Scilab Textbook Companion for Fiber Optic Communications by J. C. Palais[1]

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Book Description

Title: Fiber Optic Communications

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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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List of Scilab Codes

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Chapter 1

Fiber optic communications systems

Scilab code Exa 1.1 1

```
//fiber optic communications by joseph c. palais
//example 1.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
LP1=-11// Loss in element 1 in dB
LP2=-6// Loss in element 2 in dB
LP3=-3// Loss in element 3 in dB
//to find
total_Loss=LP1+LP2+LP3//total Loss in dB
mprintf("total Loss=%fdB",total_Loss)
input_power=5e-3// input power in Watt
output_power=input_power*10^(total_Loss/10)//output
    power in Watt
mprintf("\nOutput power=%fmW",output_power*1e3)
```

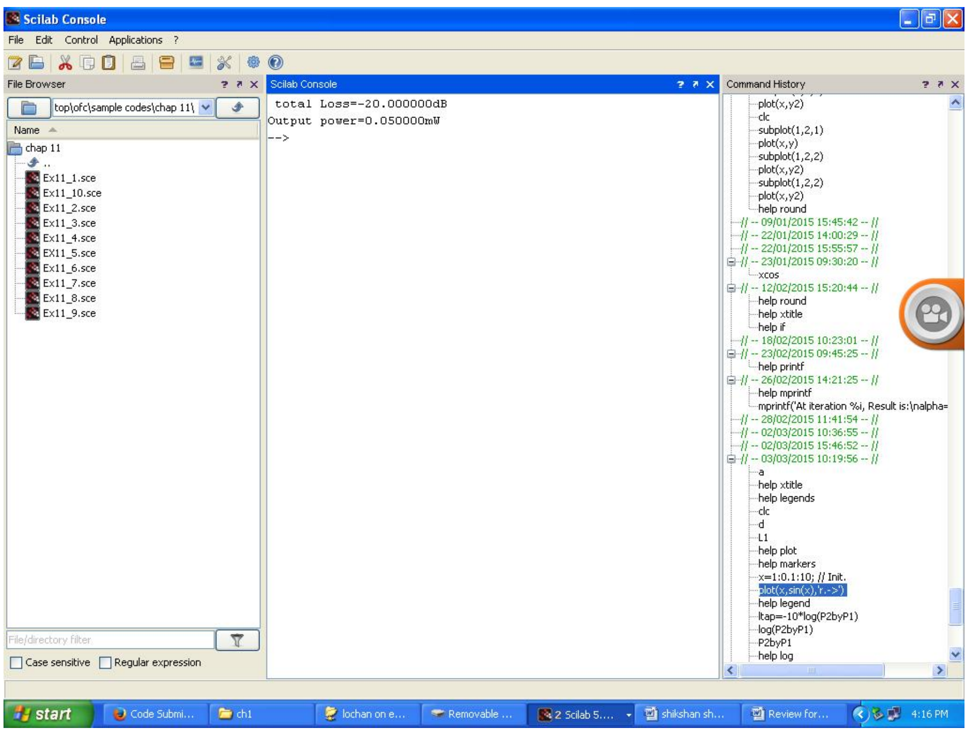

Scilab Console
File Edit Control Applications ?
File Browser
Scilab Console
Command History
total Loss=-20.000000dB
Output power=0.050000mW
-->

Figure 1.1: 1

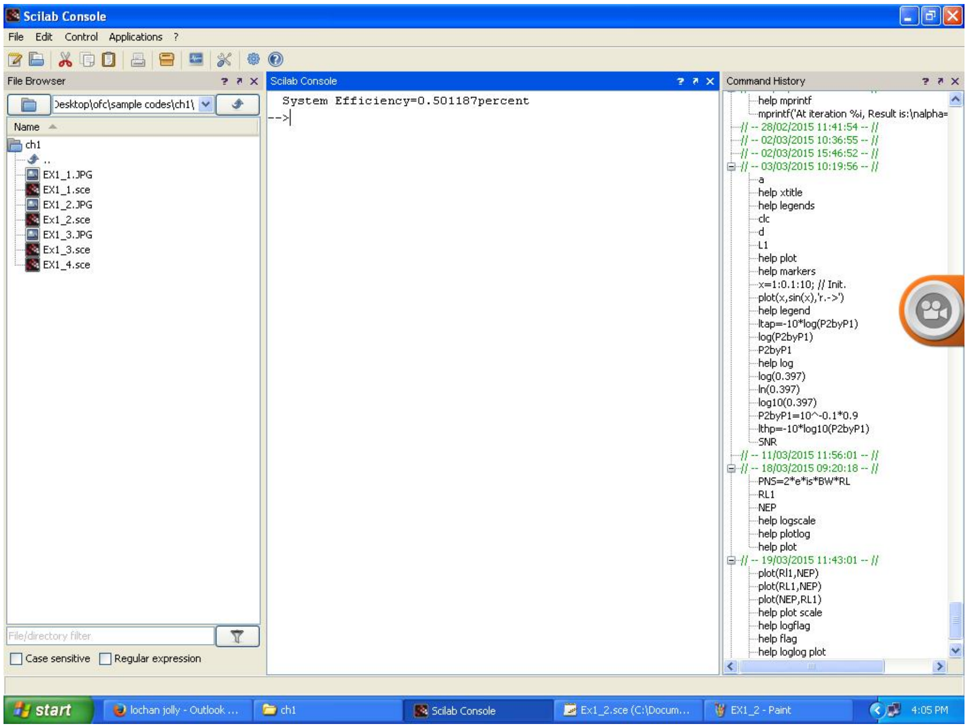


Figure 1.2: 2

Scilab code Exa 1.2 2

```
//fiber optic communications by joseph c. palais
//example 1.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given

```

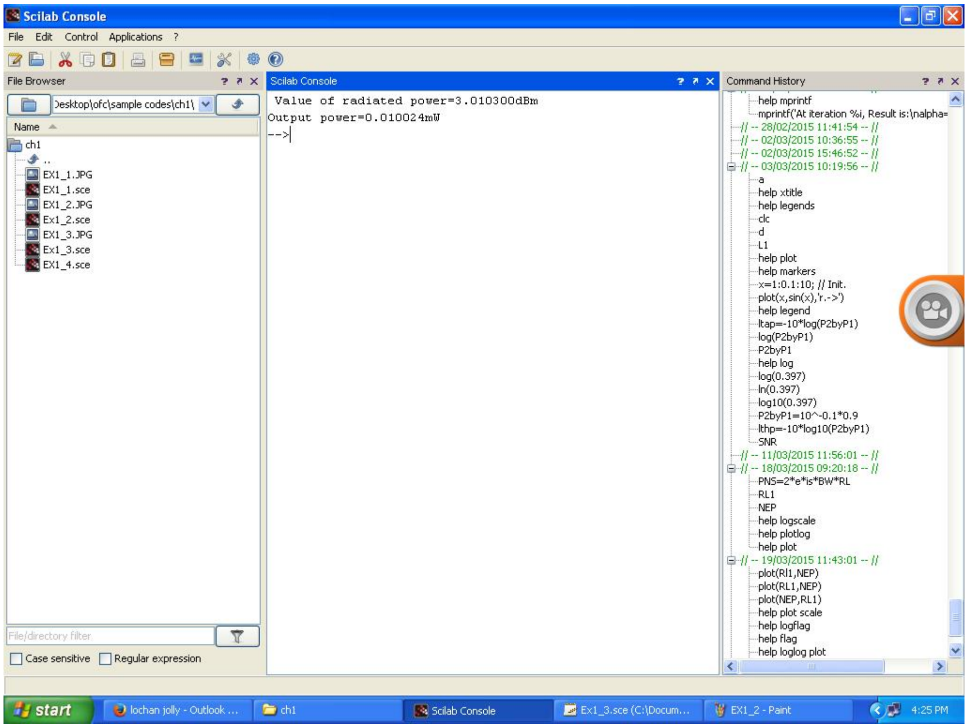


Figure 1.3: 3

```
Loss=-23// total loss in dB
//to find
P2byP1=10^(Loss/10)//P2/P1 gives efficiency
mprintf(" System Efficiency=%fpercent",P2byP1*100)
```

Scilab code Exa 1.3 3

```
//fiber optic communications by joseph c. palais
//example 1.3
//OS=Windows XP sp3
//Scilab version 5.4.1
```

```
clc
clear all
//given
total_Loss=23// total loss in components in dB
input_power=2e-3// Input power in W
//to find
Input_power_dBm=10*log10(input_power/10^-3)//
    expressing input power in dBm
output_power_dBm=Input_power_dBm-total_Loss //output
     power in dBm
output_power=10^(output_power_dBm/10)//output power
    in mW
mprintf("Value of radiated power=%fdBm",
    Input_power_dBm)
mprintf("\nOutput power=%fmW",output_power)
```

Scilab code Exa 1.4 4

```
//fiber optic communications by joseph c. palais
//example 1.4
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
h=6.626e-34// plancks constant
c=3e8// velocity of light in m/s
lambda=0.8e-6//wavelength in m
P=1e-6//input power in W
t=1// time in sec
//to find
Wp=h*c/lambda// energy of one photon
W=P*t//energy in J
```

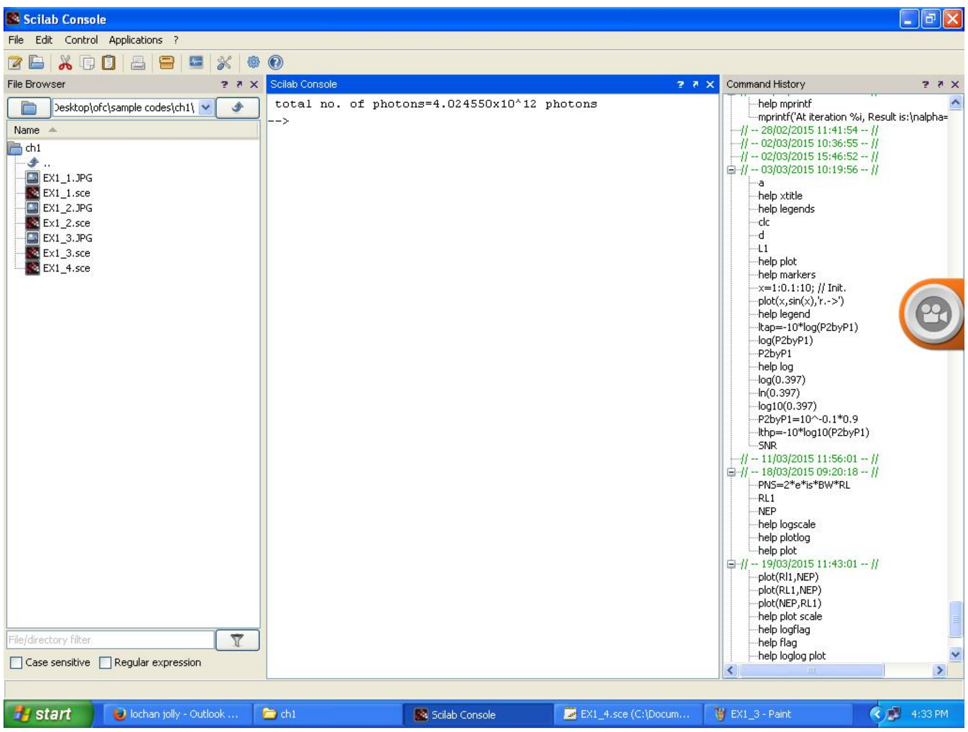

Scilab Console
File Edit Control Applications ?
File Browser
Scilab Console
Command History
total no. of photons=4.024550x10^12 photons
-->
ch1
EX1_1.JPG
EX1_1.sce
EX1_2.JPG
EX1_2.sce
EX1_3.JPG
Ex1_3.sce
EX1_4.sce
help mprintf
help plot
help log
help plot
start
4:33 PM

Figure 1.4: 4

```
n=W/Wp//no of photons
mprintf("total no. of photons=%fx10^12 photons",n
   /10^12)
```

Chapter 2

Optics Review

Scilab code Exa 2.1 1

```
//fiber optic communications by joseph c. palais
//example 2.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n1=1//refractive index of air
n2=1.5//refractive index of glass medium
theta_i_1=0//angle of incidence case 1 in degrees
theta_i_2=15//angle of incidence case 2 in degrees
//to find
theta_t_1=(asind(n1/n2*sind(theta_i_1)))//
    Tramsmission angle in degrees
mprintf("Transmission angle for %f degree incident
    angle=%fdegree",theta_i_1,theta_t_1)
theta_t_2=(asind(n1/n2*sind(theta_i_2)))
mprintf("\nTransmission angle for %f degree incident
     angle=%fdegree",theta_i_2,theta_t_2)
```

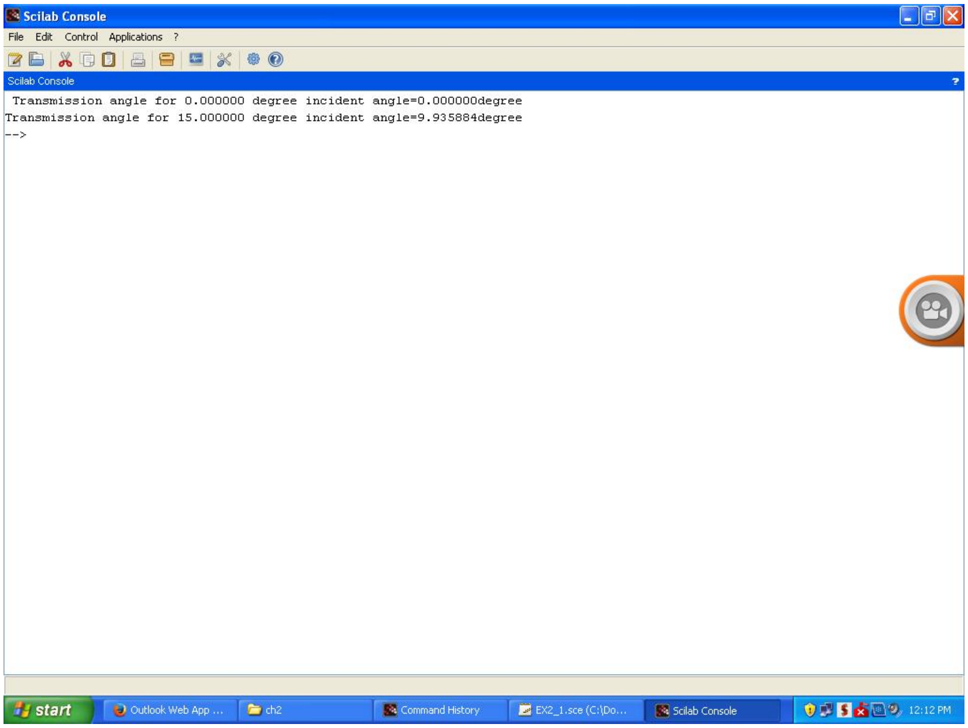


Figure 2.1: 1

Scilab code Exa 2.2 2

```
//fiber optic communications by joseph c. palais
//example 2.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
```

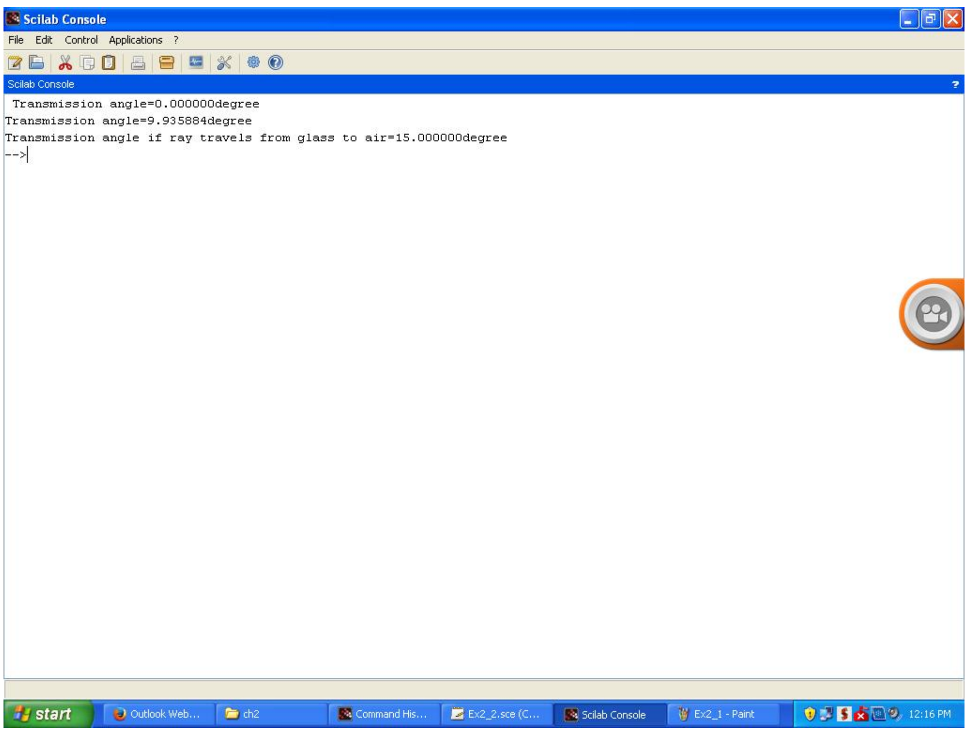

Scilab Console
File Edit Control Applications ?
Scilab Console
Transmission angle=0.000000degree
Transmission angle=9.935884degree
Transmission angle if ray travels from glass to air=15.000000degree
-->
start
Outlook Web...
ch2
Command His...
Ex2_2.sce (C...
Scilab Console
Ex2_1 - Paint
12:16 PM

Figure 2.2: 2

```
//given
n1=-1//refractive index of air
n2=1.5//refractive index of glass medium
theta_i_1=0//angle of incidence case 1 in degree
theta_i_2=15//angle of incidence case 2 in degree
//to find
theta_t_1=abs(asind(n1/n2*sind(theta_i_1)))//transmission angle in degree for case 1
mprintf("Transmission angle=%fdegree",theta_t_1)
theta_t_2=abs(asind(n1/n2*sind(theta_i_2)))
mprintf("\nTransmission angle=%fdegree",theta_t_2)//transmission angle in degree for case 2

theta_t_3=abs(asind(n2/n1*sind(theta_t_2)))// transmission angle for example 2_1 if ray travels from glass to air in degrees
mprintf("\nTransmission angle if ray travels from glass to air=%fdegree",theta_t_3)
```

Scilab code Exa 2.3 3

```
//fiber optic communications by joseph c. palais
//example 2.3
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
M=1//magnification
f=1e-3// focal length in m
do=2*f//since di=do object image distance in m
mprintf('object and image distance for unity magnification=%fm',do)
//to find
 for j = 1:5
```

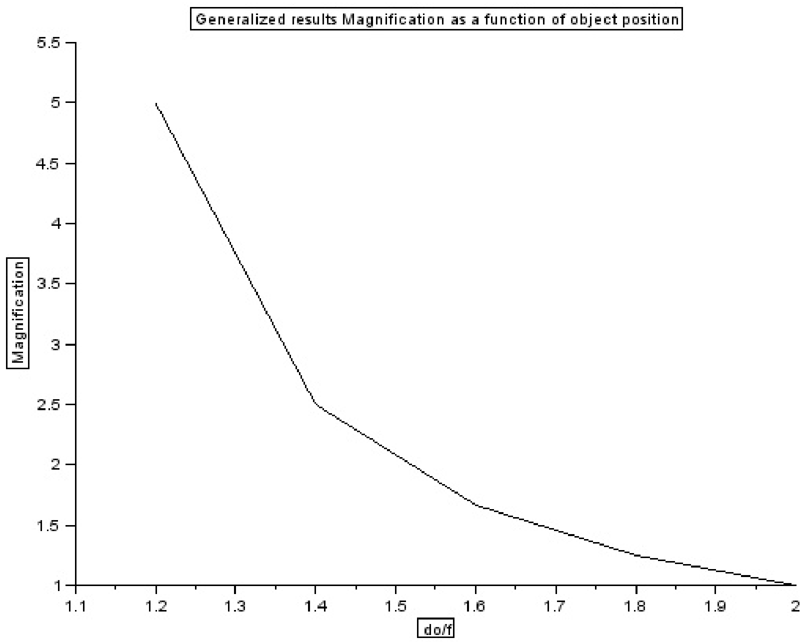


Figure 2.3: 3

```
      dobyf(j)=1+j*0.2//object image distance to focal length in m
     M(j)=1/(dobyf(j)-1)//magnification
     end;
plot2d(dobyf,M)
xtitle( 'Generalized results Magnification as a function of object position', 'do/f', 'Magnification', boxed = 1 );
```

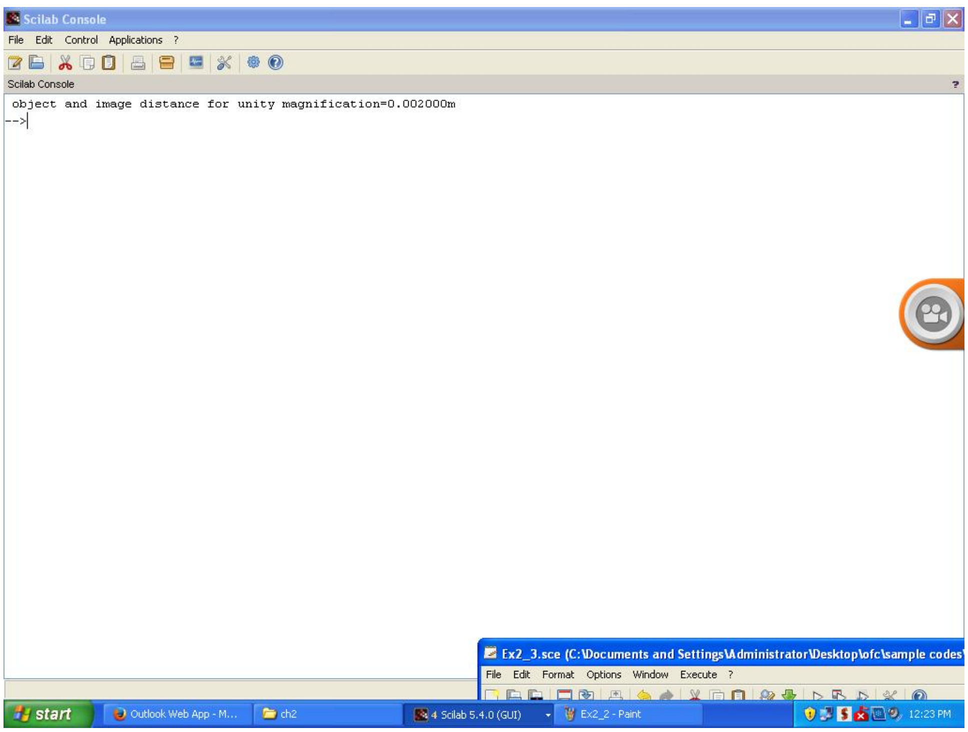

Scilab Console
File Edit Control Applications ?
Scilab Console
object and image distance for unity magnification=0.002000m
-->
Ex2_3.sce (C:\Documents and Settings\Administrator\Desktop\ofc\sample codes\
File Edit Format Options Window Execute ?
start
Outlook Web App - M...
ch2
4 Scilab 5.4.0 (GUI)
Ex2_2 - Paint
12:23 PM

Figure 2.4: 3

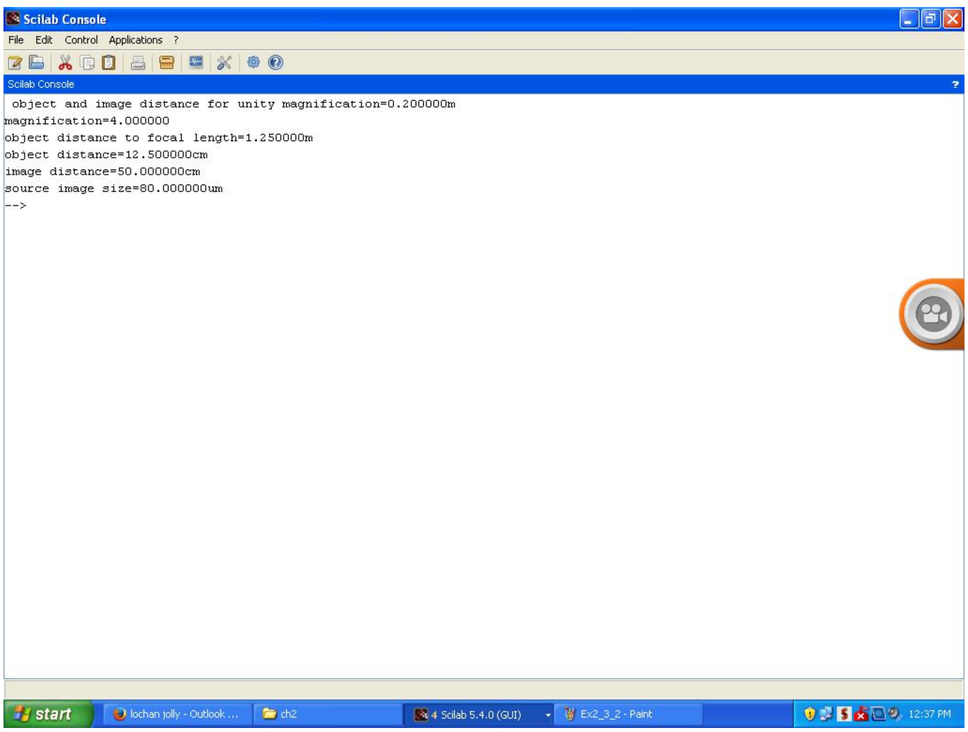

Scilab Console
File Edit Control Applications ?
Scilab Console
object and image distance for unity magnification=0.200000m
magnification=4.000000
object distance to focal length=1.250000m
object distance=12.500000cm
image distance=50.000000cm
source image size=80.000000um
-->
start
lochan jolly - Outlook ...
ch2
4 Scilab 5.4.0 (GUI)
Ex2_3_2 - Paint
12:37 PM

Figure 2.5: 4

Scilab code Exa 2.4 4

```
//fiber optic communications by joseph c. palais
//example 2.4
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
alpha0=40//source radiation cone angle (beam spread)
    in degree
alphai=10// new system source radiation cone angle (
   beam spread) in degree
f=10e-2//focal length in m
do=2*f//since di=do object image distance in m
SS=20e-6//source size in m
mprintf('object and image distance for unity
   magnification=%fm\n',do)
//to find
M=alpha0/alphai//magnification
dobyf=(1/M)+1//object distance to focal length
do=dobyf*f//object distance in m
di=M*do//image distance in m
SIS=M*SS//source image size in m
mprintf( 'magnification=%f\nobject distance to focal
    length=%fm\nobject distance=%fcm\nimage distance
   =%fcm\nsource image size=%fum',M,dobyf,do*100,di
   *100,SIS*10^6);//multiplication factors in
   results to convert it into required format
```

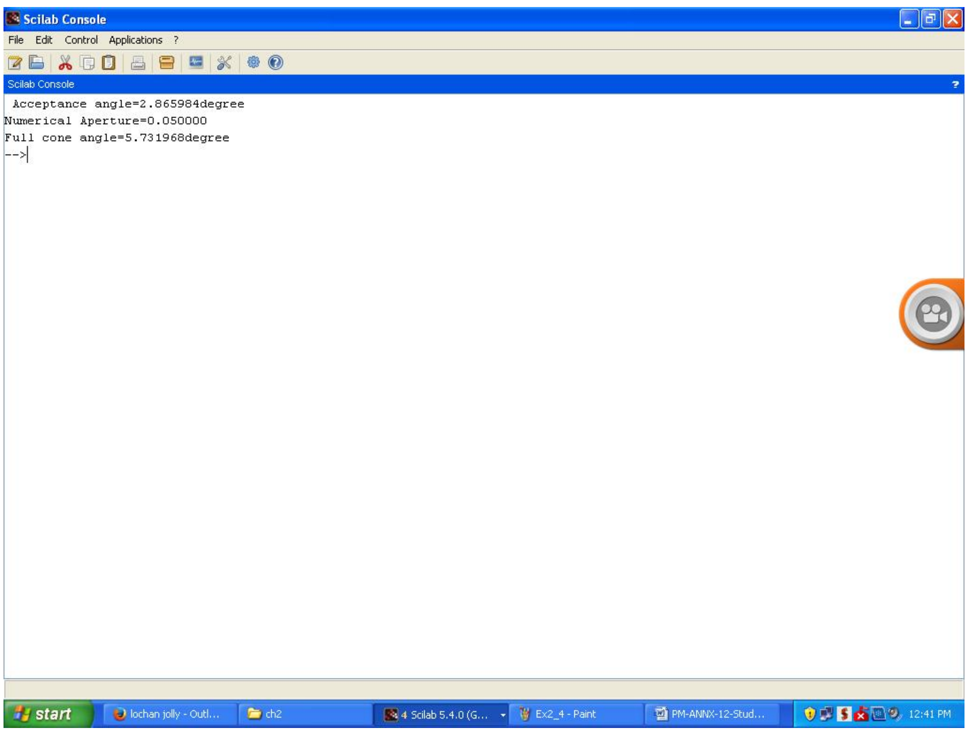

Scilab Console
File Edit Control Applications ?
Scilab Console
Acceptance angle=2.865984degree
Numerical Aperture=0.050000
Full cone angle=5.731968degree
-->

