Scilab Textbook Companion for Optoelectronics: An Introduction by J. Wilson and J. Hawkes[1]

Created by
Sai L
BTech
Electronics Engineering
SNIST
College Teacher
None
Cross-Checked by
None

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Book Description

Title: Optoelectronics: An Introduction

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Light

Scilab code Exa 1.1 1

```
//Example 1.1, Page Number 10
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
//Brewster Angle Calculation
clc;

n2=1.5 //Refractive Index of Glass in Air
n1=1   //Refractive Index of Air

theta=0 //Brewster's Angle in Degrees

theta=(atand(1.5))//(Brewster's angle= Tan Inverse (
   n2/n1))
theta=fpround(theta,2)
disp(theta,"The Brewsters Angle for the Material in
   Degrees:");
```

Scilab code Exa 1.2 Page Number 13

```
//Example 1.2, Page Number 13

clc;
n=4 //Total Number of Sources

//For Coherent Sources
mprintf("\tIn Coherant Sources The Maximum
   Irradiance is %dI\n",n*n);  //Where I is the
   Irradiance at any point

//For Incoherent Sources
mprintf("\tIn Incoherent Sources The Maximum
   Irradiance is %dI",n);
```

Scilab code Exa 1.3 Page Number 22

```
//Example 1.3, Page Number 22

clc;
D=0.1 //Diameter of the Objective Lens
d1=500 //Distance from the source
l =550*(10**-9) //Wavelength
p=1 //First Order
N=40*600 //The diffraction grating is 40 mm wide and
    has 600 lines/mm

Smin=(d1*l)/D  //Smin is the minimum separation of
   the Sources
Smin=Smin*(10**3)
mprintf("\t(A)The Minimum Seperation Between the
   Sources is %.2f mm\n",Smin);

dl=l/(N*p)//l/dl=p*N
dl=dl*(10**9)
mprintf("\t(B)The Minimum Wavelength Difference
```

```
    which may be resolved is %.3f nm",dl)
```

Scilab code Exa 1.4 4

```
//Example 1.4, Page Number 29
//Total Power Calculation

clc;

em=0.7 //Emissivity Of the Surface
T=2000 //Temperature in Kelvin
A=(10**-5) //Area in Meter Square
S=5.67*(10**-8) //Stefan-Boltzmann Constant in Watt
    per meter square Kelvin power four

W=em*S*A*(T**4) //W is the total power radiated in
    Watt

mprintf("The Total Power Radiated from the Source is
    %.2f W",W);
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 1.5 Page Number 31

```
//Example 1.5, Page Number 31
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
clc;

Z=1 //Atomic Number of Hydrogen
```

```
m=9.1*(10**-31) //Mass of an Electron
e=1.6*(10**-19) //Charge Of an Electron
p=6.6*(10**-34) //Planck's Constant
e1=8.85*(10**-12)//Permitivity of Free Space

E=(m*(Z**2)*(e**4))/(8*(p**2)*(e1**2)) //E is the
    Ionization Energy
E2=E/e //Conversion to Electron Volts
E2=fpround(E2,2)

mprintf("The Ionization Energy required to excite
    the electron from ground state to infinity:%.2f
    eV",E2);
```

Scilab code Exa 1.6 6

```
//Example 1.6, Page Number 32
//Phi Determination

clc;
e=1.6*(10**-19) //Charge Of an Electron in Coulombs
h=6.6*(10**-34) //Plancks Constant in meter square
    kilogram per second
vo=1.1*(10**15) //Threshold Frequency in Hertz

// h*vo=phi*e ,phi is the required Work Function,vo
    is the threshold frequency
// Lets assume that the ejected electron has zero
    kinetic energy

phi=h*vo/e
mprintf("The Required Work function is %.1f eV",phi)
    ;
```

Chapter 2

Elements Of Solid State Physics

Scilab code Exa 2.1 1

```
//Example 2.1, Page Number 51
//Conductivity Calculation
clc;

dc=8.93*(10**3) //Density of Copper in Kg/meter cube
N=63.54 //Atomic Mass Number of Copper in amu
t=2.6*(10**-14)//Mean free time between collision (in seconds)
m=9.1*(10**-31) //Mass of electron in kilogram
em=0.135 //Electron Mobility in meter square per volt second
hm=0.048 //Hole Mobility in meter square per volt second
n=1.6*(10**16) //Concentration per meter cube
an=6*(10**26)  //Avogadro's number per mole
e=1.6*(10**-19)  //Charge of an electron in Coulombs

n1=(an*dc)/N //Free electron concentration/No. of atoms per unit volume

rhoc=(n1*e*em)/3 //Conductivity of Copper in per ohm
```

```
m

//From equation 2.24
rhos=n*e*(em+hm) //Conductivity of Copperintrinsic silicon in per ohm m


mprintf("Free Electron Concentration is: %.2e per meter cube\n",n1);
mprintf(" Conductivity of copper is:%.2e per ohm meter\n",rhoc)//The answer provided for rhoc in the textbook is wrong
mprintf(" Conductivity of intrinsic silicon is:%.2e per ohm meter\n",rhos)
```

Scilab code Exa 2.2 2

```
//Example 2.2, Page Number 55
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Excitation Energy Calculation
clc;

r=11.8 //Relative Permeability
m=9.1*(10**-31) //Mass of electron in kilogram
me=0.26*m //Effective mass

//From equation 2.28
E=13.6*(me/m)*((1/r)**2) //E is the excitation energy in eV
E=fpround(E,4)

mprintf("The Excitation Energy is given by %.3feV",E)
```

Scilab code Exa 2.3 3

```
//Example 2.3, Page Number 60
//Effective Density Calculation
clc;

m=9.1*(10**-31) //Mass of electron in kilogram
me=0.55*m //Effective mass
T=300 //Temperature in Kelvin
k=1.38*(10**-23) //Boltzmann Constant in meter
    square kilogram per second square Kelvin
h=6.6*(10**-34) //Plancks Constant in meter square
    kilogram per second

//From equation 2.33
N=2*(((2*%pi*me*k*T)/(h*h))**1.5) //N is the
    Effective density of states in the conduction
    band

mprintf("The Effective Density of States in the
    Conduction Band is %.2e Per Meter Cube",N);
```

Scilab code Exa 2.4 4

```
//Example 2.4, Page Number 64
//Hole Lifetime Calculation
clc;
n=5*(10**24) //Donor Concentration in per meter cube

//For GaAs
B=7.2*(10**-16)//Constant of proportionality for
    GaAs
```

```
t1=1/(B*n) //t1 is the Hole lifetime for GaAs

//For Si
B=1.8*(10**-21)//Constant of proportionality for Si
t2=1/(B*n) //t2 is the Hole lifetime for Si

disp(t1,"The Hole Lifetime for GaAs in  pico seconds is:");
disp(t2,"The Hole Lifetime for Si in  micro seconds is:");
```

Scilab code Exa 2.5 5

