Scilab Textbook Companion for Radar Engineering and Fundamentals of Navigational Aids by G. S. N. Raju[1]

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

INTRODUCTION TO RADAR RADAR PARAMETERS AND THEIR DEFINITIONS

Scilab code Exa 1.1 PEAK POWER DUTY CYCLE

```
//Chapter-1, Example 1.1, Page 34
//=============================================================================
clc;
clear;

//INPUT DATA
PRF= 1000;//pulse repetitive frequency in Hz
PW = 2*10^-6;//pulse width 2us
Pav=100;//average power in watts

//Calculations

Ppeak = (Pav)/(PW*PRF);//Peak power in watts
```

```
D      = Pav/Ppeak;//Duty cycle

//Output
mprintf('Peak power is %g KW\n Duty cycle is %e',
   Ppeak/1000,D);
```

Scilab code Exa 1.2 FINDING PRT PW

```
//Chapter-1, Example 1.2, Page 35
//
   =====================================================

clc;
clear;

//INPUT DATA
PRF= 1.2*10^3;//pulse repetitive frequency in Hz
PI = 0.6*10^-3;//pulse interval in sec

//Calculations

PRT = 1/PRF;//pulse repetition frequency in Hz
PW  = PRT-PI;//pulse width in sec;

//Output
mprintf('Pulse repetitive time is %3.3f ms\n Pulse
   width is %3.3f ms',PRT*1000,PW*1000);
```

Scilab code Exa 1.3 FINDING AVERAGE POWER

```
//Chapter-1, Example 1.3, Page 35
```

```
//==============================================================
clc;
clear;

//INPUT DATA
D     = 0.001;//Duty Cycle
Ppeak=500*10^3;//Peak Power in Watts

//Calculations

Pav = D * Ppeak;// D=averagepower/Peakpower;

//Output
mprintf('Average power is %g Watts',Pav);
```

Scilab code Exa 1.4 FINDING DUTY CYCLE AND PRT

```
//Chapter-1, Example 1.4, Page 35
//==============================================================
clc;
clear;

//INPUT DATA
PRF    = 1000;//pulse repetitive frequency in Hz
Ppeak  =10*10^6;//peak power in watts
Pav    =100*10^3;//average power in watts

//Calculations

D      = Pav/Ppeak;//Duty cycle
PRT    = 1/PRF;//pulse repetitive time;
```

```

//Output
mprintf('Duty cycle is %g\n pulse repetitive time is
    %g ms',D,PRT*1000);
```

Scilab code Exa 1.5 FINDING DOPPLER FREQUENCY

```
//Chapter-1, Example 1.5, Page 36
//
=============================================================================

clc;
clear;

//INPUT DATA
F= 6*10^9;  //frequency in Hz
Vo = 3*10^8;//velocity in m/s;
Vr = 200;//Radial velocity in kmph

//Calculations

lamda = Vo/F;//wavelength = vel/freq;
Fd    = (2*Vr/lamda)*(5/18);//doppler frequency in
   Hz;
//5/18 is multiplied to convert kmph to m/s

//Output
mprintf('Doppler Frequency is %3.2f KHz',Fd/1000);
```

Chapter 2

BASIC RADARS

Scilab code Exa 2.1 FINDING RANGE OF TARGET

```
//Chapter-2 example 2.1
//=================================================
clc;
clear;
Tdelay=200*10^-6;        //time delay in sec
Vo=3*10^8;               //velocity in m/s
//Calculations
R=(Vo*Tdelay)/2;         //Range of the target in kms


//Output
mprintf('Range of the target is %3.1f Kms',R/1000);
//=================================================
```

Scilab code Exa 2.2 FINDING DUTY CYCLE PRT PULSE WIDTH PULSE ENERGY

```
//Chapter-2 example 2.2
//
================================================================
clc;
clear;
Pt=5000;     //Peak tx power in watts
Pav=1000;    //Average Power
PRF1 = 10;   //Pulse repetition frequency in khz
PRF2 = 20;   //Pulse repetition frequency in khz
//Calculations
D=Pav/Pt;//Duty cycle
PRI1=1/PRF1;     //Pulse repetitive interval in  msec
PRI2=1/PRF2;     //Pulse repetitive interval in  msec
PW1=D*PRI1;      //Pulse Width in msec
PW2=D*PRI2;      //Pulse Width in msec
PE1=Pt*PW1;      //Pulse Energy in joules
PE2=Pt*PW2;      //Pulse Energy in joules
//Output
mprintf('Duty cycle is %3.2f \n pulse repetition
   interval 1 is %3.2f msec\n pulse repetition
   interval 2 is %3.2f msec\n Pulse Width1 is %3.2f
   usec\n Pulse Width2 is %3.2f usec\n Pulse Energy1
    is %3.2f J \n Pulse Energy2 is %3.2f J',D,PRI1,
   PRI2,PW1*1000,PW2*1000,PE1/1000,PE2/1000);
```

Scilab code Exa 2.3 FINDING PRF PRT RANGE RESOLUTION AND PULSE WIDTH

```
//Chapter-2 example 2.3
//
================================================================
clc;
clear;
UR=200;//unambiguous range in kms
```

```
BW=1*10^6;//bandwidth in hz
V0=3*10^8;//velocity in m/s
//Calculations
PRF=V0/(2*UR*10^3);//pulse repetition frequency in hz
PRI=1/PRF;//pulse repetition interval in sec
RR=V0/(2*BW);//Range Resolution in mts
PW=(2*RR)/(V0);//pulse width
//Calculations
mprintf('pulse repetition frequency is %3.2f Hz\n pulse repetition interval is %3.2f msec\n Range Resolution is %3.2f m\n pulse width is %3.1fusec',PRF,PRI*1000,RR,PW*10^6);
```

Scilab code Exa 2.4 FINDING DUTY CYCLE AVERAGE POWER

```
//Chapter-2 example 2.4
//
clc;
clear;
Pt=50000;//peal power in watts
PRF=1000;//pulse repetitive frequency in hz
PW=0.8;//pulse width in usec
//Calculations
D=PW*PRF*10^-6;//duty cycle
Pav=Pt*D;//average power
//output
mprintf('Duty cycle is %g\n Average power is %g Watts',D,Pav);
```

Scilab code Exa 2.5 FINDING PRF AVERAGE POWER DUTY CYCLE AND RADAR RANGE

```
//Chapter-2 example 2.5
//
   ==================================================================
clc;
clear;
Vo=3*10^8;//velocity in m/s
Pt=1*10^6;//peak power in watts
PW=1.2*10^-6;//pulse width in sec
PRI=1*10^-3;//pulse repetition interval in sec
//Calculations
PRF=1/PRI;//pulse repetition frequency in hz
Pav=Pt*PW*PRF;//average power in watts
D=Pav/Pt;//Duty cycle;
Rmax=Vo/(2*PRF);//maximum range of the radar in m
mprintf('pulse repetition frequency is %g KHz\n
   average power is %g KW\n Duty cycle = %e\n
   maximum range of the radar is %g Km',PRF/1000,Pav
   /1000,D,Rmax/1000 );
```

Scilab code Exa 2.6 FINDING RANGE RESOLUTION AND UNAMBIGUOUS RANGE

```
//Chapter-2 example 2.6
//
   ==================================================================
clc;
clear;
PW = 2*10^-6;          //pulse width in sec
PRF=800;               //pulse repetition frequency in
   KHz
V0=3*10^8;             //velocity in m/s
//Calculations
Ru=V0/(2*PRF);         //unambigious range in mts
RR=(V0*PW)/2;          //Range resolution in m
```

```
//output
mprintf('unambigious range is %g Km\n Range
   resolution is %g m',Ru/1000,RR);
```

Scilab code Exa 2.7 FINDING PRF

```
//Chapter-2 example 2.7
//

clc;
clear;
Rmax=500;//maximum range in kms
V0=3*10^8;//velocity in m/s;
//calculations
PRF=(V0/(2*Rmax*10^3));//pulse repetitive frequency
   in Hz
//output
mprintf('pulse repetitive frequency is %g Hz',PRF);
```

Scilab code Exa 2.8 FINDING MIN RECEIVABLE SIGNAL

```
//Chapter-2 example 8
//

clc;
clear;
//input data
F           = 9;              //Noise figure in dB
BW          = 3*10^6;         // Bandwidth
To          = 290;            // Temperature in kelvin
K           = 1.38*10^-23;    // Boltzman constant
```

```

//Calculations

F1          = 10^(F/10)      //antilog calculation
Pmin        = (K*To*BW)*(F1-1);//minimum receivable
    power

//Output
mprintf('Minimum receivable power Pmin = %3.4f pW',
    Pmin*10^12);
mprintf('\n Calculation error at Pmin in textbook');


//
    ====================================================================
```

Scilab code Exa 2.9 FINDING MAX RADAR RANGE

```
//Chapter-2 example 2.9
//
    ====================================================================
clc;
clear;
Pt=500000;//peal power in watts
F=10*10^9;//operating frequency in hz
MRP=0.1*10^-12;//minimum receivable power in pico
    watts
Ac=5;//capture area of antenna in m^2;
RCS=20;//radar cross sectional area in m^2;
Vo=3*10^8//velocity in m/s
// calculations
lamda =Vo/F
Rmax=((Pt*Ac*Ac*RCS)/(4*%pi*lamda*lamda*MRP))^0.25
```

```
//output
mprintf('Maximum Radar Range is %3.1f kms',Rmax
    /1000);
```

Chapter 3

ADVANCED RADARS

Scilab code Exa 3.1 FINDING LOWEST BLIND SPEED

```
//Chapter-3, Problem 3.1 , Page104
//==============================================================================

clc;
clear;

//INPUT DATA
PRF= 1500;//pulse repetitive frequency in Hz
lamda = 3*10^-2;//wavelength in m;

//Calculations
//n =1 gives lowest blind speed
n=1;

Vb = n*(lamda/2)*PRF;//blind speed in m/s


//Output
mprintf('Lowest Blind Speed is %g m/s',Vb);
```

Scilab code Exa 3.2 FINDING SPEED OF AUTOMOBILE

```
//Chapter-3, Problem 3.2 , Page105
//
    ==================================================================================
clc;
clear;

//INPUT DATA
PRF= 1000;//pulse repetitive frequency in Hz
Fd = 1000;//doppler frequency in Hz;
F  = 10*10^9;//operating frequency of radar in Hz;
Vo = 3*10^8;//velocity in m/s

//Calculations
 lamda = Vo/F;
 Va    = (Fd*lamda)/2;//speed of automobile in m/s
 Va1   = Va*18/5; //speed of automobile in kmph

//Output
mprintf('Speed of automobile is %g m/s or %g kmph\n'
   ,Va,Va1 );
```

Scilab code Exa 3.3 FINDING LOWEST THREE BLIND SPEEDS

```
//Chapter-3, Problem 3.3 , Page105
//
    ==================================================================================
clc;
clear;
```

```
//INPUT DATA
PRF= 1000;//pulse repetitive frequency in Hz
F  = 10*10^9;//operating frequency of radar in Hz;
Vo = 3*10^8;//velocity in m/s

//Calculations
 lamda = Vo/F;
 // Blind Frequency is given by Fn = n*PRF;
 n1 = 1;
 n2 = 2;
 n3 = 3;
 F1 =n1*PRF;//blind frequency for n=1 in Hz;
 F2 =n2*PRF;//blind frequency for n=2 in Hz;
 F3 =n3*PRF;//blind frequency for n=3 in Hz;

//Output
mprintf('Lowest three Blind Frequencies are %g KHz ,
   %g KHz and %g KHz\n',F1/1000,F2/1000,F3/1000 );
```

Scilab code Exa 3.4 FINDING LOWEST THREE BLIND SPEEDS

```
//Chapter-3, Problem 3.4 , Page105
//
   ================================================================

clc;
clear;

//INPUT DATA
F  = 10*10^9;     //operating frequency in Hz
PRF= 800;        //pulse repetitive frequency in Hz
Vo = 3*10^8;    //velocity in m/s;
n1 = 1;
n2 = 2;
```

```
n3 = 3;
//Calculations

lamda = Vo/F;//Wavelength in m

// blind speed Vb = n*(lamda/2)*PRF in m/s

Vb1 = n1*(lamda/2)*PRF;//first blind speed in m/s;
Vb2 = n2*(lamda/2)*PRF;//second blind speed in m/s;
Vb3 = n3*(lamda/2)*PRF;//third blind speed in m/s;

//Output
mprintf('First Blind Speed is %g m/s\n Second Blind
   Speed is %g m/s\n Third Blind Speed is %g m/s\n',
   Vb1,Vb2,Vb3);
mprintf('NOTE: IN TEXT BOOK THIRD BLIND SPEED IS
   WRONGLY PRINTED AS 48 m/s');
```

