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| **ASSIGNMENT** | |
| **Course Code** | BSC102B |
| **Course Name** | Engineering Physics |
| **Programme** | B.Tech |
| **Department** | CSE |
| **Faculty** | FET |

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| **Semester/Year** | 02/2018 |
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| Course Title | Engineering Physics | | | | | | | |
| Course Date |  | | to | |  | | | |
| Course Leader |  | | | | | | | |
| **Declaration**  The assignment submitted herewith is a result of my own investigations and that I have conformed to the guidelines against plagiarism as laid out in the Student Handbook. All sections of the text and results, which have been obtained from other sources, are fully referenced. I understand that cheating and plagiarism constitute a breach of University regulations and will be dealt with accordingly. | | | | | | | | |
| Signature of the Student | |  | | | | | Date |  |
| Submission date stamp  (by Examination & Assessment Section) | |  | | | | | | |
| Signature of the Course Leader and date | | | | Signature of the Reviewer and date | | | | |
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# **Contents**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[**Declaration Sheet** ii](#_Toc512216121)

[**Contents** iii](#_Toc512216122)

[**List of Figures** iv](#_Toc512216123)

[**Question No. 1** 5](#_Toc512216124)

[A.1 Principle of PCFs and GFO with schematic diagram: 5](#_Toc512216125)

[A.2 Light guidance mechanism in PCFs and GFO: 6](#_Toc512216126)

[A.3 Advantages and disadvantages of PCFs and GFO: 7](#_Toc512216127)

[A.3 Stance taken with justification: 9](#_Toc512216128)

[**Question No. 2** 10](#_Toc512216129)

[B.1.1 Calculate the Force required to stretch the wire, lateral strain and work done: 10](#_Toc512216130)

[B.1.2 Time Period for torsional oscillations: 11](#_Toc512216131)

[**Question No. 3** 13](#_Toc512216132)

[B.2.1 calculate the de Broglie wavelength, group velocity and phase velocity of the neutron. Justify whether this neutron beam can be diffracted by a crystal: 13](#_Toc512216133)

[B.2.2 calculate the wavelength of a photon which has the same energy as that of the neutron and identify the part of the electromagnetic spectrum into which it falls: 14](#_Toc512216134)

[B.2.3 Uncertainty in the measurement of the neutron velocity is 1%. Calculate the uncertainty in determining the position of the neutron: 14](#_Toc512216135)

[**Question No. 4** 15](#_Toc512216136)

[B.3.1 Calculate the Bragg angles for first order diffraction from (100), (110) and (111) planes: 15](#_Toc512216137)

[B.3.2 Calculate the density of the material, if the atomic weight is 107.5 kg/kmol: 16](#_Toc512216138)

[B.3.3 Specify the maximum order of diffraction that can be observed for (100) planes: 16](#_Toc512216139)

[**Question No. 5** 17](#_Toc512216140)

[B.4.1 Calculate the number of free electrons per unit volume, if each atom contributes a single valence electron: 17](#_Toc512216141)

[B.4.2 Determine the mean free path of the electrons: 17](#_Toc512216142)

[B.4.3 Calculate the magnitude of applied electric field to produce a drift velocity of : 18](#_Toc512216143)

# **List of Figures**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[Figure 1: Schematic diagram of standard step index optical fiber. 5](#_Toc512216488)

[Figure 2: Photonic Crystal Fiber cross-section 6](#_Toc512216489)

[Figure 3: Differing Photonic Crystal Fiber cross-sections 6](#_Toc512216490)

[Figure 4: Total Internal Reflection Signal Transmission 6](#_Toc512216491)

[Figure 5: A Typical Conventional Optical Fiber 7](#_Toc512216492)

[Figure 6: Cross Section Bandgap – guided fiber 7](#_Toc512216493)

[Figure 7: Attenuation spectral of conventional optical fiber(red) and PBG fiber(black) 8](#_Toc512216494)

# **Question No. 1**

**Solution to Question No. 1 part A:**

## A.1 Principle of PCFs and GFO with schematic diagram:

GFO:

A fiber optic is composed of three general components. The light signal is transmitted down the central portion called the core, which is composed of silica. The core is surrounded by a second layer called the cladding. The buffer coating protects the internal structure from damage.

The light wave travels the length of the fiber through the core by reflecting from the core-cladding interface. This effect is called total internal reflection

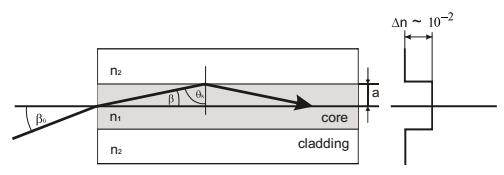


Figure : Schematic diagram of standard step index optical fiber.