Figure 2.6: 5

Scilab code Exa 2.5 5

```
//fiber optic communications by joseph c. palais
//example 2.5
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n1=1//refractive index of air
d=1e-2//daimeter of circular photodetector in m
f=10e-2//lense focal length in m
//to find
theta=asind(d/(2*f))//acceptance angle in degrees
mprintf("Acceptance angle=%fdegree",theta)
NA=n1*(sind(theta))//numerical aperture
mprintf("\nNumerical Aperture=%f",NA)
FCA=2*theta//full cone angle
mprintf("\nFull cone angle=%fdegree",FCA)
```

Scilab code Exa 2.6 6

```
//fiber optic communications by joseph c. palais
//example 2.6
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
spotsize=1e-3//spot size
lambda=0.82e-6//wave length
d1=10//distance in m
d2=1e3//distance in m
d3=10e3//distance in m
//to find
```

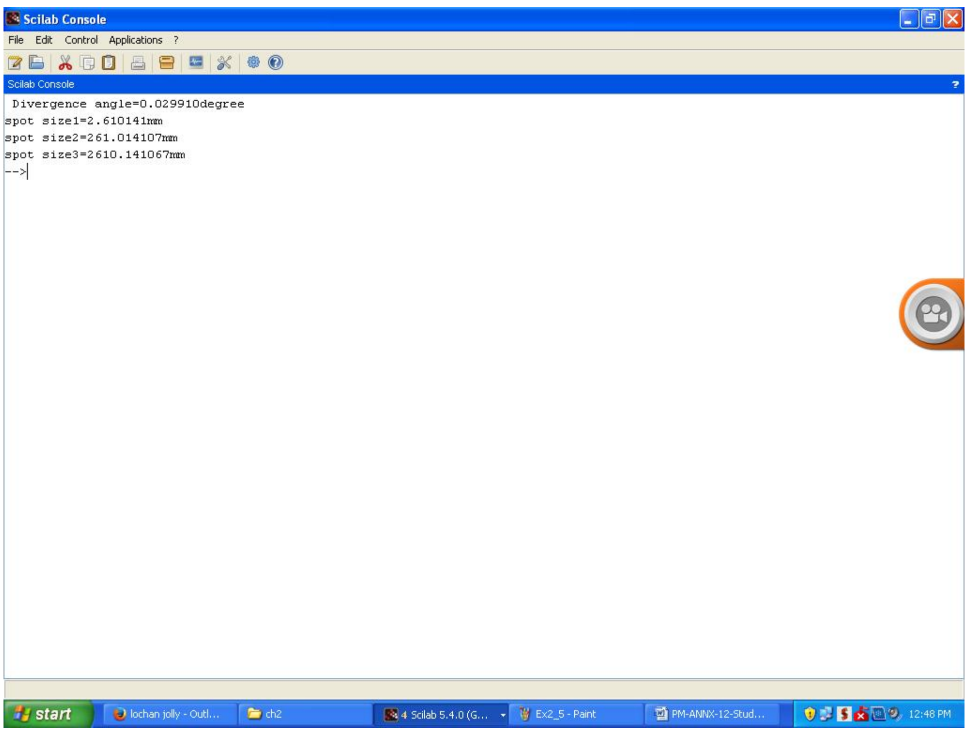

Scilab Console
File Edit Control Applications ?
Scilab Console
Divergence angle=0.029910degree
spot size1=2.610141mm
spot size2=261.014107mm
spot size3=2610.141067mm
-->

Figure 2.7: 6

```
div1=2*lambda/(%pi*spotsize)
wo1=lambda*d1/(%pi*spotsize)
wo2=lambda*d2/(%pi*spotsize)
wo3=lambda*d3/(%pi*spotsize)
disp("mm",wo1*1e3,"spot size1=","mm",wo2*1e3,"spot
    size1=","mm",wo3*1e3,"spot size1=")
```

Chapter 3

Lightwave fundamentals

Scilab code Exa 3.1 1

```
//fiber optic communications by joseph c. palais
//example 3.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
SW1=20//spectral width in nm
SW2=50//spectral width in nm
lambda1=0.82e-6//wave length in m
d=10//path length in km
lambda2=1.5e-6//wave length in m
M1=110//Material dispersion ps/(nmxKm)
M2=15//Material dispersion ps/(nmxKm)

//to find
delta_taubyL1=M1*SW1*d// pulse spreading per unit
   length in ps for lambda1
delta_taubyL2=M2*SW2*d// pulse spreading per unit
```

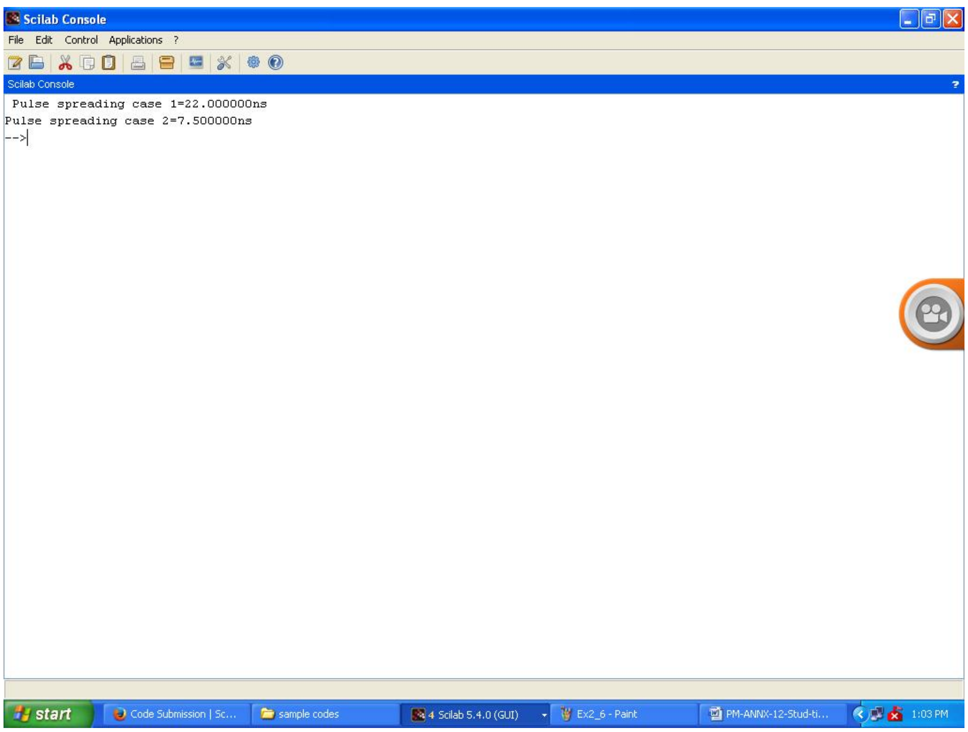

Scilab Console
File Edit Control Applications ?
Scilab Console
Pulse spreading case 1=22.000000ns
Pulse spreading case 2=7.500000ns
-->

Figure 3.1: 1

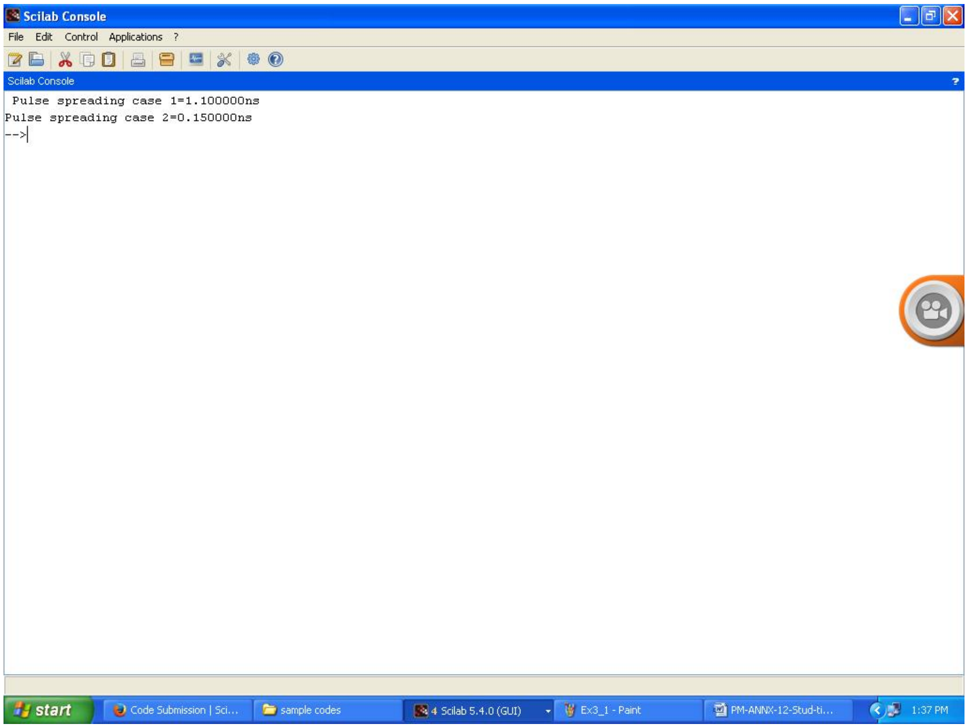


Figure 3.2: 2

```
    length in ps for lambda2
//multiplication by 1e−3 converts unit from ps to ns
mprintf("Pulse spreading case 1=%fns",delta_taubyL1
    *1e-3)
mprintf("\nPulse spreading case 2=%fns",
    delta_taubyL2*1e-3)
```

Scilab code Exa 3.2 2

```
//fiber optic communications by joseph c. palais
//example 3.2
```

```
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
SW=1//spectral width of laser in nm
lambda1=0.82e-6//wave length in m
d=10//path length in km
lambda2=1.5e-6//wave length in m
M1=110//Material dispersion ps/(nmxKm) for lambda1
M2=15//Material dispersion ps/(nmxKm) for lambda2

//to find
delta_taubyL1=M1*SW*d// pulse spreading per unit length in ps for lambda1
delta_taubyL2=M2*SW*d// pulse spreading per unit length in ps for lambda2
//multiplication by 1e-3 converts unit from ps to ns
mprintf("Pulse spreading case 1=%fns",delta_taubyL1*1e-3)
mprintf("\nPulse spreading case 2=%fns",delta_taubyL2*1e-3)
```

Scilab code Exa 3.3 3

```
//fiber optic communications by joseph c. palais
//example 3.3
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
lambda=1.55e-6*1e9//wave length in nm
```

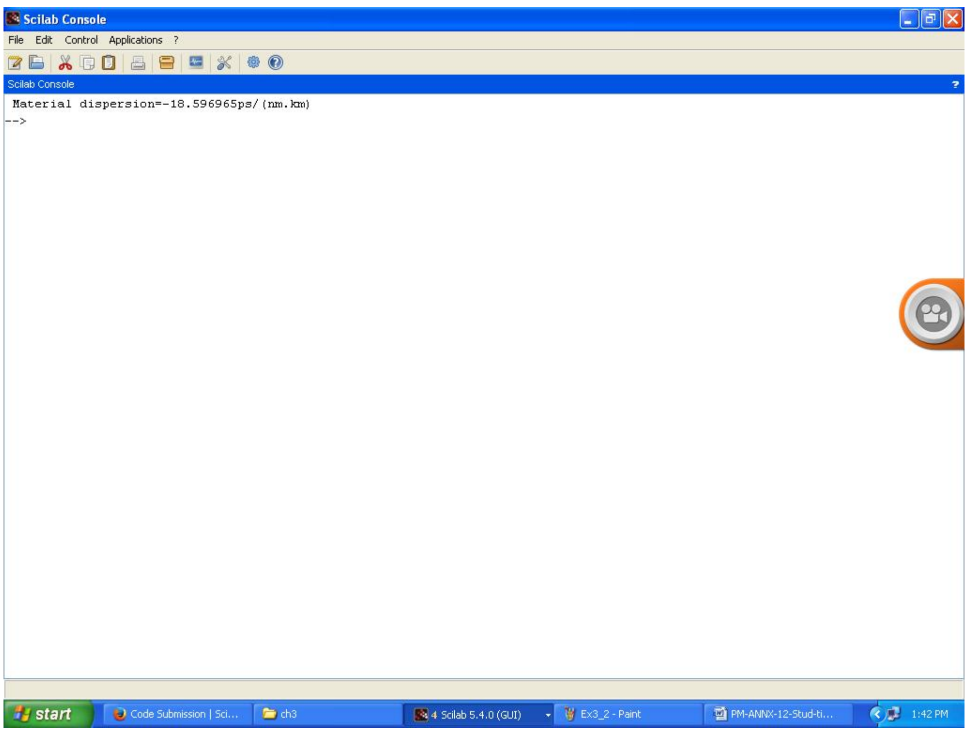

Scilab Console
File Edit Control Applications ?
Scilab Console
Material dispersion=-18.596965ps/(nm.km)
-->
start
Code Submission | Sci...
ch3
4 Scilab 5.4.0 (GUI)
Ex3_2 - Paint
PM-ANNX-12-Stud-ti...
1:42 PM

Figure 3.3: 3

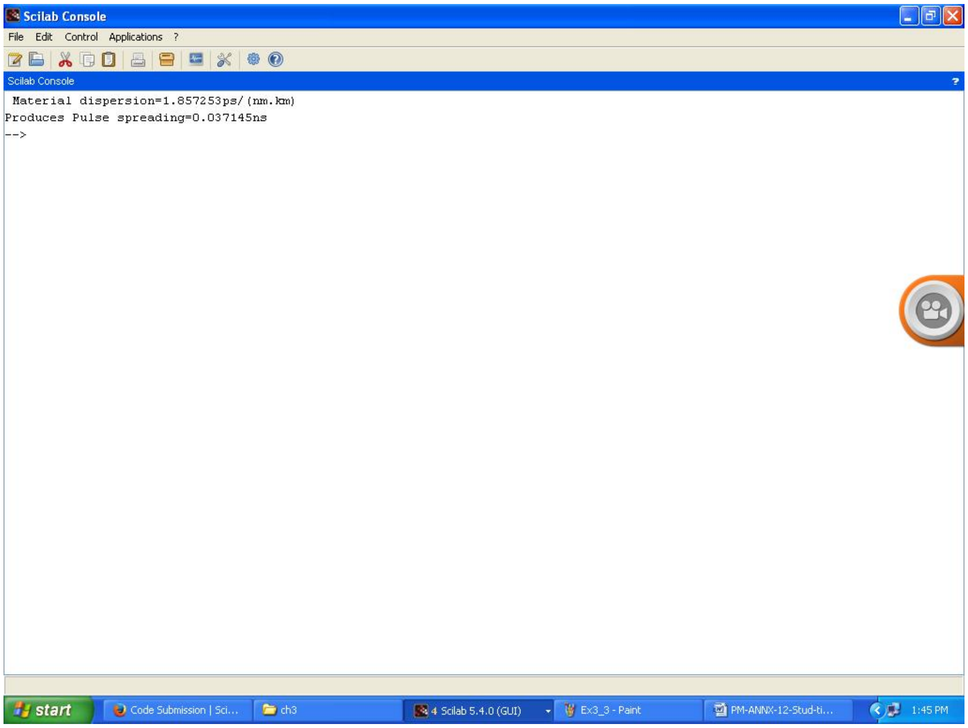


Figure 3.4: 4

```
lambda0=1.3e-6*1e9//Zero dispersion wave length in nm
M0=-0.095//slope at zero dispersion wave length ps/(nm^2xKm)

//to find
M=(M0/4)*(lambda-(lambda0)^4/(lambda)^3)//Material dispersion ps/(nmxKm)

mprintf("Material dispersion=%fps/(nm.km)",M)
```

Scilab code Exa 3.4 4

```
//fiber optic communications by joseph c. palais
//example 3.4
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
lambda=1.32e-6*1e9//wave length in nm
lambda0=1.3e-6*1e9//Zero dispersion wave length in nm
M0=-0.095//slope at zero dispersion wave length ps/(nm^2xKm)
sw=2//spectral width in nm
d=10// length of material in Km
//to find
M1=abs((M0/4)*(lambda-(lambda0)^4/(lambda)^3))//Material dispersion ps/(nmxKm)
delta_taubyL=M1*sw*d// pulse spreading per unit length in ps
mprintf("Material dispersion=%fps/(nm.km)",M1)
mprintf(" \nProduces Pulse spreading=%fns",delta_taubyL*1e-3)//multiplication by 1e-3 converts unit from ps to ns
```

Scilab code Exa 3.5 5

```
//fiber optic communications by joseph c. palais
//example 3.5
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
```

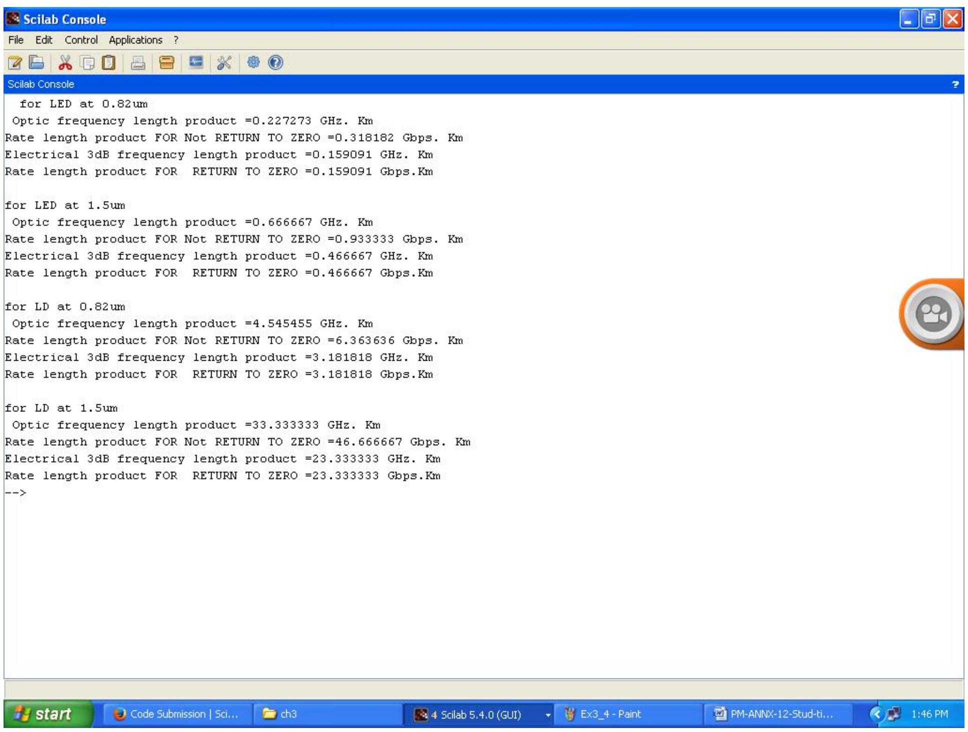

Scilab Console
File Edit Control Applications ?
Scilab Console
for LED at 0.82um
Optic frequency length product =0.227273 GHz. Km
Rate length product FOR Not RETURN TO ZERO =0.318182 Gbps. Km
Electrical 3dB frequency length product =0.159091 GHz. Km
Rate length product FOR RETURN TO ZERO =0.159091 Gbps.Km
for LED at 1.5um
Optic frequency length product =0.666667 GHz. Km
Rate length product FOR Not RETURN TO ZERO =0.933333 Gbps. Km
Electrical 3dB frequency length product =0.466667 GHz. Km
Rate length product FOR RETURN TO ZERO =0.466667 Gbps.Km
for LD at 0.82um
Optic frequency length product =4.545455 GHz. Km
Rate length product FOR Not RETURN TO ZERO =6.363636 Gbps. Km
Electrical 3dB frequency length product =3.181818 GHz. Km
Rate length product FOR RETURN TO ZERO =3.181818 Gbps.Km
for LD at 1.5um
Optic frequency length product =33.333333 GHz. Km
Rate length product FOR Not RETURN TO ZERO =46.666667 Gbps. Km
Electrical 3dB frequency length product =23.333333 GHz. Km
Rate length product FOR RETURN TO ZERO =23.333333 Gbps.Km
-->
start
Code Submission | Sci...
ch3
4 Scilab 5.4.0 (GUI)
Ex3_4 - Paint
PM-ANNX-12-Stud-ti...
1:46 PM

Figure 3.5: 5

```
clear all
//given
lambda1=0.82e-6//wave length
lambda2=1.5e-6//wave length

deta_tau_by_L1=2.2*10^-9//delta tau by L for LED at
    0.82um in ns/Km
deta_tau_by_L2=0.75*10^-9//delta tau by L for LED at
     1.5um in ns/Km
deta_tau_by_L3=0.11*10^-9//delta tau by L for LD at
    0.82um in ns/Km
deta_tau_by_L4=0.015*10^-9//delta tau by L for LD at
     1.5um in ns/Km
//to find
f3dB1=1/(2*deta_tau_by_L1)//frequency length in Hzx
    Km  for LED at 0.82um
f3dB2=1/(2*deta_tau_by_L2)//frequency length in Hzx
    Km  for LED at 1.5um
f3dB3=1/(2*deta_tau_by_L3)//frequency length in Hzx
    Km  for LD at 0.82um
f3dB4=1/(2*deta_tau_by_L4)//frequency length in Hzx
    Km  for LD at 1.5um

f3dBE1=0.35/(deta_tau_by_L1)//Electrical frequency
    length in Hzx Km  for LED at 0.82um
f3dBE2=0.35/(deta_tau_by_L2)//Electrical frequency
    length in Hzx Km  for LED at 1.5um
f3dBE3=0.35/(deta_tau_by_L3)//Electrical frequency
    length in Hzx Km  for LD at 0.82um
f3dBE4=0.35/(deta_tau_by_L4)//Electrical frequency
    length in Hzx Km  for LD at 1.5um

RRZ1=0.35/(deta_tau_by_L1)//Rate length FOR RETURN
    TO ZERO in bpsx Km  for LED at 0.82um
RRZ2=0.35/(deta_tau_by_L2)//Rate length FOR RETURN
    TO ZERO in bpsx Km  for LED at 1.5um
RRZ3=0.35/(deta_tau_by_L3)//Rate length FOR RETURN
    TO ZERO in bpsx Km  for LD at 0.82um
```

```
RRZ4=0.35/(deta_tau_by_L4)//Rate length FOR RETURN TO ZERO in bpsx Km for LD at 1.5um

NRZ1=0.7/(deta_tau_by_L1)//Rate length FOR RETURN Not TO ZERO in bpsx Km  for LED at 0.82um
NRZ2=0.7/(deta_tau_by_L2)//Rate length FOR RETURN Not TO ZERO in bpsx Km  for LED at 1.5um
NRZ3=0.7/(deta_tau_by_L3)//Rate length FOR RETURN Not TO ZERO in bpsx Km  for LD at 0.82um
NRZ4=0.7/(deta_tau_by_L4)//Rate length FOR RETURN Not TO ZERO in bpsx Km  for LD at 1.


mprintf(" for LED at 0.82um \n Optic frequency length product =%f GHz. Km \nRate length product FOR Not RETURN TO ZERO =%f Gbps. Km \nElectrical 3dB frequency length product =%f GHz. Km\nRate length product FOR  RETURN TO ZERO =%f Gbps.Km ",f3dB1/10^9,NRZ1/10^9,f3dBE1/10^9,RRZ1/10^9);
mprintf(" \n\nfor LED at 1.5um \n Optic frequency length product =%f GHz. Km \nRate length product FOR Not RETURN TO ZERO =%f Gbps. Km \nElectrical 3dB frequency length product =%f GHz. Km\nRate length product FOR  RETURN TO ZERO =%f Gbps.Km ",f3dB2/10^9,NRZ2/10^9,f3dBE2/10^9,RRZ2/10^9);
mprintf(" \n\nfor LD at 0.82um \n Optic frequency length product =%f GHz. Km \nRate length product FOR Not RETURN TO ZERO =%f Gbps. Km \nElectrical 3dB frequency length product =%f GHz. Km\nRate length product FOR  RETURN TO ZERO =%f Gbps.Km ",f3dB3/10^9,NRZ3/10^9,f3dBE3/10^9,RRZ3/10^9);
mprintf(" \n\nfor LD at 1.5um \n Optic frequency length product =%f GHz. Km \nRate length product FOR Not RETURN TO ZERO =%f Gbps. Km \nElectrical 3dB frequency length product =%f GHz. Km\nRate length product FOR  RETURN TO ZERO =%f Gbps.Km ",f3dB4/10^9,NRZ4/10^9,f3dBE4/10^9,RRZ4/10^9);
```

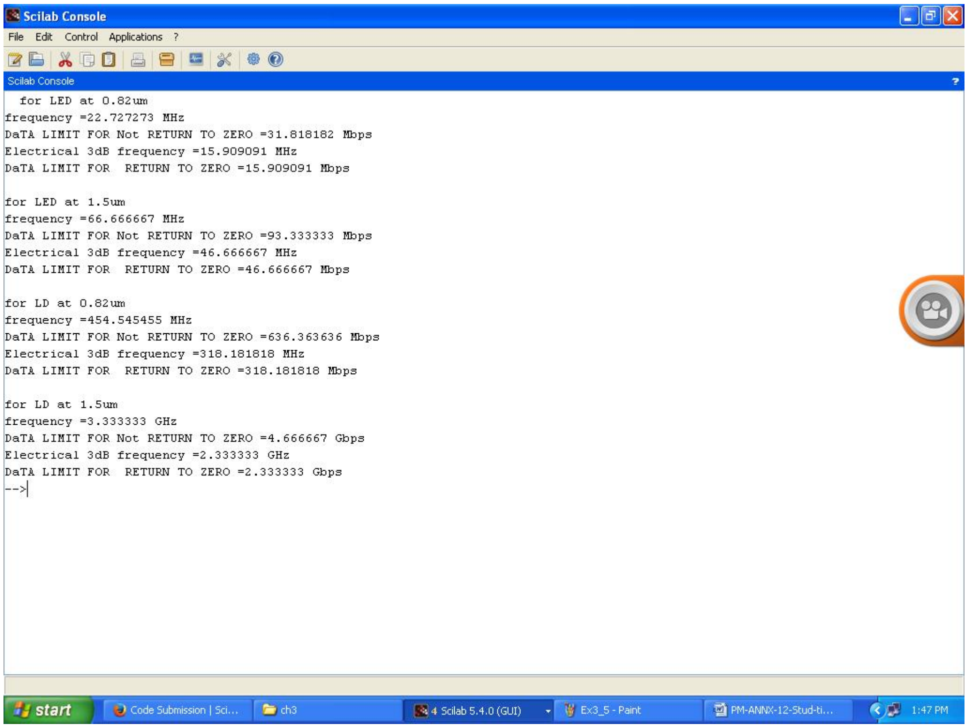


Figure 3.6: 6

Scilab code Exa 3.6 6

```
//fiber optic communications by joseph c. palais
//example 3.6
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
lambda1=0.82e-6//wave length
```

```
lambda2=1.5e-6//wave length
L=10//link length in Km
deta_tau_by_L1=2.2*10^-9//delta tau by L for LED at
    0.82um in ns/Km
deta_tau_by_L2=0.75*10^-9//delta tau by L for LED at
     1.5um in ns/Km
deta_tau_by_L3=0.11*10^-9//delta tau by L for LD at
    0.82um in ns/Km
deta_tau_by_L4=0.015*10^-9//delta tau by L for LD at
     1.5um in ns/Km
//to find
f3dB1=1/(2*L*deta_tau_by_L1)//frequency in Hz  for
    LED at 0.82um
f3dB2=1/(2*L*deta_tau_by_L2)//frequency in Hz  for
    LED at 1.5um
f3dB3=1/(2*L*deta_tau_by_L3)//frequency in Hz  for
    LD at 0.82um
f3dB4=1/(2*L*deta_tau_by_L4)//frequency in Hz  for
    LD at 1.5um

f3dBE1=0.35/(L*deta_tau_by_L1)//Electrical frequency
     in Hz  for LED at 0.82um
f3dBE2=0.35/(L*deta_tau_by_L2)//Electrical frequency
     in Hz  for LED at 1.5um
f3dBE3=0.35/(L*deta_tau_by_L3)//Electrical frequency
     in Hz  for LD at 0.82um
f3dBE4=0.35/(L*deta_tau_by_L4)//Electrical frequency
     in Hz  for LD at 1.5um

RRZ1=0.35/(L*deta_tau_by_L1)//DaTA LIMIT FOR RETURN
    TO ZERO in bps  for LED at 0.82um
RRZ2=0.35/(L*deta_tau_by_L2)//DaTA LIMIT FOR RETURN
    TO ZERO in bps  for LED at 1.5um
RRZ3=0.35/(L*deta_tau_by_L3)//DaTA LIMIT FOR RETURN
    TO ZERO in bps  for LD at 0.82um
RRZ4=0.35/(L*deta_tau_by_L4)//DaTA LIMIT FOR RETURN
    TO ZERO in bps for LD at 1.5um