Scilab code Exa 3.5 FINDING PRF

```
//Chapter-3, Problem 3.5 , Page106
//
   ================================================================

clc;
clear;

//INPUT DATA
F  = 10*10^9;     //operating frequency in Hz
Vo = 3*10^8;    //velocity in m/s;
Vb1 = 20;//lowest(first) blind speed in m/s
n   =1 ;//since first blindspeed
//Calculations

lamda = Vo/F;//Wavelength in m
```

```
// blind speed Vb = n*(lamda/2)*PRF in m/s

PRF = (2*Vb1)/(n*lamda);//pulse repetitive frequency
    in Hz

//Output
mprintf('Pulse Repetitive Frequency is %3.2f KHz',
   PRF/1000);
```

Scilab code Exa 3.6 FINDING MAX UNAMBIGUOUS RANGE

```
//Chapter-3, Problem 3.6 , Page106
//
   ==========================================================

clc;
clear;

//INPUT DATA
lamda = 3*10^-2;//wavelength in m
PRF   = 1000;  //pulse repetitive frequency in Hz
Vo    = 3*10^8;// velocity in m/s

//Calculations

Ruamb = (Vo)/(2*PRF);//max unambiguous range in m
//Output
mprintf('Maximum unambiguous range is %g Kms',Ruamb
   /1000);
```

Scilab code Exa 3.7 FINDING RATIO OF OPERATING FREQ

```
//Chapter-3, Problem 3.7 , Page106
//
=====================================================================

clc;
clear;

//INPUT DATA

n1   = 1 ;//since first blindspeed
n3   = 3 ;//since third blindspeed

//Calculations


// blind speed Vb1 = n1*(lamda_1/2)*PRF1 in m/s
// blind speed Vb3 = n3*(lamda-2/2)*PRF2 in m/s
//here PRF1 = PRF2 = PRF
//if Vb1=Vb3 then
//1*(lamda_1/2)*PRF  =  3*(lamda_2/2)*PRF
//lamda_1/lamda_2     = 3/1;
//lamda = C/F;
//therefore F1/F2 = 1/3 ;


//Output
mprintf('Ratio of Operating Frequencies of two
   Radars are (F1/F2) = 1/3');
```

Scilab code Exa 3.8 `FINDING RATIO OF PRFs`

```
//Chapter-3, Problem 3.8 , Page107
//
=====================================================================
```

```
clc;
clear;

//INPUT DATA

Vb1 = 20;//first blind speed in m/s
Vb2 = 30;//second blind speed in m/s
n1   =1 ;//since first blindspeed
n1   =2 ;//since second blindspeed
lamda = 3*10^-2;//wavelength in m;
//Calculations

PRF1 = (2*Vb2)/(n1*lamda);//pulse repetitive
    frequency in Hz of  First Radar;

PRF2 = (2*Vb2)/(n1*lamda);//pulse repetitive
    frequency in Hz of Second Radar;


//Output
mprintf('Ratio of pulse repetitive frequencies of
    the Radars is PRF1/PRF2 = %g',PRF1/PRF2);
```

Scilab code Exa 3.9 FINDING BLIND SPEEDS

```
//Chapter-3, Problem 3.9 , Page107
//
    ================================================================

clc;
clear;

//INPUT DATA
F  = 6*10^9;     //operating frequency in Hz
PRF= 1000;        //pulse repetitive frequency in Hz
```

```
Vo = 3*10^8;    //velocity in m/s;
n2 = 2;         // n value for second blind speed
n3 = 3;        // n value for third blind speed
//Calculations

lamda = Vo/F//Wavelength in m

// blind speed Vb = n*(lamda/2)*PRF in m/s

Vb2 = n2*(lamda/2)*PRF  //second blind speed in m/s;
Vb21 = Vb2*18/5 ;       //second blind speed in kmph
    ;
Vb3 = n3*(lamda/2)*PRF //third blind speed in m/s;
Vb31 = Vb3*18/5;       //third blind speed in kmph;

//Output
mprintf('Second Blind Speed is %g kmph\n Third Blind
    Speed is %g kmph\n',Vb21,Vb31);
```

Scilab code Exa 3.10 FINDING PEAK TX POWER

```
//Chapter-3 example 10
//
    ==================================================================

clc;
clear;
//input data
r             = 0.5;           //Antenna Radius in
    m
f             = 8*10^9         //operating
    frequency in Hz
Vo            = 3*10^8;        //vel. of EM wave in
    m/s
RCS           = 5;             // Radar cross
```

```
section in m^2
D               = 1;                    // antenna diameter in m
F               = 4.77;                    // noise figure in dB
Rmax            = 12*10^3               // Radar range
BW              = 500*10^3;             // bandwidth

//Calculation
F1              = 10^(F/10)             // antilog calculation
lamda           = Vo/f                  // wavelength

//Rmax          = 48*((Pt*D^4*RCS)/(BW*lamda*lamda(F-1)))^0.25

Pt              = ((Rmax/48)^4)*((BW*lamda*lamda*(F1-1))/(D^4*RCS))

//Output
mprintf('Peak Transmitted Power is %e',Pt);
mprintf('\n Note: Calculation error in textbook at Pt 10^12 missing')
//
```

Chapter 4

TRACKING RADAR

Scilab code Exa 4.1 FINDING PHASE DIFFERENCE BETWEEN ECHOS

```
//Chapter-4 example 4.1
//=============================================================================

clc;
clear;
//input data
//d = lamda/2
theta_d = 5//angle blw los and perpendicular bisector of line joining two antennas

// calculations

//PD  = (2*%pi/lamda)*(d*sin(theta));
//PD  = (2*%pi/lamda)*(lamda/2*sin(theta));
theta_r    = theta_d*(%pi/180)
PD_r       = (2*%pi)*((sin(theta_r))/2);//phase difference in radians
PD_d       = PD_r*(180/%pi);//phase difference in radians
//output
```

```
mprintf('Phase difference b/w two echo signals is %3.2f degrees;  %3.3f radians',PD_d,PD_r);

//==================end of the program========================================================
```

Scilab code Exa 4.2 FINDING SPACING BETWEEN ANTENNAS

```
//Chapter-4 example 4.2
//====================================================================================

clc;
clear;
//input data
F        = 1*10^9;        //operating frequency of monopulse radar in Hz
Vo       = 3*10^8;        //velocity of EM wave in m/s
theta_d    = 10           //angle blw los and perpendicular bisector of line joining two antennas
PD_d     = 20;            //phase difference in degrees

// calculations
lamda = Vo/F              //wavelength in m
//PD  = (2*%pi/lamda)*(d*sin(theta));
theta_r    = theta_d*(%pi/180)    //degree to radian conversion
PD_r       = PD_d*(%pi/180)       //degree to radian conversion
d          = (PD_r*lamda)/(2*%pi*sin(theta_r));

//output
mprintf('Spacing between the antennas is %3.2f cms',
```

```
d*100);

//=====================end of the program
==========================================================
```

Chapter 5

FACTORS AFFECTING RADAR OPERATION AND RADAR LOSSES

Scilab code Exa 5.1 `FINDING RCS`

```
//Chapter-5 example 1
//
   ====================================================================
clc;
clear;
//input data
mprintf('mathematically ellipsoid is represented by
   \n((x/a)^2)+((y/b)^2)+((z/c)^2) = 1\n ');
mprintf('\nThe approximate expression for ellipsoid
   backscattered RCS is given by\n ');
mprintf('\n  =(  *a^2 b^2 c^2)/[ a^2 (sin  )^2 (
   cos  )^2+ b^2 (sin  )^2 (sin  )^2+c^2 (cos  )^2
   ]^2\n');
mprintf('\nif a = b ,the ellipsoid becomes Roll
   symmetric,above eqn becomes\n');
mprintf('\n  = (  * b^4 c^2)/[ a^2 (sin  )^2 + c^2
```

```
(cos )^2 ]^2\n');

//==================end of the program====================================================
```

Scilab code Exa 5.4 FINDING RCS

```
//Chapter-5 example 4
//=============================================================================================

clc;
clear;
//input data
lamda  = 0.03;//wavelength in m
Pt     = 250*10^3;//transmitter power
G      = 2000;//antenna gain
R      = 50*10^3;//maximum range
Pr     = 10*10^-12;//minimum detectable power
//Calculations
Ae     = (lamda*lamda*G)/(4*%pi);//effective aperture area
RCS    = (Pr*(4*%pi*R*R)^2)/(Pt*G*Ae);//Radar cross section of the target

//output
mprintf('Radar cross section of the target is %3.2f m^2',RCS);

//==================end of the program====================================================
```

Chapter 6

RADAR TRANSMITTERS

Scilab code Exa 6.1 FINDING MAX POWER

```
//Chapter-6 example 1
//=============================================================================
clc;
clear;
//input data
F     = 9*10^9;//Reflex Klystron operating frequency
    in hz
Va    = 300;//beam voltage in volts
I     = 20;//Beam current in mA
n     = 1;// for 7/4 mode

//Calculations
//transit time for reflector space = n+3/4
I1        = I*10^-3;//beam current in mA
Prfmax    = (0.3986*I1*Va)/(n+3/4);//maximum RF
   power
//Output
mprintf('Maximum R-F power is %3.3f Watts',Prfmax);

```

```
//==================end of the program ==================================
```

Scilab code Exa 6.2 FINDING GAIN PARAMETER OUTPUT POWER GAIN AND Be

```
//Chapter-6 example 2
//=============================================================================

clc;
clear;
//input data
Vdc    = 2.5*10^3;//Beam voltage
Idc    = 25*10^-3;//beam current in A;
Zo     = 10;//charecteristic impedance
F      = 9.5*10^9;//TWT operating frequency in hz
N      = 40;//circuit length

//Calculations
C      = ((Idc*Zo)/(4*Vdc))^(1/3);//gain parameter
Ap      = -9.54+(47.3*N*C);//Output power gain of twt
w      = 2*%pi*F;
vdc    = 0.593*10^6*sqrt(Vdc);
Be     = w/vdc;
//Output
mprintf('Gain parameter is %3.3f\n Output Power gain
    is %3.3f dB\n phase constant of electron beam is
    %e rad/m',C,Ap,Be);

//==================end of the program ==================================
```

Scilab code Exa 6.3 FINDING CYCLOTRON ANGULAR FREQ AND CUTOFF VOLTAGE

```
//Chapter-6 example 3
//
=================================================================================
clc;
clear;
//input data
e   = 1.609*10^-19;//charge of electron
me  = 9.109*10^-31;//mass of electron in kg
B   = 0.40;//magnetic flux density
b   = 10*10^-2;//Radius of vane edge from the centre
a   = 4*10^-2;//radius of cathode

//Calculations
Wc  = (e/me)*B;//cyclotron angular frequency in
    radians
Vc  = (e/(8*me))*(B^2)*(b^2)*(1-(a/b)^2)^2;//cut-off
    voltage
//Output
mprintf('Cyclotron Angular Frequency is %g rad\n Cut
   -off voltage is %g V\n',Wc,Vc);
mprintf(' Note:Cut-off voltage obtained in textbook
    is wrongly calculated.Instead of (a/b)^2 ,(a/b)
    is calculated');

//=============end of the program
   ======================================
```

Scilab code Exa 6.4 FINDING ELECTRON VELOCITY TRANSIT ANGLE AND BEAM COUPLING COEF

```
//Chapter-6 example 4
//
=================================================================================
clc;
```

```
clear;
//input data
Va  = 900 ;//Accelarating voltage in volts
F   = 3.2*10^9;//operating frequency
d   = 10^-3;
//Calculations
Ve  = (0.593*10^6)*sqrt(Va);//electron velocity
w   = 2*%pi*F;
theta  = w*(d/Ve);//transit angle in radians
Be  = sin(theta/2)/(theta/2);//Beam Coupling Co-efficient
//output
mprintf('Electron Velocity is %g m/s\n Transit Angle is %g rad\n Beam Coupling Co-efficient is %3.3f',Ve,theta,Be);
//==============end of the program==============================================
```

Scilab code Exa 6.5 FINDING EFFICIENCY

```
//Chapter-6 example 5
//==================================================================================
clc;
clear;
//input data
I2  = 28*10^-3 ;//induced current in amperes
V2  = 850;   //fundamental component of catcher-gap voltage
Vb  = 900;   //beam voltage
Ib  = 26*10^-3;//beam current
Bc  = 0.946;//beam coupling coefficient of catcher gap
//Calculations
```

```
n   = ((Bc*I2*V2)/(2*Ib*Vb))*100;//efficiency of
    klystron
//output
mprintf('Efficiency of the klystron is %g \n',n);
mprintf(' Note:In textbook Bc value is taken as
    0.946 in calculation')
//==============end of the program
    ================================================
```

