave

```
//Ex:4.25
clc;
clear;
close;
N=15;// number of turns
A=1;// area in m^2
f=10*10^6;// frequency in Hz
Vrms=200*10^-6;// e.m.f in volt
x=1;// the value of cosine angle
u=4*%pi*10^-7;
H=(Vrms*sqrt(2))/(2*%pi*f*u*A*N);// peak value of
    the magnetic field intensity
printf("The peak value of the magnetic field
    intensity = %f uA/m", H*10^6);
```

Scilab code Exa 4.26 Calculate the input voltage to the receiver

```
//Ex:4.26
clc;
clear;
close;
N=500;// number of turns
A=1;// area in m^2
f=10;// frequency in MHz
y=300/f;// wavelength in m
x=60*%pi/180;// angle in radians
Erms=20*10^-6;// field strength in volt
Vrms=(2*%pi*Erms*A*N*cos(x))/y;// e.m.f in volt
Q=150;// quality factor
Vr=Vrms*Q;// voltage to the receiver in volt
printf("The voltage to the receiver = %d mV", Vr
    *10^3);
```

Scilab code Exa 4.27 Estimate the voltage across the capacitor

```
//Ex:4.27
clc;
clear;
close;
```

```
N=10;// number of turns
r=0.4;// radius in m
E=200*10^-6;// E-field in V/m
L=50*10^-6;// inductance in Henry
R=2;// resistance in ohm
f=1.5;// frequency in MHz
f1=1.5*10^6;// frequency in Hz
y=300/f;// wavelength in m
A=%pi*r^2;// area in m^2
Vrms=(2*%pi*E*A*N)/y;// e.m.f in volt
Q=(2*%pi*f1*L)/R;//
Vc=Vrms*Q;// voltage across the capacitor in volt
printf("The voltage across the capacitor = %f mV",
   Vc*1000);
```

Scilab code Exa 4.28 Calculate the max emf in the loop

```
//Ex:4.28
clc;
clear;
close;
A=5;// area in m^2
w=25*10^-3;// power in watt
f=15;// frequency in MHz
y=300/f;// wavelength in m
Rr=31171*(A/y^2)^2;// radiation resistance in ohm
V=sqrt(w*4*Rr);// max emf in volts
printf("The max emf = %f Volts", V);
```

Scilab code Exa 4.29 Calculate the beamwidth between first null and what will be its gain in dB

```
//Ex:4.29
clc;
clear;
close;
f=10*1000;// frequency in MHz
y=300/f;// wavelength in m
D=5;// in m
BW=(140*y)/D;// beamwidth in degree
Gp=6*(D/y)^2;// gain
Gp1=10*log(Gp)/log(10);// gain in dB
printf("The beamwidth = %f degree", BW);
printf("\n The gain in dB = %f dB", Gp1);
```

Scilab code Exa 4.30 What should be minimum distance between primary and secondary antenna

```
//Ex:4.30
clc;
clear;
close;
f=5000;// frequency in MHz
```

```
y=300/f;// wavelength in m
d=30*0.3048;// aperture dimension in m
r=(2*d^2)/y;// min distance in m
printf("The min distance = %f meter", r);
```

Scilab code Exa 4.31 Calculate the directivity in dB

```
//Ex:4.31
clc;
clear;
close;
a=14*%pi/180;// angle in radian
N=25;// number of turns
s_c=tan(a);// the ratio of s to c and c=y
D=(15*N*s_c);// directivity of 35 turn helix
d=10*log(D)/log(10);// directivities of 35 turn
    helix in dB
printf("The directivity of 35 turn helix = %f dB", d
    );
```

Scilab code Exa 4.32 Find the received power

```
//Ex:4.32
clc;
clear;
```

```
close;
wt=1;// transmitted power
Gt=10^4;// transmitter gain
Gr=10^4;// receiver gain
f=10000;// frequency in MHz
r=30000;// range of the link in m
y=300/f;// wavelength in m
wr=wt*Gt*Gr*(y/(4*%pi*r))^2;// received power in
    Watt;
printf("The received power = %f uW", wr*10^6);
```

Scilab code Exa 4.33 Find the dimensions of three element

```
//Ex:4.33
clc;
clear;
close;
f=100;// frequency in MHz
y=300/f;// wavelength in m
dr=y/2;// the driven element in m
Rf=dr+(5*dr/100);// reflective in m
Df=dr-(5*dr/100);// deflective in m
Sp=0.2*y;// the spacing between terminal
printf("The reflective = %f m", Rf);
printf("\n The director = %f m", Df);
printf("\n The spacing between terminal = %f m", Sp)
    ;
```

Scilab code Exa 4.34 How large is the dish diameter

```
//Ex:4.34
clc;
clear;
close;
G=80;// gain in dB
G1=10^(G/10);// gain
f=300;// frequency in MHz
y=300/f;// wavelength in m
D=sqrt(G1/6)*y;// the dish parameter in m
printf("The dish parameter = %f m", D);
```

Scilab code Exa 4.35 What is the change in gain and beamwidth

```
//Ex:4.35
clc;
clear;
close;
printf("new diameter=2D ");
printf("\n Gain=2*2=3 times compared to D");
printf("\n the increase in gain is 4 times or 6 dB")
    ;
printf("\n Bw varies inverse of D");
```

```
printf("\n Bw is half of previous value");
```

Scilab code Exa 4.36 Calculate the beamwidth and gain as a power ratio in dB

```
//Ex:4.36
clc;
clear;
close;
f=5000;// frequency in MHz
y=300/f;// wavelength in m
h=9/100;// height in m
w=8/100;//  width in m
D=(7.5*h*w)/y^2;// beamwidth in degree
Ap=(4.5*h*w)/y^2;
Ap1=10*log(Ap)/log(10);// gain as a power ratio in
   dB
printf("The beamwidth = %f degree", D);
printf("\n The gain as a power ratio in dB = %f dB",
    Ap1);
```

