

Scilab Textbook Companion for
Microwaves and Radar Principles and
Applications
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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Introduction To Microwaves

Scilab code Exa 1.1 Finding dielectric constant of medium

```
1 // Chapter 1 example 1
2 //


---


3 clc;
4 clear;
5
6 // Given data
7 R = 1.2; // ratio of free space wavelength of
           a microwave signal to its wavelength when prop.
           through a dielectric medium
8
9 // Calculations
10 // lamda = lamda0/sqrt(er);
11 // er = (lamda0/lamda)^2;
12 // let lamda0/lamda = R
13
14 er = (R)^2; // Dielectric constant of medium
15
16 // Output
17 mprintf('The Dielectric constant of medium = %3.2f',
```

```
er );  
18 //
```

Scilab code Exa 1.2 Finding height of antenna

```
1 // Chapter 1 example 2  
2 //  
3 clc;  
4 clear;  
5 // Given data  
6 Rmax      = 112;      // Max permissible range in  
   Kms  
7 H1        = 256;      // Ht of the antenna in m  
8 // Calculations  
9 // Rmax = 4(sqrt(H1) + sqrt(H2));  
10 // H2    = ((Rmax/4)-sqrt(H1))^2;  
11 H2      = ((Rmax/4)-sqrt(H1))^2;      // Ht of other  
   antenna  
12 // Output  
13 mprintf('Height of other antenna = %d m',H2);  
14 //
```

Chapter 2

Maxwells Equations

Scilab code Exa 2.1 Finding magnetic field intensity

```
1 // chapter 2 example 1
2 //


---


3 clc;
4 clear;
5 // r1 = 3; // relative permeability of region
6 // r2 = 5; // relative permeability of region
7 // H1 = (4ax + 3ay -6az)A/m; Magnetic field
8 // Therefore B1 = o r1 H1
9 // = o (12ax + 9ay -18az)A/m
10 // since normal component of (B) is continuous
11 // across the interface
12 // Therefore, B2 = o [12ax + 9( r2 / r1 )ay -18(
13 // r2 / r1 )az]
14 // = o [12ax + 15ay - 30az]
15 // H2 = [12/5ax + 15/5ay - 30/5az]A/m
16 // H2 = (2.4ax + 3ay - 6az)
```

```

15 H2      = sqrt(2.4^2 + 3^2 + 6^2);
16
17 // output
18 mprintf('Magnetic field intensity in region- 2 = %3
19 //

```

Scilab code Exa 2.2 finding expressions of B and H

```

1 // chapter 2 example 2
2 //

```

```

3 clc;
4 clear;
5 // ur1 = 3
6 // ur2 = 5
7 // B1 = 2ax + ay
8 // choosing the unit normal an = (ay + az)/ 2
9 // |Bn1| = ((2ax + ay)*(ay + az))/ 2 = 1/ 2
10 //Therefore Bn1 = 1/ 2 an = (1/ 2)*(ay + az)/ 2
11 // Also, Bn2 = Bn1 = 0.5ay + 0.5az
12 // the tangential component of B1 is given by
13 // Bt1 = B1 - Bn1 = (2ax + ay) - (0.5ay + 0.5az)
14 //      = 2ax + 0.5ay - 0.5az
15 // this gives Ht1 = (1/ o)((2/3)ax + (0.5/3)ay -
16 //      (0.5/3)az)
17 // Ht1 = (1/ o)*(0.66ax + 0.16ay -0.16az) = Ht2
18 // Bt2 = o r 2 H t 2 = 3.3ax + 0.8ay - 0.8az
19 // now B2 = Bn2 + Bt2 = (0.5ay + 0.5az) + (3.3ax + 0.8
20 //      ay - 0.8az)
21 //      = (3.3ax + 1.3ay - 0.3az)
22 // H2 = (1/ o)*((3.3/5)ax + (1.3/5)ay - (0.3/5)az

```

```

21 // H2 = (1/ o )*(0.66 ax +0.26 ay - 0.06 az)
22 mprintf('B2 = (3.3 ax +1.3 ay - 0.3 az)\n H2 = (1/ o )
    *(0.66 ax +0.26 ay - 0.06 az)' );
23 //

```

Scilab code Exa 2.7 Finding Amplitude of Displacement current density

```

1 // chapter 2 example 7
2 //

```

```

3 clc;
4 clear;
5
6 //      |  ax      ay      az  |
7 // v*H = |      /  x      /  y
           /  z  |
8 //      | 0  10^6 *cos(377t + 1.2566*10^-6z) 0|
9 //      = /  z (10^6 *cos(377t + 1.2566*10^-6z)) ax
10 //      = -1.2566*10^-6 *10^6 sin(377t +1.2566*10^-6 z
    )
11 //      = -1.2566 sin(377t + 1.2566*10^-6z) ax
12 mprintf('Amplitude of displacement current density =
    1.2566 A/m^2');
13 //

```

Scilab code Exa 2.8 Finding amplitude of displacement current density

```

1 // chapter 2 example 8
2 //


---


3 clc;
4 clear;
5
6 //      | ax      ay      az
7 // v*E = |      / x      / y      / z
8 //      | 0      0  80*cos(6.277*10^8t - 2.092y)
9 // Electric flux density D =  oE
10 //      = 8.85*10^-12 *80*cos(6.277*10^8t - 2.092y)ax
11 //      = 708*10^-12 *cos(6.277*10^8 t -2.092y)ax
12 // Displacement current density = D / t
13 // D / t = -708*10^-12*6.277*10^8*sin(6.277*10^8
14 //      t - 2.092y)ax
15 //      = -0.444sin(6.277*10^8t - 2.092y)ax
15 mprintf('Amplitude of displacement current density =
16 //      0.0444 A/m^2');
16 //


---



```

Scilab code Exa 2.9 Finding electric and magnetic field intensity

```

1 // chapter 2 example 9
2 //


---


3 clc;
4 clear;
5

```

```

6 // A = (10^-3 y cos(3*10^8 t) cosz) az
7 // V = 3*10^5 y sin(3*10^8 t) sinz volts
8 uo = 4*%pi*10^-7
9 ur = 1;
10 er = 1;
11
12 // | ax ay az
13 // v*A = | / x / y / z
14 // | 0 0 (10^-3 y cos(3*10^8 t) cosz)
15 // = / y (10^-3 y cos(3*10^8 t) cosz) ax
16 // = 10^-3 ax cos(3*10^8 t) cosz
17 // H = B/(uo r)
18 // H = (10^-3 ax cos(3*10^8 t) cosz)/(4*%pi*10^-7)
19 // H = 796 ax cos(3*10^8 t) cosz
20 // Electric intensity can be computed from
21 // E = -V V - A / t
22 // Now V V = V / x ax + V / y ay + V / z
az
23 // = 3*10^5 sin 3*10^8 t sinz + 3*10^5 y sin3*10^8
t cosz
24 // A / t = -10^-3 * 3*10^8 y sin 3*10^8 t cosz
25 // E = 3*10^5 sin 3*10^8 t sinz + 3*10^5 y sin3
*10^8 t cosz + 3*10^5 y sin 3*10^8 t cosz
26 // E = -3*10^5 sin 3*10^8 t sinz
27 mprintf('magnetic field intensity = 796 ax cos(3*10^8
t) cosz\n Electric field intensity = -3*10^5 sin
3*10^8 t sinz')

```

Scilab code Exa 2.10 Finding amplitude of displacement current density

```

1 // chapter 2 example 10
2 //

```

```

3 clc;
4 clear;
5 // given data
6 // D = 3*10^-7 sin(6*10^7 - 0.35x)az
7 er = 100; // relative permittivity
8
9 // Calculations
10 // D / t = 3*10^-7 * 6*10^7* cos(6*10^7 - 0.35x
    )az
11 A = 3*10^-7 * 6*10^7
12
13 // output
14 mprintf('Amplitude of displacement current density =
    %d A/m^2',A);
15 //

```

Scilab code Exa 2.12 Finding beta and Hm

```

1 // chapter 2 example 12
2 //

```

```

3 clc;
4 clear;
5 // given data
6 // E = 40 e^j(10^9t + z)ax
7 // H = Hm e^j(10^9t + z)ay
8 // w/ = 1/sqrt(e*uo) = 3*10^8
9 w = 10^9; // from given expression
10 b = w/3*10^8
11 Em = 40*%pi // from given expression

```

```

12 // E/H = 120;          // for free space
13
14 Hm = Em/(120*pi);
15 //V * E = - B / t
16 //      =|      ax      ay      az |
17 // V*E =|      / x      / y      /
18 //      t |
19 // V*E = j 40 e^j(10^9t + z) 0 0 |
20 //      = j 40 e^j(10^9t + z) ay      1
21 //      = - B / t = uo* H / t = -j*10^9 *uo*Hm e^j
22 //      (10^9t + z)ay      2
23 // Comparing 1 and 2 shoes that Hm must be negative
24 // Hence Hm = -1/3 A/m
25 mprintf('Hm = - %3.2 f A/m',Hm);
26 //

```

Scilab code Exa 2.13 Finding w and Hm

```

1 // chapter 2 example 13
2 //
3 clc;
4 clear;
5 // given data
6 // E = 20 e^j(wt - z)ax
7 // H = Hm e^j(wt + z)ay
8 lamda = 1.8;          // wavelength in m
9 c      = 3*10^8;      // vel. in m/s
10 er    = 49;          // relative permittivity
11 ur    = 1;           // relative permeability
12 Em    = 20*pi        // from the given expression

```

```

13 // Calculations
14 v      = c/sqrt(er); // velocity of propagation of
    wave in medium with er rel.permitivity
15 w      = (2*pi*v)/lamda;
16 // let k = E/H
17 k = (120*pi)*sqrt(ur/er);
18 Hm = Em/k
19 // sign of Hm can be determined by evaluating the
    maxwells eqn
20 //  $V \cdot E = B / x$ 
21 //  $V \cdot E = -j 2 0 \frac{e^{j(\omega t - z)} \text{ay}}{1}$ 
22 //  $- \frac{B}{x} = -j \omega H_m e^{j(\omega t + z)} \text{ay}$ 
23 // comparing 1 and 2 sign of Hm must be positive
24 mprintf('w = %3.1e rad/s\n Hm = %3.2f A/m',w,Hm);
25 //

```

Scilab code Exa 2.14 Finding amplitude of displacement current density

```

1 // chapter 2 example 14
2 //


---


3 clc;
4 clear;
5 // given data
6 f      = 1000; // frequency in Hz
7 sigma  = 5*10^7; // conductivity in mho/m
8 er     = 1; // relative permittivity
9 eo     = 8.85*10^-12; // permittivity
10 //J    = 10^8 sin(wt-444z)ax A/m^2
11

```

```

12 // Calculations
13 w      = 2*%pi*f
14 // J   = E
15 // E   = 10^8 sin(wt-444z) ax/sigma
16 // E   = 0.2 sin(6280t-444z) ax
17 // D   = eoerE
18 // D   = 8.85*10^-12*0.2 sin(6280t-444z) ax
19 // D / t = 1.77*10^-12*6280 cos(6280t - 444z) ax
20 A      = 1.77*10^-12*6280
21 mprintf('Amplitude of displacement current density =
           %3.2e A/m^2 ',A);
22 mprintf('\n Note: calculation mistake in textbook');
23 //

```

Chapter 3

Transmission Media Transmission lines and Waveguides

Scilab code Exa 3.2 Finding reflection coefficient and SWR

```
1 // Chapter 3 example 2
2 //


---


3 clc;
4 clear;
5 // Given data
6 Lr      = 18;           // return loss in db
7 // Calculations
8 // Lr    = 20*log(1/p);
9 p        = 1/10^(Lr/20); // reflection co-
    efficient
10 swr     = (1 + p)/(1 - p); // standing wave
    ratio
11 // Output
12 mprintf('Reflection co-efficient is %3.3f\n SWR = %3
    .2f ',p,swr);
```

13 //

Scilab code Exa 3.3 Finding min length of cable

```
1 // Chapter 3 example 3
2 //
3 clc;
4 clear;
5 // Given data
6 PW = 30*10^-6; // pulse width in sec
7 ips = 20*10^-6; // inter pulse separation
8 v = 3*10^8; // propagation speed in m/s
9
10 // Calculations
11 T = PW+ips+PW+ips+PW // time duration of the
    pulse train for having 3 pulses on the line at a
    time
12 l = v*T; // minimum length of
    cable required
13
14 // Output
15 mprintf('Minimum length of cable required = %d km',l
    /1000);
16 //
```

Scilab code Exa 3.4 Finding reflection coefficient and characteristic impedance

```

1 // Chapter 3 example 4
2 //


---


3 clc;
4 clear;
5 // Given data
6 RmsVmax    = 100;      // max value of RMS vtg
7 RmsVmin    = 25;      // min value of RMS vtg
8 Zl         = 300;     // load impedance in ohm
9
10 // Calculations
11 VSWR       = RmsVmax/RmsVmin;
12 // wkt VSWR = Zl/Zo; assuming Zl > Zo
13 Zo        = Zl/VSWR;  // charecteristic impedance
    in ohm
14 p         = (Zl - Zo)/(Zl + Zo); // reflection co
    -efficient
15
16 // Output
17 mprintf('Reflection Co-efficient = %3.1f\n
    Charecteristic impedance = %d ohm',p,Zo);
18 //


---



```

Scilab code Exa 3.5 Finding load resistance reflection coefficient and power

```

1 // Chapter 3 example 5
2 //


---


3 clc;
4 clear;
5 // Given data

```

```

6 Zo      = 75;          // charecteristic impedance in
   ohm
7 Vref    = 100;        // reflected voltage
8 Pref    = 100;        // reflected power in watts
9
10 // Calculations
11 Zl      = (Vref)^2 /Pref // load impedance
12 p       = (Zl - Zo)/(Zl + Zo); // reflection co-
   efficient
13 Pinc    = Pref/p      // incident power
14 Pobs    = Pinc - Pref // power obsorbed
15
16 // Output
17 mprintf('Load Resistance = %d ohm\n Reflection Co-
   efficient = %3.3f\n incident power = %d watts\n
   power obsorbed = %d watts',Zl,p,Pinc,Pobs);
18 //

```

Scilab code Exa 3.6 Finding length of line and characteristic impedance

```

1 // Chapter 3 example 6
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 c      = 3*10^8;          // velocity in m/s
7 f      = 100*10^6        // operating frequency in hz
8 Zin    = 100;
9 Zl     = 25;
10
11 // Calculations

```



```

12
13 lamda = c/f           // wavelength in m
14 Lreq  = lamda/4;     // required length in m
15 Zo    = sqrt(Zin*Zl); // charecteristic impedance
    in ohm
16
17 // Output
18 mprintf('Length of line required = %d cm\n
    Charecteristic impedance = %d ohm',Lreq*10^2,Zo);
19 //

```

Scilab code Exa 3.7 Finding input impedance

```

1 // Chapter 3 example 7
2 //

```

```

3 clc;
4 clear;
5 // in the first case when the line is lamda/2 long,
    the i/p impedance is same as the load resistance
6 Zl      = 300;        // load resistance in ohm
7 Zo      = 75;        // charecteristic impedance in
    ohm
8
9 // calculations
10 //Zi     = Zo*((Zl + iZo*tan l)/(Zo + iZl*tan l))
11 //       = Zo*(((Zl/tan l) + iZo)/((Zl/tan l) +
    iZo)))
12 // for l = lamda/2    l = (2*    /lamda)*(lamda/2) =

```

```

13 // therefore tan l = 0 which gives Zi = Zl
14 // in the second case when the operating frequency

```

```

        is halved, the wavelength is doubled which means
        the same line is now lamda/4 long
15 // for  $l = \text{lamda}/4$  ,  $\Gamma = (2* \quad / \text{lamda}) * (\text{lamda}/4) =$ 
        /2
16 // therefore  $\tan \Gamma =$ 
17  $Z_i = (Z_o^2)/Z_l$ ; // input impedance
18
19 mprintf('Input impedance = %3.2f ohm',Zi);
20 //

```

Scilab code Exa 3.8 Finding expressions for V_{in} and V_l

```

1 // Chapter 3 example 8
2 //