```
//Example 2.5, Page Number 70
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Contact Potential Difference
clc;
nd=10**22 //Donor Impurity Level in per meter cube
na=10**24 //Acceptor Impurity Level in per meter cube
n=2.4*(10**19) //Intrinsic Electron Concentration in per meter cube
T=290 //Temperature in Kelvin
k=1.38*(10**-23) //Botlzmann Constant in meter square kilogram per second square Kelvin
e=1.6*(10**-19) //Charge of an electron in coulombs

//From Equation 2.45
v=(k*T/e)*log1p((nd*na)/(n**2)) //v is the contact potentital difference in volts
v=fpround(v,2)
mprintf("The Contact Potential Difference is:%.2f Volts ",v)
```

Scilab code Exa 2.6 6

```
//Example 2.6, Page Number 73
//Saturation Current Density
clc;
nd=10**21 //Donor Concentration per meter cube
na=10**22 //Acceptor Concentration per meter cube
de=3.4*(10**-3) //Drift current-electron in meter
    square per second
dh=1.2*(10**-3) //Drift current-holes in meter
    square per second
le=7.1*(10**-4) //in meter
lh=3.5*(10**-4) //in meter
n=1.6*(10**16) //per meter cube
e=1.6*(10**-19) //charge of an electron in coulomb
A=10**6 //Junction area per unit area

//Assuming all ions are ionized
ni=2.56*(10**32)//per metre cube
pn=(ni)/nd
np=pn/10

//From Equation 2.51a
jo=e*((dh/lh)*pn+(de/le)*np) //Jo is the saturation
    current density

io=jo/A //io is the reverse bias saturation current

mprintf("P-N concentration is:%.2e per meter cube\n"
    ,pn)
mprintf("N-P concentration is:%.2e per meter cube\n"
    ,np)
mprintf("The Saturation Current Density is:%.1e A/
    meter square\n",jo)
```

```
mprintf("The Reverse Bias Saturation Current is:%.1e A\n",io)
```

Scilab code Exa 2.7 7

```
//Example 2.7, Page Number 78
//Junction Capacitance Calculation
clc;

V=-4 //Reverse Bias voltage in volts
nd=4*(10**21) //in per meter cube
Vo=0.8//in volts
A=4*(10**-7) //Junction Area in meter square
er=11.8 //Relative permittivity
e=1.6*(10**-19) //Charge of an Electron in coulombs
eo=8.85*(10**-12) //Absolute permittivity in farads per meter

//By equation 2.63
Cj=(A/2)*sqrt((2*eo*er*e*nd)/(Vo-V))

mprintf("The Junction Capacitance is %.2e pF",Cj)
```

Scilab code Exa 2.8 8

```
//Example 2.8, Page Number 84
//Effective Increase in the width of the Energy Gap Calculation
clc;
Lz=10*(10**-9) //Thickness in meter
m=9.1*(10**-31) //Mass of Electron in kilogram
me=0.068*m //Effective mass of electron
mh=0.56*m //Effective mass of holes
```

```
h=6.6*(10**-34) //Plancks Constant in meter square
    kilogram per second
e=1.6*(10**-19) //Charge of an electron in Coulombs

Eg=((h*h)/(8*(Lz*Lz)))*((1/me)+(1/mh)) //Eg is the
    effective increase in the width of the energy gap
Egn=Eg/e //Converting to eV
Egn=fpround(Egn,3)
mprintf("The Effective Increase in the width of the
    Energy Gap is %.3f eV",Egn)
```

Chapter 3

Modulation Of Light

Scilab code Exa 3.1 1

```
//Example 3.1, Page Number 97
//Change in Refraction Index due to Pockels effect
clc;

//Variable Initialization
l=10*(10**-3) //Width of Crystal in milli meter
V=4000 //Applied Voltage in volts
r=26.4*(10**-12)//linear electro optic coefficient in pm per volt
no=1.51**3//Value for KD*P taken from table 3.1
//Using data in Table 3.1(Page No 100)
dn=0.5*lc*(no)*(V/(10**-2)) //dn is the change in refraction index
mprintf("The Change in Refraction Index due to Pockels effect is %0.1e",dn);
```

Scilab code Exa 3.2 2

```
//Example 3.2, Page Number 101
//Half Wave Voltage
clc;

//Variable Initialization
l=1.06*(10**-6) //Wavelength in meter
no=1.51//Value for KDP taken from table 3.1
r=10.6*(10**-12)//Linear Electro Optic Coefficient in pm per volt for KDP taken from table 3.1

//Using Data from table 3.1 on page no. 100
V=l/(2*r*(no**3)) //V is the Half Wave Voltage

mprintf("\n");
disp(V,"The Half Wave Voltage for KDP in V:");
```

Scilab code Exa 3.3 3

```
//Example 3.3, Page Number 105
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Power Requirements for Modulation
clc;

//Given Values
bw=10**9 //Frequency Bandwidth in Hertz
d=25/2*(10**-3) //Diameter of Circular Aperture in meter
l=30*(10**-3) //Length in meters
wl=633*(10**-9) //Wavelength in meters
k=8.85*(10**-12) //Permittivty of free space
pr=%pi/30//Phase Retardation/Phase difference at freq bandwidth of (10**9) HZ

//The following values have been taken from Table
```

```
   3.1 on page no. 100
ur=50//Relative permeability for KD*P
r=26.4*(10**-12)//Linear Electro Optic Coefficient
   for KD*P in pm per volt
no=1.51//value for KD*P

P=((((wl**2)*%pi*((d)**2)*bw*k*ur)/(4*%pi*((r)**2)*(
   no**6)*l))*(pr**2)) //P is the power requirements
    in W
P=fpround(P,1)

mprintf("\n");
mprintf("The Power Requirements for Modulation using
    a Pockels cell is %.1f W",P);
```

Scilab code Exa 3.4 4

```
//Example 3.4, Page Number 118
//Acousto-optic modulator
clc;
l=633*(10**-9) //Wavelength in meter
bw=5.0*(10**6) //Bandwidth in hertz
L=50*(10**-3) //Modulation length in milli meter
de=0.7 //Diffraction Efficiency
al=4.3*(10**-5) //Acoustic Wavelength in meter
av=3500.0 //Acoustic velocity in meter per second

theta=asin(l/(2*al)) //theta is the angle of
   diffraction
theta1=theta *(180 /%pi) //Converting it into
   degrees

phi=2*(asin(sqrt(de))) //phi is the internal braggs
   angle
phi1=phi *(180/%pi) //Converting it into degrees
```

