DATA COMMUNICATION CONCEPTS

CHAPTER 2

TRANSMISSION MEDIA

2.0 OBJECTIVES

At the end of this chapter, you should be able to:

1. Identify the different types of wired (guided) and wireless (unguided) transmission media.
2. Identify the different characteristics of wired (guided) and wireless (unguided) transmission media.

2.1 INTRODUCTION

- located below the physical layer and are directly controlled by the physical layer.
- anything - carry information from a source to a destination.
- 2 categories – WIRED and WIRELESS

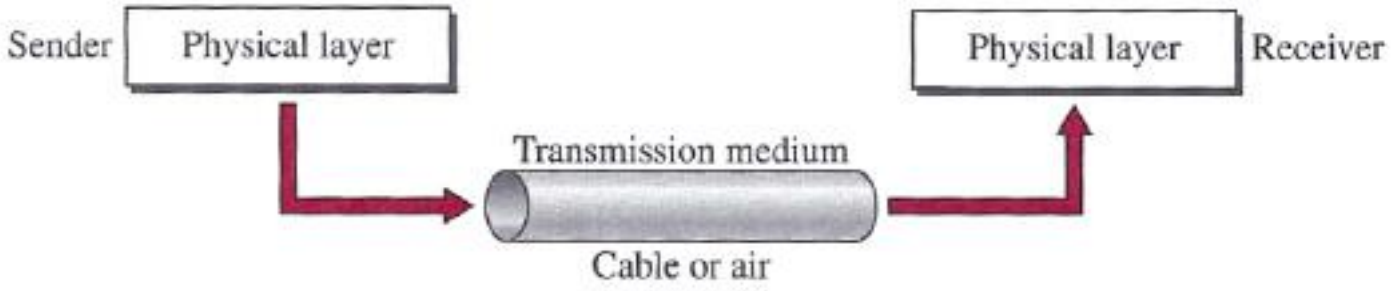


Figure 2.1 : **Transmission medium and physical layer**

➢ computers and other telecommunication devices use signals to represent data.
➢These signals are transmitted from one device to another in the form of electromagnetic energy, which is propagated through transmission media.

- 2 major categories of transmission media:
  1. ***Wired or Conducted or Guided Media (1869).***
     - Use a conductor such as a wire to move the signal from sender to receiver.
     - Has a physical boundaries.
     - E.g.: Twisted-pair, coaxial cable, fiber-optic cable.

2. ***Wireless or Unguided Media (1895).***

- Use radio waves of different frequencies and do not need a wire or cable conductor to transmit signal.
- Has no physical boundaries.
- Radio, microwave & Infrared

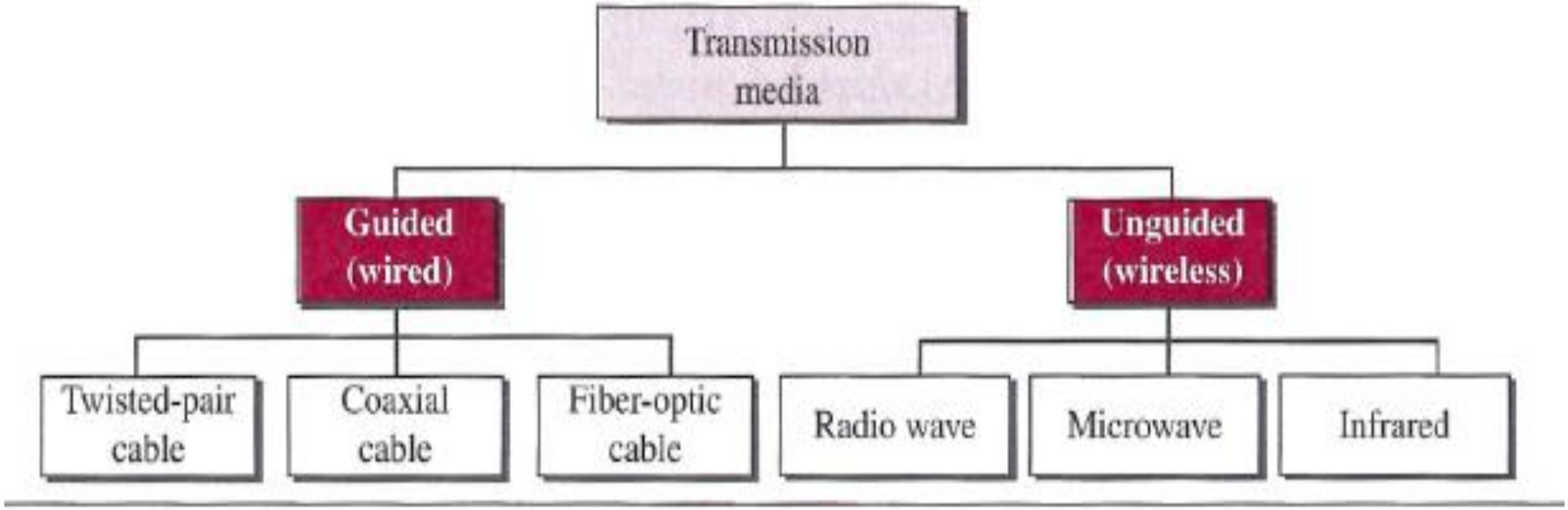
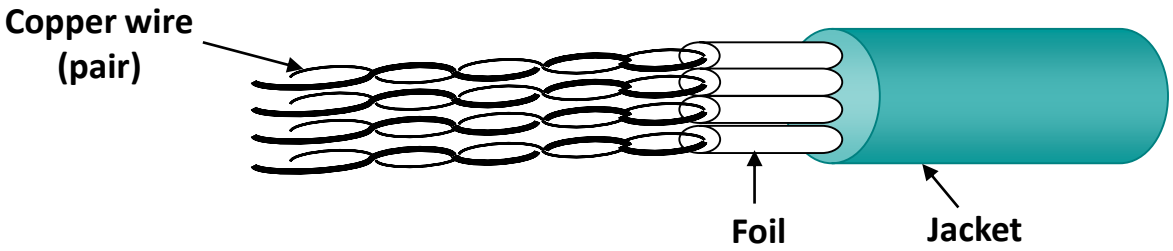


