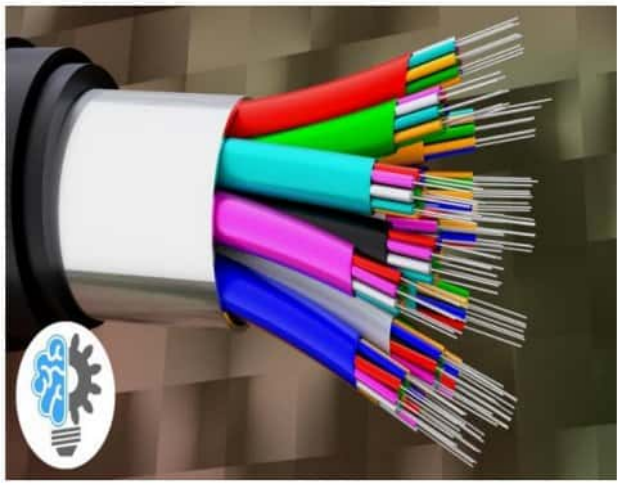
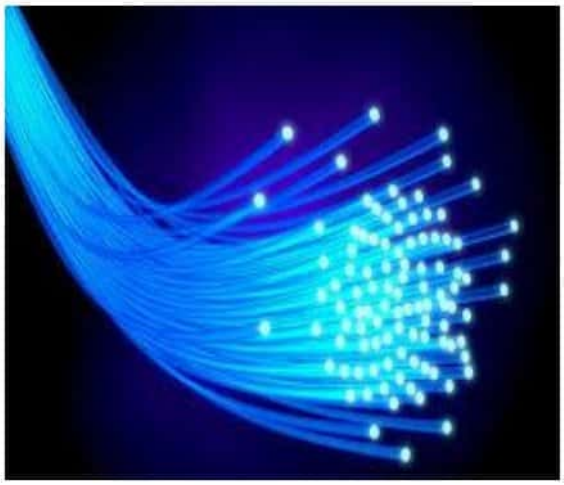
Fibre Optics

Optical fibre, the name itself suggests that it is a special fibre relating to the transmission through optics (light). Optical fiber is the technology associated with data transmission using light pulses traveling along with a long fiber which is usually made of plastic or glass. Their diameters are slightly more than the diameter of a human hair. It is best used for transmission of huge amount of data over a long range of distance at a very high rate. Optical fibres are more preferred over metal wires as there is less amount of energy loss in transmission with the optical fibres. Optical fibers are also unaffected by electromagnetic interference. The fiber optical cable uses the application of total internal reflection of light. The fibers are designed such that they facilitate the propagation of light along the optical fiber depending on the requirement of power and distance of transmission.

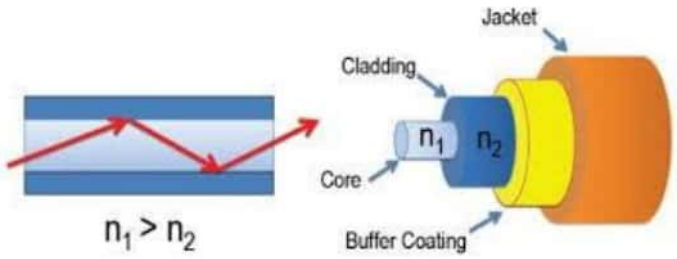




A single mode fiber is used for long-distance transmission while multimode fiber is used for shorter distances. The outer cladding of these fibers needs better protection than metal wires. When the incident ray falls on the cladding, it suffers total internal reflection as the angle formed by the ray is greater than the critical

angle. Optical fibers have revolutionized the speed with which signals are transferred, not only across cities but across countries and continents making telecommunication one of the fastest modes of information transfer.

If we look closely at a single optical fiber, we will see that it has the following parts:



- **Core** - Thin glass center of the fiber where the light travels
- **Cladding** - Outer optical material surrounding the core that reflects the light back into the core
- **Buffer coating** - Plastic coating that protects the fiber from damage and moisture

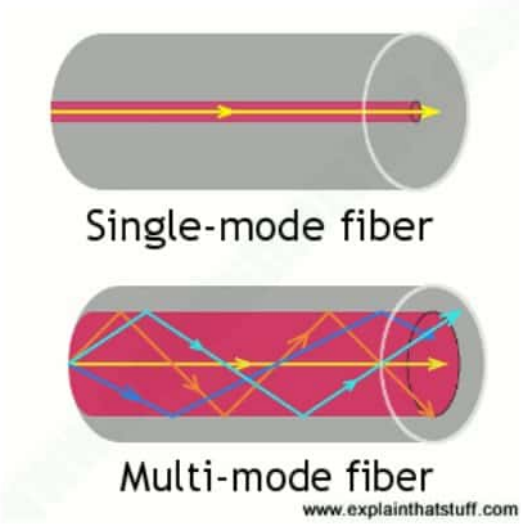
Hundreds or thousands of these optical fibers are arranged in bundles in optical cables. The bundles are protected by the cable's outer covering, called a **jacket**.

Types of fiber-optic cables

Optical fibers carry light signals down them in what are called **modes**. Mode refers to different ways of traveling: a mode is simply the path that a light beam follows down the fiber. One mode is to go straight down the middle of the fiber.