```

```
NRZ1=0.7/(L*deta_tau_by_L1)//DaTA LIMIT FOR Not RETURN TO ZERO in bps  for LED at 0.82um
NRZ2=0.7/(L*deta_tau_by_L2)//DaTA LIMIT FOR Not RETURN TO ZERO in bps  for LED at 1.5um
NRZ3=0.7/(L*deta_tau_by_L3)//DaTA LIMIT FOR Not RETURN TO ZERO in bps  for LD at 0.82um
NRZ4=0.7/(L*deta_tau_by_L4)//DaTA LIMIT FOR Not RETURN TO ZERO in bps  for LD at 1.
mprintf(" for LED at 0.82um \nfrequency =%f MHz \nDaTA LIMIT FOR Not RETURN TO ZERO =%f Mbps \nElectrical 3dB frequency =%f MHz\nDaTA LIMIT FOR RETURN TO ZERO =%f Mbps ",f3dB1/10^6,NRZ1/10^6,f3dBE1/10^6,RRZ1/10^6);
mprintf(" \n\nfor LED at 1.5um \nfrequency =%f MHz \nDaTA LIMIT FOR Not RETURN TO ZERO =%f Mbps \nElectrical 3dB frequency =%f MHz\nDaTA LIMIT FOR RETURN TO ZERO =%f Mbps ",f3dB2/10^6,NRZ2/10^6,f3dBE2/10^6,RRZ2/10^6);
mprintf(" \n\nfor LD at 0.82um \nfrequency =%f MHz \nDaTA LIMIT FOR Not RETURN TO ZERO =%f Mbps \nElectrical 3dB frequency =%f MHz\nDaTA LIMIT FOR RETURN TO ZERO =%f Mbps ",f3dB3/10^6,NRZ3/10^6,f3dBE3/10^6,RRZ3/10^6)
mprintf(" \n\nfor LD at 1.5um \nfrequency =%f GHz \nDaTA LIMIT FOR Not RETURN TO ZERO =%f Gbps \nElectrical 3dB frequency =%f GHz\nDaTA LIMIT FOR RETURN TO ZERO =%f Gbps ",f3dB4/10^9,NRZ4/10^9,f3dBE4/10^9,RRZ4/10^9)
```

Scilab code Exa 3.7 7

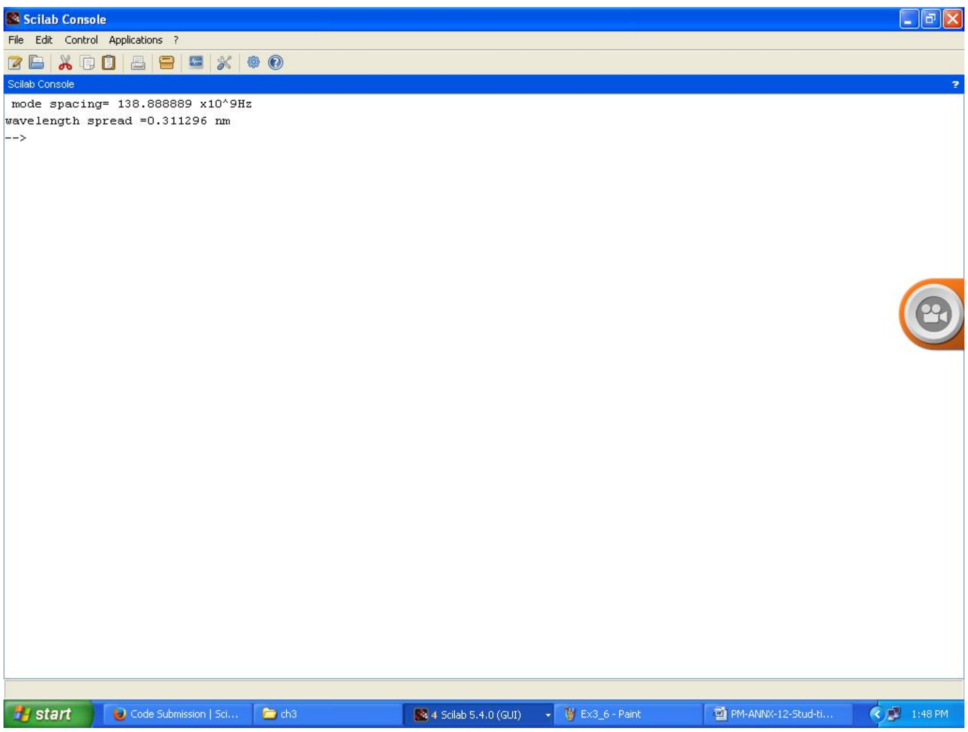

Scilab Console
File Edit Control Applications ?
Scilab Console
mode spacing= 138.888889 x10^9Hz
wavelength spread =0.311296 nm
-->
start
Code Submission | Sci...
ch3
4 Scilab 5.4.0 (GUI)
Ex3_6 - Paint
PM-ANNX-12-Stud-ti...
1:48 PM

Figure 3.7: 7

```
//fiber optic communications by joseph c. palais
//example 3.7
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
c=3*10^8//velocity of light in m/s
l=0.3*10^-3//length of cavity in m
lambda=0.82*10^-6//mean (center) wave length in m
n=3.6//refractive index of AlGaAs

//to find
delta_fc=c/(2*l*n)//mode spacing in Hz
delta_lambdac=(lambda^2)*delta_fc/c//wavelength
    spread in m

mprintf("mode spacing= %f x10^9Hz",delta_fc*10^-9)//
    for representation
mprintf("\nwavelength spread =%f nm",delta_lambdac
    *10^9)//multiplication factor 10^9 to convert m
    to nm
```

Scilab code Exa 3.8 8

```
//fiber optic communications by joseph c. palais
//example 3.8
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n=1.5//refractive index of the glass
```

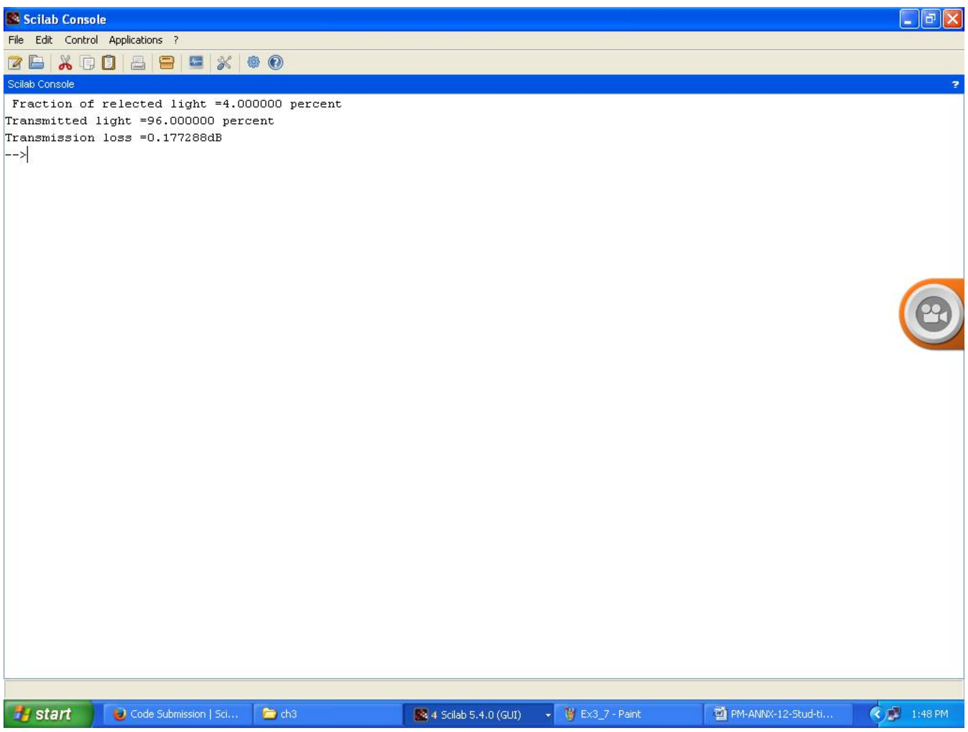

Scilab Console
File Edit Control Applications ?
Scilab Console
Fraction of relected light =4.000000 percent
Transmitted light =96.000000 percent
Transmission loss =0.177288dB
-->
start
Code Submission | Sci...
ch3
4 Scilab 5.4.0 (GUI)
Ex3_7 - Paint
PM-ANNX-12-Stud-ti...
1:48 PM

Figure 3.8: 8

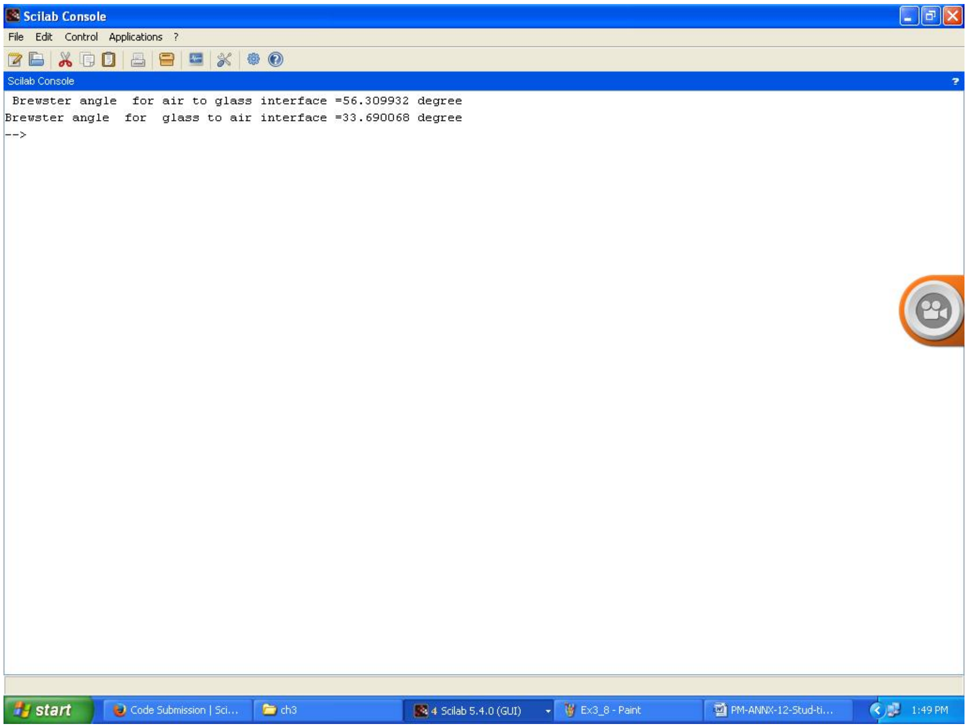


Figure 3.9: 9

```

//to find
R=((1-n)/(1+n))^2*100//Fraction of relected light in
    percent
T=100-R//Transmitted light in percent
TL=-10*log10(T/100)//Transmission loss in dB
mprintf("Fraction of relected light =%f percent",R)
mprintf("\nTransmitted light =%f percent",T)
mprintf("\nTransmission loss =%fdB",TL)
```

Scilab code Exa 3.9 9

```
//fiber optic communications by joseph c. palais
//example 3.9
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n2=1.5//refractive index of the glass
n1=1//refractive index of the air

//to find
theta_B1=atand(n2/n1)//brewster angle in degree for
    air to glass interface
theta_B2=atand(n1/n2)//brewster angle in degree for
    glass to air interface
mprintf("Brewster angle  for air to glass interface
   =%f degree",theta_B1)
mprintf("\nBrewster angle  for  glass to air
    interface =%f degree",theta_B2)
```

Scilab code Exa 3.10 10

```
//fiber optic communications by joseph c. palais
//example 3.10
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n3=1.5//refractive index of the glass
n1=1//refractive index of the air
lambda=0.8e-6//wave length in m
n4=1.38//refractive index of magnesium fluoride
```

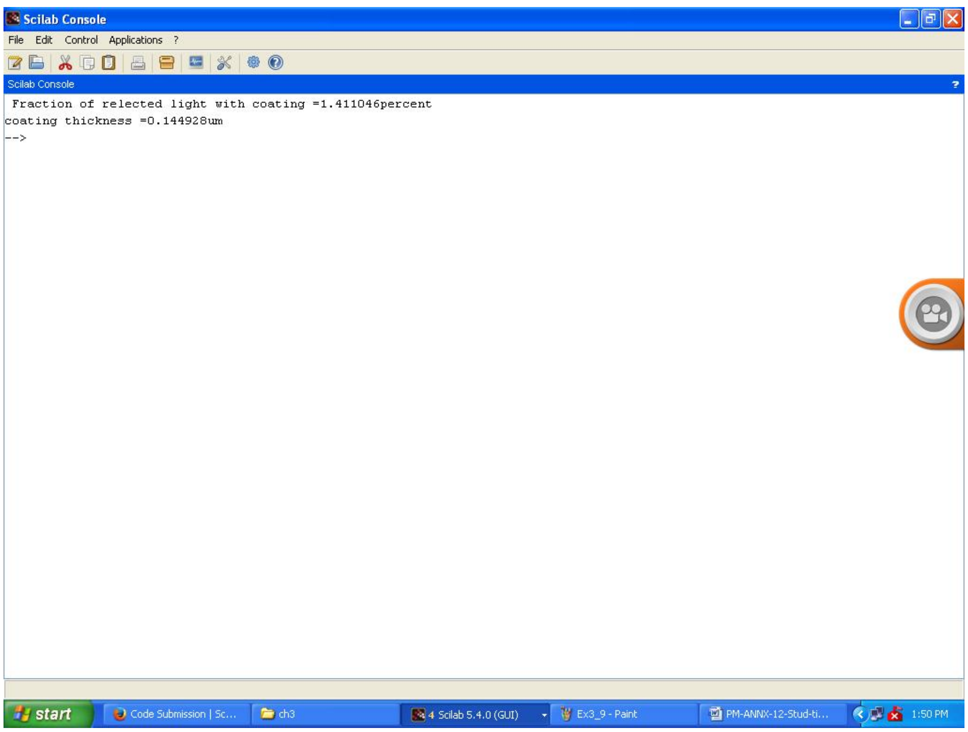


Figure 3.10: 10

```
//to find
n2=n3^0.5// index of coating layer for zero reflection
R=(n3-n4^2)^2/(n3+n4^2)^2*100//Fraction of relected light in percent
lambda_mf=lambda/n4//wavelength in magnesium flouride
t=lambda_mf/4//coating thickness in m
mprintf("Fraction of relected light with coating = %fpercent",R)
mprintf("\ncoating thickness =%fum",t*10^6)//multiplication factor 10^6 to convert unit from m to um
```

Chapter 4

Integrated Optic waveguides

Scilab code Exa 4.1 1

```
//fiber optic communications by joseph c. palais
//example 4.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
d=1.64//Daimeter of waveguide in um
lambda=0.82//wavelength in um

//to find
dbylambda=d/lambda//d by lambda ratio normalized
    thickness
neff1=3.594//for TE0 mode from figure 4.5 for
    calculated normalized thickness
theta1=86.7//for TE0 mode from figure 4.5 for
    calculated normalized thickness
neff2=3.578//for TE1 mode from figure 4.5 for
    calculated normalized thickness
```

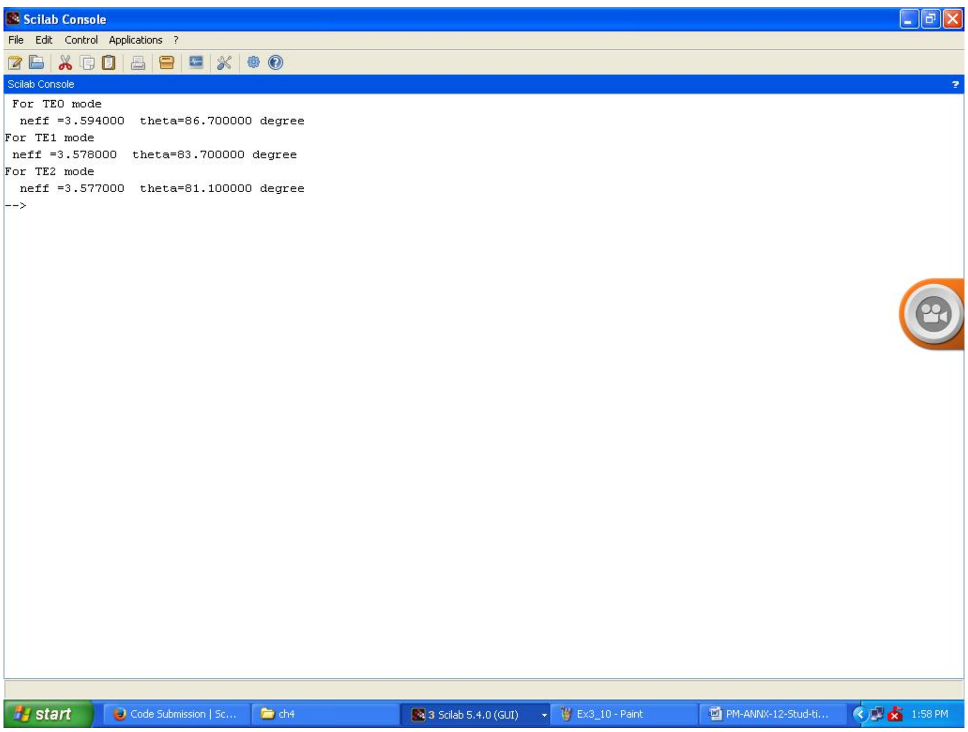

Scilab Console
File Edit Control Applications ?
Scilab Console
For TE0 mode
neff =3.594000 theta=86.700000 degree
For TE1 mode
neff =3.578000 theta=83.700000 degree
For TE2 mode
neff =3.577000 theta=81.100000 degree
-->
start
Code Submission | Sc...
ch4
3 Scilab 5.4.0 (GUI)
Ex3_10 - Paint
PM-ANNX-12-Stud-ti...
1:58 PM

Figure 4.1: 1

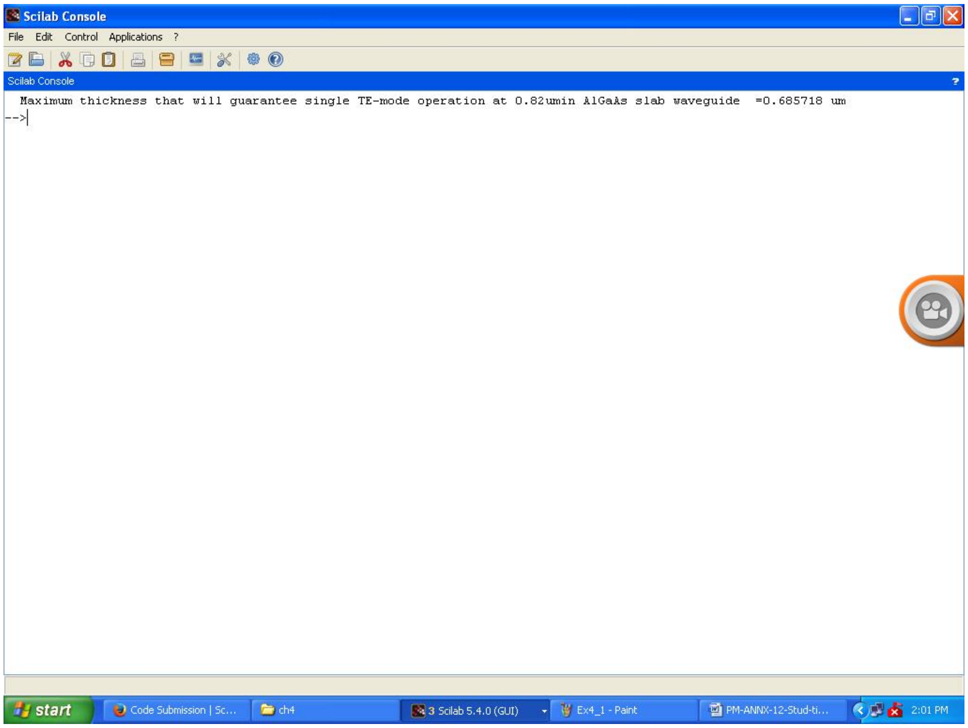


Figure 4.2: 2

```
theta2=83.7//for TE1 mode from figure 4.5 for
    calculated normalized thickness
neff3=3.577//for TE2 mode from figure 4.5 for
    calculated normalized thickness
theta3=81.1//for TE2 mode from figure 4.5 for
    calculated normalized thickness
mprintf('For TE0 mode \n  neff =%f  theta=%f degree'
    ,neff1,theta1)
mprintf(' \nFor TE1 mode \n neff =%f  theta=%f
    degree',neff2,theta2)
mprintf(' \nFor TE2 mode \n  neff =%f  theta=%f
    degree',neff3,theta3)
```

Scilab code Exa 4.2 2

```
//fiber optic communications by joseph c. palais
//example 4.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
lambda=0.82//wavelength in um
n1=3.6//refractive index of core AlGaAs slab
n2=3.55//refractive index of cladding
//to find
d=lambda/(2*sqrt(n1^2-n2^2))//Largest thickness in
   um

mprintf(' Maximum thickness that will guarantee
   single TE-mode operation at 0.82umin AlGaAs slab
   waveguide =%f um',d)
```

Scilab code Exa 4.3 3

```
//fiber optic communications by joseph c. palais
//example 4.3
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
lambda=0.82//wavelength in um
```

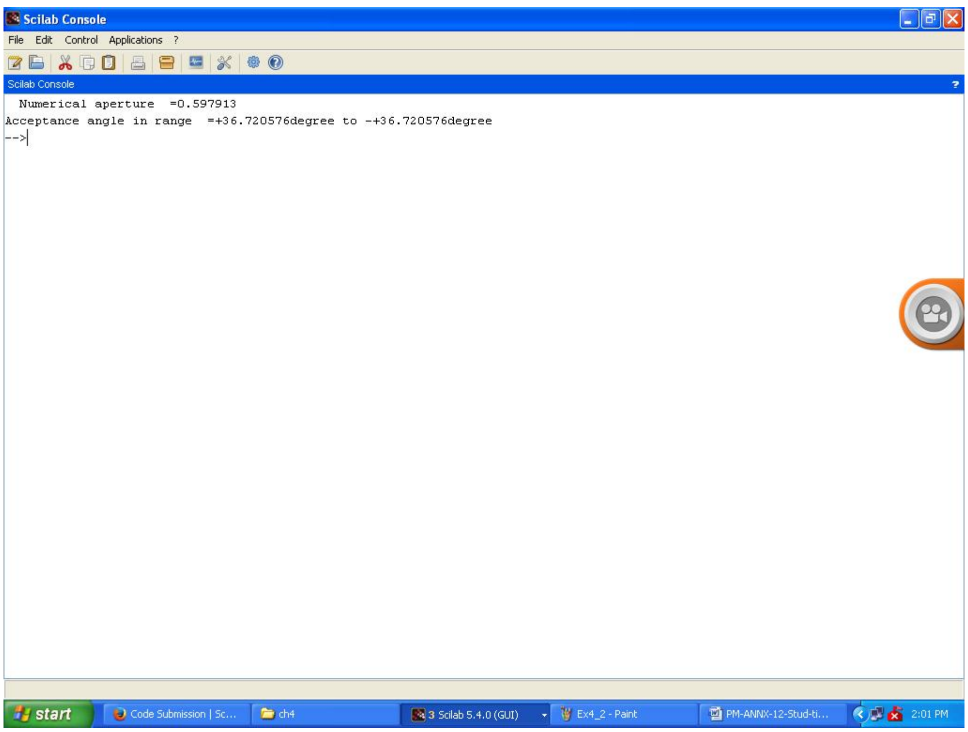

Scilab Console
File Edit Control Applications ?
Scilab Console
Numerical aperture =0.597913
Acceptance angle in range =+36.720576degree to -+36.720576degree
-->

Figure 4.3: 3

```
n1=3.6//refractive index of core AlGaAs slab
n2=3.55//refractive index of cladding
n3=3.55//refractive index of cladding
n0=1//refractive index of Air


//to find
NA=sqrt(n1^2-n2^2)//Numerical aperture
alpha0=asind(NA/n0)//Acceptance angle in degree

mprintf(' Numerical aperture =%f ',NA)
mprintf(' \nAcceptance angle in range =+%fdegree to -+%fdegree',alpha0,alpha0)
```

Chapter 5

Optic fiber waveguides

Scilab code Exa 5.1 1

```
//fiber optic communications by joseph c. palais
//example 5.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n1=1.46//core refractive index
n2=1//cladding refractive index (air)

//to find
Thetac=asind(n2/n1)//critical angle in degree

mprintf(' Critical angle =%i degree',Thetac)
```

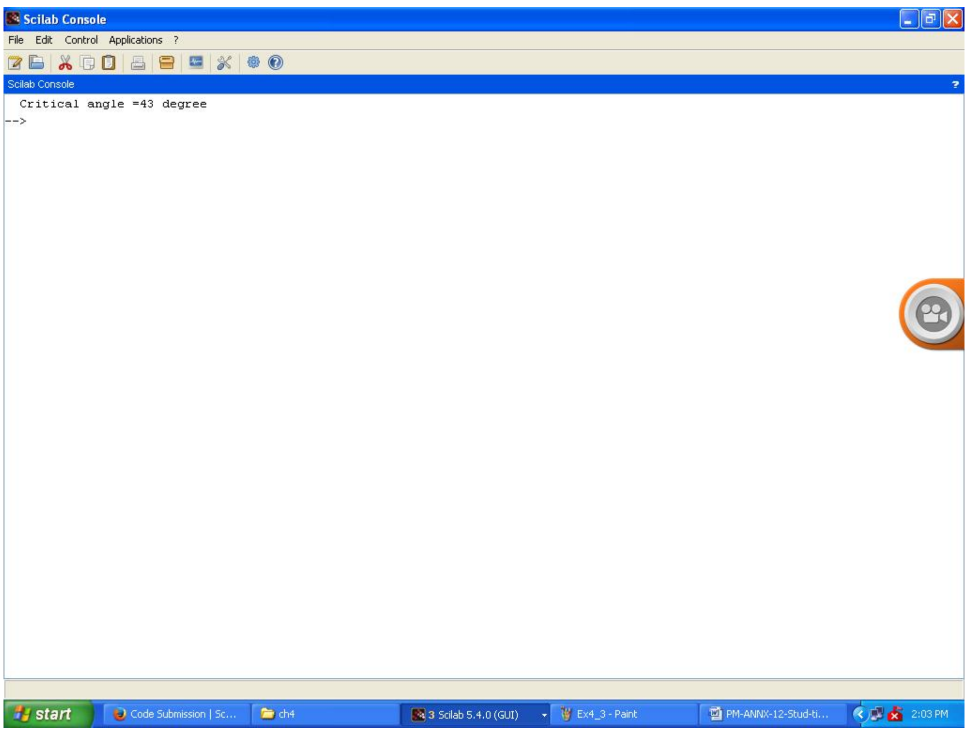

Scilab Console
File Edit Control Applications ?
Scilab Console
Critical angle =43 degree
-->
start
Code Submission | Sc...
ch4
3 Scilab 5.4.0 (GUI)
Ex4_3 - Paint
PM-ANNX-12-Stud-ti...
2:03 PM

Figure 5.1: 1

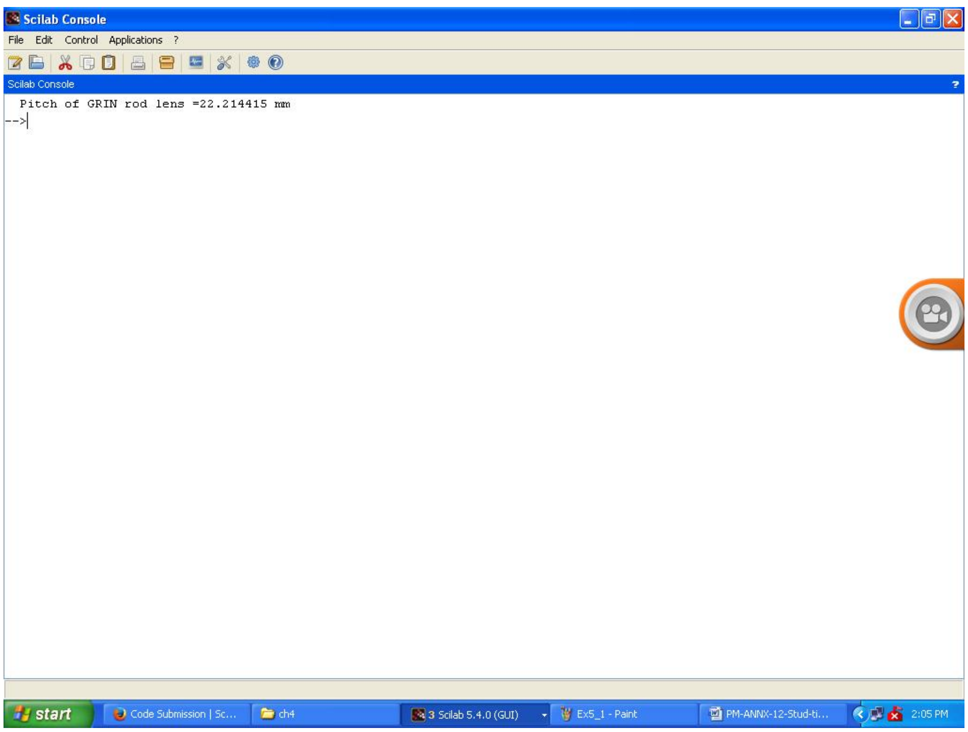

Scilab Console
File Edit Control Applications ?
Scilab Console
Pitch of GRIN rod lens =22.214415 mm
-->
start
Code Submission | Sc...
ch4
3 Scilab 5.4.0 (GUI)
Ex5_1 - Paint
PM-ANNX-12-Stud-ti...
2:05 PM

Figure 5.2: 2

Scilab code Exa 5.2 2

```
//fiber optic communications by joseph c. palais
//example 5.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
d=1//Daimeter in mm
delta=0.01//change in reractive index

//to find
a=d/2//radius in mm
P=a*%pi*sqrt(2/delta)//Pitch of GRIN rod lens in mm

mprintf(' Pitch of GRIN rod lens =%f mm',P)
```

Scilab code Exa 5.3 3

```
//fiber optic communications by joseph c. palais
//example 5.3
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
d=62.5*10^-3//Daimeter in mm
delta=0.01//change in reractive index

//to find
a=d/2//radius in mm
P=a*%pi*sqrt(2/delta)//Pitch of GRIN rod lens in mm
```