***Figure 2.2 : Categories of* Transmission media**

2.2 GUIDED MEDIA: WIRED TRANSMISSION

2.21 TWISTED PAIR CABLE



- Separately insulated
- Twisted together

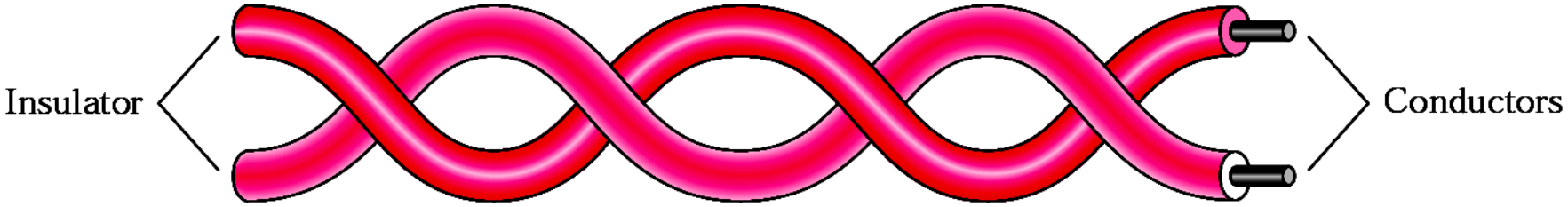


Figure 2.3 : **Transmission medium and physical layer**

- ***Physical Description:***
  - Consists of **TWO** insulated copper wires arranged in regular spiral pattern to minimize the electromagnetic interference between adjacent pairs.
  - Often used at customer facilities and also over distances to carry voice as well as data communications.
  - Function of spiral: to minimize/reduce EMI

- ***Physical Description (continue):***
  - Low frequency transmission media.
  - Shielded twisted pair is added with foil shield to reduce interference and crosstalk.
  - Two types of twisted-pair cable:
    i. ***STP (Shielded Twisted Pair):***
       * The pair is wrapped with metallic foil or braid to insulate the pair from electromagnetic interference.
    ii. ***UTP (Unshielded Twisted Pair):***
       * Each wire is insulated with plastic wrap, but the pair is encased in an outer covering.

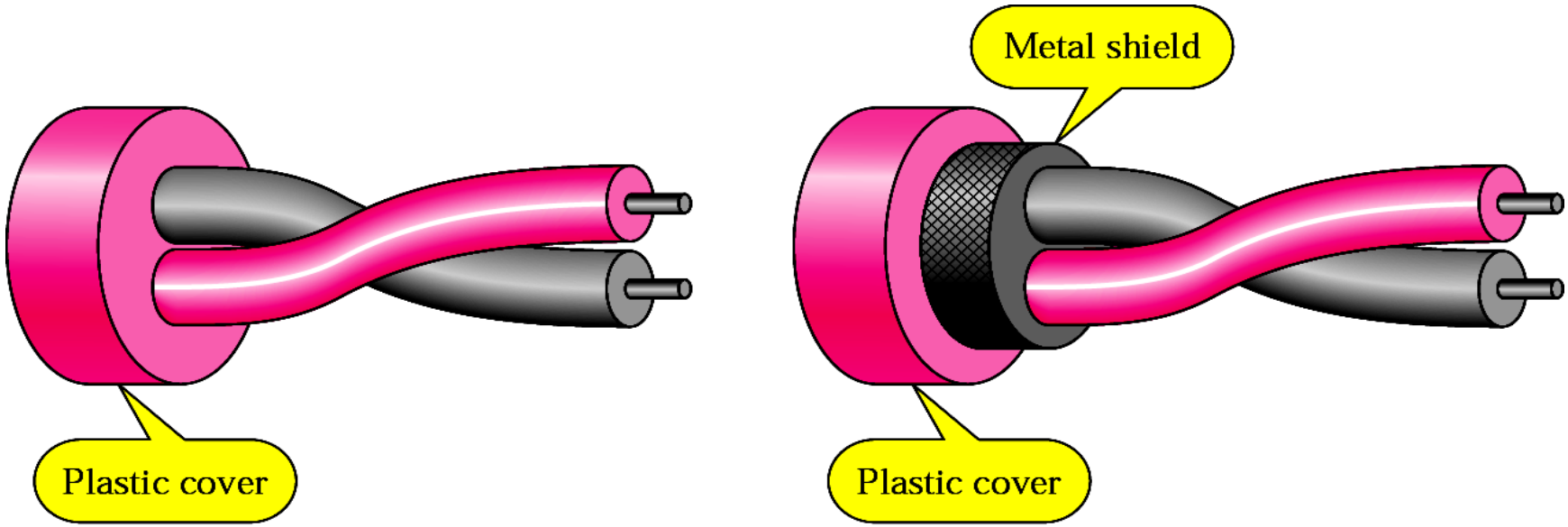
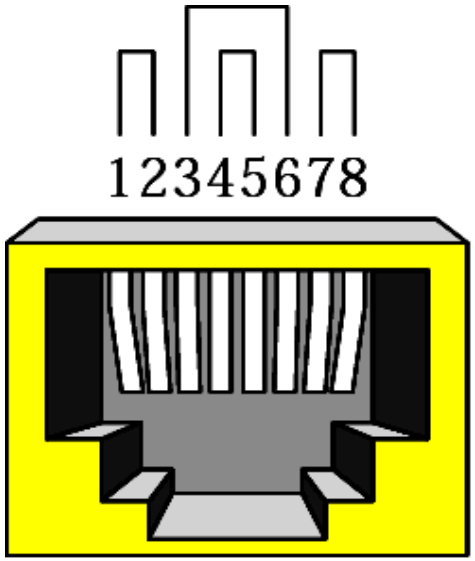