Another is to bounce down the fiber at a shallow angle. Other modes involve bouncing down the fiber at other angles, more or less steep.

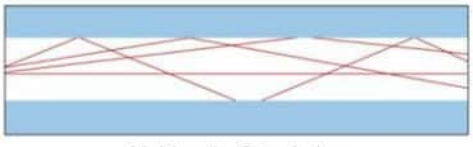
The simplest type of optical fiber is called **single-mode**. It has a very thin core about 5-10 microns (millionths of a meter) in diameter. In a single-mode fiber, all signals travel straight down the middle without bouncing off the edges (yellow line in diagram). Cable TV, Internet, and telephone signals are generally carried by single-mode fibers, wrapped together into a huge bundle. Cables like this can send information over 100 km (60 miles).

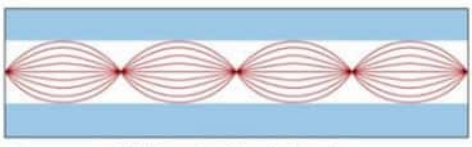


Another type of fiber-optic cable is called **multi-mode**. Each optical fiber in a multi-mode cable is about 10 times bigger than one in a single-mode cable. This means light beams can travel through the core by following a variety of different paths (yellow, orange, blue, and cyan lines)—in other words, in multiple different modes. Multi-mode cables can send information only over relatively short distances and are used (among other things) to link computer networks together.

The classification based on the refractive index is as follows:

- **Step Index Fibers:** It consists of a core surrounded by the cladding which has a single uniform index of refraction.
- **Graded Index Fibers:** The refractive index of the optical fiber decreases as the radial distance from the fiber axis increases.


Multimode, Step-Index


Multimode, Graded Index

The classification based on the materials used is as follows:

- **Plastic Optical Fibers:** The polymethylmethacrylate is used as a core material for the transmission of the light.
- **Glass Fibers:** It consists of extremely fine glass fibers.

Working of optical fibre

The optical fiber works on the principle of total internal reflection. Light rays can be used to transmit a huge amount of data but there is a problem here – the light rays travel in straight lines. So unless we have a straight long wire without any bends at all, harnessing this advantage will be very tedious. Instead, the optical cables are designed such that they bend all the light rays' inwards (using TIR). Light rays travel continuously, bouncing off the optical fiber walls and transmitting end to end data. Although light signals do degrade over progressing distances, depending on the purity of the material used, the loss is much less compared to using metal cables. A Fibre Optic Relay System consists of the following components:

- The Transmitter – It produces the light signals and encodes them to fit to transmit.
- The Optical Fibre – The medium for transmitting the light pulse (signal).
- The Optical Receiver – It receives the transmitted light pulse (signal) and decodes them to be fit to use.
- The Optical Regenerator – Necessary for long distance data transmission.

Fiber-optic cables are now the main way of carrying information over long distances because they have three very big advantages over old-style copper cables:

- **Less attenuation**: (signal loss) Information travels roughly 10 times further before it needs amplifying—which makes fiber networks simpler and cheaper to operate and maintain.
- **No interference**: Unlike with copper cables, there's no "crosstalk" (electromagnetic interference) between optical fibers, so they transmit information more reliably with better signal quality
- **Higher bandwidth**: As we've already seen, fiber-optic cables can carry far more data than copper cables of the same diameter.

Other advantages

- **Economical and cost effective**
- **Thin and non-flammable**
- **Less power consumption**
- **Flexible and lightweight**

Uses:

Internet

Fibre optic cables transmit large amounts of data at very high speeds. This technology is therefore widely used in internet cables. As compared to traditional copper wires, fibre optic cables are less bulky, lighter, more flexible, and carry more data.

Computer Networking

Networking between computers in a single building or across nearby structures is made easier and faster with the use of fibre optic cables. Users can see a marked decrease in the time it takes to transfer files and information across networks

Surgery and Dentistry

Fibre optic cables are widely used in the fields of medicine and research. Optical communication is an important part of non-intrusive surgical methods, popularly known as endoscopy. In such applications, a minute, bright light is used to light up the surgery area within the body, making it possible to reduce the number and size of incisions made. Fibre optics is also used in microscopy and biomedical research.

Automotive Industry

Fibre optic cables play an important role in safety features of present-day automobiles. They are widely used in lighting, both in the interior and exterior of vehicles. They transmit information in lightning speed and are used in airbags and traction control. They are also used for research and testing purposes in industries.

Communication

Calling telephones within or outside the country has never been so easy. With the use of fibre optic communication, you can connect faster and have clear conversations without any lag on either side.

Lighting and Decorations

The use of fibre optics in the area of decorative illumination has also grown over the years. Fibre optic cables provide an easy, economical and attractive solution to lighting projects. As a result, they are widely used in lighting decorations and illuminated Christmas trees.

Mechanical Inspections

Fibre optic cables are widely used in the inspection of hard-to-reach places. Some such applications are on-site inspections for engineers and also inspection of pipes for plumbers.

Cable Television

The use of fibre optic cables in the transmission of cable signals has grown explosively over the years. These cables are ideal for transmitting signals for high definition televisions because they have greater bandwidth and speed. Also, fibre optic cables are cheaper as compared to the same quantity of copper wire.

Military and Space Applications

With the high level of data security required in military and aerospace applications, fibre optic cables offer the ideal solution for data transmission in these areas.