FIBER OPTICS
Parameters

Physics lab 2 -PROJECT

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Preface

We have made this report file on the topic Fiber Optics Parameters. We have tried our best to elucidate all the relevant details to the topic in the report. While in the beginning , We have tried to give a general view about this topic. Our efforts and whole hearted cooperation of each group member has ended on a successful note. We express our sincere gratitude to Dr. Sandeep Chhoker who gave us this golden opportunity which helped us to get a much clear understanding on Fiber Optics. We thank him for providing us the reinforcement, confidence and most importantly the track for the topic whenever we needed it.

COMPILANCE CERTIFICATE

For fulfilment of project based learning requirement pertaining to physics lab 2 course taught by Dr.Sandeep Chhoker during semester 2 of academic year 2021-22.

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Contents

INTRODUCTION

Fiber optics, or optical fiber, refers to the technology that transmits information as light pulses along a glass or plastic fiber. A fiber optic cable can contain a varying number of these glass fibers -- from a few up to a couple hundred. Another glass layer, called *cladding*, surrounds the glass fiber core. The buffer tube layer protects the cladding, and a jacket layer acts as the final protective layer for the individual strand. Fiber optic cables are commonly used because of their advantages over copper cables. Some of those benefits include higher bandwidth and transmit speeds. Fiber optics is used for long-distance and high-performance data networking. It is also commonly used in telecommunication services, such as internet, television and telephones.