Scilab code Exa 6.6 FINDING FREQ OF IMPATT DIODE

```
//Chapter-6 example 6
//
    ========================================================================

clc;
clear;
//input data
Vd   = 2.2*10^5;//Carrier Drift Velocity in m/s
l    = 5*10^-6;//drift region length
//Calculations
F    = Vd/(2*l);//frequency of IMPATT Diode
//output
mprintf('Frequency of IMPATT Diode is %g Ghz',F
    /10^9);
//==============end of the program
    ================================================
```

Scilab code Exa 6.7 FINDING FREQ OF IMPATT DIODE

```
//Chapter-6 example 7
```

```
//==========================================================================
clc;
clear;
//input data
Vd   = 3*10^5;//Carrier Drift Velocity in m/s
l    = 7*10^-6;//drift region length
//Calculations
F    = Vd/(2*l);//frequency of IMPATT Diode
//output
mprintf('Frequency of IMPATT Diode is %3.2f Ghz',F/10^9);
//==============end of the program==========================================
```

Scilab code Exa 6.8 FINDING AVALANCHE ZONE VELOCTY

```
//Chapter-6 example 8
//==========================================================================
clc;
clear;
//input data
Na   = 1.8*10^15;//Doping Concentration
J    = 25*10^3;//current density in A/cm^2
q    = 1.6*10^-19;//charge of electron
//Calculations
Vaz  = J/(q*Na);//Avalanche Zone Velocity
//output
mprintf('Avalanche Zone Velocity of TRAPATT is %g\n',Vaz);
mprintf(' Note: wrong calculation done in Textbook');
```

```
//==============end of the program
    ==================================================
```

Scilab code Exa 6.9 FINDING FREQ OG GUNN DIODE OSCILLATOR

```
//Chapter-6 example 9
//
    =====================================================================

clc;
clear;
//input data
l  = 12*10^-3;//gunn diode oscillator length in m
Vd = 2*10^8;//Drift velocity in gunn diode
//Calculations
F  = Vd/l;//Frequency of Gunn Diode Oscillator
//output
mprintf('Frequency of Gunn Diode Oscillator is %3.2f
    Ghz',F/10^9');

//==============end of the program
    ==================================================
```

Scilab code Exa 6.10 FINDING MIN OPERATING GUNN DIODE VOLTAGE

```
//Chapter-6 example 10
//
    =====================================================================

clc;
clear;
//input data
l  = 2.5*10^-6;//Drift length of gunn diode in m
```

```
Vd = 2*10^8;//Drift velocity in gun diode
Vgmin = 3.3*10^3;//minimum voltage gradient required
     to start the diode
//Calculations
Vmin  = Vgmin*l;

//output
mprintf('Minimum Voltage required to operate gunn
    diode is %g mV',Vmin*10^3);
//==============end of the program
    ==============================================
```

Chapter 7

RADAR RECEIVERS

Scilab code Exa 7.1 FINDING PROBABILTY OF FALSE ALARM

```
//Chapter-7 example 1
//
    =============================================================================

clc;
clear;
//input data
BW    = 0.5*10^9;//bandwidth of pulsed radar in hz
Tfa   = 10;//false alarm time in minutes

//Calculations
Tfa1  = Tfa*60;//false alarm time in seconds
Pfa  = 1/(BW*Tfa1)
//Output
mprintf('probability of false alarm is %g',Pfa);

//===============end of the program
    ================================================
```

Scilab code Exa 7.2 FINDING RADAR INTEGRATION TIME

```
//Chapter-7 example 2
//=====================================================================

clc;
clear;
//input data
BW    = 1*10^9;//bandwidth of pulsed radar in hz

//Calculations
Tint  = 1/BW;//radar integration time in sec
//Output
mprintf('Radar integration time is %g nsec',Tint*10^9);

//=================end of the program==========================================
```

Scilab code Exa 7.5 FINDING RANGE RESOLUTION

```
//Chapter-7 example 5
//=====================================================================

clc;
clear;
//input data
BW     = 0.5*10^9;   //Bandwidth of waveform in Hz
PW     = 5*10^-3;    //pulse width in sec
Vo     = 3*10^8;     //velocity of EM wave

//Calculations

```

```
RR      = (Vo*PW)/2 ; //Range Resolution in m before
    compression

//RR    = Vo*tn1/2 ;
tn1     = 1/BW ;
RRc     = (Vo*tn1)/2 ; //Range Resolution in m after
    compression

//output

mprintf('Range Resolution before compression = %e m\
   n Range Resolution before compression = %3.2f m\n
   ',RR,RRc );
mprintf(' Note: Wrong Calculation in Textbook');
```

Scilab code Exa 7.8 RANGE RESOLUTION BEFORE AND AFTER COMPRESSION

```
//Chapter-7 example 8
//
   ==================================================================

clc;
clear;
//input data
BW      = 0.3*10^9;   //Bandwidth of waveform in Hz
PW      = 3*10^-3;    //pulse width in sec
Vo      = 3*10^8;     //velocity of EM wave

//Calculations

RR      = (Vo*PW)/2 ; //Range Resolution in m before
    compression

//RR    = Vo*tn1/2 ;
tn1     = 1/BW ;
```

```
RRc     = (Vo*tn1)/2 ; //Range Resolution in m after compression

//output

mprintf('Range Resolution before compression = %e m\n Range Resolution before compression = %3.2f m\n',RR,RRc );
```

Scilab code Exa 7.9 FINDING MIN RECEIVABLE SIGNAL

```
//Chapter-7 example 9
//==================================================================================

clc;
clear;
//input data
BW      =  2*10^6;       //Radar Bandwidth in Hz
Fn      =  9;            //Noise Figure in dB
k       =  1.38*10^-23;  //Boltzmann constant
To      =  290;          //Temperature in kelvin

//Antilog Calculation
// 10*log10(Fn)  = 9
//Fn              = antilog(9/10) ;
Fn      = 10^(9/10)

MRS     = k*To*BW*(Fn-1); //Minimum Receivable signal

//Output

mprintf('Minimum Receivable signal(MRS)  = %3.4f PW',MRS*10^12);
mprintf('\n Note: Calculation error in Textbook');
```

Chapter 9

RADAR ANTENNAS

Scilab code Exa 9.1 FINDING BEAMWIDTHS

```
//Chapter-9 example 1
//
    =============================================================================

clc;
clear;
//input data
Da    = 2.5;//diameter of parabolic antenna in m
F     = 5*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s

//Calculations
lamda = Vo/F;//wavelength
NNBW  = 140*(lamda/Da);
HPBW  = 70*(lamda/Da);//half power beamwidth in deg

//Output
mprintf('NNBW of parabolic reflector is %g degrees\n
    HPBW of parabolic reflector is %g degrees',NNBW,
   HPBW);

```

```
//==============end of the program
    ==================================================
```

Scilab code Exa 9.2 FINDING GAIN OF PARABOLIC REFLECTOR

```
//Chapter-9 example 2
//
    ======================================================================

clc;
clear;
//input data
Da    = 2.5;//diameter of parabolic antenna in m
F     = 5*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s

//Calculations
lamda = Vo/F;//wavelength
Gp    = 6.4*(Da/lamda)^2//gain of parabolic
   reflector
G     = 10*log10(Gp)//gain in dB
//Output
mprintf('Gain of parabolic reflector is %3.2f dB',G)
   ;

//==============end of the program
    ==================================================
```

Scilab code Exa 9.3 FINDING NNBW HPBW AND POWER GAIN OF ANTENNA

```
//Chapter-9 example 3
```

```
//==================================================================
clc;
clear;
//input data
Da     = 0.15;//diameter of parabolic antenna in m
F      = 9*10^9;//radar operating frequency in hz
Vo     = 3*10^8;//velocity of EM wave in m/s

//Calculations
lamda = Vo/F;//wavelength
Gp     = 6.4*(Da/lamda)^2//gain of parabolic reflector
G      = 10*log10(Gp)//gain in dB
NNBW   = 140*(lamda/Da);
HPBW   = 70*(lamda/Da);//half power bandwidth in deg

//Output
mprintf('NNBW of parabolic reflector is %3.2f degrees\n HPBW of parabolic reflector is %3.2f degrees\n',NNBW,HPBW);

mprintf(' Gain of parabolic reflector is %3.2f dB',G);

//===============end of the program===============================
```

Scilab code Exa 9.4 FINDING POWER GAIN

```
//Chapter-9 example 4
//==================================================================
```

```
clc;
clear;
//input data
Da    = 2;//diameter of parabolic antenna in m
F     = 2*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s

//Calculations
lamda = Vo/F;//wavelength
Gp    = 6.4*(Da/lamda)^2//gain of parabolic
    reflector
G     = 10*log10(Gp)//gain in dB
//Output
mprintf('Gain of parabolic reflector is %3.2f dB',G)
    ;

//=============end of the program
    ================================================
```

Scilab code Exa 9.5 FINDING MOUTH DIAMETER HPBW AND POWER GAIN OF PARABOLOID

```
//Chapter-9 example 5
//
    ====================================================================

clc;
clear;
//input data
F     = 6*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
NNBW  = 5;//Null to Null beamwidth

//Calculations
lamda = Vo/F;//wavelength

```

```
Da   = 140*(lamda/NNBW);
HPBW  = 70*(lamda/Da);//half power beamwidth in deg
Gp    = 6.4*(Da/lamda)^2//gain of parabolic
   reflector
G     = 10*log10(Gp)//gain in dB

//Output
mprintf('Mouth Diameter of paraboloid is %g m\n HPBW
    of parabolic reflector is %g degrees\n',Da,HPBW)
   ;

mprintf(' Gain of parabolic reflector is %g dB\n
   Gain of parabolic reflector is %g ',G,Gp);

//==============end of the program
   ====================================================
```

Scilab code Exa 9.6 FINDING BEAMWIDTH DIRECTIVITY AND CAPTURE AREA

```
//Chapter-9 example 6
//
   ====================================================================

clc;
clear;
//input data
F     = 9*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
NNBW  = 5;//Null to Null beamwidth
Da    = 5;//diameter of antenna in m

//Calculations
lamda = Vo/F;//wavelength
A     = (%pi*Da*Da)/4;//actural area of antenna
Ac    = 0.65*A;//Capture Area
```

```
D      = 6.4*(Da/lamda)^2;//directivity of antenna
D1      = 10*log10(D)//gain in dB
HPBW   = 70*(lamda/Da);//half power beamwidth in deg
NNBW   = 2*HPBW;//null to null beamwidth

//Output
mprintf('HPBW of parabolic reflector is %g degrees\n
    NNBW of parabolic reflector is %g degrees\n
    Directivity is %g dB\n Capture area is %g m^2',
    HPBW,NNBW,D1,Ac);


//==============end of the program
    ====================================================
```

Scilab code Exa 9.7 FINDING MIN DISTANCE REQUIRED BETWEEN TWO ANTENNAS

```
//Chapter-9 example 7
//
    ==================================================================================
clc;
clear;
//input data
Da     = 5;//diameter of parabolic antenna in m
F      = 5*10^9;//radar operating frequency in hz
Vo     = 3*10^8;//velocity of EM wave in m/s

//Calculations
lamda = Vo/F;//wavelength
R      = (2*Da*Da)/lamda;//min distance b/w antennas
//Output
mprintf('Minimum distance Required is %g m',R);

```

```
//==============end of the program========================================
```

Scilab code Exa 9.8 FINDING MOUTH DIAMETER AND BEAM WIDTH OF ANTENNA

```
//Chapter-9 example 8
//===========================================================================

clc;
clear;
//input data

F      = 4*10^9;//radar operating frequency in hz
Vo     = 3*10^8;//velocity of EM wave in m/s
Gp     = 500;//power gain of antenna
//Calculations
lamda = Vo/F;//wavelength
Da     = lamda*(Gp/6.4)^0.5//diameter of parabolic antenna in m

NNBW   = 140*(lamda/Da);//beamwidth b/w null to null
HPBW   = 70*(lamda/Da);//half power beamwidth in deg

//Output
mprintf('NNBW of parabolic reflector is %3.2f degrees\n HPBW of parabolic reflector is %3.2fdegrees\n',NNBW,HPBW);

mprintf(' Mouth diameter of parabolic reflector is %3.2f m',Da);

//==============end of the program========================================
```