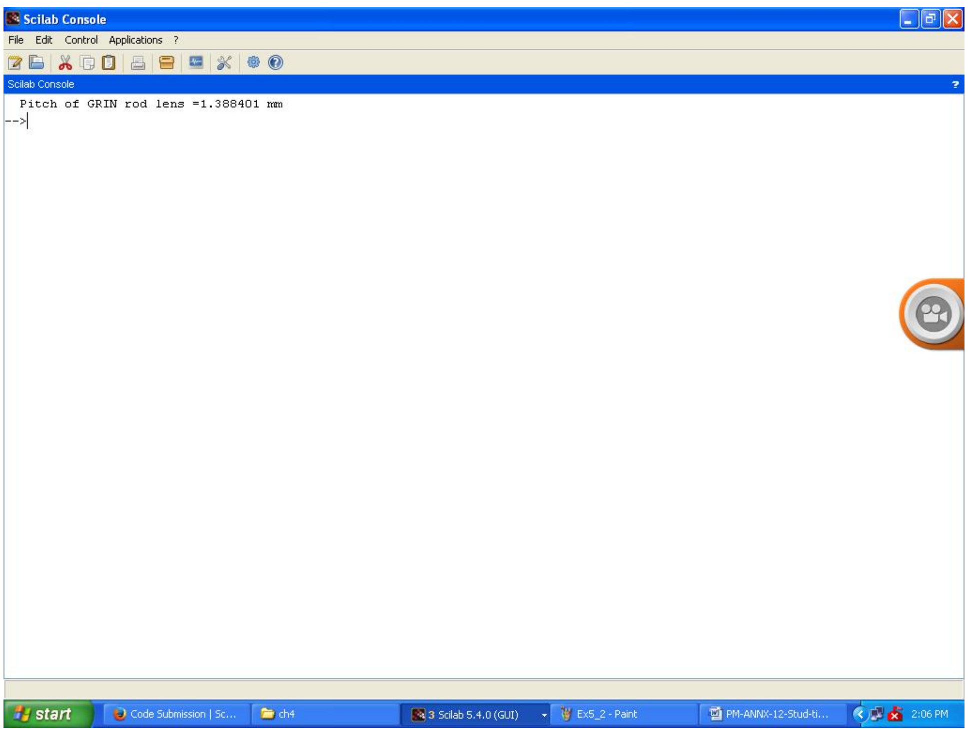

Scilab Console
File Edit Control Applications ?
Scilab Console
Pitch of GRIN rod lens =1.388401 mm
-->

Figure 5.3: 3

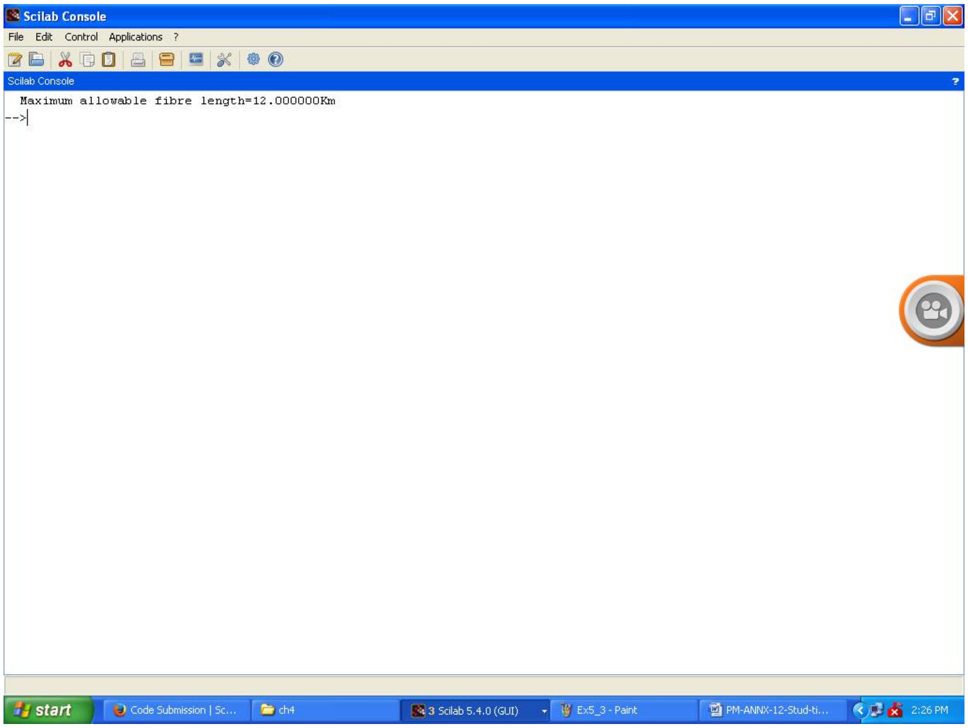


Figure 5.4: 4

```

mprintf(' Pitch of GRIN rod lens =%f mm',P)//
    converting P to mm
```

Scilab code Exa 5.4 4

```
//fiber optic communications by joseph c. palais
//example 5.4
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
```

```
clear all
//given
led_output_power=2//led output power in dBm
fiber_loss=0.5//fiber loss /dB
receiver_sensitivity=30//receiver sensitivity in dBm
coupling_loss=16//coupling loss in dB
connector_and_splices=6//connector and splices loss in dB
power_margin=4//power margin in dB
//to find
loss_budget=led_output_power+receiver_sensitivity;//loss budget in dB
total_losses=coupling_loss+connector_and_splices+power_margin;//total losses in dB
available_fibre_loss=loss_budget-total_losses;//available fibre loss in dB
maximum_allowable_fibre =available_fibre_loss/fiber_loss;//maximum allowable fibre length in Km
mprintf('Maximum allowable fibre length=%fKm',maximum_allowable_fibre)
```

Scilab code Exa 5.5 5

```
//fiber optic communications by joseph c. palais
//example 5.5
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
d=50//core diameter in um
a=d/2//core radius in um
n1=1.48//core refractive index
```

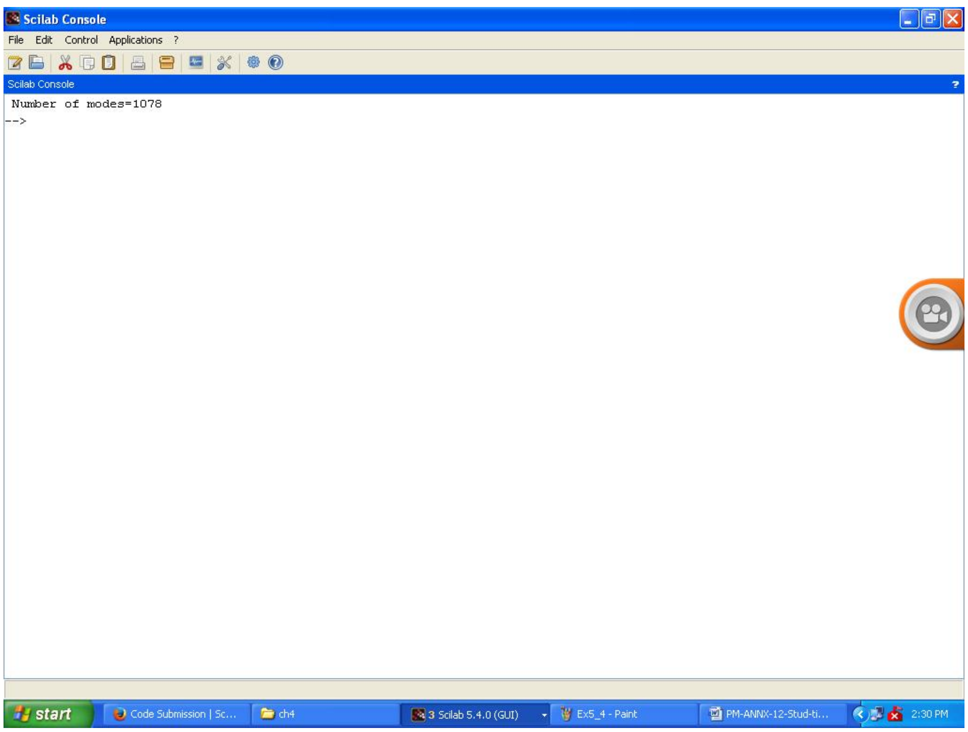

Scilab Console
File Edit Control Applications ?
Scilab Console
Number of modes=1078
-->
start
Code Submission | Sc...
ch4
3 Scilab 5.4.0 (GUI)
Ex5_4 - Paint
PM-ANNX-12-Stud-ti...
2:30 PM

Figure 5.5: 5

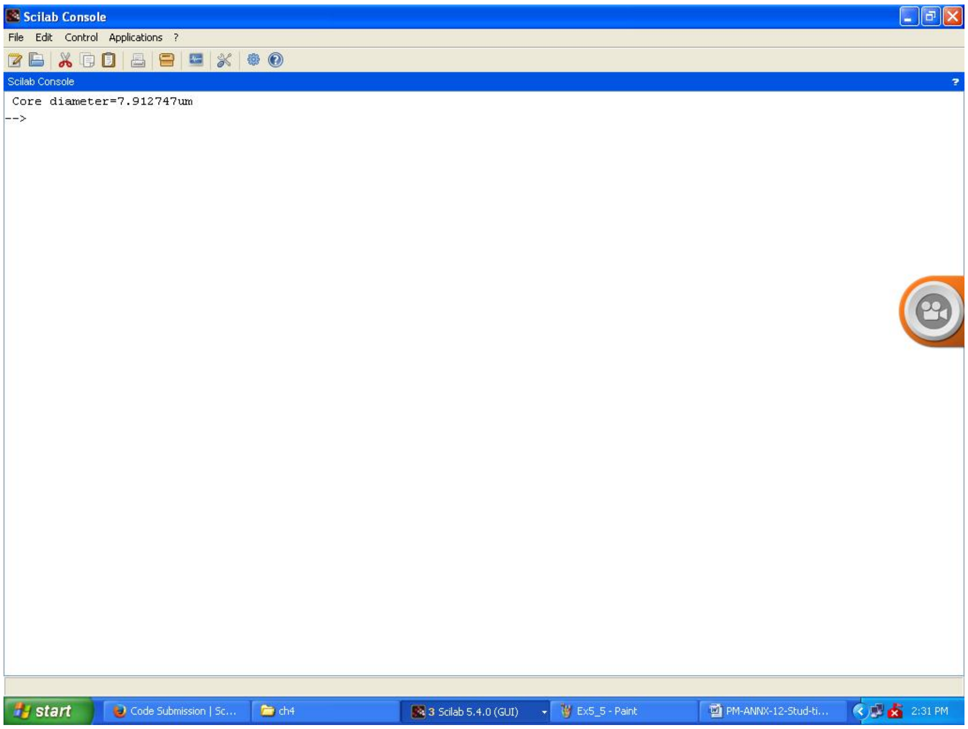


Figure 5.6: 6

```
n2=1.46//cladding refractive index
lambda=0.82//wavelength in um
//to find
V=((2*%pi*a*sqrt((n1^2)-(n2^2)))/lambda)// V number
n=(V^2/2)//number of modes
mprintf("Number of modes=%i",n)
```

Scilab code Exa 5.6 6

```
//fiber optic communications by joseph c. palais
//example 5.6
```

```
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
n1=1.465//core refractive index
n2=1.46//cladding refractive index
lambda=1250*10^-3//wavelength in um
//to find
a=((2.405*lambda)/(2*%pi*sqrt((n1^2)-(n2^2))))//
    radius of the core in um
d=a*2//core diameter in um
mprintf("Core diameter=%fum",d)
```

Scilab code Exa 5.7 7

```
//fiber optic communications by joseph c. palais
//example 5.7
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
n1=1.47//core refractive index
n2=1.46//cladding refractive index
lambda=1.3//wavelength in um
//to find
delta=((n1-n2)/n1)//fractional refractive index
abylambda=(1.4/(%pi*sqrt(n1*(n1-n2))))//radius to
    wavelength ratio
a=lambda*abylambda//radius of core in m
d=a*2//core diameter in m
neff=n1-((sqrt(2*delta))/(2*%pi*abylambda))//value
```

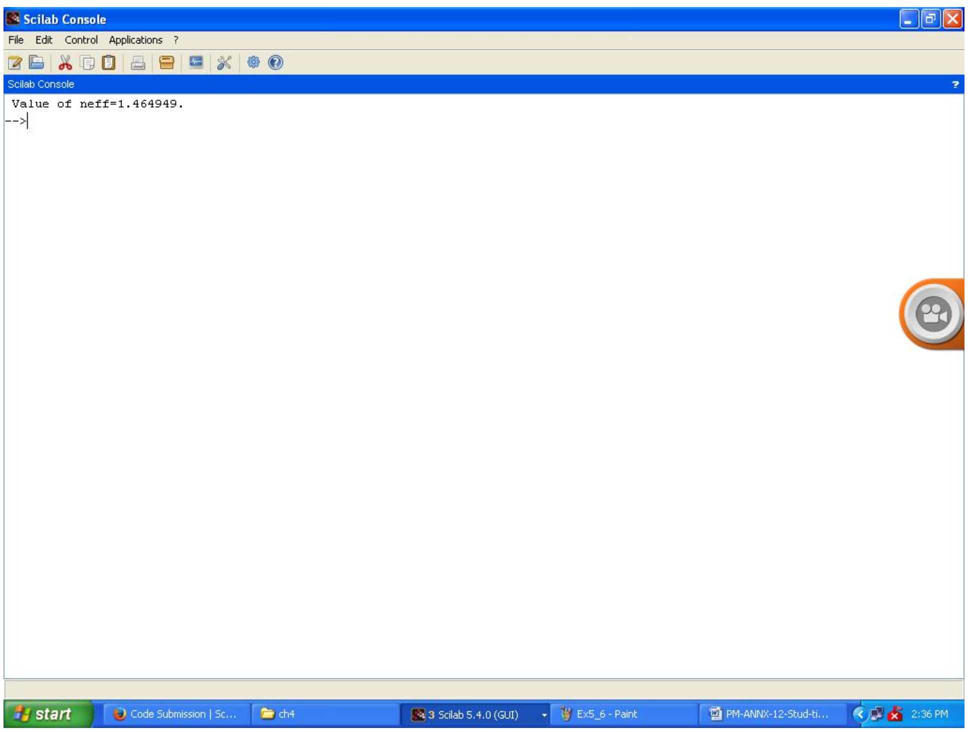

Scilab Console
File Edit Control Applications ?
Scilab Console
Value of neff=1.464949.
-->
start
Code Submission | Sc...
ch4
3 Scilab 5.4.0 (GUI)
Ex5_6 - Paint
PM-ANNX-12-Stud-ti...
2:36 PM

Figure 5.7: 7

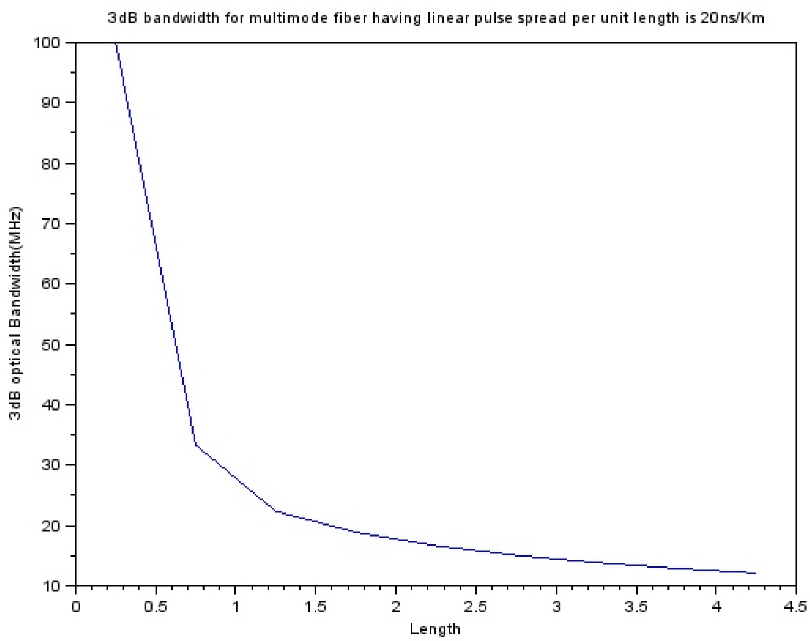


Figure 5.8: 8

```
    of neff.
mprintf("Value of neff=%f.",neff)
```

Scilab code Exa 5.8 8

```
//fiber optic communications by joseph c. palais
//example 5.8
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
```

```
//given
detla_tauby_Lp=20;//linear pulse spread in ns/Km
Le=1;//equilibrum length in km
//to find
L=0.25:0.5:4.25//Length in Km
for i=1:9
    if L(i) > 1 then
f3db(i)=(25/(sqrt(L(i))))//for lengths beyound 1km
else
f3db(i)=25/L(i);//maximum vandwidth(3db)for length less than 1 km
end
end
plot(L,f3db)
xtitle("3dB bandwidth for multimode fiber having linear pulse spread per unit length is 20ns/Km","Length","3dB optical Bandwidth(MHz)");
```

Chapter 6

Light Sources

Scilab code Exa 6.1 1

```
//fiber optic communications by joseph c. palais
//example 6.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
w=25//spot size in um
lambda=0.633//wavelength in um
//to find
thetar=(2*lambda)/(%pi*w)//divergence angle in
   radians
thetad=thetar*180/(%pi)//divergence angle in degrees
mprintf("divergence angle is=%fradians or =%fdegrees
    ",thetar,thetad)
```

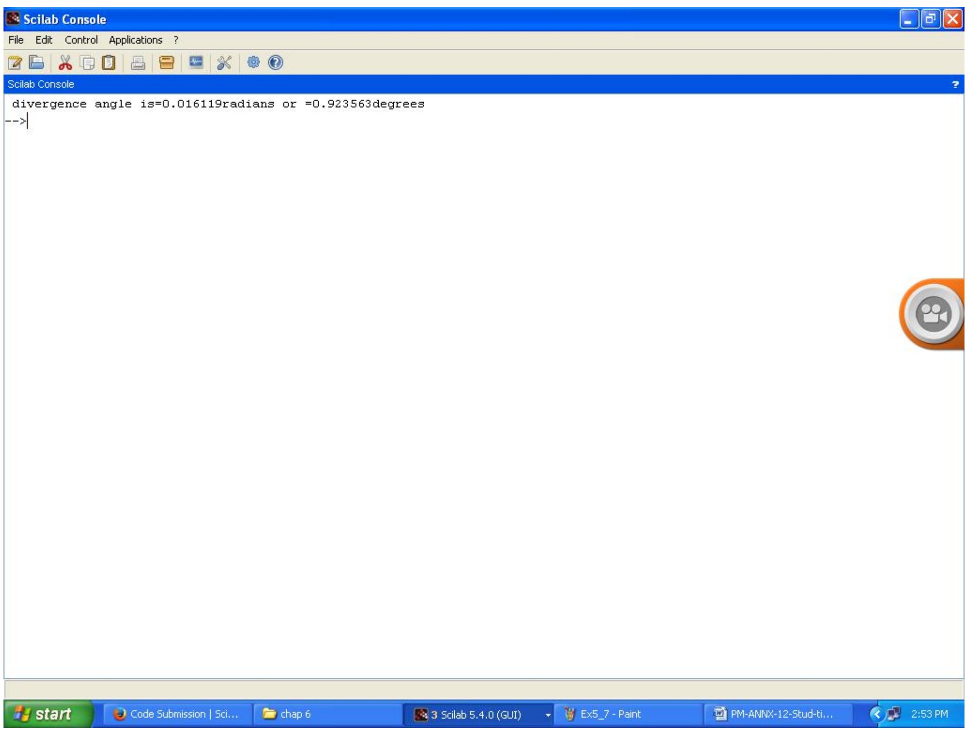

Scilab Console
File Edit Control Applications ?
Scilab Console
divergence angle is=0.016119radians or =0.923563degrees
-->
start
Code Submission | Sci...
chap 6
3 Scilab 5.4.0 (GUI)
Ex5_7 - Paint
PM-ANNX-12-Stud-ti...
2:53 PM

Figure 6.1: 1

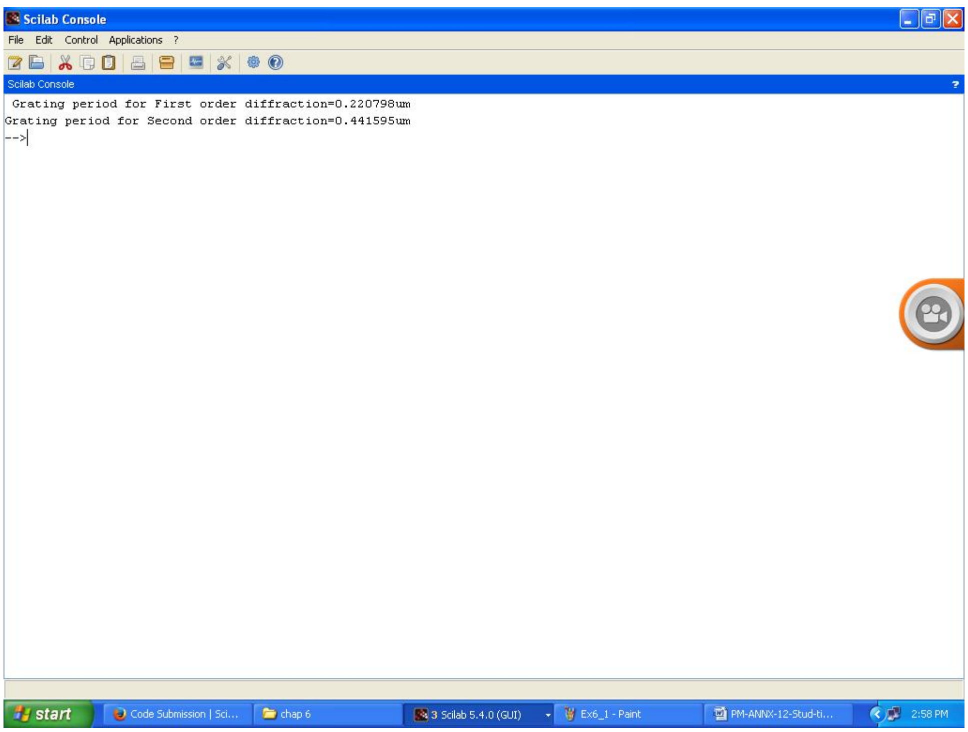

Scilab Console
File Edit Control Applications ?
Scilab Console
Grating period for First order diffraction=0.220798um
Grating period for Second order diffraction=0.441595um
-->
start
Code Submission | Sci...
chap 6
3 Scilab 5.4.0 (GUI)
Ex6_1 - Paint
PM-ANNX-12-Stud-ti...
2:58 PM

Figure 6.2: 2

Scilab code Exa 6.2 2

```
//fiber optic communications by joseph c. palais
//example 6.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
n=3.51; //for GaAsP refractive index
Lambda=1.55;//wavelength in um
//to find
grating_period1=Lambda/(2*n);//grating period in um
    for firstorder diffraction
grating_period2=2*grating_period1;//grating period
    in um for second order diffraction
mprintf("Grating period for First order diffraction=
    %fum",grating_period1);
mprintf("\nGrating period for Second order
    diffraction=%fum",grating_period2);
```

Scilab code Exa 6.3 3

```
//fiber optic communications by joseph c. palais
//example 6.3
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
```

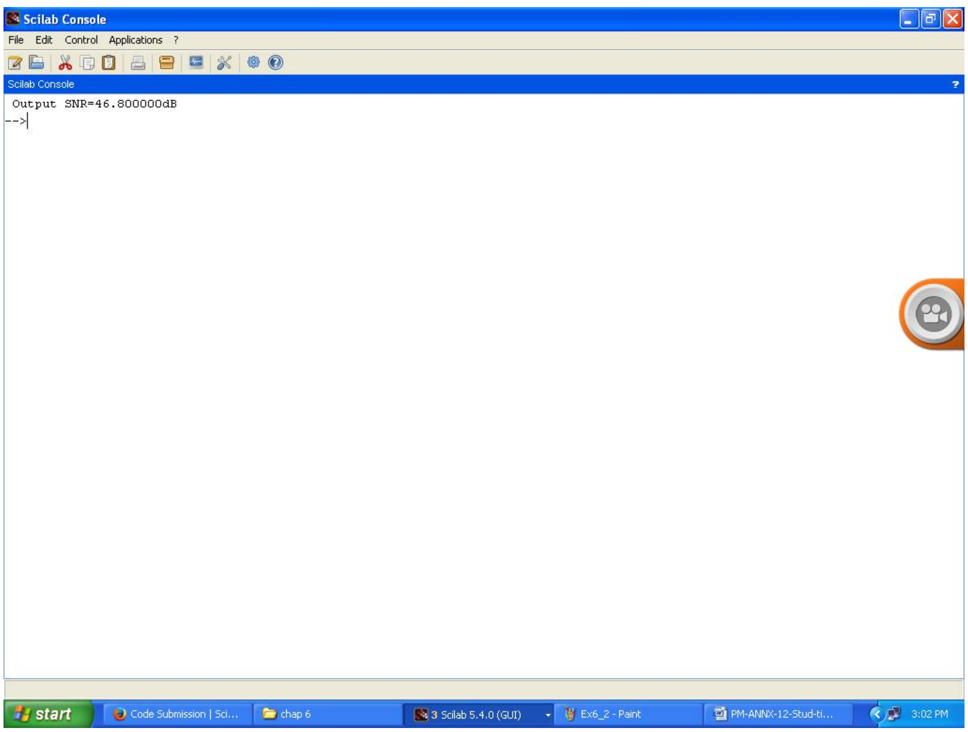

Scilab Console
File Edit Control Applications ?
Scilab Console
Output SNR=46.800000dB
-->
start
Code Submission | Sci...
chap 6
3 Scilab 5.4.0 (GUI)
Ex6_2 - Paint
PM-ANNX-12-Stud-ti...
3:02 PM

Figure 6.3: 3

```
NFdb=3.2//noise figure in dB
SNRidb=50//input snr in dB
//to find
NF=10^(NFdb/10)//converting from decibels to ratios
SNRi=10^(SNRidb/10)//converting from decibels to
    ratios
SNRo=SNRi/NF//output signal to noise ratio
SNRodb=10*log10(SNRo)//converting from  ratios to
    decibels
mprintf("Output SNR=%fdB",SNRodb)
```

Chapter 7

Light Detectors

Scilab code Exa 7.1 1

```
//fiber optic communications by joseph c. palais
//example 7.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
phi=1.9//workfunction of photoemmissive material
    Cesium in eV
//to find
lambda=1.24/(phi)//cutoff wavelength in um
mprintf("Cutoff wavelength =%f um",lambda)
```

Scilab code Exa 7.2 2

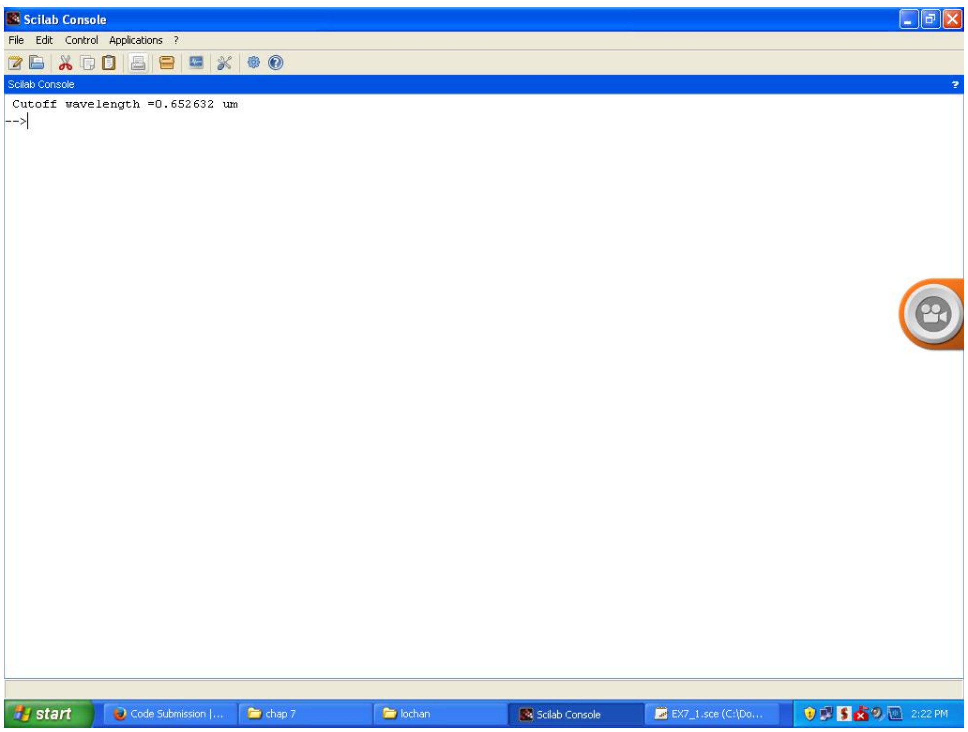

Scilab Console
File Edit Control Applications ?
Scilab Console
Cutoff wavelength =0.652632 um
-->
start
Code Submission |...
chap 7
lochan
Scilab Console
EX7_1.sce (C:\Do...
2:22 PM

