JAYPEE INSTITUTE OF INFORMATION TECHNOLOGY
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JAYPEE INSTITUTE OF INFORMATION TECHNOLOGY

PHYSICS LECTURE PBL
(Wave Propagation and Fiber optics)

SUBMITTED BY

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SUBMITTED TO

Dr. Suneet kumar Awasthi

Preface

I have made this report file on the topic Wave Propagation and Fiber optics parameters. I have tried my best to elucidate all the relevant details to the topic in the report. While in the beginning , I have tried to give a general view about this topic.My efforts ended on a successful note. I express my sincere gratitude to Dr. Suneet kumar Awasthi sir who gave me this golden opportunity which helped me to get a much clear understanding on Wave Propagation and Fiber optics. I thank him for providing us the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

COMPILANCE CERTIFICATE
OF
PBL OUTCOME

For the fulfillment of PBL requirement pertaining to the Physics 2 course taught by **Dr. S.K. Awasthi sir** during semester 2 of the academic year 2021 - 2022 . **Nitin Chaudhary** has successfully created the Physics project based learning on the topic **"Wave Propagation and Fiber Optics Parameters "** under the supervision of **Dr. Suneet kumar Awasthi sir.**

Signature

Nitin Chaudhary

Dr. Suneet kumar Awasthi Sir

Contents

INTRODUCTION

WAVE PROPAGATION-

Wave propagation refers to the travelling of electromagnetic wave. The discovery of EMW causes a drastic change in physics .

During the incidence of wave there might be two possibilities the it is normally incident on interface plane or it is oblically incident. Oblique incident further having two cases of transverse magnetic and transverse electric. The study of wave propagation results in a various discoveries like polarization of light by brewster's law , proof of phase change of light as told by stokes law etc.

FIBER OPTICS-

Fiber optics, or optical fiber, refers to the technology that transmits information as light pulses along a glass or plastic fiber. Another glass layer, called *cladding*, surrounds the glass fiber core.. Fiber optic cables are commonly used because of their advantages over copper cables. Some of those benefits include higher bandwidth and transmit speeds. It is also commonly used in telecommunication services, such as internet, television and telephone. Hence it is very important to study the various parameters of fiber optics.