PCFs:

The newest approach to solving the problem of signal degradation came on the heals of a prediction in the early 1990’s by Eli Yablonovitch. He predicted that certain three-dimensionally periodic photonic crystal structures contained complete photonic bandgaps. The presence of these bandgaps meant that for certain frequency range there were no propagating modes through the material. This means that if used as a cladding material, the signal would not be able to propagate into and through the cladding. This prediction opened the field of fiber optic manufacturing to the possibility of producing a core-cladding interface that produces total internal reflection.

These three dimensionally periodic crystal structures are however incredibly complicated to fabricate, requiring the correct refractive index contrast, pitch and structural integrity to achieve the desired interface behavior. The solution was to create a two-dimensionally periodic material that is periodic in the plane perpendicular to the axis of the fiber but constant along its length. This new technique in fiber development creates optically an excellent approximation of this 2-D structure by imbedding microscopic holes running the length of the cladding parallel to the core axis as shown in Figure 3.

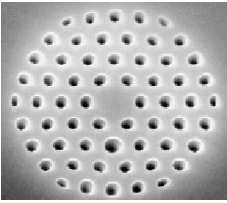


Figure : Photonic Crystal Fiber cross-section

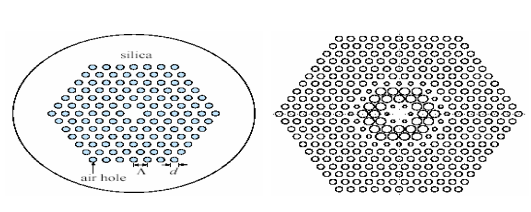


Figure : Differing Photonic Crystal Fiber cross-sections

## A.2 Light guidance mechanism in PCFs and GFO:

GFO:

Optical communication over the years has relied on conventional optical fibers whose main guiding mechanism is essentially the phenomenon of total internal reflection. Light is trapped in an inner transparent solid core wrapped with a second material (cladding) of higher index of refraction

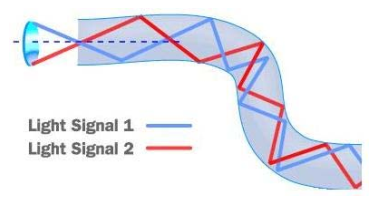


Figure : Total Internal Reflection Signal Transmission

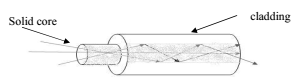


Figure : A Typical Conventional Optical Fiber

PCF:

Photonic crystal fibers (PCF) usually fall into two categories:

High – index guiding fibers and photonic bandgap fibers. The first kind of PCFs are more similar to conventional optical fibers because light is confined in a solid core by exploiting a “special” kind of total internal reflection mechanism. This guiding principle is different from that of conventional optical fibers in that the refractive index of the cladding is not constant but varies with wavelength.

We are actually concerned with the later type of PCFs which employs the PBG effect. A photonic crystal designed with the ability to forbid the propagation of electromagnetic waves in certain frequency ranges (forming band gaps) is known as a photonic bandgap (PBG) material. The phenomenon of forming band gaps in a photonic crystals is known as the PBG effect. Optical fibers fabricated to employ the PBG effect are known as Photonic bandgap fibers (PGBF).

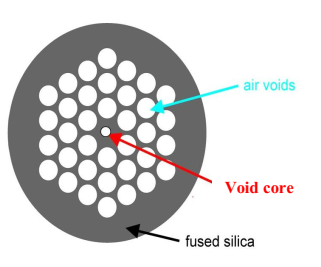


Figure : Cross Section Bandgap – guided fiber

Once light is induced to travel along the fiber, it really has nowhere to go, since the frequency of the guided mode lies within the photonic bandgap, the mode is forbidden to escape.

## A.3 Advantages and disadvantages of PCFs and GFO:

These fibers, known as single-mode, do have significant disadvantages. First the diameter of the fiber is significantly smaller, about 9 µm resulting in a weaker fiber more susceptible to physical damage. The small diameter also introduces problems in coupling these fibers to light sources and in aligning the junction properly so that the fiber is infused with light. These fibers transmit infrared laser light (λ=1,300 - 1,550 nanometers).

The other major cause of loss through the fiber comes from the imperfections in the core or cladding and the nature of their interface. In attempting to increase the transmission effectiveness a new area of research has begun to engineer new cladding materials that enhance the nature of that interface.

In conventional fiber–optic cables, along a tight bend (curve) the angle of incidence is too large for total internal reflection to occur, so light escapes at the corners and is lost. PBG fibers continue to confine light around tight corners since they do not depend on total internal reflection.

