Scilab Textbook Companion for Fiber Optics Communication by H. Kolimbiris[1]

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Book Description

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

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Chapter 1

Elements of Optics And Quantum Physics

Scilab code Exa 1.1 Arrival time difference between two monochromatic optical beams

```
//Example1-1
//Given
clc;
clear all;
printf("(i)    t1=d/c   \n");
printf(" (ii)  t2=[(d-5)/c]+[5/v2] \n");
printf("       v2=c/n2        \n");
printf("       t2=(d+2.5)/c\n");
printf(" (iii) delta_t=t2-t1=(d+2.5-d)/c\n");
c=3*10^8;        //Speed of light in m/s
delta_t=2.5*10^-2/c;             //converted 2.5 cm
   into meters
printf('The time difference %e s",delta_t );
```

```
printf("\n Arrival time difference of two monochromatic beams is %0.0f ps",delta_t*10^12)
// Answer misprinted in the book
```

Scilab code Exa 1.2 Calculate angle of refraction velocity wavelength

```
//given
//page no 5
clc;
clear;
//Applying Snell's law
a=1*sin(428)/1.333; //a=sin(w2)
printf("Angle of refraction is %0.1f\n ",a)
printf("\n Angle of refraction is %0.0f degree \n ",asin(a)*57.27)
c=3*10^8;              //speed of light in m/s
n2=1.333;              //refractive index of 2nd medium
v2=c/n2;               //velocity in second medium in m/s
n1=1;                  //refractive index of 1st medium
l1=620;                //in nm   wavelength
printf("\n Velocity of optical ray through medium second %0.02f*10^8 m/s\n",v2/10^8);
l2= (n1*l1)/n2;        //wavelength in 2nd medium in nm
printf("\n Wavelenght of optical ray through medium second %0.1f nm",l2);        //Result
```

Scilab code Exa 1.3 Angle of refration and Deviation

```
//given
//page no 5
clc;
clear;
n1=1;                   //refractive index of air
n2=1.56;                //refractive index of medium
w1=60;      //in deg C
//using snell's law
a= n1*sind(w1)/n2;              //a=sin(w1)
w2=asind(a);                    //in degree
printf("Angle of refraction is %0.2f degree\n ",w2);
B=w1-w2;                          //in degree
printf("Angle of deviation is %0.1f degree\n ",B)
// The answer doesn't match because of priting errorsin calculation as sin(608)
```

Scilab code Exa 1.4 Find optical Path and angle phi

```
//given
//page no 6
clc;
disp('Solution (i)');
 w=5/12.5; //          tan(w)=5/12.5;
printf("\n The value of tan(w2) is %0.1f \n",w);
w2=atan(w)*180/%pi;
//w2=atan(w)*180/%pi
printf("\n The value of w2 is %0.1f degree\n",w2);
printf("\n The value of sin(w2) is %0.2f \n",sin(w2*%pi/180));
disp('Solution (ii)');
```

```
//Applying snell's law
n1=1.05;
n2=1.5;
w1=(n2*sin(w2*%pi/180))/n1;//a=sin(w1)
printf("\n The value of sin(w1) is %0.2f \n",w1);
printf("\n The value of w1 is  %0.0f degree \n",asin(w1)*180/%pi);
//value of w1
//tan(w1)=(p-x)12.5;
k=0.62*12.5;
d=1.05*[(12.5)^2+(k)^2]^0.5 +1.5*(12.5^2+5^2)^0.5;//d=1.05[(h1)^2+(k)^2]^0.5 +n2(h2^2+x^2)^0.5;
printf("\n the optical distance is %0.2f cm\n",d);
```

Scilab code Exa 1.5 Find Phase velocity

```
//Ex1_5
//given
//page no 11
clc;
clear;
c=3*10^8;
disp('Solution (i) is ');
ri=1.5;//refractive index
u=830// in nm
l=u/ri;        //in nm
printf("\n Wavelength is %0.0f nm \n",l);
disp('Solution (ii) is ');
l=round(l);                    // rounding to nearest integer
f=c/(l*10^-9)*10^-12;          //in THz
printf("\n  frequency is %0.0f THz\n",f);
disp('Solution (iii) is ');
f=round(f);                    // rounding to nearest integer
```

```
v=l*10^-9*f*10^12;            //in m/s
mprintf("\n  phase velocity  is %.3e m/s\n",v);//
    answer is getting rounding off due to larger
    calculation
```

Scilab code Exa 1.6 find wavelength

```
//Ex1_6
//given
//page no 12
clc;
clear;
disp('Solution (i) is ');
l=720;       //wavelength in nm
n=1.5;            //refractive index
lm=l/n;
disp('nm',lm,'Wavelenth is');        //result
disp('Solution (ii) is ');
c=3*10^8;             //in m/s speed of light
u=c/n;
disp('m/s',u,'Velocity  is');        //result
```

Scilab code Exa 1.7 Find wavelength of Light

```
//Ex1_7
//given
//page no 12
clc;
clear;
disp('Solution (i)');
c=3*10^8;         //in m/s speed of light
l=640;            //in nm
u=2.2*10^8;       //in m/s
```

```
lm=u*l/c;            //wavelenth in medium
printf("\n The wavelength is %0.1f nm\n",lm);// The
    answer in the book is misprinted
disp('Solution (ii)');
n=l/lm;          //refractive index
printf("\n Refractive Index is %0.3f \n",n);//The
    answer in the book is misprinted
```

Scilab code Exa 1.8 Ratio of input output intensity

```





//Ex1_8
//given
//page no 12
clc;
clear;
//k=aa+as=6.3;
//Given values from research
k=6.3;        //combined attenuation due to absorption
     and scattering
d=25;        //in cm
disp('Solution (ii)');
//Io/Ii=exp(-(ao+ai)*d);   d in m
j=exp(-(k)*d/100);  //Io/Ii ratio
printf("\n  Io is %0.3f of Ii \n",j);        //result
```

Scilab code Exa 1.9 Compute length of Tube

```
//Ex1_9
```

```
//given
//page no 13
clc;
clear;
//       Given formula    Io/Ii=exp(-(ao+ai)*d);
//        k=aa+as=63.1;
//        Io/Ii=1.5
d=log(.15)/-63.1;         //length of tube
printf("\nLength of tube, d = %0.0f cm    \n",d*100);
         //Result
```

Scilab code Exa 1.10 Degree of polarisation

```
//Example no 1-10
//page no. 26
clc;
clear;
//p=m/{m+[2*n/(1-n)^2]^2};

m=5;               //no. of reflective plates
n=1.33;            //refractive indices
p=m/{m+[2*n/(1-(n)^2)]^2}; //degree of polarisation
printf("\n The degree of polarisation is %0.1f     \n
   ",p);
```

Scilab code Exa 1.11 Number of refractive Plates

```
//Example no 1-11
//page no. 26
clc;
clear;
//m= p*{m+[2*n/(1-n)^2]^2};

```

```
n=1.5;            //refractive indices
p=0.45;           //degree of polarisation
m={p*[2*n/(1-n^2)]^2}/(1-p);
printf("\n Thus it will require %0.0f reflective
   plate to achive a degree of polarization equal to
    0.45",m);          //Result mis rounded of to
   nearest integer
```

Scilab code Exa 1.12 Ratio of Optical Ray

```

//Example no 1-12
//page no. 27
clc;
clear;
//I1/I0=cos(w)^2
//k=I1/I0;

w=30;                  //angle bw polarizer and
   analyser in degee
k=cosd(w)^2;
disp(k,'The ratio of optical ray intensity ,I1/I0=')
   ;              //Result
```

Scilab code Exa 1.13 Angle between polariser and analyzer

```
//Example no 1-13
//page no. 27
clc;
clear;
//I1/I0=cos(w)^2
//Given I1/I0=0.55

```

```
k=sqrt(0.55);  //from above formulae
printf("\n cos w is %0.2f ",k);
printf("\n The angle bw polarizer and analyser , w is %0.0f degree",acos(k)*180/%pi);//Result
```

Scilab code Exa 1.14 find time difference and phase difference

```
//Example no 1-14
//page no. 29
clc;
clear;
disp('Solution (i) is ');
ne=1.4;//refractive index
no=1.25;            //refractive index
c=3*10^8;                   //in m/s
T=2*10^-5;  //in m
l=740;      //in nm
t=[ne-no]*T/c;      //time difference
printf("\n Time difference , t is %0.2f ps",t*10^12); // result
disp('Solution (ii) is ');
le=l/ne;
lo=l/no;
fi=2*%pi*T*(1/le-1/lo)*10^9;
printf("\n Phase difference is %0.1f rad",fi);// result
// Answer misprinted in book
```

Scilab code Exa 1.15 Find wavelength

```


//page no. 31
```

```
//Example no 1-15
//E=h*v=h*c/l;
clc;
clear;
E=3;        //In KeV
//1eV=1.6*10^-19
h=6.63*10^-34;  //plank constant in J/s
c=3*10^8;            // speed of light in m/s
l=h*c/(E*10^3*1.6*10^-19);// wavelength  in nm
printf("wavelength of a electromagnetic radiation is
    %0.3f nm",l*10^9);//result
```

Scilab code Exa 1.16 Compute the constant phi

```

//page no. 31
//Example no 1-16
clc;
clear;
disp('Solution (i) is ');
l=670//in nm
h=6.63*10^-34;  // plank constant in J/s
c=3*10^17//speed of light in nm/sec
Ek=0.75//In eV
phi=(h*c/l)/(1.6*10^-19) -Ek;
phi=round(phi*10)/10;            //round to 1 decimal
    point
printf("\n Characteristic of material = %0.1f eV\n",
   phi);//result
disp('Solution (ii) is ');
fc=phi*1.6*10^-19/h*10^-12;// frequency in THz//
   result
fc=round(fc);
printf("\n Cuttoff frequency is = %0.0f THz\n",fc);
   //result
```

```
lc=c/(fc*10^12);        //in nm
printf("\n Cuttoff wavelength is = %0.0f nm\n",lc); //result
```

Scilab code Exa 1.17 Voltage required to accelerate an electron

```


//page no. 31
//Example no 1-17
clc;
clear all;
disp('Solution (i) is ');
l=0.045;//wavelength in nm
h=6.63*10^-34;      //planks constant in J/s
c=3*10^8;         //speed of light in m/s
E=h*c/l/10^-9;     //energy of photon in eV
mprintf("\n E = %e J",E);
E1=E/(1.6*10^-19);     // energy in joule
mprintf("\n E = %e eV",E1);
e=1.6*10^-19;     // charge of electron
disp('Solution (ii) is ');
V=E/e;
printf("\n Required voltage is = %0.2f KV",V/1000); // result

// Value of wavelenght in problem is .45 but in the solution is .045
//the value considered above is .045
```

Scilab code Exa 1.18 Compute uncertainity in electron velocity

```
//page no. 36
```

```
//Example no 1-18
clc;
clear;

disp('Solution (i) is ');
x=620// difference in particle momentum In nm
h=6.63*10^-34// planks constant In J/s
//p=h/(4*%pi*x);
//m*v=h/(4*%pi*x);
m=9.11*10^-31 //In kg // mass of electron
v=h /(4*%pi* x *10^-9*m);// electron velocity
printf("\n The uncertanity in electron velocity is
   %0.0f m/s  \n",v);// result
```

Chapter 2

Fundamental of Semi Conductor Theory

Scilab code Exa 2.1 maximum number of electron

```
//Chapter 2
//page no 43
//given
clc;
clear ;
n=1;
Ne=2*n^2;
printf("\n Maximum number of electron in 1st shell
    is %.0f\n ",Ne);//Result
n2=2;// shell no
Ne2=2*n2^2;// shell no
printf("\n Maximum number of electron in 2nd shell
    is %.0f ",Ne2);//Result
```