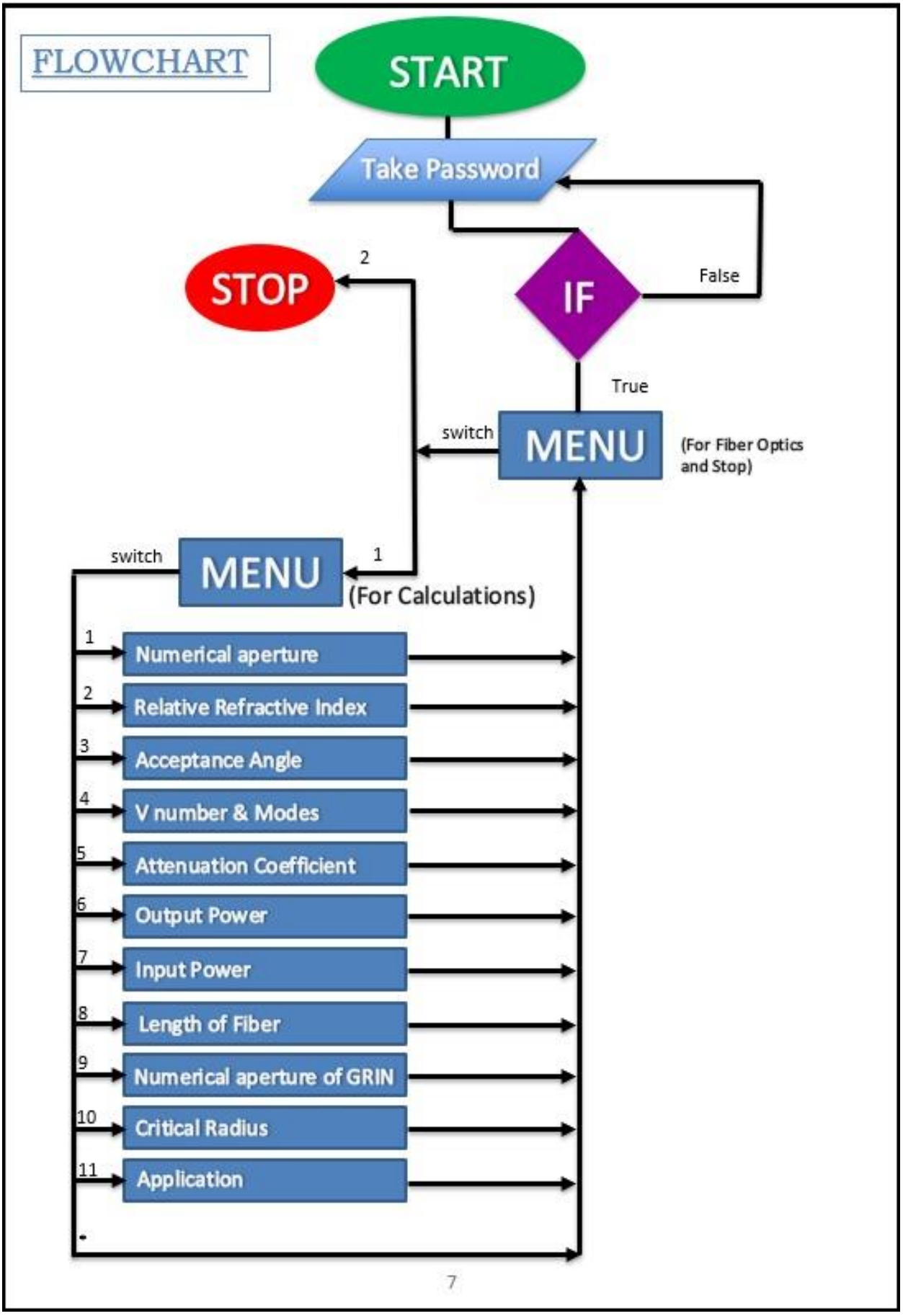
PROBLEM STATEMENT

The problem statement of the report is to find various parameters such as critical angle, numerical aperture, number of modes, cut off parameters, critical radius, attenuation coefficient etc. when certain other parameters are given such as refractive index of core, refractive index of cladding, diameter of core, angle of incidence of light, length of fiber etc.

This problem could be resolved via a c++ code where by just inputting some values we could get each and every desired parameter of fiber optics.

Graphical representation of algorithm of the same is followed.

METHODOLOGY



Explanation-

We have used C++ language to implement above flow chart.We form a class named FiberOptics and define 11 member functions in it as given in flow chart.In the driver code main, we asked the choice from user to enter 1 for fiber optics calculations and 2 exit.If user chooses one then again we provide choice to select any one calculation and hence we call the corresponding member function to perform the required calculation.

SPECIAL FEATURES-

1:PASSWORD:This feature provides only owner access. So, no other can access the application if he/she is not aware about password.

2:BEEP SOUND: Whenever user will enter wrong input then immediately a beep sound will be created followed by "Wrong input!" statement.

3:COLOR VARIENT: Different colours in different functions are used by us to make code output interactive and best looking.

4:PATTERNS:Different patterns at different positions are used to make project good looking.

5:USER FRIENDLY: Instructions are properly given at every statement and

6:ERROR HANDLING : Code is written in such a way that it can handle any wrong input by the user at any time and at any place.

7-COMMENTS : It is very easy to understand code with the help of comments provided in the code at all relevant and required places.

FORMULAE USED

1. Numerical aperture=$(n_1^2-n_2^2)^{½}$
2. Relative refractive index=(n1-n2)/n1;
3. Acceptance angle=$\sin^{-1}((n_1^2-n_2^2)^{½})$
4. V number=π*Numerical aperture*d/λ
5. Number of modes=$(V\ number)^2/2$
6. Attenuation coefficient=-(10/a)*(log10(k))
7. Critical radius for multimode fiber: $(3*n_1^2*\lambda)/(4*3.14*g^{3/2})$

   And Critical radius for single mode fiber: $3*(n_1)^2*½*\lambda_c$
8. λ_c= (π*d*numerical aperture)/2.405

where
n_1=refractive index of core
n_2=refractive index of cladding
λ=wavelength of light/signal
$k=p_{out}/p_{in}$
λ_c=crtical wavelength