```

ca=cos(theta1)

dn=(phi*l*ca)/(3.14*2*L) //dn is the maximum change
    in refraction index

B=av/bw
B=B*(10**3)
mprintf("The Angle of Diffraction is %.2f Degree\n"
    ,theta1)
mprintf(" The Internal Braggs Angle is %.1f Degree\
    n",phi1)
mprintf(" The Maximum Change in Refraction index is
    %.2e\n",dn)//The Answer for Maximum Change in
    Refraction index is miscalculated in the book
mprintf(" The Maximum Optical Beam Width is %.1f mm
    \n",B)
```

Scilab code Exa 3.5 5

```
//Example 3.5, Page Number 123
//Phase Matching Angle
clc;

//The following values have been taken from the
    table on page no 123
no1=1.4943//no for l=1.06
no2=1.5132//no for l=0.53
nc=1.4712//nc for l=0.53
t2=((no1**-2)-(no2**-2))/((nc**-2)-(no2**-2))
theta=asin(t2)

//Converting it into degrees
degrees=theta * (180/%pi) //theta is the phase
    matching angle
```

```
mprintf("The Phase matching angle is %d degrees",
    degrees);
```

Scilab code Exa 3.6 6

```
//Example 3.6, Page Number 124
//Coherence Length
clc;
nw=1.5019 //Refraction index at 0.8 micrometer
n2w=1.4802 //Refraction index at 0.4 micrometer
l=0.8*(10**-6) //Vaccum Wavelength at the
    fundamental frequency in m

lc=l/(4*(nw-n2w)) //lc is the coherence length in
    meters

mprintf("The Coherence Length is %.2e m",lc);
```

Chapter 4

Display Devices

check Appendix AP 1 for dependency:

`fproround.sci`

Scilab code Exa 4.1 Page Number 131

```
//Example 4.1, Page Number 131
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
clc;

kt=0.025
E=0.4 //(The difference between Ec & Ed)
Q=(10**8)

j=E/kt
p=Q*exp(-j) //p is the required probability
p=fpround(p,2)
Q1=1/p
Q1=fpround(Q1,2)
mprintf("The Probability of Escape per second of the
    trapped electron:%.2f/s\n",p)
mprintf(" The Luminescence Lifetime is:%.2fs",Q1)
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 4.2 Page Number 152

```
//Example 4.2, Page Number 152
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
clc;

n1=3.6//For GaAs/Air Interface
n2=1//For Air

//Using Equation 4.14
n3=n1-n2
n4=n1+n2
n6=(n3/n4)**2
n5=(n2/n1)**2

F=0.25*(n5)*(1-n6) //F is the Fractional
   Transmission for Isotropic Radiation
F=fpround(F,3)

theta=asin(1/n1)  //Critical Angle in Degrees
theta=theta *(180/%pi)
theta=fpround(theta,0)

mprintf("The Fractional Tranmission for Isotropic
   Radiation originating inside GaAs is:%.3f \n",F)
mprintf(" The Critical Angle is:%d Degrees",theta)
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 4.3 Page Number 158

```
//Example 4.3, Page Number 158
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
clc;

d=0.2*(10**-3) //Chip Diameter in meter
d1=1 //Distance in Meter
l=550*(10**-9 ) //Wavelength in Meter
q=0.001 //External Quantum Efficiency
i=50*(10**-3) //Operational Current
h=6.6*(10**-34)//Plancks Constant
c=3*(10**8)//Speed of Light
e=1.6*(10**-19)//Charge of an electron

theta=(d/2)
mprintf("Angle Theta of Emitting Area :%f\n",theta)
mprintf(" Since theta is less than one, the LED acts
    as a Point Source\n")

W=((h*c)/l)*q*(i/e) //W is the Total Radiant Power
W=fpround(W,6)

mprintf(" The Total Radiant Power is :%.2e W\n",W)

//From the graph(Fig 1.24 Page No.33)
l1=600 //Average Luminosity

lf=W*l1 //lf is the luminous flux from the source
lf=fpround(lf,3)

mprintf(" The Luminous Flux from the source is:%.2e
   lm\n",lf)
```

```
li=lf/(2*3.14)//li is the luminous intensity at
    normal incidence since flux is distributed over
    angle 2PI
li=fpround(li,4)

mprintf(" The Luminous Intensity at normal incidence
     is: %.2e candela\n",li)

X = [400,500,555,600,650,700]
V = [0.0,0.3,1.0,0.7,0.3,0.0]
plot(X,V);
xlabel("Wavelength in nm")
ylabel("V")
title("Fig 1.24")
```

Chapter 5

Lasers I

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 5.1 Page Number 173

```
//Example 5.1, Page Number 173
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
clc;
T=2000 // In Kelvin
v=5*(10**14) //Frequency In Hertz
h=6.6*(10**-34) //Plancks Constant
k=1.38*(10**-23) //Boltzman Constant

R=exp((h*v)/(k*T))-1
R=fpround(R,2)
mprintf("The Ratio of rates of spontaneous &
   stimulated emission is %0.2e",R);
```

Scilab code Exa 5.2 2

```
//Example 5.2, Page Number 176
//Relative Populations of energy levels
clc;
T=300 //Given Room Temperature in Kelvin
l=550*(10**-9) //Average Wavelength of Visible
    Radiation in meter
h=6.6*(10**-34) //Planck's Constant in meter square
    kilogram per second
c=3*(10**8) //Speed Of Light in meters per second
k=1.38*(10**-23) //Boltzman Constant in meter square
     kilogram per second square Kelvin
e=1.6*(10**-19) //Charge of an Electron in Coulombs

E=(h*c)/l //E is the given Energy Difference
E1=E/e

N=exp((-1*E)/(k*T)) //N is the ratio of N2 and N1

mprintf("\tThe Given Energy Difference of the Two
    Levels is %.2f eV\n",E1);

mprintf("\tThe Relative Population of the Energy
    Levels is %.2e\n",N);
//The minor difference arising is due to a round off
     error
```

Scilab code Exa 5.3 3

```
//Example 5.3, Page Number 184
//Small signal gain coefficient
clc;
//For Nd:YAG
t=230*(10**-6) //Spontaneous Lifetime in seconds
l=1.06*(10**-6) //Wavelength in meter
n=1.82 //Refractive Index
```

```
w=3*(10**12) //Linewidth in Hertz
h=6.6*(10**-34) //Plancks Constant in meter square
    kilogram per second

B21=(l**3)/(8*%pi*h*t*(n**3)) //B21 is the Einstein
    Coefficient in metre cube per W second cube

k=1

kvs=(k*l*w)/(B21*h*n) //Small Signal Gain
    Coefficient per meter cube

mprintf("Small Signal Gain Coefficient is %0.2e /
    meter cube",kvs);
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 5.4 Page Number 205

```
//Example 5.4, Page Number 205
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
clc;
n2=3.6 //Refractive Index for GaAs
n1=1 //Refractive Index for Air
//From Fresnels Equation

R=((n2-n1)/(n2+n1))**2
R=fpround(R,2)

mprintf("The Reflectance at a GaAs/Air Interface is
    %0.2f",R);
```