```

```

3 clc;
4 clear;
5 // Given data
6  $f = 100 * 10^6$ ; // operating
   frequency in Hz
7  $v = 2 * 10^8$  ; // propagation
   velocity in m/s
8  $Z_o = 300$ ; // charecteristic
   impedance in ohm
9  $Z_{in} = 300$ ; // input impedance
   in ohm
10  $l = 1$ ; // length in m
11  $V = 100$ ;
12
13 // Calculations
14  $\text{lamda} = v/f$  // wavelength in m
15 if  $\text{lamda}/2 == 1$  then

```

```

16     Zl  = Zin;
17 end
18 k      = (V*Zin)/(Zin+Zl)
19 //Vin   = k*cos(2*%pi*f*t)
20 // since the line is lamda/2 long ,the signal
    undergoes a phase delay of  $\phi = (2\pi \cdot \text{length}) / \text{lamda} \cdot (\text{lamda}/2) =$ 
21 // Output
22 mprintf('Vin = %dcos(2 *%3.0 et)\n V1 = %dcos(2 *%3
    .0 et - )',k,f,k,f );
23 //

```

Scilab code Exa 3.9 Finding magnitude of reflection coefficient and frequency of operation

```

1 // Chapter 3 example 9
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 VSWR    = 3;           // voltage standing wave ratio
7 d       = 20*10^-2    // separation b/w 2 successive
    minimas
8 er      = 2.25;       // dielectric constant
9 v       = 3*10^8;     // velocity in m/s
10
11 // Calculations
12 // VSWR = (1 + p)/(1 - p)
13 p       = (VSWR - 1)/(VSWR + 1); // reflection co
    -efficient
14 lamda   = 2*d;       // wavelength of

```

```

    tx line
15 lamda_fr= lamda*sqrt(er);           // free space
    wavelength
16 f      = v/lamda_fr;                // operating
    frequency in Hz
17
18 // output
19 mprintf('Magnitude of Reflection Co-efficient = %3.1
    f\n Frequency of Operation = %3.0 f Mhz',p,f/10^6)
    ;
20 //

```

Scilab code Exa 3.10 Finding per unit inductance Zo phase shift constant and reflection coefficient

```

1 // Chapter 3 example 10
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 C   = 30;           // per unit capacitance in pF/m
7 Vp  = 260;         // velocity of propagation in m/
    us
8 f   = 500*10^6     // freq in Hz
9 Zl  = 50;          // terminating load impedance in
    ohm
10
11 // calculations
12 v   = Vp/10^-6     // conversion from m/us to m/s
13 C1  = C*10^-12    // conversion from pF/m to F/m
14 // 1/sqrt(LC) = Vp

```

```

15 L    = 1/(v^2 * C1);    // per unit inductance
16 Zo   = sqrt(L/C1);     // charecteristic impedance in
    ohm
17 lamda = v/f            // wavelength
18 b     = (2*%pi)/lamda  // phase shift constant
19 p     = (Zl - Zo)/(Zl + Zo);    // Reflection
    coefficient
20
21 // Output
22 mprintf('Per Unit inductance = %d nH/m\n
    Charecteristic Impedance = %d ohm\n Phase shift
    Constant = %d rad/m\n Reflection co-efficient =
    %3.3 f ',L*10^9,Zo,b,abs(p));
23 //

```

Scilab code Exa 3.11 showing certain freq passing through waveguide

```

1 // Chapter 3 example 11
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 a    = 1.5*10^-2;      // width of waveguide
7 b    = 1*10^-2        // narrow dimension of
    waveguide
8 er   = 4;             // dielectric constant
9 f    = 8*10^9;        // frequency in Hz
10 c   = 3*10^8         // velocity in m/s
11
12 // calculations
13 lamda_c    = 2*a;    // cut-off wavelength for

```

```

    TE10 mode
14 lamda      = c/f           // wavelength corresponding
    to given freq.
15 lamda_d    = lamda/sqrt(er); // wavelength when
    waveguide filled with dielectric
16 if lamda_d < lamda_c then
17     mprintf('8 Ghz frequency will pass through the
    guide');
18 end

```

Scilab code Exa 3.12 Finding min frequency

```

1 // Chapter 3 example 12
2 //


---


3 clc;
4 clear;
5 // Given data
6 a  = 4*10^-2;           // width of waveguide
7 b  = 2*10^-2           // narrow dimension of
    waveguide
8 er = 4;                // dielectric constant
9 c  = 3*10^8            // velocity in m/s
10
11 // Calculations
12 lamda_c    = 2*a;       // max cut-off wavelength
13 fcmin      = c/lamda_c // min freq
14 lamda_d    = lamda_c/sqrt(er); // wavelength if
    we insert dielectric
15 fc        = c/lamda_d  // min frequency
    in presence of dielectric
16
17 // Output
18 mprintf('Minimum Frequency that can be passed with

```

```
19 // dielectric in waveguide is %3.1f Ghz',fc/10^9);  
//
```

Scilab code Exa 3.13 Showing certain frequency does not pass through waveguide

```
1 // Chapter 3 example 13  
2 //  
3 clc;  
4 clear;  
5 // Given data  
6 f = 1*10^9; // frequency in Hz  
7 a = 5*10^-2; // wall separation  
8 c = 3*10^8; // velocity of EM wave in m/s  
9 m = 1; // for TE10  
10 n = 0; // for TE10  
11  
12 // Calculations  
13 // lamda0 = 2/sqrt((m/a)^2 + (n/b)^2)  
14 lamda0 = (2*a)/m  
15 lamda_frspc = c/f;  
16 if lamda_frspc > lamda0 then  
17     mprintf('1 Ghz signal cannot propagate in TE10  
18     mode')  
19 else  
19     mprintf('1 Ghz signal can propagate in TE10 mode  
20     ');  
20 end
```

Scilab code Exa 3.14 Finding longest cutoff wavelength

```
1 // Chapter 3 example 14
2 //


---


3 clc;
4 clear;
5 // Given data
6 a = 30; // width of waveguide
7 b = 20; // narrow dimension of waveguide
8 c = 3*10^8; // velocity of EM wave in m/s
9 m = 1; // for TE10
10 n = 0; // for TE10
11
12 // Calculations
13 // lamda0 = 2/sqrt((m/a)^2 + (n/b)^2)
14 lamda0 = (2*a)/m; // longest cut-off
    wavelength in dominant mode TE10
15
16 // Output
17 mprintf('longest cut-off wavelength = %d mm', lamda0
    );
18 //
```

Scilab code Exa 3.15 Finding frequency range

```
1 // Chapter 3 example 15
2 //


---


3 clc;
4 clear;
```



```

5 // Given data
6 a = 4*10^-2; // width of waveguide
7 b = 2*10^-2; // narrow dimension of waveguide
8 c = 3*10^8; // velocity of EM wave in m/s
9 m1 = 1; // for TE10
10 m2 = 2; // for TE20
11 n = 0; // for TE10
12 // Calculations
13 lamda_c = 2*a // cutoff wavelength for
    TE10 mode
14 f1 = c/lamda_c // frequency in Hz
15 // the frequency range for single mode operation is
    the range of frequencies corresponding to the
    dominant mode and the second highest cutoff
    wavelength
16 lamda_c_2 = 2/sqrt((m2/a)^2 + (n/b)^2)
17 f2 = c/lamda_c_2; // freq at second
    largest cutoff wavelength
18
19 // Output
20 mprintf('Therefore, single mode operating range = %3
    .2f Ghz to %3.1f Ghz\n', f1/10^9, f2/10^9 );
21 mprintf(' Note: instead of 3.75,3.5 is printed in
    textbook ');
22 //

```

Scilab code Exa 3.16 Finding group and phase velocity

```

1 // Chapter 3 example 16
2 //

```

```

3 clc;

```

```

4 clear;
5 // Given data
6 a = 7.2 ; // width of waveguide in cm
7 b = 3.4; // narrow dimension of waveguide
   in cm
8 c = 3*10^10; // free space velocity of EM
   wave in cm/s
9 f = 2.4*10^9; // frequency in Hz
10
11 // Calculation
12 lamda = c/f // free space wavelength in cm
13 lamda_c = 2*a // cutoff wavelength in cm
14 lamda_g = lamda/sqrt(1 - (lamda/lamda_c)^2); //
   guide wavelength in cm
15 vp = (lamda_g * c)/lamda //
   phase velocity in cm/s
16 vg = c^2/vp; //
   group velocity in cm/s
17
18 // Output
19 mprintf('Group velocity = %3.1e cm/s\n Phase
   Velocity = %3.1e cm/s',vg, vp);
20 //

```

Scilab code Exa 3.18 proof

```

1 // Chapter 3 example 18
2 //

```

```

3 clc;
4 clear;
5 // let 'a' and 'b' be the broad and narrow

```

```

        dimensions of the rectangular guide and 'r' be
        internal radius of circular guide
6 // Dominant mode in rectangular guide =TE10
7 // cutoff wavelength = 2a
8 // dominant mode in circular guide = TE11
9 // cut-off wavelength = 2*pi*r/1.841 = 3.41r
10 // for the two cut-off wavelengths to equal
11 // 2a = 3.41r
12 // a = 1.705r
13 // now area of cross section of rectangular guide =
    a*b
14 //assuming a= 2b,which is very reasonable assumption
    ,we get
15 // area of cross section of rectangular waveguide =
    a*a/2 = ((1.705^2)*r*r)/2 = 1.453r^2
16 // area of cross-section of circular guide = pi*r*r
    = 3.14r^2
17 // ratio of two cross sectional areas = (3.14r^2)
    /(1.453r^2) = 2.16
18 mprintf('Circular guide is 2.16 times larger in
    cross section as compared to rectangular guide');
19 //

```

Scilab code Exa 3.19 Finding all the possible modes that will propagate in a waveguide

```

1 // Chapter 3 example 19
2 //

```

```

3 clc;
4 clear;
5 // Given data

```

```

6 a = 4*10^-2; // width of waveguide
7 b = 2*10^-2; // narrow dimension of waveguide
8 c = 3*10^8; // velocity of EM wave in m/s
9 f = 5*10^9 // operating frequency in Hz
10 m0 = 0; // for TE01
11 m1 = 1; // for TE10 / TE11 /TM11
12 n0 = 0; // for TE10
13 n1 = 1; // for TE11 or TM11
14 // Calculations
15 lamda = c/f; //
    operating wavelength
16 lamda_TE01 = 2/sqrt((m0/a)^2 + (n1/b)^2) //
    cutoff wavelength for TE01
17 lamda_TE10 = 2/sqrt((m1/a)^2 + (n0/b)^2) //
    cutoff wavelength for TE10
18 lamda_TE11 = 2/sqrt((m1/a)^2 + (n1/b)^2) //
    cutoff wavelength for TE11 or TM11
19 if lamda_TE01 >lamda then
20     mprintf('TE01 propagates in the given guide at
    the given operating frequency');
21     elseif lamda_TE10 >lamda then
22     mprintf('TE10 propagates in the given guide at
    the given operating frequency');
23     elseif lamda_TE11 >lamda then
24     mprintf('TE11 propagates in the given guide at
    the given operating frequency');
25 end

```

Scilab code Exa 3.20 Finding frequency of wave

```

1 // Chapter 3 example 20
2 //
3 clc;

```

```

4 clear;
5 // Given data
6 a = 4*10^-2; // width of waveguide
7 b = 2*10^-2; // narrow dimension of waveguide
8 c = 3*10^8; // velocity of EM wave in m/s
9 d = 4*10^-2; // distance b/w field maxima and
    minima
10 // Calculations
11 lamda_c = 2*a; // cut-off wavelength in
    dominant mode
12 lamda_g = 4*d; // guide wavelength
13 // lamda_g = lamda0/(sqrt(1 - (lamda0/lamda_c)^2))
14 lamda0 = sqrt((lamda_c * lamda_g)^2 / (lamda_c
    ^2 + lamda_g^2));
15 f0 = c/lamda0; // frequency of the wave
16
17 // Output
18 mprintf('Frequency of the wave = %3.3f Ghz',f0/10^9)
    ;
19 //

```

Scilab code Exa 3.21 computing guide wavelength phase shift constant and phase velocity

```

1 // Chapter 3 example 21
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 a = 6; // width of waveguide in cm
7 b = 3; // narrow dimension of waveguide in cm

```

```

8 lamda = 4;      // operating wavelength in cm
9 c      = 3*10^8;    // velocity of EM wave in cm/s
10
11 // Calculations
12 lamda_c = 2*a;      // cut-off wavelength in
    dominant mode
13 lamda_g = lamda/(sqrt(1 - (lamda/lamda_c)^2)) //
    guide wavelength
14 Vp      = (lamda_g/lamda)*c
15 b      = (2*pi)/lamda_g;    // phase shift
    constant
16
17 // Output
18 mprintf('Guide wavelength = %3.2f cm\n Phase
    velocity = %3.2e m/s\n Phase shift constant = %3
    .2f radians/cm', lamda_g, Vp, b)
19 //

```

Scilab code Exa 3.22 computing cutoff freq phase velocity and guided wavelength

```

1 // Chapter 3 example 22
2 //
3 clc;
4 clear;
5 // Given data
6 er      = 9;      // relative permittivity
7 c      = 3*10^10; // velocity of EM wave in free
    space
8 f      = 2*10^9;  // operating frequency in Ghz
9 a      = 7;      // width of waveguide in cm

```

```

10 b          = 3.5;      // narrow dimension of waveguide
    in cm
11
12 // calculations
13 lamda_c    = 2*a;      // cut-off
    wavelength in dominant mode
14 fc         = c/lamda_c // cut-off frequency
    in Hz
15 lamda      = c/(sqrt(er)*f); // operating
    wavelength
16 lamda_g    = lamda/(sqrt(1 - (lamda/lamda_c)^2)) //
    guide wavelength
17 Vp         = (lamda_g/lamda)*c
18
19 // Output
20 mprintf('Cut-off frequency = %3.3f Ghz\n Phase
    velocity = %3.2e m/s\n Guide wavelength = %3.2 f
    cm',fc/10^9,Vp/10^2,lamda_g);
21 //

```

Chapter 4

Microwave Components

Scilab code Exa 4.1 Finding power at coupled port

```
1 // chapter 4 example 1
2 //


---


3 clc;
4 clear;
5 // given data
6 Pi      = 10;           // Input power in mW
7 CF      = 20;           // coupling factor in dB
8
9 // calculations
10 // CF(db) = 10log(Pi/Pc)
11 Pc      = Pi/(10^(CF/10)) // antilog conversion and
    coupling power
12
13 // Output
14 mprintf('Coupled Power = %d uW', Pc*10^3);
15 //
```

Scilab code Exa 4.2 Finding power available at the straight through port output

```
1 // chapter 4 example 2
2 //


---


3 clc;
4 clear;
5 // given data
6 Pi      = 10;           // Input power in mW
7 IL      = 0.4;         // insertion loss in dB
8 // calculations
9 // ILdb  = 10log(Pi/Po)
10 Po     = Pi/(10^(IL/10)) // antilog conversion and
    coupling power
11
12 // Output
13 mprintf('Power available at the straight through
    port output = %3.3f mW',Po);
14 //
```

Scilab code Exa 4.3 Finding directivity power at isolated port

```
1 // chapter 4 example 3
2 //


---


3 clc;
4 clear;
```

```

5 // given data
6 CF      = 20;           // Coupling factor in dB
7 I       = 50;           // Isolation in dB
8 Pc      = 100*10^-6;   // coupling power in W
9
10 // calculations
11 // D     = 10log(Pc/Piso)
12 D       = I - CF;      // Directivity in dB
13 Piso    = Pc/(10^(D/10)) // antilog conversion and
    coupling power
14
15 // Output
16 mprintf('Directivity = %d dB\n Power at isolated
    port = %d nW',D,Piso*10^9);
17 //

```

Scilab code Exa 4.4 Finding power available at output port

```

1 // chapter 4 example 4
2 //

```

```

3 clc;
4 clear;
5 // given data
6 CF      = 20;           // coupling factor in dB
7 D       = 30;           // Directivity in dB
8 Pin     = 10;           // input power in dBm
9
10 // Calculations
11 // 10logPi = Pin
12 Pi      = 10^(Pin/10); // power in mW
13 I       = D + CF       // isolation in dB