Scilab code Exa 4.37 Calculate the gain of the horn antenna

```
//Ex:4.37
clc;
```

```
clear;
close;
r=0.35;// distance in m
f=9*10^3;// frequenc in MHz
y=300/f;// wavelength in m
Wtr=8.9;
wtr=10^(Wtr/10);
wrt=1/wtr;
D=(4*%pi*r/y)*(sqrt(wrt));// gain of the horn
    antenna
d=10*log(D)/log(10);// gain of the horn antenna in
    dB
y1=10;// in m
Gp=1000;
D=sqrt((Gp*y1^2)/6);// diameter in m
HPBW=(58*y1)/D;// the half power band width in
    degree
printf("The gain of the horn antenna = %f dB", d);
printf("\n The half power band width = %f degree",
    HPBW);
```

Scilab code Exa 4.38 Define folde dipole antenna and drive its input impedance

```
//Ex:4.38
clc;
clear;
close;
// Equation of Input impedence- Let V be the emf
    applied at the end of terminals. This is being
    divided equally in each dipole. Hence voltage in
    each dipole V/2 as shown and by nodal analysis
```

```
// V/2=I1.z11+I2z.12
// where I1, I2 are the currents flowing at
   terminals of dipole no. 1 and 2 and z11 & z12 are
    self impedance between dipole 1 & 2 respectively
// But, I1=I2
// Then, V/2=I1(z11+z12)
// The two dipole in system are very close to each
   other. The spacing between two dipoles is of the
   order of y/100, i.e., z11=z12
// Then, V/2=I1*(2z11)
// z=V/I1 then, z=4*z11,      z11=73 for a dipole
z11=73;// for a dipole
z=4*z11;// input impedance in ohm
printf("The input impedance = %d ohm", z);
```

Scilab code Exa 4.39 Calculate the capture area of antenna

```
//Ex:4.39
clc;
clear;
close;
G=75;// gain in dB
G1=10^(G/10);// gain
f=15000;// frequency in MHz
y=300/f;// wavelength in m
ca=(G1*y^2)/(4*%pi);// the capture area in m^2
D=sqrt(G1/6)*y;// the dish parameter in m
BWFN=(140*y)/D;// 3-dB beamwidth
printf("The capture area = %f m^2", ca);
printf("\n The 3-dB beamwidth = %f degree", BWFN);
```

Scilab code Exa 4.40 What is the antenna gain in decibels

```
//Ex:4.40
clc;
clear;
close;
f=6000;// frequency in MHz
y=300/f;// wavelength in m
A=%pi*100*0.54;// aperture area in m^2
G=(4*%pi*A)/y^2;// gain of the reflector antenna
G1=10*log(G)/log(10);// gain of the reflector
    antenna in dB
printf("The gain of the reflector antenna = %f dB",
    G1);
```

Scilab code Exa 4.41 What is the corresponding value of illumination efficiency

```
//Ex:4.41
clc;
clear;
close;
// G=4*piAn/y^2=7.4ab/y^2", where y is wavelength
n=7.4/(4*%pi);// illumination efficiency
```

```
printf("The illumination efficiency = %f%%", n*100);
```

Scilab code Exa 4.42 What is its gain

```
//Ex:4.42
clc;
clear;
close;
D=10;// beam width
y=30.54;// wavelength in cm
X=(58*y)/D;// 3-dB beam width
Ar=(%pi*X^2)/4;// area of the cross section in m^2
G=(4*%pi*Ar)/y^2;// the gain for y=30.54 cm
G1=10*log(G)/log(10);// the gain for y=30.54 cm in
    dB
y1=3.054;// wavelength in cm
X1=(58*y1)/D;// 3-dB beam width
Ar1=(%pi*X1^2)/4;// area of the cross section in m^2
G2=(4*%pi*Ar1)/y1^2;// the gain for y=3.054 cm
G3=10*log(G2)/log(10);// the gain for y=3.054 cm in
    dB
printf("The gain for y=30.54 cm = %f dB", G1);
printf("\n The gain for y=3.054 cm = %f dB", G3);
```

Scilab code Exa 4.43 Calculate the power gain and half power point beam width

```
//Ex:4.43
clc;
clear;
close;
f=8*10^3;// frequency in MHz
y=300/f;// wavelength in m
BW=6;// beamwidth in degree
D=(70*y)/BW;// in m
hpbw=(58*y)/D;// the half power point beam width in
    degree
Ap=(6*D^2)/y^2;// power gain
Ap1=10*log(Ap)/log(10);// power gain in dB
printf("The half power point beam width = %f degree"
    , hpbw);
printf("\n The power gain = %f", Ap);
printf("\n The power gain in dB = %f dB", Ap1);
```

Scilab code Exa 4.44 Calculate the diameter of antenna and half power point beam width

```
//Ex:4.44
clc;
clear;
close;
f=3*10^3;// frequency in MHz
y=300/f;// wavelength in m
Ap=26;// power gain in dB
Ap1=10^(Ap/10);// power gain
```

```
D=sqrt((Ap1*y^2)/6);// diameter of antenna in m
hpbw=(58*y)/D;// the half power point beam width in
   degree
printf("The diameter of antenna = %f cm", D*100);
printf("\n The half power point beam width = %f
   degree", hpbw);
```