Scilab code Exa 5.5 5

```
//Example 5.5, Page Number 209
//Threshold Current Density
clc;
//For GaAs Junction
l=0.84*(10**-6) //Wavelength in meter
w=1.45*(10**13) //Linewidth in Hertz
y=3.5*(10**3) //Loss Coefficient per meter
n=3.6 //Refractive Index for GaAs
q=1 //Quantam Efficiency
le=300*(10**-6)//Length in meter
d=2*(10**-6) //in metres
R=0.32 //Reflectance
c=3*(10**8) //Speed of light in m/s
e=1.6*(10**-19) //Charge of electron in Coulombs

v=c/l //Frequency

k=y+((1/(2*le))*log1p(1/(R*R)))//k is the threshold
    gain
k=fpround(k,0)

J=(8*%pi*w*e*(n**2)*d*k*(v**2))/(c**2)
J=J*(10**-6)
mprintf("\tThe Threshold Gain is %d /m\n",k)
mprintf("\tThe Threshold Current Density is %.2f A/
   mm square\n",J)
```

Scilab code Exa 5.6 6

```
//Example 5.6, Page Number 225
```

```
//Efficiency of He-Ne Laser
clc;
i=1*(10**-2) //Current in Ampere
V=2500 //in volts
P=5*(10**-3) //Optical Output in Watt

E=P/(i*V) //E is the overall Power Efficiency
E=E*100
mprintf("The Overall Power Efficiency is %0.2f
    percent ",E);
```

Chapter 6

Laser II

Scilab code Exa 6.1 1

```
//Example 6.1, Page Number 252
//Mode locked Pulses
clc;
lw=1.1*(10**11) //Fluorescent Linewidth in Hertz
l=0.1 //length of laser rod in meter
n=1.8 //Refractive Index
c=3*(10**8) //Speed of light in meters per second

ms=c/(2*l*n) //ms is the mode seperation in hertz
ps=1/ms //ps is the Pulse seperation in seconds
Nm=lw/ms //Nm is the Number of modes oscillating
pd=(1/Nm)*ps //pd is the pulse duration

disp(ms,"The Mode Seperation in Hz is:")
disp(Nm,"The Number of Modes Oscillating is:")
disp(ps,"The Pulse Seperation in s is:")
disp(pd,"The Pulse Duration in s is:")
```

Scilab code Exa 6.2 2

```
//Example 6.2, Page Number 256
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
//Energyof Q Switched Pulses
clc;

//In a typical Laser
N1=10**24 //per meter cube
f=5*(10**14) //Frequency in hertz
v=(10**-5) //Volume in per meter cube
h=6.63*(10**-34) //Plancks Constant in meter square
    kilogram per second

//Assuming Nf<<<Ni

E=0.5*(h*v*N1*f) //Where E is the Energy of the
    pulses
E=fpround(E,1)

mprintf("The Energy of the Pulse is %.1f J",E)
```

Scilab code Exa 6.3 3

```
//Example 6.3, Page Number 256
//Power in Q-switched pulses
clc;

//Using the Energy of the pulses from the previous
    example(Ex6.2)
E=1.657 //Energy of the pulses in Joules
l=0.1 //Cavity length in meter
r=0.8 //Mirror reflectance
c=3*(10**8) //Speed of light in meters per second

tc=l/((1-r)*c) //tc is the cavity lifetime
```

```

P=E/tc //P is the pulse power

disp(tc,"The Cavity Lifetime in s is:")
disp(P," The Pulse Power in W is:")
```

Scilab code Exa 6.4 4

```
//Example 6.4, Page Number 260
//Beam collimation
clc;

//Considering a He-Ne Laser
d=3*(10**-3) //Diameter in meter
l=633*(10**-9) //Wavelength of the laser in meter

theta=l/d //theta is the divergence of the beam
mprintf("The Divergence of the Beam is %.1e rad\n",
    theta)

//After Collimation
theta=theta/30 //Reduced by a factor of 30
mprintf(" After Collimation,The angle of divergence
    is reduced to %.0e rad",theta)
```

Scilab code Exa 6.5 5

```
//Example 6.5, Page Number 263
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
//Coherent lengths of conventional and laser
    radiation sources
clc;
```

```
//Assuming all lights are emitted from a low pressure Sodium Lamp

l=589*(10**-9) //Wavelength in meter
lw=5.1*(10**11) //Linewidth in Hertz
c=3*(10**8) //Speed of light in meters per second

//From equation 6.9
tc=1/lw //tc is the cavity lifetime in s

//From Equation 6.8
Lc=tc*c //Lc is the length of the Wave Train in metres
Lc=fpround(Lc,4)

disp(tc,"The Cavity lifetime in s:")
disp(Lc," The Length of the Wave Train or the Coherence Length in m is:")

//If Many modes are operating
lw=1500*(10**6)//in Hz
tc=1/lw//tc is the cavity lifetime in s
Lc=tc*c
Lc=fpround(Lc,4)//Lc is the length of the Wave Train in metres

disp(tc,"The Cavity lifetime in s:")
disp(Lc," The Length of the Wave Train or the Coherence Length in m is:")

//If There is only one mode
lw=1*(10**6)//in Hz
tc=1/lw//tc is the cavity lifetime in s
Lc=tc*c
Lc=fpround(Lc,4)//Lc is the length of the Wave Train in metres

```

```
disp(tc,"The Cavity lifetime in s:")
disp(Lc," The Length of the Wave Train or the
    Coherence Length in m is:")
```

Scilab code Exa 6.6 6

```
//Example 6.6, Page Number 266
//Focused Power Density
clc;

P=10*(10**-3) //Power of the He-Ne Laser in W
F=1 //F Number
l=633*(10**-9) //Wavelength of the laser in m

//From equation 6.10a
rs=(2/%pi)*l*F //rs is the radius of the focused
    spot in m

P1=(P*%pi)/((2*l)**2) //P1 is the Power per unit
    area in Watt per meter square

mprintf("The Radius of the Focused Spot is %.2e m\n"
    ,rs)
mprintf("The Power Per unit Area is:%.2e Watt per
    meter square",P1)
```