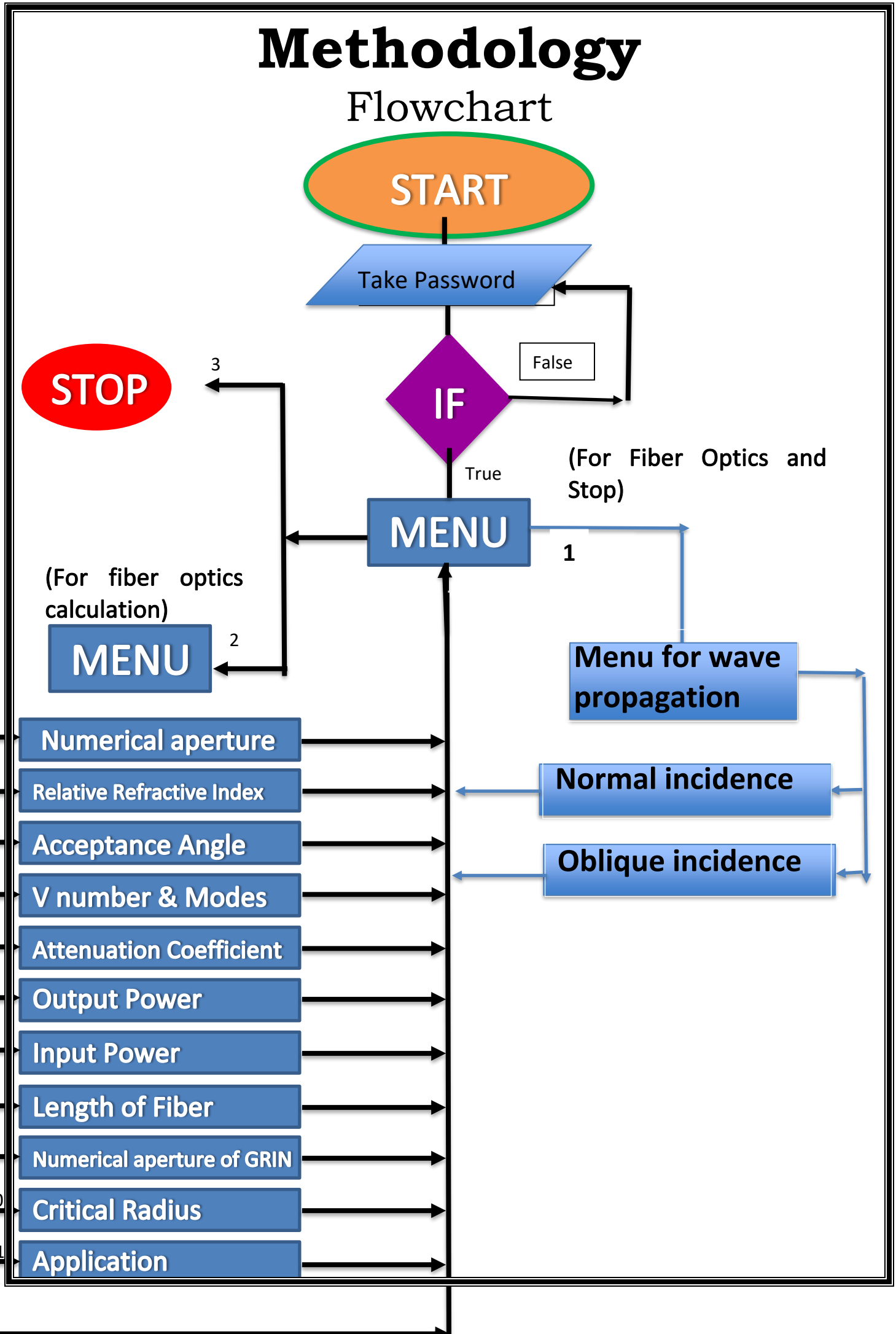
PROBLEM STATEMENT

The problem statement of the report is to find various parameters related to wave propagation and fiber optics such as Ratio of amplitude of reflected and refracted light to the amplitude of refracted light ,reflectance, transmittance , critical angle, numerical aperture, number of modes, cut off parameters, critical radius, attenuation coefficient etc. when other parameters are given such as refractive index of mediums involved,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 wave propagation and fiber optics.Graphical representation of algorithm of the same is followed.

Methodology

Flowchart



Explanation

I have used C++ OOP language to implement above flow chart. I forms two classes namely WavePropagation and FiberOptics respectively and defines 3 and 11 member functions respectively inside them as given in flow chart. In the driver code main, I asked the choice from user to enter 1 for wave propagation calculation ,2 for fiber optics calculations and 3 to 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.

This programs runs continuously till when you do not chooses 3 to exit.

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=$(\text{V number})^2/2$
6. Attenuation coefficient=-(10/a)*(log10(k))
7. Numerical aperture for graded index fiber=
8. Critical radius for multimode fiber: $(3*n_1^2*1)/(4*3.14*g^{3/2})$

And Critical radius for single mode fiber: $3*(n_1)^2*½*\lambda_c$

9. 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 boundary incidence contains member functons to perform various
operaions realted to incidence of light.
class WavePropagation{
    float n1,n2;
    public:
    void get(){
        system("color 5");
        label:
        cout<<"\nEnter value of refrective index of first medium ";
        cin>>n1;
        if(n1<=0||!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input!";
            goto label;}
            lnew:
        cout<<"\nEnter value of refractive index of second medium";
        cin>>n2;
        if(n2<=0||!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"\nWrong input!";
            goto lnew;
            }
    }
    void normal(){
        system("color 3");
        float r=(n1-n2)/(n1+n2);
        float t=(2*n1)/(n1+n2);
        cout<<"\nThe value of raito of Er to Ei is:"<<r;
        cout<<"\nThe value of raito of Et to Ei is:"<<t;
        cout<<"\nThe value of Reflectance(R) is:"<<r*r;
        cout<<"\nThe value of Transmittance(T) is:"<<(n2/n1)*t*t;
        cout<<"\nAs the sum of R and T is 1 , So Conservation of enery is proved.";
    }
    //For electric field is perpendicular to plane of incidence
    void oblique1(){
```

```
    system("color 6");
    float in;
    float ref;
    label:
    cout<<"\nEnter angle of incidence in degrees:";
    cin>>in;
    if(in==90||!cin){
        fflush(stdin);
        cin.clear();
        Beep(300,500);
        cout<<"\nWrong input!";
        goto label;
        }
        ln:
    in=in*pi/180;
    cout<<"\nEnter angle of refraction in degrees:";
    cin>>ref;
    if(ref==90||!cin){
        fflush(stdin);
        cin.clear();
        Beep(300,500);
        cout<<"\nWrong input!";
        goto ln;}
    ref=ref*pi/180;
    float r=(n1*cos(in)-n2*cos(ref))/(n1*cos(in)+n2*cos(ref));
    float t=(2*n1*cos(in))/(n1*cos(in)+n2*cos(ref));
    cout<<"\nThe value of raito of Er to Ei is:"<<r;
    cout<<"\nThe value of raito of Et to Ei is:"<<t;
    cout<<"\nThe value of Reflectance(R) is:"<<r*r;
    cout<<"\nThe value of Transmittance(T) is:"<<((n2*cos(ref))/(n1*cos(in)))*t*t;
    cout<<"\nAs the sum of R and T is 1 , So Conservation of enery is proved.";
}
  //For electric field is parallel to plane of incidence
 void oblique2(){
     system("color 9");
    float in;
    float ref;
    label:
    cout<<"\nEnter angle of incidence in degrees:";
    cin>>in;
    if(in==90||!cin){
        fflush(stdin);
        cin.clear();
        Beep(300,500);
        cout<<"\nWrong input!";
        goto label;}
    in=in*pi/180;
    labelne:
    cout<<"\nEnter angle of refraction in degrees:";
    cin>>ref;
    if(ref==90||!cin){
        fflush(stdin);
        cin.clear();
        Beep(300,500);
```