Scilab code Exa 4.45 Calculate the directivity and power gain as a ratio and in dB

```
//Ex:4.45
clc;
clear;
close;
f=8*10^3;// frequency in MHz
y=300/f;// wavelength in m
A=8*4/100^2;// Area in m^2
D=(7.5*A)/y^2;// directivity of the horn antenna
Ap=(4.5*A)/y^2;// power gain
Ap1=10*log(Ap)/log(10);// power gain in dB
printf("The directivity of the horn antenna = %f
   degree", D);
printf("\n The power gain = %f", Ap);
printf("\n The power gain in dB = %f dB", Ap1);
```

Scilab code Exa 4.46 Calculate the aperture height

```
//Ex:4.46
clc;
clear;
close;
f=4*10^3;// frequency in MHz
y=300/f;// wavelength in m
w=10/100;// width in m
Ap=25;// power gain in dB
Ap1=10^(Ap/10);// power gain
h=(Ap1*y^2)/(4.5*w);// aperture height in m
printf("The aperture height in m = %f m", h);
printf("\n The aperture height in cm = %f cm", h
    *100);
```

Scilab code Exa 4.47 Determine the dimensions of the horn mouth and the directive gain

```
//Ex:4.47
clc;
clear;
close;
Y1=10;// the half power beam width in E-plane in
    degree
Y2=10;// the half power beam width in H-plane in
    degree
// Y1=51y/b, where y= wavelength
// b=51y/10=5.1y
// Y2=67y/a, then a=67y/10=6.7y
// the directive gain, G=4.5*l*h/y^2=4.5*6.7y*5.1y/y
```

```
^2=4.5*6.7*5.1
G=4.5*6.7*5.1;// the directive gain over the y/2
    antenna
G1=10*log(G)/log(10);// the directive gain over the
    y/2 antenna in dB
printf("The dimension of the horn mouth, a=6.7*y,
    where y is wavelength in m");
printf("\n The dimension of the horn mouth, b=5.1*y,
     where y is wavelength in m");
printf("\n The directive gain over the y/2 antenna =
     %f", G);
printf("\n The directive gain over the y/2 antenna
    in dB = %f dB", G1);
```

Scilab code Exa 4.48 Calculate the gain of the transmitting antenna

```
//Ex:4.48
clc;
clear;
close;
f=9*10^3;// frequency in MHz
y=300/f;// wavelength in m
Pr=5.4*10^-3;// received power in watt
Pt=20;// transmitted power in watt
Gr=15;// receiver gain in dB
Gr1=10^(Gr/10);// receiver gain
d=10;// distance in m
Gt=(Pr*(4*%pi*d)^2)/(Pt*Gr1*(y^2));// transmitter
    antenna gain
Gt1=10*log(Gt)/log(10);// transmitter antenna gain
    in dB
```

```
printf("The transmitter antenna gain = %f", Gt);
printf("\n The transmitter antenna gain in dB = %f dB", Gt1);
```

Scilab code Exa 4.49 Calculate the gain and half power beam widths

```
//Ex:4.49
clc;
clear;
close;
f=10*10^3;// frequency in MHz
y=300/f;// wavelength in m
a=5.2/100;// height in m
b=3.8/100;// width in m
A=a*b;// area in m^2
G=(4*%pi*A)/y^2;// the gain of the horn
G1=10*log(G)/log(10);// the gain of the horn in dB
he=(51*y)/b;// the half power point beam width in E-plane in degree
hh=(67*y)/a;// the half power point beam width in H-plane in degree
printf("The gain of the horn = %f", G);
printf("\n The the gain of the horn in dB = %f dB", G1);
printf("\n The half power point beam width in E-plane = %f degree", he);
printf("\n The half power point beam width in H-plane = %f degree", hh);
```

Scilab code Exa 4.50 Calculate the HPBW and directivity

```
//Ex:4.50
clc;
clear;
close;
N=30;// number of turns
// Diameter, d=y/3, where, y= wavelength
// spacing, S=y/5
// hpbw=52/((pi*d/y)*sqrt(NS/y))=52/((pi*y/3y)*sqrt
   (30y/5y))
hpbw=53*3/(%pi*sqrt(30/5));// half power point beam
   width in degree
// the directivity, D=15*NS*(pi*d)^2/y^3=((15*30*y)
   /(5y^3))*(pi*y/3)^2
D=15*30*%pi^2/(5*3^2);// the directivity
D1=10*log(D)/log(10);// the directivity in dB
printf("The half power point beam width = %f degree"
   , hpbw);
printf("\n The directivity = %f", D);
printf("\n The directivity in dB= %f dB", D1);
```

Scilab code Exa 4.51 Calculate the number of turns and directivity in dB and the half power point beam width in degree and axial ratio of the helix

```
//Ex:4.51
clc;
clear;
close;
f=1.7*10^3;// frequency in MHz
y=300/f;// wavelength in m
D=4.84/100;// diameter in m
a=11.7*%pi/180;// angle in radian
C=%pi*D;// circumference of the helix in m
S=C*tan(a);// in m
L=78.7/100;// length in m
N=L/S;// the number of turns
Dr=(15*N*S*(%pi*D)^2)/y^3;// the directivity of the
    antenna
Dr1=10*log(Dr/10);// the directivity of the antenna
    in dB
h_3dB=52/((%pi*D/y)*sqrt(N*S/y));// half power point
     beam width in degree
Ar=(2*N+1)/(2*N);// the axial ratio
printf("The number of turns = %f", N);
printf("\n The directivity of the antenna = %f", Dr)
    ;
printf("\n The directivity of the antenna in dB = %f
     dB", Dr1);
printf("\n The half power point beam width in degree
     = %f degree", h_3dB);
printf("\n The axial ratio = %f", Ar);
```