Scilab code Exa 2.2 Find band gap energy

```
//Chapter 2
//page no 45
//given
clc;
clear ;
//Given  for silicon for temp 0-400K
Eg0_Si=1.17;       //in eV
A=4.73*10^-4;       //in eV/K
B=636;
for i=1:8
T=50*i;      //degree/Kelvin
Eg_Si=Eg0_Si-(A*T^2)/(B+T);
printf("\n Band gap energy of silicon at %.0f K is %
   .3f eV ",T,Eg_Si);//result
end
//Given  for Germanium for temp 0-400K
disp("");
Eg0_Ge=0.7437;       //in eV
A_Ge=4.774*10^-4;       //in eV/K
B_Ge=235;
for i=1:8
T=50*i;      //degree/Kelvin
Eg_Ge=Eg0_Ge-(A_Ge*T^2)/(B_Ge+T);
printf("\n Band gap energy of germanium at %.0f K is
    %.3f eV ",T,Eg_Ge);//result
end

//Given  for GaAs for temp 0-400K
disp("");
Eg0_Ga=1.519;       //in eV
A_Ga=5.405*10^-4;       //in eV/K
B_Ga=204;
for i=1:8
T=50*i;      //degree/Kelvin
Eg_Ga=Eg0_Ga-(A_Ga*T^2)/(B_Ga+T);
printf("\n Band gap energy of GaAs at %.0f K is %.3f
    eV ",T,Eg_Ga);//result
end
```

Scilab code Exa 2.3 Find carrier velocity and current density

```
//Chapter 2
//page no 52
//given
clc;
clear ;
l=10*10^-3;          //in m
w=2*10^-3;           //in m
h=2*10^-3;           //in m
V=12;                //in V
u_n=0.14;            //in  m*m/V*s
u_p=0.05;            //in m*m/V*s
q_n=1.6*10^-19;      //in Columbs
q_p=1.6*10^-19;      //in Columbs
p_i=2.4*10^19;       //in columbs
n_i=2.4*10^19;       //in columbs
E=V/l;
v_n=E*u_n;
v_p=E*u_p;
J_n=n_i*q_n*v_n;
J_p=p_i*q_p*v_p;
J=J_n+J_p;
printf("\n Electron velocity :vn is  %.0f m/s ",v_n);//result
printf("\n Hole velocity :vp is  %.3f km/s ",v_p/1000);  // result
printf("\n Current density : Jn %0.2f A/m^2",J);             //Result
A=88*10^-6;
I_T=J*A;
printf("\n Total current :I_T is  %.0f mA ",I_T*1000);       //Result
```

Scilab code Exa 2.4 Find electron density and type of semi conductor and extrensic semiconductivity

```
//Chapter 2
//page no 53
//given
clc;
clear ;
n_i=2*10^17;              //electron/m*m*m
p=5.7*10^20;                //holes/m*m*m
u_n=0.14;           //in  m*m/V*s
u_p=0.05;            //in m*m/V*s
q_n=1.6*10^-19;       //in Columbs
q_p=1.6*10^-19;       //in Columbs
n=(n_i)^2/p;
mprintf("\n Electron :n is  %e electrons ",n);//
   result
n=7*10^13
P=(n*u_n*q_n)+(p*u_p*q_p);
printf("\n Conductivity :P is  %.2f S/m ",P);//
   result
// answer misprinted
```

Scilab code Exa 2.5 Find barrier voltage

```
//Chapter 2
//page no 55
//given
clc;
clear ;
NA=10^22;             //acceptors/m*m*m
ND=1.2*10^21;         //donors/m*m*m
```

```
T=298;                //in Kelvin
k=1.38*10^-23;         //Boltzman Constant in J/K
q=1.6*10^-19;         //  charge of electron  in C
Vt=k*T/q;        //thermal voltage  in V
printf("\n VT is  %0.1f mV \n",Vt*1000);       //
   result
n_i=2.4*10^17;         //carrier/m^3 for silicon
VB=Vt*log(NA*ND/n_i^2);// barrier voltage in V
printf("\n Barrier Voltage of Silicon VB is  %0.0f
   mV ",VB*1000);       //result
```

Scilab code Exa 2.6 Calculate current

```
//Chapter 2
//page no 56
//given
clc;
clear ;
Is=0.12;              //in pAmp
V=0.6;              //in V
T=293;                //in Kelvin
k=1.38*10^-23;         //Boltzmann's Constant in J/K
q=1.6*10^-19;        // charge of electron in C
Vt=k*T/q;         //thermal voltage
printf("\n VT(20 deg Cel) is  %0.5f V \n",Vt);//
   result in book is misprint
T1=373;                //in Kelvin
n=1.25;
Vt1=k*T1/q;        //thermal voltage
printf("\n VT(100 deg Cel) is  %0.5f V \n",Vt1);
```

```
I=Is*(exp(V/(n*Vt1))-1);          //forward biasing current in mircoA
printf("\n I(100 deg Cel) is  %0.2f microA \n",I/10^6);//result
```

Scilab code Exa 2.7 compute saturation current

```
//Chapter 2
//page no 56
//given
clc;
clear ;
Is=100;              //in nAmp
Ts=100;                 //in Kelvin
I_s=Is*10^-9*2^(Ts/10);          //I_s will be in nm
printf("\n I(100 deg Cel) is  %0.2f microA \n",I_s*10^6);    //converted to microA from nm
// wrong calculation in the book
```

Scilab code Exa 2.8 calculate radiative minority

```





//Chapter 2
//page no 59
//given
clc;
clear ;
Br_Si=1.79*10^-15;               //Recombination coefficient for Si
```

```
Br_Ge=5.25*10^-14;            //Recombination coefficient for Ge
Br_GeAs=7.21*10^-10;            //Recombination coefficient for GeAs
Br_InAs=8.5*10^-11;            //Recombination coefficient for InAs
P_N=2*10^20;         //per cubic cm
T_Ge=1/Br_Ge/P_N;//radiative minority carrier lifetime
printf("\n T_Ge is  %0.3f micro-s \n",T_Ge/10^-6);//result
T_Si=1/Br_Si/P_N;//radiative minority carrier lifetime
printf("\n T_Si is  %0.2f micro-s \n",T_Si/10^-6);//result
T_InAs=1/Br_InAs/P_N;//radiative minority carrier lifetime
printf("\n T_InAs is  %0.0f ps \n",T_InAs/10^-12);//result
T_GeAs=1/Br_GeAs/P_N;//radiative minority carrier lifetime
printf("\n T_GeAs is  %0.0f ps \n",T_GeAs/10^-12);//result
```

Chapter 3

Optical Sources

Scilab code Exa 3.1 Determine the power coupled into fiber

```
//Chapter 3
//page no 67
//given
clc;
clear all;
Pin=1;          //microW
W=15;               //in degree
NA=sin(W*%pi/180);
NAA=0.26;               //NA=0.2588190 which is rounded
    off
C_c=(NAA)^2;
printf("\n Coupling coefficient is  %0.4f  \n",C_c);
Pf=C_c*Pin;
printf("\n Power coupled into fiber  %0.1f  nW\n",Pf
    *1000);
```

Scilab code Exa 3.2 Power Coupled into fiber

```
//Chapter 3
//page no 67
//given
clc;
clear all;
n=0.02;           //in percentage
W=20;             //in degree
Vf=1.5;           //in Volts
If=20;            //in mAmps
Pin=If*Vf;
printf("\n Power coupled into fiber ,Pin = %0.0f mW
   \n",Pin);
Po=n*Pin;
printf("\n Output Power of the optical source is
   %0.1f mW\n",Po);
///from nc=20 degree
C_c=(sin(W*%pi/180))^2;
Pf=C_c*Po
printf("\n Optical power coupled into fibre is ,Pf =
    %0.0f microW\n",Pf*1000);
```

Scilab code Exa 3.3 Bandwidth of Led Source

```
//Chapter 3
//page no 68
//given
clc;
clear all;
tr=10;            //in nsec
BW=0.35/tr/10^-9;
printf("\n Maximum operating bandwidth is %0.0f MHZ
   \n",BW/10^6);     //divided by 10^6 to convert
   answer in MHZ
```

Scilab code Exa 3.4 Coupling efficiency of an optical source

```
//Chapter 3
//page no 70
//given
clc;
clear all;
T=1; //Air
NA=0.3;
n0=1;
//x=y;
disp("for step index :A=infinite");
//for infinite alpha
//nc=T*(NA/n0)^2*(x/y)^2*(A/(A+2))
nc=T*(NA/n0)^2*(1)^2*1;          // A/(A+2)=1 for A=infinite
printf("\n Coupling Coefficient,nc = %0.0f percent \n\n",nc*100);

disp("for graded index :A=2");
A=2;
//n_c=(T*(NA/n0)^2*[A+[1-(y/x)^2]]/(A+2))
n_c=(T*(NA/n0)^2*[A+[1-(1)^2]]/(A+2))        //x/y=1
printf("\n Coupling Coefficient,nc = %0.1f percent \n",n_c*100);
```

Scilab code Exa 3.5 Coupling efficiency

```
//Chapter 3
//page no 71
//given
clc;
```

```
clear all;
T=1; //Air
NA=0.3;
n0=1;
A=2;
//y=0.75x;
disp("for step index :");
//for infinite alpha
//nc=T*(NA/n0)^2*(x/y)^2*(A/(A+2))
nc=T*(NA/n0)^2*(1/0.75)^2*A/(A+2);           //     y/x=0.75
printf("\n Coupling Coefficient ,nc = %0.0f percent \n\n",nc*100);

disp("for graded index :A=2");
A=2;
//n_c=(T*(NA/n0)^2*[A+[1-(y/x)^2]]/(A+2))
n_c=(T*(NA/n0)^2*[A+[1-(0.75)^2]]/(A+2))       //y/x=0.75
printf("\n Coupling Coefficient ,nc = %0.1f percent \n",n_c*100);
```

Scilab code Exa 3.6 MTBF of LED source

```
//Chapter 3
//page no 72
//given
clc;
clear all;
//calculate Tf
If=85;            //in mAmps
Vf=2.5;           //in Volts
Ta=25;             //in deg C
//calculate Tj
W=150;            //in C/W for hermetric led
```

```
Pd=If*Vf;
Tj=Ta+W*Pd/1000;
printf("\n Value of Tj is %0.1f deg C\n",Tj);
TF=8.01*10^12 *%e^-(8111/(Tj+273));
printf("\n Value of TF is %0.0f deg C\n",TF);
//calculate RF
BF=6.5*10^-4;                    //from table
QF=0.5;                          //from table
EF=1;                            //from table
RF=BF*TF*EF*QF*1/10^6;
disp(RF,"Value of RF")
printf("\n Value of MTBF is %0.0f*10^6 hours \n",1/RF/10^6);//Answer in book is misprint in last line
```

Scilab code Exa 3.7 Calculate MTBF

```
//Chapter 3
//page no 74
//given
clc;
clear all;
//calculate Tf
If=120;            //in mAmps
Vf=1.8;           //in Volts
Ta=80;             //in deg C
//calculate Tj
W=150;            //in C/W for hermetric led
Pd=0.5*If*Vf;
Tj=75+W*Pd/1000;
printf("\n Value of Tj is %0.1f degree cel \n",Tj);
TF=8.01*10^12 *%e^-(8111/(Tj+273));
printf("\n Value of TF is %0.0f \n",TF);
//calculate RF
BF=6.5*10^-4;                    //from table
```

```
QF=0.2;                              //from table
EF=0.75;                                //from table
RF=BF*TF*EF*QF*1/10^6;
printf("\n Value of RF is %0.3f*10^6 \n",RF*10^6);
printf("\n Value of MTBF is %0.0f*10^6 hours \n",1/
   RF/10^6);
```

Chapter 4

Optical Detectors

Scilab code Exa 4.1 Response time of PIN photodetector

```
//Chapter 4
//page no 99
//given
clc;
Tn=5;                    //in micrometer
Vs=10^7;              //in m/s
tr=Tn*10^-6/Vs;
disp("ps",tr/10^-12,"Response time");
```