The hollow (gas filled) transmission path in PBG fibers offer a much lower loss high power channel than glass which is highly limited by Rayleigh scattering. Though the lowest lost figure of PBG fibers is still very high compared to typical standard single – mode conventional optical fibers. The main effects causing the loss in hollow core PBG fibers are the width of the bandgap and the confinement loss due to the finite number of air holes. Thus the design and fabrication of PBG fibers that exhibit the largest bandgap is of profound importance. An example of such ingenious designs is the triangular lattice – consisting of a circular array of air holes packed in a triangular arrangement.

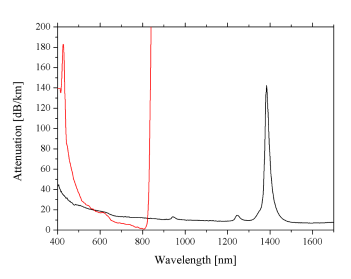


Figure : Attenuation spectral of conventional optical fiber(red) and PBG fiber(black)

PBG fibers have a significantly larger optical bandwidth than single mode conventional optical fibers for the same mode–field diameter. In conventional fibers, the single–mode optical bandwidth is limited by higher– order mode cutoff at short wavelengths and micro–bend loss at long wavelengths.

## A.3 Stance taken with justification:

Through photonic bandgap manipulation cladding material can be engineered that does not support any modes for certain frequencies, creating total internal reflection. The engineerable birefringence allows for relatively high refractive index contrasts. This allows a mode to be confined in a core much smaller than previously possible, less than the wavelength of the light. The current performance of single-mode optical fibers results from many years of intensive research. There appears to be no reason why the losses in Photonic Crystal Fibers cannot be reduced to or below that of standard optical fibers. Similar development effort could lead to explosive growth in photonic crystal fiber technology over the coming years. The optical properties of PBG fibers presented confirm the superiority of this artificial material as the optical waveguide for next generation optical communication. The fabrication challenges and the still relatively high transmission loss of PBG fibers open up avenues for more fundamental research.

# **Question No. 2**

**Solution to Question No. 1 part B:**

## B.1.1 Calculate the Force required to stretch the wire, lateral strain and work done:

Given that the wire has to be wrapped around a wooden circular disc of Circumference cm.

The circumference to be wrapped is greater than the length of the wire, the wire has to be stretched by to be able to wrap the wooden circular disc completely.

Hence the change in length is,

Using the relation of Young’s Modulus,

Or,

Here,

Substituting this into

Lateral Strain is given by the poisson’s ratio,

Work done in stretching the wire is given by,

## B.1.2 Time Period for torsional oscillations:

The time period of oscillations is given by,

Where,

Here

is the radius of the wire

is the length of the unstrained wire

1. Moment of Inertia about the diameter of the disc

Where

is the mass of the wooden cylinder

is the radius of this cylinder

Now,

1. Moment of Inertia about an axis passing through the centre

Where

is the mass of the wooden cylinder

is the radius of this cylinder

Now,

# **Question No. 3**

**Solution to Question No. 2 part B:**

## B.2.1 calculate the de Broglie wavelength, group velocity and phase velocity of the neutron. Justify whether this neutron beam can be diffracted by a crystal:

Where is the mass of neutron

Since the Wavelength of the neutron beam is comparable to that of interatomic distance of a crustal, the neutron beam can be diffracted by the crystal.

## B.2.2 calculate the wavelength of a photon which has the same energy as that of the neutron and identify the part of the electromagnetic spectrum into which it falls:

Which lies in,

IR-C (infrared) | FIR (far infrared) 

## B.2.3 Uncertainty in the measurement of the neutron velocity is 1%. Calculate the uncertainty in determining the position of the neutron:

Since the uncertainty in velocity is

Uncertainty in momentum is

From Heisenberg’s Uncertainty Principle,

# **Question No. 4**

**Solution to Question No. 3 part B:**

## B.3.1 Calculate the Bragg angles for first order diffraction from (100), (110) and (111) planes:

Taking , since it’s for first order diffraction, Bragg’s Law,

1. Plane
2. Plane
3. Plane

## B.3.2 Calculate the density of the material, if the atomic weight is 107.5 kg/kmol:

The relation of density of material is given by,

Where,

for FCC

## B.3.3 Specify the maximum order of diffraction that can be observed for (100) planes:

To maximize , must be maximized, the maximum value of is at

For plane

# **Question No. 5**

**Solution to Question No. 4 part B:**

## B.4.1 Calculate the number of free electrons per unit volume, if each atom contributes a single valence electron:

Where,

## B.4.2 Determine the mean free path of the electrons:

To calculate the mean free path of the electron the relaxation time is to be calculated, which is given by,

The thermal velocity is given by,

Now,

Where

## B.4.3 Calculate the magnitude of applied electric field to produce a drift velocity of :

**Bibliography**

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