Chapter 5

Propagation

Scilab code Exa 5.1 Calculate max line of sight range and the field strength and also calculate the distance

```
//Ex:5.1
clc;
clear;
close;
ht=100;// transmitter height in m
hr=9;// receiver height in m
D=3550*(sqrt(ht)+sqrt(hr));// distance to horizon in
    m
f=60;// frequency in MHz
y=300/f;// wavelength in m
p=10*1000;// power in watt
d=10*1000;// distance in m
h=5;
Et=(88*sqrt(p)*hr*ht)/(h*d^2);// the field strength
    in V/m
et=10^-3;// field strength in V/m
d2=(88*sqrt(p)*hr*ht)/(h*et);
d1=sqrt(d2);// distance at which the field strength
    reuces to 1 mV/meter
printf("The field strength = %f mV/m", Et*1000);
```

```
printf("\n The distance at which the field strength
    reuces to 1 mV/meter = %f*10^3 meter", d1/1000);
```

Scilab code Exa 5.2 Calculate the field strength

```
//Ex:5.2
clc;
clear;
close;
p=100;// power in kW
d=10;// distance in km
Eo=(300*sqrt(p))/d;/// the field strength in mV/m
printf("The field strength = %d mV/m", Eo);
```

Scilab code Exa 5.3 What will be the range for which the MUF is ten MHz

```
//Ex:5.3
clc;
clear;
close;
u=0.9;// refractive index
f=10*10^6;// frequency in Hz
h=400;// height in km
Nmax=((1-0.81)*f^2)/81;
```

```
fc=9*sqrt(Nmax);// frequency in Hz
Ds=(2*h)*(sqrt((f/fc)^2-1));// range in km
printf("The range = %f km", Ds);
```

Scilab code Exa 5.4 Calculate the max electron concentrations of the layers

```
//Ex:5.4
clc;
clear;
close;
fc1=2.5*10^6;// critical frequency in Hz of E layer
fc2=8.4*10^6;// critical frequency in Hz of F layer
Nmax1=fc1^2/81;// maximum electron concentration of
    E layer
Nmax2=fc2^2/81;// maximum electron concentration of
    F layer
printf("The maximum electron concentration of E
    layer = %f*10^11 per cubic meter", Nmax1/10^11);
printf("\n The maximum electron concentration of F
    layer = %f*10^11 per cubic meter", Nmax2/10^11);
```

Scilab code Exa 5.5 What is the critical frequency for the reflection at vertical incidence

```
//Ex:5.5
clc;
clear;
close;
Nm=1.24*10^6/10^6;// electron density in per m^3
fc=9*sqrt(Nm);// critical frequency in MHz
printf("The critical frequency = %f MHz", fc);
```

Scilab code Exa 5.6 What is the max distance and what is the radio horizon in this case

```
//Ex:5.6
clc;
clear;
close;
ht=169;// transmeter height in m
hr=16;// receiver height in m
d=4.12*(sqrt(ht)+sqrt(hr));// in km
Rh=4.12*(sqrt(ht));/// radio horizon in km
printf("The radio horizon = %f km", Rh);
```

Scilab code Exa 5.7 Find the basic path loss

```
//Ex:5.7
clc;
```

```
clear;
close;
f=3000;// frequency in MHz
d=384000;// distance in km
Lp=32.45+20*log(f)/log(10)+20*log(d)/log(10);// path loss in dB
printf("The path loss = %f dB", Lp);
```

Scilab code Exa 5.8 Find the max range of a tropospheric transmission

```
//Ex:5.8
clc;
clear;
close;
ht=100;// transmeter height in m
hr=50;// receiver height in m
d=1.4142*(sqrt(ht)+sqrt(hr));// max range in miles
printf("The max range = %f miles", d);
```

Scilab code Exa 5.9 Find the range of LOS system

```
//Ex:5.9
clc;
clear;
close;
```

```
ht=100;// transmeter height in m
hr=10;// receiver height in m
d=4.12*(sqrt(ht)+sqrt(hr));// line of sight range in
    km
printf("The line of sight range = %f km", d);
```

Scilab code Exa 5.10 At what frequency a wave must propagate for the D region

```
//Ex:5.10
clc;
clear;
close;
u=0.5;// refractive index
N=400;// electron/cc
f=sqrt(81*N/(1-u^2));// frequency in KHz
printf("The frequency = %f KHz", f);
```

Scilab code Exa 5.11 What will be the range for which the MUF is twelve MHz

```
//Ex:5.11
clc;
clear;
close;
```

```
u=0.75;// refractive index
f=10*10^6;// frequency in Hz
fmuf=12*10^6;// frequency in Hz
h=350;// height in km
Nmax=((1-u^2)*f^2)/81;
fc=9*sqrt(Nmax);// frequency in Hz
Ds=(2*h)*(sqrt((fmuf/fc)^2-1));// range in km
printf("The range = %f km", Ds);
printf("\n The ans is wronge in the given textbook")
    ;
```

Scilab code Exa 5.12 What is the max distance and the radio horizon in this case

```
//Ex:5.12
clc;
clear;
close;
ht=256;// transmeter height in m
hr=25;// receiver height in m
d=4.12*(sqrt(ht)+sqrt(hr));// in km
Rh=4.12*(sqrt(ht));/// radio horizon in km
printf("The radio horizon = %f km", Rh);
```

Scilab code Exa 5.13 What is the critical frequency for the reflection at vertical incidence

```
//Ex:5.13
clc;
clear;
close;
Nm=2.58*10^6/10^6;// electron density in m^-3
fc=9*sqrt(Nm);// critical frequency in MHz
printf("The critical frequency = %f MHz", fc);
```