Scilab code Exa 4.2 MTBF of photodetector

```
//Chapter 4
//page no 106
//given
clc;
//calculate Tf
Pd=1.15;                //in mW
//calculate Tj
```

```
TA=25;                  //in deg C
theta_JA=200;               //in C/W for hermetric led
TJ=TA+theta_JA*Pd/10^3;
TF=8.01*10^12 *%e^-(8111/(TJ+273));
printf("\n Value of TJ is %0.2f deg C\n",TJ);
printf("\n Value of TF is %0.2f deg C\n",TF);
//calculate RF
BF=1.1*10^-3;                      //from table
QF=0.5;                            //from table
EF=1;                              //from table
RF=BF*TF*EF*QF*1/10^6;
disp(RF,"Value of RF");
printf("\n Value of MTBF is %0.0f*10^6 hours \n",1/
   RF/10^6);
```

Scilab code Exa 4.3 Photon Lifetime

```
//Chapter 4
//page no 114
//given
clc;
R1=0.7;
R2=0.99;
ad=0.1;
//compute Ld
Ld=1-R1*R2*%e^-(2*ad);
printf("\n Decay Loss %0.4f \n",Ld);
trt=40;//fs
tph=trt/Ld;
printf("\n Photon lifetime %0.2f fs\n",tph);
BW=1/tph;
printf("\n Bandwidth %0.1f Thz\n",BW*1000);//Answer
   in Thz
```

Chapter 5

Optical Amplifiers

Scilab code Exa 5.1 Input power

```
//Chapter 5
//page no 128
//given
clc;
Vrms=0.3;        //in V
CF=0.75;           //in V/mW
Pi=Vrms/CF;
printf("\n input power %0.1f mW\n",Pi);
```

Scilab code Exa 5.2 Compute pseudo random binary sequence

```
//Chapter 5
//page no 131
//given
clc;
Di=155;            //in Mb/s
sl=10^-3*Di*10^6;              //in  bitstream
//PRBS=2^x-1=sl;
```

```
x=log(sl+1)/log(2);//equation is made to pick value
    of x
printf("\n PRBS =2^%0.0f -1 \n",x);
```

Chapter 6

Optical Transmittor

Scilab code Exa 6.1 Determine whether heat sink or not

```
//Chapter 6
//page no 139
//Given
clear;
clc;
Tj=125;      //in degree celsius
Tamp=60;          //n degree celsius
Pt=1.8;      //in W
RthJ_a =34;           //in k/w(Assumption)
Rth=(Tj-Tamp)/Pt;
printf("\n Rth = %0.0f K/W",Rth);
if Rth>RthJ_a then
    printf("\n No Heat sink is required");
else
    printf("\n Yes,Heat sink is required");
end ;
```

Scilab code Exa 6.2 determine whether or not heat sink

```
//Chapter 6
//page no 140
//Given

clear;
clc;
Tj=120;//in degree celsius
Tamp=80;//n degree celsius
Pt=2.1;//in W
RthJ_a =34;          //in k/w(Assumption)
Rth=(Tj-Tamp)/Pt;
printf("Rth = %0.0f K/W",Rth);
if Rth>RthJ_a then
    printf("\n No Heat sink is required");
else
    printf("\n Yes,Heat sink is required");
end ;
```

Scilab code Exa 6.3 Determine wheather heat sink

```
//chapter6
//page no 140
//example 6-3
//given
clear;
clc;
//data insufficient
Rth=17.70;           // Rth assumed minimum
Rthc_H=0.65;         //k/w
Rthj_a=33;           //k/w
Rthj_c=3;            //k/w
RthH_a=1/(1/Rth-1/Rthj_a)-Rthj_c-Rthc_H;
printf("RthH-a <= %0.1f K/W",RthH_a);
//disp(RthH_a," heat sink thermal resistance");
```

Scilab code Exa 6.4 Find Junction Temperature

```
//chapter6
//page no 148
//example 6-4
//given
clear;clc;
Vcc=5;//in volt
Icc=24;//in mA
Vset=0.65;//in volt
Vf=1.5;//in volt
IMOD=15;//in mA
TA=25;//in degree celsius
Pdynamic=(Vcc-Vf-Vset)*Icc;
disp("mW",Pdynamic,"Power dissipation under dynamic condition")
Pstatic=(Vcc*Icc);
disp("mW",Pstatic,"power dissipation under static condition")
PD=Pdynamic+Pstatic;
disp("mW",PD,"total power dissipation")
//Tj=TA+PD*wj_a;
TA=25;//in degree cel
wj_a=84;//degree cel/w
PD=188.4;        //mW
Tj=TA+PD*10^-3*wj_a;
printf("\n Temp. of junction temp %0.0f degree C",Tj)
```

Scilab code Exa 6.5 calculate value of r1 r2 r3 and c1

```
//chapter 6
```

```
//page no150
//exa 6_5Ex6_5
//given
clc;
clear;
Ifon=120;                    //in mA
Vcc=5;         //in V
Vfon=2;            //in V
R3=(Vcc-Vfon)/Ifon/10^-3 +3.2*(Vcc-Vfon-1.4)/Ifon/10^-3;
printf("\n R3= %0.0f ohm",R3);
R0=(R3-32)/3.2;
printf("\n R0= %0.0f ohm",R0);
R1=(R0+10)/2;
printf("\n R1= %0.0f ohm",R1);
R2=R1-10;
printf("\n R2= %0.0f ohm",R2);
C1=2*10^-9/R1;
printf("\n C1= %0.0f pF",C1*10^12);            //answer in book is approximately written
```

Scilab code Exa 6.6 Compute required reference current

```

//chapter 6
//page no155
//Ex6_6
//given
clear;
clc;
Impd1=250;       //in microA
Impd0=25;       //in microA
Iref=(1/16)*Impd1*10^-6;
printf("\n Reference current is %0.3f microA",Iref*10^6)
```

```
Rref=1.5/Iref;
printf("\n External bias resistor value Rref1is %0.0f kohm",Rref/1000)
//or
Rref1=24/Impd1/10^-6;
printf("\n Also,Rref1=24/Impd \n External bias resistor value is %0.0f kohm",Rref1/1000)
Irefz=(1/4)*Impd0;
printf("\n Ref0 current is %0.2f microA",Irefz)
Rrefz=1.5/Irefz/10^-6;
printf("\n External bias resistor value Rrefz is %0.0f kohm",Rrefz/1000)
```

Scilab code Exa 6.7 Find bandwidth for optical one and zero

```
//chapter 6
//page no157
//Ex 6_7
//given
clear;
clc;
R=400;              //in mA
nEO=25;             //in mW
nlaser=nEO*10^-3*R*10^-3;
printf("\n nlaser = %0.2f ",nlaser);
 Tone=(40*10^-12)*(80*10^3)/nlaser;
printf("\n Tone = %0.0f micros ",Tone*10^6);
 BWone=1/(2*%pi*Tone);
printf("\n BWone = %0.0f Hz ",BWone);
Tzero=(40*10^-12)*80*10^3/nlaser;
BWzero=1/2/%pi/Tzero;          //Hz
printf("\n BWzero = %0.0f Hz ",BWzero);
//answer misprinted
```

Scilab code Exa 6.8 compute external resistance and alarm current

```
//chapter 6
//page no159
//exa 6_8
//given
clear;clc;
iol =5;       //in mA
ioh=80;         //bias current in mA
ralarmH=(1.5*1500)/ioh/10^-3;
printf("\n Alarm resistor RalarmH is %0.0f kOhm",ralarmH/1000);
ralarmL=(1.5*300)/iol/10^-3;
printf("\n Alarm resistor RalarmL is %0.0f kOhm",ralarmL/1000);
ialarmh=80*10^-3;
ialarmH=ioh*10^-3/1500;
printf("\n Alarm current  IalarmH is %0.0f microA",ialarmH*10^6);  //unit of anwer misprinted in book
ialarml=5*10^-3;
ialarmL=iol*10^-3/300;
printf("\n Alarm current  IalarmL is %0.0f microA",ialarmL*10^6);
```

Scilab code Exa 6.9 Total power dissipation

```
//chapter 6
//page no160
//exa 6_9
//given
clear;clc;
```

```
Ibias=15;          //in mA  assumption
Ild=35;            //in mA
Rld=50;            //in ohm
Ildi=100;            //in mA
Ilde=50;           //in mA
Imod=(Ildi+Ilde)/Ildi*35;  //mA
printf("Total modulation current is \nImod=%.2f mA\n
   ",Imod);
Ildq=1.2/100*10^3;              //in mA
printf("The current complementary output is \nIldq=%
   .1f mA\n",Ildq);
Vld=-1.2-Rld*(Ibias+Ild)*10^-3;        //optical high
printf("The laser voltage for optical high is \nVld=
   %.2f V\n",Vld);
Vld=-1.2-Rld*(Ibias)*10^-3;            //optical dark
printf("The laser voltage for optical dark is \nVld=
   %.2f V\n",Vld);
Vldq=-Ild*10^-3*Rld;
printf("The laser voltage at complimentary o/p is \
   nVldq=%.2f V\n",Vldq);
Rchock=5;              //in Ohm
Vchock=-Rchock*Ibias*10^-3;
printf("\nVchock=%.3f V\n",Vchock);
Vbias=0.5*(-3.7+Vld)+Vchock;
printf("\nVbias=%.1f V\n",Vbias);

//(i) Pdvee1
Pdvcc=5*2.5;           //in mW
printf("\nPdvcc=%.1f mW\n",Pdvcc);
Pdvee1=4.5*80;           //in mW
printf("\nPdvee1=%.0f mW\n",Pdvee1);
//(ii) Pdvee2
Pdvee2=6*160;           //in mW
printf("\nPdvee2=%.0f mW\n",Pdvee2);
//(iii) PdLD
PdLD=0.5*(3.75*50);          //in mW
printf("\nPdLD=%.2f mW\n",PdLD);
//(iv) PdLQ
```

```
PdLDQ=0.5*abs(Vld)*50;          //in mW
printf("\nPdLDQ=%.2f mW\n",PdLDQ);
//(v) PdLDQ
Pdbias=abs(Vbias)*Ibias;          //in mW
printf("\nPdbias=%.1f mW\n",Pdbias);
//PT
PT=Pdvcc+Pdvee1+Pdvee2-[PdLD+PdLDQ+Pdbias];
printf("\nTotal power dissipation (PT)=%.1f mW\n",PT
   );
```

Scilab code Exa 6.10 find maximum power dissipation

```

//chapter 6
//page no161
//exa 6_10
//given
clear;
clc;
vcc=-5;                    //in v
imod=35;                   //in mA
ibias=18;                  //in mA
vbias=-2;                  //in v
vout=2;                    //in v
tj=30;                   //degree cel
icc=140;                   //in mA
Pt=(-vcc*icc*10^-3)+(-vcc-vout)*imod*10^-3+(-vcc+
   vbias)*ibias*10^-3;
printf("Pt= %0.0f mW",Pt*1000);
Tj=30;//in degree
Tj_a=Tj*Pt;
Tcase=125-Tj_a;//in degree
printf("\n Tcase(max)= %0.0f degree Cel",Tcase);
```

Scilab code Exa 6.11 Calculate differential and common mode impedance

```
//chapter 6
//page no-174
//Ex6_11
//given
clear;clc;
z11=49.95;                    //in ohm
z12=0.15;                  //in ohm
z21=0.15;                  //in ohm
z22=49.95;                 //in ohm
zdiff=2*(z11-z12);
printf("\n Zdiff= %0.1f ohm",zdiff);          //answer
    misprinted
zcm=z11+z12;
printf("\n Zcm= %0.1f ohm",zcm);
```

Scilab code Exa 6.12 Compute differential mode and common mode impedance

```
//chapter 6
//page no174
//Ex6_11
//given
clear;clc;
z11=65.4;//in ohm
z12=8.2;//in ohm
z21=8.2;//in ohm
z22=65.4;//in ohm
zdiff=2*(z11-z12);
printf("\n Zdiff= %0.1f ohm",zdiff);
zcm=z11+z12;
printf("\n Zcm= %0.1f ohm",zcm);
```

Scilab code Exa 6.13 Compute intermediate frequency

```
//chapter 6
//page no181
//Ex6_13
//given
clear;clc;
dV=50;                  //in mV
di=3;               //in Amp
Lcable=15;              //in nH
fL=dV*10^-3/di/2/%pi/Lcable/10^-9;
printf("fLcable = %0.0f kHz",fL/1000);
```