```

```

14 Pc      = Pin - CF;
15 Pcwatts = 10^(Pc/10)    // power at coupled port in
    mW
16 Piso    = Pin - I
17 Pisowatts = 10^(Piso/10) // Power at isolated port
    in mW
18 Po      = Pi -(Pcwatts + Pisowatts);    // power at
    o/p port in mW
19
20 // Output
21 mprintf('Power Available at the output port = %3.5 f
    mW',Po);
22 //

```

Scilab code Exa 4.5 Finding directivity

```

1 // chapter 4 example 5
2 //

```

```

3 clc;
4 clear;
5 // given data
6 Pi      = 5*10^-3;          // Input power in W
7 CF      = 10;              // coupling factor
8 Piso    = 10*10^-6         // power at isolated
    port in w
9 // calculations
10 // CF  = 10log(Pi/Pc)
11 Pc      = Pi/(10^(CF/10)) // antilog conversion and
    coupling power
12 // D   = 10log(Pc/Piso)   // Directivity
13 D      = 10*log10(Pc/Piso)

```

```
14 // Output
15 mprintf('Directivity = %3.0f dB\n',D);
16 //
```

Scilab code Exa 4.6 Finding lowest resonant frequency

```
1 // chapter 4 example 6
2 //
3 clc;
4 clear;
5 // given data
6 a      = 2;           // width in cm
7 b      = 1;           // Height in cm
8 d      = 3;           // length in cm
9 c      = 3*10^10;     // vel in free space in cm/s
10 // For TE101 mode
11 m      = 1;
12 n      = 0;
13 p      = 1;
14
15 // Calculations
16 fo     = (c/2)*sqrt((m/a)^2 + (n/b)^2 + (p/d)^2);
17
18 // Output
19 mprintf('Resonant Frequency = %d Ghz',fo/10^9);
20 //
```

Scilab code Exa 4.7 Finding resonant frequency

```
1 // chapter 4 example 7
2 //


---


3 clc;
4 clear;
5 // given data
6 fo      = 10;           // resonant freq in Ghz
7 mprintf('The Resonant frequency for a TM mode in a
           rectangular cavity resonator for a given integral
           \n');
8 mprintf(' values of m,n and p is same as that of a
           TE mode for same values of m,n and p\n');
9 mprintf(' Therefore ,TM111 mode resonant frequency =
           %d Ghz',fo);
10 //
```

Scilab code Exa 4.8 Finding length of cavity resonator

```
1 // chapter 4 example 8
2 //


---


3 clc;
4 clear;
5 // given data
6 a      = 4;           // width in cm
7 b      = 2;           // Height in cm
8 c      = 3*10^10;     // vel in free space in cm/s
9 fo     = 6*10^9;      // resonator frequency in Ghz
10 // For TE101 mode
```

```

11 m      = 1
12 n      = 0;
13 p      = 1;
14
15 // Calculations
16 //fo    = (c/2)*sqrt((m/a)^2 + (n/b)^2 + (p/d)^2);
17 d      = sqrt((p^2)/((2*fo/c)^2 - (m/a)^2 - (n/b)
    ^2));
18 // Output
19 mprintf('Length of cavity resonator = %3.1f cm',d);
20 //

```

Scilab code Exa 4.9 Finding length of cavity resonator

```

1 // chapter 4 example 9
2 //

```

```

3 // Note : some data from is problem is taken from
    Ex4.8
4 clc;
5 clear;
6 // given data
7 a      = 4;           // width in cm
8 b      = 2;           // Height in cm
9 c      = 3*10^10;     // vel in free space in cm/s
10 fo     = 6*10^9;     // resonator frequency in Ghz
11 d      = 3.2;        // length of cavity resonator
    in cm
12 // For TE101 mode
13 m      = 1
14 n      = 0;
15

```

```

16 // Calculations
17 lamda_c = 2/sqrt((m/a)^2 + (n/b)^2); // cut-
    off wavelength in m
18 lamda    = c/fo; //
    operating wavelength in m
19 lamda_g = lamda/sqrt(1 - (lamda/lamda_c)^2) // guide
    wavelength in m
20
21 mprintf('Length of resonator is %3.1f cm and guide
    wavelength is %3.1f cm',d,lamda_g);
22 mprintf('\n length of resonator is half of guide
    wavelength');
23 //

```

Scilab code Exa 4.10 Finding length of resonator

```

1 // chapter 4 example 10
2 //

```

```

3 clc;
4 clear;
5 // given data
6 di    = 8; // internal diameter in cms
7 a     = 4; // internal radius in cms
8 fo    = 10*10^9; // operating frequency in Ghz
9 ha01  = 2.405; // Eigen value of bessel
    function
10 c     = 3*10^10 // velocity of EM wave in cm/sec
11 // For TM011 mode
12 m     = 0
13 n     = 1
14 p     = 1

```

```

15
16 // Calculutions
17 //f0 = (c/2*pi)*sqrt((ha/a)^2 + (p*pi/d)^2)
    operating frequency
18 d = (p*pi)/(sqrt((fo*2*pi/c)^2 - (ha01/a)^2))
    //length of resonator
19
20 // Output
21 mprintf('Length of resonator = %3.3 f cm',d);
22 //

```

Scilab code Exa 4.11 Finding resonant frequency

```

1 // chapter 4 example 11
2 //

```

```

3 clc;
4 clear;
5 // given data
6 di = 6; // internal diameter in cms
7 d = 5; // length in cm
8 a = 4; // internal radius in cms
9 fo = 10*10^9; // operating frequency in Ghz
10 ha01 = 2.405; // Eigen value of bessel
    function
11 ha11 = 1.841; // Eigen value of bessel
    function
12 c = 3*10^10 // velocity of EM wave in cm/sec
13 // For TM011 mode and TE111 mode
14 m0 = 0
15 m1 = 1
16 n1 = 1

```



```

17 p1      = 1
18 p2      = 2
19
20 // Calculations
21 f0  = (c/(2*pi))*sqrt((ha01/a)^2 + (p2*pi/d)^2)
           //resonant frequency for TM012 mode
22 f01  = (c/(2*pi))*sqrt((ha11/a)^2 + (p1*pi/d)^2)
           //resonant frequency for TE111 mode
23
24 // Output
25 mprintf('Resonant frequency for TM012 mode = %3.3 f
           Ghz\n Resonant frequency for TM111 mode = %3.3 f
           Ghz\n ',f0/10^9,f01/10^9 );
26 //

```

Chapter 5

Microwave Tubes

Scilab code Exa 5.1 Finding transit time of electron in repeller space

```
1 //chapter 5 example 1 pg no-226
2 //


---


3 clc;
4 clear;
5 //Given Data
6 F      = 100*10^9;//reflex klystron operating
           frequency
7 n      = 3;//integer corresponding to mode
8
9 //Calculations
10 T_c   = (n+(3/4))//transit time in cycles
11 T     = T_c/F//transit time in seconds
12
13 //Output
14 mprintf('Transit Time of the electron in the
           repeller space is %3.1f ps',T/10^-12);
15
16 //
```

Scilab code Exa 5.2 Finding change in frequency

```
1 //chapter 5 example 1 pg no-227
2 //


---


3 clc;
4 clear;
5 //Given Data
6 F      = 2*10^9; //reflex klystron operating
           frequency
7 Vr     = 2000; //Repeller voltage
8 Va     = 500; //Accelerating voltage
9 n      = 1; //integer corresponding to mode
10 e     = 1.6*10^-19; //charge of electron
11 m     = 9.1*10^-31; //mass of electron in kg
12 s     = 2*10^-2; //space b/w exit of gap and
           repeller electrode
13 dVr1  = 2; //(change in Vr in percentage
14 //Calculations
15 dVr   = dVr1*Vr/100; //conversion from percentage to
           decimal
16 //dVr/df = ((2*pi*s)/((2*pi*n)-pi/2))*sqrt(8*m*Va/e)
           );
17 //let df = dVr/((2*pi*s)/((2*pi*n)-pi/2))*sqrt(8*m*
           Va/e));
18
19 df    = (dVr)/((2*pi*s)/((2*pi*n)-pi/2))*
           sqrt(8*m*Va/e); //change in freq as a fun of
           repeller voltage
20
21
22 //Output
```

```

23 mprintf('Change in frequency is %3.0f MHz',df/10^6);
24
25 //

```

Scilab code Exa 5.3 Finding percentage change in frequency

```

1 //chapter 5 example 3
2 //

```

```

3 clc;
4 clear;
5 //Given Data
6 //let l = dVr/Vr ; f = df/f ; Vr/f = R
7 l = 5; //percentage change in repeller voltage
8 f = 1; //percentage change in operating frequency
9 R = 1; //ratio of repeller voltage to operating
    frequency
10 NR = 1.5; //new ratio of repeller voltage to
    operating frequency in volts/MHz
11 e = 1.6*10^-19; //charge of electron
12 m = 9.1*10^-31; //mass of electron in kg
13
14 //Calculations
15
16 //dVr/df = ((2*pi*s)/((2*pi*n)-pi/2))*sqrt(8*m*Va/e)
    );
17 //((df/f)/(dVr/Vr)) = (Vr/f)*((2*pi*n)-pi/2)/(2*pi*s
    )*sqrt(e/(8*m*Va));
18 //((df/f)/(dVr/Vr)) = K*(Vr/f);
19 //where K = (((2*pi*n)-pi/2)/(2*pi*s))*sqrt(e/(8*m*
    Va))
20 K = (f/l)*(1/R)

```

```

21 PCF = NR*K*1//percentage change in frequency when
    new ratio (Vr/f)=1.5
22
23 //Output
24 mprintf('Percentage Change in frequency is %3.2f
    percent ',PCF);
25
26 //

```

Scilab code Exa 5.4 Finding electronic efficiency and output power

```

1 //chapter 5 example 4
2 //

```

```

3 clc;
4 clear;
5 //Given Data
6 Va = 40*10^3;//Anode voltage of cross field
    amplifier
7 Ia = 15;//Anode current in Amp
8 Pin = 40*10^3;//input power in watts
9 G = 10;//gain in dB
10 n = 40/100;//overall efficiency converted from
    percentage to decimal
11 //Calculations
12 //Gain = (1+(Pgen/Pin))
13 Pgen = (G-1)*Pin//Generated power
14 ne = (Pgen/(Va*Ia))//electronic efficiency
15 nc = n/(ne)//circuit efficiency
16 Pout = Pin+(Pgen*nc)//output power
17 //Output
18 mprintf('Electronic Efficiency is %3.2f\n Output

```

```

    power is %g KW',ne,Pout/1000);
19
20 //

```

Scilab code Exa 5.5 Finding no of cycles

```

1 //chapter 5 example 5
2 //

```

```

3 clc;
4 clear;
5 //Given Data
6 F      = 1*10^9; //two cavity klystron operating
           frequency
7 Va     = 2500; //Accelerating voltage in volts
8 e      = 1.6*10^-19; //charge of electron
9 m      = 9.1*10^-31; //mass of electron in kg
10 s     = 0.1*10^-2; //input cavity space
11 //Calculations
12
13 u      = sqrt((2*e*Va)/m); //velocity at which
           electron beam enters the gap
14 T      = s/u ; //Time spent in the gap
15 f      = T*F; //number of cycles
16
17 //Output
18 mprintf('Number of cycles that elase during transit
           of beam through input gap is %3.3f cycle ',f);
19
20 //

```

Scilab code Exa 5.6 Finding phase difference and number possible useful modes of resonance

```
1 //chapter 5 example 6
2 //


---


3 clc;
4 clear;
5 //Given Data
6 N = 8; //no. of resonators
7
8 //Calculations
9 mprintf(' = (2* *n)/N \n'); //phase difference
10 mprintf(' = (n* )/4\n'); //phase difference
11 K = N/2; //useful no. of nodes
12 //Most dominant mode is the one for which phase
    difference b/w adjacent resonators is radians
13 //Therefore (n* )/4 =
14 n = 4
15
16
17 //Output
18 mprintf('Number of possible modes of Resonance is %d
    \n',N);
19 mprintf('Number of useful modes of Resonance is %d\n
    ',K);
20 mprintf('value of integer n for the most dominant
    mode is %d',n);
21
22 //


---


```

Scilab code Exa 5.7 Finding peak amplitude

```
1 //chapter 5 example 7
2 //


---


3 clc;
4 clear;
5 //Given Data
6 Va    = 1200; //Anode potential
7 F     = 10*10^9; //Operating frequency in Hz
8 S     = 5*10^-2; //spacing b/w 2 cavities
9 GS    = 1*10^-3; //gap spacing in either cavity
10 e     = 1.6*10^-19; //charge of electron
11 m     = 9.1*10^-31; //mass of electron in kg
12 //Calculations
13 //Condition of maximum output is  $(V1/Vo)_{max} =$ 
14 //  $(3.68)/((2*\pi*n)-(pi/2))$ ;
15 //  $(2*\pi*n)-(pi/2) =$  Transit angle b/w two cavities
16 //V1 = Peak amplitude of RF i/p
17 //Vo = accelarating potential
18 Vo    = sqrt(2*e*Va/m); //velocity of the electrons
19 T     = S/Vo; //Transit time b/w the cavities
20 TA    = 2*%pi*F*T; //transit angle in radians
21 V1    = (3.68*Va)/TA;
22 //Output
23 mprintf('Required Peak Amplitude of i/p RF signal is
24 %3.2f volts ',V1);


---


```


Scilab code Exa 5.8 Finding anode voltage of TWT

```
1 //chapter 5 example 8
2 //


---


3 clc;
4 clear;
5 // Given Data
6 R      = 10;           // circumference to pitch
   ratio
7 e      = 1.6*10^-19;  // charge of electron
8 m      = 9.1*10^-31;  // mass of electron in Kg
9 c      = 3*10^8;      // vel. of EM waves in m/s
10
11 // Calculations
12 Vp     = c/R;         // axial phase velocity =
   free space vel*(pitch/circumference)
13 Va     = (Vp^2 * m)/(2*e);
14
15 // Output
16 mprintf('Anode Voltage = %3.2f kV',Va/1000);
17 disp('In practice ,the electron beam velocity is kept
   slightly greater than the axial phase velocity
   of RF signal')
18 //
```

Chapter 6

Semiconductor Microwave Devices and Integrated Circuits

Scilab code Exa 6.1 proof

```
1 // Chapter 6 example 1
2 //


---


3 clc;
4 clear;
5 // Given data
6 gs      = 0.0025;      // output conductance in mho
7 gl      = 0.0025;      // load conductance
8 r       = -250;        // negative resistance of
                        microwave device
9
10 // calculations
11
12 // P1 = V1^2 * gl      // power that is
                        transferred to load
13 // P  = V1^2 * gs      // source is matched to
                        load
14 // P  = [Is/(gl+gs)]^2 * gs
```

```

15 //      = ((Is ^2)/(4*gs ^2))*gs
16 //      = (Is ^2)/(4*gl)
17 // P2   = V1^2 *gl           // Load power
18 //      = [Is/(gs+gl-g)]^2 *gl
19 //      = (Is ^2 *gl)/(2gl - g)^2
20 // P2/P1 = ((Is ^2 *gl)/(2gl - g)^2)*(4*gl)/(Is ^2)
21 //      = (4*gl ^2)/(2gl - g)^2;
22 //      = (4*gl ^2)/(4gl ^2 + g(g-4gl))
23 // For P2/P1 > 1 , 4gl > g so that denominator is
    less than numerator
24 g      = 1/r
25 // let k = P2/P1
26 k      = (4*gl*gl)/((2*gs)+ g)^2
27
28 // output
29     mprintf('Power gain = %d',k);

```

Scilab code Exa 6.2 Finding max negative differential conductance

```

1 // Chapter 6 example 2
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 R1      = 500;           // load resistance
7
8 // Calculations
9 gl      = 1/R1;         // load conductance
10 gmax   = 4*gl;         // max negative diff.
    conductance
11
12 // Output
13 mprintf('gmax = %3.3 f mho',gmax);