Scilab code Exa 5.14 Find the basic path loss

```
//Ex:5.14
clc;
clear;
close;
f=4000;// frequency in MHz
d=384000;// distance in km
Lp=32.45+20*log(f)/log(10)+20*log(d)/log(10);// path
    loss in dB
printf("The path loss = %f dB", Lp);
```

Scilab code Exa 5.15 Find the field strength at a distance of twenty km

```
//Ex:5.15
clc;
clear;
close;
p=150;// power in kW
d=20;// distance in km
Eo=(300*sqrt(p))/d;// field strength mV/m
printf("The field strength = %f mV/m", Eo);
```

Scilab code Exa 5.16 Determine the ground range for which this frequency is the MUF

```
//Ex:5.16
clc;
clear;
close;
u=0.9;// refractive index
f=10*10^6;// frequency in Hz
h=400;// height in km
Nmax=((1-0.81)*f^2)/81;
fmuf=10*10^6;// in Hz
fc=9*sqrt(Nmax);// frequency in Hz
R=6370;// in km
d=1651.76;
D=2*(h+(d^2/(8*R)))*(sqrt((fmuf/fc)^2-1));// skip
    distance in km
printf("The skip distance = %f km", D);
```

Scilab code Exa 5.17 Determine the transmitter power required

```
//Ex:5.17
clc;
clear;
close;
f=1690*1000;// frequency in Hz
d=16*1000;// distance in m
E=15;// dielectric constant
k=5*10^-5;// conductivity in ohms/cm
Eg=0.5*10^-3;// V/m
c=3*10^8;// the speed of ligth in m/s
y=c/f;// wavelength in m
// tan(b)=(E+1)/x=(E+1)/(1.8*10^12*k/f=f*(E+1))
    /(1.8*10^12*k)
// then b=atan(f*(E+1))/(1.8*10^12*k))
x=1.8*10^12*k/f;
b=(atan((f*(E+1))/(k*1.8*10^12)))*(180/3.14);// in
    degree
p=((%pi*d)/(x*y))*cos(b*%pi/180);
p1=5.1;// approx. value of p
A=(2+0.3*p1)/(2+p1+0.6*p1^2);
A1=0.15
ps=(Eg*d)/(300*A1);
P=ps^2;// transmitter power in KW
P1=P*1000;// transmitter power in watts
printf("The transmitter power = %f watts", P1);
printf("\n since antenna efficiency is 50 percent,
    the transmitter must deliver 31.6049*2=63.2098
    watts to the antenna.");
```

Scilab code Exa 5.18 Determine the strength of its ground wave

```
//Ex:5.18
clc;
clear;
close;
f=900*1000;// frequency in Hz
c=10^-4;// conductivity in mhos/cm
p=10;// power in kw
d=100*1000;// distance in m
d1=100;// distance in km
Er=20;// relative dielectric constant
y=3*10^8/f;// wavelength in m
w=2*%pi*f;
Eo=(10^-9)/(36*%pi);
x=c/(w*Eo);
b=(atan((Er+1)/x))*180/3.14;// in degree
P=(%pi*d*cos(b*%pi/180))/(x*y);
A1=(2+0.3*P)/(2+P+0.6*P^2);
// tower efficiency is 80% so effective power is
    10/.80=12.5kW=Pef
Pef=12.5;// effective power in kW
Eg=(1.1*300*A1*sqrt(Pef))/d1;// strength of ground
    wave in mV/meter
printf("The strength of ground wave= %f mV/meter",
    Eg);
```

Scilab code Exa 5.19 Calculate the transmission path distance for an ionospheric transmission

```
//Ex:5.19
clc;
clear;
close;
h=200;// height in km
B=20;// angle of elevation in degree
B1=B*3.14/180;// angle of elevation in radians
R=6370;// radius of earth in km
D=2*h/tan(B1);// in km
D1=2*R*((3.14/2)-(B1)-asin((R*cos(B1))/(R+h)));//
    transmission-path distance in km
printf("The transmission-path distance= %f km", D1);
```

Scilab code Exa 5.20 Find the effective area

```
//Ex:5.20
clc;
clear;
close;
d=10*1000;// distance in m
wt=500;// transmeter power in Watt
```

```
wr=2*10^-6;// receiver power in Watt
Gt=10;// antenna gain
Ae=(wr*4*%pi*d^2)/(wt*Gt);// effective area in m^2
printf("The effective area = %f m^2", Ae);
```

Scilab code Exa 5.21 Calculate the open circuit voltage

```
//Ex:5.21
clc;
clear;
close;
f=150;// frequency in MHz
y=300/f;// in m
wt=10;// transmeter power in Watt
Gt=1.641;// antenna gain
d=50*10^3;// in m
E=sqrt(30*wt*Gt)/d;// electric field strength in V/m
Voc=E*y/%pi;// open circuit voltage in mV
printf("The open circuit voltage = %f mV", Voc*1000);
```

Scilab code Exa 5.22 Calculate the field strength at a receiving antenna

```
//Ex:5.22
clc;
```

```
clear;
close;
f=150;// frequency in MHz
y=300/f;// wavelength in m
ht=20;// transmeter height in km
hr=2;// receiver height in km
d=40*10^3;// distance in m
p=100;// power in watt
Er=(88*sqrt(p)*ht*hr)/(y*d^2);// field strength in
   uV/m
printf("The field strength = %d uV/m", Er*10^6);
```

Scilab code Exa 5.23 Calculate the the attenuation

```
//Ex:5.23
clc;
clear;
close;
Gt=20;// transmeter gain in dB
Gr=20;// receiver gain in dB
d=40;// distance in km
f=600;// frequency in MHz
Ls=32.45+20*log(f)/log(10)+20*log(d)/log(10);// loss
    in dB
at=Gt+Gr-Ls;// attenuation in dB
printf("The attenuation = %f dB", at);
printf("\n Negative sign shown attenuation");
```