Figure 2.4 : **UTP and STP**

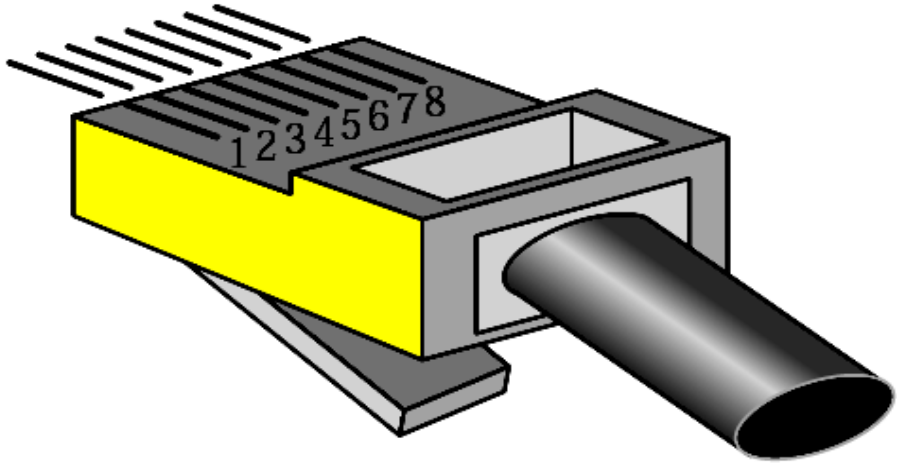
Twisted Pair Cable

Category	Specification	Data Rate (Mbps)	Use
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called *SSTP (shielded screen twisted-pair)*. Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs

Table 2.1 Categories of unshielded twisted-pair cables



RJ-45 Female



RJ-45 Male

Figure 2.5 : **UTP Connector**

- ***Transmission Characteristics:***
  - Can transmit both analog and digital signals.

Disadvantages

- Relatively low bandwidth
- Susceptible to interference and noise.
- Attenuation problem & Near End Cross Talk (NEXT).
  - For analog, amplifier is needed every 5 – 6 km.
  - For digital, repeater is needed every 2 – 3 km.

Advantages

- Inexpensive and readily available.
- Flexible and light weight.
- Easy to work with and install.

- ***Application:***
  - RESEARCH by STUDENTS

2.22 COAXIAL CABLE (COAX)

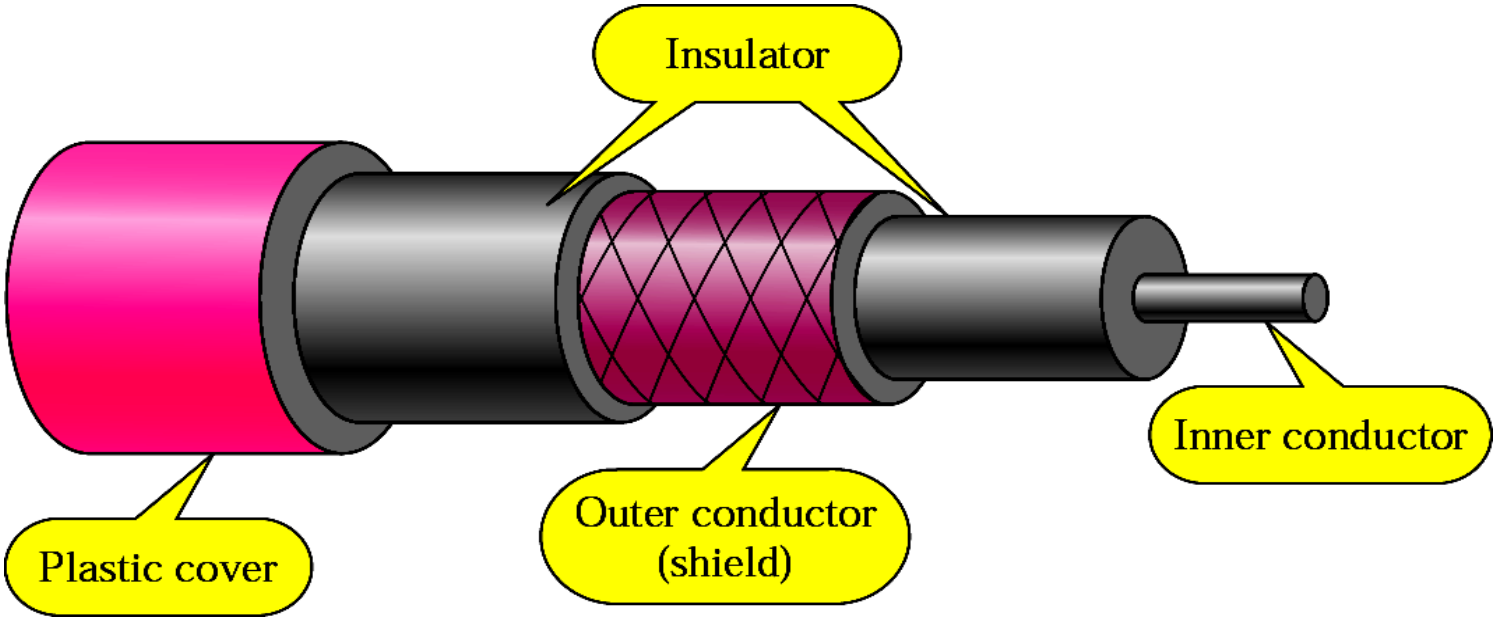


Figure 2.6 : **Coaxial Cable**

- Has an inner conductor surrounded by a braided mesh.
- Both conductors share a common center axial, hence the term “co-axial”.