Scilab code Exa 6.14 Allowed parasitic cable inductance

```
//chapter 6
//page no181
//Ex6_14
//given
clear;clc;
dV=50;                  //in mV
di=4;               //in Amp
fL=120;             //in kHz
Lcable=dV*10^-3/di/2/%pi/fL/10^3;
printf("\n The maximum allowed parasitic cable inductance (Lcable) must not exceed %0.1f nH",Lcable*10^9);
```

Scilab code Exa 6.15 Calculate high frequency component

```
//chapter 6
//page no182
//Ex6_15
//given
clear;
clc;
dV=40;                    //in mV
di=2.5;                //in Amp
Lbypas=0.5;               //in nH
fL=dV*10^-3/di/2/%pi/Lbypas/10^-9;
printf("fHnoise = %0.1f MHz",fL/10^6);
```

Scilab code Exa 6.16 compute low frequency component

```
//chapter 6
//page no182
//Ex6_16
//given
clear;
clc;
dV=50;                    //in mV
di=2.5;                //in Amp
Cbypas=220;               //in microF
fL=di/(dV*10^-3*2*%pi*Cbypas*10^-6);
printf("fLnoise = %0.0f kHz",fL/1000);                //Result
```

Scilab code Exa 6.17 Calculate noise bandwidth

```
//chapter 6
//page no182
//Ex6_17
//given
```

```
clear;
clc;
dV=50;                  //in mV
di=4;              //in Amp
Cbypas=200;             //in microF
Lbypas=0.2;             //in nH
fL=di/(dV*10^-3*2*%pi*Cbypas*10^-6);
printf("\n fLnoise = %0.0f kHz\n ",fL/1000);           //Result misprinted
fH=dV*10^-3/di/2/%pi/Lbypas/10^-9;
printf("\n fHnoise = %0.0f MHz\n ",fH/10^6);
Bw=fH-fL;
printf("\n Bwnoise = %0.2f MHZ",Bw/10^6);          // Result miscalculated
```

Scilab code Exa 6.18 Calculate effective hight frequency component

```
//chapter 6
//page no184
//Ex6_18
//given
clear;
clc;
dV=40;                  //in mV
di=3;              //in Amp
LT=0.05;             //in nH
fH=dV*10^-3/di/2/%pi/LT/10^-9;
printf("\n fCdecoupling(high) = %0.1f MHz\n ",fH/10^6);           //Result
```

Scilab code Exa 6.19 Calculate the effective low frequency component

```
//chapter 6
```

```
//page no184
//Ex6_19
//given
clear;
clc;
dV=45;                  //in mV
di=2.5;               //in Amp
CT=2.2;              //in microF
LT=0.05;              //in nH
fCL=di/(dV*10^-3*2*%pi*CT*10^-6);
printf("\n fLnoise = %0.0f MHz\n ",fCL/10^6);              //Result
fCH=42.3;               //in MHz taken from last question i.e. 6.18
printf("\n fHnoise (from last question i.e. 6.18)= %0.1f MHz\n ",fCH);
printf("\n  %0.0fMHz <= B.W. noise <= %0.2fMHZ",fCL/10^6,fCH);           //Result
```

Chapter 7

Optical Receivers

Scilab code Exa 7.1 PWD of optical receiver

```
//Chapter 7
//page no 203
//given
clc;
clear all;
Trec=54;            //in ns
Ttrans=40;            //in ns
Pwd=(Trec-Ttrans)/Ttrans*100;
printf("\n PWD= %0.0f percent",Pwd)
```

Scilab code Exa 7.2 Value of Radj

```
//Chapter 7
//page no 214
//given
clc;
clear all;
//Vc=Vdin-Vdinq
```

```
Vc=5;               //in mV   Vdin−Vdinq=Vc
Irset =1.8*10^-3*(Vc*10^-3);       //in A
printf("\n Irset %0.0f microA",Irset*10^6) ;
Vs=1.5;                    //Voltage at signal level below
    Vcc in V
Radj=Vs/Irset;                        //in Ohm
printf("\n Radj %0.0f kohm",Radj*10^-3) ;
```

Scilab code Exa 7.3 Reference voltage and reference resistor

```
//Chapter 7
//page no 223
//given
clc;
clear all;

Rl=50;          //in Ohm
Ro=100;         //in Ohm
Vos=450;                //in mV
Vref=(Rl+Ro)/Rl*Vos/2;
printf("\n Vref= %0.0f mV",Vref) ;
Vee=3.3;                //in V
R1=500;             //in Ohm
R2=16000;                //in Ohm
//Rref=(Vee/Vref/10^3−1)*R1/[1−{R1/R2*(Vee/Vref
    /10^3−1)}]
Rref={(Vee/Vref/10^-3-1)*R1}/[1-R1/R2*(Vee/Vref
    /10^-3-1)]
printf("\n Rref= %0.0f kohm",Rref) ;
printf("\n Approx. Rref= %0.1f kohm",Rref*10^-3) ;
```

Chapter 9

Optical Fibers

Scilab code Exa 9.1 Compute angle of acceptance critical angle and NA

```
//Chapter 9
//page no 296
//given
clc;
clear all;
n2=1.35;                //refractive index
n1=1.4;                //refractive index
Wo=asind(n2/n1);                //in radians
printf("\n Critical Angle,Wo = %0.2f degree\n",Wo);
NA=sqrt(n1^2-n2^2);
printf("\n Numerical Aperture,NA = %0.2f \n",NA);
Wa=asind(NA);                //in radians
printf("\n Angle of acceptance,Wa = %0.2f degree\n",
   Wa);
```

Scilab code Exa 9.2 Fiber Attenuation

```
//Chapter 9
```

```
//page no 300
//given
clc;
clear all;
Po=8;            //in mW
Pi=50;                //in mW
l=15;            //in km
TA=-10*log10(Po/Pi);
printf("\n Total fibre Attenuation,L = %0.2fdB/%0.0
    fkm \n",TA,l);
Alpha=TA/l;
printf("\n Alpha is  = %0.2f dB/km\n",Alpha);
```

Scilab code Exa 9.3 Maximum length of optical fibre

```
//Chapter 9
//page no 300
//given
clc;
clear all;
Po=10;           //in mW
Pi=150;              //in mW
Alpha=0.8;          //in dB/km
TA=-10*log10(Po/Pi);
printf("\n Total fibre Attenuation,L = %0.2f dB \n",
    TA);
l=TA/Alpha;
printf("\n maximum length is,l = %0.2f km\n",l);
//Round off Variations appear
```

Scilab code Exa 9.4 Rayleigh attenuation of an optical fibre

```
//Chapter 9
```

```
//page no 302
//given
clc;
clear all;
B=92*10^-12;              //in m^2/N
Tf=1550;          //in K
n=1.46;              //refractive index
p=0.29;
K=1.38*10^-23;            //in J/K
l=1;              //in km
L1=630;           //in nm
L2=1330;           //in nm
L3=1550;           //in nm
disp("Rayleight scattering coefficient");
Y1=8*%pi^3*n^8*p^2*B*K*Tf/3/(L1*10^-9)^4;
Y2=8*%pi^3*n^8*p^2*B*K*Tf/3/(L2*10^-9)^4;
Y3=8*%pi^3*n^8*p^2*B*K*Tf/3/(L3*10^-9)^4;
mprintf(" for L1= 630nm, is %e",Y1);
mprintf("\n for L2= 1330nm, is %e",Y2);
mprintf("\n for L3= 1550nm, is %e",Y3);
//Misprinted answer

disp("Rayleight scattering attenuation factor");
Fr1=%e^-(Y1*l*10^3);
Fr2=%e^-(Y2*l*10^3);
Fr3=%e^-(Y3*l*10^3);
printf(" \n for Y1=  0.00179 is %0.2f",Fr1);
printf(" \n for Y2=  0.00009 is %0.2f",Fr2);
printf(" \n for Y3=  0.0000182 is %0.2f\n",Fr3);
//

disp("Rayleight scattering attenuation ");
Ar1=10*log10(Fr1^-1);
Ar2=10*log10(Fr2^-1);
Ar3=10*log10(Fr3^-1);
printf(" \n for Ar1=  0.17 is %0.2f dB/km",Ar1);
printf(" \n for Ar2=  0.91 is %0.2f dB/km",Ar2);
printf(" \n for Ar3=  0.98 is %0.3f dB/km",Ar3);
```

```
//For L3 answers in book are misprinted
//Rounding off errors in answer
```

Scilab code Exa 9.5 SBS threshold optical power

```
//Chapter 9
//page no 304
//given
clc;
clear all;
L=850;          //in nm
L1=0.850;            //converted L in micrometer for using in given formula
A=0.5;          //in dB/km
d=5;         //in micrometer
Bw=1;           //in Gz
Po=4.4*10^-3*A*Bw*L1^2*d^2;
printf(" \n Po(Th) =  %0.3f W",Po);
printf(" \n Therefore,Po(Th) =  %0.0f mW",Po*1000);
```

Scilab code Exa 9.6 SBS threshold optical power

```
//Chapter 9
```

```
//page no 304
//given
clc;
clear all;
L=1330;          //in nm
L1=1.330;          //converted L in micrometer for using in given formula
A=0.5;          //in dB/km
d=5;        //in micrometer
Bw=1;          //in Gz
Po=4.4*10^-3*A*Bw*L1^2*d^2;
printf(" \n Po(Th) =  %0.3f W",Po);
printf(" \n Therefore,Po(Th) =  %0.0f mW",Po*1000);
```

Scilab code Exa 9.7 SBS threshold optical power

```
//Chapter 9
//page no 304
//given
clc;
clear all;
L=1550;          //in nm
L1=1.550;          //converted L in micrometer for using in given formula
A=0.5;          //in dB/km
d=5;        //in micrometer
Bw=1;          //in Gz
Po=4.4*10^-3*A*Bw*L1^2*d^2;
printf(" \n Po(Th) =  %0.3f W",Po);
printf(" \n Therefore,Po(Th) =  %0.0f mW",Po*1000);
```

Scilab code Exa 9.8 SBS threshold optical power

```
//Chapter 9
//page no 304
//given
clc;
clear all;
L=850;            //in nm
L1=0.850;              //converted L in micrometer for
   using in given formula
A=0.5;            //in dB/km
d=8;          //in micrometer
Bw=1;             //in Gz
Po=4.4*10^-3*A*Bw*L1^2*d^2;
printf(" \n Po(Th) =  %0.3f W",Po);
printf(" \n Therefore,Po(Th) =  %0.0f mW",Po*1000);
   //answer is slightly different due to rounding
   off
```

Scilab code Exa 9.9 SBS threshold optical power

```
//Chapter 9
//page no 304
//given
clc;
clear all;
L=850;            //in nm
L1=0.850;             //converted L in micrometer for
    using in given formula
A=0.5;            //in dB/km
d=10;          //in micrometer
Bw=1;             //in Gz
Po=4.4*10^-3*A*Bw*L1^2*d^2;
printf(" \n Po(Th) =  %0.3f W",Po);
printf(" \n Therefore,Po(Th) =  %0.0f mW",Po*1000);
```

Scilab code Exa 9.10 Raman scattering threshold power

```
//Chapter 9
//page no 305
//given
clc;
clear all;
L=850;            //in nm
L1=L/1000;            //converted L in micrometer for
    using in given formula
A=0.4;            //in dB/km
d=5;          //in micrometer
Po=5.9*10^-2*A*L1*d^2;
printf(" \n Po(Th) =  %0.0f mW",Po*1000);         //
    rounding off error
```

Scilab code Exa 9.11 Raman scattering threshold power

```
//Chapter 9
//page no 305
//given
clc;
clear all;
L=1330;            //in nm
L1=L/1000;              //converted L in micrometer for
    using in given formula
A=0.4;             //in dB/km
d=5;           //in micrometer
Po=5.9*10^-2*A*L1*d^2;
printf(" \n Po(Th) =  %0.0f mW",Po*1000);          //
   unit in book is wrong
```