```
            cout<<"\nWrong input!";
            goto labelne;}
        ref=ref*pi/180;
        float r=(n2*cos(in)-n1*cos(ref))/(n2*cos(in)+n1*cos(ref));
        float t=(2*n1*cos(in))/(n2*cos(in)+n1*cos(ref));
        cout<<"\nThe value of raito of Er to Ei is:"<<r;
        cout<<"\nThe value of raito of Et to Ei is:"<<t;
        cout<<"\nThe value of Reflectance(R) is:"<<r*r;
        cout<<"\nThe value of Transmittance(T) is:"<<((n2*cos(ref))/(n1*cos(in)))*t*t;
        cout<<"\nAs the sum of R and T is 1 , So Conservation of enery is proved.";
    }
};

//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);
            Beep(300,500);
            cout<<"\nWrong input!";
            goto a;}
            la2:
        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 la2;}
        if(n1<n2){
            cout<<"\nWrong inputs- TIR not possible for this case as n1<n2.";
            goto a;
        }
    }
    //To calculate numerical aperture of fiber, 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 70");
    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 coefficient(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<<"\nEnter 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<<"\ncritical 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;
    }


WavePropagation B;
Fiberoptics F;
int x;
int choice;
while(true){
system("color 4");
system("cls");
cout<<"\n\n\n\n\n1:Wave Propagation \n2:For Fiberoptics calculation\n3:Exit\nEnter
choice:";
cin>>x;
if(!cin){
            fflush(stdin);
            cin.clear();
            Beep(300,500);
            cout<<"Wrong input! Press enter to choose again";
            getchar();
            continue;}
cout<<"\n_____________________________________________________________________________
_____________________________\n";
switch(x){
    case 1:
        label:
        system("color 9F");
        cout<<"\n\n1:For the case of Normal incidence \n2: For the case of Oblique
incidence:\nEnter choice:";
        cin>>choice;
        if(!cin){
            fflush(stdin);
            cin.clear();
```

```
            Beep(300,500);
            cout<<"\nWrong input!";
            goto label;}
        switch(choice){
            int obliquecase;
            case 1:
                B.get();
                B.normal();
                break;
            case 2:
                cout<<"\n1:For Electric field is perpendicular to place of incidence
\n2:For Electric field is parallel to plane of incidence\nEnter choice:";
                cin>>obliquecase;
                switch(obliquecase){
                    case 1:
                        B.get();
                        B.oblique1();
                        break;
                    case 2:
                        B.get();
                        B.oblique2();
                        break;
                    default:
                        break;
                }
                break;
            default:
                break;
        }
        break;


    case 2:
        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 3:
        break;
    default:
        Beep(300,500);
        cout<<"\nwrong input!\nPress enter to try again";
        break;
}
if(x==3){
    system("cls");
    system("color F");
    cout<<"\n********************Program exit successfully*****************************";
    cout<<"\n_____
_____\n";
    break;}
```

```
fflush(stdin);
getchar();
}
return 0;
}
//Respected sir , this project is formed by me with great dedication.
//Hoping your positive response.
```

Few Screenshots of output

```
1:Wave Propagation
2:For Fiberoptics calculation
3:Exit
Enter choice:1

------------------------------------------------------------------------


1:For the case of Normal incidence
2: For the case of Oblique incidence:
Enter choice:1

Enter value of refrective index of first medium 2

Enter value of refractive index of second medium1

The value of raito of Er to Ei is:0.333333
The value of raito of Et to Ei is:1.33333
The value of Reflectance(R) is:0.111111
The value of Transmittance(T) is:0.888889
As the sum of R and T is 1 , So Conservation of enery is proved.
```

```
1:Wave Propagation
2:For Fiberoptics calculation
3:Exit
Enter choice:2

------------------------------------------------------------------------


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 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
```

RESULT

I had tried to cover each and every aspect of wave propagation and fiber optics that was taught to me. I had tried to deal with every parameter and every formulae such as reflectance , transmittance ,critical angle, numerical aperture, number of modes, critical radius ,V number in all possible cases. One could easily get these parameters with minimal requirement of several other parameters. I had learnt a lot from this project.

Extreme concept clarity, improved coding skills .

I am thankful that I have been given this self learning based opportunity that at last had amended me.

FUTURE SCOPE

Wave propagation-

1. To provide the local radio communications coverage, we generally use ground wave propagation, especially by radio broadcast stations that are required to cover a particular locality.
2. Ground wave propagation can be used for one-way communication from the military to submerged submarines as they penetrate to a significant depth into seawater.
3. AM, FM, and television broadcasting can be done with the help of ground waves.
4. Ground wave propagation of radio signals is ideal for relatively short distance propagation on these frequencies during the daytime.

Fiber optics-

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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**********THANK YOU**********