Code

```
//Project is designed using OBJECT ORIENTED PROGRAMMING LANGUAGE C++
#include<iostream>
#include <conio.h>//Used because it contains getch() function which is used in password code.
#include <windows.h>//Used because it contains beep function to create sounds of different frequencies.
#include<math.h>//Used because it contains mathematical functions
float pi = 3.14159265359;
using namespace std;
//This is the class of Fiberoptics which contains various member functions which will perform various parameters operatons as per user choice.
class Fiberoptics{
    float n1,n2;
    public:
    void get(){
        system("color 0A");
        a:
        cout<<"\nEnter value of refrective index of core:";
        cin>>n1;
        if(n1<=0||!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input!";
            goto a;}
        lnew:
        cout<<"\nEnter value of refractive index of cladding:";
        cin>>n2;
        if(n2<=0||!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input!";
            goto lnew;}
        if(n1<n2){
            cout<<"\nWrong inputs- TIR not possible for this case as n1<n2.";
            goto a;
        }
    }
     //To calculate numerical aperture , i.e.; light gathering capacity of fiber.
    void NA(){
        system("color 2F");
        cout<<"\nLet the outside ambient medium be air";
        float na=sqrt(n1*n1-n2*n2);
        cout<<"\nThe numerical aperture of the given fiber is :"<<na;
    }
    //To calculate relative refractive index and percentage relative refractive index of fiber.
    void RRI(){
            system("color FD");
```

```
            float rr=(n1-n2)/n1;
            cout<<"\nThe relative refractive index of the given medium
is:"<<rr;
            cout<<"\nThe percentage relative refractive index of the given
fiber is:"<<rr*100<<"%";
    }
//To calculate the angle of acceptance of an optical fiber cable
    void AA(){
        system("color 4F");
        if((n1*n1-n2*n2)>1){
            cout<<"\nThis configuration is not possible";
            fflush(stdin);
            getchar();
            get();
        }
        cout<<"\nLet the outside ambient medium be air";
        float a=asin(sqrt(n1*n1-n2*n2));
        cout<<"\nThe acceptance of given fiber is "<<a*180/pi<<" degrees";
    }
    //To calculate the V number and possible number of modes of optical fiber.
    void VM(){
        system("color 02");
        cout<<"\nLet the outside ambient medium be air and the given fiber is
step index fiber";
        float d,w;
        label:
        cout<<"\nEnter diameter of fiber and wavelength of incident light in
same units:";
        cin>>d>>w;
        if(d<=0||w<=0||!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input!";
            goto label;}
        float v=(pi*d*sqrt(n1*n1-n2*n2))/w;
        cout<<"\nThe V number of the given fiber is:"<<v;
        if(v>2.405)
            cout<<"\nAs V number is greater than 2.405 so, the given fiber is
multimode fiber";
        else
            cout<<"\nAs V number is <= 2.405 so, the given fiber is stepindex
fiber";
        cout<<"\nNumber of modes possible by the given fiber
is:"<<floor(v*v/2);
    }
    //To calculate the attenuation losses (attenuation coeficient in dB/Km)
    void ACa(){
    system("color D");
    float po,pi,l;
    float a;
    cout<<"\nFor Attenuation Coefficient"<<endl;
    q:
```

```
    cout<<"\nEnter the output power(in W):";
    cin>>po;
    if(po<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto q;
    }
    g:
    cout<<"\nEnter the input power(in W):";
    cin>>pi;
    if(pi<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto g;
    }
    if(pi<po){
        Beep(300,500);
        cout<<"\nWrong input!";
        goto q;
    }
    dis:
    cout<<"\nEnter the distance(in km) between which the energy loss is
observed:";
    cin>>l;
    if(l<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto dis;
    }
    float k=po/pi;
    a=-(10/l)*(log10(k));
    cout<<"\nThe attenuation coefficient of fiber (in dB/km) is: "<<a<<"dB/km";
}
//To calculate the output power of an optical fiber after reduction of losses
in inputted power in optical fiber
void ACpo(){
    system("Color E4");
    float po,pi,l;
    float a;
    cout<<"\nFor Output Power:-"<<endl;
    lab:
    cout<<"\nEnter the value of attenuation coefficient (dB/km):";
    cin>>a;
    if(a<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
```

```
        cout<<"\nWrong input!";
        goto lab;
    }
    label:
    cout<<"\nEnter the input power(in W):";
    cin>>pi;
    if(pi<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto label;
    }
    Dis:
    cout<<"\nEnter the distance(in km) between which the energy loss is
observed:";
    cin>>l;
    if(l<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto Dis;
    }
    float k=-(a*l)/10;
    float x=pow(10,k);
    po=pi*x;
    cout<<"\nThe output power here is: "<<po<<" W";
}