Scilab code Exa 9.9 FINDING CAPTURE AREA AND BEAMWIDTH OF ANTENNA

```
//Chapter-9 example 9
//

clc;
clear;
//input data

F     = 9*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
Gp    = 100;//power gain of antenna in dB
//Calculations
lamda = Vo/F;//wavelength
//antilog calculation
//100 = 10log10(Gp);
//10  = log(Gp);
G     = 10^10;//gain of antenna
Da    = lamda*sqrt(G/6.4)//diameter of parabolic
    antenna in m
A     = (%pi*Da*Da)/4;//Area of antenna
Ac    = 0.65*A;//capture area
NNBW  = 140*(lamda/Da);//beamwidth b/w null to null
HPBW  = 70*(lamda/Da);//half power beamwidth in deg

//Output
mprintf('NNBW of parabolic reflector is %g degrees\n
     HPBW of parabolic reflector is %g degrees\n',
    NNBW,HPBW);

mprintf('\n Mouth diameter of parabolic reflector is
     %3.3f m\n Capture area is %3.2f m^2',Da,Ac);

```

```
//=================end of the program =============================================
```

Scilab code Exa 9.10 FINDING BEAMWIDTH AND POWER GAIN

```
//Chapter-9 example 10
//=======================================================================================
clc;
clear;
//input data
F     = 10*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
Da    = 5;//antenna diameter in m

//Calculations
lamda = Vo/F;//wavelength
Gp    = 6.4*(Da/lamda)^2//gain of parabolic reflector
G     = 10*log10(Gp)//gain in dB

BWFN  = 140*(lamda/Da);//beam width b/n nulls
HPBW  = 70*(lamda/Da);//half power beamwidth in deg


//Output
mprintf('BWFN of parabolic reflector is %g degrees\n HPBW of parabolic reflector is %g degrees\n',BWFN,HPBW);

mprintf(' Gain of parabolic reflector is %g dB ',G);

//=================end of the program =============================================
```

Scilab code Exa 9.11 FINDING POWER GAIN

```
//Chapter-9 example 11
//==================================================================
clc;
clear;
//input data
F     = 10*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
IE    =0.6;//illumination efficiency
Da    =12;//diameter of antenna
//Calculations
lamda = Vo/F;//wavelength
Gp    = IE*(Da/lamda)^2//gain of parabolic reflector
G     = 10*log10(Gp)//gain in dB

//Output
mprintf(' Gain of parabolic reflector is %3.2f dB',G
    );

//==============end of the program
    =========================================
```

Scilab code Exa 9.12 FINDING MOUTH DIAMETER AND CAPTURE AREA

```
//Chapter-9 example 12
//==================================================================
```

```
clc;
clear;
//input data

F     = 4*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
NNBW  = 8;//Null to Null beamwidth in degrees
//Calculations
lamda = Vo/F;//wavelength
Da    = (140*lamda)/NNBW;
A     = (%pi*Da*Da)/4;//Area of antenna
Ac    = 0.65*A;//capture area

//Output
mprintf('\n Mouth diameter of parabolic reflector is
    %3.3f m \n Capture area is %3.2f m^2',Da,Ac);

//==============end of the program
    ================================================
```

Scilab code Exa 9.13 FINDING MOUTH DIAMETER AND POWER GAIN

```
//Chapter-9 example 13
//
    ====================================================================

clc;
clear;
//input data
F     = 4*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
NNBW  = 2;//Null to Null Beamwidth in degrees

//Calculations
lamda = Vo/F;//wavelength
```

```
Da    = (140*lamda)/2;//diameter of antenna in m
Gp    = 6.4*(Da/lamda)^2//gain of parabolic reflector
G     = 10*log10(Gp)//gain in dB


//Output
mprintf('Gain of parabolic reflector is %g dB\n mouth diameter of the antenna is %g m ',G,Da);

//=============end of the program==============================
```

Scilab code Exa 9.14 FINDING BEAMWIDTH AND POWERGAIN

```
//Chapter-9 example 14
//==================================================================================
clc;
clear;
//input data

HPBW  = 6;//Half power Beamwidth in degrees

//Calculations
NNBW  = 2*HPBW;//Null to Null beamwidth in degrees
//HPBW = 70*(lamda/Da);
//(70/HPBW)= (Da/lamda);
Gp    = 6.4*(70/HPBW)^2//gain of parabolic reflector
G     = 10*log10(Gp)//gain in dB


//Output
mprintf('Gain of parabolic reflector is %3.2f dB\n
```

```
    NNBW of the antenna is %g degrees',G,NNBW);

//==============end of the program====================================
```

Scilab code Exa 9.15 FINDING POWER GAIN

```
//Chapter-9 example 15
//==================================================================================
clc;
clear;
//input data
//Da = 6*lamda;

//Calculations

//Gp  = 6.4*(Da/lamda)^2; //power gain

//Gp  = 6.4*(6*lamda/lamda)^2 //power gain of parabolic reflector
Gp    =6.4*(6)^2;
G     = 10*log10(Gp)//gain in dB


//Output
mprintf('Gain of parabolic reflector is %3.2f dB\n',G);

//==============end of the program====================================
```

Scilab code Exa 9.16 FINDING BEAMWIDTH AND DIRECTIVITY OF ANTENNA

```
//Chapter-9 example 16
//
=====================================================================
clc;
clear;
//input data
//Da = 7*lamda; diameter of antenna

//Calculations
//HPBW = 70*(lamda/Da)
//HPBW = 70*(lamda/(7*lamda));
HPBW   = 70/7;//half power beamwidth
NNBW   = 2*HPBW;//null to null beamwidth
//Gp  = 6.4*(Da/lamda)^2; //power gain

//Gp  = 6.4*((7*lamda)/lamda)^2 ;  power gain of
    parabolic reflector
Gp    =6.4*(7)^2;
G     = 10*log10(Gp)//gain in dB


//Output
mprintf('Gain of parabolic reflector is %3.1f \n
   HPBW of Antenna is %3.1f degrees\n NNBW of
   Antenna is %3.1f degrees  ',Gp,HPBW,NNBW);

//==============end of the program
   ==================================================
```

Scilab code Exa 9.17 FINDING BEAMWIDTH POWERGAIN AND DIRECTIVITY

```
//Chapter-9 example 17
```

```
//
  ==================================================================
clc;
clear;
//input data
F      = 8*10^9;//radar operating frequency in hz
Vo     = 3*10^10;//velocity of EM wave in cm/s
D      = 9;//pyramida horn  diameter in cm
W      = 4;//pyramida horn  width in cm
//Calculations
lamda = Vo/F//wavelength in cm
HPBW_E = 56*(lamda/D)//halfpower beamwidth in E-
   plane;
HPBW_H = 67*(lamda/W)//halfpower beamwidth in H-
   plane;
Gp      = (4.5*W*D)/(lamda*lamda);//power gain
G       = 10*log10(Gp);//power gain in dB
Di      =(7.5*W*D)/(lamda*lamda);//directivity


//Output
mprintf('Halfpower beamwidth ib E-plane is %3.2f
   degrees\n Halfpower beamwidth iN H-plane is %3.2f
    degrees\n Powergain is %3.2f dB\n Directivity is
    %3.2f',HPBW_E,HPBW_H,G,Di);


//==============end of the program
  ===============================================
```

Scilab code Exa 9.18 FINDING POWER GAIN OF HORN ANTENNA

```
//Chapter-9 example 18
//
```

```
==================================================================================

clc;
clear;
//input data
//Aperture size = 10*lamda
//Calculations
//Gp = (4.5*W*D)/(lamda*lamda);
//Gp = (4.5*(10*lamda)*(10*lamda))/(lamda*lamda);
Gp   = (4.5*10*10);//power gain of square horn antenna
G    = 10*log10(Gp);//power gain in dB

//Output
mprintf('Power Gain of Square Horn Antenna is %3.2f dB',G);
//==============end of the program ==================================================
```

Scilab code Exa 9.19 FINDING POWER GAIN AND DIRECTIVITY

```
//Chapter-9 example 19
//==================================================================================

clc;
clear;
//input data
F     = 8*10^9;//radar operating frequency in hz
Vo    = 3*10^10;//velocity of EM wave in cm/s
D     = 10;//pyramida horn  diameter in cm
W     = 5;//pyramida horn  width in cm
//Calculations
lamda = Vo/F//wavelength in cm
Gp     = (4.5*W*D)/(lamda*lamda);//power gain
```

```
G       = 10*log10(Gp);//power gain in dB
Di      =(7.5*W*D)/(lamda*lamda);//directivity
DI      =10*log10(Di);//Directivity in dB


//Output
mprintf('Powergain is %3.2f dB\n Directivity is %3.2
   f dB',G,DI);


//==============end of the program
   ==================================================
```

Scilab code Exa 9.20 FINDING COMPLEMENTARY SLOT IMPEDANCE

```
//Chapter-9 example 20
//
   ============================================================================

clc;
clear;
//input data
no     = 377;//Free space intrinsic impedance in ohms
Zd1    = 73+50*%i;//dipole impedance;
Zd2    = 70;//dipole impedance;
Zd3    = 800;//dipole impedance;
Zd4    = 400//dipole impedance;
Zd5    = 50+10*%i;//dipole impedance;
Zd6    = 50-30*%i;//dipole impedance;
Zd7    = 350;//dipole impedance;

//Calculations
K       = (no^2)/4;
//Zs    = (no*no)/(4*Zd); slot impedance
Zs1     = K/Zd1//slot impedance
```

```
Zs2     = K/Zd2;//slot impedance
Zs3     = K/Zd3;//slot impedance
Zs4     = K/Zd4;//slot impedance
Zs5     = K/Zd5;//slot impedance
Zs6     = K/Zd6;//slot impedance
Zs7     = K/Zd7;//slot impedance

//output

mprintf('slot impedance if Zd = 73+i50 ohm is '),
    mprintf( prettyprint(Zs1)),mprintf(' ohm \n');
mprintf(' slot impedance if Zd = 70     ohm is '),
    mprintf( prettyprint(Zs2)),mprintf(' ohm \n');;
mprintf(' slot impedance if Zd = 800    ohm is '),
    mprintf( prettyprint(Zs3)),mprintf(' ohm \n');;
mprintf(' slot impedance if Zd = 400    ohm is '),
    mprintf( prettyprint(Zs4)),mprintf(' ohm \n');;
mprintf(' slot impedance if Zd = 50+i10 ohm is '),
    mprintf( prettyprint(Zs5)),mprintf(' ohm \n');;
mprintf(' slot impedance if Zd = 50-i30 ohm is '),
    mprintf( prettyprint(Zs6)),mprintf(' ohm \n');;
mprintf(' slot impedance if Zd = 350    ohm is '),
    mprintf( prettyprint(Zs7)),mprintf(' ohm \n');;




//==================end of the program
    ==================================================================
```

Scilab code Exa 9.21 FINDING RADIATION RESISTANCE OF HERTZIAN DIPOLE

```
//Chapter-9 example 21
//
    ==========================================================================================
```

```
clc;
clear;
//input data

//dl1   = lamda/20;
//dl2   = lamda/30;
//dl3   = lamda/40;

//Calculations
//Rr   = 80*(pi*pi)*(dl/lamda)^2 Radiation Resistance in ohms
//Rr1 = 80*(pi*pi)*(dl1/lamda)^2 Radiation Resistance in ohms
//Rr1 = 80*(pi*pi)*((lamda/20)/lamda)^2 Radiation Resistance in ohms
Rr1   =80*(%pi*%pi)*(1/20)^2 ;
//Rr2 = 80*(pi*pi)*(dl2/lamda)^2 Radiation Resistance in ohms
//Rr2 = 80*(pi*pi)*((lamda/30)/lamda)^2 Radiation Resistance in ohms
Rr2   =80*(%pi*%pi)*(1/30)^2 ;
//Rr3 = 80*(pi*pi)*(dl3/lamda)^2 Radiation Resistance in ohms
//Rr3 = 80*(pi*pi)*((lamda/40)/lamda)^2 Radiation Resistance in ohms
Rr3   =80*(%pi*%pi)*(1/40)^2 ;


//Output
mprintf('If Hertzian dipole length is lamda/20 then Radiation Resistance = %3.3f ohm\n If Hertzian dipole length is lamda/30 then Radiation Resistance = %3.3f ohm\n If Hertzian dipole length is lamda/40 then Radiation Resistance = %3.3f ohm\n',Rr1,Rr2,Rr3) ;

//==============end of the program==================
```

