1.Fiber optics

What is fiber optics?

We're used to the idea of information traveling in different ways. When we speak into a landline telephone, a wire cable carries the sounds from our voice into a socket in the wall, where another cable takes it to the local telephone exchange. Cellphones work a different way: they send and receive information using invisible radio waves—a technology called wireless because it uses no cables. Fiber optics works a third way. It sends information coded in a beam of lightdown a glass or plastic pipe. It was originally developed for endoscopes in the 1950s to help doctors see inside the human body without having to cut it open first. In the 1960s, engineers found a way of using the same technology to transmit telephone calls at the speed of light (normally that's 186,000 miles or 300,000 km per second in a vacuum, but slows to about two thirds this speed in a fiber-optic cable).

Optical technology

Photo: A section of 144-strand fiber-optic cable. Each strand is made of optically pure glass and is thinner than a human hair. Picture by Tech. Sgt. Brian Davidson, courtesy of US Air Force.

A fiber-optic cable is made up of incredibly thin strands of glass or plastic known as optical fibers; one cable can have as few as two strands or as many as several hundred. Each strand is less than a tenth as thick as a human hair and can carry something like 25,000 telephone calls, so an entire fiber-optic cable can easily carry several million calls.

Fiber-optic cables carry information between two places using entirely optical (light-based) technology. Suppose you wanted to send information from your computer to a friend's house down the street using fiber optics. You could hook your computer up to a laser, which would convert electrical information from the computer into a series of light pulses. Then you'd fire the laser down the fiber-optic cable. After traveling down the cable, the light beams would emerge at the other end. Your friend would need a photoelectric cell (light-detecting component) to turn the pulses of light back into electrical information his or her computer could understand. So the whole apparatus would be like a really neat, hi-tech version of the kind of telephone you can make out of two baked-bean cans and a length of string!

How fiber-optics works

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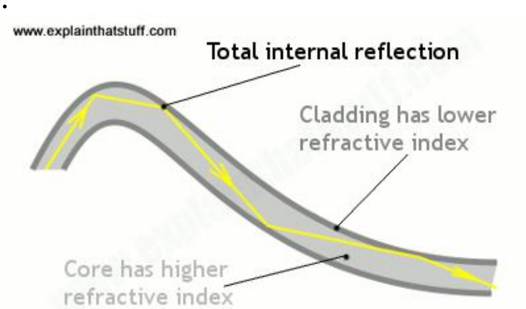
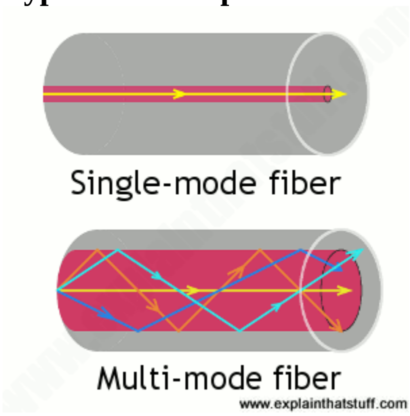


Artwork: Total internal reflection keeps light rays bouncing down the inside of a fiber-optic cable.

Light travels down a fiber-optic cable by bouncing repeatedly off the walls. Each tiny **photon** (particle of light) bounces down the pipe like a bobsleigh going down an ice run. Now you might expect a beam of light, traveling in a clear glass pipe, simply to leak out of the edges. But if light hits glass at a really shallow angle (less than 42 degrees), it reflects back in again—as though the glass were really a mirror. This phenomenon is called total internal reflection. It's one of the things that keeps light inside the pipe.

The other thing that keeps light in the pipe is the structure of the cable, which is made up of two separate parts. The main part of the cable—in the middle—is called the **core** and that's the bit the light travels through. Wrapped around the outside of the core is another layer of glass called the **cladding**. The cladding's job is to keep the light signals inside the core. It can do this because it is made of a different type of glass to the core. (More technically, the cladding has a lower refractive index.)

Types of fiber-optic cables



Optical fibers carry light signals down them in what are called **modes**. That sounds technical but it just means 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.

Artworks: Above: Light travels in different ways in single-mode and multi-mode fibers. Below: Inside a typical single-mode fiber cable (not drawn to scale). The thin core is surrounded by cladding roughly ten times bigger in diameter, a plastic outer coating (about twice the diameter of the cladding), some strengthening fibers made of a tough material such as Kevlar®, with a protective outer jacket on the outside.