Coaxial Cable

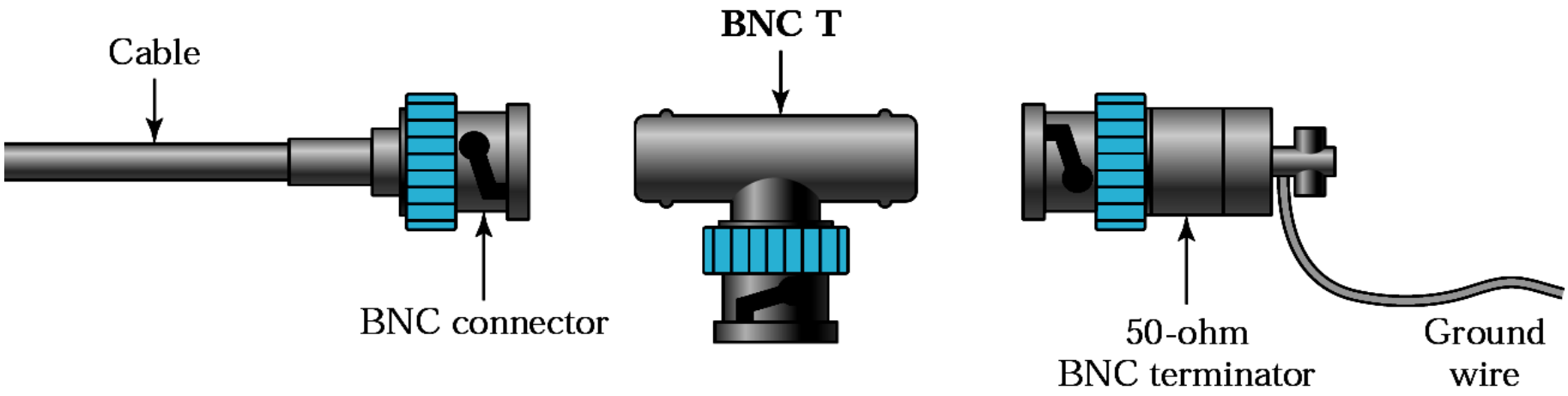


Figure 2.7 : BNC Connector

Advantages

- Higher bandwidth; 400 to 600 MHz.
- Much less susceptible to interference than twisted pair.
- Better noise immunity.

Disadvantages

- High attenuation rate makes it expensive over long distance.
- *Heavy*
- *Hard to install*

- ***Application:***
- - RESEARCH by STUDENTS

2.23 OPTICAL FIBER CABLE

- Consists of three concentric section.