```

14 //

Scilab code Exa 6.3 Finding operational frequency

```
1 // Chapter 6 example 3
2 //
3 clc;
4 clear;
5 // Given data
6 L      = 10*10-6;      // width of N-region
7 Vs     = 105;         // saturated vel. of
      carriers
8
9 // Calculations
10 fo    = (3*Vs)/(4*L);   // oscillation frequency
11
12 // output
13 mprintf('Operational frequency = %3.1f Ghz\n',fo
      /109);
14 mprintf(' Note: In textbook it is wrongly printed as
      6.5 Ghz')
15 //
```

Scilab code Exa 6.4 finding unity gain cutoff frequency

```
1 // Chapter 6 example 4
```

```

2 //


---


3 clc;
4 clear;
5 // Given data
6 L      = 10^-6;           // gate length
7 Vs     = 10^5;           // saturation velocity in m/
                           s
8
9 // calculations
10 fT     = Vs/(2*%pi*L); // cut-off freq.
11
12 // Output
13 mprintf('Unity gain cut-off frequency = %3.0f Ghz',
          fT/10^9);
14 //


---



```

Scilab code Exa 6.5 Finding length of active layer

```

1 // Chapter 6 example 5
2 //


---


3 clc;
4 clear;
5 // Given data
6 f      = 10*10^9;        // oscillating freq. of Gunn
                           diode
7 Vs     = 10^5;           // saturation carrier
                           velocity in m/s
8
9 // calculations

```

```

10 L      = Vs/f;           // length of active layer
11
12 // Output
13 mprintf('Length of active layer = %3.0f m ',L/10^-6
14 //

```

Scilab code Exa 6.6 Finding doping concentration

```

1 // Chapter 6 example 5
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 f      = 10*10^9;        // oscillating freq. of Gunn
   diode
7 Vs     = 10^5;           // saturation carrier
   velocity in m/s
8 er     = 13;             // relative permittivity
9 u      = 100*10^-4;      // mobility in m^2/V-s
10 eo    = 8.85*10^-12;    // permittivity in F/m
11 e     = 1.6*10^-19;     // charge of electron
12
13 // Calculations
14 L      = Vs/f;           // length of active layer
15 no     = (eo*er*Vs)/(L*e*u); // doping
   concentration
16
17 // Output
18 mprintf('Doping Concentration no >> %3.2g /m^3 ',no);
19 //

```

Scilab code Exa 6.7 Proof

```
1 // Chapter 6 example 7
2 //
3 clc;
4 clear;
5 // Given data
6 fo      = 40*10^9;      // oscillating freq. of Gunn
   diode
7 no      = 10^15;      // doping concentration
8 up      = 8000;      // mobility in positive
   conductance region
9 er      = 13;      // relative permittivity
10 um     = 100;      // mobility in m^2/V-s
11 eo     = 8.85*10^-14; // permittivity in F/cm
12 e      = 1.6*10^-19; // charge of electron
13
14 // Calculations
15 // (eo*er)/(e*up) << no/fo < (eo*er)/(e*um) //
   condition to be satisfied
16 // let k = (eo*er)/(e*up) , l = (eo*er)/(e*um) , p =
   no/fo
17 p      = no/fo
18 k      = (eo*er)/(e*up)
19 l      = (eo*er)/(e*um)
20 if (k<p) then
21     if p<l then
22         mprintf('Necessary Condition satisfied')
23     end
24 end
```

Scilab code Exa 6.8 Finding dielectric relaxation time

```
1 // Chapter 6 example 8
2 //
3 clc;
4 clear;
5 // Given data
6 n      = 10^15;           // doping concentration in /
   cm^3
7 u      = 8500;           // mobility in m^2/V-s
8 er     = 13;             // relative permittivity
9 eo     = 8.85*10^-14;    // permittivity in F/cm
10 e     = 1.6*10^-19;     // charge of electron
11
12 // Calculations
13 Td     = (eo*er)/(n*u*e) // Dielectric
   relaxation time
14
15 // Output
16 mprintf('Dielectric relaxation time = %3.3f ps ',Td
   *10^12);
17 //
```

Scilab code Exa 6.9 Finding length of GUN device

```
1 // Chapter 6 example 9
```



```

2 //


---


3 clc;
4 clear;
5 // Given data
6 f      = 20*10^9;      // oscillating freq. of Gunn
   device
7 Vs     = 10^5;        // saturation carrier
   velocity in m/s
8
9 // Calculations
10 L     = Vs/f          // length of device
11
12 // output
13 mprintf('length of device = %d m ',L*10^6);
14 //


---



```

Scilab code Exa 6.10 Finding mobility values

```

1 // Chapter 6 example 10
2 //


---


3 clc;
4 clear;
5 // Given data from graph
6 up    = (2*10^7)/3000;      // mobility of
   diode in positive conductance region
7 un    = (2*10^7 - 10^7)/((10-3)*10^3); // mobility of
   diode in negative conductance region
8
9 // Output

```

```

10 mprintf('mobility of diode in positive conductance
    region = %d cm^2/V-s\n mobility of diode in
    negative conductance region = %3.0f cm^2/V-s',up,
    un);
11 //

```

Scilab code Exa 6.11 Finding electric field and punch through voltage

```

1 // Chapter 6 example 11
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 e      = 1.6*10^-19; // charge of electron
7 Nd     = 10^15*10^6; // mobility
8 L      = 10*10^-6;   // active layer of Barritt
    diode
9 er     = 12.5        // relative permittivity
10 eo    = 8.85*10^-12; // permittivity in F/cm
11
12 // calculations
13 Ex     = (e*Nd*L)/(2*eo*er) // electric field for
    Va = Vpt and x = L/2
14 E      = Ex/10^2;       // electric field in v/
    cm
15 Vpt    = 10*10^-4*E
16
17 // Output
18 mprintf('Electric field E(x) = %3.0f KV/cm\n Punch
    through voltage = %3.0f Volts',E/1000,Vpt);
19 //

```

Scilab code Exa 6.12 Finding Hfe

```
1 // Chapter 6 example 12
2 //
3 clc;
4 clear;
5 // Given data
6 fT      = 10;           // ft specification of BJT
7 f_a     = 2;           // operating freq in Ghz case a
8 f_b     = 10;          // operating freq in Ghz case b
9
10 // calculations
11 hFE_a   = fT/f_a;
12 hFE_b   = fT/f_b;
13
14 // Output
15 mprintf('case a:\n hFE = %d\n case b:\n hFE = %d\n
16         ',hFE_a,hFE_b);
17 //
```

Scilab code Exa 6.13 Finding dielectric relaxation time

```
1 // Chapter 6 example 13
2 //
```

```

3  clc;
4  clear;
5  // Given data
6  n      = 1015;           // doping concentration in /
   cm3
7  er     = 15;             // relative permittivity
8  eo     = 8.85*10-14;    // permittivity in F/cm
9  e      = 1.6*10-19;    // charge of electron
10 sigma  = 133*10-2;     // conductivity in ohm/cm
11
12 // calculations
13 Td     = (eo*er)/sigma    // dielectric relaxation
   time constant
14 u      = sigma/(n*e)     // mobility
15
16 // Output
17 mprintf('Dielectric relaxation time constant = %3.0 f
   ps\n Carrier Mobility = %d cm2/V-s\n',Td*1012,
   u );
18 //

```

Scilab code Exa 6.14 Finding frequency

```

1 // Chapter 6 example 14
2 //

```

```

3  clc;
4  clear;
5  // Given data
6  gm     = 50*10-3;       // conductance in mho
7  cgs    = 0.6*10-12;    // gate to source
   capacitance

```

```

8  cgd      = 0.015*10^-12; // gate to drain
   capacitance
9  Rg      = 3;           // gate resistance in ohm
10 Rs     = 2;           // source resistance in ohm
11 Ri     = 2.5;         // intrinsic channel
   resistance
12 Rds    = 400;         // drain to source
   resistance
13
14 // Calculations
15 fT      = gm/(2*pi*cgs); // device's fT
16 t3     = 2*pi*Rg*cgd;
17 r1     = (Rg+Rs+Ri)/Rds;
18 fmax   = fT/(2*sqrt(r1 + (fT*t3))); // max
   usable frequency
19 if fmax>40*10^9 then
20     mprintf('Operation at 40 GHz is Theoretically
   possible\n');
21 end
22
23 // Output
24 mprintf(' fT = %3.1 f Ghz\n fmax = %3.1 f ',fT/10^9,
   fmax/10^9 )

```

Scilab code Exa 6.15 Finding power gain

```

1 // Chapter 6 example 15
2 //


---


3 clc;
4 clear;
5 // Given data
6 f2    = 20;           // pump frequency in GHz
7 f1    = 2;           // signal frequency in GHz

```

```

8
9 // Calculations
10 Gp      = (f1+f2)/f1;      // power gain if
    parametric amp. operated as USB up-converter
11 Gp_dB   = 10*log10(Gp);    // power gain in dB
12 Gp_lsb  = (f2-f1)/f1;    // power gain if
    parametric amp. operated as LSB up-converter
13 Gp_db_lsb = 10*log10(Gp_lsb )// power gain in dB
14
15 // output
16 mprintf('Power gain of parametric amplifier when
    operated as USB up-converter = %3.1f dB\n Power
    gain of parametric amplifier when operated as LSB
    up-converter = %3.1f dB',Gp_dB,Gp_db_lsb)
17 //

```

Scilab code Exa 6.16 Finding output laser wavelength

```

1 // Chapter 6 example 16
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 h      = 6.63*10^-34;      // planck's constant in
    Joule-sec
7 e1     = 0.25;            // lower energy level in
    eV from energy level diag.
8 e2     = 1.5;            // higher energy level
    in eV from energy level diag.
9 e      = 1.6*10^-19;      // charge of electron
10 c     = 3*10^8;          // vel. of light in m/s

```

```

11
12 // calculations
13 hf      = (eh - e1)*e           // energy diff b/w
    two levels in J
14 f       = hf/h;                // frequency
15 lamda   = c/f                  // o/p laser
    wavelength in m
16
17 // Output
18 mprintf('Output laser wavelength = %3.0e m or%3.0f
    m ',lamda,lamda*10^6)

```

Scilab code Exa 6.17 Finding resistance

```

1 // Chapter 6 example 17
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 p   = 0.1*10^-2;           // resistivity in ohm-m
7 t   = 100*10^-6;          // thickness in m
8 AR  = 10/1;                // aspect ratio
9
10 // Calculations
11 ps  = p/t
12 R   = ps*AR;              // Resistance in ohm
13
14 // Output
15 mprintf('Resistance = %d ',R);
16 //

```

Scilab code Exa 6.18 Finding sheet resistivity and Resistance

```
1 // Chapter 6 example 18
2 //


---


3 clc;
4 clear;
5 // Given data from fig
6 R_a = 1000; // resistance shown in fig a
7 W1 = 0.15*10^-3 // width of geometry fig 6.72a
8 L1 = 3*10^-3 // Length of geometry fig 6.72a
9 W2 = 75*10^-6 // width of geometry fig 6.72b
10 L2 = 1500*10^-6 // Length of geometry fig 6.72b
11 t1 = 10*10^-6 // thickness of geometry fig 6.72a
12 t2 = 20*10^-6 // thickness of geometry fig 6.72b
13
14 //R1 = s1*(L1/W1) // resistor geometry of fig
15 // s1 = (R1*W1)/L1
16 ps1 = (R_a*W1)/L1 // sheet resistivity of
17 // geometry of fig 6.72a
18 p = ps1*t1; // resistivity
19 ps2 = p/t2; // sheet resistivity of geometry
20 // of fig 6.72b
21 R2 = ps2*(L2/W2); // resistance of geometry of
22 // fig 6.72b
23 //


---


24 // Output
25 mprintf('For Geometry in Fig 6.72b\n sheet
26 resistivity = %3.0f / \n Resistance = %d ',
27 ps2, R2)
28 //
```

Scilab code Exa 6.19 Finding capacitance

```
1 // Chapter 6 example 19
2 //
3 clc;
4 clear;
5 // Given data
6 A      = 100*100*10^-12;      // Area of electrode
7 er     = 9.6;                // relative
    permitivity
8 t      = 500*10^-6;          // substrate
    thickness
9 eo     = 8.85*10^-12;        // permitivity
10 // Calculations
11 C      = (eo*er*A)/t;        // capacitance in
    farad
12
13 // Output
14 mprintf('Capacitance = %3.2e pF',C*10^12);
15 //
```

Scilab code Exa 6.20 Semiconductor Microwave Devices and Integrated Circuits

```
1 // Chapter 6 example 20
```

```
2 //


---


3 clc;
4 clear;
5 // Given data
6 ps      = 100;      // sheet resistivity
7 L       = 1.04     // length
8 W       = 0.02     // width
9
10 // Calculations
11 NOS     = L/W      // number of squares
12 R       = ps * NOS // resistance
13
14 // Output
15 mprintf('Resistance = %3.1f K ',R/1000);
16 //
```

Chapter 7

Antennas

Scilab code Exa 7.1 Calculating Q

```
1 // chapter 7 example 1
2 //


---


3 clc;
4 clear;
5 // given data
6 Ldipole = 50; // Length of dipole in cm
7 c = 3*10^10; // velocity of EM wave in cm
  /s
8 BW = 10*10^6; // bandwidth in Hz
9
10 // Calculations
11 lamda = 2*Ldipole; // wavelength in cm
12 fo = c/lamda; // operating frequency
  in Hz
13 Q = fo/BW // quality factor
14
15 // Output
16 mprintf('Q = %d',Q);
17 //
```

Scilab code Exa 7.2 Finding Directivity

```
1 // chapter 7 example 2
2 //
3 clc;
4 clear;
5 // given data
6 Rr      = 72;      // Radiation resistance in ohms
7 Rl      = 8;      // Loss resistance in ohms
8 Ap      = 27;     // power gain
9
10 // Calculations
11 n       = Rr/(Rr + Rl); // radiation efficiency
12 D       = Ap/n;      // Directivity
13 D_dB    = 10*log10(D); // directivity in dB
14
15 // Output
16 mprintf('Directivity = %3.2f dB',D_dB );
17 //
```

Scilab code Exa 7.3 Finding Aperture and gain of antenna

```
1 // chapter 7 example 3
2 //
```

```

3  clc;
4  clear;
5  // given data
6  AZ_BW      = 0.5;          // beamwidth in degrees
7  E_BW       = 0.5;          // beamwidth in degrees
8  lamda      = 3*10^-2;     // radar emission wavelength
9
10 // Calculations
11
12 AZ_BW_r    = AZ_BW*pi/180; // azimuth beamwidth
    in radians
13 E_BW_r     = E_BW*pi/180; // elevation
    beamwidth in radians
14 G          = (4*pi)/(AZ_BW_r *E_BW_r ) //
    antenna gain
15 G_db       = 10*log10(G)    // gain in dB
16 A          = (G*lamda*lamda)/(4*pi); // antenna
    aperture
17
18 // Output
19 mprintf('Gain of Antenna = %3.2f dB\n Antenna
    Aperture = %3.3f m',G_db,A);
20 //

```

Scilab code Exa 7.4 Finding effective aperture of antenna

```

1 // chapter 7 example 4
2 //

```

```

3 clc;
4 clear;
5 // given data

```

```

6 n_az      = 0.5;          //length efficiency in
    azimuth direction
7 n_el      = 0.7;          //length efficiency in
    elevation direction
8 A         = 10;          // area in square mts
9
10 // Calculations
11 n         = n_az * n_el;    // aperture efficiency
12 Ae        = n*A;          // Effective aperture
13
14 // Output
15 mprintf('Effective aperture of the antenna = %3.1f
    sq.m',Ae);
16 //

```

Scilab code Exa 7.5 finding Directivity

```

1 // chapter 7 example 5
2 //

```

```

3 clc;
4 clear;
5 // given data
6 Ptot      = 100;          // certain antenna radiating
    power
7 Ptot_iso  = 10*10^3;     // isotropic antenna
    radiating power
8
9 // Calculations
10 D         = 10*log10(Ptot_iso/Ptot); //
    Directivity of antenna
11

```

```

12 // Output
13 mprintf('Directivity of antenna = %d dB',D);
14 //

```

Scilab code Exa 7.6 Finding beamwidth effective aperture and gain

```

1 // chapter 7 example 6
2 //