Scilab code Exa 6.7 7

```
//Example 6.7, Page Number 266
//Depth of Focus
//clc;

//For A Carbon Dioxide Laser Beam
```

```
l=10.6*(10**-6) //Wavelength in meter
d=50/2*(10**-3) //radius in meter
fl=200*(10**-3) //Focal Length in meter

//Using Equation 6.10
rs=(l*fl)/(%pi*(d)) //rs is the radius of the focused spot

//Suppose that spot size can be tolerated by 10 percent
w=1.1
w1=1

fd=((%pi*(rs**2))*sqrt((w**2)-(w1**2)))/l //fd is the depth of focus
fd=fd*(10**3)
rs=rs*(10**6)
rs=ceil(rs)
mprintf("The Radius of the Focussed spot is %d um\n",rs)
mprintf(" The Depth of the Focus is %.2f mm",fd)

//The answers provided in the textbook are wrong
```

Chapter 7

Photodetectors

Scilab code Exa 7.1 1

```
//Example 7.1, Page Number 296
//Detector sensitivity
clc;

D=10**9 //in meter square root hertz per watt
l=2*(10**-6) //Wavelength in meter
A=25*(10**-6) //Area in meter square
db=10*(10**3) //Detection Bandwidth in hertz

//From equation 7.2
NEP=(sqrt(A*db))/D //NEP is the detector sensitivty
    in W

mprintf("The Sensitivty of the device at given
    wavelength is:%.0e W",NEP)
```

Scilab code Exa 7.2 2

```
//Example 7.2, Page Number 306
//Vacuum photodiode output
clc;

l=500*(10**-9) //Wavelength of radiation in metres
P=1*(10**-6) //Power in Watts
q=0.5 //Quantum Efficiency
e=1.6*(10**-19) //Charge of an electron in Coulombs
h=6.63*(10**-34) //Plancks Constant in meter square kilogram per second
c=3*(10**8) //Speed of light in meters per second

//From equation 7.9
i=(q*e*P*l)/(h*c) //i is the current generated in Amperes

mprintf("The Current Generated is:%.0e A",i)
```

Scilab code Exa 7.3 3

```
//Example 7.3, Page Number 311
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Minimum detectable signal
clc;

A=1000*(10**-6) //Cathode Area in metre square
wf=1.25 //Work function in eV
T=300 //Cathode temperature in Kelvin
e=1.6*(10**-19) //Charge of an electron in Coulombs
k=1.38*(10**-23) //Boltzman Constant in meter square kilogram per second square Kelvin
a1=1.2*(10**6) //constant for pure metals in Ampere per metre square kelvin square
l=0.5*(10**-6) //Wavelength in meters
```

```
q=0.25 //Quantum Efficiency
h=6.63*(10**-34) //Plancks Constant in meter square kilogram per second
c=3*(10**8) //Speed of light in meters per second
f=1//bandwidth in hertz

//From equation 7.11
e1=(k*T)/e
e1=fpround(e1,3)
c2=(-1*wf)/e1
c2=fpround(c2,4)
c3=exp(c2)
it=a1*A*(T**2)*c3 //it is the current generated in Amperes

mprintf("The Thermionic Emission Current is:%.2e A\n",it)

//Using Equation 7.9
r=(q*e*l)/(h*c) //r is the responsivity in A/W
r=fpround(r,2)
mprintf(" The Responsivity is:%0.1f A/W\n",r)

//Using Equation 7.13
W=(sqrt(2*it*e*f))/r //W is the minimum detectable power in Watts
mprintf(" The Minimum detectable signal power is:%.3e W",W)

//The answer provided in the textbook is wrong
```

Scilab code Exa 7.4 4

```
//Example 7.4, Page Number 311
//Noise in photomultipliers
```

```
clc;

T=300 //Temperature in Kelvin
lr=10**3 //Load resistor in ohms
bw=10**3 //Bandwidth in hertz
k=1.38*(10**-23) //Boltzman Constant in meter square kilogram per second square Kelvin
i=10**-14 //Photomultiplier current in Amperes
e=1.6*(10**-19) //Charge of an electron in Coulombs
g=10**7 //Photomultiplier Gain

//From equation 7.14
V=sqrt(4*k*T*bw) //V is the shot noise voltge

//From equation 7.12
is=sqrt(2*i*e*bw) //is is the shot noise current in Amperes

V1=is*g*lr //V1 is the voltage observed across load resistance

mprintf("The RMS Value of the Voltage is:%.1e V\n",V)
mprintf(" The Shot Noise Current is:%.1e A\n",is)
mprintf(" The Shot Noise Voltage across load resistor is:%.1e V",V1)
```

Scilab code Exa 7.5 5

```
//Example 7.5, Page Number 324
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Depletion wavelength
clc;

```

```
n3=1//Energy Level
n2=2//Energy Level
Lz=10*(10**-9) //Width of the well in metres
m=9.1*(10**-31) //Mass of an electron in kilogram
me=0.068*m//effective mass
h=6.63*(10**-34) //Plancks Constant in meter square
    kilogram per second
c=3*(10**8) //Speed of light in meters per second
e1=1.6*(10**-19) //Charge of an electron in Coulombs

//By Equation 2.64

E=((h**2)/(me*8))*(((n2/Lz)**2)-((n3/Lz)**2)) // E
    is the energy difference between the levels in eV
E1=E/e1 //Conversion to electron volt
E1=fpround(E1,2)
l=(h*c)/E1 //l is the optical wavelength in metres
l1=l/e1
l1=l1*(10**6)
mprintf("The Energy Difference between the two
    levels is:%0.3feV\n",E1)
mprintf(" The Optical Wavelength is:%0.1f um",l1)
```

Scilab code Exa 7.6 6

```
//Example 7.6, Page Number 329
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
//Depletion region thickness
clc;

//Taking Silicon Diode with moderately doped N-
    region
V=100 //Applied Voltage in volts
Nd=5*(10**21) //in per metre cube
```

```
eo=8.85*(10**-12) //Absolute permittivity in farads
    per meter
er=11.7
e=1.6*(10**-19) //Charge of an electron in Coulombs

//Using equation 7.31
xn=sqrt((2*eo*er*V)/(e*Nd))

ac=10**5 //Absorption Coefficient per meter

//ignoring Fresnel reflection
f=1-exp(-1*xn*ac)
f=fpround(f,3)

disp(xn,"The Depletion region thickness in m:")
mprintf(" The Fraction of the incident radiation
    absorbed is: %.1f",f)

//This is insufficient if a high efficiency
    photodiode is required
//To absorb 80% of radiation,depletion region
    thickness has to be 20um wide
xn=xn*(10**6)//This conversion is done to get the xn
     value as 5 which is used in the calculation of
    V1
t=20
V1=V*((t/int(xn))**2)
mprintf("\nHence the required applied voltage is:%d
    V",V1)
```