Scilab code Exa 9.22 DIRECTIVITY OF HALFWAVE DIPOLE

```
//Chapter-9 example 22
//
=============================================================================

clc;
clear;
disp('For half wave dipole Emax  =  60I/r')
disp('But Pr  = 73 I^2 Watts');
disp('For Pr  = 1 W');
disp('I = 1/sqrt(73)');
disp('Emax = (60/r)*I');
disp('Gdmax = (4*pi*phi)/Pr'),disp('as Pr =1 and phi
    = (r^2)*(E^2)/no')
disp('Gdmax = 4*pi*(r^2)*(E^2)/no');
disp('      = (4*pi*(r^2)*60*60)/(no*r*r*73)' );
disp('      = (4*pi*60*60)/(120*pi*73)');
Gdmax       = 120/73;

mprintf('Directivity of half wave dipole is %3.2f',
   Gdmax );
//==============end of program
=============================================================================
```

Scilab code Exa 9.23 FINDING RADIATED POWER

```
//Chapter-9 example 23
//
=============================================================================
```

```
clc;
clear;
//input data
F   = 12*10^9;//operating frequency in Ghz
I   = 2;//current in amperes
Rr  = 300;//radiation resistance in ohms

//Calculations
Pr  = I*I*Rr;

//output
mprintf('Radiated Power is %3.1f Watts',Pr);

//==================end of the program
    ==================================================
```

Scilab code Exa 9.24 FINDING EFFECTIVE AREA OF HALF WAVE DIPOLE

```
//Chapter-9 example 24
//
    ================================================================================

clc;
clear;
//input data
F     = 600*10^6;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
D     = 1.644;//Directivity of the half wave dipole
//Calculations
lamda = Vo/F;//wavelength
Ae    = (lamda^2*D)/(4*%pi);//effective area of
    antenna
//Output
mprintf('Effective Area of the antenna is %3.4f m^2'
    ,Ae);
```

```

//==============end of the program==================================================
```

Scilab code Exa 9.25 FINDING EFFECTIVE AREA OF HERTZIAN DIPOLE

```
//Chapter-9 example 25
//=====================================================================================

clc;
clear;
//input data
F     = 200*10^6;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s
D     = 1.5;//Directivity of the Hertzian dipole
//Calculations
lamda = Vo/F;//wavelength
Ae    = (lamda^2*D)/(4*%pi);//effective area of antenna
//Output
mprintf('Effective Area of the antenna is %3.4f m^2',Ae);

//==============end of the program==================================================
```

Chapter 11

SOLVED PROBLEMS

Scilab code Exa 11.1 FINDING RECEIVED SIGNAL POWER

```
//Chapter-11 example 1
//
    ========================================================================
clc;
clear;
//Given data
F  = 10*10^9;    //radar operating frequency in Hz
Vo = 3*10^8;     //vel in m/s;
G  = 20;         //antenna gain in dBi;
R  = 20*10^3;    //distance of radar reflected signal
     from target
Pt = 10*10^3      //Tx power in watts
CS = 10;         //cross sectional area in m^2
// Calculations
Gain = 10^(G/10)     //G = 10log(Gain) ==>gain -
   antilog(20/10);
Gr = Gain;  //gain of tx antenna and Rx antenna
Gt = Gain
lamda = Vo/F
Pr= (lamda*lamda*Pt*Gt*Gr*CS)/((4*4*4*%pi*%pi*%pi)*(
```

```
R^4))//received power in watts

// Output
mprintf('Received signal Power is %g',Pr);
mprintf('\n Note : Calculation error in Textbook');
```

Scilab code Exa 11.2 FINDING TARGET DISTANCE FROM RADAR

```
//Chapter-11 example 2
//=====================================================================================

clc;
clear;
Vo = 3*10^8;//velocity of EM wave in m/s
t  = 20*10^-6;//echo time in sec
// calculations

R = (Vo*t)/2;//distance b/n target and Radar in m

// Output
mprintf('Distance of Target from the Radar is %g Km'
,R/1000 );

//==========end of program==========================================================
```

Scilab code Exa 11.3 FINDING MAX AND MIN RANGES OF RADAR

```
//Chapter-11 example 3
```

```
//
   ==================================================================
clc;
clear;
Vo = 3*10^8;//velocity of EM wave in m/s
F  = 0.8*10^3;//pulse repetitive frequency
Tp = 1.2*10^-6;//pulse width in sec
//Calculations
Rmax = Vo/(2*F);//maximum Range of Radar in m
Rmin = (Vo*Tp)/2;//minimum Range of radar in m

//Output
mprintf('Maximum Range of Radar is %g Km\n Minimum
   Range of the Radar is %g m',Rmax/1000,Rmin);

//==========end of program
   ==================================================
```

Scilab code Exa 11.4 FINDING DUTY CYCLE

```
//Chapter-11 example 4
//
   ==================================================================
clc;
clear;
PW  = 1.5*10^-6;//pulse width in sec
PRF = 2000//per second

//Calculations
Dc = PW*PRF;//duty cycle

//Output
```

```
mprintf('Duty Cycle is %e',Dc);
//===========end of program==============================================
```

Scilab code Exa 11.5 FINDING AVERAGE TX POWER

```
//Chapter-11 example 5
//=========================================================================

clc;
clear;
PW  =  2*10^-6//pulse width in sec
PRF =  1000//pulse repetitive frequency
Pp  = 1*10^6;//peak power in watts

//Calculations
Dc   =  PW*PRF;//duty cycle
AvgTp = Pp*Dc;//average transmitted power in watts

//Output
mprintf('Average Transmitted power is %g KW',AvgTp
    /1000);

//===========end of program==============================================
```

Scilab code Exa 11.6 FINDING RANGE RESOLUTION

```
//Chapter-11 example 6
```

```
//
    ====================================================================
clc;
clear;
PW  = 2*10^-6;//pulse width in sec
Vo  = 3*10^8;//velocity of EM wave in m/s

//Calculations

RR  = (Vo*PW)/2;//Range Resolution in m

//Output
mprintf('Range Resolution is %g m',RR);

//=============end of program
    ================================================
```

Scilab code Exa 11.7 FINDING TARGET RANGE

```
//Chapter-11 example 7
//
    ====================================================================
clc;
clear;
t   = 50*10^-6;//echo time in sec
Vo  = 3*10^8;//velocity of EM wave in m/s

//Calculations

R  = (Vo*t)/2;//Range in m

//Output
```

```
mprintf('Target Range is %g Kms',R/1000);

//==========================end of program==================================================================
```

Scilab code Exa 11.8 FINDING DOPPLER SHIFT

```
//Chapter-11 example 8
//=======================================================================================================

clc;
clear;
//input data
Tvel  = 1000;//target speed in kmph
F     = 10*10^9;//radar operating frequency in hz
Vo    = 3*10^8;//velocity of EM wave in m/s

//Calculations
Vr    = 1000*(5/18);//target speed in m/s
Fd    = (2*Vr*F)/Vo;//Doppler Frequency shift in Hz

//Output
mprintf('Doppler Frequency shift Caused by aircraft is %3.2f KHz',Fd/1000);

//==========================end of the program==========================================================
```

Scilab code Exa 11.9 FINDING DOPPLER SHIFT FREQUENCY

```
//Chapter-11 example 9
```

```
//
    ==========================================================================

clc;
clear;
//input data
F  = 6*10^9;//Transmitting Frequency of Radar
Vr = 250;//velocity of automobile in Kmph
Vo    = 3*10^8;//velocity of EM wave in m/s

//Calculations

Va    = Vr*(5/18)//velocity of automobile in m/s
Fd    = (2*Va*F)/Vo//Doppler Frequency shift in Hz

//Output
mprintf('Doppler Frequency shift is %3.3f KHz',Fd
    /1000)

//=================end of the program
    ==========================================================
```

Scilab code Exa 11.10 FINDING DOPPLERSHIFT FREQUENCY AND FREQ OF RELECTED ECHO

```
//Chapter-11 example 10
//
    ==========================================================================

clc;
clear;
//input data
F  = 9*10^9;//Transmitting Frequency of Radar
Vr = 800;//velocity of aircraft in Kmph
Vo = 3*10^8;//velocity of EM wave in m/s

```

```
//Calculations

Va    = Vr*(5/18)//velocity of aircraft in m/s
Fd    = (2*Va*F)/Vo//Doppler Frequency shift in Hz
Fr    = F+Fd;//frequency of reflected echo in Hz
//Output
mprintf('Doppler Frequency shift is %g Hz\n
    frequency of reflected echo is %e Khz\n',Fd,Fr
    /1000)
mprintf('Note: doppler frequency shift wrongly
    printed in Text Book as 1333.3 Hz');
//===============end of the program
    ==================================================
```

Scilab code Exa 11.11 FINDING DOPPLER SHIFT FREQUENCY AND FREQUENCY OF REFLECTED S

```
//Chapter-11 example 11
//
    ============================================================================

clc;
clear;
//input data
F  = 2*10^9;//Transmitting Frequency of Radar
Vr = 350;//velocity of sports Car in Kmph
Vo = 3*10^8;//velocity of EM wave in m/s

//Calculations

Va    = Vr*(5/18)//velocity of aircraft in m/s
Fd    = (2*Va*F)/Vo//Doppler Frequency shift in Hz
//Car moving away from Radar
Fr    = F-Fd;//frequency of reflected signal in Hz

//Output
```

```
mprintf('Doppler Frequency shift is %g Hz\n frequency of reflected echo is %g Ghz - %g Hz\n',Fd,F/10^9,Fd)
mprintf(' Note: doppler frequency shift wrongly printed in Text Book as 129.6 Hz\n Vr is printed as 9.72 m/s instead of 97.2 m/s');
//=============end of the program==============================================
```

Scilab code Exa 11.12 FINDING AVERAGE POWER

```
//Chapter-11 example 12
//=============================================================================

clc;
clear;
//input data
PRF   =  2000;//pulse repetition frequency per second
PW    =  1*10^-6;//pulse width in sec
Pp    =  500*10^3;//Peak power in watts

//Calculations
Dc    =  PW*PRF;//Duty Cycle
Pav   =  Pp*Dc;//average power in watts
pavdB = 10*log10(Pav);

//Output

mprintf('Average power is %g KW\n Average Power is %g dB',Pav/1000,pavdB);

//=============end of the program==============================================
```

Scilab code Exa 11.13 FINDING DUTY CYCLE AVERAGE POWER AND MAX RANGE OF RADAR

```
//Chapter-11 example 13
//=====================================================================

clc;
clear;
//input data
PRF   =  1000;//pulse repetition frequency per
    second
PW    =  0.8*10^-6;//pulse width in sec
Pp    =  10*10^6;//Peak power in watts
Vo    =  3*10^8;//velocity of EM wave in m/s;

//Calculations
Dc    =  PW*PRF;//Duty Cycle
Pav   =  Pp*Dc;//average power in watts
Rmax  =  Vo/(2*PRF);


//Output

mprintf('Average power is %g KW\n Maximum Radar
    Range is %g Km',Pav/1000,Rmax/1000);

//=============end of the program
    ============================================
```

Scilab code Exa 11.14 FINDING PRF

```
//Chapter-11 example 14
//==================================================================================
clc;
clear;
//input data
Rmax  =  500*10^3;//maximum Range of Radar in ms
Vo    =  3*10^8;//Velocity of EM wave in m/s
//Calculations

PRF   = Vo/(2*Rmax);//pulse repetitive frequency in
   Hz

//output
mprintf('Pulse repetive frequency required for the
   range of 500km is %g Hz',PRF);

//========end of program==========================================================
```

Scilab code Exa 11.15 FINDING RANGE

```
//Chapter-11 example 15
//==================================================================================
clc;
clear;
//input data
Te    =  0.2*10^-3;//echo time in sec
PRF   =  1000;//pulse repetitive Frequency in Hz
Vo    =  3*10^8;//Velocity of EM wave in m/s
//Calculations
```

```
R      =  (Vo*Te)/2;//Range of the target in m
Runamb  =  (Vo/(2*PRF));//Maximum unambiguous Range
    in m

//Output
mprintf('Target range is %g Km\n Maximum Unambiguous
     Range is %g Km',R/1000,Runamb/1000);

//====================end of program
    ==================================================
```

Scilab code Exa 11.16 FINDING FREQUENCIES

```
//Chapter-11 example 16
//
    ==================================================

clc;
clear;
//input data
F      = 10*10^9;//operating frequency of radar in Hz
Vo     =  3*10^8;//Velocity of EM wave in m/s
Vr     =  100;//velocity of car in kmph
//Calculations
lamda = Vo/F;//wavelength in m
Vc     = Vr*(5/18);//velocity of car in m/s
Fd     = (2*Vc)/lamda;//doppler shift in Hz
//Output
mprintf('Doppler Shift is %g KHz\n Frequency of the
    Received echo when car is approaching radar is %g
     Ghz + %g Khz\n Frequency of the Received echo
    when car is moving away from radar is %g Ghz - %g
     Khz',Fd/1000,F/10^9,Fd/1000,F/10^9,Fd/1000);

//====================end of program
```

```
==================================================
```