Figure 7.1: 1

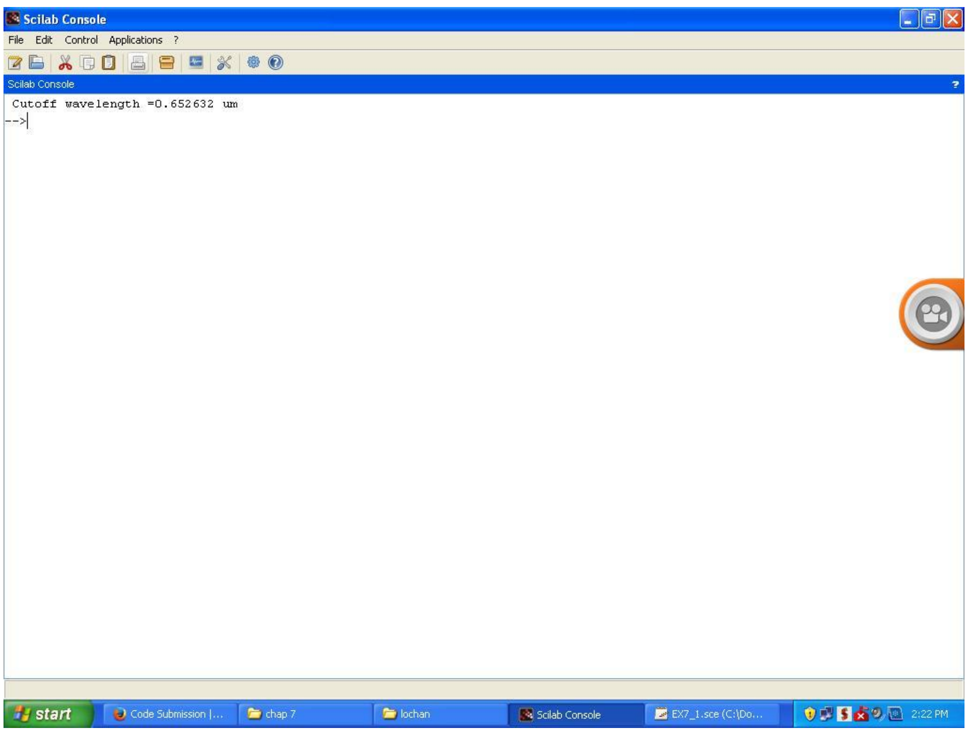

Scilab Console
File Edit Control Applications ?
Scilab Console
Cutoff wavelength =0.652632 um
-->
start
Code Submission |...
chap 7
lochan
Scilab Console
EX7_1.sce (C:\Do...
2:22 PM

Figure 7.2: 2

```
//fiber optic communications by joseph c. palais
//example 7.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
eta=0.01//quantum efficiency of a detector
lambda=0.8*(10^-6)//wavelength in m
e=1.6*10^-19//charge of an electron in columb
h=6.63*10^-34//plancks constant
c=3*10^8//velocity of light in m/s
// to find
Row=(eta*e*lambda)/(h*c)//responsivity of detector
    in mA/W
mprintf("Responsivity of detector=%f mA/W",Row*10^3)
    //multiplication with 10^3 converts the unit from
     A/W to mA/W
```

Scilab code Exa 7.3 3

```
//fiber optic communications by joseph c. palais
//example 7.3
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
R=50;//load resistor in ohm
P=1*10^-6;//optic power absorbed by the detector
Row=6.4*10^-3;//responsivity in A/W
//to find
i=Row*P;//current produced by detector in A
```

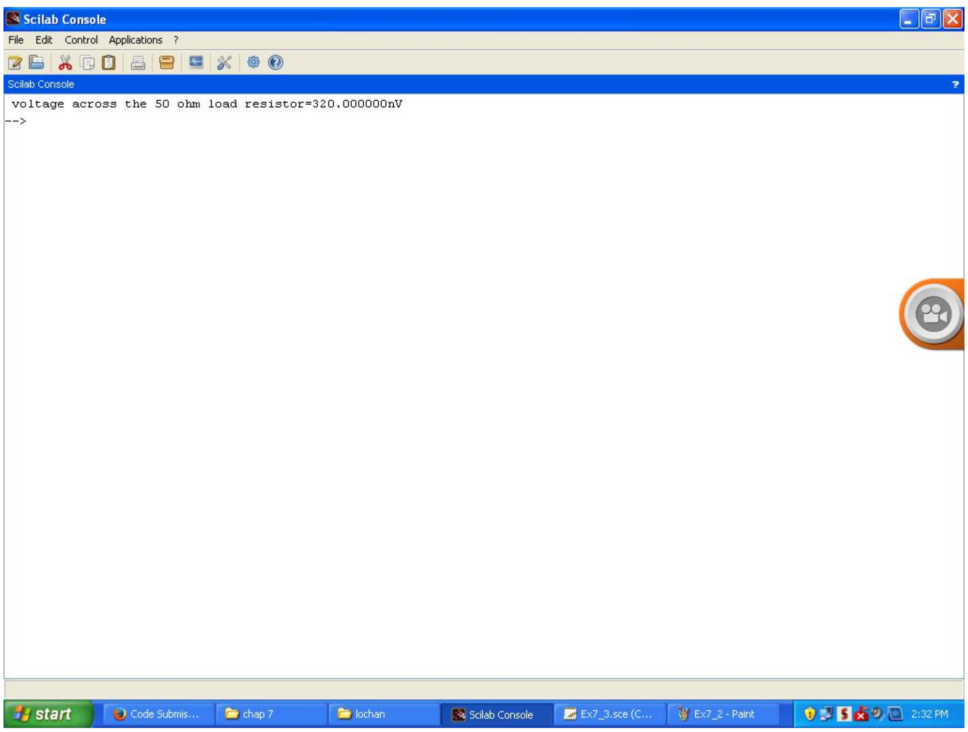

Scilab Console
File Edit Control Applications ?
Scilab Console
voltage across the 50 ohm load resistor=320.000000nV
-->
start
Code Submis...
chap 7
lochan
Scilab Console
Ex7_3.sce (C...
Ex7_2 - Paint
2:32 PM

Figure 7.3: 3

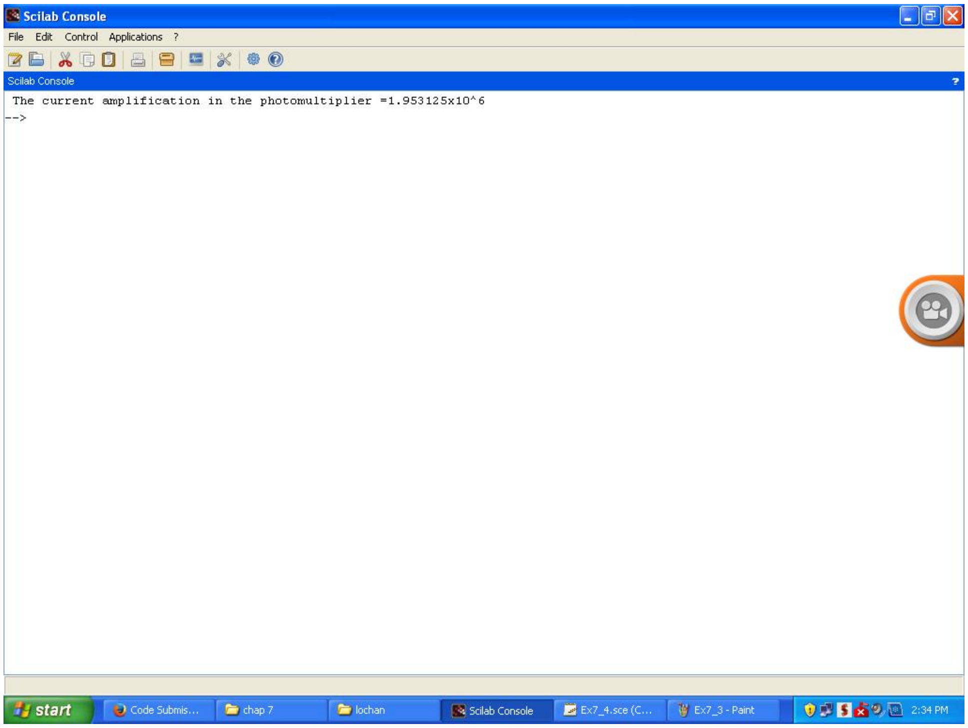


Figure 7.4: 4

```
v=i*R;//output voltage in V
mprintf('voltage across the 50 ohm load resistor=
    %fnV',v*1e9)//multiplication by 1e9 converts unit
     from V to nV
```

Scilab code Exa 7.4 4

```
//fiber optic communications by joseph c. palais
//example 7.4
//OS=Windows XP sp3
//Scilab version 5.4.1
```

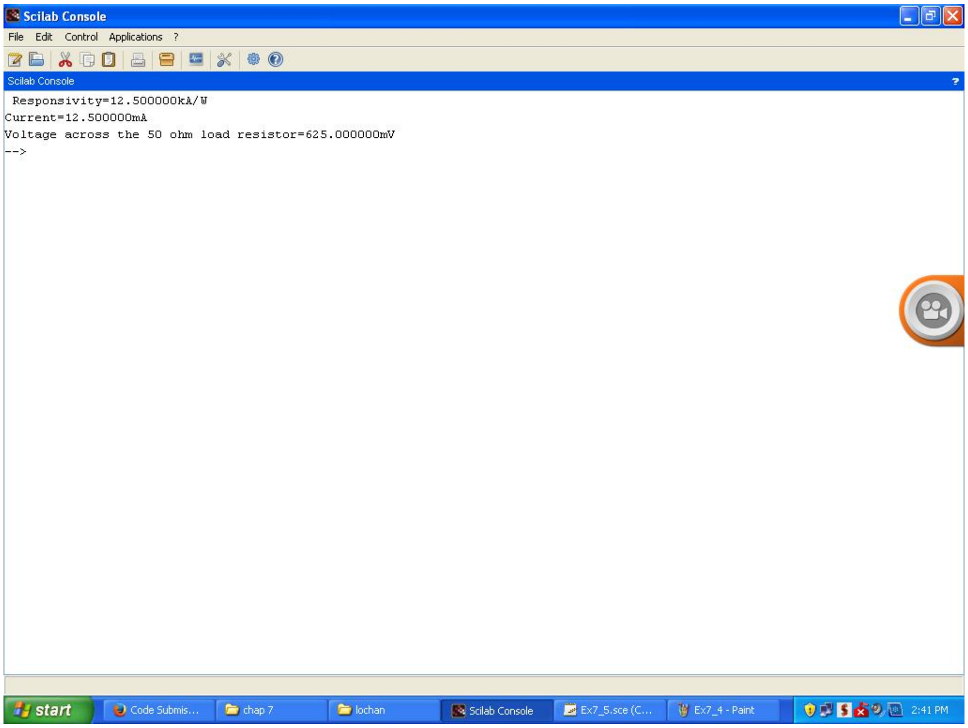


Figure 7.5: 5

```
clc;
clear all;
//given
G=5//Gain of each dynode
N=9//No. of Dynode
//to find
M=G^N//current amplification in photomultiplier
mprintf('The current amplification in the
    photomultiplier =%fx10^6',M/10^6)//division by
    10^6 to repsesent the result in th form ax10^6
```

Scilab code Exa 7.5 5

```
//fiber optic communications by joseph c. palais
//example 7.5
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
R=50//load resistor in ohms
eta=0.01//efficiency
e=1.6*10^-19//Charge of electron in columbs
lambda=0.8*10^-6//wavelength in m
h=6.63*10^-34//planks constant
c=3*10^8//speed of light in m/s
P=1*10^-6//optic power in W
G=5^9//current amplification
Row=.0064//reponsivity in A/W
//to find
Row_amp=G*Row//amplified responsivity in A/W
i=Row_amp*P//current in A
v=i*R//output voltage in V
mprintf('Responsivity=%fkA/W',Row_amp/1000)//
    division by 1000 to make unit from A to KA
mprintf('\nCurrent=%fmA',i*1000)//multiplication by
    1000 to make unit from A to mA
mprintf('\nVoltage across the 50 ohm load resistor=
    %fmV',v*1000)//multiplication by 1000 to make
    unit from V to mV
```

Scilab code Exa 7.6 6

```
//fiber optic communications by joseph c. palais
```

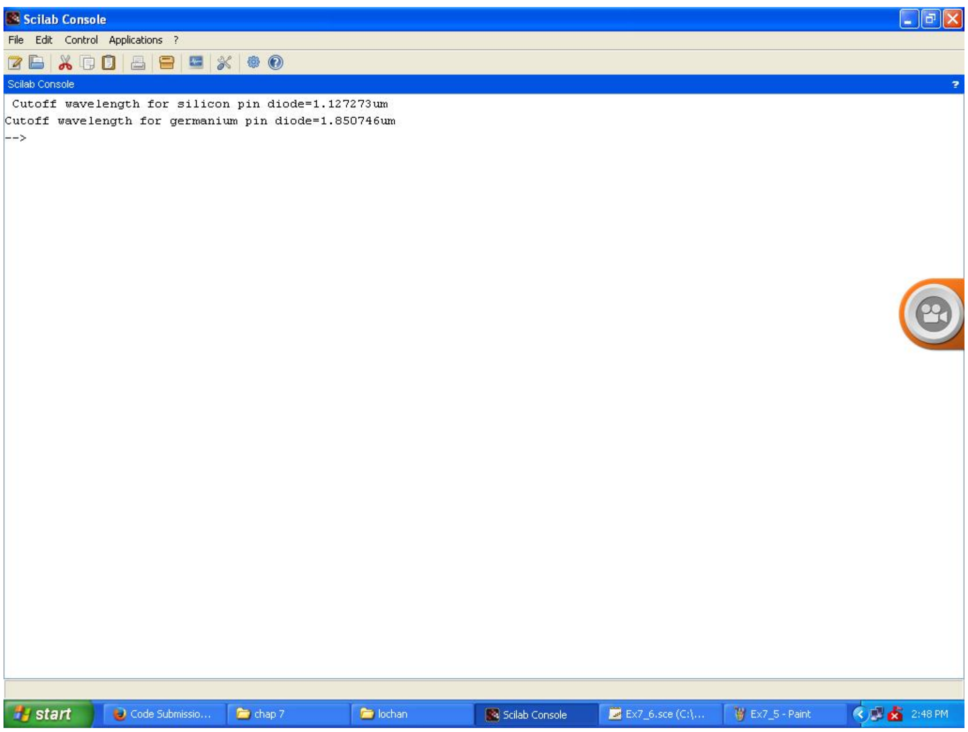

Scilab Console
File Edit Control Applications ?
Scilab Console
Cutoff wavelength for silicon pin diode=1.127273um
Cutoff wavelength for germanium pin diode=1.850746um
-->

Figure 7.6: 6

```
//example 7.6
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
Wg1=1.1//band gap energy of silicon pin diode in eV
Wg2=0.67//band gap energy of germanium pin diode in eV
//to find
lambda_c1=1.24/Wg1//wavelength in um
lambda_c2=1.24/Wg2//wavelength in um
mprintf('Cutoff wavelength for silicon pin diode=%fum',lambda_c1)
mprintf('\nCutoff wavelength for germanium pin diode=%fum',lambda_c2)
```

Scilab code Exa 7.7 7

```
//fiber optic communications by joseph c. palais
//example 7.7
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
Row=0.5//responsivity in A/W
Id=1*10^-9//dark current in A
//to find
P=Id/Row//minimum detectable power in W
mprintf('minimum detectable power =%fnW',P*10^9)//multiplication by 10^9 to convert unit from W to nW
```

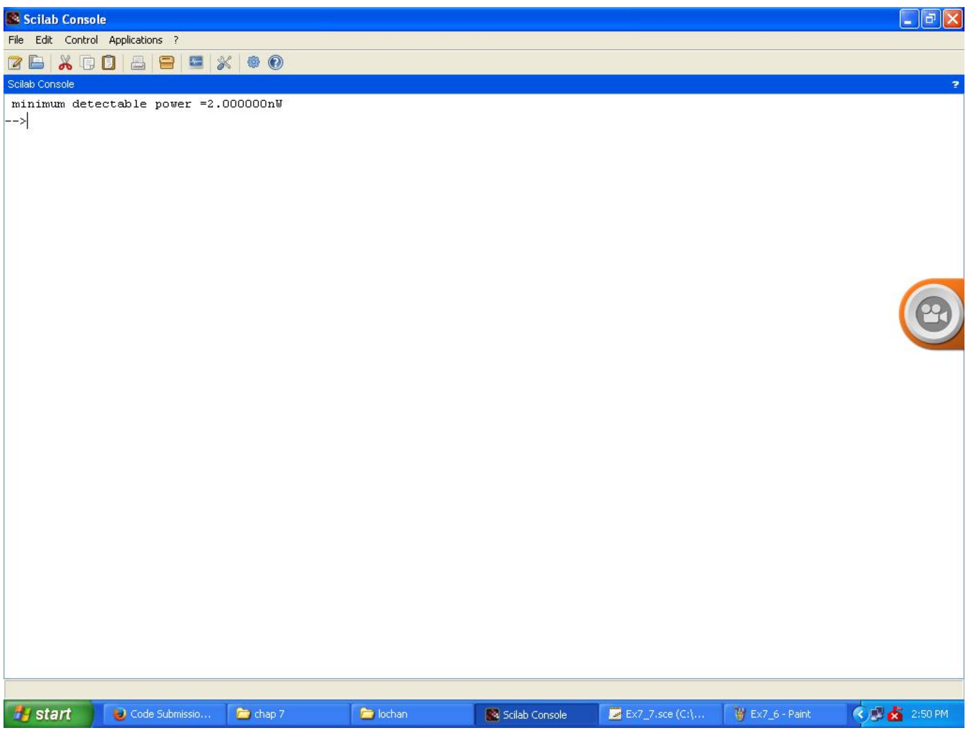

Scilab Console
File Edit Control Applications ?
Scilab Console
minimum detectable power =2.000000nW
-->

Figure 7.7: 7

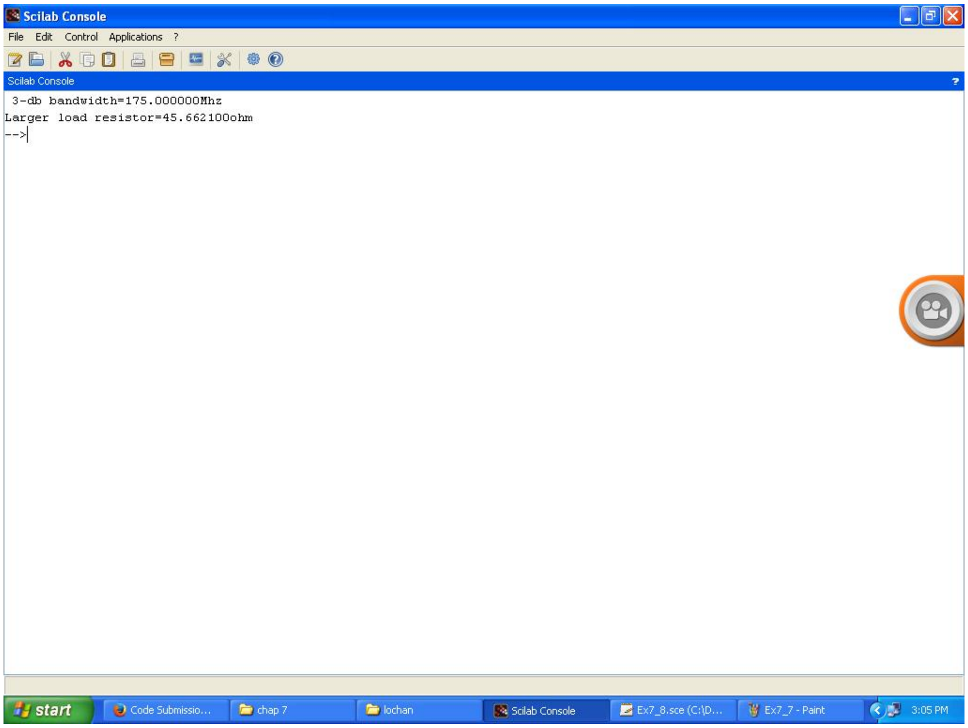


Figure 7.8: 8

Scilab code Exa 7.8 8

```
//fiber optic communications by joseph c. palais
//example 7.8
//OS=Windows XP sp3
//Scilab version 5.4.1
clc;
clear all;
//given
Cd=5*(10^-12)//capacitance in Farads
```

```
tr=2*(10^-9)//transit time in s
f3db=0.35/tr//3dB bandwidth in Hz
mprintf("3-db bandwidth=%fMhz",f3db*10^-6)//
    multiplcation by 10^-6 to convert bandwith unit
    from Hz to MHz
Tc=tr/4// RC time constant  condition for
    insignificant Load resistance in s
Rl=Tc/(2.19*Cd)//largest load resistance in ohm
mprintf("\nLarger load resistor=%fohm",Rl)
```

Chapter 8

Couplers and connectors

Scilab code Exa 8.1 1

```
//fiber optic communications by joseph c. palais
//example 8.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
d=50//core daimeter in um
a=d/2//core radius in um
L1=1//coupling loss in dB case 1
L2=0.5//coupling loss in dB case 2
L3=0.1//coupling loss in dB case 3
//to find
eta1=10^(-L1/10)//coupling efficiency for L1
eta2=10^(-L2/10)//coupling efficiency for L2
eta3=10^(-L3/10)//coupling efficiency for L3
dby2a1=(1-eta1)*(%pi/4)//displacement by twice
    radius ratio d/2a for case 1
dby2a2=(1-eta2)*(%pi/4)//displacement by twice
```

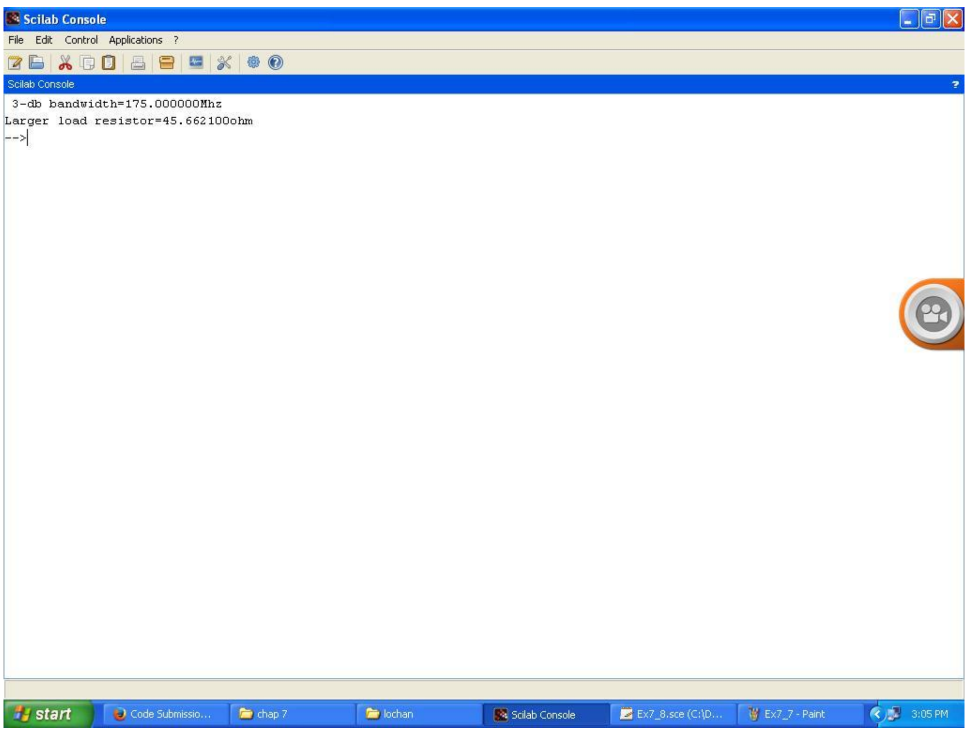

Scilab Console
File Edit Control Applications ?
Scilab Console
3-db bandwidth=175.000000Mhz
Larger load resistor=45.662100ohm
-->

Figure 8.1: 1

```
radius ratio d/2a for case 2
dby2a3=(1-eta3)*(%pi/4)//displacement by twice radius ratio d/2a for case 3
d1=(1-eta1)*(%pi*a/2)//axial displacement for coupling loss=1dB since d/2a<0.2
d2=(1-eta2)*(%pi*a/2)//axial displacement for coupling loss=0.5dB since d/2a<0.2
d3=(1-eta3)*(%pi*a/2)//axial displacement for coupling loss=0.1dB since d/2a<0.2
mprintf('Axial displacement for coupling loss=1dB with d/2a=%f is=%fum',dby2a1,d1)
mprintf('\nAxial displacement for coupling loss=0.5 dB with d/2a=%f is=%fum',dby2a2,d2)
mprintf('\nAxial displacement for coupling loss=0.1 dB with d/2a=%f is=%fum',dby2a3,d3)
```

Scilab code Exa 8.2 2

```
//fiber optic communications by joseph c. palais
//example 8.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
n1=1.465//core refractive index
n2=1.46//cladding refractive index
lambda1=1.3//wavelength in um
lambda2=1.55//wavelength in um
a=3.96//core radius in um
d=0:0.1:5//offset in um
//to find
V1=2*%pi*a/lambda1*(sqrt(n1^2-n2^2))//V number for
```

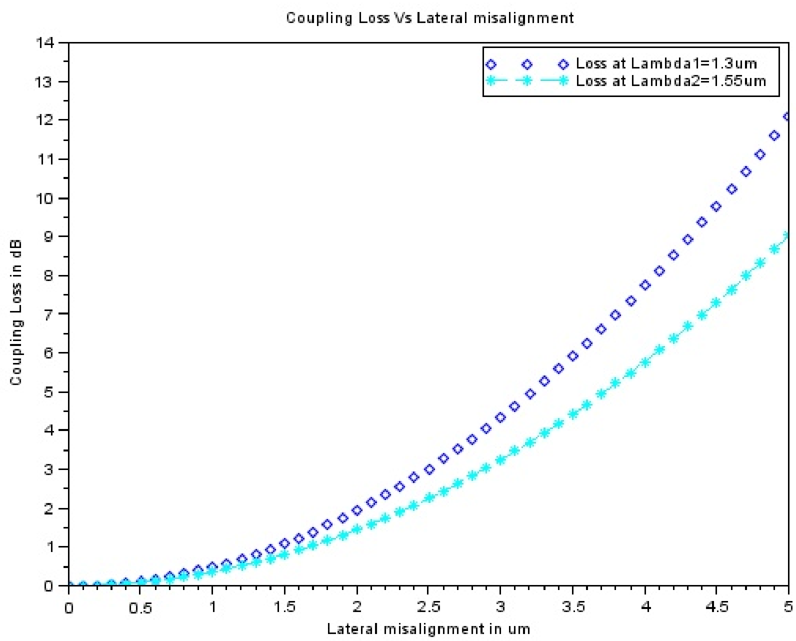

Coupling Loss Vs Lateral misalignment
Loss at Lambda1=1.3um
Loss at Lambda2=1.55um
Coupling Loss in dB
Lateral misalignment in um
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
0.5
1.5
2.5
3.5
4.5

Figure 8.2: 2

```
lambda1
V2=2*%pi*a/lambda2*(sqrt(n1^2-n2^2))//V number for
    lambda2
wbya1=0.65+1.69*V1^(-1.5)+2.879*V1^(-6)//mode field
    radiusto core radius for lambda1
wbya2=0.65+1.69*V2^(-1.5)+2.879*V2^(-6)//mode field
    radiusto core radius for lambda2
w1=wbya1*a//mode field radius in um for lambda1
w2=wbya2*a//mode field radius in um for lambda2
dbyw1=d./w1//d/w ratio for lambda1
dbyw2=d./w2//d/w ratio for lambda2
L1=-10*log(exp(-(dbyw1)^2))//Coupling Loss for
    lambda1
L2=-10*log(exp(-(dbyw2)^2))//Coupling Loss for
    lambda2
xtitle( 'Coupling Loss Vs Lateral misalignment', '
    Lateral misalignment in um', 'Coupling Loss in dB
    ') ;
plot(d,L1,'d')
plot(d,L2,'*cya--')
hl=legend(['Loss at Lambda1=1.3um';'Loss at Lambda2
    =1.55um']);
```

Scilab code Exa 8.3 3

```
//fiber optic communications by joseph c. palais
//example 8.3
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
n1=1.465//refrative index of core
```

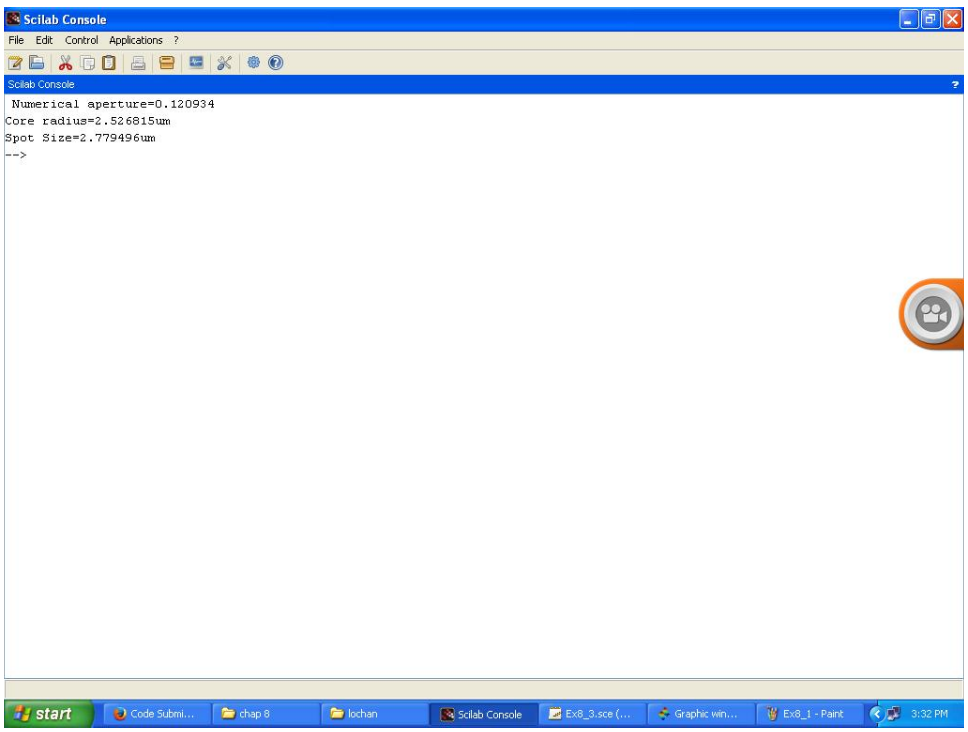

Scilab Console
File Edit Control Applications ?
Scilab Console
Numerical aperture=0.120934
Core radius=2.526815um
Spot Size=2.779496um
-->
start
Code Submi...
chap 8
lochan
Scilab Console
Ex8_3.sce (...
Graphic win...
Ex8_1 - Paint
3:32 PM

