Optical Fiber

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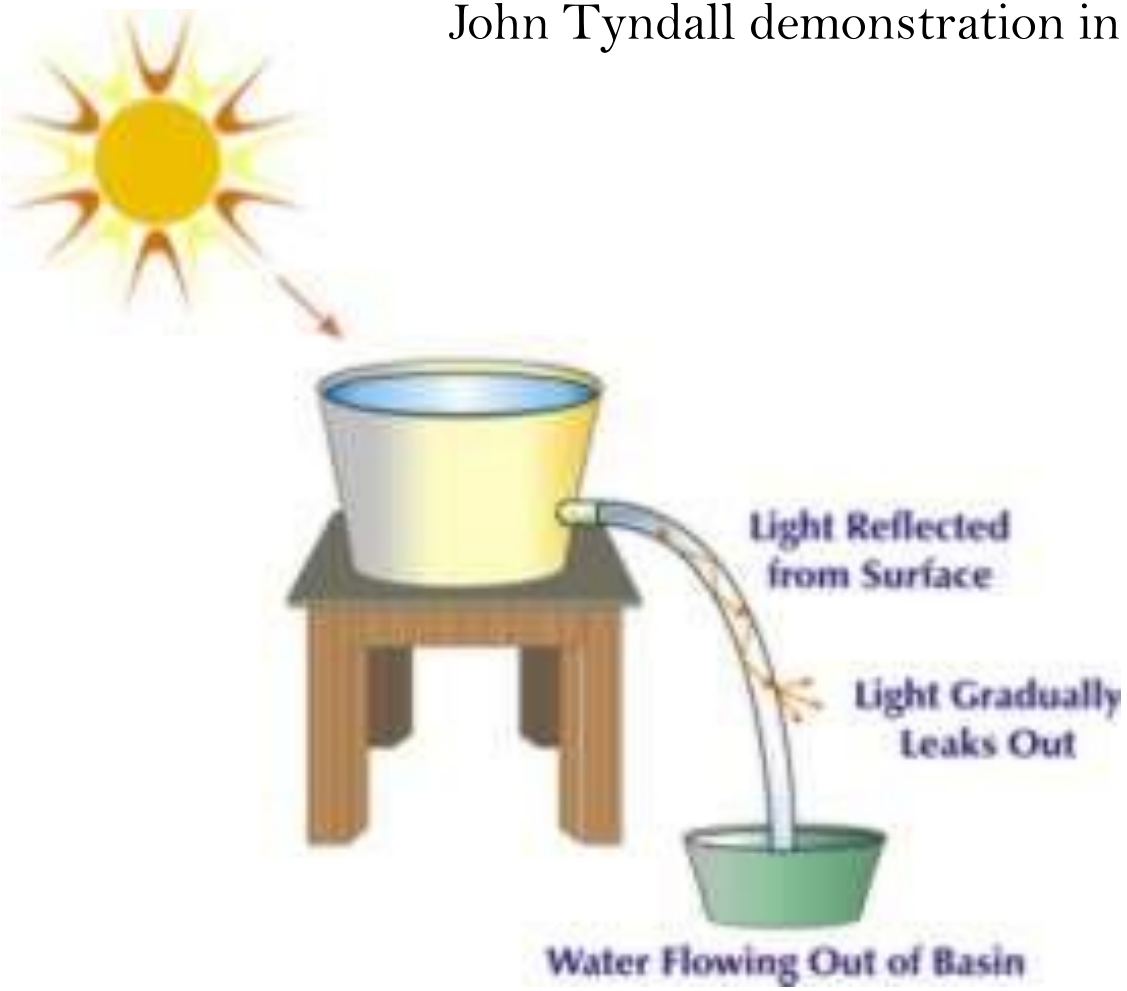
History of Fiber Optics