```

```

3 clc;
4 clear;
5 // given data
6 D      = 3;           // diameter of the antenna in m
7 n_l    = 0.7;        // length efficiency
8 nr     = 0.9;        // radiation efficiency
9 f      = 10*10^9;    // antenna operating freq.
10 c     = 3*10^8;     // vel of EM waves in m/s
11
12 // calculations
13 def    = D*n_l      // Effective diameter
14 lamda = c/f        // wavelength in m
15 Beam_w = lamda/def // beamwidth in radian
16 Beam_w_d= Beam_w*180/%pi; // beam width in
    degree;
17 n_a    = n_l * n_l; // Aperture efficiency
18 AA     = (%pi*D*D)/4; // actual area in sq m
19 Ae     = AA*n_a;    // Effective aperture
20 G      = (4*%pi*Ae)/(lamda^2); // Gain
21 G_db   = 10*log10(G);
22
23 // Output
24 mprintf('Beam Width = %3.2f degrees\n Effective

```

```
Aperture = %3.2 fsq m\n Gain = %3.1 f dB',Beam_w_d,  
Ae,G_db);  
25 //
```

Scilab code Exa 7.7 Finding radiation resistance

```
1 // chapter 7 example 7  
2 //  
  
3 clc;  
4 clear;  
5 // given data  
6 // given (lamda/10) wire dipole  
7 // Radiation resistance of short dipoles is Rr =  
790*(1/lamda)^2;  
8 // Rr = 790*(lamda/(10*lamda))^2;  
9 // Rr = 7.9;  
10 mprintf('Radiation resistance = 7.9 ohms');  
11 //
```

Scilab code Exa 7.8 Finding Beamwidth effective aperture and gain

```
1 // chapter 7 example 8  
2 //  
  
3 clc;  
4 clear;
```



```

5 // given data
6 a_l      = 6;           // Azimuth length in m
7 n_a      = 0.7;        // Azimuth length efficiency
8 n_e      = 0.5;        // elevation length efficiency
9 e_l      = 4;           // elevation length in m
10 w       = 6;           // width of antenna
11 h       = 4;           // height of antenna
12 lamda   = 3*10^-2;    // wavelength
13
14 // Calculations
15 Eff_A_l  = a_l*n_a;    // effective azimuth length
16 Eff_E_l  = e_l*n_e;    // effective elevation length
17 A        = w*h         // actual area
18 n        = n_a*n_e;    // aperture efficiency
19 Ae       = A*n;        // effective aperture
20 Az_BW    = lamda/Eff_A_l // Azimuth beam width
21 E_BW     = lamda/Eff_E_l // elevation beam width
22 Az_BW_d  = Az_BW*180/%pi // rad to deg conv
23 E_BW_d   = E_BW*180/%pi; // rad to deg conv
24 G        = (4*%pi*Ae)/(lamda^2); // Gain
25 G_dB     = 10*log10(G); // gain in dB
26
27 // Output
28 mprintf('Azimuth Beamwidth = %3.2f degrees\n
          Elevation Beamwidth = %3.2f degrees\n Gain = %3.1
          f dB',Az_BW_d,E_BW_d,G_dB);
29 //

```

Scilab code Exa 7.9 Finding beamwidth

```

1 // chapter 7 example 9
2 //

```

```

3  clc;
4  clear;
5  // given data
6  Beam_w_3db = 0.4;
7
8  // Calculations
9  N2N_Beam_w = 2*Beam_w_3db; // Null to Null
    beamwidth
10
11 // output
12 mprintf('Null to Null Beam width = %3.1f degrees',
    N2N_Beam_w);
13 //

```

Scilab code Exa 7.10 Finding Received signal strength

```

1  // chapter 7 example 10
2  //

```

```

3  clc;
4  clear;
5  // given data
6  RSSR      = 20; // Rx signal strength in
    horizontal polarised antenna when rx RHCP
7
8  // Calculations
9  // When incident polarisation is circularly
    polarised and the antenna is linearly polarised,
    there is a polarisation loss of 3dB
10 ISS      = RSSR + 3;
11 // a

```

```

12 // when the Rx polarisation is same as the antenna
    polarisation , the polarisation loss is zero
13 RSS_HP      = ISS;      // rx signal strength for
    incident wave horizontally polarised
14 // b
15 // when the incident wave is vertically polarised ,
    the angle between the incident polarisation and
    the antenna polarisation is 90
16 // polarisation loss = 20log(1/cos( ))
17 //                = 20log(1/cos90) =
18 RSS_VP      = 0;      // rx signal strength for
    incident wave vertically polarised
19 // c
20 // When the incident wave is LHCP and the antenna
    polarisation is linear ,there will be a 3dB
    polarisation loss and the
21 // Rx signal strength therefore will be 20 dB only
22 RSS_LHCP    = RSSR;    // rx signal strength for
    incident wave Left hand circularly polarised
23 // d
24 // The angle between the incident wave polarisation
    and the antenna polarisation is 60 degrees
25 phi        = 60;      //
    rx wave polarisation angle with horizontal
26 PL         = 20*log10(1/cos(60*pi/180)); //
    polarisation loss in dB
27 RSS_Pangle  = ISS - PL;
28 //output
29 mprintf('Received signal strength if incident wave
    horizontally polarised = %d dB\n Received signal
    strength if incident wave vertically polarised =
    %d dB\n Received signal strength if incident wave
    Left hand circularly polarised is %d dB\n
    Received signal strength if Received wave
    polarisation making 60deg angle with horizontal
    is %3.0f dB',RSS_HP ,RSS_VP ,RSS_LHCP ,RSS_Pangle);
30 //

```

Scilab code Exa 7.11 Finding length of halfwave dipole

```
1 // chapter 7 example 11
2 //


---


3 clc;
4 clear;
5 // given data
6 f      = 300*106;      // operating frequency in Hz
7 c      = 3*1010;      // velocity of EM wave in
      cm/s
8
9 // Calculations
10 lamda  = c/f;          // wavelength in cm
11 // Physical length of antenna is made 5% shorter
      than desired length as per rule of thumb
12 l      = lamda/2;      // length of halfwave dipole
13 lphy   = 1-(5/100)*l; // as per rule of thumb
14
15 // Output
16 mprintf('Length of a half wave dipole to be cut = %3
      .1 f cm',lphy);
17 //
```

Scilab code Exa 7.12 Finding input impedance

```
1 // chapter 7 example 12
```

```

2 //


---


3 clc;
4 clear;
5 // given data
6 Zi      = 72;          // input impedance in ohms
7 // A     = 1.5a       // area of cross section in sq.
                        cm
8 // Zif = Zi*[(sum of areas of cross section of
                        various components)/(Area of cross section of the
                        driven element )]^2
9 // Zif = 72*((a + 1.5a)/a)^2;
10 // Zif = 72*(2.5*a/a)^2;
11 Zif     = 72*(2.5)^2;
12 mprintf('Input impedance for a folded dipole = %d
           ',Zif);
13 //


---



```

Scilab code Exa 7.13 Designing yagi antenna

```

1 // chapter 7 example 13
2 //


---


3 clc;
4 clear;
5 // given data
6 f      = 60*10^6;      // frequency in Hz
7 c      = 3*10^8       // velocity of EM wave in m/
                        s
8
9 // Calculations

```

```

10 lamda    = c/f;           // wavelength in m
11 l_dipole= lamda/2        // length of dipole
12 // Physical length of antenna is made 5% shorter
   than desired length as per rule of thumb
13 L        = l_dipole - (5/100)*l_dipole; // actual
   physical length
14 L_D      = L - (4/100)*L;           // length of
   director
15 L_R      = L + (4/100)*L;           // length of
   reflector
16 DDS      = 0.12*lamda;             // director
   dipole spacing
17 RDS      = 0.2*lamda;              // Reflector
   dipole spacing
18
19 // Output
20 mprintf('Length of dipole = %3.3f m\n length of
   Director = %3.2f m\n length of Reflector = %3.2f
   m\n director dipole spacing = %3.1f m\n Reflector
   dipole spacing = %3.1f m',L,L_D,L_R,DDS,RDS);
21 //

```

Scilab code Exa 7.14 finding beamwidth

```

1 // chapter 7 example 14
2 //
3 clc;
4 clear;
5 // given data
6 D      = 2;           // Mouth diameter in m
7 f      = 2;           // focal length in m

```

```

8 bw3db    = 90/100;    // beamwidth of antenna chosen
   to be 90% of angle subtended by feed
9
10 // Calculations
11 theta    = 4*atan(1/(4*f/D));    // angle subtended
   by the focal point feed at edges of reflector
12 theta_d  = theta*180/%pi
13 Beam_w_3dB = bw3db*theta_d;    // 3 dB beam width
14 NNBW     = 2*(Beam_w_3dB );
15
16 // Output
17 mprintf('3 dB Beamwidth = %3.1 f \n Null-to-Null
   beam width = %3.2 f \n',Beam_w_3dB,NNBW);
18 //

```

Scilab code Exa 7.15 Finding focal length of antenna

```

1 // chapter 7 example 15
2 //

```

```

3 clc;
4 clear;
5 f      = 3;    // focal length in m
6 fpos   = 1.5; // feed is placed 1.5m from pt
   of intersection os sec.reflector and antenna axis
7
8 // Calculation
9 f_hyp  = f-fpos; // focal length of hyperboloid
   from figure;
10
11 // Output
12 mprintf('focal length of hyperboloid = %3.1 f m',

```

```
13     f_hyp);  
14 //
```

Scilab code Exa 7.16 Finding distance of the feed

```
1 // chapter 7 example 16  
2 //  
  
3 clc;  
4 clear;  
5 // given data  
6 D      = 3;           // Mouth diameter in m  
7 //f     = 2;           // focal length in m  
8 bw3db  = 63;         // 3dB beam width  
9 k      = 0.9;        // beam width is k times  
    subtended angle  
10  
11 // Calculations  
12 theta  = bw3db/k;    // subtended angle  
13 theta_r = theta  
14 //theta = 4*atan(1/(4*f/D));  
15 f      = D/(4*tan((theta_r/4)*(pi/180)));  
16  
17 // Output  
18 mprintf('Distance of feed from the point of  
    intersection of antenna axis and the reflector  
    surface = %3.2f m',f);  
19 //
```

Scilab code Exa 7.17 Finding desired phases of all elements

```
1 // chapter 7 example 17
2 //


---


3 clc;
4 clear;
5 // given data
6 c      = 3*10^8;           // velocity of EM waves in m
   /s
7 f      = 2.5*10^9;       // operating frequency in
   Ghz
8 S      = 10*10^-2;       // inter element spacing
9 theta  = 10;             // steering angle
10
11 // Calculations
12 lamda  = c/f              // Wavelength in m
13 phi    = (360*(S/lamda))*sin(theta*(%pi/180))
14 phi1   = 0*phi           // phase angle for element 1
15 phi2   = 1*phi           // phase angle for element 2
16 phi3   = 2*phi           // phase angle for element 3
17 phi4   = 3*phi           // phase angle for element 4
18 phi5   = 4*phi           // phase angle for element 5
19
20 // Output
21 mprintf('Phase angles for elements 1,2,3,4,5 are
   %d , %d , %d , %d , %d ',phi1,phi2,phi3,phi4
   ,phi5);
22 //
```

Scilab code Exa 7.18 Finding Phase angles

```
1 // chapter 7 example 17
2 //


---


3 clc;
4 clear;
5 // Data is taken from Example 17. The beam steers
   towards left of the axis with all parameters
   remaining in Ex 17 are same
6 c      = 3*10^8;      // velocity of EM waves in m
   /s
7 f      = 2.5*10^9;   // operating frequency in
   Ghz
8 S      = 10*10^-2;   // inter element spacing
9 theta  = -10;       // steering angle
10
11 // Calculations
12 lamda  = c/f        // Wavelength in m
13 phi    = (360*S/lamda)*sin(theta*%pi/180)
14 phi1   = 0*phi      // phase angle for element 1
15 phi2   = 1*phi      // phase angle for element 2
16 phi3   = 2*phi      // phase angle for element 3
17 phi4   = 3*phi      // phase angle for element 4
18 phi5   = 4*phi      // phase angle for element 5
19
20 // Output
21 mprintf('Phase angles for elements 1,2,3,4,5 are
   %d , %d , %d , %d , %d ',phi1,phi2,phi3,phi4
   ,phi5);
22 //
```

Scilab code Exa 7.19 Finding beam position

```
1 // chapter 7 example 8
2 //


---


3 clc;
4 clear;
5 // given data
6 S      = 5*10^-2;           // inter spacing distance
7 lamda  = 6*10^-2;           // operating wavelength in
                               cms
8 phi_Az  = 25                // angle in azimuth
                               direction
9 phi_E   = 35                // angle in Elevation
                               direction
10
11 // Calculations
12 theta_Az = asin((lamda*phi_Az)/(360*S))
13 theta_E  = asin((lamda*phi_E)/(360*S))
14 Theta_Az = theta_Az*(180/%pi)
15 Theta_E  = theta_E*(180/%pi)
16
17 // Output
18 mprintf('Steering angle in Azimuth = %3.1 f \n
          Steering angle in Elevation = %3.1 f ',Theta_Az,
          Theta_E);
19 //
```

Chapter 9

Radar Fundamentals

Scilab code Exa 9.1 Finding max unambiguous range of radar

```
1 // Chapter 9 example 1
2 //


---


3 clc;
4 clear;
5 // Given Data
6 PRF      = 1000;           // Pulse repetitive
   frequency in Hz
7 t        = 0.15*10^-3;    // Round propagation time in
   s
8 c        = 3*10^8;        // velocity of EM waves in m
   /s
9 // calculations
10 R        = (c*t)/2;       // Range
11 Runamb   = c/(2*PRF)      // Max unambiguous range
12
13 // Output
14 mprintf('Target Range = %3.1 f Km\n Maximum
   Unambiguous range = %d Km',R/1000,Runamb/1000);
15 //
```

Scilab code Exa 9.2 Finding Rx signal frequency

```
1 // Chapter 9 example 2
2 //
3 clc;
4 clear;
5 // Given Data
6 f      = 10*109;      // radar Tx frequency
7 c      = 3*108;      // velocity of EM waves in m
                        // /s
8 V      = 108;         // vel of car in kmph
9
10 // Calculations
11 lamda  = c/f;        // wavelength in m
12 Vr     = V*(5/18);   // vel of car in m/s
13 fd     = (2*Vr)/lamda // Doppler shift in Hz
14 fr     = f + fd     // received freq
15 fr_away = f-fd      // Rx frequency if the car
                        // is moving away from radar
16
17 // Output
18 mprintf('Doppler Shift = %d Khz\n Frequency of
          Received signal = %3.6f Ghz\n Received Frequency
          if car is moving away from radar = %3.6f Ghz',fd
          /1000,fr/109,fr_away/109);
19 //
```

Scilab code Exa 9.3 Determining whether radar is capable of measuring certain radial velocity

```
1 // Chapter 9 example 3
2 //


---


3 clc;
4 clear;
5 // Given Data
6 f      = 10*10^9;      // radar Tx frequency
7 PRF    = 2000;        // Pulse repetitive
                        frequency in Hz
8 Vr     = 0.5;         // radial vel in Mach
9 c      = 3*10^8;      // velocity of EM waves in m
                        /s
10 vs    = 330;         // velocity of sound in m/s
11
12 // Calculations
13 lamda  = c/f;         // wavelength in m
14 max_unamb_fd = PRF/2; // maximum
                        unambiguous doppler shift
15 Vrunamb = (lamda*max_unamb_fd)/2; // doppler
                        shift
16 Vaircraft = 0.5*vs;  // Converting from
                        Mach to m/s
17 fd_desired = (2*Vaircraft)/lamda;
18 PRF_desired = 2*fd_desired; // desired PRF
19
20 // Output
21 if Vrunamb < Vaircraft then
22     mprintf('The radar is not capable of determining
                unambiguously the velocity of the
                approaching aircraft\n');
```

```

23 end
24 mprintf(' Desired Pulse Repetition Rate = %d Khz',
          PRF_desired/1000);
25 //

```

Scilab code Exa 9.4 Determining Range Resolution

```

1 // Chapter 9 example 4
2 //