//To calculate the inputted  power of an optical fiber if attenuation losses
and output power is known to us.
void ACpi(){
    system("Color 6");
    float po,pi,l;
    float a;
    cout<<"\nFor Input Power:-"<<endl;
    labelnew:
    cout<<"\nEnter the value of attenuation (dB/km):";
    cin>>a;
    if(a<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto labelnew;
    }
    labpo:
    cout<<"\nEnter the output power(in W):";
    cin>>po;
    if(po<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
```

```
        cout<<"\nWrong input!";
        goto labpo;
    }
     j:
    cout<<"\nEnter the distance(in km) between which the energy loss is
observed:";
    cin>>l;
    if(l<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto j;
    }
    float k=-(a*l)/10;
    float x=pow(10,k);
    pi=po/x;
    cout<<"\nThe input power here is: "<<pi<<" W";
}
//To calculate the length of optical fiber if output , input power and
attenuation losses are known to us.
void ACl(){
    system("Color 5");
    float po,pi,l;
    float a;
    cout<<"\nFor Length of Fiber"<<endl;
    newl:
    cout<<"\nEnter the output power(in W):";
    cin>>po;
    if(po<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto newl;
    }
    nl:
    cout<<"\nEnter the input power(in W):";
    cin>>pi;
    if(pi<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto nl;
    }
    all:
    cout<<"\nEnter the attenuation coefficient(in dB/km):";
    cin>>a;
    if(a<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
```

```
        cout<<"\nWrong input!";
        goto all;
    }
    float k=po/pi;
    l=-(10/a)*(log10(k));
    cout<<"\nThe length of fiber is: "<<l<<"km";
}
//To calculate the numerical aperture of graded index fiber.
void GRIN(){
    system("Color 9");
    float a,r;
    l1:
    cout<<"\nEnter the value of core radius:";
    cin>>a;
    if(a<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto l1;
    }
    l2:
    cout<<"\nEnter the value of position across core:";
    cin>>r;
    if(r>2*a||r<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto l2;
    }
    float rr=(n1-n2)/n1;
    //cout<<"\nIn the graded index fiber , the nuerical aperture is a function
of position across the core(r)";
    if(r<a){
        float var=r/a;
        if((2*rr*pow(var,2)>1)){
        Beep(300,500);
        cout<<"\nWrong inputs!";
        goto l1;
        }
        float g1=n1*sqrt(1-2*rr*pow(var,2));
        cout<<"\nThe numerical aperture of the graded index fibre will be:
"<<g1<<endl;
    }
    else{
        if((2*rr)>1){
        Beep(300,500);
        cout<<"\nWrong inputs!";
        goto l1;
        }
    float g=n1*sqrt(1-2*rr);
```

```
    cout<<"\nThe numerical aperture of the graded index fibre will be:
"<<g<<endl;}
}
//To calculate the critical radius of a given optical fiber cable on particular
operating wavelength.
void CR(){
    system("Color B");
    int mode;
    float critical_radius,g,l,lc,d;
    l3:
    cout<<"Enter the value for diameter index of core in centi-meters:"<<endl;
    cin>>d;//d:diameter of core
    if(d<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto l3;
    }
    l4:
    cout<<"\nEnter the value for operating wavelength:"<<endl;
    cin>>l;
    if(l<0||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto l4;
    }
    cho:
    cout<<"\nEnter 0 for single-mode optical fibre and 1 for multi-mode optical
fiber"<<endl;
    cin>>mode;
    if((mode!=0&&mode!=1)||!cin){
        cin.clear();
        fflush(stdin);
        Beep(300,500);
        cout<<"\nWrong input!";
        goto cho;
    }
    if(mode==1){
    g=pow(n1,2)-pow(n2,2);
    critical_radius=(3*pow(n1,2)*l)/(4*3.14*pow(g,1.5));//-----------
>l:operating wavelength
    cout<<"\ncritical radius of your multimode fiber is:"<<critical_radius<<"
"<<"centi-meters"<<endl;
}
else{
    g=pow(n1,2)-pow(n2,2);
    lc=3.14*d*pow(g,0.5)/2.405;//lc:cut-off wavelength
    critical_radius=((20*l)/g)*pow((((2.748)*lc-0.996*g)/lc),-3);
    cout<<"critical radius of your singlemode fiber is:"<<critical_radius<<"
"<<"centi-meters"<<endl;
```

```
}
}
//To explain various applications of optical fiber.
void application(){
    system("Color 5");
    cout<<"\nApplications of optical fibers are as follows:"<<endl;
    cout<<"1."<< " "<<"Optical Fibres uses in Medical industry:"<<endl;
    cout<<"Because of the extremely thin and flexible nature,it used in various
instruments to view internal body parts by inserting into hollow spaces in the
body.";
    cout<<"It is used as lasers during surgeries, endoscopy, microscopy and
biomedical research."<<endl;
    cout<<"2."<< " "<<"Optical Fibres used in Communication:"<<endl;
    cout<<"In the communication system, telecommunication has major uses of
optical fibre cables for transmitting and receiving purposes.";
    cout<<"It is used in various networking fields and even increases the speed
and accuracy of the transmission data.";
    cout<<"Compared to copper wires, fibre optics cables are lighter, more