Scilab code Exa 9.12 Raman sscattering threshold power

```





//Chapter 9
//page no 305
//given
clc;
clear all;
L=1550;            //in nm
L1=L/1000;              //converted L in micrometer for
    using in given formula
A=0.4;             //in dB/km
d=5;           //in micrometer
Po=5.9*10^-2*A*L1*d^2;
printf(" \n Po(Th) =  %0.0f mW",Po*1000);          //
   unit in book is wrong
```

Scilab code Exa 9.13 Maximum modal number

```
//Chapter 9
//page no 310
//given
clc;
clear all;
R=25;              //in nm
R1=25*10^-6;                //in m
L=1000;                     //in nm
L1=10^-6;              //in m
NA=0.2;
V=2*%pi/L1*R1*NA;
printf(" \n Normalised frequency(V) =  %0.1f ",V);
y=2;                   //for parabolic
Mmax=y/(y+2)*(V^2)/2;
printf(" \n Maximum number of modes is equal to =
    %0.0f ",Mmax);//answer in book is wrong
```

Scilab code Exa 9.14 Maximum operating bandwidth

```
//Chapter 9
//page no 313
//given
clc;
clear all;
Tp=0.25;              //in microsec
fB=0.529/Tp/10^-6;         //channel bitrate
fBw=fB;                //channel bandwidth = channel
    bitrate when zero ISI and RZ input data is
    modulated
```

```
printf(" \n Maximum operating bandwidth =  %0.3f MHz
   ",fBw*10^-6);
L=50;             //in km
D=Tp*10^-6/L;     //Dispersion
printf(" \n Dispersion =  %0.0f ns/km",D*10^9);
fBwL=fBw*10^-6*L;                 //bandwidth length
   product
printf(" \n Bandwidth length product(fBw*L) =  %0.1f
    MHz/km",fBwL);
```

Scilab code Exa 9.15 Maximum operating bandwidth

```
//Chapter 9
//page no 314
//given
clc;
clear all;
Tp=2;             //in microsec
fB=0.529/Tp/10^-6;   //channel bit rate
fBw=fB;              //channel bandwidth = channel
   bitrate when zero ISI and RZ input data is
   modulated
printf(" \n Maximum operating bandwidth =  %0.2f MHz
   ",fBw*10^-6);
L=50;             //in km
D=Tp*10^-6/L;     //Dispersion
printf(" \n Dispersion =  %0.0f ns/km",D*10^9);
   //unit in book is wrong
fBwL=fBw*10^-6*L;              //bandwidth length product
printf(" \n Bandwidth length product(fBw*L) =  %0.0f
    MHz/km",fBwL);
```

Scilab code Exa 9.16 Maximum operating bandwidth

```
//Chapter 9
//page no 314
//given
clc;
clear all;
Tp=5;              //in microsec
fB=0.529/Tp/10^-6;    //channel bit rate
fBw=fB;               //channel bandwidth = channel bitrate when zero ISI and RZ input data is modulated
printf(" \n Maximum operating bandwidth =  %0.3f MHz ",fB*10^-6);
L=50;              //in km
D=Tp*10^-6/L;      //Dispersion
printf(" \n Dispersion =  %0.1f micro sec/km",D*10^6);
fBwL=fBw*10^-6*L;          //bandwidth length product
printf(" \n Bandwidth length product(fBw*L) =  %0.1f MHz/km",fBwL);
```

Scilab code Exa 9.17 RMS pulse chirping

```
//Chapter 9
//page no 315
//given
clc;
clear all;
Slw=25;            //in nm
L=850;             //in nm           given
c=3*10^5;          //in km/s
ofmd=0.02;             //optical fiber material dispersion
Mdp=1/L/c*ofmd;            //answer mismatch due to differnt value chosen for calculation
printf(" \n Material Dispersion parameter Mdp =  %0
```

```
.0f ps/nm.km",Mdp*10^12);
l=1;                //in km
dmd=Slw*l*Mdp;          //pulse chirping
printf(" \n pulse chirping dmd =  %0.2f ns/km",dmd
    *10^9);
```

Scilab code Exa 9.18 RMS pulse broadening

```
//Chapter 9
//page no 315
//given
clc;
clear all;
Slw=2;              //in nm
L=850;              //in nm             given
c=3*10^5;             //in km/s
ofmd=0.02;              //optical fiber material
    dispersion
Mdp=1/L/c*ofmd;    //answer mismatch due to differnt
    value chosen for calculation
printf(" \n Material Dispersion parameter Mdp =  %0
    .0f ps/nm.km",Mdp*10^12);
l=1;                //in km
dmd=Slw*l*Mdp;
printf(" \n pulse chirping dmd =  %0.3f ns/km",dmd
    *10^9);
```

Scilab code Exa 9.19 Channel capacity

```
//Chapter 9
//page no 325
//given
clc;
```

```
clear all;
fb1=2.5;                //in Gb/s
D1=20;              //in ps/nm.km
D2=5;              //in ps/nm.km
fb2=D1/D2*fb1;
printf("\n fb2 = %0.0f Gb/s(OC−192)",fb2)
//Values of D1 and D2 are conflicted in question , however solution is correct
```

Scilab code Exa 9.20 Channel capacity

```
//Chapter 9
//page no 325
//given
clc;
clear all;
fb1=2.5;                //in Gb/s
DV1=100;              //in GHz
DV2=50;              //in GHz
fb2=DV1/DV2*fb1;
printf("\n fb2 = %0.0f Gb/s",fb2)
```

Scilab code Exa 9.21 Total chromatic dispersion

```
//Chapter 9
//page no 332
//given
clc;
clear all;
L=400;              //in km
dAV=4;              //in ps/km
dTL=L*dAV;          //total chromatic dispersion
printf("dTL =%0.0f ps/nm.km",dTL);
```

```
printf("\n or,dTL =%0.1f ns/nm.km",dTL/10^3);
```

Scilab code Exa 9.22 Compute optical attenuation

```
//Chapter 9
//page no 335
//given
clc;
clear all;
no=1;              //refractive index
n1=1.35;              //refractive index
Po=[(n1-no)/(n1+no)]^2;      //fresnal reflection
printf("\n Po(refl)= %0.3f",Po);
Lrefl=-10*log10(1-Po);       //attenuation loss
printf("\n L(refl)= %0.1f dB",Lrefl);
```

Scilab code Exa 9.23 Compute total attenuation

```
//Chapter 9
//page no 335
//given
clc;
clear all;
no=1;              //refractive index
n1=1.55;              //refractive index
Po=[(n1-no)/(n1+no)]^2;     //fresnal reflection
printf("\n Fresnel reflective coefficient,Po(refl)=
   %0.5f\n",Po);
Lrefl=-10*log10(1-Po);      //attenuation loss
printf("\n Attenuation based on Fresnel reflective
   coefficient,L(refl)= %0.1f dB\n",Lrefl);
Ltot=5*Lrefl;
```

```
printf("\n Total link attenuation on Fresnel
    reflections ,Ltotal = %0.1 f dB",Ltot);
```

Scilab code Exa 9.24 Compute the insertion loss

```
//Chapter 9
//page no 336
//given
clc;
clear all;
n1=1;
n2=1.5;
a=25;            //in micrometer
y=3;             //in micrometer
Csim=16*(n1/n2)^2/%pi/[1+(n1/n2)]^4*[2*acos(y/2/a)-(
    y/a)*[1-(y/2/a)^2]^0.5];
//lateral coupling coefficient
a=2*acos(y/2/a)-(y/a)*sqrt(1-(y/2/a)^2);
b=16*(n1/n2)^2/%pi/[1+(n1/n2)]^4;
printf("\n Lateral  coupling coefficient ,Csim= %0.2 f
    \n",Csim);
Lsim=-10*log10(1-Csim);
printf("\n Insertion Loss ,Lsim= %0.1 f dB\n",Lsim);
//Answer wrong in book
```

Scilab code Exa 9.25 Compute insertion loss

```
//Chapter 9
//page no 337
//given
clc;
clear all;
Alpha=2;
```

```
a=25;              //in micrometer
y=2;               //in micrometer
Cgim=2/%pi*(y/a)*(Alpha+2)/(Alpha+1);        //
   lateral coupling coefficient
printf("\n Csim= %0.3f\n",Cgim);
Lgim=-10*log10(1-Cgim);      //insertion loss
printf("\n Insertion Loss,Lgim= %0.1f dB\n",Lgim);
```

Scilab code Exa 9.26 Compute insertion loss

```
//Chapter 9
//page no 339
//given
clc;
clear all;
n1=1.5;              //refractive index
n2=1.5;              //refractive index
W=2.5;        //in degree
NA1=0.3;
NA2=0.4;
Csim1=16*(n1/n2)^2/[1+(n1/n2)^4]*[1-n2*W/(180*NA1)];
      //angular coupling coefficient
//Answer wrong in book
printf("\n Csim= %0.3f\n",Csim1);
Lsim1=-10*log10(Csim1);
printf("\n Insertion Loss,Lsim= %0.3f dB\n",Lsim1);
Csim2=16*(n1/n2)^2/[1+(n1/n2)^4]*[1-n2*W/(180*NA2)];
    //angular coupling coefficient
//Answer wrong in book
printf("\n Csim= %0.3f\n",Csim2);
Lsim2=-10*log10(Csim2);
printf("\n Insertion Loss,Lsim= %0.2f dB\n",Lsim2);
```

Scilab code Exa 9.27 Compute total insertion loss

```
//Chapter 9
//page no 340
//given
clc;
clear all;
a=4;                //in micrometer
V=2.4;
aw=1;               //in degree
NA1=0.2;
n1=1.45;                //refractive index
y=1;                //in micrometer
omega=a*[0.65+1.62*V^-1.5+2.88*V^-6]/sqrt(2);
printf("\n Normalised spot view (w)= %0.2f
   micrometer",omega);
Lsml=2.17*(y/omega)^2;
printf("\n Insertion loss due to lateral,Lsm= %0.2f
    dB",Lsml);      //answer is wrong in book
Lsmg=2.17*(aw*%pi/180*omega*n1*V/a/NA1)^2;
printf("\n Insertion loss due to angular,Lsm= %0.2f
    dB",Lsmg);

printf("\n Total Insertion loss,Lsmtotal= %0.2f dB"
   ,Lsml+Lsmg);
```

Scilab code Exa 9.28 Compute insertion loss at the joint

```
//Chapter 9
//page no 340
//given
clc;
clear all;
a1=4.5;                 //in micrometer
a2=4;                 //in micrometer
```

```
V=2.1;
aw=1;                //in degree
NA=0.2;
n1=1.45;
y=1;                 //in micrometer
w1=a1*[0.65+1.62*V^-0.5+2.88*V^-6]/sqrt(2);       //insertion loss
printf("\n Wo1=  %0.1f ",w1);
w2=a2*[0.65+1.62*V^-0.5+2.88*V^-6]/sqrt(2);       //insertion loss
printf("\n Wo2=  %0.1f ",w2);
Lintr=-10*log10(4*[(w1/w2+w2/w1)^-2]);         //toatl insertion loss at joint
printf("\n Lintr=  %0.2f dB",Lintr);         //Answer wrong in book
```

Chapter 10

Optical Modulation

Scilab code Exa 10.1 Required Biasing voltage

```
//Chapter 10
//page no 354
//given
clc;
clear all;
Vpi=1;          //Assumed 1 because we can not use a
    variable on RHS
//Vpi is Violtage swing
A=0.25;          //chirping
//V1=(AV1p+Vp)/2
V1=(A*Vpi+Vpi)/2;
printf("\n V1= %0.3f Vpi",V1)
V2=V1-Vpi;
printf("\n V2= %0.3f Vpi",V2)
```