```

```

3 clc;
4 clear;
5 // Given Data
6 PW_tx    = 10^-6;           // Transmitted pulse
   width
7 Rx_PW    = 10^-6;           // Received pulse width
8 c        = 3*10^8;          // velocity of EM waves
   in m/s
9
10 // Calculations
11 RR      = (c*Rx_PW)/2;     // Range Resolution in m
12
13 // output
14 mprintf('This Radar can resolve upto an inter target
          separation in range of %d m\n Therefore ,given
          radar will be able to resolve the targets',RR);
15 //

```

Scilab code Exa 9.5 Determining max beamwidth

```
1 // Chapter 9 example 5
2 //


---


3 clc;
4 clear;
5 // Given Data
6 CRR      = 100;           // Cross range resolution in m
7 R        = 3000;        // radial range
8
9 // Calculations
10 // CRR = (R*theta3)*(%pi/180);
11 theta3   = (180*CRR)/(%pi*R)           // 3 dB
    beamwidth
12
13 // Output
14 mprintf('3 dB beamwidth = %3.2 f ',theta3);
15 //
```

Scilab code Exa 9.6 Finding min look time

```
1 // Chapter 9 example 6
2 //


---


3 clc;
4 clear;
5 // Given Data
6 Vs      = 330;           // velocity of sound in m/s
7 NM      = 1.85*(5/18)    // 1NM equivalent in m/s
8 V1      = 0.5;          // velocity of first
```



```

    aircraft in mach
9 V2      = 400;           // velocity of second
    aircraft in NM/hr
10 theta  = 30;           // angle with radial axis in
    degrees
11 lamda  = 3*10^-2;      // wavelength in m
12
13 // Calculations
14 v1      = V1*Vs         // velocity of first
    aircraft in m/s
15 fd1     = (2*v1)/lamda // doppler freq.
16 v2      = V2*NM*cos(30*(%pi/180)) // velocity of
    second aircraft in m/s
17 fd2     = (2*v2)/lamda // doppler freq
18 dd      = fd2 - fd1    // doppler difference
19 T1      = 1/dd         // look time in s
20
21 // Output
22 mprintf('Required minimum look time = %3.2 f ms',T1
    /10^-3);
23 mprintf('\n Note: Cos(30) value is taken as 0.5 in
    textbook');
24 //

```

Scilab code Exa 9.7 Significance of denominator

```

1 // Chapter 9 example 7
2 //


---


3 clc;
4 clear;
5 // Given Data

```

```

6 // Rmax      = [1000000/(12.4*PRF)]NM
7 //          = [1000000*t/12.4]NM
8 mprintf('The Numerator represents round trip
propagation time in us\n');
9 mprintf(' Therefore , number 12.4 represents the
units microseconds per nautical miles\n');
10 mprintf(' In other words , this means that the round
propagation time for one nautical mile is 12.4 us
which is equivalent to 6.66us for 1km range')

```

Scilab code Exa 9.8 Finding center frequency

```

1 // Chapter 9 example 8
2 //

```

```

3 clc;
4 clear;
5 // Given Data
6 PW      = 10*10^-6;           // pulse width in sec
7 f       = 10*10^9;           // frequency in Hz
8 fm      = 1000;              // modulating frequency
9
10 // calculations
11 BW_M    = 1/PW               // matched bandwidth
12 cf1     = f+fm;              // closest freq.
13 cf2     = f-fm;              // closest freq.
14 fo      = f;                 // centre freq.
15
16 // Output
17 mprintf('Centre of frequency spectrum = %d Khz\n The
two closet frequencies to the center of the
spectrum are %d Khz and %d Khz',fo/10^3,cf1/10^3,
cf2/10^3);
18 //

```

Scilab code Exa 9.9 Finding centre of spectrum bandwidth and compressed pulse width

```
1 // Chapter 9 example 9
2 //
3 clc;
4 clear;
5 // Given Data
6 fc1      = 495;      // freq in Mhz
7 fc2      = 505;      // freq in Mhz
8
9 // Calculations
10 fo       = (fc1 + fc2)/2;      // Center of
    spectrum in Mhz
11 BW       = fc2 - fc1;          // Bandwidth in Mhz
12 PW       = 1/BW;              // compressed pulse
    width in us
13
14 // Output
15 mprintf('Center of spectrum = %d Mhz\n Matched
    Bandwidth = %d Mhz\n Compressed Pulse width = %3
    .1 fus ',fo,BW,PW);
16 //
```

Scilab code Exa 9.10 Finding Bandwidth and range resolution

```

1 // Chapter 9 example 10
2 //


---


3 clc;
4 clear;
5 // Given Data
6 f      = 10^9;           // CW radar waveform freq.
7 fm     = 100;           // modulation freq. in Hz
8 MaxfD  = 500;           // max freq deviation in Hz
9 c      = 3*10^8;        // vel. of EM waves in m/s
10
11 // Calculations
12 Mf     = MaxfD/fm       // Modulation index
13 BW     = 2*(Mf + 1)*fm  // Bandwidth
14 RR     = c/(2*BW);      // Range Resolution in m
15
16 // Output
17 mprintf('Bandwidth = %d Hz\n Range Resolution = %d
18 Km', BW, RR/1000);
19 //


---



```

Scilab code Exa 9.11 Finding matched bandwidth and center frequency of spectrum

```

1 // Chapter 9 example 11
2 //


---


3 clc;
4 clear;
5 // Given Data
6 f      = 10^9;           // Centre freq. of spectrum

```

```

7 t      = 13           // pulse width in us
8 N      = 13;         // N-bit Barker code
9
10 // Calculations
11 Sub_PW = t/N;        // sub pulsewidth
12 match_BW= 1/Sub_PW; // Matched bandwidth in Mhz
13
14 // Output
15 mprintf('Matched Bandwidth = %d Mhz\n Center
          Frequency of the spectrum = %d Ghz',match_BW,f
          /10^9 );
16 //

```

Scilab code Exa 9.12 Finding average power and look energy

```

1 // Chapter 9 example 12
2 //

```

```

3 clc;
4 clear;
5 // Given Data
6 PW      = 10^-6;      // Pulse width in sec
7 Pp      = 100*10^3;   // Peak power in watts
8 PRF     = 1000;       // pulse rep.rate
9 N_target= 20;         // no of target hits in
   1 dwell period
10
11 // Calculations
12 PE      = Pp*PW;      // Pulse energy in Joule
13 LE      = N_target *PE; // look energy
14 DC      = PW*PRF      // Duty cycle
15 Pav     = Pp*DC;      // Average power

```

```

16 Pavg      = 10*log10(Pav);    // Avg power in dB
17
18 // Output
19 mprintf('Average power = %d dB\n Look Energy = %3.0 f
        Joules ',Pavg,LE);
20 //

```

Scilab code Exa 9.13 finding duty cycle correction factor

```

1 // Chapter 9 example 13
2 // Data taken from Ex 12
3 //

```

```

4 clc;
5 clear;
6 // Given Data
7 PW      = 10^-6;           // Pulse width in sec
8 Pp      = 100*10^3;       // Peak power in watts
9 PRF     = 1000;          // pulse rep.rate
10 N_target= 20;           // no of target hits in
    1 dwell period
11
12 // Calculations
13 PE      = Pp*PW;         // Pulse energy in Joule
14 LE      = N_target *PE;  // look energy
15 DC      = PW*PRF        // Duty cycle
16 Pav     = Pp*DC;        // Average power
17 Pavg    = 10*log10(Pav); // Avg power in dB
18 Pp_dB   = 10*log10(Pp);  // Peak power in dB
19 DCCF    = Pp_dB - Pavg   // Duty cycle correction
    factor
20 // Output

```

```

21 mprintf('Duty cycle correction factor = %d dB',DCCF)
    ;
22 //

```

Scilab code Exa 9.14 Finding Equivalent noise temperature

```

1 // Chapter 9 example 14
2 //

```

```

3 clc;
4 clear;
5 // Given Data
6 G_rx      = 97;           // Rx gain in dB
7 Bn        = 5*10^6;      // Bandwidth in Hz
8 To        = 300;         // temperature in kelvin
9 K          = 1.38*10^-23; // Boltzmann constant in
    J/k
10 n         = -3           // o/p noise power in dBm
11
12 // calculations
13 Pn_dB     = n-G_rx       // input noise power
14 Pn        = 10^(Pn_dB/10)*10^-3 // converting
    from dBm to watts
15 // Pn     = KToBnF;
16 F         = Pn/(K*To*Bn) // Noise Factor
17 T         = To*[F - 1]   // Equivalent Noise
    Temperature
18
19 // Output
20 mprintf('Equivalent Noise Temperature = %d K ',T );
21 //

```

Scilab code Exa 9.15 Determining ratio of noise powers

```
1 // Chapter 9 example 15
2 //
3 clc;
4 clear;
5 // Given Data
6 Gx      = 60;      // gain of Rx 'X' in dB
7 Gy      = 70;      // gain of Rx 'Y' in dB
8 Fx      = 3;      // Noise factor of 'X'
9 Fy      = 2;      // Noise factor of 'Y'
10
11 // calculations
12 Gx_W    = 10^(Gx/10) // gain in watts
13 Gy_W    = 10^(Gy/10) // gain in watts
14 // k    = Pnx/Pny;    // Ratio of noise power
    levels produced at the o/p's of Rx 'X' and 'Y'
15 k      = (Fx*Gx_W)/(Fy*Gy_W); // Ratio of noise
    power levels produced at the o/p's of Rx 'X' and
    'Y'
16
17 // output
18 mprintf('Ratio of noise power levels produced at the
    outputs of Rx X and Y = %3.2f',k);
19 //
```

Scilab code Exa 9.16 Finding noise power


```

1 // Chapter 9 example 16
2 //


---


3 clc;
4 clear;
5 // Given Data
6 Pn      = -70;           // Noise power in dBm
7 fl      = 10^6;         // lower cut-off freq in Hz
8 fh      = 11*10^6;      // upper cut-off freq in Hz
9 BP_fl   = 13*10^6;      // Bandpass filter lower
    cutoff freq
10 BP_fh  = 14*10^6;      // Bandpass filter lower
    cutoff freq
11
12 // Calculations
13 Pn_W    = 10^(Pn/10)*10^-3; // conversion from
    dBm to Watts
14 BW     = fh - fl
15 PSD    = Pn_W/BW        // Noise power
    spectral density
16 // Since white noise has the same spectral power
    density through the frequency spectrum,
17 // therefore Noise power in second case
18 B      = BP_fh - BP_fl
19 Pn_2   = PSD*B;        // Noise power in
    second case
20
21 // Output
22 mprintf('Noise power for BandPass filter having
    Cutoff frequencies 13Mhz and 14Mhz = %3.0e W',
    Pn_2);
23 //


---



```

Scilab code Exa 9.17 Finding azimuth coordinates

```
1 // Chapter 9 example 16
2 //


---


3 clc;
4 clear;
5 // Given Data from Figure triagle OAB
6 OA      = 100      // in Km
7 OB      = OA*cos(60*%pi/180); // Range of
      Target 2
8
9 // Output
10 mprintf('Range of Target-2 = %d Km\n Azimuth angle
      of target-1 = 60 \n Azimuth angle of Target-2 =
      120 ',OB);
11 //
```

Chapter 10

Radar Systems

Scilab code Exa 10.1 Finding Target range

```
1 // Chapter 10 example 1
2 //


---


3 clc;
4 clear;
5 c      = 3*10^8;           // velocity of EM waves
   in m/s
6 f      = 10*10^9;        // carrier freq in Hz
7 fm     = 100;           // freq of modulating
   signal
8 dphi   = 10;             // separation b/w tx FM
   signal and demod echo signal in degrees
9
10 // Calculations
11 Tp     = dphi/(360*fm);  // round trip
   propagation time
12 R      = (c*Tp)/2;      // target range
13
14 // output
15 mprintf('Target Range = %3.2 f Km',R/1000);
```

16 //

Scilab code Exa 10.2 Finding Target Range and Radial velocity

```
1 // Chapter 10 example 1
2 //
3 clc;
4 clear;
5 f      = 10*10^9;           // center freq. in Hz
6 f_us   = 60*10^3;          // upsweep freq. in Hz
7 f_ds   = 80*10^3;          // down sweep freq. in
   Hz
8 fm     = 100;              // modulation freq. in
   Hz
9 B      = 2*10^6;           // sweep bandwidth in Hz
10 c     = 3*10^8;           // vel. of EM waves in m
   /s
11 T     = 5*10^-3;
12
13 // Calculations
14 fd     = (f_ds - f_us)/2;
15 df     = (f_ds + f_us)/2;
16 R      = (c*T*df)/(2*B);   // range in m
17 // fd  = (2*Vr*f)/c
18 Vr     = (c*fd)/(2*f);     // target radial
   velocity
19 Vr_kmph = Vr*(18/5);       // target radial
   velocity in kmph
20 Vr_nmph = Vr_kmph/1.85;   // target radial
   velocity in Nautical miles per hour
21
```

```

22 // Output
23 mprintf('Target Range = %3.2f Km\n Radial velocity =
        %3.1f Nmi/hr ',R/1000,Vr_nmph);
24 //

```

Scilab code Exa 10.3 Finding error in doppler shift measurement

```

1 // Chapter 10 example 3
2 //

```

```

3 clc;
4 clear;
5 Vr = 150
6 c = 3*10^8
7 df1= 10^6;
8 // Given data
9 // fd = (2*Vr)/lamda = (2*Vr*f)/c
10 // for 'Vr' and 'c' as constant(for a given radial
    velocity,Vr is constant)
11 // fd = K.f where 'f' is the operating frequency
    and K = (2*Vr)/c
12 // Therefore df = 1 Mhz around the center
    frequency
13 k = (2*Vr)/c
14 df_d = df1*k
15
16 // Output
17 mprintf('Doppler shift due to carrier frequency
    sweep = %d Hz',df_d);
18 //

```

Scilab code Exa 10.4 Finding Range and radial velocity

```
1 // Chapter 10 example 4
2 //
3 clc;
4 clear;
5
6 // Given data
7 f      = 10*10^9;           // operating frequency
   in Hz
8 f_us   = 100*10^3;        // upsweep freq
9 f_ds   = 100*10^3;        // downsweep freq
10 Tus   = 5*10^-3;         // up-sweep period
11 Tds   = 5*10^-3;         // down-sweep period
12 T     = 10*10^-3
13 B     = 10*10^6;          // sweep bandwidth
14 c     = 3*10^8;           // vel of EM waves in m/
   s
15 f_us_b = 80*10^3;         // upsweep freq in fig b
16 f_ds_b = 50*10^3;         // downsweep freq in fig
   b
17 f_us_c = 50*10^3;         // upsweep freq in fig b
18 f_ds_c = 80*10^3;         // downsweep freq in fig
   b
19
20 // Calculations
21 // a
22 fd     = (f_us - f_ds)/2;   // doppler shift
23 df     = (f_us + f_ds)/2;   // freq diff
24 Vr_a   = (c*fd)/(2*f);      // radial velocity
25 R     = (c*Tus*df)/(2*B);   // Range
26 if Vr_a == 0 then
```

```

27     mprintf('Case a:\n Radial velocity = %d \n Range
           = %3.3 f Km\n', Vr_a, R/1000);
28 end
29 // b
30 fd      = (f_us_b - f_ds_b)/2;      // doppler shift
31 df_b     = (f_us_b + f_ds_b)/2;      // freq
           difference due to range
32 R_b      = (c*T*df_b)/(2*B);        // Range
33 Vr_b     = (c*fd)/(2*f);            // radial velocity
34 mprintf(' Case b:\n Radial velocity = %3.2fm/s \n
           Range = %3.3 f Km\n', Vr_b, R_b/1000');
35 mprintf(' As the up-sweep frequency difference is
           less than downspeed freq diff, this implies that
           doppler shift is\n contributing towards an
           increase in the echo signal freq. so, target is
           moving towards radar\n')
36 // c
37 fd      = (f_us_c - f_ds_c)/2;      // doppler shift
38 df_c     = (f_us_c + f_ds_c)/2;      // freq
           difference due to range
39 R_c      = (c*T*df_c)/(2*B);        // Range
40 Vr_c     = (c*fd)/(2*f);            // radial velocity
41 mprintf(' Case c:\n Radial velocity = %3.2 f m/s \n
           Range = %3.3 f Km\n', abs(Vr_c), R_c/1000');
42 mprintf(' As the up-sweep frequency difference is
           greater than downspeed freq diff, this implies
           that doppler shift is\n contributing towards an
           decrease in the echo signal freq. so, target is
           moving away from radar')