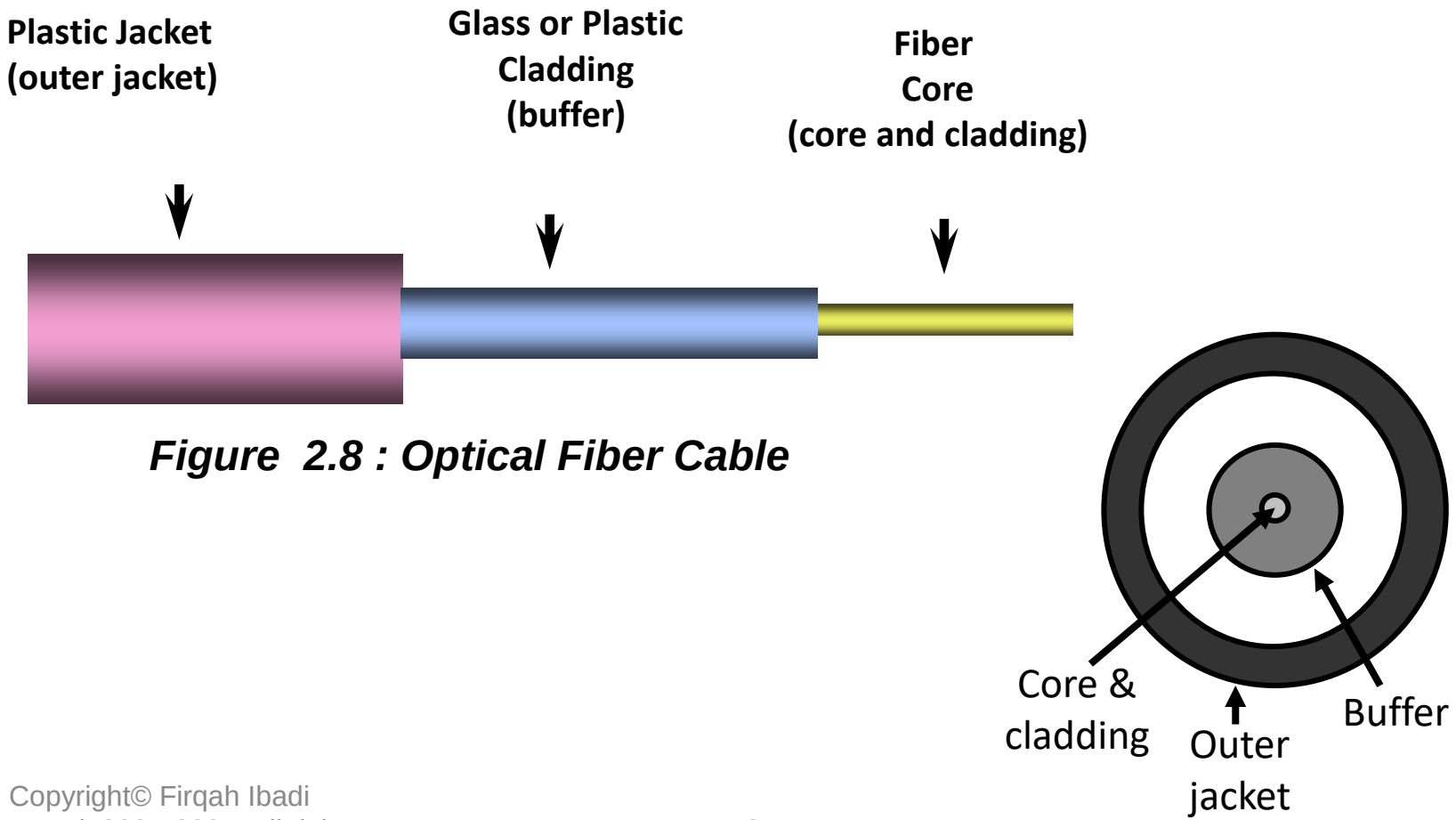
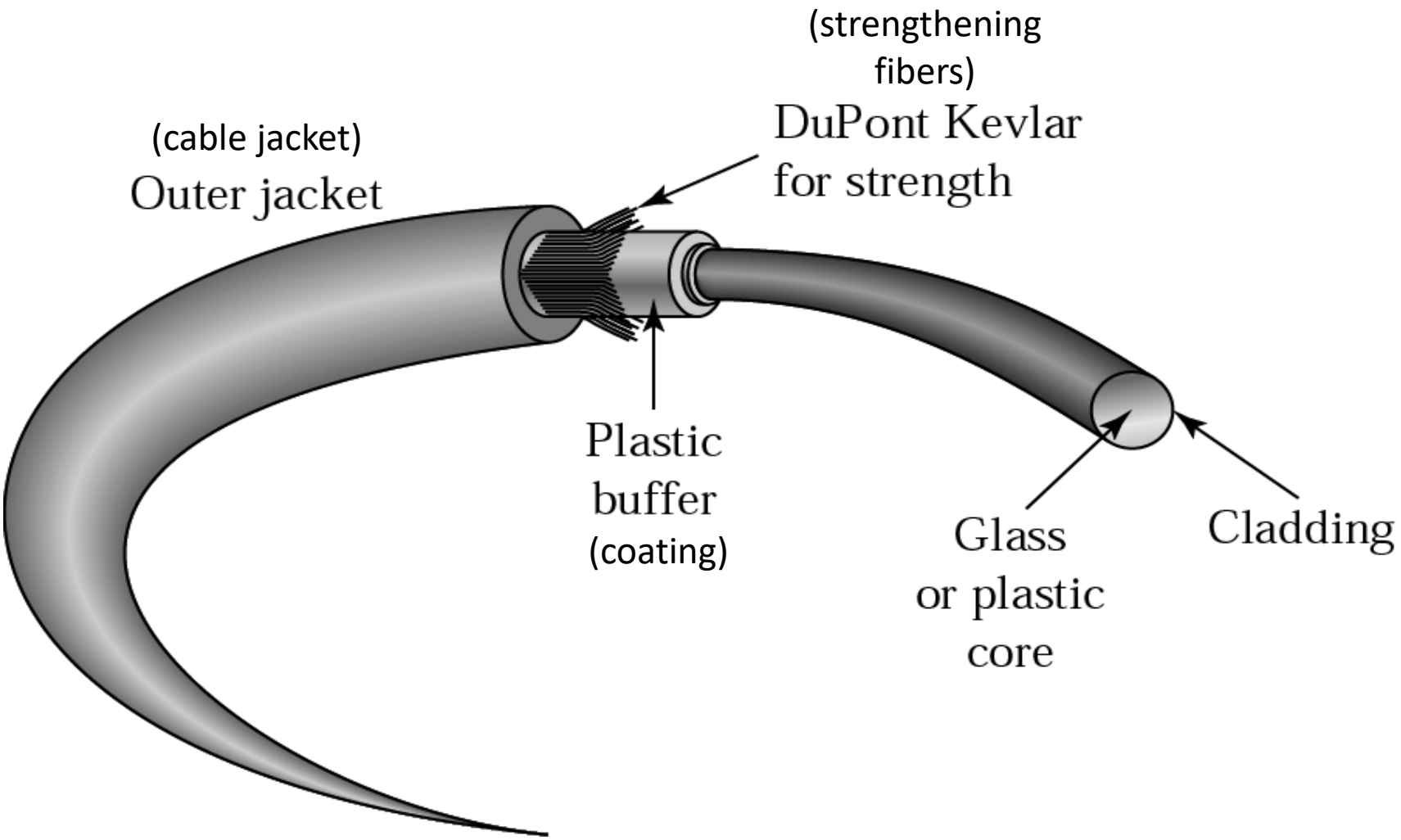
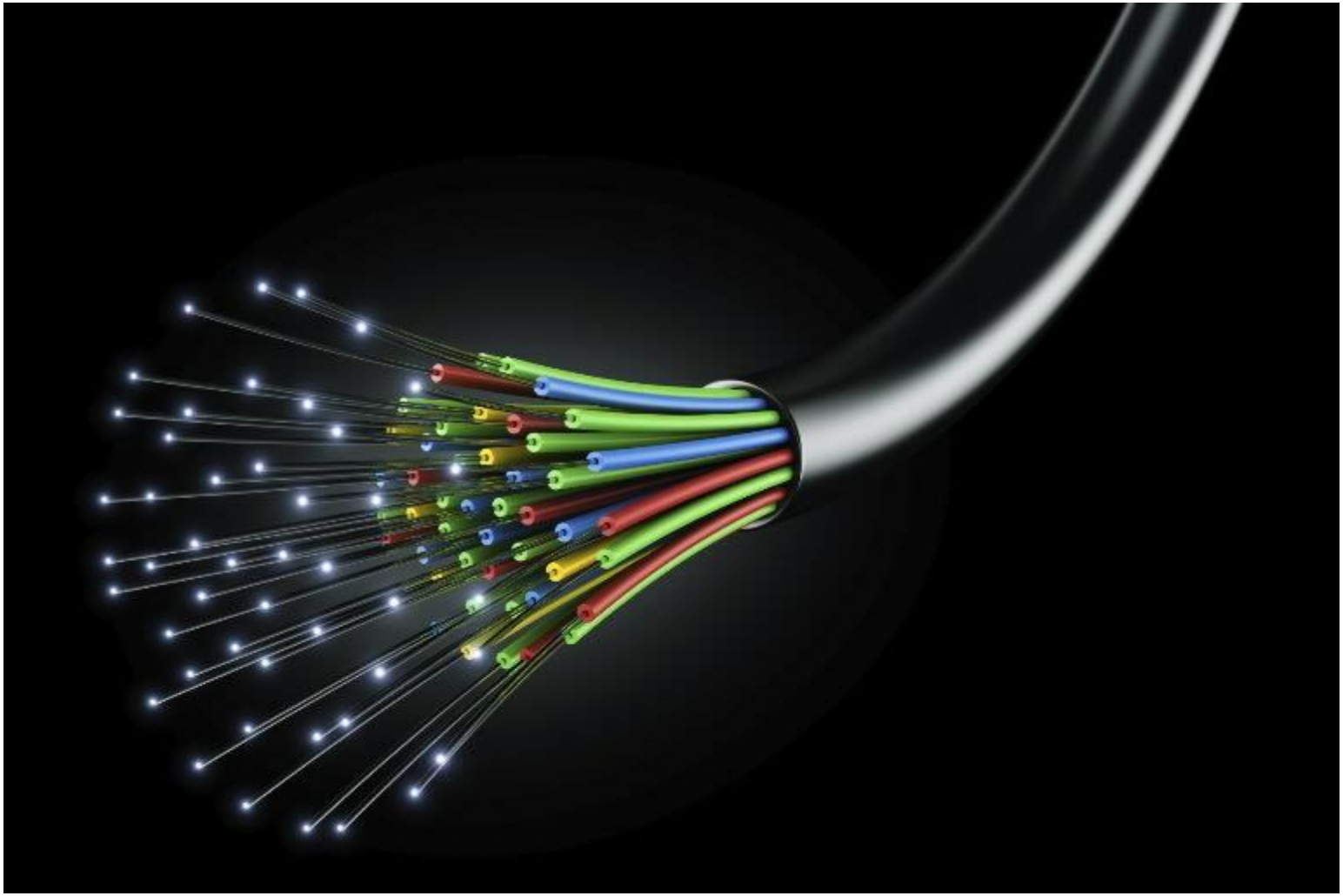