Scilab code Exa 11.17 FINDING BEAMWIDTH

```
//Chapter-11 example 17
//======================================================================
clc;
clear;
//input data
D   =  200;//azimuth distance between two radars
R   =  10*10^3;//Range of radar

//Calculations
BWdB = (D/R)*(180/%pi);//3dB beam width in degrees

//Output
mprintf('Maximum 3db beamwidth of radar resolving
   the target is %3.3f degrees',BWdB);

//==============end of the program
   ===================================================
```

Scilab code Exa 11.18 FINDING MIN TIME REQUIRED TO RESOLVE AIRCRAFTS

```
//Chapter-11 example 18
//======================================================================
clc;
clear;
//input data
```

```
F      = 10*10^9;//operating frequency of radar in Hz
Vo     =  3*10^8;//Velocity of EM wave in m/s
Vr1     =  100;//velocity of one aircraft in m/s
theta  = 45;//angle b/n velocity vector and radar axis for second aircraft
Vr     = 200;//vel in m/s
//Calculations
lamda = Vo/F;//wavelength in m
Fd1    = (2*Vr1)/lamda//doppler shift due to 1st aircraft
Vr2    = Vr*cos(45*%pi/180)//radial velocity of the second aircraft
Fd2    = (2*Vr2)/lamda//doppler shift due to 2nd aircraft
Fd     = Fd2-Fd1//difference in doppler shift in Hz
T      = 1/Fd;//time required to resolve the aircraft in sec

//Output
mprintf('Minimum time required to resolve the aircrafts is %g usec\n',T*10^6);
mprintf(' Note: in textbook there is a mistake in the calculation of doppler shift Fd1');
//=============end of the program==========================================
```

Scilab code Exa 11.19 FINDING DUTY CYCLE CORRECTION FACTOR

```
//Chapter-11 example 19
//=============================================================================
clc;
clear;
//input data
```

```
Pp  = 100*10^3;//peak power in watts
Pav = 100;//average power in watts

//Calculations
PdB = 10*log10(Pp);//peak power in dB
PavdB = 10*log10(Pav);//average power in dB;
DCC  = PdB-PavdB;//Duty Cycle Correction factor

//Output
mprintf('Duty Cycle Correction Factor is %g dB\n',
   DCC);
mprintf(' Note: In question given peak power  is 100
   KW but while solving 1KW is taken instead of 100
   KW')

//============end of the program
   ===============================================
```

Scilab code Exa 11.20 FINDING AVERAGE POWER DUTY CYCLE AND PULSE ENERGY

```
//Chapter-11 example 20
//
   ===================================================================

clc;
clear;
//input data
Pp   = 1*10^6;//peak power in watts
PW   = 1*10^-6;//pulse width in sec
NPd   = 20;//pulses in one dwell period
PRF  = 1000;//pulse repetitive frequency

//calculations
PE   = Pp*PW;//pulse energy in joule
PED  = NPd*PE;//pulse energy in one dwell period
```

```
D    = PW*PRF;//Duty cycle
Pav  = Pp*D;//average power in watts

//output
mprintf('Average Power is %g watts\n Duty Cycle is %e\n Pulse Energy is %g Joules\n Pulse Energy in one Dwell Period is %g Joules\n',Pav,D,PE,PED);
mprintf(' Note: In textbook Values of PRF and pulses in one dwell period are varied from given values in question while solving ');
;
//================end of the program================================
```

Scilab code Exa 11.21 FINDING NOISE POWER SPECTRAL DENSITY

```
//Chapter-11 example 21
//==========================================================================

clc;
clear;
//input data
Noise_power = -50;//noise power in dBm
Fl = 1*10^6;//lower cutoff frequency in Hz
Fh = 21*10^6;//upper cutoff frequency in Hz

//calculation
BW = Fh-Fl;//bandwidth
NP =10^-8//noise power in watts; -50dBm = 10log10(NP) =>10^-5 mwatts
NPSD = NP/BW;//noise power spectral density in W/Hz

//output
mprintf('Noise Power Spectral Density is %3.0e W/Hz'
```

```
,NPSD);

//==================end of the program===========================================================
```

Scilab code Exa 11.22 FINDING RANGE OF TARGET

```
//Chapter-11 example 22
//=====================================================================================

clc;
clear;
//input data
Ra = 1000;//Range of target A in Kms
//Calculations
Rb =Ra*cos(45*%pi/180);//range of target B in kms

//output
mprintf('Range of target B is %g Kms\n',Rb);
mprintf(' Note:value of cos(45) is incorrectly taken as 1/2 in textbook');

//==========================end of the program==================================================
```

Scilab code Exa 11.23 FINDING RANGE OF TARGET

```
//Chapter-11 example 23
//=====================================================================================

clc;
```

```
clear;
//input data
Az = 60;//azimuth angle of the target in degrees
Height = 10;//height of target in kms
//Calculations
R = 10/sin(Az*%pi/180);

//output
mprintf('Range of the Target is %g Kms',R);

//==========end of the program ==================================================
```

Scilab code Exa 11.24 FINDING TARGET BLIND SPEED

```
//Chapter-11 example 24
//==================================================================================

clc;
clear;
//input data
F = 10*10^9;//MTI radar operating Frequency
Vo = 3*10^8;//velocity of EM wave in m/s;
PRF = 2*10^3;//pulse repetitive frequency in hz
n=1;//for lowest blind speed
//Calculations
lamda = Vo/F;//wavelength in m
BS   =(n*lamda/2)*PRF;//blind speed

//output
mprintf('Lowest Blind Speed is %g m/s',BS);

//==========end of the program ==================================================
```

Scilab code Exa 11.25 RATIO OF OPERATING FREQUENCIES

```
//Chapter-11 example 25
//
    =====================================================================

clc;
clear;
//input data
PRF = 2*10^3;//pulse repetitive frequency in Hz
Vo  = 3*10^8;//velocity of EM wave in m/s
mprintf('f1 = first operating frequency of MTI Radar
    \n');
mprintf(' f2 = second operating frequency of MTI
    Radar\n');
mprintf(' 2nd blind speed of 1st radar = (2Vo/2f1)*
    PRF\n 5th blind speed of 2nd radar = (5Vo/2f2)*
    PRF\n');
mprintf(' PRF(V0/f1) = (5/2)*(Vo/f2)*PRF\n');
mprintf(' (f2/f1) = 5/2\n');

//===============end of the program
    ================================================
```

Scilab code Exa 11.26 RATIO OF OPERATING FREQUENCIES

```
//Chapter-11 example 26
//
    =====================================================================

clc;
```

```
clear;
//input data
mprintf('(PRF1)  =  2(PRF2)\n');
mprintf(' Vb3 = 4Vb5\n');
mprintf(' (3Vo/2F1)(PRF1)) = 4(5Vo/2F2)(2PRF2)\n');
mprintf(' 3/2F1  =  20/F2\n');
mprintf(' Ratio of operating frequencies is F2/F1  = 40/3\n');

//==================end of the program====================================================
```

Scilab code Exa 11.27 FINDING COMPRESSION RATIO AND COMPRESSED PULSE WIDTH

```
//Chapter-11 example 27
//=============================================================================

clc;
clear;
//input data
PW  = 5;//FM pulse width before compression in us
Fl  = 40;//lower cut off Frequency in Mhz
Fh  = 60;//upper cut off Frequency in Mhz

// Calculations
BW   = Fh-Fl;//bandwidth of signal in Mhz
CPW  = 1/BW;//Compression pulse width in us
CR   = PW/CPW;//compression ratio

//output
mprintf('Compression ratio is %g\n Compression Pulse Width is %g us\n',CR,CPW);
//================end of the program====================================================
```

Scilab code Exa 11.28 FINDING COMPRESSION PULSEWIDTH AND RATIO

```
//Chapter-11 example 28
//==================================================================================
clc;
clear;
//input data
BW = 100//band width in Mhz
PW = 4;//pulse width in us
//Calculations
CPW  = 1/BW;//compressed pulse width in us
CR   = PW/CPW;//compression ratio

//output
mprintf('compressed pulse width is %g us\n compression ratio is %g\n',CPW,CR);
mprintf(' Note: In textbook compression ratio is wrongly printed as 40');

//==========================end of the program==============================
```

Scilab code Exa 11.29 FINDING COMPRESSED PULSE WIDTH AND BANDWIDTH

```
//Chapter-11 example 29
//==================================================================================
clc;
```

```
clear;
//input data
CR = 50;//compression ratio
PW = 2;//pulse width in us
//Calculations
CPW = PW/CR //compression pulse width in us
BW  = 1/CPW //compression band width in Mhz

//output
mprintf('compressed pulse width is %g us\n
   compression Bandwidth is %g MHz\n',CPW,BW);


//======================end of the program
   ===========================================
```

Scilab code Exa 11.30 FINDING RANGE RESOLUTION

```
//Chapter-11 example 30
//
   ======================================================================

clc;
clear;
//input data
PW  = 1*10^-6;//transmitted pulse width in sec
Vo  = 3*10^8;//velocity of EM wave in m/s

//Calculations
RR  = (Vo*PW)/2;
//output
mprintf('Range Resolution is %g m\n',RR);
mprintf(' As the targets are separated by 100m it is
    possible to resolve');
//=================end of program
```

```
=========================================================
```

Scilab code Exa 11.31 FINDING CLOSEST FREQUENCIES

```
//Chapter-11 example 31
//=============================================================================
clc;
clear;
//input data
F = 10*10^9;//operating frequency in Hz
PRF = 1000;//pulse repetitive frequency in Hz
Fm  = PRF;//modulating frequency
//Calculations
Fc1  = F+Fm;//closest frequency in Hz
Fc2  = F-Fm; //closest frequency in Hz
//output
mprintf('Closest Frequencies are %3.3f Mhz and %3.3f
    Mhz',Fc1/10^6,Fc2/10^6  );

//=================end of the program===============================================
```

Scilab code Exa 11.32 FINDING SPECTRUM CENTRE BANDWIDTH AND COMPRESSED PULSE WIDTH

```
//Chapter-11 example 32
//=============================================================================
clc;
clear;
//input data
```

```
F1  = 490;//freq shift lower limit in Mhz
F2  = 510;//freq shift upper limit in Mhz

//calculations

SC = (F1+F2)/2;//Spectrum Centre in Mhz
BW = F2-F1;//bandwidth in Mhz
CPW = 1/BW;//compressed bandwidth in us

//Output
mprintf('Spectrum centre is %g MHz\n BandWidth is %g
    MHz\n Compressed pulse Width is %g us',SC,BW,CPW
    );

//==============end of the program
    ====================================================
```

Scilab code Exa 11.33 FINDING MINIMUM RECEIVABLE SIGNAL

```
//Chapter-11 example 33
//
    ===========================================================================

clc;
clear;
//input data
F           = 9;                //Noise figure in dB
BW          = 2*10^6;           // Bandwidth
To          = 300;              // Temperature in kelvin
K           = 1.38*10^-23;      // Boltzman constant

//Calculations

F1          = 10^(F/10)        //antilog calculation
Pmin        = (K*To*BW)*(F1-1);//minimum receivable
```

```
power

//Output
mprintf('Minimum receivable power Pmin = %e W',Pmin);

//==========================================================================
```

Scilab code Exa 11.34 FINDING MAXIMUM RANGE OF RADAR

```
//Chapter-11 example 34
//==========================================================================
clc;
clear;
//input data
Pt = 500*10^3;//peal pulse power in watts
Pmin = 1*10^-12;//minimum receivable power
Ac   = 5;//area of capture in m^s
RCS  = 16;//radar cross sectional area in m^2
F    = 10*10^9;//radar operating frequency
Vo   = 3*10^8;//vel of Em wave in m/s;

//calculations
lamda = Vo/F;//wavelength

Rmax = ((Pt*Ac*Ac*RCS)/(4*%pi*lamda*lamda*Pmin))^0.25;

//output
mprintf('Maximum Radar range of the Radar system is %g Kms\n',Rmax/1000);
```

```
mprintf(' Note:Calculation mistake in textbook
    instead of RCS,RCS^2 is calculated');
//==================end of the program
    ========================================================
```