Scilab code Exa 7.7 7

```
//Example 7.7, Page Number 334
//Response time of photodiode
clc;
```

```
it=2*(10**-6) //I−region thickness in metres
A=(100*(10**-6))*(100*(10**-6)) //Given Area in
    metres
lr=50 //Load resistor in ohms
v=10**5 //Saturation Velocity in Metre/second
er=12 //relative permittivity of InGaAs
k=8.85*(10**-12) //Absolute permittivity in farads
    per meter

t=it/v //Transit Velocity of electrons in m/s

//From equation 7.34
cj=(A*k*er)/it //cj is the device capacitance in
    farads

trc=cj*lr //in seconds

total=sqrt((t**2)+(trc**2)) //total is the total
    response time
mprintf("The Device Capacitance is:%0.1e F\n",cj)
mprintf(" The Total response time for the detector
    is:%.2e s",total)
```

Scilab code Exa 7.8 8

```
//Example 7.8, Page Number 334
//Diffusion time of carrier
clc;

t=5*(10**-6) //Thickness of the layer in metres
Dc=3.4*(10**-3) //Dc is the Minority diffusion
    coefficient in metre square per second

//From equation 7.37
```

```
td=(t**2)/(2*Dc) //td is the diffusion time in
    seconds

mprintf("The Time taken for the excess carriers to
    diffuse is:%.1e s",td)
```

Chapter 8

Fiber Optical Waveguides

Scilab code Exa 8.1 1

```
//Example 8.1, Page Number 364
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
//Field Decay Factor Calculation
clc;
clear all;

n1=1.5 //Refraction index of glass/air interface
n2=1 //Refraction index of air

c1=1*2*3.14*n2
a=60//given
d=(a*(%pi/180))
a1=(sin(d))**2  //By equation 8.8
a2=(n1/n2)**2
a3=(a1*a2)-1
a4=sqrt(a3)
a5=a4*c1

//assuming wavelength = field distance
F=exp(-1*a5) //F is the field decay factor
```

```
disp(F,"The Field Decay factor at 60 degrees is:")

//at theta1=42 degrees
c1=1*2*3.14*n2
//disp(c1)
a=42//given
d=a*(%pi/180)
b1=(sin(d))**2 //By equation 8.8
b2=(n1/n2)**2
b3=(b1*b2)-1
b4=sqrt(b3)
c4=b4*c1

//assuming wavelength = field distance
F1=exp(-1*c4)//F1 is the field decay factor at 42 degrees
F1=fpround(F1,3)

disp(F1," The Field Decay factor at 42 degrees is:")
```

Scilab code Exa 8.2 2

```
//Example 8.2, Page Number 369
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Number of modes in a planar dielectic guide
clc;

w=100*(10**-6) //Thickness in meter
n1=1.48//refractive index
n2=1.46//refractive index
l=1*(10**-6) //Wavelength of light in meters

V=((%pi*w)/l)*sqrt((n1**2)-(n2**2))
V1=(2*V)/%pi
```

```
mprintf("The value of V is:%.2f\n",V)

//from equation 8.15
N=2*(1+int(V1)) //N is the total number of possible modes
N=fpround(N,0)
mprintf(" The Total number of possible modes is:%d",N)
```

Scilab code Exa 8.3 3

```
//Example 8.3, Page Number 370
//Single mode guide dimensions
clc;

n1=1.48//refractive index
n2=1.46//refractive index
l=1*(10**-6) //Wavelength in meter

//from equation 8.16

d=l*(1/(2*sqrt((n1**2)-(n2**2))))

disp("meters",d,"The Waveguide core thickness must be less than")
```

Scilab code Exa 8.4 4

```
//Example 8.4, Page Number 375
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Number of modes in a fiber
clc;
```

```
n1=1.48//refractive index
n2=1.46//refractive index
l=0.9*(10**-6) //Wavelength in meters
r=100*(10**-6) //Core radius in meter

V=(2*%pi*r*sqrt((n1**2)-(n2**2)))/l
V=fpround(V,1)
N=(V**2)/2 //N is the Number of Modes
N=fpround(N,1)
mprintf("The Value of V is:%.1f\n",V)
mprintf(" The Number of Modes able to propagate is:%.1f",N)

//The difference arising is due to approximation
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 8.5 `Page Number 377`

```
//Example 8.5, Page Number 377
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
clc;

n1=1.48
n2=1.46
no=1

theta=asin(n2/n1)
theta=theta*(180/%pi)

//Using equation 8.22
delta=((n1**2)-(n2**2))/(2*(n1**2))
```

```
delta=fpround(delta,4)

//Using expression 8.22a
deltaa=(n1-n2)/n1
deltaa=fpround(deltaa,4)

NA=sqrt((n1**2)-(n2**2))
NA=fpround(NA,3)

a=asin(NA) //a is a fiber parameter
a=a*(180/%pi)
a=fpround(a,2)

mprintf("The Delta Parameter is:%.4f\n",delta)
mprintf(" The Approximated Delta Parameter is:%.4f\n
   ",deltaa)
mprintf(" The Numerical aperture is:%.3f\n",NA)
mprintf(" The Value of Alpha Max is:%d degrees",a)
```

Scilab code Exa 8.6 6

```
//Example 8.6, Page Number 380
//Intermodal Dispersion in step index fibers
clc;

n1=1.48//refractive index
n2=1.46//refractive index
L=1*(10**3) //Length of Fiber in kilometer
c=3*(10**8) //Speed of Light in meters per second

//Using equation 8.24
td=((L*n1)/(c*n2))*(n1-n2) //t is the time
   difference due tp intermodal dispersion
disp(td,"The Time difference due to Intermodal
   dispersion in s is:")
```

Scilab code Exa 8.7 7

```
//Example 8.7, Page Number 383
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
//Intermodal Dispersion
clc;

n1=1.48//refractive index
n2=1.46//refractive index
l=10**3 //Length of the Fiber in kilometer
c=3*(10**8) //Speed of light meters per second

delta=((n1**2)-(n2**2))/(2*(n1**2)) //delta is one
   of the fiber parameter
delta=fpround(delta,4)

//Using Equation 8.26
t=(l*n1*(delta**2))/(c*8) //t is the minimum pulse
   broadening

mprintf("The Delta Paramter is:%.4f\n",delta)
mprintf(" The Minimum Pulse Broadening is %.2e s",t)
```

Scilab code Exa 8.8 8

```
//Example 8.8, Page Number 387
//Single Mode Fiber in graded index fibers
clc;

n1=1.48//refractive index
```

```
n2=1.46//refractive index
NA=0.242//numerical aperture
l=1.5*(10**-6) //Wavelength of radiation in meters

//From equation 8.27
a=(2.405*l)/(2*%pi*NA) // a is the maximum core
    radius in meters

disp(a,"The Maximum Core Radius is less than(in
    meters)")