Figure 2.8 : Optical Fiber Cable



Fiber Construction



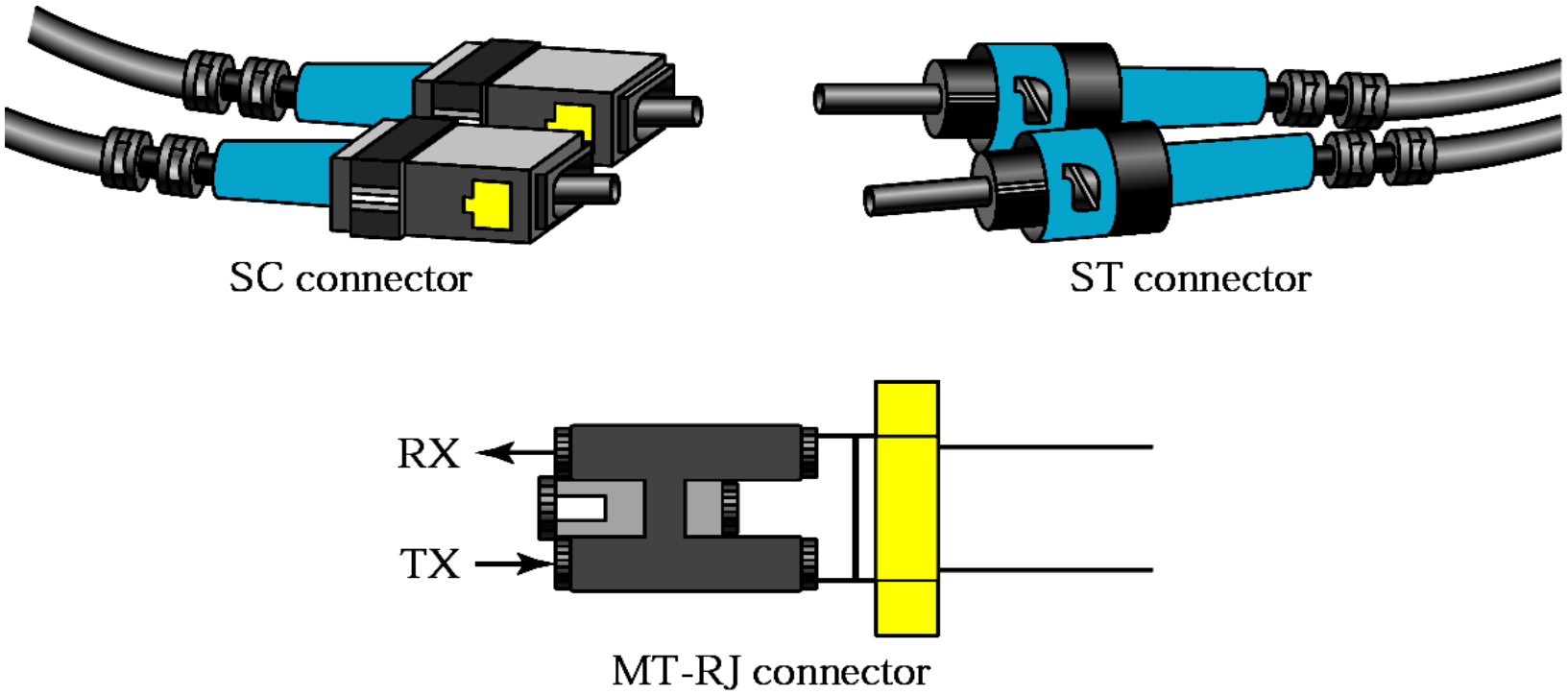


Figure 2.9 : Fiber-optic cable connectors

Propagation Modes

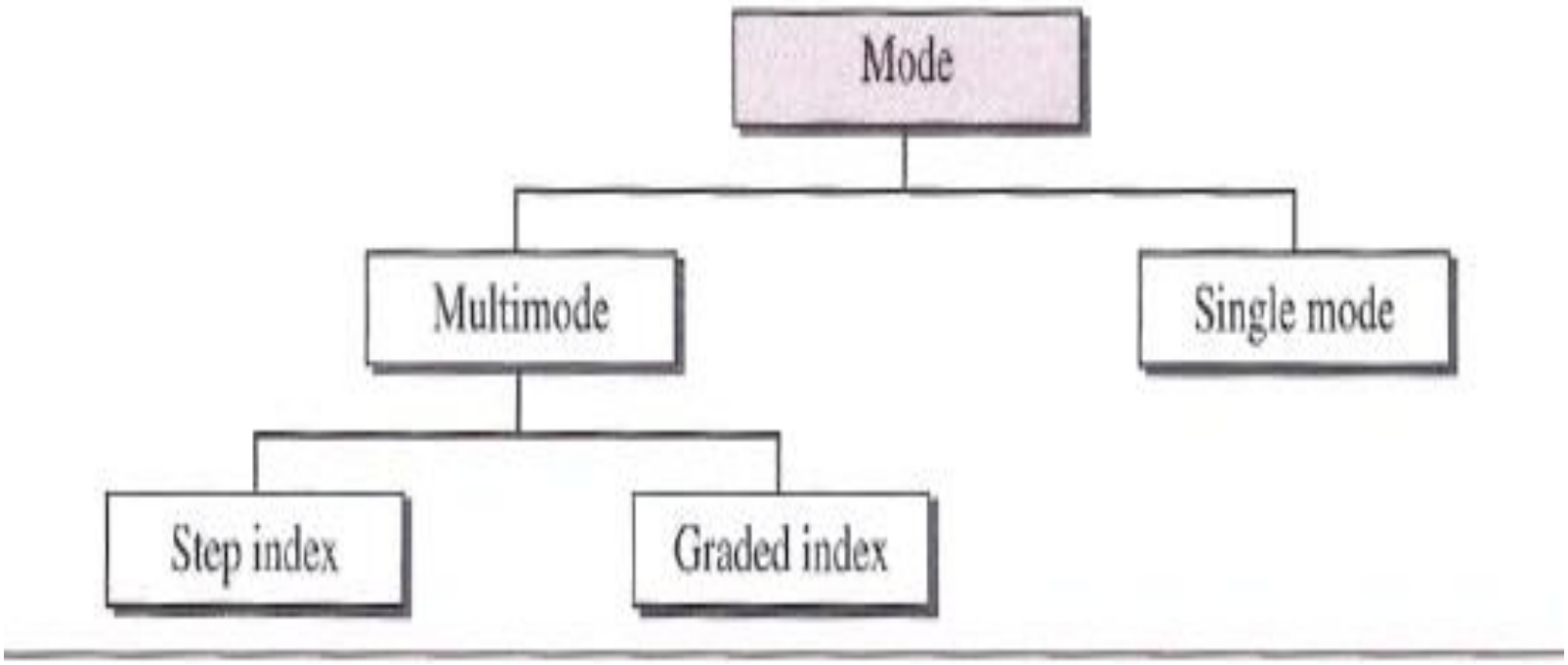


Figure 2.10 : Fiber-optic Propagation Modes

Multimode

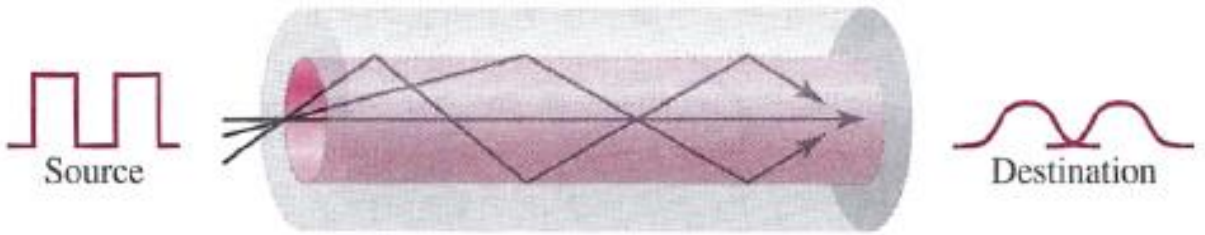
Multimode is so named because **multiple beams** from a light source move through the core in different paths.

Single-Mode

Single-mode uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal.

The **single-mode fiber** itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density (index of refraction).

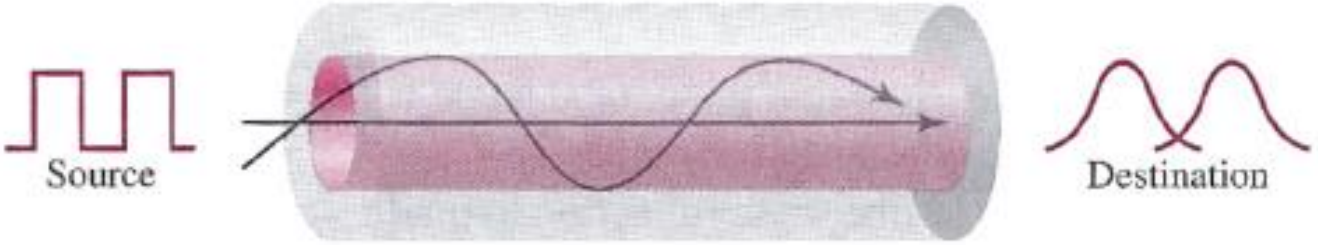
- ***Multimode*** types:
  a. ***Multimode Step-Index Fiber (Constant Density)***
    * The core density is constant and the light beam changes direction suddenly at the interface between the core and the cladding.
    * *Step index:* the suddenness of this change
    * The reflective walls of the fiber move the light pulses to the receiver.