John Tyndall demonstration in 1870



Total Internal reflection is the basic idea of fiber optic

- **1880 Alexander G. Bell**
  - Photo phone, transmit sound waves over beam of light
- 1930: TV image through uncoated fiber cables
  - Few years later image through a single glass fiber
- 1951: Flexible fiberscope: Medical applications
- **1956: The term "fiber optics" used for the first time**
- 1958: Paper on Laser & Maser
- 1960: Laser invented
- **1967: New Communications medium: cladded fiber**
- 1960s: Extremely glossy fiber: More than 1000 dB /km
- 1970: Corning Glass Work NY, Fiber with loss of less than 2 dB/km
- 70s & 80s : High quality sources and detectors
- Late 80s : Loss as low as 0.16 dB/km
- 1990: Deployment of SONET systems

What is Optical Fiber or Fiber Optics?

❑***A technology that uses glass (or plastic) threads (fibers) to transmit data.*** *A fiber optic cable consists of a bundle of glass threads, each of which is capable of transmitting messages.*

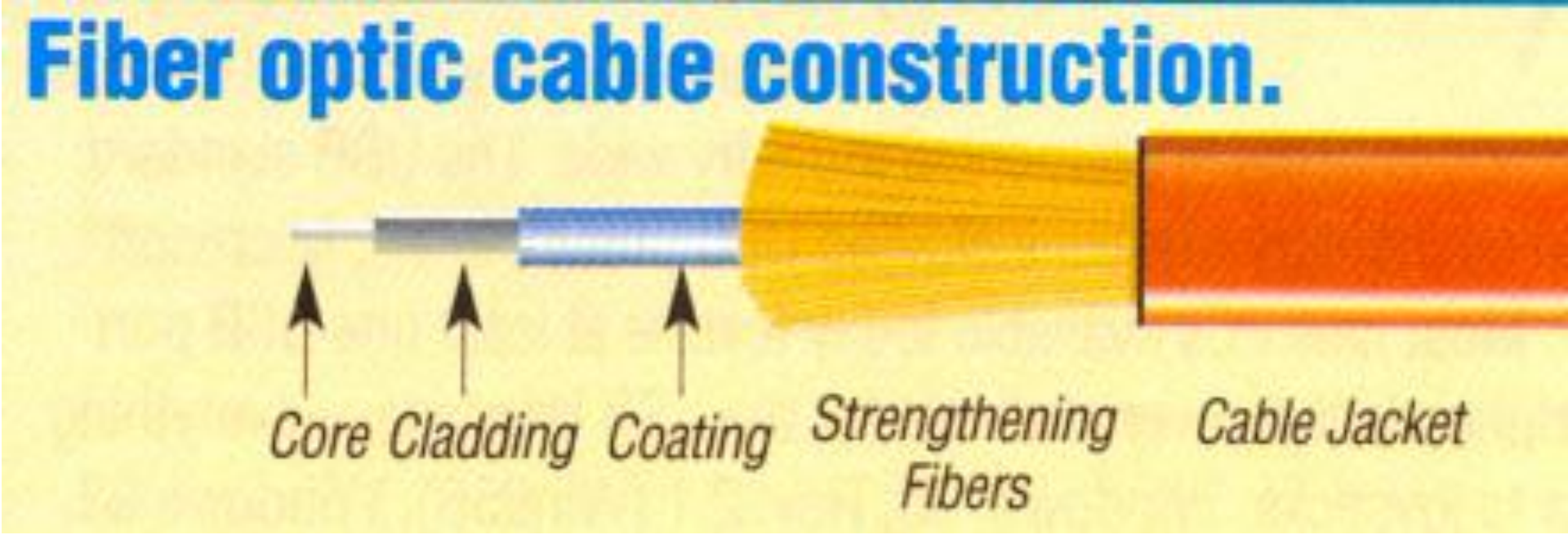
Fiber optics has several advantages over traditional metal communications lines:

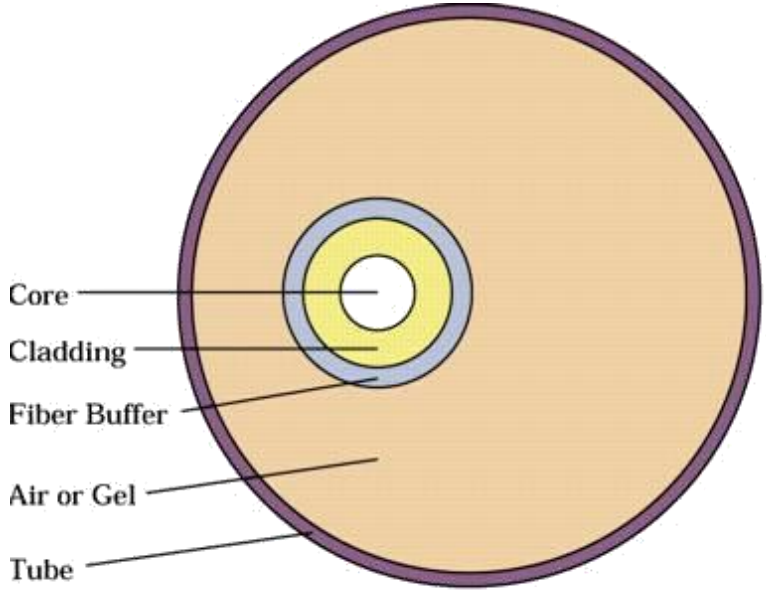
•Fiber optic cables have a much **greater bandwidth** than metal cables. This means that they can carry more data..
•Fiber optic cables are much **thinner and lighter** than metal wires.
•Data can be transmitted **digitally** (the natural form for computer data) rather than analogically.

Fiber Optic Communications

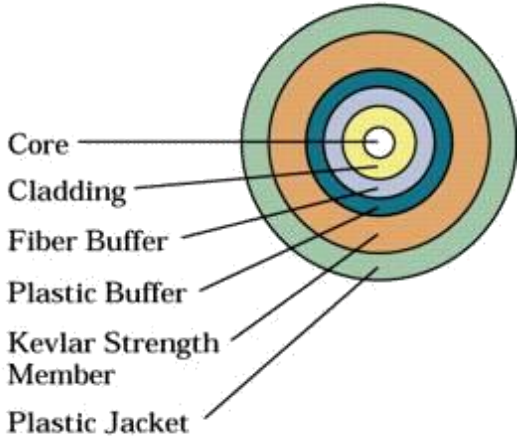
- Applications include
  - Telephones
  - Internet
  - LANs - local area networks
  - CATV - for video, voice and Internet connections
  - Utilities - management of power grid
  - Security - closed-circuit TV and intrusion sensors
  - Military - everywhere!

Fiber optic cable construction.





(a) Loose-tube construction

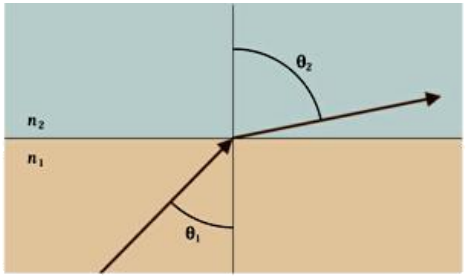


(b) Tight-buffer construction

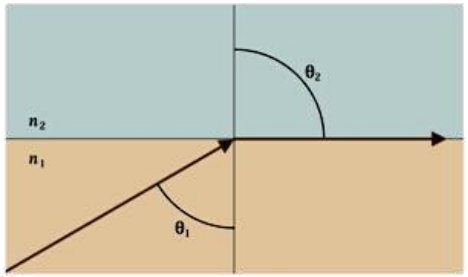
Basic Principle

- Optical fibers work on the principle of **total internal reflection**
- The **angle of refraction** at the interface between two media is governed by Snell's law:

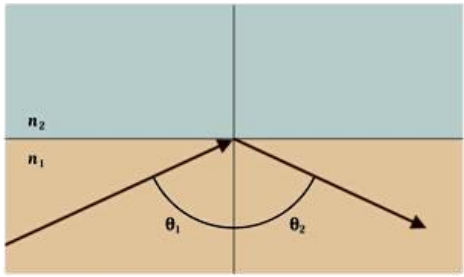
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$



(a) Angle of incidence less than critical angle



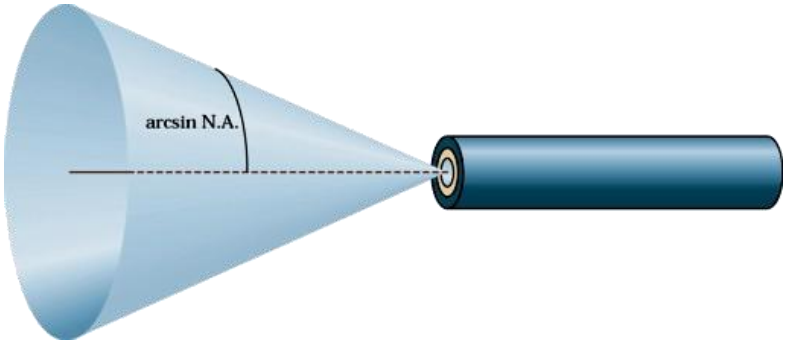
(b) Angle of incidence equal to critical angle



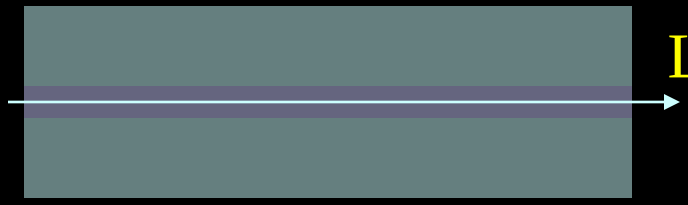
(c) Angle of incidence greater than critical angle

- The **numerical aperture** of the fiber is closely related to the critical angle and is often used in the specification for optical fiber and the components that work with it
- The numerical aperture is given by the formula:

$$N.A. = \sqrt{n_1^2 - n_2^2}$$

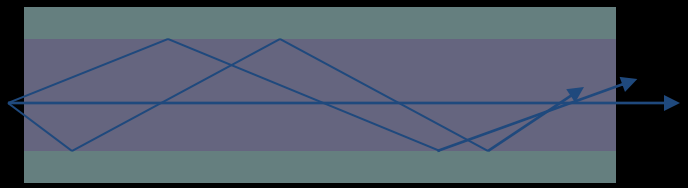


Types Of Optical Fiber

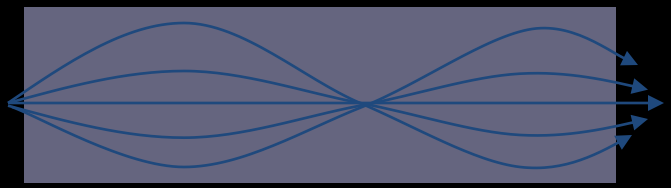


Light ray

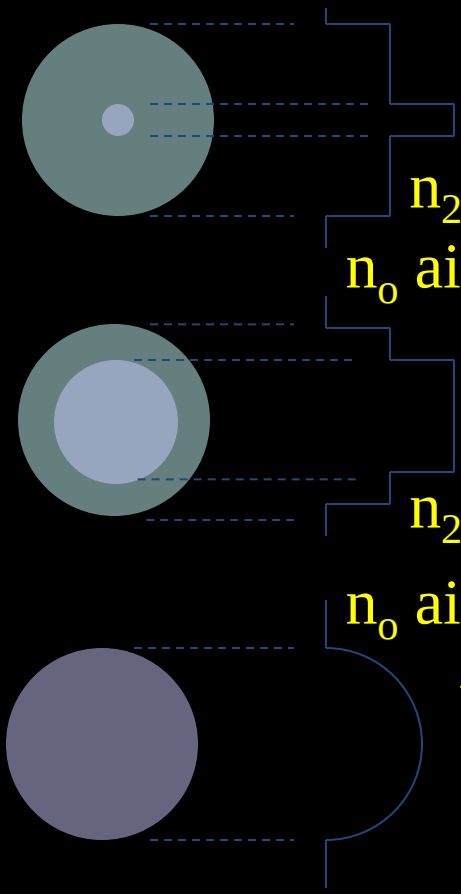
Single-mode step-index Fiber



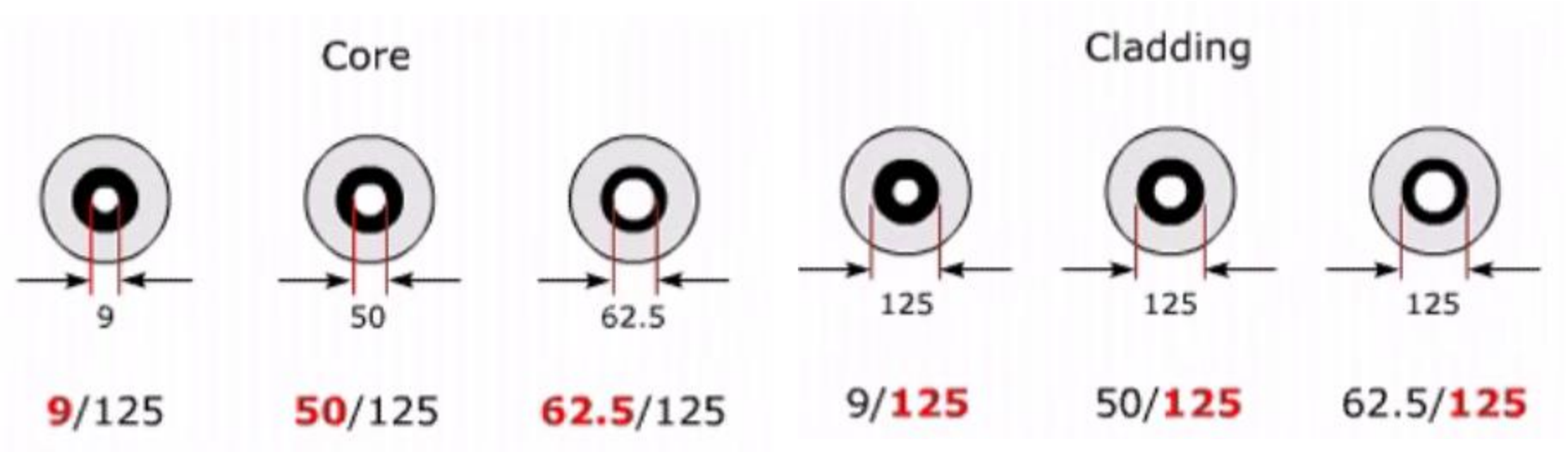
Multimode step-index Fiber



Multimode graded-index Fiber

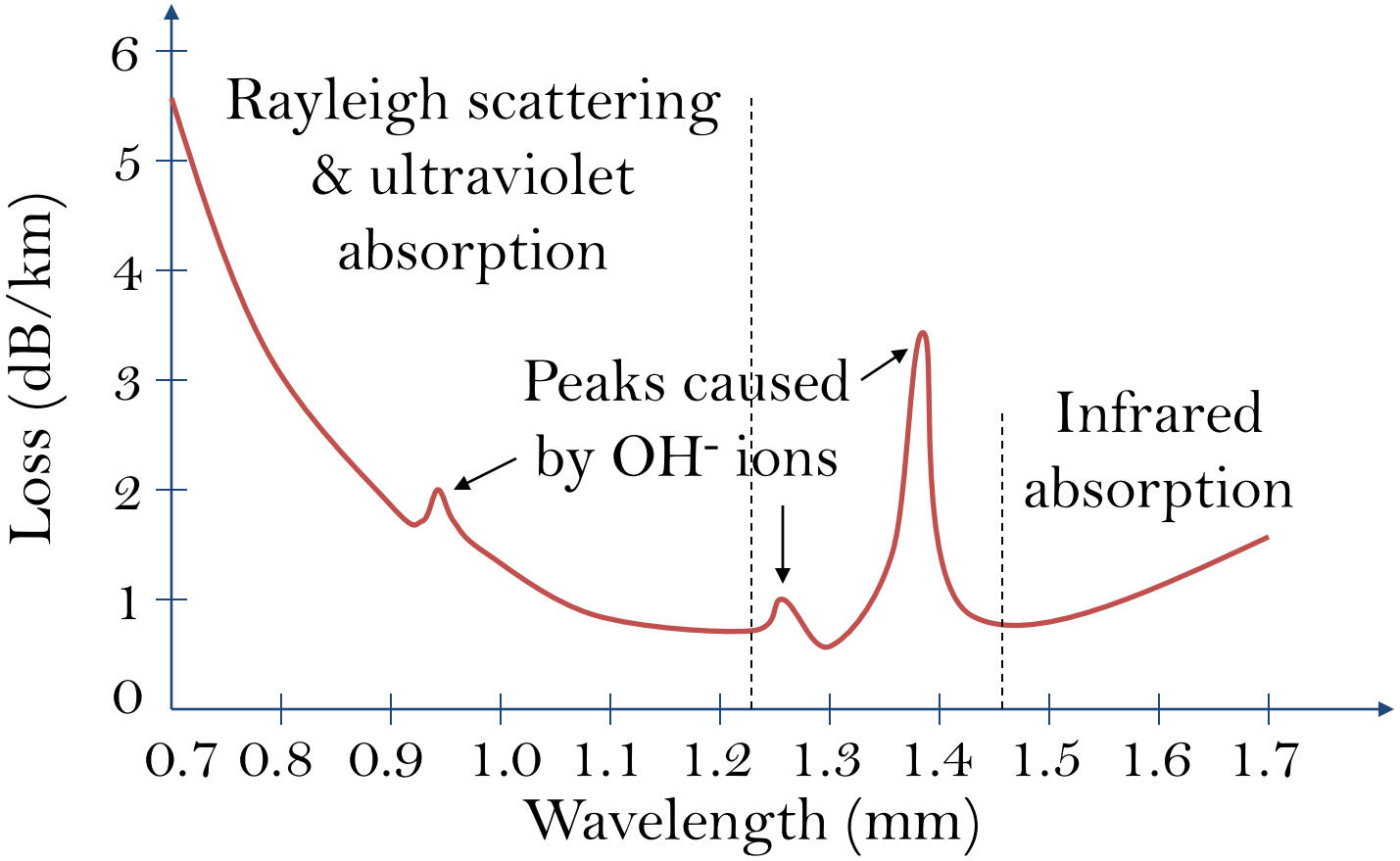


What do the fiber terms 9/125, 50/125 and 62.5/125 (micron)



Typically n(cladding) < n(core)

Absorption Losses In Optic Fiber



Fiber Alignment Impairments

Axial displacement

Gap displacement

Angular displacement

Imperfect surface finish

Causes of power loss as the light travels through the fiber!

Advantage

- **SPEED:** Fiber optic networks operate at high speeds - up into the gigabits
- **BANDWIDTH:** large carrying capacity
- **DISTANCE:** Signals can be transmitted further without needing to be "refreshed" or strengthened.
- **RESISTANCE:** Greater resistance to electromagnetic noise such as radios, motors or other nearby cables.
- **MAINTENANCE:** Fiber optic cables costs much less to maintain.

Disadvantage

- Higher initial cost in installation
- Interfacing cost
- Strength
  - Lower tensile strength
- Remote electric power
- More expensive to repair/maintain
  - Tools: Specialized and sophisticated