//With NA=0.1
NA=0.1
a=(2.405*l)/(2*%pi*NA) //a is the maximum core
    radius in meters

disp(a," The Maximum Core radius increase in m:")
mprintf(" With a design criterion of V=2 the core
    diameter would then be 9.5 um")
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 8.9 Page Number 387

```
//Example 8.9, Page Number 387
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
clc;

V=2

//From equation 8.29a
w=0.65+(1.619*(V**(-1.5)))+(2.879*(V**-6))
w=fpround(w,3)
```

```
mprintf("The Mode Field Irradiance Diameter is:%.3f"
    ,w)

//The answer provided in the textbook is wrong
```

Scilab code Exa 8.10 10

```
//Example 8.10, Page Number 390
//Material dispersion for a laser and LED source
clc;
clf();
//Fig 8.26 Page No 390
X=[0.5,0.75,1,1.25,1.4,1.5,1.75,2,2.5]//Values as
    observed from graph
V=[0.07,0.04,0.02,0.0,-0.01,-0.02,-0.03,-0.04,-0.06]
    //Values as observed from graph
plot(X,V);
xlabel("Wavelength (um)")
ylabel("D (Dimensionless Quantity)")
title("Fig 8.26")

l=10.0**3 //length of the fiber in kilometer
w1=850.0*(10**-9) //Wavelength in meter
lw=50.0*(10**-9) //Linewidth in meter
w2=1550.0*(10**-9) //Wavelength 2 in meter
lw2=3.0*(10**-9) //Linewidth 2 in meter
c=3.0*(10**8) //Speed of light in meters per second


mprintf(" The Dimensionless Quantity is calculated
    from Figure 8.26\n")
d1=2.14*(10**-2) //For w1 after observation
d2=-1.02*(10**-2) //For w2 after observation

//From equation 8.34
```

```
t1=(l/c)*d1*(lw/w1) //t1 is the material dispersion
   effects for w1
t2=(l/c)*d2*(lw2/w2) //t2 is the material dispersion
    effects for w2

mprintf(" (a) The Material Dispersion Effect
   Parameter for the LED is %.1e s\n",t1)
mprintf(" (b) The Material Dispersion Effect
   Parameter for the Laser is %.1e s",-1*t2)
```

Scilab code Exa 8.11 11

```
//Example 8.11, Page Number 396
//The Function fpround(dependency) is used to round
   a floating point number x to n decimal places
//Rayleigh scattering loss
clc;

l=1*(10**-6) //Wavelength in meter
l1=10**3 //Length of the Fiber in kilometer
n=1.45 //Refractive Index
p=0.286
B=7*(10**-11) //in meter square per Newton
T=1400 //in kelvin
k=1.38*(10**-23) //Boltzman Constant in meter square
    kilogram per second square Kelvin

//From equation 8.38
ar=((8*(%pi**3))/(3*(l**4)))*((n**8)*B*T*k*(p**2))
      //ar is the attenuation due to Rayleigh
   scattering per meter
ar=fpround(ar,6)
mprintf("The Attenuation due to Rayleigh scattering
   in a silica fiber is %.2e /m\n",ar)

```

```
i1=(ar*-1*l1)
j=exp(i1)
L=-10*log10(j) //L is the given loss generated from attenuation in dB
L=fpround(L,5)
mprintf(" The Total loss due to Attenuation is %.2f db/km\n",L)

//at a wavelength of 1.55 micro meter
l=1.55*(10**-6) //new Wavelength in meters

ar=((8*(%pi**3))/(3*(l**4)))*((n**8)*B*T*k*(p**2)) //ar is the attenuation due to Rayleigh scattering per meter
ar=fpround(ar,6)
mprintf(" The Attenuation due to Rayleigh scattering in a silica fiber is %.1e /m\n",ar)

L=-10*log10(exp(ar*-1*l1))    //L is the given loss generated from attenuation in dB
L=fpround(L,2)
mprintf(" The Total loss due to Attenuation is %.2f db/km",L)
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 8.12 `Page Number 398`

```
//Example 8.12, Page Number 398
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
clc;

n=1.48//Refractive index of fiber
```

```
n0=1//Refractive index between the fibers in air

//From equation 8.39
Rf=(((n-1)/(n+1))**2) //Rf is the fraction of light
Rf=fpround(Rf,4)

Tf=((1-Rf)**2)  //Tf is the total transmission for each face due to Fresnel reflection
Tf=fpround(Tf,4)

L=-10*log10(Tf) //L is the Transmission Loss
L=fpround(L,2)

mprintf("The Fraction of light reflected back at each end is %.4f\n",Rf)
mprintf(" The Total Transmission for each face due to Fresnel Reflection is %.3f\n",Tf)
mprintf(" The Total Transmission loss is %.2f db",L)
```

Scilab code Exa 8.13 13

```
//Example 8.13, Page Number 399
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Transmission loss from lateral misalignment
clc;

l=0.1 //where l=D/2a and occurs due to lateral misalignment where D is the lateral displacement and a is the fiber core radius

//From equation 8.40
T=(2/%pi)*(acos(l)-l*(sqrt(1-(l**2))))
L=-10*log10(T) //L is the Transmission loss in dB
L=fpround(L,2)
```

```
mprintf("The Total Transmission loss is %.2f dB\n",L)

//Including Fresnel loss from the previous example
LT=L+0.33
mprintf(" The Total Transmission loss including Fresnel loss is %.2f dB",LT)
```

Scilab code Exa 8.14 14

```
//Example 8.14, Page Number 404
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Fiber Couple Losses
clc;

d1=200*(10**-6) //Core Diameter in meters
d2=250*(10**-6) //Core + Cladding Diameter in meters

d3=3*d2//Mixing rod diameter in meters

//Power Levels P1=(B*3.14*(3d2**2))/4 & P2=(B*3.14*(d1**2)/)/4

//From equation 8.41
L=-10*log10((d1**2)/(d3**2)) //L is the Insertion Loss in dB
Le=-10*log10((7*(d1**2))/(d3**2)) //Le is the Excess loss in dB
L=fpround(L,1)
Le=fpround(Le,2)
mprintf("The Insertion loss is %.1f dB\n",L)
mprintf(" The Excess Loss is %d dB",Le)
```

Chapter 9

Optical Communication Systems

Scilab code Exa 9.1 1

```
//Example 9.1, Page Number 449
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
//Signal to Noise Ratio Calculation
clc;
//For Given P-I-N Diode
q=0.6 //Quantam Efficiency
l=1.3*(10**-6) //Wavelength in Meters
i=3*(10**-9) //Reverse Bias Leakage Current in
    Ampere
r=50 //Resistance in Ohm
b=500*(10**6) //Bandwidth in Hertz
P=10*(10**-6) //Optical Power in Watt
e=1.6*(10**-19) //Charge of an Electron in Coulombs
h=6.6*(10**-34) //Plancks Constant in meter square
    kilogram per second
c=3*(10**8)  //Speed Of Light in meters per second
k=1.38*(10**-23) //Boltzmann Constant in meter
    square kilogram per second square Kelvin
```