```

Scilab code Exa 10.5 Finding radial velocity

```

1 // Chapter 10 example 5
2 //

```

```

3  clc;
4  clear;
5
6  // Given data
7  f      = 10*10^9;           // operating freq in Hz
8  PRF    = 1000;            // pulse rep. rate
9  Vr     = 1000;            // radial velocity
10 c      = 3*10^8;           // vel. of EM waves in m
    /s
11
12 // Calculations
13 fd      = (2*Vr*f)/c        // true doppler shift
14 fA1     = modulo( modulo(fd,PRF)-PRF,PRF)
15 fA2     = modulo( modulo(fd,PRF)+PRF,PRF)
16 if fA1 < fA2 then
17     fd   = fA1;            // apparent doppler shift
18 else
19     fd   = fA2;            // apparent doppler shift
20 end
21 Vr      = (c*fd)/(2*f);     // radial velocity in m/
    s
22
23 //output
24 mprintf('Radial velocity = %3.2f m/s\n The radar
    measures the target to be moving away from the
    radial velocity at %3.2f m/s though in reality\n
    it is moving towards the radar with a velocity of
    1000 m/s ',Vr,abs(Vr));
25 //

```

Scilab code Exa 10.9 Finding lowest blind speed


```

1 // Chapter 10 example 9
2 //


---


3 clc;
4 clear;
5 //Given data
6 lamda = 3*10^-2; // Operating Wavelength in m
7 PRF = 2000; // pulse rep. freq in Hz
8 n = 1; // for lowest blind speed
9
10 // Calculations
11 LBS = (n*lamda*PRF)/2; // lowest blind speed
12 Vb_kmph = LBS*(18/5) // lowest blind speed in
    kmph
13
14 // Output
15 mprintf('Lowest Blind speed = %d Kmph',Vb_kmph)
16 //


---



```

Scilab code Exa 10.10 Finding ratio of operating frequencies

```

1 // Chapter 10 example 10
2 //


---


3 clc;
4 clear;
5 //Given data
6 disp('Let the operating frequency of first radar =
    f1');
7 disp('Let the operating frequency of second radar =
    f2');

```

```

8 disp('Third blind speed of Radar = (3*c/(2*f1)')
9 disp('fifth blind speed of Radar = (5*c/(2*f1)')
10 disp('(3*c/(2*f1) = (5*c/(2*f1)')');
11 disp('(f1/f2) = 3/5')

```

Scilab code Exa 10.11 Finding Apparent Range

```

1 // Chapter 10 example 11
2 //


---


3 clc;
4 clear;
5 //Given data
6 R      = 100;           // Range in kms
7 PRR    = 10*10^3;     // pulse rep. rate in Hz
8 c      = 3*10^5;     // vel. in km/s
9
10 // Calculations
11 PRI    = 1/PRR        // pulse rep. interval
12 Ra     = modulo(R,(c*PRI/2)); // apparent
    range in km
13
14 // Output
15 mprintf('Apparent Range = %d Km\n',Ra);
16 //

```

Scilab code Exa 10.12 Finding true range

```

1 // Chapter 10 example 12

```

```

2 //


---


3 clc;
4 clear;
5 //Given data
6 Ra      = 25;           // Apparent Range in km
7 PRF     = 2000;        // Pulse rep. freq.
8 c       = 3*10^5;      // vel. of EM waves in km/s
9 Nr      = 3;           // Range zone
10
11 // Calculations
12 R       = Ra + ((c/2)*((Nr - 1)/PRF)) // true
    range in km
13
14 // Output
15 mprintf('True Range of the target = %d Km',R);
16 //


---



```

Scilab code Exa 10.13 Estimating true range

```

1 // Chapter 10 example 13
2 //


---


3 clc;
4 clear;
5 //Given data
6 PRF_1   = 750;         // pulse rep. freq in Hz
7 PRF_2   = 1000;        // pulse rep. freq in Hz
8 PRF_3   = 1250;        // pulse rep. freq in Hz
9 Ra_1    = 100;         // Apparent range for PRF_1
10 Ra_2    = 50;         // Apparent range for PRF_2

```

```

11 Ra_3      = 20;           // Apparent range for PRF_3
12 c         = 3*10^5;     // Vel of EM waves in Km/s
13
14 // Calculations
15 for Nr = 1:6             // Nr = Radar Zones
16     R1(Nr)              = Ra_1 + ((c/2)*((Nr - 1)/PRF_1))
                          // true range in km
17     R2(Nr)              = Ra_2 + ((c/2)*((Nr - 1)/PRF_2))
                          // true range in km
18     R3(Nr)              = Ra_3 + ((c/2)*((Nr - 1)/PRF_3))
                          // true range in km
19 end
20
21 // Output
22 mprintf('Possible True Range measurements for 750
          PPS\n');
23 mprintf(' = %dkm \n',R1);
24 mprintf('Possible True Range measurements for 1000
          PPS\n');
25 mprintf(' = %dkm \n',R2);
26 mprintf('Possible True Range measurements for 1250
          PPS\n');
27 mprintf(' = %dkm \n',R3);
28 mprintf('The shortest possible range that has been
          measured at all PRFs is %d Km True Range = %d km',
          ,R1(3),R1(3))

```

Scilab code Exa 10.14 Finding compression ratio and width of compressed pulse

```

1 // Chapter 10 example 14
2 //

```

```

3 clc;

```

```

4 clear;
5 //Given data
6 Te      = 4      // Expanded pulse width in usec
7 f1      = 50     // RF freq in Mhz
8 f2      = 70     // RF freq in Mhz
9
10 // Calculations
11 B       = f2 - f1; // Signal bandwidth
12 Tc      = 1/B;    // Compressed pulse width in
      us
13 CR      = Te/Tc   // compression ratio
14
15 // Output
16 mprintf('Compression Ratio = %d\n Width of
      compressed pulse = %3.2f us',CR,Tc);
17 //

```

Scilab code Exa 10.15 Finding synthesised aperture and cross range resolution

```

1 // Chapter 10 example 15
2 //

```

```

3 clc;
4 clear;
5 //Given data
6 f      = 10*10^9; // operating freq in Hz
7 c      = 3*10^8;  // vel. of EM waves in m/s
8 Ae     = 2;      // Antenna aperture in m
9 R      = 10*10^3; // Target Range in m
10
11 // Calculations

```

```

12 lamda    = c/f;           // Wavelength in m
13 bw3db    = lamda/2;      // 3dB beamwidth in radian
14 Leff     = bw3db * R;    // effective length
15 Xs       = (R*lamda)/(2*Leff); // Cross range
           resolution
16
17 // Output
18 mprintf('Effective Length = %d m\n',Leff);
19 mprintf('Cross range resolution = %d m',Xs);
20 //

```

Scilab code Exa 10.16 Finding round trip time

```

1 // Chapter 10 example 16
2 //

```

```

3 clc;
4 clear;
5 //Given data
6 R      = 6000;           // Target Range
7 c      = 3*10^8;        // speed of light in m/s
8
9 // Calculations
10 t      = (2*R)/c;       // round trip time
11
12 // Output
13 mprintf('Round Trip time = %d us',t/10^-6);
14 //

```

Scilab code Exa 10.17 Finding doppler shift

```
1 // Chapter 10 example 17
2 //


---


3 clc;
4 clear;
5 //Given data
6 v      = 250;           // velocity in m/s
7 lamda  = 10.6*10^-6 // operating wavelength
8 theta  = 60;           // angle of depression
9
10 // Calculations
11 Vr     = v*cos(theta*%pi/180); // radial
    velocity
12 fd     = (2*Vr)/lamda; // doppler shift
13
14 // Output
15 mprintf('Doppler Shift = %3.2 f Mhz',fd*10^-6);
16 //
```

Scilab code Exa 10.18 Finding Range Resolution

```
1 // Chapter 10 example 18
2 //
```

```
3 clc;
4 clear;
```

```
5 //Given data
6 B      = 10^6;    // Bandwidth in Mhz
7 c      = 3*10^8; // speed of light in m/s
8
9 // Calculations
10 RR     = c/(2*B); // Range Resolution in m
11
12 // Output
13 mprintf('Range Resolution = %d m\n',RR);
14 //
```

Chapter 11

Satellites and Satellite Communications

Scilab code Exa 11.1 Finding orbital velocity

```
1 // Chapter 11 example 1
2 //


---


3 clc;
4 clear;
5
6 // Given data
7 h      = 150;           // height of satellite from
   earth in km
8 G      = 6.67*10^-11;   // Gravitational
   constant
9 M      = 5.98*10^24;    // mass of the earth in
   kg
10 Re    = 6370;          // radius of earth in km
11
12 // Calculations
13 u      = G*M
14 V      = sqrt(u/((Re + h)*10^3)) // orbital
```

```

    velocity
15 V1      = V/1000;           // orbital
    velocity in km/s
16
17 // Output
18 mprintf('Orbital velocity = %3.3f km/s ',V1);
19 //

```

Scilab code Exa 11.2 Finding orbital eccentricity

```

1 // Chapter 11 example 2
2 //

```

```

3 clc;
4 clear;
5
6 // Given data
7 Ap_Pe_diff = 30000;           // difference between
    apogee and perigee in Km
8 a          = 16000;           // semi major axis of
    orbit
9
10 // Calculations
11 e          = Ap_Pe_diff/(2*a); // Eccentricity
12
13 // Output
14 mprintf('Eccentricity = %3.2f ',e);
15 //

```

Scilab code Exa 11.3 Finding relationship between orbital periods

```
1 // Chapter 11 example 3
2 //


---


3 clc;
4 clear;
5
6 // Given data
7 a1      = 18000;           // semi major axis of
   the elliptical orbits of satellite 1
8 a2      = 24000;           // semi major axis of
   the elliptical orbits of satellite 2
9
10 // Calculations
11 // T      = 2*%pi*sqrt(a^3/u);
12 //let K = T2/T1;
13 K       = (a2/a1)^(3/2);   // Ratio of orbital
   periods
14
15 // Output
16 mprintf('The orbital period of satellite -2 is %3.2f
   times the orbital period of satellite -1',K);
17 //
```

Scilab code Exa 11.4 Finding magnitude of velocity impulse

```
1 // Chapter 11 example 4
```

```

2 //


---


3 clc;
4 clear;
5
6 // Given data
7 h      = 35800;           // height of satellite
   orbit from earth in km
8 G      = 6.67*10-11;    // Gravitational
   constant
9 M      = 5.98*1024;    // mass of the earth in
   kg
10 Re    = 6364;           // radius of earth in km
11 i     = 2;              // inclination angle
12
13 // Calculations
14 u     = G*M
15 r     = Re+h
16 Vi    = sqrt(u/r*103)*tan(i*%pi/180); //
   magnitude of velocity impulse
17 V     = Vi/1000;       //
   magnitude of velocity impulse in m/s
18 // Output
19 mprintf('Magnitude of velocity impulse = %d m/s',V);
20 //


---



```

Scilab code Exa 11.5 Finding maximum shadow angle and max daily eclipse duration

```

1 // Chapter 11 example 5
2 //


---



```

```

3  clc;
4  clear;
5  // Given data
6  h      = 13622;           // ht of circular orbit from
    earth's surface
7  Re     = 6378;           // Radius of earth in km
8
9  // Calculations
10 R      = Re+h;           // Radius of circular orbit
11 pimax  = 180 - (2*acos(Re/R))*(180/%pi); //
    Maximum shadow angle
12 eclipsmax_time = (pimax/360)*24; //
    maximum daily eclipse duration
13
14 // output
15 mprintf('maximum shadow angle = %3.1 f \n Maximum
    daily eclipse duration = %3.2f hours ',pimax,
    eclipsmax_time);
16 //

```

Scilab code Exa 11.6 Finding total time from first day of eclipse to last day of eclipse

```

1 //Chapter 11 example 6
2 //

```

```

3  clc;
4  clear;
5  // Given data
6  h      = 35786;           // ht of geo.stationary
    orbit above earth surface

```

```

7 T      = 365;           // time in days
8 r      = 6378          // radius of earth in km
9
10 // ie(t) = 23.4*sin(2*%pi*t/T)
11 // for a circular orbit of 20000 km radius ,phi =
    37.4 ,Therefore , the time from first day of
    eclipse to equinox is given by substituting ie(t)
    = 37.4/2 = 18.7
12 phi    = 37.4
13 ie     = (phi/2)*(%pi/180)
14 k      = 23.4*(%pi/180)
15 t      = (365/(2*%pi))*asin((ie/k))
16 // for geostationary orbit
17 phimax = 180 - 2*(acos(r/(r+h)))*(180/%pi)
18 t_geo  = (365/(2*%pi))*asin((8.7*%pi/180)/k)
19
20 // Output
21 mprintf('Total time from first day of eclipse to
    last day of eclipse = %3.1f days\n Total time
    from first day of eclipse to last day of eclipse
    for geostationary orbit = %3.2f days',t,t_geo)
22 //

```

Scilab code Exa 11.7 Finding centrifugal force

```

1 // Chapter 11 example 7
2 //
3 clc;
4 clear;
5 // Given data
6 m      = 100;          // mass of satellite

```

```

7 V      = 8000;      // orbital velocity in m/s
8 Re     = 6370;      // radius of earth in Km
9 H      = 200;      // satellite height above earth
    surface
10
11 // Calculations
12 CF     = (m*V^2)/((Re+H)*10^3);      // centrifugal
    force
13
14 // output
15 mprintf('Centrifugal Force = %d Newtons ',CF);
16 //

```

Scilab code Exa 11.8 Finding semi major axis

```

1 // Chapter 11 example 8
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 Apogee = 30000;      // Apogee pt of satellite
    elliptical orbit
7 Perige = 1000;      // perigee pt of satellite
    elliptical orbit
8
9 // Calculations
10 a      = (Apogee + Perige)/2;      // semi major axis
11
12 // output
13 mprintf('Semi-major axis = %d Km',a);
14 //

```

Scilab code Exa 11.9 Finding apogee perigee and orbit eccentricity

```
1 // Chapter 11 example 9
2 //
3 clc;
4 clear;
5 // Given data
6 farth   = 30000;           // farthest point in
   satellite elliptic eccentric orbit
7 closest = 200;           // closest point in
   satellite elliptic eccentric orbit
8 Re      = 6370;           // Radius of earth in km
9
10 // Calculations
11 Apogee  = farth + Re;     // Apogee in km
12 Perigee = closest + Re;  // perigee in km
13 a       = (Apogee + Perigee)/(2); // semi-
   major axis
14 e       = (Apogee - Perigee)/(2*a); // orbit
   eccentricity
15
16 // Output
17 mprintf('Apogee = %d km\n Perigee = %d km\n orbit
   eccentricity = %3.3f', Apogee, Perigee, e);
18 //
```

Scilab code Exa 11.10 Finding apogee and perigee distances

```
1 // Chapter 11 example 10
2 //


---


3 clc;
4 clear;
5 // Given data
6 e      = 0.5;      // orbit eccentricity
7 ae     = 14000;    // from fig. the distance from
      center of ellipse to the centre of earth
8
9 // Calculations
10 a      = ae/e;     // semi major axis
11 apogee = a*(1 + e); // Apogee in km
12 perige = a*(1 - e); // perigee in km
13
14 // output
15 mprintf('Apogee = %d km\n Perigee = %d km', apogee,
      perige);
16 //
```

Scilab code Exa 11.11 Finding escape velocity

```
1 // Chapter 11 example 11
2 //


---


3 clc;
4 clear;
5 // Given data
6 G      = 6.67*10^-11; // Gravitational
```

```

    constant
7 M      = 5.98*10^24;      // mass of the earth in
    kg
8 Re     = 6370*10^3;      // radius of earth in m
9
10 // Calculations
11 u      = G*M
12 Vesc   = sqrt(2*u/Re);
13 Ves    = Vesc/1000;     // escape velocity in km/s
14
15 // Output
16 mprintf('Escape velocity = %3.1f km/s',Ves);
17 //