Scilab code Exa 10.2 Biasing range

```
//Chapter 10
```

```
//page no 354
//given
clc;
clear all;
Vpi=1;          //Assumed 1 because we can not use a
   variable on RHS
//Vpi is Violtage swing
disp("for alpha=0.3");
A=0.3;          //chirping
//V1=(AV1p+Vp)/2
V1=(A*Vpi+Vpi)/2;
printf("\n V1= %0.2f Vpi",V1)
V2=V1-Vpie;
printf("\n V2= %0.2f Vpi\n",V2)
disp("for alpha=0.8");
A=0.8;          //chirping
//V1=(AV1p+Vp)/2
V1x=(A*Vpi+Vpi)/2;
printf("\n V1= %0.1f Vpi",V1x)
V2x=V1x-Vpi;
printf("\n V2= %0.1f Vpi",V2x)
printf("\n Biasing range is %0.2f Vpi <= V1 <= %0.2f
    Vpi",V1,V1x)
printf("\n Biasing range is %0.1f Vpi <= V2 <= %0.2f
    Vpi",V2x,V2)
```

Chapter 11

Multiplexing

Scilab code Exa 11.1 Cross talk in refrence to the number of channel

```
//Chapter 11
//page no 386
//given
clc;
clear all;
q=4.9*10^-18;              //in m/W.GHz raman  gain
    slope
f=100;                     //in GHz
A=50*10^-6;                //cross sectional area in
    micro  meter square
P0=3.5;              //in mW
Le=10*10^3;
G=q*f*10^6/2/A;
N=20;
mprintf("\n G = %e ",G);
CT=N*(N-1)*(P0*10^-3*G*Le)/2;
printf("\n CT(L) = %0.2f ",CT);
```

Scilab code Exa 11.2 Capacitor value of PLL section

```
//Chapter 11
//page no 410
//given
clc;
clear all;
K0=2*%pi*625;                //in MHz/V
Ip=0.6;                 //in mA
N=64;
w=2.44;                 //in Mhz
Z=5;
Vout=5;             //in V
C=(4*K0*10^6*Ip*10^-3*Z)/(2*%pi*N*w*w*10^12);
printf("\n The value of capacitance is %0.0f nF",C
    *10^9)
```

Scilab code Exa 11.3 Value of damping coefficient

```
//Chapter 11
//page no 410
//given
clc;
clear all;
K0=2*%pi*625;                //in MHz/V
Ip=0.35;                 //in mA
N=64;
w=2.44;             //in MHz
Z=5;
Vout=4;             //in V
C=22;               //in nF
Z=sqrt((2*%pi*N*w^2*C)/(4*Ip*K0*0.25))
printf("\n Zeta is = %0.0f" ,Z)
```

Chapter 12

Optical Systems

Scilab code Exa 12.1 Compute power margin

```
//Chapter 12
//page no 431
//given
clc;
clear all;
Pt=10;            //in microW
Pr=1;             //in microW
PtdBm=10*log10(Pt*10^-6/10^-3)                  //in dBm
printf("\n Transmitter Power = %0.0f dBm",PtdBm);
PrdBm=10*log10(Pr*10^-6/10^-3)                  //in dBm
printf("\n Receiver Power = %0.0f dBm",PrdBm);
Pm=PtdBm-PrdBm;
printf("\n Power margin= %0.0f dBm",Pm);      //misprint in book
```

Scilab code Exa 12.2 Compute power margin

```
//Chapter 12
//page no 431
//given
clc;
clear all;
Pt=25;                  //in microW
Prd=15;                  //in dBm
Ptd=10*log10(Pt*10^-6/10^-3)                              //in
    dBm
printf("\n Transmitter Power = %0.0f dBm",Ptd);
Pm=Ptd-Prd;
printf("\n Power margin= %0.0f dBm",Pm);
```

Scilab code Exa 12.3 Calculate level of additional power launched

```
//Chapter 12
//page no 432
//given
clc;
clear all;
Pt1=-18;                  //in dBm for 50/125 micron fiber
Pt2=-10;                  //in dBm for 100/125 micron
    fiber
Pd=Pt1-Pt2;
printf("\n Additional  Power = %0.0f dBm",Pd);
```

Scilab code Exa 12.4 Compute link power budget

```
//Chapter 12
//page no 432
//given
clc;
clear all;
```

```
Plb=10;                 //in dBm for 50/125 micron fiber
Ps=3;                 //in dBm for safety margin
Prs=-30;                 //in dBm for receiver sensivity
Pt=Plb+Ps+Prs;
printf("\n Link power budget = %0.0f dBm",Pt);
Ptw=10^(Pt/10)*1000;
printf("\n Transmitter Power = %0.0f microW",Ptw);
```

Scilab code Exa 12.5 Calculate PIN diode required operating power and total power budget

```




//Chapter 12
//page no 433
//given
clc;
clear all;
Is=0.5;              //in A/W
Ir=1.5;              //in microA
Xw=Ir/Is;
printf("\n Electrical power required by PIN diode is
     = %0.0f microW",Xw);
Pxw=10*log10(Xw/10^3);
printf("\n Therefore, Electrical power required by
   PIN diode is = %0.1f dBm",Pxw);

Ps=3;                 //in dB for safety margin
Tp=5;              //in dB
Pt=Tp+Ps+Pxw;
printf("\n Total Power Required = %0.1f dBm",Pt);
```

Scilab code Exa 12.6 Calculate maximum link distance

```
//Chapter 12
//page no 442
//given
clc;
clear all;
fb=1.25;              //in Gb/s
D=17;             //in ps/nm.km
dL=0.5;      //in nm
Lmax=1/fb/10^9/dL/10^-9/D/10^-12*10^-9;
printf("\n Maximum Link span,Lmax = %0.0f km",Lmax);
```

Scilab code Exa 12.7 Compute chromatic dispersion

```
//Chapter 12
//page no 442
//given
clc;
clear all;
fb=2.5;              //in Gb/s
Lmax=50;             //in km
dL=0.4;      //in nm
D=1/fb/10^9/dL/10^-9/Lmax/10^-12*10^-9;
printf("\n Maximum allowable dispersion,D = %0.0f ps
   /nm-km",D);
```

Scilab code Exa 12.8 Compute maximum bit rate

```
//Chapter 12
//page no 443
//given
clc;
clear all;
Lmax=60;                //in km
D=17;               //in ps/nm.km
dL=0.5;         //in nm
fb=1/Lmax/10^9/dL/10^-9/D/10^-12*10^-9;
printf("\n Maximum system bit rate,fb = %0.2f Gb/s",
    fb);
```

Scilab code Exa 12.9 Compute Maximum link span

```
//Chapter 12
//page no 443
//given
clc;
clear all;
c1=4;                   //channel1
c2=8;                   //channel2
c3=16;                   //channel3
fb=2.5;               //in Gb/s
Lmax1=6.1*10^3/(c1*fb)^2;
printf("\n Maximum Link span for %0.0f channel, Lmax
     = %0.0f km \n",c1,Lmax1);
Lmax2=6.1*10^3/(c2*fb)^2;
printf("\n Maximum Link span for %0.0f channel, Lmax
     = %0.2f km \n",c2,Lmax2);
Lmax3=6.1*10^3/(c3*fb)^2;
printf("\n Maximum Link span for %0.0f channel, Lmax
     = %0.1f km \n",c3,Lmax3);
```

Scilab code Exa 12.10 Calculate chromatic dispersion

```
//Chapter 12
//page no 444
//given
clc;
clear all;
L=200;      //in km
dL=1550;                //in nm
R=10;             //in Gb/s
Cd=17;            //in ps/nm-km
w=0.1;            //Assused bandwidth
Cd200=Cd*L;
printf("\n Dispersion by 200km ofc = %0.1f*10^3 ps/
   nm",Cd200/10^3);
TCd=w*Cd200;
printf("\n total chromatic  dispersion = %0.2f*10^3
   ps",TCd/10^3);
```

Scilab code Exa 12.11 Calculate dispersion penalty

```
//Chapter 12
//page no 480
//given
clc;
clear all;
L=1.5;            //in km
Ls=L/3;           //in km
BwF=600;                  //in MHz
fb=1;                 //in Gbps
Bdlaser=0.71*BwF*L^-0.7*Ls^-0.25;
printf("Laser bandwidth is %0.0f MHz",Bdlaser);
   //Answer in book is approx
mD=0.85*(fb*10^3/Bdlaser)^2;
printf("\n Mean dispersion penalty is %0.1f dB",mD);
```

```
//Answer in book is approx
```

Scilab code Exa 12.12 Calculate maximum length

```
//Chapter 12
//page no 481
//given
clc;
clear all;
E=0.182;                //from table 12-11 for 2dB
   dispersion penalty
fb=622;             //in Mb/s
dl=4;               //in nm
ofdisp=3;           //in ps/km-nm
Dmax=E/(10^-6*fb*dl);
printf("\n Dmax is %0.1f ps/nm",Dmax);
Lmax=Dmax/ofdisp;
printf("\n Maximum link distance is %0.1f km",Lmax);
//Answer in the book is rounded
```

Scilab code Exa 12.13 Calculate the maximum length of optical link

```
//Chapter 12
//page no 481
//given
clc;
clear all;
E=0.115;                //from table 12-11 for 2dB
   dispersion penalty
fb=622;             //in Mb/s
dl=4;               //in nm
ofdisp=3;           //in ps/km-nm
Dmax=E/(10^-6*fb*dl);
```

```
printf("\n Dmax is %0.1f ps/nm",Dmax);
Lmax=Dmax/ofdisp;
printf("\n Maximum link distance is %0.1f km",Lmax);
```

Scilab code Exa 12.14 Calculate maximum dispersion mean link margin sigma link margin

```
//Chapter 12
//page no 481
//given
clc;
clear all;
mc=0.4;          //in dB
sc=0.0;          //in dB
dmax=2.8;        //in dB
mt=-4.9;        //in dBm
st=0.5;        //in dBm
mr=-38.1;        //in dBm
sr=0.48;          //in dBm
mco=0.35;        //in dB
sco=0.20;        //in dB
ms=0.2;        //in dB
ss=0.1;        //in dB
E=0.182;               //from table 12-11 for 2dB
    dispersion penalty
fb=156;          //in Mb/s
dl=4;            //in nm
ofdisp=2.8;            //in ps/nm-km
Nco=7;
mD=2;
sD=0.1;
sH=2;
sCR=0.25;
Ns=4;
mH=0;
```

```
mCR=0.5;
L=50;
Ls=10;
Dmax=E/(10^-6*fb*dl);
printf("\n Dmax is %0.0f ps/nm\n",Dmax);
Lmax=Dmax/ofdisp;
printf("\n Maximum link distance is %0.0f km\n",Lmax
    );
mM=mt-mr-(mc*L+mco*Nco+ms*Ns+mD+mH+mCR);
printf("\n Mean link margin is %0.2f dB\n",mM);
sM=sqrt(st^2+sr^2+sc^2*L*Ls+sco^2*Nco+sD^2*sH^2+sCR
    ^2);
printf("\n Sigma link margin is %0.3f dB\n",sM);
```

Scilab code Exa 12.15 Compute maximum dispersion and nominal distribution

```
//Chapter 12
//page no 483
//given
clc;
clear all;
E=0.115;
fb=622;             //in Mb/s
dl=4;               //in nm
mt=0.1;           //in dBm
mr=-31.5;             //in dBm
mc=0.41;            //in dB
L=25;
mco=0.12;           //in dB
Nco=2;
ms=0.15;          //in dB
Ns=4;
mD=1;
mH=0;
```

```
mCR=0;

sc=0.0;          //in dB
st=-0.15;        //in dBm
sr=0.3;        //in dBm
sco=0.08;        //in dB
ss=0.1;        //in dB
ofdisp=2.8;          //in ps/nm-km
sD=2;
sH=0;
sCR=0.0;
Ls=12;

Dmax=E/(10^-6*fb*dl);
printf("\n Dmax is %0.2f ps/nm\n",Dmax);
Lmax=Dmax/ofdisp;
printf("\n Maximum link distance is %0.1f km\n",Lmax
    );    //in book 4 is misprint for solving
mM=mt-mr-(mc*L+mco*Nco+ms*Ns+mD+mH+mCR);
printf("\n Mean link margin is %0.1f dB\n",mM);
            //wrong in book
L=60;
Ls=12;
sM=sqrt(st^2+sr^2+sc^2*L*Ls+sco^2*Nco+ss^2*Ns+sD^2*
    sH^2+sCR^2);
printf("\n Sigma link margin is %0.2f dB\n",sM);
spm=mM-2*sM-1;
printf("\n System power margin is %0.2f dB\n",spm);
      //answer is slighty difeerent due to mM=19.5
```