Figure 8.3: 3

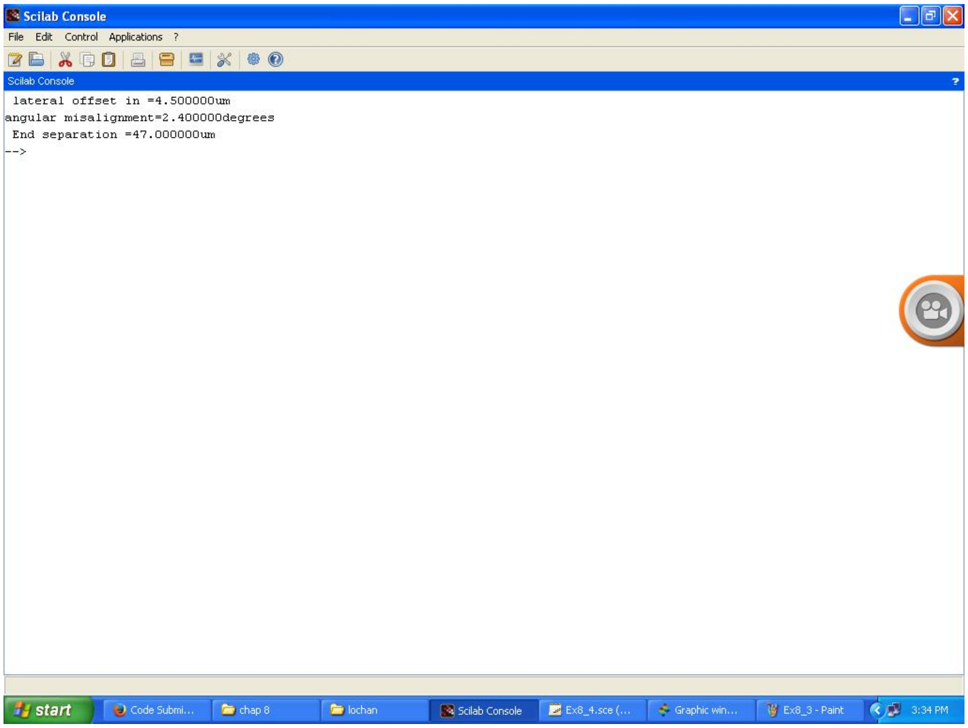


Figure 8.4: 4

```
n2=1.46//refractive index of cladding
lambda=0.8//wave length in um
V=2.4//normalized frequency
wbya=1.1//w/a ratio for V=2.4
na=sqrt((n1^2)-(n2^2))//numerical aperture
mprintf("Numerical aperture=%f",na)
a=(lambda*V)/(2*%pi*na)//core radius
mprintf("\nCore radius=%fum",a)
spot_size=wbya*a//spot size in um
mprintf("\nSpot Size=%fum",spot_size)
```

Scilab code Exa 8.4 4

```
//fiber optic communications by joseph c. palais
//example 8.4
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
loss=0.25//loss for each type of misalignment in dB
a=50//core radius in um
NA=0.24//numerical aperture
dby2a=0.045//lateral offset from given plots for
    loss of 0.25dB
theta=2.4//angular misalignment from given plots for
     loss of 0.25dB
xbya=0.94//end separation from given plots for loss
    of 0.25dB

//tofind
d=dby2a*a*2//lateral offset in um
x=xbya*a//end separation in um
mprintf("lateral offset in =%fum",d)
mprintf("\nangular misalignment=%fdegrees",theta)
mprintf("\n End separation =%fum",x)
```

Scilab code Exa 8.5 5

```
//fiber optic communications by joseph c. palais
//example 8.5
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
```

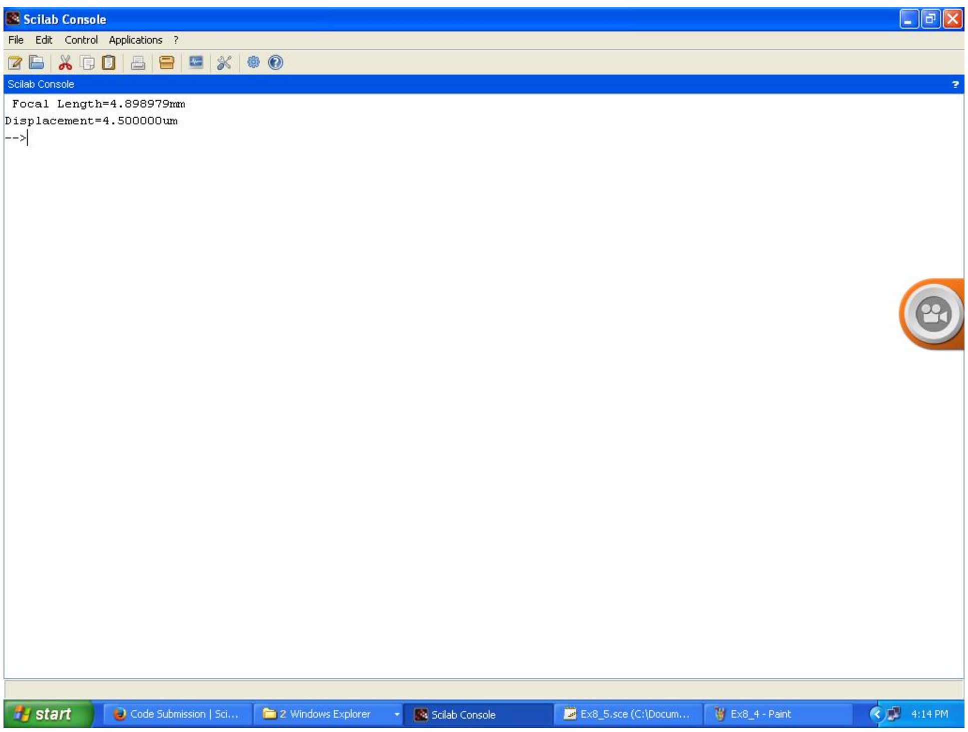

Scilab Console
File Edit Control Applications ?
Scilab Console
Focal Length=4.898979mm
Displacement=4.500000um
-->
start
Code Submission | Sci...
2 Windows Explorer
Scilab Console
Ex8_5.sce (C:\Docum...
Ex8_4 - Paint
4:14 PM

Figure 8.5: 5

```
clc
 clear all
NA=0.2//numerical aperture
dia=50*(10^(-6))//core diameter in m
a=dia/2//core radius in m
lateral_loss=0.5//allowable lateral loss in dB
Beam_dai=2//beam daimeter in mm
dby2a=0.09//since loss is 0.5dB d/2a is 0.09 from given figure 8.3
//to find
r=Beam_dai/2//beam radius in mm
Beam_divergence=asind(NA)//beam diverges in degrees
f=r/tand(Beam_divergence)//focal length in mm
d=dby2a*2*a//allowed offset in m
mprintf("Focal Length=%fmm",f)
mprintf("\nDisplacement=%fum",d*1e6)//multiplication by 1e6 will convert the unit from m to um
```

Scilab code Exa 8.6 6

```
//fiber optic communications by joseph c. palais
//example 8.6
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
NA1=0.24//numerical aperture SI fiber 1 ALl glass
NA2=0.41//numerical aperture SI fiber 2 PCS
NA3=0.48//numerical aperture SI fiber 3 All plastic
NA_loss1=-10*log10(NA1^2)//losses SI fiber 1
NA_loss2=-10*log10(NA2^2)//losses SI fiber 2
NA_loss3=-10*log10(NA3^2)//losses SI fiber 3
```

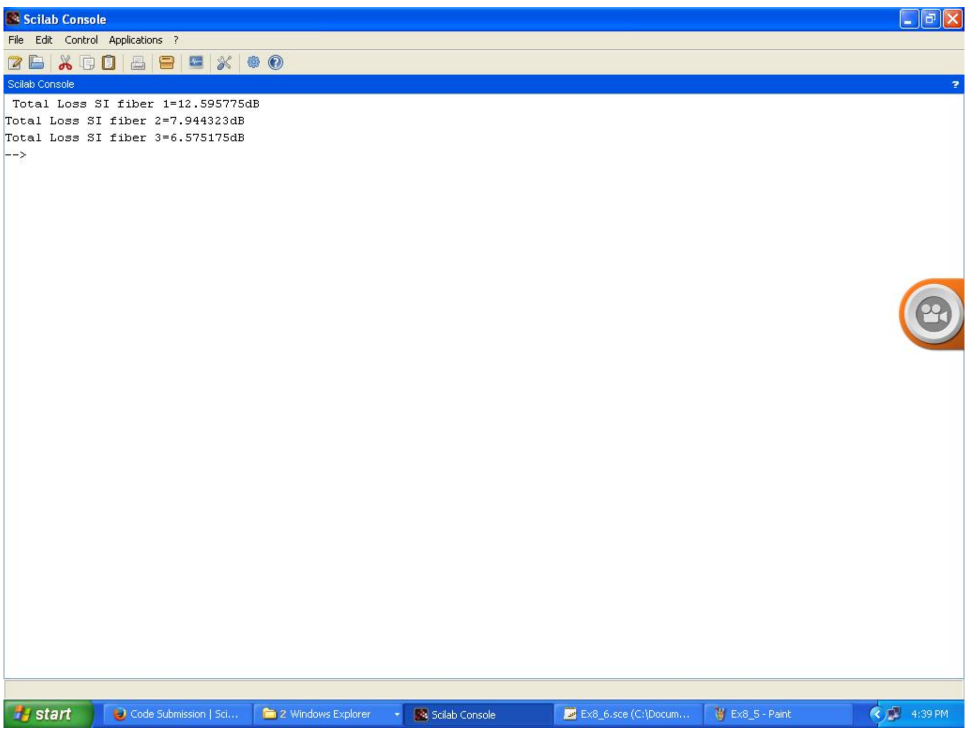

Scilab Console
File Edit Control Applications ?
Scilab Console
Total Loss SI fiber 1=12.595775dB
Total Loss SI fiber 2=7.944323dB
Total Loss SI fiber 3=6.575175dB
-->
start
Code Submission | Sci...
2 Windows Explorer
Scilab Console
Ex8_6.sce (C:\Docum...
Ex8_5 - Paint
4:39 PM

Figure 8.6: 6

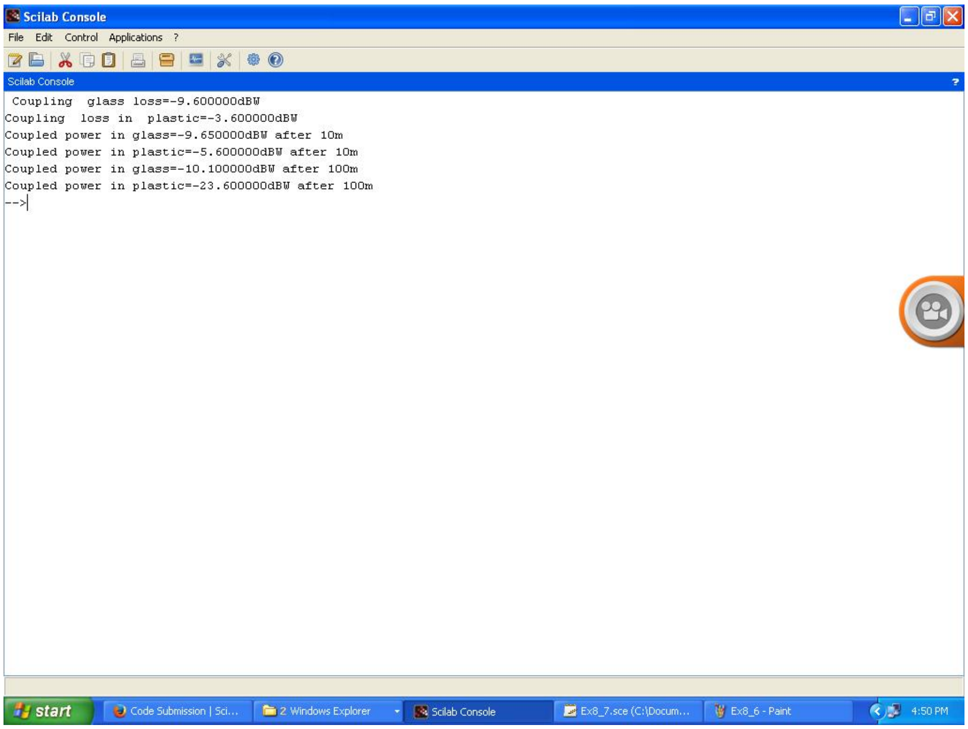


Figure 8.7: 7

```
ref_loss=0.2//Reflection_loss in dB
total_loss1=NA_loss1+ref_loss//Total Loss in dB
mprintf('Total Loss SI fiber 1=%fdB',total_loss1)
total_loss2=NA_loss2+ref_loss
mprintf('\nTotal Loss SI fiber 2=%fdB',total_loss2)
total_loss3=NA_loss3+ref_loss
mprintf('\nTotal Loss SI fiber 3=%fdB',total_loss3)
```

Scilab code Exa 8.7 7

```
//fiber optic communications by joseph c. palais
```

```
//example 8.7
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
Ps=3//source power in dBm
NA_glass=0.24//numerical aperture for glass
NA_plastic=0.48//numerical aperure for plastic
loss_glass=12.4//loss for glass fiber in dB
loss_plastic=6.4//loss for plastic fiber in dB
reflectn_loss=0.2// reflection losses in dB
atten_glass=5//attenuation in glass dB/Km
atten_plastic=200//attenuation in plastic dB/Km
L1=10*10^-3//fiber length in Km
L2=100*10^-3//fiber length in Km
//to find
glass_coup_loss=Ps-(reflectn_loss + loss_glass)// Glass fiber coupling Loss in dBW
mprintf('Coupling  glass loss=%fdBW',glass_coup_loss)
plastic_coup_loss=Ps-(reflectn_loss + loss_plastic) //plastic coupling fiber  loss in dBW
mprintf('\nCoupling  loss in  plastic=%fdBW',plastic_coup_loss)
glass_cp= glass_coup_loss-atten_glass*L1//Coupled power in glass in dBW for 10m
mprintf('\nCoupled power in glass=%fdBW after 10m',glass_cp)
plastic_cp=plastic_coup_loss-atten_plastic*L1// Coupled power in plastic in dBW for 10m
mprintf('\nCoupled power in plastic=%fdBW after 10m',plastic_cp)
glass_cp= glass_coup_loss-atten_glass*L2// Coupled power in glass in dBW for 100m
mprintf('\nCoupled power in glass=%fdBW after 100m',glass_cp)
plastic_cp=plastic_coup_loss-atten_plastic*L2 //
```

```
    Coupled power in plastic in dBW for 100m
mprintf('\nCoupled power in plastic=%fdBW after 100m
    ',plastic_cp)
```

Chapter 9

Distribution networks and Fiber components

Scilab code Exa 9.1 1

```
//fiber optic communications by joseph c. palais
//example 9.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
LE=1//coupler has excess loss of 1dB
P2byP1=(10^(-LE/10))/2//since P2/P1 is equal to P3/
    p1 since spliting ratio is 1:1
Ltap=-10*log10(P2byP1)//Taploss in dB
Lthp=-10*log10(P2byP1)//throughput Loss in dB
Ltap1=Ltap-LE//excess loss of 1 dB
Lthp2=Lthp-LE//excess loss of 1dB
mprintf('\nThe portion of the input power reaching
    output for splitting ratio 1:1 is =%f',P2byP1)
```

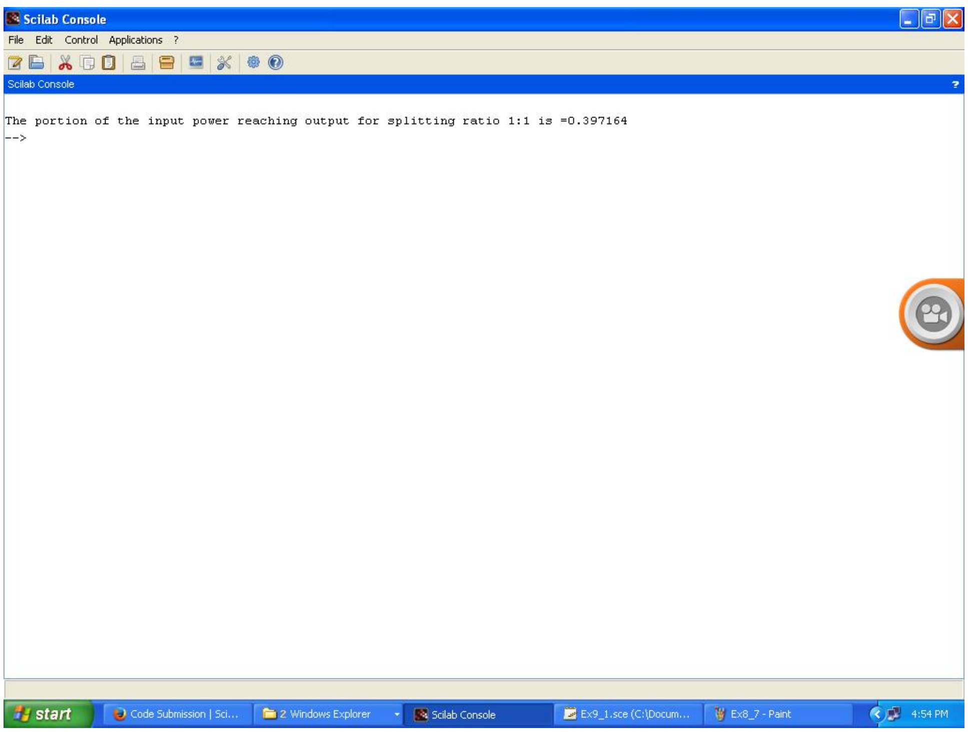

Scilab Console
File Edit Control Applications ?
Scilab Console
The portion of the input power reaching output for splitting ratio 1:1 is =0.397164
-->

Figure 9.1: 1

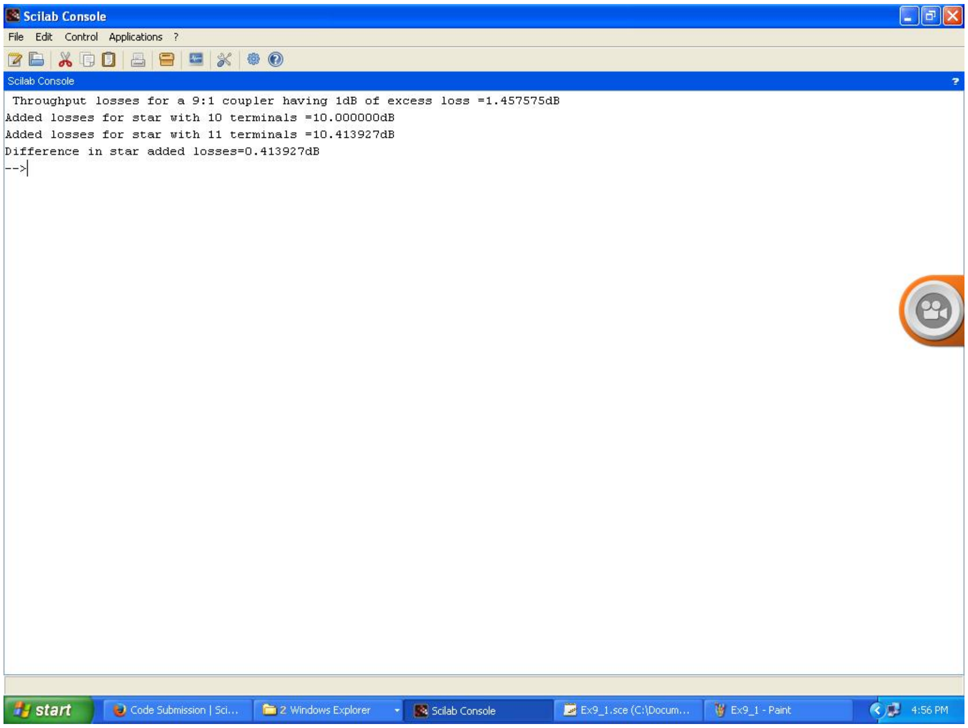


Figure 9.2: 2

Scilab code Exa 9.2 2

```
//fiber optic communications by joseph c. palais
//example 9.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
terminals_in=10//initial terminals
```

```
terminals_ex=11//extended terminals
S_ratio=9//splitting ratio
ELT=1//excess losss tee coupler in dB
connector_loss=1//connector loss in dB
//to find
P2byP1=10^-0.1*0.9//P2/P1 for spliting ratio 9:1
lthp=-10*log10(P2byP1)//through loss loss for a 9:1 coupler having 1dB of excess loss
tee_adlos=lthp+2//loss of one directional coupler plus the loss of two connectors
star_adlos1= -10*log10(1/terminals_in)//Loss for star network with 10 terminals in dB
star_adlos2= -10*log10(1/terminals_ex)//Loss for star network with 11 terminals in dB
d2=star_adlos2 - star_adlos1//Change in loss with change in no. of terminals from 10-11
mprintf('Throughput losses for a 9:1 coupler having 1dB of excess loss =%fdB',lthp)
mprintf('\nAdded losses for star with 10 terminals = %fdB',star_adlos1)
mprintf('\nAdded losses for star with 11 terminals = %fdB',star_adlos2)
mprintf('\nDifference in star added losses=%fdB',d2)
```

Scilab code Exa 9.3 3

```
//fiber optic communications by joseph c. palais
//example 9.3
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc;
clear all;
```

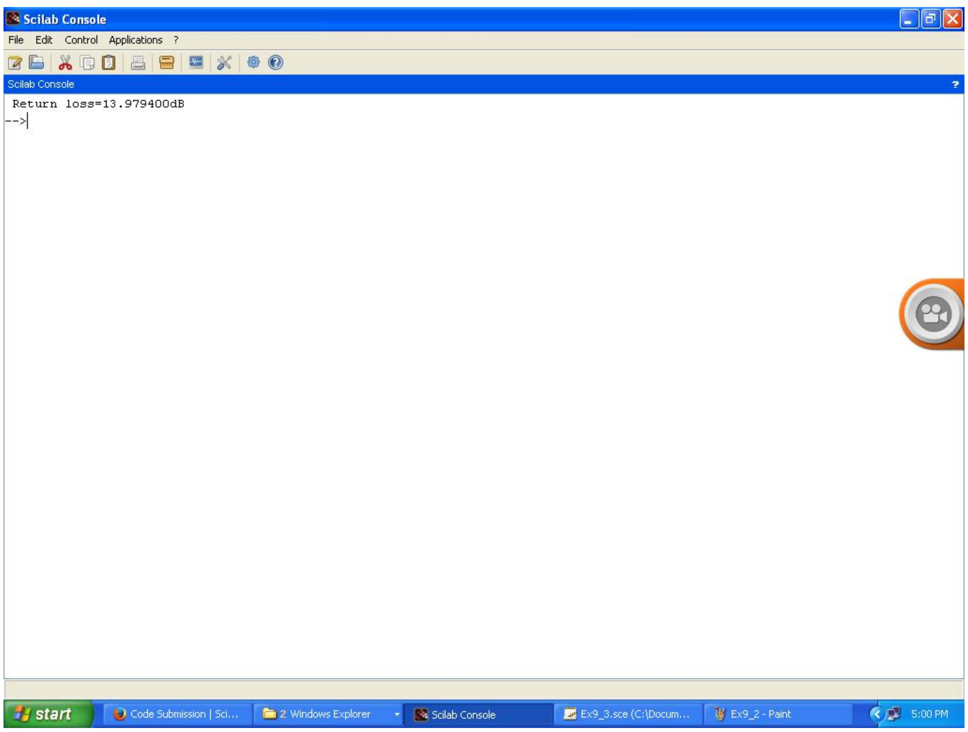

Scilab Console
File Edit Control Applications ?
Scilab Console
Return loss=13.979400dB
-->
start
Code Submission | Sci...
2 Windows Explorer
Scilab Console
Ex9_3.sce (C:\Docum...
Ex9_2 - Paint
5:00 PM

Figure 9.3: 3

```
n2=1.5//Assuming refractive index of glass fiber
n1=1//refractive index if air
R=((n1-n2)/(n1+n2))^2// fraction of light reflected
//to find
LR=-10*log10(R)//Return loss in dB
mprintf('Return loss=%fdB',LR)
```

Chapter 10

Modulation

Scilab code Exa 10.1 1

```
//fiber optic communications by joseph c. palais
//example 10.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
clc;
clear all;
Vdc=5;//Power supply across transistor in V
R=45//Resistancein ohm
vd=1.4//forward bias voltage drop in V
vce=0.3//cut-off voltage in V
//to find
ic=(Vdc-vce-vd)/R//diode current when fully on in A
mprintf("Collector current=%fmA",ic*1000)
```

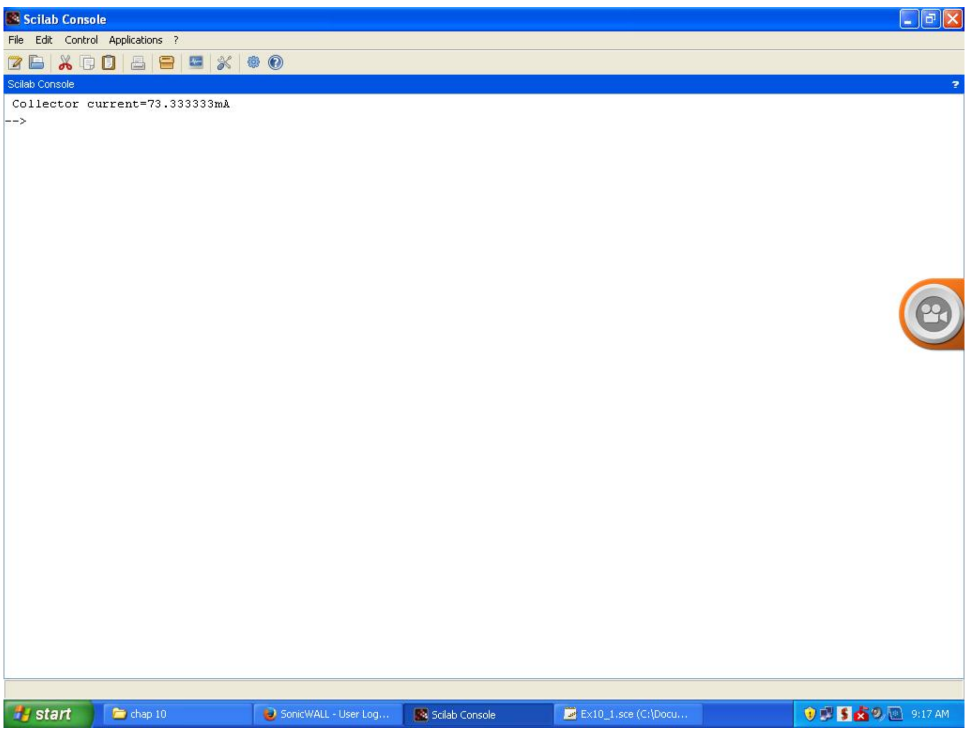

Scilab Console
File Edit Control Applications ?
Scilab Console
Collector current=73.333333mA
-->
start
chap 10
SonicWALL - User Log...
Scilab Console
Ex10_1.sce (C:\Docu...
9:17 AM

Figure 10.1: 1

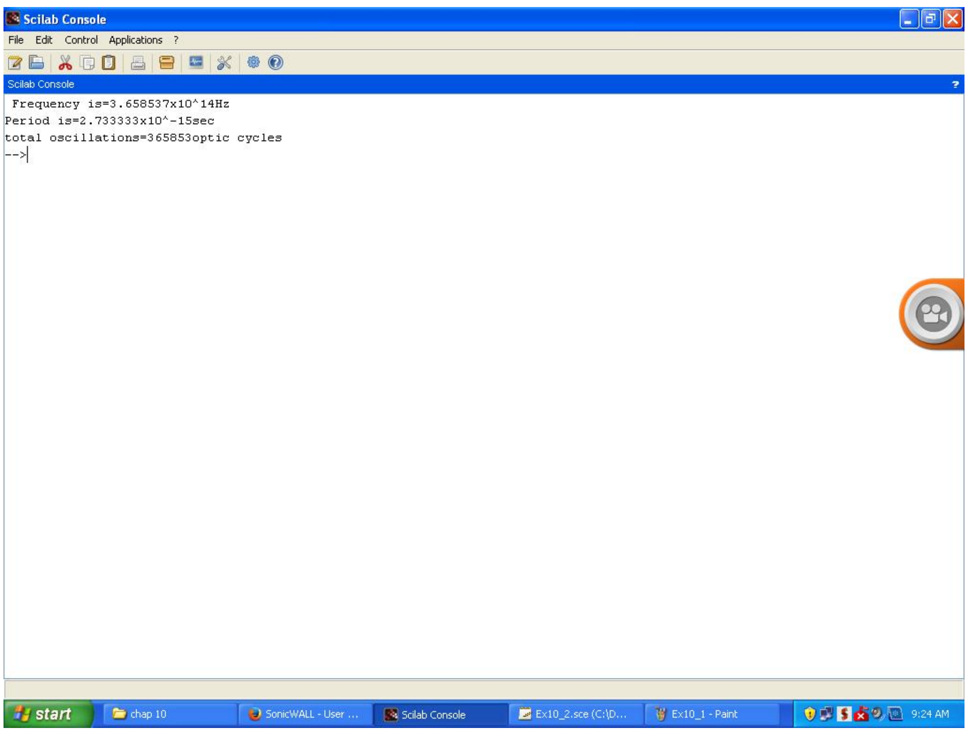

Scilab Console
File Edit Control Applications ?
Scilab Console
Frequency is=3.658537x10^14Hz
Period is=2.733333x10^-15sec
total oscillations=365853optic cycles
-->
start
chap 10
SonicWALL - User ...
Scilab Console
Ex10_2.sce (C:\D...
Ex10_1 - Paint
9:24 AM