```
c1=1*(10**-12) //Assumed Capacitance in Farad

ip=(q*P*e*l)/(h*c)  //i is the Photogenerated current in Amperes
disp(ip,"The Photogenereated Current in A is:");

itotal=sqrt(2*(i+ip)*e*b) //itotal is the Total Shot Noise Current in Amperes
disp(itotal," The Total shot noise Current in A is:");

ij=sqrt(4*k*r*b*300)/r //ij is the Total Johnson Noise Current in Amperes
disp(ij," The Total Johnson Noise Current in A is:");

sn=(ip**2)/((itotal**2)+(ij**2)) //sn is the Signal to Noise Ratio in Decibel
disp(sn," The Required Signal to Noise ratio in dB is:");

rl=1/(2*%pi*c1*b) //rl is the optimum Load Resistance in ohms
rl=fpround(rl,1)
disp(rl," The Optimum Load Resistance in ohms:");

ij2=sqrt(4*k*rl*b*300)/rl
mprintf("\n The Optimum Johnson Noise Current in A is reduced to:\n\n   %.2e\n",ij2)

sn1=(ip**2)/((itotal**2)+(ij2**2))
disp(sn1," The Signal to Noise Ratio increases to:");
```

Scilab code Exa 9.2 2

```
//Example 9.2, Page Number 462
//Flux budget
clc;

to=0//The Transmitter Output in dBm
rs=-50//The Receiver Sensitivity in dBm
rm=50//The Required Margin in dBm

//System Loss
f=30//Fiber loss in db
d=1//Detector Coupling Loss in db
t=5//Total Splicing Loss (0.5 DB x 10) in db
h=5//Headroom for Temperature range,ageing effects &
    Future Splices in db
t=f+d+t+h  //The total power attenuation
p=50-t

mprintf("The total attenuation is:%d dB",t)
mprintf("\nHence the excess power margin is 50 - %d
    =%d dB\n",t,p);
```

check Appendix AP 1 for dependency:

`fpround.sci`

Scilab code Exa 9.3 Page Number 474

```
//Example 9.3, Page Number 474
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
clc;
n1=2.286 //The Ordinary Refractive Index
d=6*(10**-3) //Refractive Index Change
n2=n1-d //Difference of the Two

NA=sqrt((n1**2)-(n2**2))
```

```
first=1/(4*NA)
first=fpround(first,2)

second=3/(4*NA)
second=fpround(second,2)

mprintf("The Requirement for Single Mode Behaviour
    becomes:\n");
mprintf("\t%0.2f <= d/lambda <= %0.2f",first,second)
    ;//d=5*Lambda for suitable thickness design

//The answer provided in the textbook for the higher
     region is wrong
```

Chapter 10

Non Communication Applications Of Fibers

Scilab code Exa 10.1 1

```
//Example 10.1, Page Number 497
//Sensor Periodicity
clc;
d=50*(10**-6) //Core Diameter in meters
n2=1.48 //Core refractive index
n1=1.46 //Cladding refractive index
a=d/2//in meters

n=(n2-n1)/n2;

delta=(2*%pi*a)/(sqrt(2*n)); //delta is the
   microbending sensor periodicity
disp(delta,"The Microbending Sensor Periodicity in m
    is:");
```

Scilab code Exa 10.2 2

```
//Example 10.2, Page Number 498
//Sensitivity Calculation
clc;
a=5*(10**-7) //Thermal expansion Coefficient per Kelvin
b=6.8*(10**-6) //Thermal Expansion Coefficient per Kelvin
l=1.55*(10**-6) //Wavelength in meter
p11=0.126  //Constant Coeffiecient
p12=0.274  //Constant Coeffiecient
u=0.17
n=1.46//cladding refractive index

dl=l*(a+b); // dl is the wavelength sensitivity to temp. changes
disp(dl,"The Wavelength Sensitivity to temperature changes of the filter structure in nm/K is:");

pe=((n**2)/2)*(((1-u)*p12)-(u*p11));  //pe is the effective photoelastic coefficient
disp(pe," The Effective Photoelastic Coefficient is:");

dl=l*(1-pe)
disp(dl," As far as Strain is concerned the Sensitivity in m/   is:");
```

Scilab code Exa 10.3 3

```
//Example 10.3, Page Number 502
//The Function fpround(dependency) is used to round a floating point number x to n decimal places
//Raman Scattering Sensor Temperature Sensitivity
clc;
v=1.5*(10**13) //Raman shift of silcia in terms of
```

```
Hertz
T=(273+50) //Temperature in terms of Kelvin
d=1 //Fractional change in r in terms of per degree
k=1.38*(10**-23) //Boltzman Constant in meter square
    kilogram per second square Kelvin
h=6.6*(10**-34) //Plancks Constant in meter square
    kilogram per second

dr=(h*v)/(k*(T**2))  //dr is the fractional change
    of temperature sensitivity of Raman sensor
dr=dr*100
dr=fpround(dr,1)
mprintf("The Fractional Change of Temperature
    Sensitivity of Raman Scattering Sensor is %0.1f
    percent per degree celsius",dr)
```

Scilab code Exa 10.4 4

```
//Example 10.4, Page Number 509
//The Function fpround(dependency) is used to round
    a floating point number x to n decimal places
//Sagnac Gyroscope Phase Shift
clc;
n=1000 //Turns on the Fibre
r=0.1 //Radius in meter
r2=15 //Earth's rotation rate per hour
c=3*(10**8) //Speed of light in meters per second
l=1*(10**-6) //Wavelength in meter
r1=(r2*%pi)/(180*3600) //Conversion to radian per
    second

theta=(8*%pi*n*%pi*(r**2)*r1)/(l*c) //theta is the
    phase shift
theta=fpround(theta,5)

```

```
mprintf("The Phase Shift in Sagnac Gyroscope is:%0.1
   e radian",theta);
```

Scilab code Exa 10.5 5

```
//Example 10.5, Page Number 514
//Polarization Rotation
clc;
//For Silica
V=4 //in Radian / m T
n=10 //No of turns
I=30 //Current in Ampere
ur=1 //Relative permeability
uo=4*%pi*(10**-7) //Absolute permeability

t=%pi/180
thetar=uo*n*V*I*t //thetar is the polarization
   rotation

mprintf("The Amount of Polarization rotation is  %f
   degree\n",thetar);
//The answer provided in the textbook is wrong
```

Appendix

Scilab code AP 1 `Function to round a floating point number x to n decimal places`

```
// Function to round a floating point number x to n
   decimal places
function [f]= fpround(x,n)
f=round(x*10^n)/10^n;
endfunction
```