flexible and carry more data."<<endl;
    cout<<"3."<< " "<<"Optical Fibres used in Defense Purpose:"<<endl;
    cout<<"Fibre optics are used for data transmission in high-level data
security fields of military and aerospace applications." ;
    cout<<" These are used in wirings in aircraft, hydrophones for SONARs and
Seismics applications."<<endl;
    cout<<"4."<< " "<<"Uses of Optical Fibre for Lightening and
Decorations:"<<endl;
    cout<<"they give an attractive, economical and easy way to illuminate the
area and ";
    cout<<"that is why it is widely used in decorations and Christmas
trees."<<endl;
    cout<<"5."<< " "<<"Optical Fibres used in Mechanical Inspections:"<<endl;
    cout<<"On-site inspection engineers use optical fibres to detect damages
and faults which are at hard to reach places.";
    cout<<"Even plumbers use optical fibres for inspection of pipes."<<endl;
}
};
//This is the driver code , which controls the complete flow of program .
int main(){
    system("color 4");
char mypassword[]="n123";
 START:
    system("cls");
    cout<<"\nEnter Password  : ";
    char pass[32];//to store password.
    int i = 0;
    char a;
    for(i=0;;)
    {
        a=getch();
        if((a>='a'&&a<='z')||(a>='A'&&a<='Z')||(a>='0'&&a<='9'))
            //check if a is numeric or alphabet
        {
            pass[i]=a;
```

```
            ++i;
            cout<<"*";
        }
        if(a=='\b'&&i>=1)//if user typed backspace
            //i should be greater than 1.
        {
            cout<<"\b \b";//rub the character behind the cursor.
            --i;
        }
        if(a=='\r')//if enter is pressed
        {
            pass[i]='\0';
            break;
        }
    }
    fflush(stdin);
     if(strlen(pass)==strlen(mypassword))
     {
        int len=strlen(pass);
        int i=0;
        while(len){
            if(pass[i]==mypassword[i])
            {
                i++;
            }
            else{
                Beep(300,500);
                cout<<"\nWRONG PASSWORD!";
                cout<<"\nPress enter to try again";
                getchar();
                goto START;
            }
            len--;
        }
    }
    else{
        Beep(300,500);
        cout<<"\nWRONG PASSWORD!";
        cout<<"\nPress enter to try again";
        getchar();
        goto START;
    }

Fiberoptics F;
int x;
int choice;
while(true)
{
system("cls");
system("color 9F");
cout<<"\n\n\n\n\n1:For Fiberoptics calculation\n2:Exit\nEnter choice:";
cin>>x;
if(!cin){
```

```
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input! Press enter to choose again";
            getchar();
            continue;
            }
cout<<"\n_____
_____\n";
switch(x){
    case 1:
        system("color 3F");
        label2:
        cout<<"\n\n1:For Numerical Aperture \n2: For Relative refractive
index:\n3:For acceptance angle \n4:For V number and Number of modes \n5:For
Attenuation Coefficient \n6:For Output Power\n7:For Input Power\n8:For Length
of Fiber\n9:For Numerical Aperture of graded index fiber\n10:For Critical
radius\n11:To know verious applications of optical fiber\nEnter choice:";
        cin>>choice;
        if(!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input!";
            goto label2;
            }
        switch(choice){
            case 1:
                F.get();
                F.NA();
                break;
            case 2:
                F.get();
                F.RRI();
               break;
            case 3:
                F.get();
                F.AA();
                break;
            case 4:
                F.get();
                F.VM();
                break;
            case 5:
                F.ACa();
                break;
            case 6:
                F.ACpo();
                break;
            case 7:
                F.ACpi();
                break;
            case 8:
```

```
                F.ACl();
                break;
            case 9:
                F.get();
                F.GRIN();
                break;
            case 10:
                F.get();
                F.CR();
                break;
            case 11:
                F.application();
                break;
            default:
                Beep(300,500);
                cout<<"\nwrong input";
                goto label2;
                break;
        }
        break;
    case 2:
        break;
    default:
        Beep(300,500);
        cout<<"\nwrong input!\nPress enter to try again";
        break;
}
if(x==2){
    system("cls");
    system("color F");
    cout<<"************************Program exit
successfully**************************";
    cout<<"\n_____________________________________________________________________
_____________________________________________\n";
    break;}
    fflush(stdin);
    getchar();
}
return 0;
}
//Respected sir , we have designed this project with great dedication.
//Hoping your positive response.
```