Scilab code Exa 5.24 Explain what is meant by the gyro frequency and Calculate the max range obtain able in a single hop transmission utilizing

```
//Ex:5.24
clc;
clear;
close;
R=6370;// radius of earth in km
hm=400;// height of the ionospheric layer in km
d=2*R*(acos(R/(R+hm)));// max range in a single hop
   transmission in km
printf("The max range in a single hop transmission =
    %f km", d);
```

Scilab code Exa 5.25 Calculate the max range obtainable in single hop transmission utilizing E layer

```
//Ex:5.25
clc;
clear;
close;
R=6370;// radius of earth in km
hm=140;// height of the ionospheric layer in km
```

```
d=2*R*(acos(R/(R+hm)));// max range in a single hop transmission in km
printf("The max range in a single hop transmission = %f km", d);
```

Scilab code Exa 5.26 Calculate the max range obtainable in single hop transmission utilizing D layer

```
//Ex:5.26
clc;
clear;
close;
R=6370;// radius of earth in km
hm=90;// height of the ionospheric layer in km
d=2*R*(acos(R/(R+hm)));// max range in a single hop transmission in km
printf("The max range in a single hop transmission = %f km", d);
```

Scilab code Exa 5.27 Find the virtual heightof the reflected layer

```
//Ex:5.27
clc;
clear;
close;
```

```
T=5/1000;// period in sec
c=3*10^8;// the speed of the light in m/s
h=c*T/2;// virtual height in m
printf("The virtual height = %f km", h/1000);
```

Scilab code Exa 5.28 Calculate the max line of sight range and the field strength and also distance

```
//Ex:5.28
clc;
clear;
close;
ht=120;// transmeter height in m
hr=16;// receiver height in m
Los=4.12*(sqrt(ht)+sqrt(hr));// line of sight range
    in km
f=50;// frequency in MHz
y=300/f;// wavelength in m
d=12*10^3;// distance in m
p=15000;// power in watt
Er=(88*sqrt(p)*ht*hr)/(y*d^2);// field strength in v
    /m
Er1=1/1000;// field strength in V/m
d1=sqrt((88*sqrt(p)*ht*hr)/(y*Er1));// distance in
    km
printf("The line of sight range = %f km", Los);
printf("\n The field strength = %f mV/m", Er*1000);
printf("\n The distance = %d km", d1);
```

Scilab code Exa 5.29 Calculate the power density reating the moon surface

```
//Ex:5.29
clc;
clear;
close;
wt=10*10^6;// power in Watt
Gt=65;// antenna gain in dB
Gt1=10^(Gt/10);// antenna gain
d=4000000*100;// distance in m
Pd=(wt*Gt1)/(4*%pi*d^2);// power density in uW
printf("The power density = %f uW", Pd*10^6);
```

Scilab code Exa 5.30 What is the max disance along the surface of the earth

```
//Ex:5.30
clc;
clear;
close;
ht=4000;// transmeter height in m
hr=7000;// receiver height in m
```

```
Los=4.12*(sqrt(ht)+sqrt(hr));// line of sight range
    in km
printf("The line of sight range = %f km", Los);
```

Scilab code Exa 5.31 What will be the range for which the MUF is twenty MHz

```
//Ex:5.31
clc;
clear;
close;
u=0.8;// refractive index
f=15*10^6;// frequency in Hz
fmuf=20*10^6;// MUF in Hz
h=350;// height in km
Nmax=((1-u^2)*f^2)/81;
fc=9*sqrt(Nmax);// frequency in Hz
Ds=(2*h)*(sqrt((fmuf/fc)^2-1));// range in km
printf("The range = %f km", Ds);
```

Scilab code Exa 5.32 Calculate the power received by an antenna

```
//Ex:5.32
clc;
clear;
```

```
close;
wt=35;// transmeter power in Watt
wt1=10*log(wt)/log(10);// transmeter power in dB
Gt=40;// transmeter gain in dB
Gr=40;// receiver gain in dB
d=150;// distance in km
y=6/100;// wavelength in m
f=300/y;// frequency in MHz
Ls=32.45+20*log(f)/log(10)+20*log(d)/log(10);// loss in dB
wr=wt1+Gt+Gr-Ls;// receive power in dB
WR=10^(wr/10);// receive power in watt
printf("The receive power = %f dB", wr);
printf("\n The receive power = %f uW", WR*10^6);
```

Scilab code Exa 5.33 What is the max power received by the receiver

```
//Ex:5.33
clc;
clear;
close;
wt=2*10^3;// transmeter power in Watt
Gt=1.64;// directivity of transmeter
Gr=1.64;// directivity of receiver
d=200*10^3;// distance in m
f=150;// frequency in MHz
y=300/f;// wavelength in m
wr=(wt*Gt*Gr)*(y/(4*%pi*d))^2;// max received power in Watt
printf("The max received power = %f*10^-9 Watts", wr*10^9);
```

Scilab code Exa 5.34 Calculate the MUF for the given path

```
//Ex:5.34
clc;
clear;
close;
D=400;// depth in km
h=300;// height in km
f=5;// critical frequency in MHz
fmuf=f*sqrt(1+(D/(2*h))^2);// MUF in MHz
printf("The MUF in MHz = %d MHz", fmuf);
```

Scilab code Exa 5.35 Calculate the value of frequency at which an electromagnetic wave must be propagate

```
//Ex:5.35
clc;
clear;
close;
u=0.6;// refractive index
N=4.23*10^4;// electron/m^3
f=sqrt(81*N/(1-u^2));// frequency in Hz
printf("The frequency = %f Hz", f);
```