Scilab code Exa 12.16 Calculate maximum dispersion and maximum distance

```
//Chapter 12
//page no 484
```

```
//given
clc;
clear all;
E=0.115;
fb=1062;            //in Mb/s
dl=6;               //in nm
mt=-8;         //in dBm
mr=28.7;            //in dBm
mc=0.4;             //in dB
L=5;
mco=0.12;           //in dB
Nco=8;
ms=0.2;           //in dB
Ns=4;
mD=1;
mH=0;
mCR=1;

sc=0.0;             //in dB
st=0.6;           //in dBm
sr=0.75;            //in dBm
sco=0.08;           //in dB
ss=0.1;           //in dB
ofdisp=2.8;             //in ps/nm-km
sD=2;
sH=0;
sCR=0.25;
Ls=12;

Dmax=round(E/(10^-6*fb*dl));          //taking to
   nearest integer in ps/nm
printf("\n Dmax is %0.0f ps/nm\n",Dmax);
Lmax=Dmax/ofdisp;
printf("\n Maximum link distance is %0.2f km\n",Lmax
   );
mM=mt+mr-(mc*L+mco*Nco+ms*Ns+mD+mH+mCR);
printf("\n Mean link margin is %0.1f dB\n",mM);
L=60;
```

```
Ls=12;
sM=sqrt(st^2+sr^2+sc^2*L*Ls+sco^2*Nco+ss^2*Ns+sD^2*sH^2+sCR^2);
printf("\n Sigma link margin is %0.2f dB\n",sM);
mM=round(mM*10)/10;      //talking only to 1 decimal place and rounding of other values
spm=mM-2*sM-1;
printf("\n mM-2*sM = %0.2f\n",mM-2*sM);
printf("\n System power margin is %0.2f dB\n",spm);   //answer is slighty diferent due to m\sM=1.03
```

Scilab code Exa 12.17 Calculate the CSO distortion

```
//Chapter 12
//page no 486
//given
clc;
clear all;
Ncso=50;
a=3.6*10^-3;
m=0.05;
CSO=10*log10(Ncso*(a*m)^2);
printf("\n CSO distortion for 50 channel optical system = %0.1f dB\n",CSO);
```

Scilab code Exa 12.18 Calculate the required AM modulation

```
//Chapter 12
//page no 486
//given
clc;
clear all;
CSO=-59.8;   //in dB
```

```
y=10^(CSO/10);
mprintf("AM modulation depth (m) = %e\n",y);
asq=3.6*10^-3;
Ncso=50;
msq=(y/Ncso/asq/asq);
mprintf("\n m^2  = %e\n",msq);
printf("\n Decrease of AM modulation depth decrease
   the CSO distortion by  = %0.0f percent",sqrt(msq)
   *100);
```

Scilab code Exa 12.19 Compute the CTO distortion

```
//Chapter 12
//page no 486
//given
clc;
clear all;
Ncto=50;
b=1.07*10^-2;
m=0.05;
CTO=10*log10(Ncto*(1.5*b*m)^2);
printf("\n CTO distortion for 50 channel optical
   system = %0.1f dB\n",CTO);
//Answer in the book is misprinted
//The solution in the book is calculated without
   multipication of Ncto
```

Scilab code Exa 12.20 Calculate the CSO and CTO

```
//Chapter 12
//page no 487
//given
clc;
```

```
clear all;
Ncso=80;
a=2.43*10^-3;
b=4.65*10^-3;
m=0.05;
//Part (i)
CSO=10*log10(Ncso*(a*m)^2);
printf("\n CSO distortion for 50 channel optical
    system for m = 5 percent \n CSOdB = %0.1f dB\n",
    CSO);
//Part (ii)
CTO=10*log10(Ncso*(1.5*b*m)^2);
printf("\n CTO distortion for 50 channel optical
    system for m = 5 percent \n CTOdB = %0.1f dB\n",
    CTO);
//Part (iii)
m=0.03;

CSO=10*log10(Ncso*(a*m)^2);
// Value of a in the book is considered 2.4 instead
    of 2.43
printf("\n CSO distortion for 50 channel optical
    system for m = 3 percent \n CSOdB = %0.1f dB\n",
    CSO);

//Part (iv)
CTO=10*log10(Ncso*(1.5*b*m)^2);
printf("\n CTO distortion for 50 channel optical
    system for m = 3 percent \n CTOdB = %0.1f dB\n",
    CTO);
```

Scilab code Exa 12.21 Calculate the CNR

```
//Chapter 12
//page no 487
```

```
//given
clc;
clear all;
RIN=-150;            //in dB
B=4*10^6;
m=0.04;
CNR=10*log10(m^2/(2*10^-15*B));
printf("\n CNR = %0.0f dB",CNR);
```

Scilab code Exa 12.22 Calculate the RIN

```





//Chapter 12
//page no 488
//given
clc;
clear all;
CNR=50;            //in dB
Bch=4*10^6;
m=0.03;
RIN=m^2/2/Bch/10^(CNR/10)
mprintf("\n RIN = %e ",RIN);
//Miscalculated answer in the book
RINdB=10*log10(RIN);
printf("\nRIN in Db is %.2f",RINdB)
```

Scilab code Exa 12.23 Calculate the required optical power

```
//Chapter 12
```

```
//page no 490
//given
clc;
clear all;
Ipd=0.15;              //in mA
n=0.75;
e=1.6*10^-19;            //electron charge
hv=1.55*10^-19;
Pin=hv*Ipd/n/e;
printf("\n Pin = %0.6f mW",Pin);          //Result
//answer in book is misprint
```

Scilab code Exa 12.24 Calculate the percentage of optical power reflected back

```
//Chapter 12
//page no 492
//given
clc;
clear all;
OBR=-40;               //in dB
//y=Pref/Pin
y=10^(OBR/10);
printf("\n Prefl = %0.2f percent Pin",y*100);
```

Scilab code Exa 12.25 Calculate the output voltage of an optical receiver

```
//Chapter 12
//page no 493
//given
clc;
clear all;
R=800;                 //in V/W
```

```
Pin=1.5;                //in mW
m=0.04;
Voutp=R*Pin*m;
printf("\n Vout(peak) = %0.0f mV",Voutp);
Vavg=Voutp/sqrt(2);
printf("\n Vavg = %0.1f mV",Vavg);
//in dB
Vavgd=20*log10(Vavg*10^-3);
printf("\n Vavg(in dBmV) = %0.1f ",Vavgd);
```

Scilab code Exa 12.26 Determine the optical receiver responsivity

```
//Chapter 12
//page no 494
//given
clc;
clear all;
Voutp=20;               //in dB
Pin=1.2;                //in mW
m=0.035;
Vavg=10^(Voutp/20);             //in
R=Vavg*sqrt(2)/Pin/m;
printf("\n R = %0.1f V/W",R);
```

Scilab code Exa 12.27 Calculate the modulation depth

```
//Chapter 12
//page no 494
//given
clc;
clear all;
Voutp=28;               //in dB
Pin=1;              //in mW
```

```
R=800;              //in V/W
Vavg=10^(Voutp/20);              //in
m=Vavg*sqrt(2)/Pin/R;
printf("\n The modulation depth ,m = %0.1f percent",
    m*100);
```

Scilab code Exa 12.28 Calculate the CNR

```
//Chapter 12
//page no 495
//given
clc;
clear all;
Ipd=1.2;               //in mA
m=0.04;
RINd=-160;                 //in dB/Hz
e=1.6*10^-19;
nth=8;              //in pA/Hz
BW=4;               //in MHz
Rin=10^(RINd/10);               //in

CNR=[0.5*(m*Ipd*10^-3)^2]/[(2*e*Ipd*10^-3)+(Rin*Ipd
    *10^-3)^2+((nth*10^-12)^2)*BW/10^6];
printf("Value of CNR=%e",CNR)
CNRdB=10*log10(CNR)
printf("\nValue of CNR in dB=%.2f dB",CNRdB)
//Answer in the book is misprinted or wrong
    calculation performed in the book
```

Scilab code Exa 12.29 Total fiber span attenuation

```
//Chapter 12
//page no 509
```

```
//given
clc;
clear all;
L1=40;           //in km
L2=100;          //in km
A=0.2;        //in dB/Km
TFA1=A*L1;

printf("\n Total fibre span attenuation %0.0f dB\n",
   TFA1);
TFA2=A*L2;
printf("\n Total fibre span attenuation %0.0f dB\n",
   TFA2);
nsd=TFA2-TFA1;
printf("\n Noise spectral density = %0.0f dB ",nsd);
nsd_abs=10^(nsd/10)
printf("\n\n Absolute value of noise spectral
   density = %0.0f dB ",nsd_abs);
```

Scilab code Exa 12.30 Calculate the SNR

```





//Chapter 12
//page no 510
//given
clc;
clear ;
P1=2.75;               //in mW
NFd=5;              //in dB
bw=5;             //in GHz
G=10;          //in dB
```

```
hv=1.6*10^-19; //photon energy in J
N=1;           //no of amplifiers
NF=10^(NFd/10);      //amplifier noise figure
SNR=10*log10(P1*10^-3/[G*hv*bw*10^9*N*NF]);      //
   signal to nois eratio
printf("\n Spectral Noise density = %0.0f dB ",SNR);
   //result
```

Scilab code Exa 12.31 Calculate the optical power in fiber

```
//Chapter 12
//page no 510
//given
clc;
clear all;
SNRdB=40;              //in dB
NFd=6;             //in dB
bw=4;            //in GHz
Gd=8;           //in dB
hv=1.6*10^-19; //photon energy in J
N=8; //no of amplifiers
SNR=10^(SNRdB/10);
NF=10^(NFd/10);      //amplifier noise figure
G=10^(Gd/10);             //amplifer gain
P1=10*(SNR/10)*[G*hv*bw*10^9*N*NF]/10^-3;          //
   optical power launched into fibre
printf("\n Optical power required , P1 = %0.1f mW ",
   P1);     //Result
```

Scilab code Exa 12.32 Compute the transmission length

```
//Chapter 12
//page no 518
//given
clc;
clear all ;
l=1550;      //wavelength in nm
fb=10;       //system bit rate Gb/s
Df=17;       //fiber dispersion in ps/nm-km
L=10^5/Df/fb^2;      //fiber length in km
printf("\n Transmission length is %0.1f km",L);
fb2=2.5;       //system bit rate Gb/s
disp("for fb=2.5 Gb/s")
L2=10^5/Df/fb2^2;        //fiber length in km
printf(" Transmission length is %0.0f km",L2);//
   result misprint in book
```

Scilab code Exa 12.33 Compute the maximum bit rate

```
//Chapter 12
//page no 518
//given
clc;
clear all;
lembda=1550;      //wavelength in nm
Df=17;       //fiber dispersion in ps/nm-km
L=80      //fiber length in km
fb=sqrt(10^5/Df/L)
printf("\n Maximum bit rate fb = %.1f Mb/s",fb);
```

Scilab code Exa 12.34 Compute the solition characteristic length

```
//Chapter 12
//page no 530
//given
clc;
clear all;
D=0.2;                          //dispersion constant in
    ps/nm/km
Tfwhm=18;                        //ps
Zs=0.25*Tfwhm^2/D;              // Characteristic length
printf("\n Zs = %0.0f km",Zs);        //answer in book
    is miscalculated
```

Scilab code Exa 12.35 Determine maximum dispersion

```
//Chapter 12
//page no 530
//given
clc;
clear all;
lembda=1550;            //wavelength in nm
c=3*10^5;              //speed of light in km/s
Zs=600;                         //in km
Tfwhm=20;                        //in ps
D=1/1.763^2*[2*%pi*c*Tfwhm^2/(lembda^2*Zs)];   //
   dispersion constant
printf("\n dispersion constant, D = %0.2f ps/nm/km",
   D);       //result
```