Figure 10.2: 2

Scilab code Exa 10.2 2

```
//fiber optic communications by joseph c. palais
//example 10.2
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc;
clear all;
lambda=0.82*(10^-6)//wavelength in m
pulse=10^-9//duration of pulse in sec
c=3*10^8//velocity of light in m/s
//to find
f=c/lambda;//frequency of oscillation in Hz
mprintf("Frequency is=%fx10^14Hz",f/10^14) //division by 10^14 AND SHOWING THE RESULT AS X 10^14
T=1/f;//Pulse duration in sec
mprintf("\nPeriod is=%fx10^-15sec",T*10^15)//MULTIPLICATION by 10^15 AND SHOWING THE RESULT AS X 10^-15
Oscillations=pulse/T;//no. of oscillations
mprintf("\ntotal oscillations=%ioptic cycles",Oscillations)
```

Scilab code Exa 10.3 3

```
//fiber optic communications by joseph c. palais
//example 10.3
//OS=Windows XP sp3
```

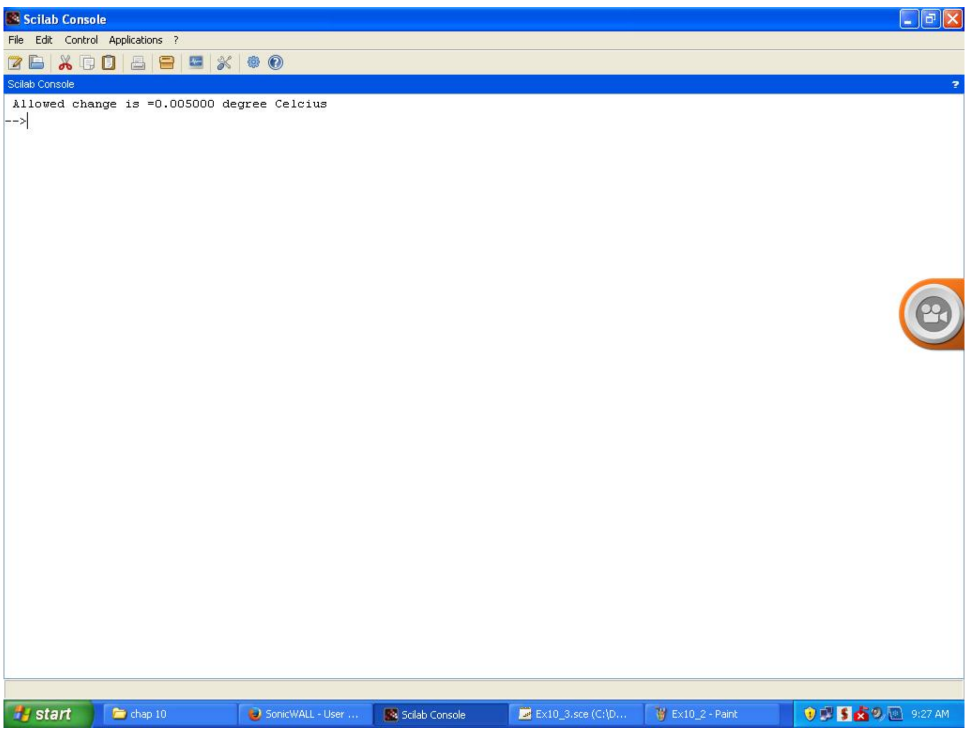

Scilab Console
File Edit Control Applications ?
Scilab Console
Allowed change is =0.005000 degree Celcius
-->

Figure 10.3: 3

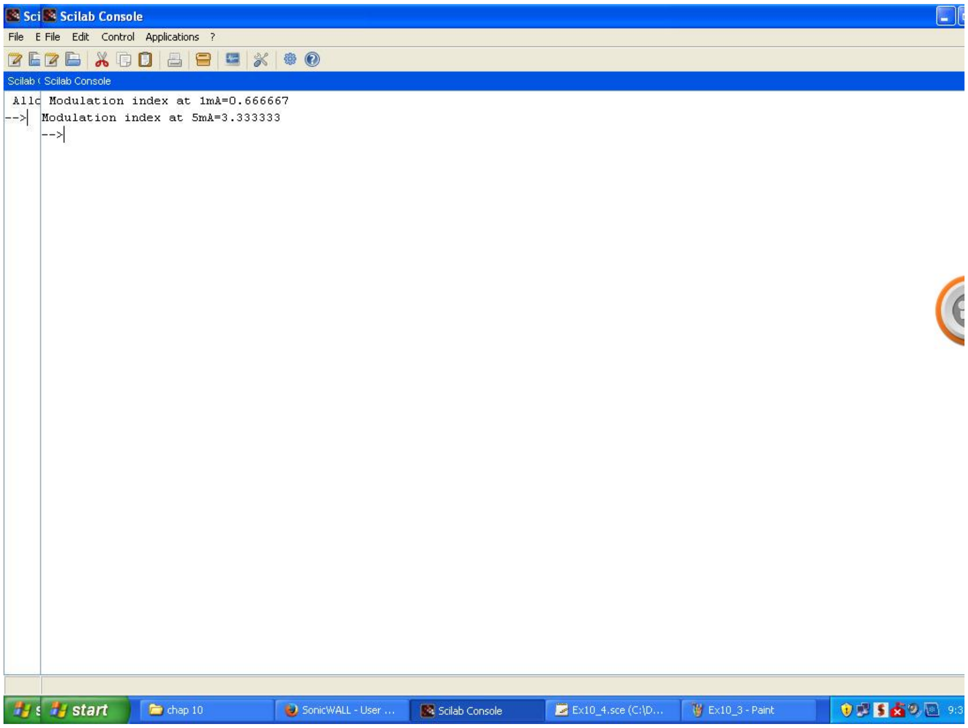


Figure 10.4: 4

```
//Scilab version 5.4.1
//given
clc;
clear all;
wc=20//wavelength change in Ghz/degree celcius
fo=100//frequency offset in MHz

//to find
allowed_change=fo*10^-3/wc//allowed change in temperature in degree celcius
mprintf("Allowed change is =%f degree Celcius",allowed_change)
```

Scilab code Exa 10.4 4

```
//fiber optic communications by joseph c. palais
//example 10.4
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc;
clear all;
deltaf=200//Frequency deviation in MHz/mA
fm=300//modulation frequency in MHz
pac_current1=1//peak ac current in mA
pac_current2=5//peak ac current in mA


//to find
deltaf1=deltaf*pac_current1//frequency deviation for
    1mA in MHz
deltaf2=deltaf*pac_current2//frequency deviation for
    5mA in MHz
beta1=deltaf1/fm//modulation index at 1mA
mprintf("Modulation index at 1mA=%f",beta1)
beta2=deltaf2/fm//modulation index at 5mA
mprintf("\nModulation index at 5mA=%f",beta2)
```

Scilab code Exa 10.5 5

```
//fiber optic communications by joseph c. palais
//example 10.5
//OS=Windows XP sp3
```

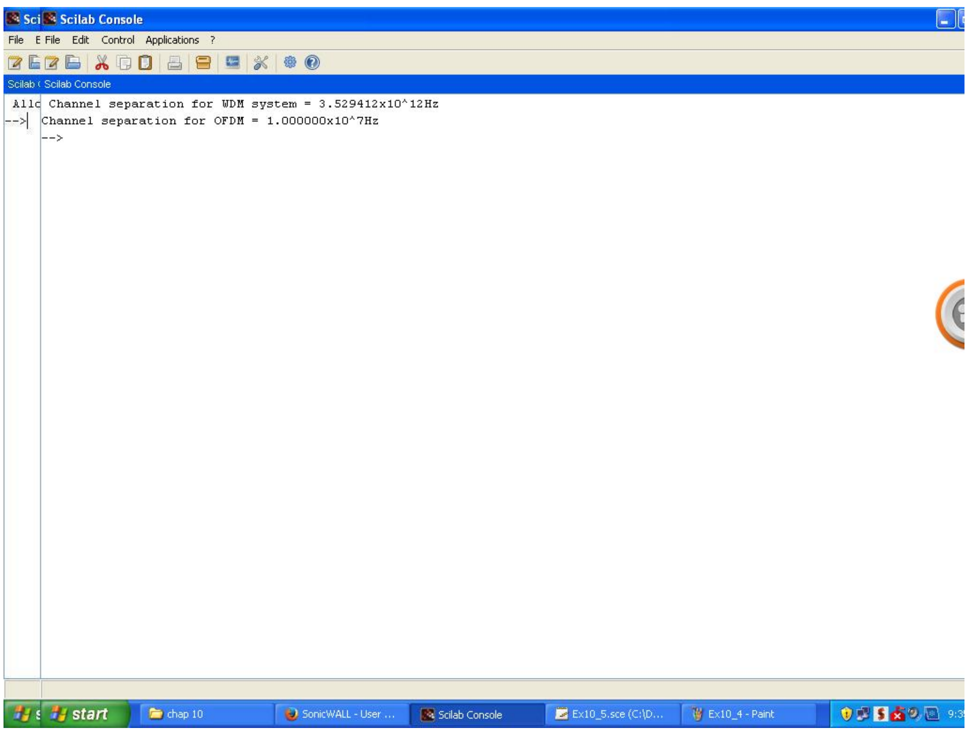

Scilab Console
File Edit Control Applications ?
Scilab Console
Channel separation for WDM system = 3.529412x10^12Hz
Channel separation for OFDM = 1.000000x10^7Hz
-->
start
chap 10
SonicWALL - User ...
Scilab Console
Ex10_5.sce (C:\D...
Ex10_4 - Paint

Figure 10.5: 5

```
//Scilab version 5.4.1
clc
//given
lambda=850*10^-9//spectral width in m
f_bw=0.01//fractional bandwidth
OS=1*10^9//optic separation in short wavelength window and IF frequency in Hz
delta_lambda=lambda*f_bw//spectral separation in m
c=3*10^8//speed of light
delta_f1=c*delta_lambda/(lambda^2)//channel separation in GHz in WDM
delta_f2=OS*f_bw//channel separation in GHz in OFDM
mprintf('Channel separation for WDM system = %fx10^12Hz',delta_f1/10^12)//division by 10^12 to convert the result in the form x10^12
mprintf('\nChannel separation for OFDM = %fx10^7Hz',delta_f2/10^7)//division by 10^7 to convert the result in the form x10^7
```

Chapter 11

Noise and Detection

Scilab code Exa 11.1 1

```
//fiber optic communications by joseph c. palais
//example 11.1
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
//given
lambda=0.85e-6//wave length in um
Pi=10*10^-3//led Power in W
L=20//fiber cable loss in dB
Row=0.5//respomsivity in A/W
ID=2*10^-9//Detector dark current in A
RL=50//load resistance in ohm
BW=10*10^6//receiver's bandwidth in Hz
Ta=300//temperature in Kelvin
SCL=14//source coupling loss in dB
CL=10//connector loss in dB
e=1.6*10^-19//charge of electron in columbs
```

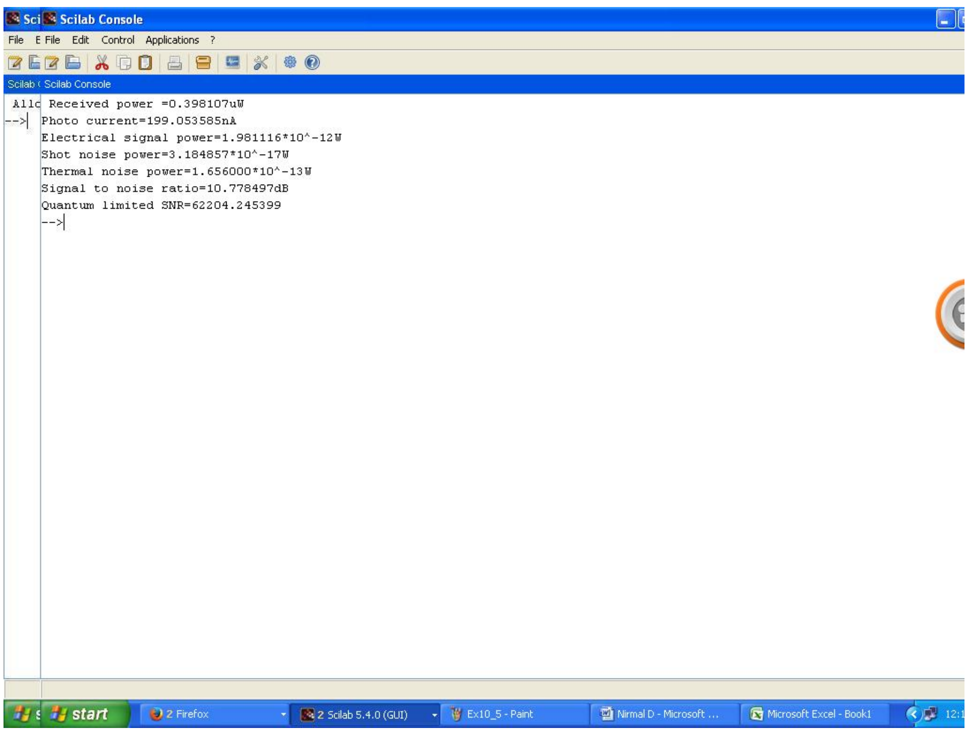

Scilab Console
File Edit Control Applications ?
Scilab Console
Received power =0.398107uW
Photo current=199.053585nA
Electrical signal power=1.981116*10^-12W
Shot noise power=3.184857*10^-17W
Thermal noise power=1.656000*10^-13W
Signal to noise ratio=10.778497dB
Quantum limited SNR=62204.245399
start
2 Firefox
2 Scilab 5.4.0 (GUI)
Ex10_5 - Paint
Nirmal D - Microsoft ...
Microsoft Excel - Book1

Figure 11.1: 1

```
k=1.38e-23//boltzman constant
//to find
TL=SCL+CL+L//total Loss in dB
Tn=10^(-TL/10)//transmission efficiency
PR=Pi*Tn//received power in W
is=Row*PR//photo current in A
PES=is^2*RL//Electrical signal power in W
PNS=2*e*is*BW*RL//shot noise power in W
PNT=4*k*Ta*BW//Thermal noise power in W
SNR=PES/PNT//signal to noise ratio
SNRdB=10*log10(SNR)//signal to noise ratio in dB
SNRQL=is/(2*e*BW)//quantum limited SNR


mprintf("Received power =%fuW",PR*10^6)//multiplication by 10^6 to convert the unit from W to uW
mprintf("\nPhoto current=%fnA",is*10^9)//multiplication by 10^9 to convert the unit from A to nA
mprintf("\nElectrical signal power=%f*10^-12W",PES*10^12)//multiplication by 10^12 to convert the unit from W to x10^-12W
mprintf("\nShot noise power=%f*10^-17W",PNS*10^17)//multiplication by 10^17 to convert the unit from W to x10^-17W
mprintf("\nThermal noise power=%f*10^-13W",PNT*10^13)//multiplication by 10^13 to convert the unit from W to x10^-13W
mprintf("\nSignal to noise ratio=%fdB",SNRdB)
mprintf("\nQuantum limited SNR=%f",SNRQL)
//this is the exact answer, book has taken approximated values of parameters  and its Quantum limited SNR is 62500
```

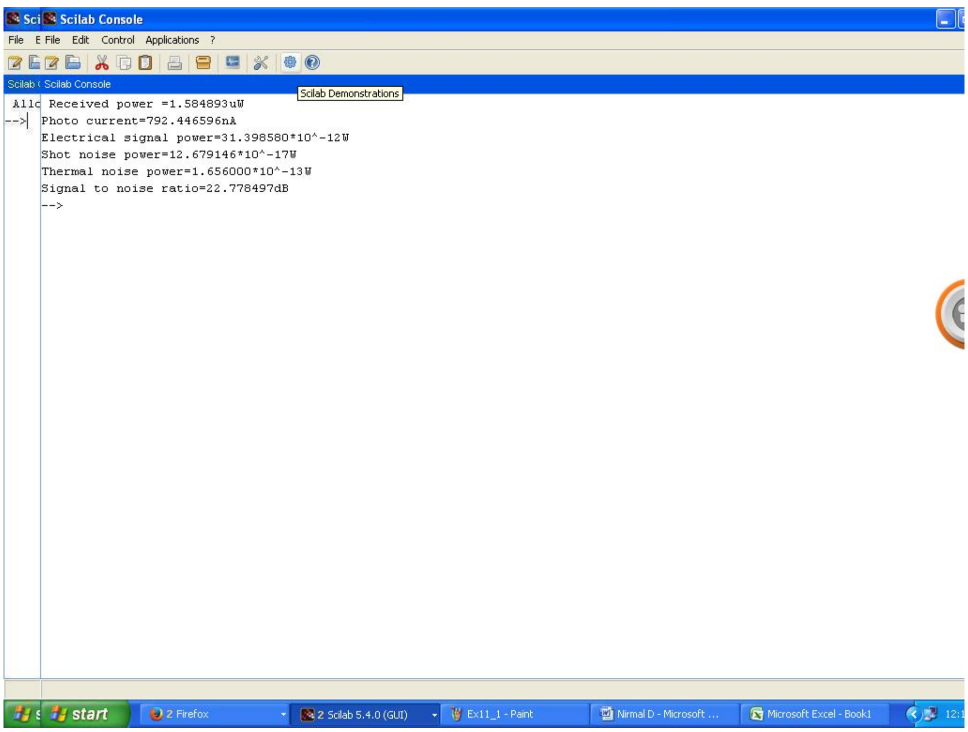

Scilab Console
File Edit Control Applications ?
Scilab Console
Scilab Demonstrations
Received power =1.584893uW
Photo current=792.446596nA
Electrical signal power=31.398580*10^-12W
Shot noise power=12.679146*10^-17W
Thermal noise power=1.656000*10^-13W
Signal to noise ratio=22.778497dB
-->
start
2 Firefox
2 Scilab 5.4.0 (GUI)
Ex11_1 - Paint
Nirmal D - Microsoft ...
Microsoft Excel - Book1

Figure 11.2: 2

Scilab code Exa 11.2 2

```
//fiber optic communications by joseph c. palais
//example 11.2
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
//given
lambda=0.85e-6//wave length in um
Pi=10*10^-3//led Power in W
L=20//fiber cable loss in dB
Row=0.5//respomsivity in A/W
ID=2*10^-9//Detector dark current in A
RL=50//load resistance in ohm
BW=10*10^6//receiver's bandwidth in Hz
Ta=300//temperature in Kelvin
SCL=14//source coupling loss in dB
CL=10//connector loss in dB
e=1.6*10^-19//charge of electron in columbs
k=1.38e-23//boltzman constant
DL=6//decreased loss in dB
//to find
TL=SCL+CL+L-DL//total Loss in dB
Tn=10^(-TL/10)//transmission efficiency
PR=Pi*Tn//received power in W
is=Row*PR//photo current in A
PES=is^2*RL//Electrical signal power in W
PNS=2*e*is*BW*RL//shot noise power in W
PNT=4*k*Ta*BW//Thermal noise power in W
SNR=PES/PNT//signal to noise ratio
SNRdB=10*log10(SNR)//signal to noise ratio in dB
```

```
mprintf("Received power =%fuW",PR*10^6)//multiplication by 10^6 to convert the unit from W to uW
mprintf("\nPhoto current=%fnA",is*10^9)//multiplication by 10^9 to convert the unit from A to nA
mprintf("\nElectrical signal power=%f*10^-12W",PES*10^12)//multiplication by 10^12 to convert the unit from W to x10^-12W
mprintf("\nShot noise power=%f*10^-17W",PNS*10^17)//multiplication by 10^17 to convert the unit from W to x10^-17W
mprintf("\nThermal noise power=%f*10^-13W",PNT*10^13)//multiplication by 10^13 to convert the unit from W to x10^-13W
mprintf("\nSignal to noise ratio=%fdB",SNRdB)
```

Scilab code Exa 11.3 3

```
//fiber optic communications by joseph c. palais
//example 11.3
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
//given
lambda=0.85e-6//wave length in um
Pi=10*10^-3//led Power in W
L=20//fiber cable loss in dB
Row=0.5//respomsivity in A/W
ID=2*10^-9//Detector dark current in A
RL=50//load resistance in ohm
```

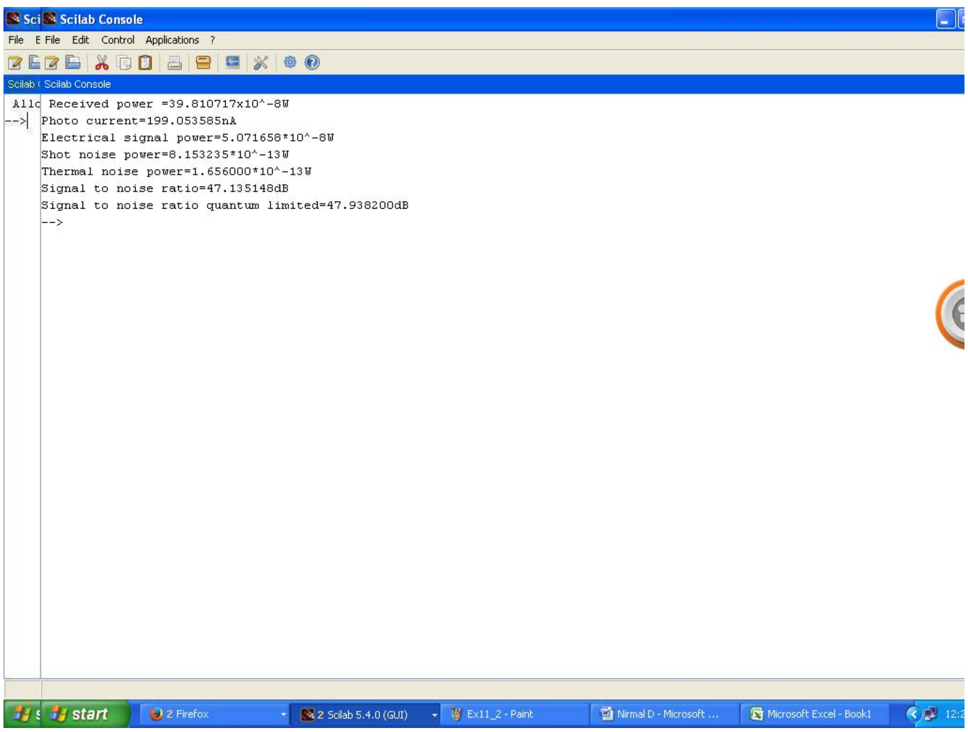

Scilab Console
File Edit Control Applications ?
Scilab Console
Received power =39.810717x10^-8W
Photo current=199.053585nA
Electrical signal power=5.071658*10^-8W
Shot noise power=8.153235*10^-13W
Thermal noise power=1.656000*10^-13W
Signal to noise ratio=47.135148dB
Signal to noise ratio quantum limited=47.938200dB
-->

Figure 11.3: 3

```
BW=10*10^6//receiver's bandwidth in Hz
Ta=300//temperature in Kelvin
SCL=14//source coupling loss in dB
CL=10//connector loss in dB
e=1.6*10^-19//charge of electron in columbs
k=1.38e-23//boltzman constant
M=160//multiplication factor
//to find
TL=SCL+CL+L//total Loss in dB
Tn=10^(-TL/10)//transmission efficiency
PR=Pi*Tn//received power in W
is=Row*PR//photo current in A
PES=is^2*RL*M^2//Electrical signal power in W
PNS=2*e*is*BW*RL*M^2//shot noise power in W
PNT=4*k*Ta*BW//Thermal noise power in W
SNR=PES/(PNT+PNS)//signal to noise ratio
SNRdB=10*log10(SNR)//signal to noise ratio in dB
SNRQL=is/(2*e*BW)//quantum limited SNR
SNRQLdB=10*log10(SNRQL)//quantum limited SNR in dB
//mprintf("Received power =%fx10^-8W",PR*10^8)//multiplication by 10^8 to convert the unit from W to x10^-8W
//mprintf("\nPhoto current=%fnA",is*10^9)//multiplication by 10^9 to convert the unit from A to nA
mprintf("\nElectrical signal power=%f*10^-8W",PES*10^8)//multiplication by 10^12 to convert the unit from W to x10^-8W
mprintf("\nShot noise power=%f*10^-13W",PNS*10^13)//multiplication by 10^13 to convert the unit from W to x10^-13W
mprintf("\nThermal noise power=%f*10^-13W",PNT*10^13)//multiplication by 10^13 to convert the unit from W to x10^-13W
mprintf("\nSignal to noise ratio=%fdB",SNRdB)//The answers vary due to round off error
mprintf("\nSignal to noise ratio quantum limited=%fdB",SNRQLdB)// The answers vary due to round
```

```
off error
```

Scilab code Exa 11.4 4

```
//fiber optic communications by joseph c. palais
//example 11.4
//OS=Windows XP sp3
//Scilab version 5.4.1
//given
clc
clear all
//given
lambda=0.85e-6//wave length in um
Row=0.5//respomsivity in A/W
ID=2*10^-9//Detector dark current in A
RL=100//load resistance in ohm
deltaf=1*10^6//receiver's bandwidth in Hz
T=300//temperature in Kelvin
e=1.6*10^-19//charge of electron in columbs
k=1.38e-23//boltzman constant

//to find

for i=1:6
    RL1(i)=10^(i*2);//range of load resistance in ohm
    logRL(i)=log10(RL1(i))//log scale representation of load resistance
    iNT(i)=sqrt(4*k*T*deltaf/RL1(i))//rms thermal noise current in A
iNSD(i)=sqrt(2*e*ID*deltaf)//rms shot noise current in A
NEP(i)=sqrt(iNSD(i)^2+iNT(i)^2)/(R*sqrt(deltaf))//Noise equivalent power (NEP) in W/Hz^1/2

```

```
logNEP(i)=log10(NEP(i))
end
iNT1=sqrt(4*k*T*deltaf/RL)//rms thermal noise
    current in A
iNSD1=sqrt(2*e*ID*deltaf)//rms shot noise current in
     A
NEP1=sqrt(iNSD1^2+iNT1^2)/(R*sqrt(deltaf))//Noise
    equivalent power (NEP) in W/Hz^1/2
Pmin=NEP1*sqrt(deltaf)//minimum detectable power
mprintf("Minimum detectable power =%fnW",Pmin*10^9)
    //multiplication by 10^9 to convert unit from W
    to nW
plot2d('ll', RL1, NEP)

xtitle( "Noise equivalent power for a PIN diode
    having 2nA of Dark current and a 0.5W/A
    responsivity at 300K", "Load Resistance (Ohms)",
    "NEP  (W/Hz^1/2)") ;
```

Scilab code Exa 11.5 5

```
//fiber optic communications by joseph c. palais
//example 11.5
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
 clear all
//given
RL=100//load in ohm
T=300//temperature in kelvin
lambda=0.82*10^-6//wavelength in um
```

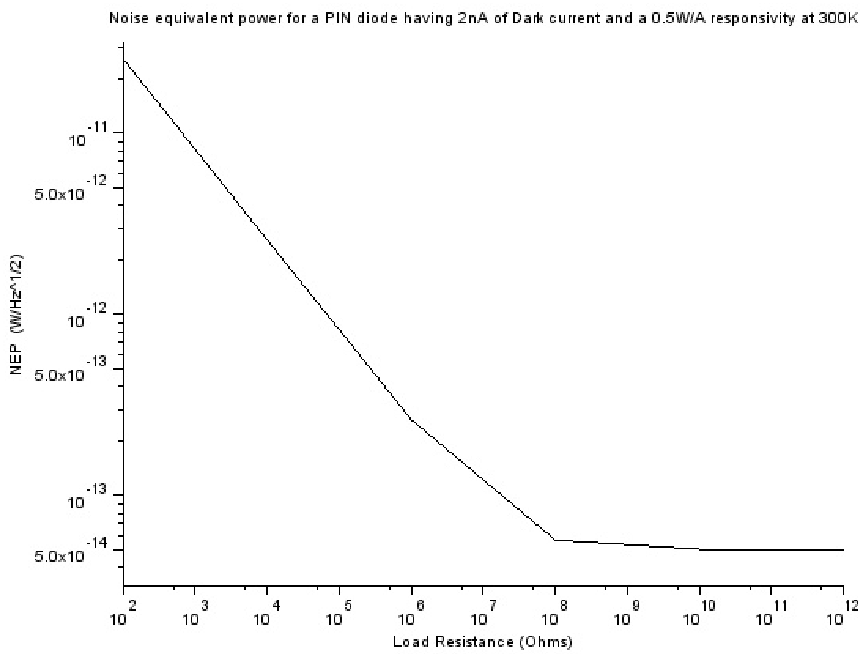

Noise equivalent power for a PIN diode having 2nA of Dark current and a 0.5W/A responsivity at 300K
NEP (W/Hz^1/2)
Load Resistance (Ohms)