Scilab code Exa 5.36 Determine the ground range for which this frequency is MUF

```
//Ex:5.36
clc;
clear;
close;
h=300;// height in km
fmuh=15*10^6;// in Hz
// we know that u=sqrt(1-81N/f^2)
u=0.8;// refractive index
//then 0.8^2=1-81N/f^2");
// fc=9*sqrt(Nmax)
// 0.36=fc^2/fmuh^2
fc=sqrt(0.36*fmuh^2);// in Hz
fc1=fc/10^6;// cut off frequancy in MHz
printf("The cut off frequancy, fc= %d MHz", fc1);
// skip distance D=2*(h+D^2/8R^2)*sqrt((fmuh/fc)^2-1)
// D=2*(300+D^2/8*6370)*sqrt((15/9)^2-1)
// D^2-19.11*10^3D+15.29*10^16=0
// after solve this equation, we get D=18.27*10^6 meter
D=18.27*10^3;// skip distance in meter
printf("\n The skip distance = %f*10^3 meter", D/10^3);
```

Scilab code Exa 5.37 At what frequency a wave must propogate for the D regions

```
//Ex:5.37
clc;
clear;
close;
u=0.6;// refractive index
N=500;// electron/cc
f=sqrt(81*N/(1-u^2));// frequency in KHz
printf("The frequency = %f KHz", f);
```

Scilab code Exa 5.38 Find the received power

```
//Ex:5.38
clc;
clear;
close;
u=0.5;// refractive index
N=500;// electron/cc
f=sqrt(81*N/(1-u^2));// frequency in KHz
printf("The frequency = %f Hz", f);
```

Scilab code Exa 5.39 Explain the Directivity polarization and virtual height

```
//Ex:5.39
clc;
clear;
close;
printf("Directivity: The max directive gain is
    called directivity of an antenna.");
printf("\n Directivity= max radiation intensity of
    test antenna/average radiation intensity of test
    antenna ");
printf("\n Polarization: Polarization of an antenna
    means the direction of electric field of the
    electromagnetic wave being radiated by the
    transmitting syatem.");
printf("\n Virtual Height: Virtual height of an
    ionospheric layer may be defined as the height to
     which short pulse of energy sent vertically
    upward and travelling with speed of light would
    reach taking the same ways travel time as does
    the actual pulse reflected from the layer.");
printf("\n Practically the virtual height is alway
    greater than actual height");
```

Scilab code Exa 5.40 Calculate the LOS range and field strength

```
//Ex:5.40
clc;
clear;
close;
ht=120;// height of transmitting antenna in m
hr=16;// height of receiving antenna in m
d=4.12*(sqrt(ht)+sqrt(hr));// line of sight range in
    km
p=15*1000;// power in watts
f=50;// frequency in MHz
y=300/f;// wavelenght in m
r=12*1000;// distance in m
E=(88*sqrt(p)*ht*hr)/(y*r^2);// field strength at a
    receiving antenna
printf("The line of sight range = %f km", d);
printf("\n The field strength at a receiving antenna
    = %f mV", E*1000);
```

Scilab code Exa 5.41 Find the field strenght

```
//Ex:5.41
clc;
clear;
close;
f=500/1000;// frequency in MHz
A=1;// area in m^2
y=300/f;// wavelength in m
Vrms=2/1000;// potential difference in Volt
N=10;// no. of turns
```

```
Erms=(Vrms*y)/(2*%pi*A*N);// field strength in v/m
printf("The field strength = %f mV/m", Erms*1000);
```

Scilab code Exa 5.42 What is standing wave ratio and explain how it is measured experimentally

```
//Ex:5.42
clc;
clear;
close;
printf("SWR may be defined as ratio of max to min
   current on voltage on a line having standing
   waves. ");
printf("\n VSWR=Vmax/Vmin");
printf("\n S=Vmax/Vmin=Imax/Imin");
printf("\n The SWR is a measure of mismatch between
   load of transmission line and is first and
   foremost quantity calculated for a particular
   load. Its value is always greater than unity when
    termination is not correct. But when termination
    is correct, its value is equal to unity, if
   termination is perfectly matched.");
```

Scilab code Exa 5.43 Calculate the value of the frequency

```
//Ex:5.43
clc;
clear;
close;
u=0.5;// refractive index
N=3.25*10^4;// electron/m^3
f=sqrt(81*N/(1-u^2));// frequency in Hz
printf("The frequency = %f KHz", f/1000);
```

Scilab code Exa 5.44 What will be the effects of earth magnetic field on refractive index of th eionosphere

```
//Ex:5.44
clc;
clear;
close;
printf("Effect of Earth Magnetic Field on Refractive
    Index of the Ionosphere: The theory which deals
   with the propagation of Radio wave through
   Ionosphere in presence of earth magnetic field is
    known as Magneto-Ionic-theory. ");
printf("\n The phenomenon of propagation of radio
   waves through Ionosphere in the presence of earth
    magnetic field is changed.");
printf("\n because is the presence of earth magnetic
    field , the formula of refractive Index u is
   changed,");
printf("\n u=sqrt(1-81N/f^2)");
printf("\n i.e.,");
printf("\n u^2=sqrt(1-(2/(2a-(yt^2/a-1)+sqrt(yt^2/(a
   -1)^2+4yL^2)))))");
```

```
printf("\n where");
printf("\n    a=(EoMw^2)/(Ne^2)=d^2/dc^2");
printf("\n    yt=aBt.e/wm");
printf("\n    yL=aBL.e/wm and y=sqrt(yt^2+yL^2)");
printf("\n    BL=component of earth magnetic field intensity B along the direction of propagation.");
printf("\n    Bt=component of earth magnetic field intensity traverse to the direction of propagation.");
printf("\n    B=uo.H");
printf("\n    M=mass of electron=9.1*10^-31 kg");
printf("\n    e=charge of electron=1.6*10^-19c");
printf("\n    w=2*3.14*d=angular frequency");
printf("\n    N=electron density");
printf("\n    Eo=dielectric constant=8.854*10^-12 F/M");
printf("\n    u=refractive index of Ionosphere.");
```