Few Screenshots of output

```
1:For Fiberoptics calculation
2:Exit
Enter choice:1

_____________________________________________________________________________________________________


1:For Numerical Aperture
2: For Relative refractive index:
3:For acceptance angle
4:For V number and Number of modes
5:For Attenuation Coefficient
6:For Output Power
7:For Input Power
8:For Length of Fiber
9:For Numerical Aperture of graded index fiber
10:For Critical radius
11:To know verious applications of optical fiber
Enter choice:1
```

```
Enter choice:1

Enter value of refrective index of core:2

Enter value of refractive index of cladding:1

Let the outside ambient medium be air
The numerical aperture of the given fiber is :1.73205
```

```
1:For Fiberoptics calculation
2:Exit
Enter choice:1

_____________________________________________________________________________________________________


1:For Numerical Aperture
2: For Relative refractive index:
3:For acceptance angle
4:For V number and Number of modes
5:For Attenuation Coefficient
6:For Output Power
7:For Input Power
8:For Length of Fiber
9:For Numerical Aperture of graded index fiber
10:For Critical radius
11:To know verious applications of optical fiber
Enter choice:2

Enter value of refrective index of core:2

Enter value of refractive index of cladding:1

The relative refractive index of the given medium is:0.5
The percentage relative refractive index of the given fiber is:50%
```

RESULT

We had tried to cover each and every aspect of fiber optics that was taught to us. We had tried to deal with every parameter and every formulae such as critical angle, numerical aperture, number of modes, critical radius ,V number and one could easily get these parameters with minimal requirement of several other parameters.
We had learnt a lot from this project.
Extreme concept clarity, improved coding skills and even we learnt how to deal in a group.
We are thankful that we are given this self learning based opportunity that at last had amended us.

FUTURE SCOPE

Today's global businesses demand faster, more secure and larger capacity communication systems for their network operations. Fiber optic technology is expected to play a major part in this growth. A research and market study determined that the compound annual growth rate for the fiber optic market could reach 8.5 percent by 2025, meaning more industries will be looking to the solutions presented by this technology. From healthcare systems to the marine environment, fiber optic cable is proving to be a crucial component of industrial infrastructure.

Fiber optic cable assemblies are also playing an increasingly vital role in residential applications. Homeowners now expect high-speed internet access as part of their daily lives, and telecom and data industry leaders are turning to fiber optic technology as a clean, reliable way to provide expected services. In the next five years and beyond, contractors expect to use fiber optic cable for improved connectivity in a wide variety of projects.

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