```

Scilab code Exa 11.12 Finding orbital period

```

1 // Chapter 11 example 12
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 a      = 25000*10^3;      // semimajor axis in m
    from fig
7 G      = 6.67*10^-11;    // Gravitational
    constant
8 M      = 5.98*10^24;     // mass of the earth in
    kg
9 h = 0
10
11 // Calculations
12 u      = G*M;

```

```

13 T      = 2*%pi*sqrt((a^3)/u)
14 hr      = T/3600           // conv.
      from sec to hrs and min
15 t      = modulo(T,3600)   // conv.
      from sec to hrs and min
16 mi      = t/60           // conv.
      from sec to hrs and min
17
18 // Output
19 mprintf('Orbital time period = %d Hours %d minutes',
      hr,mi)

```

Scilab code Exa 11.13 Finding orbital time period velocity at apogee and perigee points

```

1 // Chapter 11 example 13
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 apogee = 35000;           // farthest point in kms
7 perigee = 500;           // closest point in kms
8 r      = 6360;           // radius of earth in kms
9 G      = 6.67*10^-11     // gravitational constant
10 M     = 5.98*10^24;     // mass of earth in kgs
11 // calculations
12 //funcprot(0)
13 apogee_dist = apogee + r // apogee distance in
      kms
14 perigee_dist = perigee+r ; // perigee distance
      in kms
15 a           = (apogee_dist + perigee_dist)/2; //
      semi-major axis of elliptical orbit

```

```

16 T          = (2*%pi)*sqrt((a*10^3)^3/(G*M));
           // orbital time period
17 hr         = T/3600                               // conv.
           from sec to hrs and min
18 t         = modulo(T,3600)                       // conv.
           from sec to hrs and min
19 mi         = t/60                                 // conv.
           from sec to hrs and min
20 u          = G*M
21 Vapogee    = sqrt(u*((2/(apogee_dist*10^3)) - (1/(a
           *10^3)))); // velocity at apogee point
22 Vperigee   = sqrt((G*M)*((2/(perigee_dist*10^3)
           -(1/(a*10^3)))) // velocity at perigee point
23
24 // Output
25 mprintf('Orbital Time Period = %d Hrs %d min \n
           Velocity at apogee = %3.3f Km/s\n Velocity at
           perigee = %3.3f Km/s',hr,mi,Vapogee/1000,Vperigee
           /1000)
26 mprintf('\n Note: Calculation mistake in textbook in
           finding velocity at apogee point')

```

Scilab code Exa 11.14 Finding target eccentricity

```

1 // Chapter 11 example 14
2 //


---


3 clc;
4 clear;
5 // Given data
6 ra_S_rp     = 50000; // sum of apogee and
           perigee distance
7 ra_D_rp     = 30000; // difference of apogee
           and perigee distances

```

```

8
9 // Calculations
10 e          = ra_D_rp/ra_S_rp; // eccentricity
11
12 // Output
13 mprintf('Target eccentricity = %3.1f',e);
14 //

```

Scilab code Exa 11.15 Finding apogee and perigee distances

```

1 // Chapter 11 example 15
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 a      = 20000; // semi major axis of
   elliptical sate. orbit in kms
7 b      = 16000; // semi minor axis of
   elliptical sate. orbit in kms
8
9 // calculations
10 // a = (ra + rp)/2
11 // b = sqrt(ra*rp)
12 // let k = (ra + rp)
13 // let l = ra*rp
14 k      = 2*a; // ra+ rp
   -----1
15 l      = b^2; // ra*rp
   -----2
16 // ra^2 -40000ra + 256000000
17 p      = [ 1 -k l]

```

```

18 x      = roots(p)
19 r1     = x(1)
20 r2     = x(2)
21 rp = k - r1;
22 mprintf('Apogee distance = %d km\n Perigee distance
          = %d km',r1,rp);
23 //

```

Scilab code Exa 11.16 Finding max deviation in latitude and longitude

```

1 // Chapter 11 example 16
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 H      = 35800;           // height of orbit in kms
7 re     = 6364;           // radius of earth in kms
8 i      = 2;              // angle of inclination in
                          degrees
9
10 // Calculations
11 r      = H+re;           // radius of orbit in kms
12 lamdamax = i;           // max latitude deviation
13 long_dev = (i^2)/228;    // max. longitude deviation
14 disp_lamda = (r*i*pi/180) // max disp in km due to
                          lamdamax
15 max_disp1 = disp_lamda*(long_dev/lamdamax) // max
                          disp.due to max.longitude deviation
16
17 // Output
18 mprintf('Maximum deviation in latitude = %d \n

```

```

Maximum deviation in longitude = %3.4 f \n
Maximum displacements due to latitude
displacement = %d Km\n Maximum displacements due
to longitude displacement = %3.1 f Km\n',lamdamax,
long_dev,disp_lamda,max_disp1 );

```

Scilab code Exa 11.17 Finding angle of inclination

```

1 // Chapter 11 example 17
2 //


---


3 clc;
4 clear;
5 // Given data
6 r      = 42164;           // orbital radius in kms
7 Dlamda_max = 500;       // max displacement due to
   latitude deviation
8
9 // Calculations
10 i     = Dlamda_max/r;   // angle of inclination in
   radians
11 i_deg = i*180/%pi      // rad to deg conv
12
13 // Output
14 mprintf('Angle of inclination = %3.2 f ',i_deg);
15 //


---



```

Scilab code Exa 11.18 Finding maximum coverage angle and max slant range

```

1 // Chapter 11 example 18
2 //


---


3 clc;
4 clear;
5 // Given data
6 H   = 35786;           // ht of orbit from earth
   surface
7 Re  = 6378            // radius of earth in kms
8
9 // Calculations
10 // For theoretical max coverage angle ,elevation
   angle E = 0
11 E = 0
12 // max coverage angle = 2amax
13 // 2amax = 2*asin(Re/(Re+H)*cosE)
14 amax = 2*asin((Re/(Re+H))*cos(E))
15 amax_deg = amax*180/%pi // rad to deg conversion
16 D   = sqrt( Re^2 + (Re+H)^2 - 2*Re*(Re + H)*asin(E +
   asin((Re/(Re+H))*cos(E)))) // Max slant range
17
18 // Output
19 mprintf('Maximum Coverage angle = %3.1 f \n Maximum
   slant Range = %d Km',amax_deg,D);
20 //


---



```


Chapter 13

Microwave Communication link Basic Design Considerations

Scilab code Exa 13.1 Finding path length

```
1 //Chapter 13 example 1
2 //


---


3 clc;
4 clear;
5 // Given data
6 f      = 6;           // microwave terrestrial
   comm link oper. freq in Ghz
7 D      = 50;         // single hop path length in
   miles
8 // mid way of path length
9 D1     = 25;
10 D2    = 25;
11 N     = 3;           // N value for third fresnal
   zone
12
13 // calculations
14 F1     = 72.2*((D1*D2)/(D*f))^0.5;   // first
```

```

    fresnel zone
15 F3      = F1*sqrt(N);           // Third fresnal
    zone
16
17 // Output
18 mprintf('First Fresnel zone distance = %3.1f feet\n
    Third Fresnel zone distance = %3.1f feet\n',F1,F3
    );
19 //

```

Scilab code Exa 13.2 Finding max tolerable obstacle height

```

1 //Chapter 13 example 2
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 f      = 4.5;           // microwave terrestrial
    comm link oper. freq in Ghz
7 D      = 40;           // single hop path length in
    miles
8 hant   = 200;          // antenna ht. above surface
    of earth
9 // from fig
10 D1     = 5;
11 D2     = 35;
12 K      = 1;           // for normal case
13
14 // calculations
15 F1     = 72.2*((D1*D2)/(D*f))^0.5;   // first
    fresnel zone

```

```

16 // computing curvature 'h' of earth at a distance of
    10 miles from Transmitter if given by (D1*D2)
    /(1.5*K)
17 h          = (D1*D2)/(1.5*K);           // curvature
    of earth in feet
18 PLabove = hant - h;                     // path line
    is PLabove feet above surface of earth
19 hmaxtol = PLabove - F1;                 // max
    tolerable height in feet
20
21 // Output
22 mprintf('Maximum tolerable height of obstacle above
    surface of earth = %3.1f feet',hmaxtol);
23 //

```

Scilab code Exa 13.3 Finding whether first fresnal zone pass without any obstruction

```

1 //Chapter 13 example 3
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 f          = 4.5;                       // microwave terrestrial
    comm link oper. freq in Ghz
7 D          = 40;                         // single hop path length in
    miles
8 hant       = 200;                        // antenna ht. above surface
    of earth
9 // from fig
10 D1        = 5;

```

```

11 D2      = 35;
12 K       = 2/3;           // K-factor
13
14 // calculations
15 F1      = 72.2*((D1*D2)/(D*f))^0.5;   // first
    fresnel zone
16 // computing curvature 'h' of earth at a distance of
    10 miles from Transmitter if given by (D1*D2)
    /(1.5*K)
17 h       = (D1*D2)/(1.5*K);           // curvature
    of earth in feet
18 PLabove = hant - h;               // path line
    is PLabove feet above surface of earth
19 if PLabove < F1 then
20     mprintf('Available clearance above the surface
    of earth = %d feet\n Required first fresnel
    zone clearance = %3.1f feet ,So it would be
    obstructed ',PLabove,F1 )
21 end
22 //

```

Scilab code Exa 13.4 Finding outage time

```

1 //Chapter 13 example 4
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 UF      = 2*10^-4;           // unavailability factor
7
8 // Calculations

```

```

9  outage_t = UF*8760;    // outage time in hours per
    year
10
11 // Output
12 mprintf('Outrage time = %3.3f hours per year',
    outage_t);
13 //

```

Scilab code Exa 13.5 Finding improvement in probability of fade margin

```

1 //Chapter 13 example 5
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 PL      = 50;    // path length in miles from fig
7 FM      = 40;    // fade margin in dB
8 P_fm_ex = 7*10^-5; // prob. of fade margin getting
    exceeding
9 P_fm_ex_50db = 6*10^-6; // prob. of fade margin
    getting exceeding for fade margin 50dB
10 p_fig_30m_40db = 2*10^-5; // prob fig for patl
    length of 30miles and fade margin 40dB
11
12 // Calculations
13 impr_prob_a = P_fm_ex/P_fm_ex_50db; //
    improvement in prob. of fade margin for a
14 impr_prob_b = P_fm_ex/p_fig_30m_40db //
    improvement in prob. of fade margin for b
15
16 // Output

```

```

17 mprintf('(a):\n Improvement in probability of fade
    margin = %3.1f\n (b):\n Improvement in
    probability of fade margin = %3.1f\n',impr_prob_a
    ,impr_prob_b);
18 //

```

Scilab code Exa 13.6 Finding unavailability factor

```

1 //Chapter 13 example 6
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 UF_sh = 0.01; // unavail. factor for single
    hop
7 IF_SD = 100; // improvement factor due to
    space diversity
8
9 // Calculations
10 UF_4hl = 4* UF_sh/100; // unavail. factor for 4
    hop link and conv from %
11 UF = UF_sh/(100*IF_SD); // unavail. factor for
    single hop link if it employs space diversity
12
13 // Output
14 mprintf('unavail. factor for 4 hop link = %3.4f\n
    unavail. factor for single hop link if it employs
    space diversity = %3.0e',UF_4hl,UF);
15 //

```

Scilab code Exa 13.7 Finding Outrage Time

```
1 //Chapter 13 example 7
2 //
3 clc;
4 clear;
5 // Given data
6 f      = 3.5;           // operating freq. of
   microwave link in Ghz
7 D      = 30;           // single hop path
   length in miles
8 a      = 1;            // roughness
9 b      = 0.5;          // humid climate
10 F     = 40;           // fade margin in dB
11
12 // Calculations
13 U      = a*b*2.5*10^-6 *f*D^3 *10^(-F/10); //
   unavailability factor
14 U1     = U*525600;    //
   unavailabilty factor in minutes per year
15 U4     = U1*4;        //
   unavailabilty factor for 4-hop link
16 // Output
17 mprintf('Outage Time = %3.1f minutes per year',U4);
18 //
```

Scilab code Exa 13.8 Finding change in value of unavailability Factor

```

1 //Chapter 13 example 8
2 //


---


3 clc;
4 clear;
5 // Given data
6 // D2 = 2*D1 // path length is doubled
7 // F2 = F1+10; // fade margin is increased
  by 10dB
8 // f2 = 1.25 f1 // frequency operation
  increased by 25 %
9
10 // (U1/U2) = (f1 * D1^3 * 10^(-F1/10)) / (f1 * D1^3 *
  10^(-F1/10))
11 // sub above values
12 // (U1/U2) = (f1 * D1^3 * 10^(-F1/10)) / (1.25 * f1 * 8 *
  D1^3 * 10^(-F1/10) * 10^-1) = 1
13 mprintf('Unavailability Factor remains unaltered');
14 //


---



```

Scilab code Exa 13.9 Finding improvement in outage time

```

1 //Chapter 13 example 9
2 //


---


3 clc;
4 clear;
5 mprintf('The improvement factor is proportional to
  square of antenna spacing. Therefore, it will
  increase by a factor of 4\n Consequently, the
  unavailability factor and hence the outage time

```



```
will also reduce by a factor of 4');  
6 //
```

Scilab code Exa 13.10 Finding composite Fade margin

```
1 //Chapter 13 example 10  
2 //  
  
3 clc;  
4 clear;  
5 // Given data  
6 DFM      = 40;      // dispersive fade margin  
7 FFM      = 30;      // flat fade margin  
8  
9 // Calculations  
10 CFM      = -10*log10(10^(-FFM/10) + 10^(-DFM/10));  
11  
12 // Output  
13 mprintf('Composite Fade Margin = %3.2f dB\n',CFM);  
14 mprintf(' minus sign is wrongly printed in Textbook '  
15 // ');
```

Scilab code Exa 13.11 proof

```
1 //Chapter 13 example 11
```

```

2 //


---


3 clc;
4 clear;
5 // Given data
6 DFM1    = 50;           // dispersive fade margin
7 FFM     = 30;           // flat fade margin
8 DFM2    = 40;           // dispersive fade margin
9
10 // Calculations
11 CFM1    = -10*log10(10^(-FFM/10) + 10^(-DFM1/10));
12 CFM2    = -10*log10(10^(-FFM/10) + 10^(-DFM2/10));
13 d_CFM   = CFM1 -CFM2;
14
15 // Output
16 mprintf('CFM increases by %3.2f dB for a 10 dB
17         increase in DFM',d_CFM);
18 //


---



```

Scilab code Exa 13.12 Finding outage time

```

1 //Chapter 13 example 12
2 //


---


3 clc;
4 clear;
5 // Given data
6 f      = 23;           // operating freq. of
   microwave link in Ghz
7 D      = 10;           // single hop path
   length in miles

```

```

8 a      = 1;           // topographic factor
9 b      = 0.5;        // climatic factor
10 DFM   = 40;         // dispersive fade
    margin
11 FFM   = 30;         // flat fade margin
12
13 // Calculations
14 CFM    = -10*log10(10^(-FFM/10) + 10^(-DFM/10));
    // composite fade margin
15 U      = a*b*2.5*10^-6 *f*D^3 *10^(-CFM/10); //
    unavailability factor
16 U1     = U*525600; //
    outage time in min per year
17
18 // Output
19 mprintf('Outrage time = %3.2f minutes per year ',U1);
20 //

```

Scilab code Exa 13.13 Finding improvement in MTBF

```

1 //Chapter 13 example 13
2 //

```

```

3 clc;
4 clear;
5 // Given data
6 MTBF2 = 20000; // microwave Tx output MTBF
    figure
7 MTBF3 = 60000; // power amplifier portion
    of MTBF
8
9 // Calculations

```

```
10 MTBF1      = (MTBF2*MTBF3)/(MTBF3-MTBF2);
11 impr       = MTBF1-MTBF2      // improvement in MTBF
      if power amplifier not used
12
13 // output
14 mprintf('Improvement in MTBF of transmitter if power
      amplifier is not used = %d hours',impr);
15 //
```