Scilab code Exa 5.45 At what frequency a wave must propogate for D region and what is the critical frequency

```
//Ex:5.45
clc;
clear;
close;
u=0.5;// refractive index
N=400;// electron/cc
f=sqrt(81*N/(1-u^2));// frequency in Hz
N1=1.24*10^6;// in per cm^3
fc=9*sqrt(N1);// critical frequency in Hz
```

```
printf("The frequency = %f KHz", f/1000);
printf("\n The critical frequency = %d KHz", fc
    /1000);
```

Scilab code Exa 5.46 Find the skip distance

```
//Ex:5.46
clc;
clear;
close;
h=300;// height in km
fmuh=15*10^6;// in Hz
// we know that u=sqrt(1-81N/f^2)
u=0.8;// refractive index
//then 0.8^2=1-81N/f^2");
// fc=9*sqrt(Nmax)
// 0.36=fc^2/fmuh^2
fc=sqrt(0.36*fmuh^2);// in Hz
fc1=fc/10^6;// cut off frequancy in MHz
printf("The cut off frequancy, fc= %d MHz", fc1);
// skip distance D=2*(h+D^2/8R^2)*sqrt((fmuh/fc)
    ^2-1)
// D=2*(300+D^2/8*6370)*sqrt((15/9)^2-1)
// D^2-19.11*10^3D+15.29*10^16=0
// after solve this equation, we get D=18.27*10^6
    meter
D=18.27*10^6;// skip distance in meter
printf("\n The skip distance = %f*10^6 meter", D
    /10^6);
```

Scilab code Exa 5.47 What is the max power thet can be received

```
//Ex:5.47
clc;
clear;
close;
Gt=25;// transmitter gain in dB
gt=10^(Gt/10);// transmitter gain
Gr=30;// receiver gain in dB
gr=10^(Gr/10);// receiver gain
f=1.5*1000;// frequency in MHz
R=1.5*1000;// distance in m
y=300/f;// wavelength in m
pt=200;// transmitted power in watt
pr=(pt*gt*gr)*(y/(4*%pi*R))^2;// received power in watt
printf("The received power = %f mW", pr*1000);
```

Scilab code Exa 5.48 Find the max range of the radar and also the max range when frequency is doubled

```
//Ex:5.48
clc;
clear;
```

```
close;
A=12.5;// cross section area of the target in m^2
pr=10^-13;// max received power in Watt
Gr=2000;// receiver gain
Gt=2000;// transmitter gain
y=16/100;// wavelength in m
pt=250*10^3;// transmitted power in Watts
Rmax=((pt*Gt^2*y^2*A)/((4*%pi)^3*pr))^(1/4);// max range in m
Rmax2=sqrt(2)*Rmax;// max range in m
printf("The max range Rmax1 = %f km", Rmax/1000);
printf("\n The max range Rmax2 = %f km", Rmax2/1000);
```

Scilab code Exa 5.49 Find the max allowable distance between the two antennas

```
//Ex:5.49
clc;
clear;
close;
f=30;// frequency in MHz
y=300/f;// wavelength in m
l=y/2;// in m
I=10;// current in amp
Gt=1.5;// gain
Gr=1.5;// gain
Pr=10^-3;// receiver power in Watts
Ptmax=(80*%pi^2*I^2*l^2)/y^2;// max transmitter power in watts
Ptav=Ptmax/2;// average power in Watts
```

```
d=(Ptav*Gt*Gr*y^2)/(16*%pi*%pi*Pr);// max allowable
    distance in m
printf("The max allowable distance = %f km", d/1000)
    ;
printf("\n The answer is wronge in the textbook");
```

Scilab code Exa 5.50 What is the voltage available at the terminals

```
//Ex:5.50
clc;
clear;
close;
f=2*10^9;// frequency in Hz
c=3*10^8;// speed of light in m/s
R1=50;// lengt in km
R=50*1000;// lengt in meter
y=c/f;// wavelength in m
GT=20;// gain in db
GR=20;// gain in db
Gt=10^(GT/10);// gain
Gr=10^(GR/10);// gain
pt=1;// power in watt
pr=(pt*Gt*Gr)*(y/(4*%pi*R))^2;// the received power
    in watt
V=sqrt(pr*R1);// voltage available at the terminals
    in micro volt
printf("voltage available at the terminals in micro
    volt = %f uV", V*10^6);
```

Scilab code Exa 5.51 What transmitter power is required for a received signal

```
//Ex:5.51
clc;
clear;
close;
f=4*10^9;// frequency in Hz
c=3*10^8;// speed of light in m/s
y=c/f;// wavelength in m
D=1.22;// in meter
A=(%pi*D*D)/4;// area in m^2
d=96*1000;// in m
Pr=(10^-3)*(10^(-90/10));// received power in watt
//the received power is given by
//Pr=Pt*Gt*Gr*(y/4*%pi*d)
//antennas are symmetrical, Gt=Gr=G
//Pr/Pt=G^2*(y/4*%pi*d)^2
// =A^2/(y*d)^2
// then
//Pt=Pr*(y*d/A)^2
Pt=Pr*(y*d/A)^2;// the transmitted power in watts
printf("the transmitted power = %f micro watt", Pt
    *10^6);
```