Figure 11.4: 4

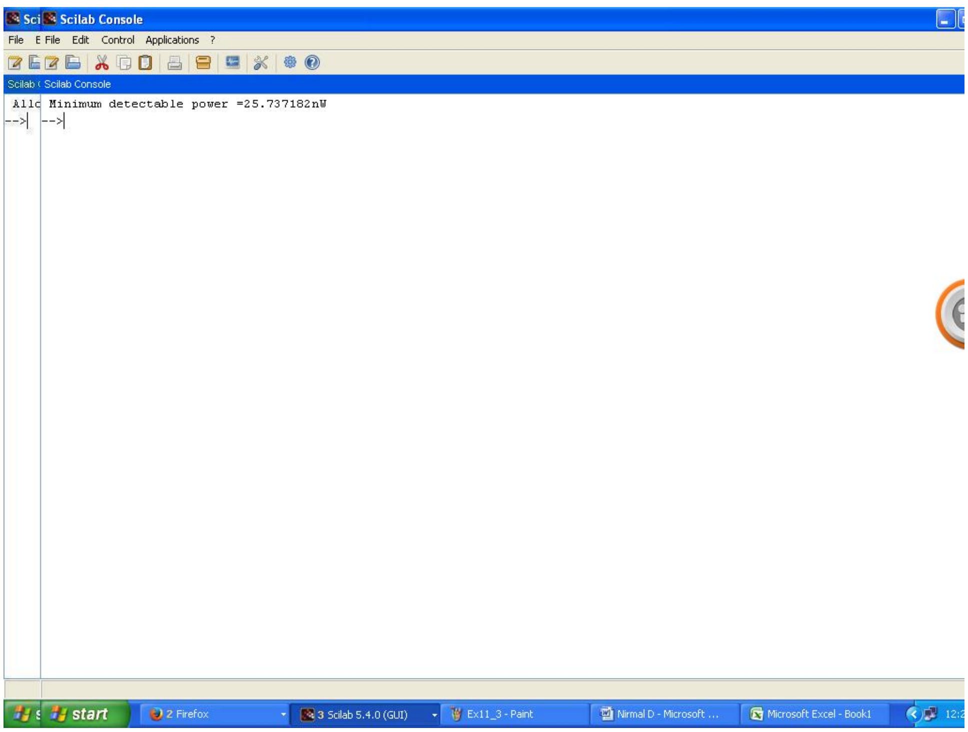

Scilab Console
File Edit Control Applications ?
Scilab Console
Minimum detectable power =25.737182nW
-->
start
2 Firefox
3 Scilab 5.4.0 (GUI)
Ex11_3 - Paint
Nirmal D - Microsoft ...
Microsoft Excel - Book1

Figure 11.5: 4

```
e=1.6e-19//charge of electron in colums
k=1.38e-23//boltzman constant
h=6.63e-34//plancks constant
deltaf=1e6//link bandwidth in Hz
Error_rate=10^-4//desired error rate
eta=1//quantum efficiency
c=3*10^8//speed of light in m/s
snr=17.5//Signal to noise ratio from plot
    correspnding to error rate of 10^-4 in dB
SNR=10^(snr/10)//signal to noise ratio in normal
    scale
tau=10^-6//bit interval in Sec
//to find
f=c/lambda//optic frequency in Hz
P=(h*f/(eta*e) )*sqrt((4*k*T*deltaf)/RL)*sqrt(SNR)//
    Optic power incident in Watts
mprintf("Optic power incident=%fnW",P*10^9)//
    multiplication by 10^9 is to convert the unit
    from W to nW
i=eta*e*P/(h*f)//current in Amperes
mprintf("\nCurrent=%fnA",i*10^9)//multiplication by
    10^9 is to convert the unit from A to nA
np=P/(h*f)*tau// No. of photons per bit
mprintf("\nNo. of Photons per bit=%fx10^5 photons/
    bit",np/10^5)//multiplication by 10^5 is to
    convert the unit x10^5
```

Scilab code Exa 11.6 6

```
//fiber optic communications by joseph c. palais
//example 11.6
```

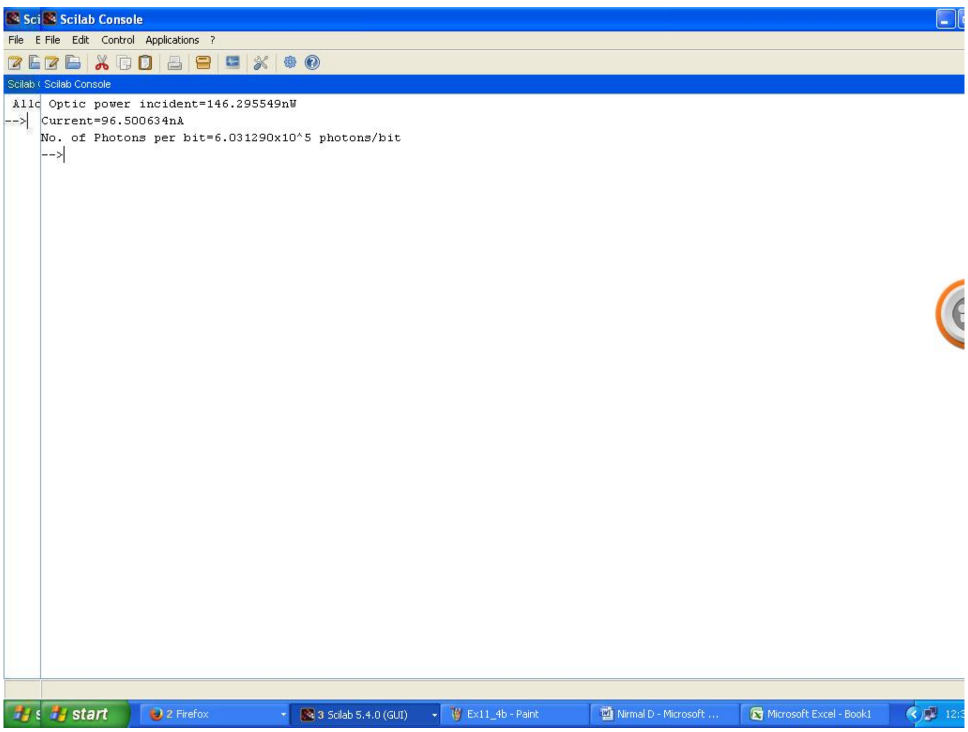
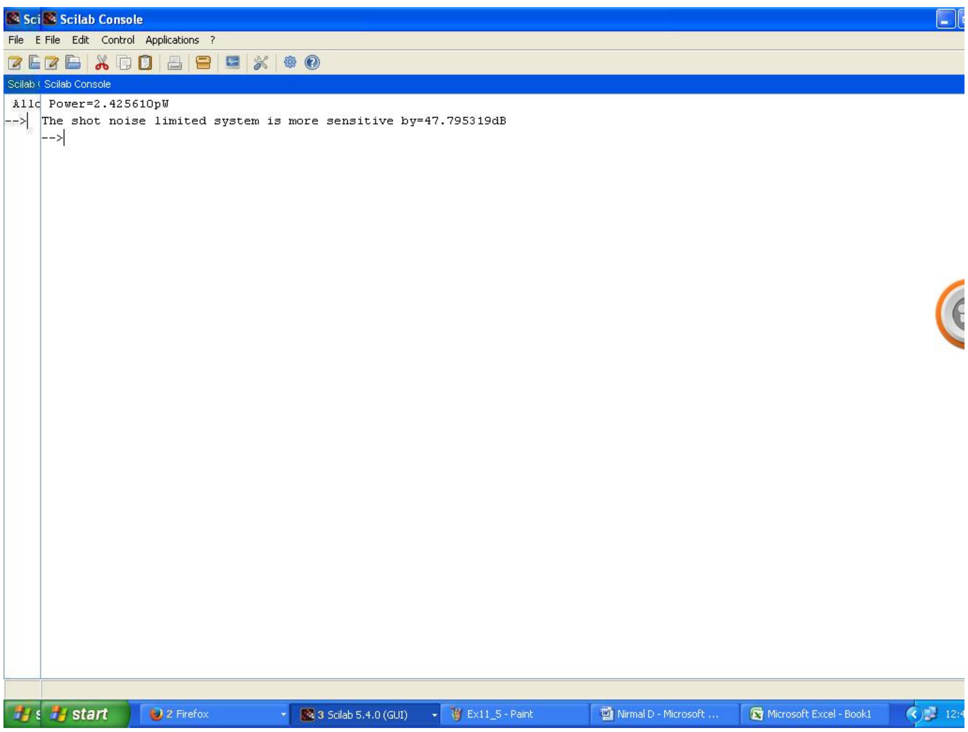

Scilab Console
File Edit Control Applications ?
Scilab Console
Optic power incident=146.295549nW
Current=96.500634nA
No. of Photons per bit=6.031290x10^5 photons/bit
-->
start
2 Firefox
3 Scilab 5.4.0 (GUI)
Ex11_4b - Paint
Nirmal D - Microsoft ...
Microsoft Excel - Book1

Figure 11.6: 5



Scilab Console
File Edit Control Applications ?
Scilab Console
Power=2.425610pW
The shot noise limited system is more sensitive by=47.795319dB
-->
start
2 Firefox
3 Scilab 5.4.0 (GUI)
Ex11_5 - Paint
Microsoft Excel - Book1

Figure 11.7: 6

```
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
lambda=0.82e-6//wave length in m
h=6.63e-34//planks constant
tau=1e-6//bit period in Sec
c=3e8//light speed in m/s
ns=10//no. of photons required per bit
eta=1//Quantum efficiency
Pt=146*10^-9//power in thermal system from Ex11
    .5=146nW
//to find
P=(h*c*ns)/(eta*lambda*tau)// optic power in W
mprintf("Power=%fpW",P*10^12)
sensitivity=10*log10(Pt/P)//The shot noise limited
    system sensitivity
mprintf("\nThe shot noise limited system is more
    sensitive by=%fdB",sensitivity)
```

Scilab code Exa 11.7 7

```
//fiber optic communications by joseph c. palais
//example 11.7
//OS=Windows XP sp3
clc
clear all
//given
Pi=2e-12//signal power in W
K=1.38e-23//temperature in kelvin
deltaf=1e7//bandwidth in Hz
TA=300//Ambient temperature in Kelvin
```

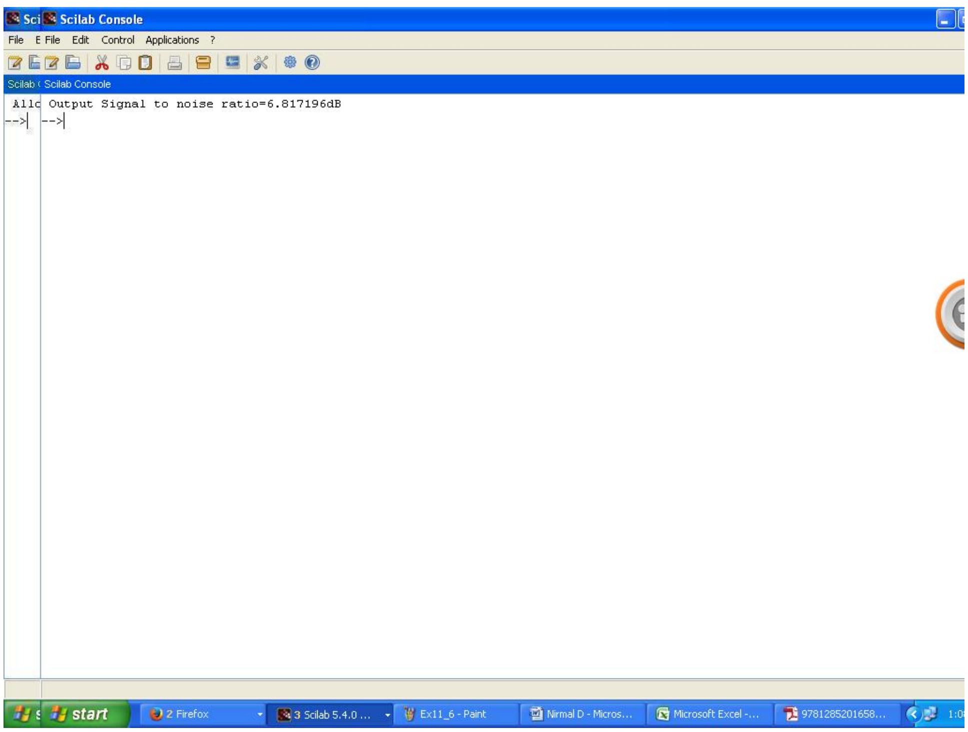

Scilab Console
File Edit Control Applications ?
Scilab Console
Output Signal to noise ratio=6.817196dB
-->

Figure 11.8: 7

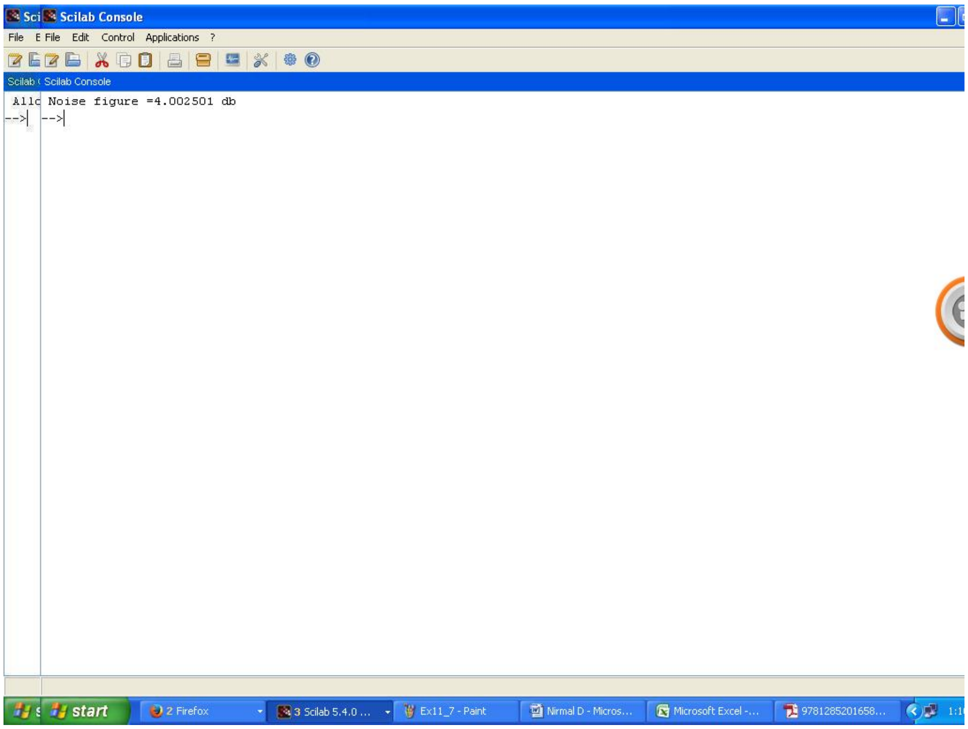


Figure 11.9: 8

```
T=454//noise temperature in Kelvin
PNT=1.66*10^-11//thermal noise power in W at 300K
G=10//power gain of amplifier in dB
//to find
Te=T+TA//equivalent noise temperature in Kelvin
PN=4*K*Te*deltaf//Noise power in W
SNR=Pi/PN//Signal to noise ratio
SNRdb=10*log10(SNR)//Signal to noise ratio in dB
mprintf("Output Signal to noise ratio=%fdB",SNRdb)
```

Scilab code Exa 11.8 8

```
//fiber optic communications by joseph c. palais
//example 11.8
//given
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
TA=300//Ambient temperature in Kelvin
T=454//noise temperature in Kelvin
//to find
F=1+(T/TA)//Noise figure
Fdb=10*log10(F)//Noise figure in dB
mprintf("Noise figure =%f db",Fdb)
```

Scilab code Exa 11.9 9

```
//fiber optic communications by joseph c. palais
//given
//example 11.9
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
alphadb=30//transmission loss in dB
Gi=1e3//gain
Fidb=3//noise figure of amplifier in dB
N=10//Number of amps
SNRin=1e8//signal to noise at transmitter at input
//to find
alpha=10^(alphadb/10)//transmission loss in normal
    scale
```

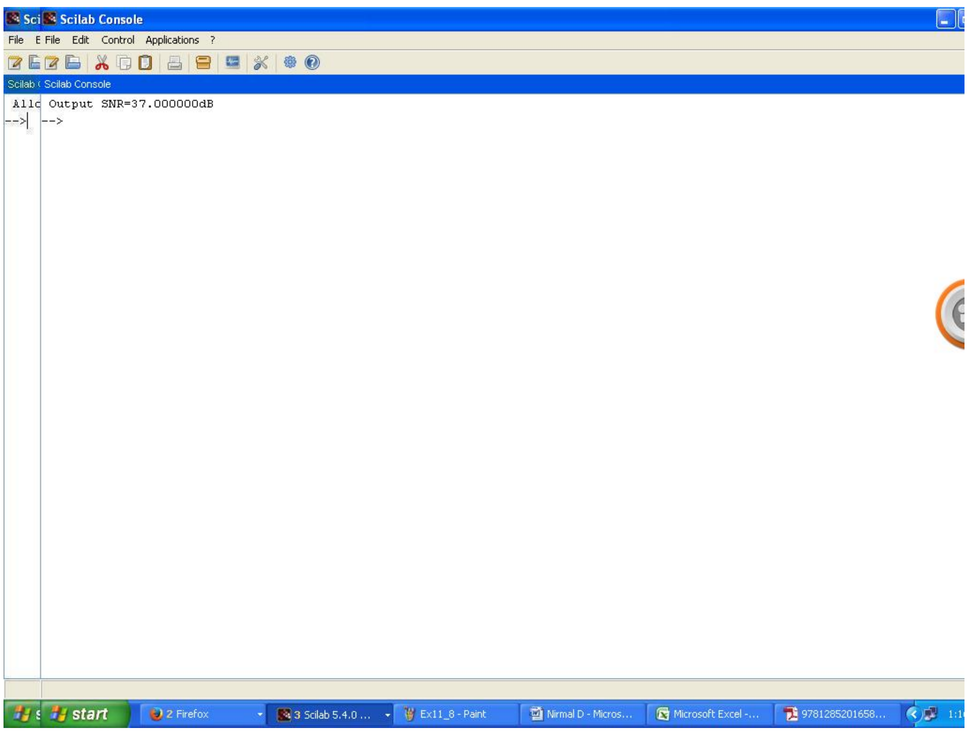


Figure 11.10: 9

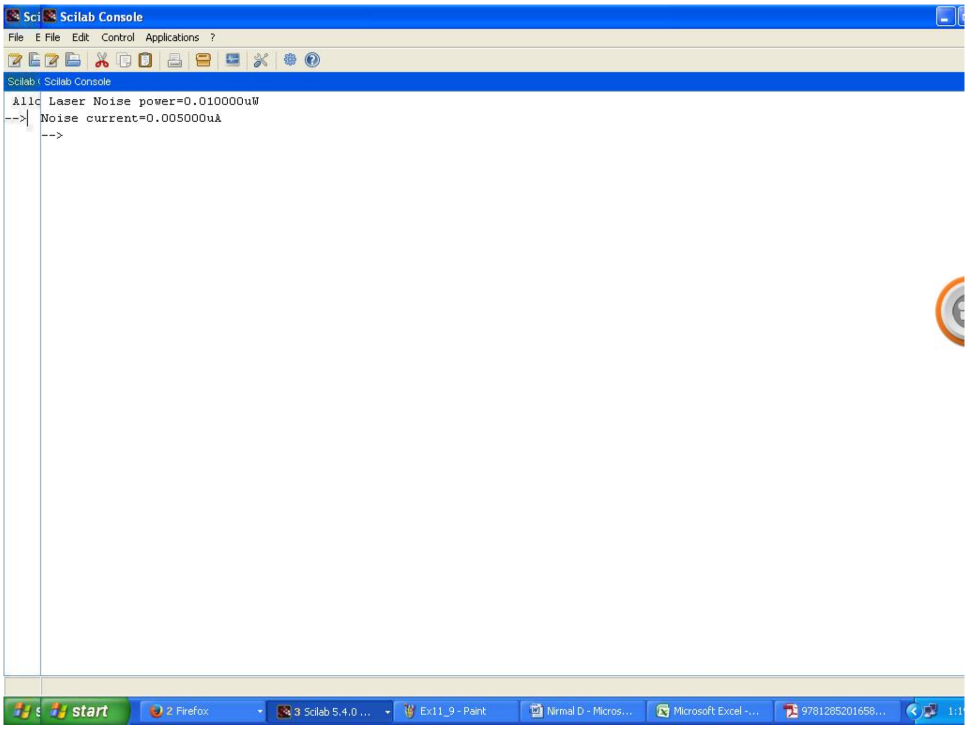


Figure 11.11: 10

```
Fi=10^(Fidb/10)//noise figure of amplifier in normal scale
F=N*Fi*Gi//Noise Figure
SNRout=SNRin/F//output signal to noise
SNRoutdb=10*log10(SNRout)//output signal to noise in dB
mprintf("Output SNR=%fdB",SNRoutdb)
```

Scilab code Exa 11.10 10

```
//fiber optic communications by joseph c. palais
```

```
//example 11.10
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
clear all
//given
RINdB=-140//RIN in dB/Hz
deltaf=100*10^6//bandwidth in Hz
P=10*10^-6//Average incident power in Watts
Row=0.5//Responsivity in uA/uW

//to find
RIN=10^(RINdB/10)//RIN in /Hz
PNL=sqrt(RIN*P^2*deltaf)//Laser Noise power in Watt
mprintf("Laser Noise power=%fuW",PNL*10^6)//
    multiplication by 10^6 to cinvert the unit from W
     to uW
IN=Row*PNL// Noise current in A
mprintf(" \nNoise current=%fuA",IN*10^6)//
    multiplication by 10^6 to cinvert the unit from A
     to uA
```

Chapter 12

System Design

Scilab code Exa 12.1 1

```
//fiber optic communications by joseph c. palais
//example 12.1
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
 clear all
//given
lambda=0.82//wavelength in um
ER=10^-9//Error rate
datarate=100//dta rate for RZ system in Mbps
NRZ_Qpl=-63//powerl level for NRZ in dBm from figure
    12.4
NRZ_TL=-36//thermal limit for NRZ in dBm from figure
    12.4
//to find
RZ_Qpl=NRZ_Qpl+3//powerl level for RZ in dBm
RZ_TL=NRZ_TL+3//thermal limit for RZ in dBm
//mprintf("Power level for NRZ=%fdBm",NRZ_Qpl)
//mprintf("\nThermal limit for NRZ =%fdBm",NRZ_TL)
mprintf("Power level for RZ=%fdBm",RZ_Qpl)
mprintf("\nThermal limit for RZ =%fdBm",RZ_TL)
```

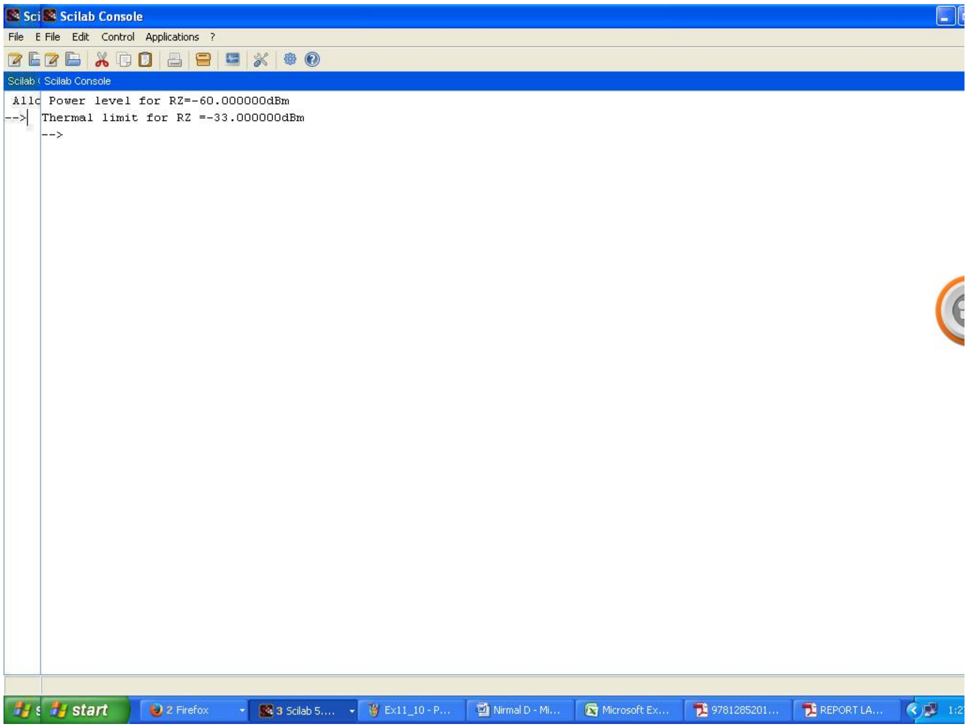


Figure 12.1: 1

Scilab code Exa 12.2 2

```
//fiber optic communications by joseph c. palais
//example 12.2
//OS=Windows XP sp3
//Scilab version 5.4.1
clc
 clear all
```

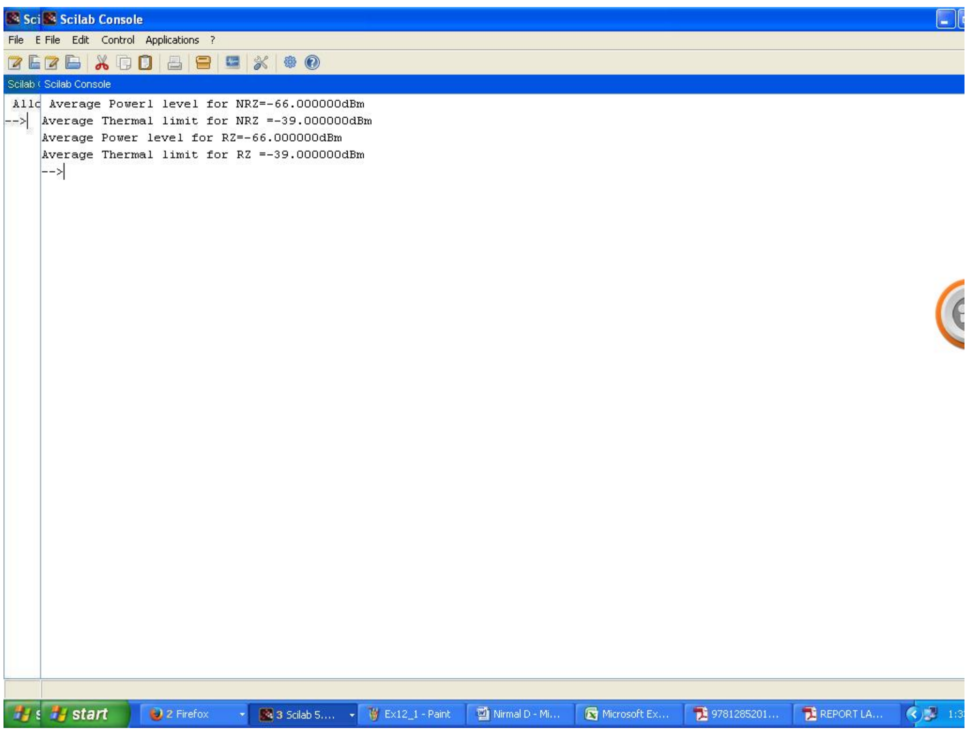

Scilab Console
File Edit Control Applications ?
Scilab Console
Average Powerl level for NRZ=-66.000000dBm
Average Thermal limit for NRZ =-39.000000dBm
Average Power level for RZ=-66.000000dBm
Average Thermal limit for RZ =-39.000000dBm
-->

Figure 12.2: 2

```
//given
//from example 12.1
lambda=0.82//wavelength in um
ER=10^-9//Error rate
datarate=100//dta rate for RZ system in Mbps
NRZ_Qpl=-63//powerl level for NRZ in dBm
NRZ_TL=-36//thermal limit for NRZ in dBm
//to find
RZ_Qpl=NRZ_Qpl+3//powerl level for RZ in dBm from fig 12.4
RZ_TL=NRZ_TL+3//thermal limit for RZ in dBm from fig 12.4
Avg_NRZ_Qpl=NRZ_Qpl-3//Average for NRZ is half so 3 db LESS in dBm
Avg_NRZ_TL=NRZ_TL-3//Average for NRZ is half so 3db LESS in dBm
Avg_RZ_Qpl=RZ_Qpl-6//Average for RZ is ONE FOURTH so 6db LESS in dBm
Avg_RZ_TL=RZ_TL-6//Average for RZ is ONE FOURTH so 6 db LESS in dBm

mprintf("Average Powerl level for NRZ=%fdBm",Avg_NRZ_Qpl)
mprintf("\nAverage Thermal limit for NRZ =%fdBm",Avg_NRZ_TL)
mprintf("\nAverage Power level for RZ=%fdBm",Avg_RZ_Qpl)
mprintf("\nAverage Thermal limit for RZ =%fdBm",Avg_RZ_TL)
```