**Losses in Optical Fibre:**

As an optical signal propagates through an optical fibre, it undergoes a loss in signal strength due to different causes.

**Attenuation in Optical Fibres:**

If $P_m$ represents the input power and $P_{out}$ the output power at the receiving end of the optical fibre the attenuation loss in dB/km is given by the following expression-

Where L represents the fibre length in km.

Power loss is given by the following expression-

Power loss(dB) = (1)

Thus, Atttenuation = (2)

Using equation (1) and (2), we have,

Or, (3)

Where $P_m$ and $P_{out}$ are expressed in W and L is expressed in km.

Conversely, using equation (3), the length of the optical fibre in km is given by the following expression-

(4)

Losses in an Optical Fiber occurs due to various phenomena such as-

**1) Losses due to Dispersion-**

As an optical signal travels along the fiber, it becomes increasingly distorted. This distortion is a sequence of intermodal and intramodal dispersion.

i) Intermodal Dispersion-
Pulse broadening due to intermodal dispersion results from the propagation delay differences between modes within a multimode fiber.

ii) Intramodal Dispersion-
It is the pulse spreading that occurs within a single mode.

For a step-index optical fibre, pulse broadening per unit length is given as,

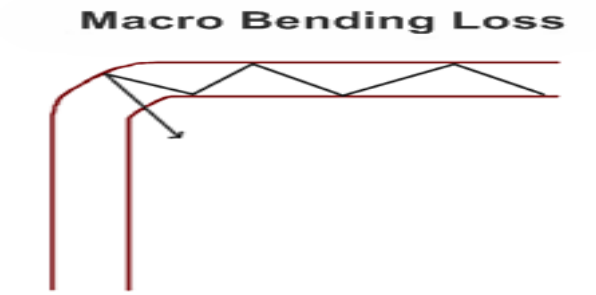
Where, $\Delta t$- Time interval
L- Distance covered
$n_1$- Refractive index of the core
$n_2$- Refractive index of the cladding
c- Velocity of light

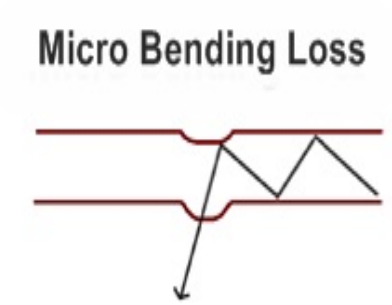
The term  is referred to as 'solidus multipath time dispersion' of the optical fibre. Multipath time dispersion can be minimized or even eliminated using a graded-index optical fibre.

**2) Losses due to bending of optical fibre:**

Optical fibres radiate the propagating power if they are bent. Generally, two types of bends are encountered:

a) bends with radii much larger than the fibre diameter, called Macrobends. In such types of bends, generally the complete fiber undergoes bends which causes certain modes not to be reflected and therefore causes loss to the cladding.






b) smaller bends called Microbends. In microbends, either the core or cladding undergoes slight bends at its surface. It causes light to be reflected at angles when there is no further reflection.

3) **Losses due to Absorption-**
Light signals, when travel through an optical fibre get absorbed by the atoms or molecules of the core or sometimes by the impurities in them.

Two different types of absorptions-

i. Intrinsic Absorption:
Intrinsic absorption occurs when a light particle(photon) interacts with an electron and excites it to a higher energy level. In silica glass, absorption is caused by the vibration of silicon-oxygen(Si-O) bonds. The interaction between the vibrating bond and the electromagnetic field of the optical signal causes intrinsic absorption.

ii. Extrinsic Absorption:

Extrinsic absorption is much more significant than intrinsic absorption. It is caused by the impurities introduced into the fibre material during manufacture like iron, nickel, chromium etc.

4) **Losses due to Scattering-**
Scattering loss in an optical fibre occurs due to microscopic variations in the material density, compositional fluctuations, structural in homogeneities and manufacturing defects. It can be further divided into two types-

i) Linear Scattering- These types of scattering cause the transfer of some or all of the optical power contained within one propagating mode to be transferred linearly into a different mode. In this process, frequency of the light wave does not change upon scattering. **Rayleigh Scattering** and **Mie Scattering** are two types of linear scattering.

ii) Non Linear Scattering- These types of scattering cause the the optical power from one mode to be transferred in either the forward or backward direction to the same, or other modes, at a different frequency. It depends critically upon the optical power density within the fibre and hence only becomes significant above threshold power levels. **Stimulated Brillouin Scattering** and **Stimulated Raman Scattering** are the two types of non linear scattering.