a. Multimode, step index

b. ***Multimode Graded-Index Fiber (Varying Density)***

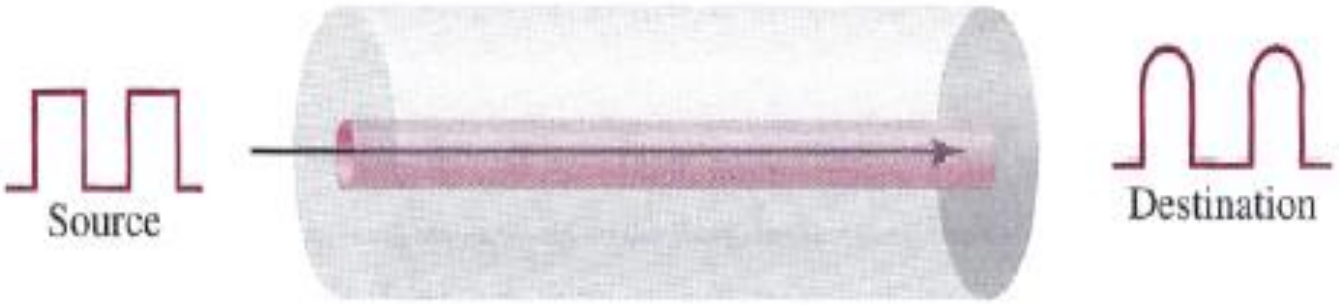
* The core density decreases with distance from the center. This causes a curving of the light beams.
* Acts to refract the light toward the centre of the fiber by variations in the density.



b. Multimode, graded index

- *Single-mode Fiber*

* An optical fiber with an extremely small diameter (diameter of 8.3 to 10 microns)that limits beams to a few angles, resulting in an almost horizontal beam.
* The light is guided down the centre on an extremely narrow core.



- ***Transmission Characteristics:***

  - Use light wave: require a light source with injection laser diode (ILD) or light-emitting diodes (LED) technology.

ADVANTAGES

- Greater bandwidth
- Smaller size and lighter weight.
- Lower attenuation.
- Immunity to electromagnetic interference.
- Highly secure due to tap difficulty and lack of signal radiation.
- Resistance to corrosive materials.