Scilab code Exa 11.35 FINDING PEAK TX POWER

```
//Chapter-11 example 35
//
    ====================================================================

clc;
clear;
//input data
lamda           = 0.03;           //wavelength in m
RCS             = 5;              // Radar cross
    section in m^2
D               = 1;              // antenna diameter
    in m
F               = 5;              // noise figure in
   dB
Rmax            = 10*10^3         // Radar range
BW              = 500*10^3;       // bandwidth

//Calculation
F1              = 10^(F/10)       // antilog
    calculation

//Rmax          = 48*((Pt*D^4*RCS)/(BW*lamda*lamda(F
    -1)))^0.25

Pt              = ((Rmax/48)^4)*((BW*lamda*lamda*(F1
    -1))/(D^4*RCS))

//Output
```

```
mprintf('Peak Transmitted Power is %e',Pt);
mprintf('\n Note: Antilog Calculation error in textbook at F')
//
```

Scilab code Exa 11.36 FINDING MAX RANGE OF RADAR

```
//Chapter-11 example 36
//

clc;
clear;
//input data
Pt = 20*10^6;//peak pulse power in watts
RCS  = 1;//radar cross sectional area in m^2
f   = 3*(10^9);//radar operating frequency
Vo   = 3*(10^8);//vel of Em wave in m/s;
D    = 50;//diameter of antenna in m
F    = 2;//receiver noise figure
BW   = 5000;//receiver bandwidth

//calculations

lamda = Vo/f//wavelength in m
Rmax = 48*((Pt*(D^4)*RCS)/(BW*lamda*lamda*(F-1)))^0.25;

//output
mprintf('Maximum Radar range of the Radar system is %g Kms\n ',Rmax/1000);
mprintf('Note:In textbook All values are correctly substituted in calculating Rmax.\n but incorrect
```

```
final answer is printed in the book');

//=============end of the program=================================
```

Scilab code Exa 11.37 FINDING LOWEST BLIND SPEEDS

```
//Chapter-11 example 37
//=================================================================
clc;
clear;
//Given data
lamda     = 6*10^-2;     //Wavelength in m
PRF       = 800;         //Pulse Repetitive frequency in Hz
n1        = 1 ;          //n value for first blind speed
n2        = 2 ;          //n value for first blind speed
n3        = 3 ;          //n value for first blind speed

//Calculations

//Vb      = (n*lamda/2)*PRF;    Blind speed of the Radar

//For n = 1

Vb1       = (n1*lamda/2)*PRF;    //Blind speed of the Radar in m/s
Vb2       = (n2*lamda/2)*PRF;    //Blind speed of the Radar in m/s
```

```
Vb3         = (n3*lamda/2)*PRF;    //Blind speed of the
    Radar in m/s

//multiply by 18/5 to convert from m/s to kmph

//Output
mprintf('The lowest Blind speeds are %3.1f, %3.2f
   and %3.2f Km/hr',Vb1*(18/5),Vb2*(18/5),Vb3*(18/5)
   );

//=============end of program
   ==================================================
```

Scilab code Exa 11.38 FINDING RANGE OF BEACON

```
//Chapter-11 example 37
//
   ==================================================================

clc;
clear;
//Given data

Pt          = 500*10^3;    // Peak pulse power in Watts
pt          = 50;          // peak power transmitted by
    beacon in watts
f           = 2500*10^6;   // Radar Operating frequency
    in Hz
lamda       = 0.12;        // wavelength in m
D           = 64;          // antenna diameter in m
BW          = 5000;        // Radar Bandwidth
Ab          = 0.51;
k           =  1.38*10^-23;   // Boltzmann constant
F           = 20              // Noise figure
```

```
Fb          = 1.1               // Noise figure of beacon
To          = 290;              // Temperature in kelvin

//Calculations

Ar          = (0.65*%pi*D*D)/4
Rmax        = sqrt((Ar*Pt*Ab)/(lamda*lamda*k*To*BW*(F-1)));  // Max tracking range of radar

Rmax1        = sqrt((Ar*pt*Ab)/(lamda*lamda*k*To*BW*(Fb-1))); // Max tracking range of radar if Fb = 1.1

//output
mprintf('Maximum Tracking Range of Radar is %3.3e Km\n Range of beacon if noise figure is 1.1 = %3.3e Km\n ',Rmax/1000,Rmax1/1000);
mprintf('Note: Calculation mistake in textbook in calculating Range of beacon\n instead of 1.36*10^9 km range is wrongly printed as 136*10^6 km')

//========================end of program========================================
```

Scilab code Exa 11.39 FINDING DOPPLER SHIFT

```
//Chapter-11 example 39
//==================================================================================

clc;
clear;
//Given data
lamda       = 0.06;         // wavelength in m
```

```
Vr          = 100 ;        // Radial velocity of target
    in kmph

//Calculations
Vr1         = Vr*(5/18);  //Radial vel. in m/s
fd          = (2*Vr1)/lamda; //doppler shift

//output

mprintf('Doppler Shift is %3.3f Khz',fd/1000);

//
    ================================================
```

Scilab code Exa 11.40 FINDING RX SIGNAL POWER

```
//Chapter-11 example 40
//
    ================================================

clc;
clear;
//Given data
F   = 9.5*10^9;        //radar operating frequency in
   Hz
Vo  = 3*10^8;         //vel in m/s;
G   = 20;             //antenna gain in dBi;
R   = 50*10^3;        //distance of radar reflected
   signal from target
Pt  = 10*10^3         //Tx power in watts
CS  = 10;             //cross sectional area in m^2

// Calculations
Gain   = 10^(G/10)    //G = 10log(Gain) ==>gain -
```

```
antilog(20/10);
Gr    = Gain;        //gain of tx antenna and Rx antenna
Gt    = Gain
lamda = Vo/F
Pr= (lamda*lamda*Pt*Gt*Gr*CS)/((4*4*4*%pi*%pi*%pi)*(R^4))//received power in watts

// Output
mprintf('Received signal Power is %g Watts',Pr);
//==========================================================================
```

Scilab code Exa 11.41 FINDING DISTANCE OF TARGET

```
//Chapter-11 example 41
//==========================================================================
clc;
clear;
//Given data

Vo    = 3*10^8;        // vel of EM wave m/s;
t     = 10*10^-6;      // time taken to rx echo

//Calculations

R     = (Vo*t)/2;      // Distance of the Target

//output

mprintf('Distance of the target is %3.2f Km',R/1000);
```

```
//
```

Scilab code Exa 11.42 FINDING MIN AND MAX TARGET RANGE

```
//Chapter-11 example 42
//
clc;
clear;
//Given data

PW    = 10^-6;          // Pulse Width in sec
PRF   = 1000;           // Pulse Repetitive Freq in
   Hz
Vo    = 3*10^8;         // vel of EM wave m/s;

//Calculations

Rmax  = Vo/(2*PRF);     // max range of radar
Rmin  = (Vo*PW)/2 ;     // min range of radar

//output
mprintf('Maximum Range of radar is %e m\n Minimum
   Range of radar is %d m',Rmax,Rmin );

//
```

Scilab code Exa 11.43 FINDING DOPPLER SHIFT FREQUENCY

```
//Chapter-11 example 43
//
==========================================================================

clc;
clear;
//Given data
Vr          = 100;        // speed of car in kmph
f           = 10*10^9;    // Radar operating frequency
Vo          = 3*10^8;     // vel. of EM wave

//Calculations

Vr1         = Vr*(5/18); // kmph to m/s conversion
fd          = (2*Vr1*f)/Vo; // Doppler shift in Hz

//Output
mprintf('Doppler shift = %3.2f Khz',fd/1000);

//
==========================================================================
```

Scilab code Exa 11.44 FINDING DISTANCE OF TARGET

```
//Chapter-11 example 44
//
==========================================================================

clc;
clear;
//Given data

```

```
Vo     = 3*10^8;          // vel of EM wave m/s;
t      = 200*10^-6;        // time taken to rx echo

//Calculations

R      = (Vo*t)/2;        // Distance of the Target

//output

mprintf('Distance of the target is %3.2f Km',R/1000);

//
```

Scilab code Exa 11.45 FINDING DUTY CYCLE AND AVERAGE POWER

```
//Chapter-11 example 45
//

clc;
clear;
//Given data
Pt       = 100*10^3;          // Peak tx. power
PRF      = 1000;              // pulse repetitive freq. in Hz
PW       = 1.2*10^-6;         // Pulse Width in sec

//Calculations
DC       = PRF*PW             // Duty cycle
Pav      = Pt*DC              // Avg. power

//Output
```

```
mprintf('Duty cycle is %3.4f\n Average power is %3.0
    f Watts',DC,Pav);

//
    ========================================================
```

Scilab code Exa 11.46 FINDING PRF

```
//Chapter-11 example 46
//
    ========================================================

clc;
clear;
//Given data
Runamb      = 300*10^3;      // unambiguous range in
    m
Vo          = 3*10^8;        // Vel. of EM wave in m/
    s

//Calculations

PRF         = Vo/(2*Runamb); // Pulse repetitive
    freq.

//Output
mprintf('Pulse repetitive frequency = %g Hz',PRF);
//
    ========================================================
```

Scilab code Exa 11.47 FINDING DUTY CYCLE AND MAX UNAMBIGUOUS RANGE

```
//Chapter-11 example 47
//
=================================================================

clc;
clear;
//Given data

Vo     = 3*10^8;          // vel of EM wave m/s;
PRF    = 1000;            // pulse repetitive freq. in
    Hz
PW     = 10^-6;           // Pulse width in sec

//Calculations

DC       = PRF*PW          // Duty cycle

Runamb   = Vo/(2*PRF);       // Distance of the Target

//output

mprintf('Duty cycle = %g\n Maximum unambiguous range
     = %g Km',DC,Runamb/1000 );

//
=================================================================
```

Scilab code Exa 11.48 FINDING MAX UNAMBIGUOUS RANGE AND RANGE RESOLUTION

```
//Chapter-11 example 48
//
=================================================================

clc;
```

```
clear;
//Given data

Vo     = 3*10^8;          // vel of EM wave m/s;
PRF    = 1000;            // pulse repetitive freq. in Hz
PW     = 4*10^-6;         // Pulse width in sec

//Calculations

Runamb   = Vo/(2*PRF);       // Distance of the Target
RR       = (Vo*PW)/2;        // Range Resolution
//output

mprintf('Maximum unambiguous range = %g Km\n Range Resolution = %g m',Runamb/1000,RR );

//==================================================================================
```

Scilab code Exa 11.49 CALCULATING RADAR PARAMETERS

```
//Chapter-11 example 49
//==================================================================================
clc;
clear;
//Given data
f      = 6*10^9;          // Radar operating freq. in Hz
Vo     = 3*10^8;          // vel of EM wave m/s;
PRF    = 1000;            // pulse repetitive freq. in Hz
```

```
PW     = 1.2*10^-6;       // Pulse width in sec
DC     = 10^-3;           // Duty Cycle
Smin   = 5*10^-12;        // min. detectable signal
R      = 60*10^3;         // Max. Range in m
G      = 4000;             // power gain of antenna
Ae     = 1                // effective area in m^2
RCS    = 2                // Radar cross sec. in m^2
//Calculations

lamda    = Vo/f;              // Wavelength in m
PRT      = PW/DC;             // pulse repetitive time
PRF      = 1/PRT;             // Pulse repetitive freq.
Pt       = ((Smin*(4*%pi*R*R)^2))/(Ae*G*RCS);  //Peak power
Pav      = Pt*DC;             // average power

Runamb   = Vo/(2*PRF);        // Distance of the Target
RR       = (Vo*PW)/2;         // Range Resolution
//output

mprintf('Operating Wavelength = %g m\n PRT = %3.2f ms\n PRF = %3.1f Hz\n Peak power = %3.3f KW\n Average power = %3.3f Watts\n unambiguous range = %g Km\n Range Resolution = %g m',lamda,PRT*1000,PRF,Pt/1000,Pav,Runamb/1000,RR );
mprintf('\n Note: Calculation error in textbook for Pt and Pav');

//
```

Scilab code Exa 11.50 FINDING AVERAGE POWER

```
//Chapter-11 example 50
```

```
//
    ====================================================================
clc;
clear;
//Given data

Vo    = 3*10^8;          // vel of EM wave m/s;
PRT   = 1.4*10^-3;       // pulse repetitive time. in
   sec
PW    = 5 *10^-6;            // Pulse width in sec
Pt    = 1000*10^3;       //Peak power in watts

//Calculations

DC      = PW/PRT              // Duty cycle
Pav     = Pt*DC               // avg. power in W

//output

mprintf('Duty cycle = %e\n Average power = %g W',DC,
   Pav );

//
    ====================================================================
```