Scilab code Exa 12.36 Calculate the solition pulse width

```
//Chapter 12
//page no 530
//given
clc;
clear all;
l=1557;           //wavelength in nm
c=3*10^5;             //speed of light in km/s
Zs=550;                           //in km
D=0.25;                          //in ps/nm/km
Tfwhm=sqrt(1.763^2*l^2*D*Zs/(2*%pi*c));//Soliton
   pulse width
printf("\n Tfwhm = %0.0f ps",Tfwhm);       //Result
```

Scilab code Exa 12.37 Calculate the solition peak pulse

```
//Chapter 12
//page no 531
//given
clc;
clear ;
Aeff=55;              //in sq micrometer
l=1557;           //wavelength in nm
c=3*10^5;             //speed of light in km/s
n2=2.6*10^-16;            //in cm^2/W
D=0.20;                          //Dispersion constant in
    ps/nm/km
Tfwhm=30;                  //in ps
Zs=[2*%pi*c*Tfwhm^2/l^2/D]/(1.763)^2 ;//
   charecteristic length
printf("\n Zs = %0.0f km",Zs);         //result
Ps=(Aeff*10^-12*l*10^-9)/(2*%pi*n2*10^-4*Zs*10^3);//
   Peak pulse power
//Miscalculation in the book
```

```
printf("\n Ps = %0.2f mW",Ps*1000);          //Result
```

Scilab code Exa 12.38 Compute the standard deviation

```

//Chapter 12
//page no 533
//given
clc;
clear all;
Z=10;                    //in mm
Tfwhm=22;                //in ps
D=0.5;                   //ps/nm/km
Aeff=55;                 //in microm^2
A=0.05;                  //in km^-1
nsp=1.5;            //spontaneous emission
F=2;                //amplifier noise
s=3.6*10^3*nsp*F*A*D*Z^3/(Aeff*Tfwhm);
printf("\n sigma = %0.0f ps",s);          //Result

//answer in book is misprint
```

Scilab code Exa 12.39 Calculate the system BER

```
//Chapter 12
//page no 533
//given
clc;
clear ;
Q1=4;               //quality factor
Q2=6;               //quality factor
BER1=[2*%pi*(Q1^2+2)]^-0.5*exp(-Q1*Q1/2);
BER2=[2*%pi*(Q2^2+2)]^-0.5*exp(-Q2*Q2/2);
```

```
printf("\n For Q=4 ,BER = %0.0f*10^-5 ",BER1*10^5);          //Result
printf("\n For Q=6 ,BER = %0.1f*10^-10 ",BER2*10^10);          //Result
//Answer second is misprinted in the book
```

Scilab code Exa 12.40 Compute the standard deviation

```
//Chapter 12
//page no 534
//given
clc;
clear all;
D=0.5;                    //Dispersion constant ps/nm/km
Ts=22;                    //Pulse width in ps
fb=10;                    //system transmission rate in Gb/s
Z1=1;                      //System total length Mm
Z2=10;                      //System total length Mm
sa1=8.6*D*D*Z1*Z1*sqrt(fb-0.99)/22/2;          //standard deviation based on accoustic effect
sa2=8.6*D*D*Z2*Z2*sqrt(fb-0.99)/22/2;          //standard deviation based on accoustic effect
printf("\n For Z=1000km ,sigma acoustic = %0.2f ps ",sa1);          //Result
printf("\n For Z=10000km ,sigma acoustic = %0.0f ps ",sa2);          //Result
```

Scilab code Exa 12.41 Calculate the collision length

```
//Chapter 12
//page no 535
//given
```

```
clc;
clear all;
D=0.45;                    //dispersion coefficient in ps/
    nm/km
Ts=22;                     //Pulse width in ps
l=0.5;              //length in nm
Lcollision=2*Ts/l/D;           //collision length  in
    km
printf("\n Lcollision  = %0.1f km ",Lcollision);
        //Result
```

Scilab code Exa 12.42 Calculate the half channel length

```
//Chapter 12
//page no 537
//given
clc;
clear all;
f=70;                 //Maximum frequencyshift in Ghz
Ts=22;                //Pulse width in ps
CS=1.783*f*10^9*Ts*10^-12;       //half channel
    seperation
printf("\n The half channel seperation %0.2f ",CS);
df=0.105/f/10^9/Ts/Ts/10^-24;          //maximum
    frequency shift
printf("\n The maximum frequency shift %0.0f GHz",df
    /10^9);
dt=0.1786/f/10^9/f/10^9/Ts/10^-12;   //time
    displacement
printf("\n The time displacement %0.2f ps",dt*10^12)
    ;
```

Scilab code Exa 12.43 Calculate the minimum number of soliton

```
//Chapter 12
//page no 538
//given
clc;
clear ;
M=1;
N=1;                //no of collision
S1=4;               //soliton colllision
S2=5;          //soliton colllision
Nc=S1*S1/4*[M*S1/2-M+N];          //minimum no of collision
printf("\n Ncollision for S=4,is %0.0f",Nc);
Nc2=(S2*S2-1)/4*[M*S2/2-M+N];          //minimum no of collision
printf("\n Ncollision for S=5,is %0.0f",Nc2);
```

Scilab code Exa 12.44 Compute the maximum number of soliton

```
//Chapter 12
//page no 539
//given
clc;
clear;
S=4;
n=5;
printf("\n Maximum number of solition Collisions\n");
for M = 1:n
N=M;
Nc=S*[M*S*S/3+S*(N/2-M)-N/2+2*M/3];          //minimum no of collision
printf("\n M=%0.0f     N=%0.0f       S=%0.0f  ,is       %0.0f",M,N,S,Nc);//result


```

```
end
```

Scilab code Exa 12.45 Compute the number of collision

```
//Chapter 12
//page no 539
//given
clc;
clear all;
M=1;          //number of solition Collisions
N=1;         // number of solition Collisions
x=2;
y=1/2;
p=3;
p2=4;
Tb=100;           //ps
l=1;              //difference in wavelength in nm
D=7*10^-2;        //ps/nm^2*km
Zr=y*y*(Tb/l/l/D);       //regeration spacing in km
printf("\n Zr = %0.0f km\n",Zr);
P=(p-1)*N+(p-2)*(p-1)*M/2;
printf("\n P(%0.0f) =%0.0f",p,P);        //result
   number of Collisions
P2=(p2-1)*N+(p2-2)*(p2-1)*M/2;
printf("\n P(%0.0f) =%0.0f",p2,P2);       //result
   number of Collisions
```

Scilab code Exa 12.46 Calculate the channel spacing

```
//chapter 12
//page no 540
//exa 12_46
//given
```

```
clear;
clc;
Tb=100;             //bit period in ps
dZ=0.4;             //in ps/nm/km
Zr=150;             //Modulator spacing in km
Ta=Tb/(dZ*Zr);          //channel spacing in nm
printf("\n Channel spacing %0.1f nm",Ta);    //result
```

Scilab code Exa 12.47 Compute the bit period

```
//chapter 12
//page no 540
//exa 12_47
//given
clear;
clc;
Zr=200;                //Modulator spacing in km
D=0.6;                  //in ps/nm/km
l=2;              //in nm
Tb=l*(Zr*D);            //bit period in ps
printf("\n Bit period Tb = %0.0f ps",Tb);//result
```

Scilab code Exa 12.48 Calculate the maximum modulator spacing

```
//chapter 12
//page no 540
//exa 12_48
//given
clear;
clc;
D=0.5;              //ps/nm-km
Tb=80;              //bit period in ps
l=1.5;        //in nm
```

```
Zr=Tb/(D*l);            //Modulator spacing in km
printf("\n Maximum modulator spacing Zr = %0.2f km",
    Zr);
```

Scilab code Exa 12.49 Calculate the length of dispersion

```
//chapter 12
//page no 541
//exa 12_49
//given
clear;
clc;
Zd=100;            //in km
Do=0.07;           //in ps/nm^2
D1=-0.3;           //in ps/nm^2
Ldsf=(Zd*Do)/(Do-D1);        //length of dispersion
    compensation fiber in km
printf("\n Length of Dispersion compensation fiber,
    Ldsf = %0.0f km",Ldsf);//Result
```

Scilab code Exa 12.50 Calculate the collision length

```
//chapter 12
//page no 542
//ex 12_50
//given
clear;
clc;
m=3;
n=1;
Tb=100;             //ps
l=1;                //nm
D=0.07;             //ps/nm^2*km
```

```
lmn=1;              //nm
lmo=2;              //nm
Do=0.1;             //ps/nm-km
Lc=4*Tb/[5*D*lmn*(lmn+2*lmo)];//Collision length  in km
printf("\n Collision length without dispersion slope compensation = %0.1f km\n",Lc);//result
Lc2=2*Tb/[5*Do*lmn];//Collision length in km
printf("\n Collision length with dispersion slope compensation = %0.0f km",Lc2);//result
```

Scilab code Exa 12.51 Compute the soliton collision length

```
//chapter 12
//page no 542
//ex 12_51
//given
clear;
clc;
Zr=200;             //in km
S=4;
Ltot1=2*Zr*(S-1);           //total solition collion length in km
printf("\n Total solition Collisions length With DSC,Ltotal = %0.0f km\n",Ltot1);//Result
Ltot2=(2/5)*Zr*(S-1);           //total solition collion length in km
printf("\n Total solition Collisions length With non-DSC ,Ltotal = %0.0f km\n",Ltot2);//result
```

Chapter 13

Networks

Scilab code Exa 13.1 Calculate R9 R7 R8 C4

```
//Chapter 13
//page no 568
//given
clc;
clear all;
Vcc=5;                          //in V
Vf=1.5;                   //in V
If=60;                    //in mA
B=3.97;
N=3;
R9=(Vcc-Vf)*(B+1)/If/10^-3;
printf("\n R9 = %0.0f ohm\n",R9);
R7=R9/2/B-3/N;
printf("\n R7 = %0.1f ohm\n",R7);
R8=R9/2/B;
printf("\n R8 = %0.1f ohm\n",R8);
C4=2*10^-9/R8;
printf("\n C4 = %0.0f pF",C4*10^12);
```

Scilab code Exa 13.2 Calculate Led If R3 C4

```
//Chapter 13
//page no 569
//given
clc;
clear all;
Vu3=1.24;            //in V
Vbeq3=0.7;           //in V
Vbeq4=0.7;           //in V
R5=17.5;             //in Ohm
R6=17.5;             //in Ohm
Voh=5;           //in V
Vol=0;           //in V
If=(Vu3-Vbeq3)/R5+(Vu3-Vbeq4)/R6;
printf("\n If= %0.1f mA\n",If*1000);
R3=(Voh-Vol)/If;
printf("\n R3= %0.0f ohm\n",R3);
C4=2*10^-9/R3;
printf("\n C4= %0.0f pF\n",C4*10^12);
//Chapter 13
//page no 581
//given
disp("Page number 581 again  Example 13-2 (numbering mistake)")
Er=4.9;
h=5;                 //in mils
w=10;                 //in mils
t=0.5;                 //in mils
Z=60/sqrt(0.475*Er+0.67)*log(4*h/0.67/(0.8*w+t));
printf("\n Z = %0.1f ohm\n",Z);
tpd=1.017*sqrt(0.475*Er+0.67);
printf("\n tpd = %0.2f ns/ft\n",tpd);
Tpd=tpd*1000/12;             //converted into ps/in
printf("\n tpd = %0.2f ps/in\n",Tpd);
Co=Tpd/Z;
printf("\n Co = %0.1f pF/in\n",Co);
```

Scilab code Exa 13.3 Characteristic impedance and propagation delay

```
//Chapter 13
//page no 583
//given
clc;
clear all;
Er=4.7;
b=10;                    //in mils
w=4;                     //in mils
t=0.5;                   //in mils
Z=60/sqrt(Er)*log(4*b/0.67/%pi/(0.8*w+t));
printf("\n Z = %0.2f ohm\n",Z);
tpd=1.017*sqrt(Er);
printf("\n tpd = %0.1f ns/ft\n",tpd);
Tpd=tpd*1000/12;              //converted into ps/in
printf("\n Also,tpd = %0.0f ps/in\n",Tpd);//answer is slightly different due to rounding off
```