Scilab code Exa 11.51 FINDING MIN RECEIVABLE SIGNAL

```
//Chapter-11 example 51
//
    ====================================================================
clc;
clear;
```

```
//Given data
F        = 5;              // Noise Figure in dB
BW       = 1.2*10^6;       // Bandwidth in Hz
T        = 290;            // Ambient temp in kelvin
K        = 1.38*10^-23;    // boltzmann constant

//Calculations
F1       = 10^(5/10) ;      // antilog calc of noise figure
Prmin    = K*(F1-1)*T*BW; // min. rx. signal

//Output
mprintf('Minimum Receivable signal = %3.4e W\n ', Prmin);
mprintf('Note:In textbook All values are correctly substituted in calculating Prmin.\n but incorrect final answer is printed in the book')

//
```

Scilab code Exa 11.52 FINDING MAX RANGE OF RADAR

```
//Chapter-11 example 52
//
clc;
clear;
//input data
Pt   = 1*10^6;          //peak pulse power in watts
Pmin = 1*10^-12;        //minimum receivable power
Ae   = 16;              //effective area in m^s
RCS  = 4;               //radar cross sectional area
```

```
    in m^2
F     = 9*10^9;          //radar operating frequency
Vo    = 3*10^8;          //vel of Em wave in m/s;
G     = 5000;            //Power gain of antenna

//calculations

Rmax = ((Pt*G*Ae*RCS)/(16*%pi*%pi*Pmin))^0.25;

//output
mprintf('Maximum Radar range of the Radar  is %g Kms
    ',Rmax/1000);

//=================end of the program
    ====================================================
```

Scilab code Exa 11.53 FINDING MAX RANGE OF RADAR

```
//Chapter-11 example 53
//
    ====================================================================

clc;
clear;
//input data
Pt = 500*10^3;//peal pulse power in watts
Pmin = 1*10^-12;//minimum receivable power
Ac   = 5;//area of capture in m^s
RCS  = 20;//radar cross sectional area in m^2
F    = 10*10^9;//radar operating frequency
Vo   = 3*10^8;//vel of Em wave in m/s;
lamda = 3*10^-2;//wavelength in cms

//calculations

```

```
Rmax = ((Pt*Ac*Ac*RCS)/(4*%pi*lamda*lamda*Pmin))^0.25;

//output
mprintf('Maximum Radar range of the Radar system is %g Kms',Rmax/1000);

//================end of the program================================
```

Scilab code Exa 11.54 FINDING BEAMWIDTH OF ANTENNA

```
//Chapter-11 example 54
//=============================================================================

clc;
clear;
//input data
f         = 10*10^9;       // operating freq. of radar in Hz
Vo        = 3*10^8;        //vel of Em wave in m/s;
D         = 5;             //Diameter of antenna in m

//calculations
lamda     = Vo/f;          // wavelength in m
BW        = 70*(lamda/D)   // BeamWidth in degrees

//output
mprintf('Beamwidth  = %3.3f degrees',BW);
//=============================================================================
```

Scilab code Exa 11.55 FINDING OPERATING FREQ PEAK POWER AND RANGE OF RADAR

```
//Chapter-11 example 55
//=============================================================================
clc;
clear;
//input data
Pav  = 200;//average power in watts
PRF  = 1000;//pulse repetitive frequency in Hz
PW   = 1*10^-6;//pulse width in sec
Pmin = 1*10^-12;//minimum receivable power
Ac   = 10;//area of capture in m^s
RCS  = 2;//radar cross sectional area in m^2
Vo   = 3*10^8;//vel of Em wave in m/s;
lamda = 0.1;//wavelength in cms

//calculations
F    = Vo/lamda;//operating frequency in hz
Pt   = Pav/(PRF*PW);

Rmax = ((Pt*Ac*Ac*RCS)/(4*%pi*lamda*lamda*Pmin))
    ^0.25;

//output
mprintf('Operating frequency is %g Ghz\n Radar peak
    power is %g KW\n Maximum Radar range of the Radar
    system is %g Km\n',F/10^9,Pt/1000,Rmax/1000);

//===============end of the program
    ==========================================================
```

Scilab code Exa 11.56 FINDING RADIAL VELOCITY OF TARGET

```
//Chapter-11 example 56
//
=====================================================================
clc;
clear;
//input data
f       = 9*10^9;        // operating freq. of radar
    in Hz
Vo      = 3*10^8;        //vel of Em wave in m/s;
fd      = 1000;          // doppler shift freq. in Hz

//Calculations
lamda   = Vo/f;         // Wavelength in m
Vr      = lamda*fd/2;   // radial velocity of target

//output
mprintf('Radial velocity of target Vr = %3.2f m/s',
    Vr);

//
=====================================================================
```

Scilab code Exa 11.57 FINDING DOPPLER SHIFT FREQUENCY

```
//Chapter-11 example 57
//
=====================================================================
```

```
clc;
clear;
//input data
f       = 10*10^9;       // operating freq. of radar in Hz
Vr      = 800;           // radial ve. of of aircraft in kmph
Vo      = 3*10^8;        //vel of Em wave in m/s;

//calculations

lamda   = Vo/f;          // Wavelength in m
Vr1     = Vr*5/18        // kmph to m/s conversion
fd      = 2*Vr1/lamda;   // Doppler shift freq, in Hz

//Output
mprintf('Doppler shift frequency fd = %3.2e Hz',fd);

//
```

Scilab code Exa 11.58 FINDING DOPPLER SHIFT FREQUENCIES

```
//Chapter-11 example 58
//

clc;
clear;
//input data
f       = 6*10^9;        // operating freq. of radar in Hz
Vr      = 600;           // radial ve. of of aircraft in kmph
```

```
Vo      = 3*10^8;        //vel of Em wave in m/s;

//calculations

lamda   = Vo/f;          // Wavelength in m
Vr1     = Vr*5/18        // kmph to m/s conversion
fd      = 2*Vr1/lamda;   // Doppler shift freq, in Hz

V       = Vr1*cos((45*%pi/180)) // vel in direction of radar if  target direction changes by 45 deg
fd1     = 2*V/lamda ;    //doppler shift freq. in Hz


//Output
mprintf('Doppler shift frequency fd = %3.2f KHz\n Doppler shift frequency if the target changes its direction by 45deg = %3.2f KHz',fd/1000,fd1/1000);

//==========================================================================
```

Scilab code Exa 11.59 FINDING BLIND SPEED

```
//Chapter-11 example 59
//==========================================================================
clc;
clear;
//Given data
lamda     = 3*10^-2;     //Wavelength in m
PRF       = 1000;        //Pulse Repetitive frequency in Hz
```

```
n          = 1'            // n value for lowest blind
   speed

//Calculations
Vb         = (n*lamda/2)*PRF;    //Blind speed of the
   Radar in m/s

//Output
mprintf('Lowet blind speed = %d m/s',Vb);
//
   ============================================================
```

Scilab code Exa 11.61 FINDING PULSE WIDTH AND PULSE ENERGY

```
//Chapter-11 example 60
//
   ============================================================

clc;
clear;
//Given data
PRF1         = 10*10^3;           //pulse repetitive
   freq.1
PRF2         = 20*10^3;           //pulse repetitive
   freq.2
Pav          = 1000;              // average tx. power
Pt           = 10*10^3;           // peak power

//Calculations
PRT1         = 1/PRF1;            // pulse repetitive
   interval in sec
PRT2         = 1/PRF2;            // pulse repetitive
   interval in sec
DC           = Pav/Pt;            // duty cycle
```

```
PW1          = DC*PRT1           // pulse width for freq1
PW2          = DC*PRT2           // pulse width for freq2
E1           = Pt*PW1;            // energy of first pulse
E2           = Pt*PW2;            // energy of second pulse

//output
mprintf('PW1 = %3.2f ms\n PW2 = %3.3f ms\n Pulse Energy for PRF = 10KHz is %3.1f Joules\n Pulse Energy for PRF = 20KHz is %3.2f Joules\n',PW1*1000,PW2*1000,E1,E2 );
//==================================================================================
```

Scilab code Exa 11.62 FINDING PRT PRF RANGE RESOLUTION AND PULSE WIDTH

```
//Chapter-11 example 62
//==================================================================================
clc;
clear;
//Given data
Runamb      = 150*10^3;       // unambigiuous range in m
BW          = 10^6;           // bandwidth in Hz
Vo          = 3*10^8;            //vel of Em wave in m/s;

//Calculations
PRF          = Vo/(2*Runamb) ;    //pulse repetitive
```

```
    freq. in Hz
PRT          = 1/PRF;            // pulse repetition
    interval
RR           = Vo/(2*BW);        // Range Resolution
PW           = (2*RR)/Vo;        //Pulse width in sec

//Output
mprintf('PRF = %3.2f Hz\n pulse repetition interval
    = %3.1f ms\n Range Resolution = %d m\n PulseWidth
     = %3.2f us',PRF,PRT*1000,RR,PW*10^6 );

//
    ===================================================================
```

Scilab code Exa 11.63 FINDING DOPPLER FREQUENCY

```
//Chapter-11 example 63
//
    ===================================================================

clc;
clear;
//Given data
Vr      = 300;          // Velocity of radar in m/s
Vair    = 200;          // veloccty of aircraft in m/
    s
f       = 10*10^9;      // Radar operating frequency
Vo      = 3*10^8;       //vel of Em wave in m/s;

//Calculations

lamda   = Vo/f;         // wavelength in m
Vrel    = Vr+Vair;      //relative radial vel. b/w
    radar and aircraft when approaching each other
```

```
fd      = (2*Vrel)/lamda// Doppler frequency

//Output
mprintf('Doppler frequency = %3.2f KHz',fd/1000);
//
```

Scilab code Exa 11.64 FINDING MAX RANGE OF RADAR

```
//Chapter-11 example 63
//

clc;
clear;
//Given data
Pt      = 2*10^6;         //Peak power in Watts
G       = 45;             // antenna gain in dB
f       = 6*10^9;         // operating frequency
Te      = 290;            // effective temp in kelvin
SNRmin  = 20;             // min SNR in dB
PW      = 0.2*10^-3       // pulse width in sec
F       = 3;              // Noise Figure
B       = 10*10^3;        // bandwidth in KHz
RCS     = 0.1;            // Radar cross section in m^2
K       = 1.38*10^-23;    // boltzman constant
Vo      = 3*10^8;         //vel of Em wave in m/s;

//antilog acalculations
G1     = 10^(45/10);      // antilog conversion of gain
SNR    = 10^(20/10);      // antilog conversion of SNRmin
```

```
F1      = 10^(3/10);       // antilog conversion of Noise Figure

lamda   = Vo/f;            //wavelength in m
Rmax    = ((Pt*G1*G1*lamda*lamda*RCS)/((64*%pi*%pi*%pi)*(K*Te*B*F1*SNR)))^0.25;
//pt1     = 10*log10(Pt)
//lamda1  = 10*log10(lamda^2)
//G2      = 2*G
//KTB     = 10*log10(K*Te*B)
//RCS1    = 10*log10(RCS)
//p       = 10*log10((4*%pi)^3)
//R4max   = [pt1+G1+lamda1+RCS1-p-KTB-F-SNRmin];

//Output
mprintf('Maximum Range of the Radar is %3.2f Km',Rmax/100);
mprintf('\n Note: Calculation error i Textbook in multiplying K*Te*B');
```

Scilab code Exa 11.65 FINDING APERTURE SIZE AND PEAK POWER OF TXR

```
//Chapter-11 example 63
//==================================================================================

clc;
clear;
//Given data
G         = 50;             // antenna gain in dB
f         = 6*10^9;         // operating frequency
Te        = 1000;            // Noise temp in kelvin
SNR       = 20;             // min SNR in dB
L         = 10;             // Losses in dB
F         = 3;              // Noise Figure in dB
```

```
RCS      = -10;          // Radar cross section in dB
K        = 1.38*10^-23;  // boltzman constant
Vo       = 3*10^8;       //vel of Em wave in m/s;
DC       = 0.3;          // Duty cycle
R        = 300*10^3;     // Range in kms
Pav      = 1000;         // Average power in watts
SV       = 20;           //search volume
Ts       = 3;            //Scan time

//calculations

Pav1     = 10*log10(Pav)              //conversion to dB
KT        = 10*log10(Te*K)              //conversion to dB
R4       = 10*log10(R^4)              //conversion to dB
Ts1      = 10*log10(Ts)               //conversion to dB
//SNR    = (Pav*A*RCS*Ts)/(16*R^4*K*Te*L*F*SV)
A        = (SNR-Pav1-Ts-RCS+16+R4+KT+L+F+SV);//aperture
Pt       = Pav/DC;                        // peak ower in watts
//A1      =10^(A/10);                     // antilog calculation

//output
mprintf('A = %3.2f dB\n Peak power Pt = %3.2f KW\n',A,Pt/1000);
//mprintf('A = %3.2f m^2\n',A1)
mprintf(' Note: calculation error in textbook at KT')
//
```