DISADVANTAGES

- Requires highly skilled installers.
- Adding additional nodes is difficult.
- Expensive over short distance.
- fragile
- Unidirectional light propagation.

- ***Application:***
  - RESEARCH by STUDENTS

2.3 UNGUIDED MEDIA : WIRELESS

- Wireless transmission involves electromagnetic waves & not require any physical connection.
- Appropriate for long distance transmission.
- Transmission and reception are achieved by means of an antenna:
  i. ***Directional (point-to-point):***
     * Transmitting antenna puts out focused beam.
     * Transmitter and receiver must be aligned.
  ii. ***Omni-directional (broadcast):***
     * Signal spreads out in all directions & can be received by many antennas.

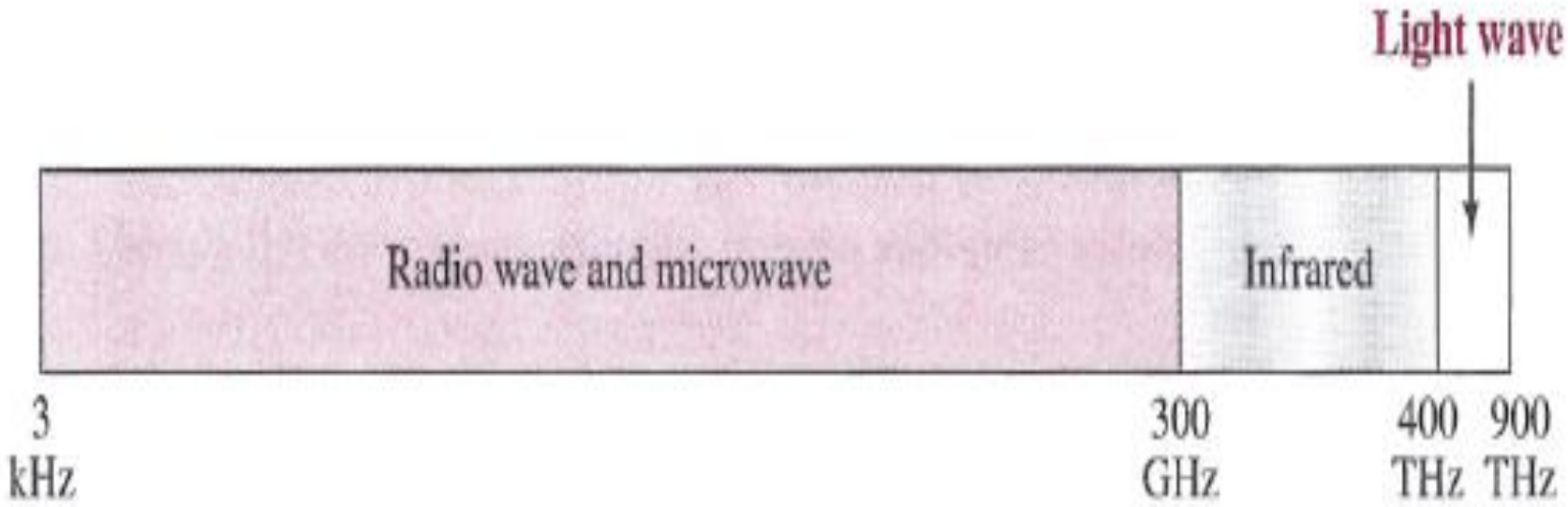
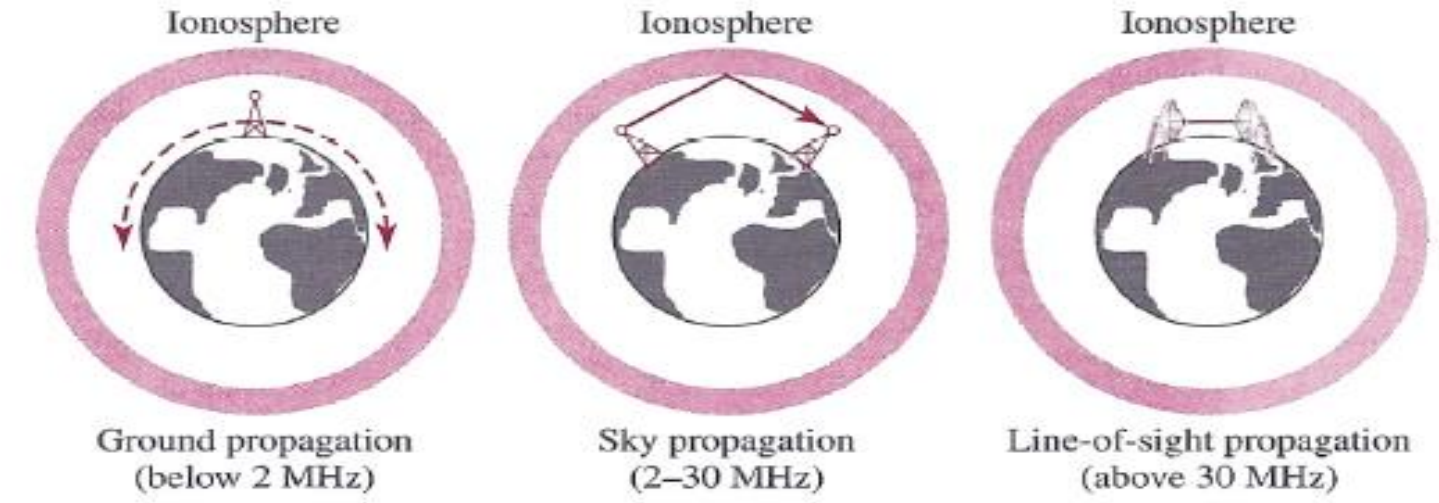


Figure 2.10 : **Electromagnetic spectrum for wireless communication**

2.31 PROPAGATION

Unguided signals can travel from the source to the destination in several ways:

- Ground propagation,
- Sky propagation,
- Line-of-sight propagation



2.32 RADIO WAVES

- Electromagnetic waves – LOW/MEDIUM frequencies between 3 kHz and 1 GHz
- Omnidirectional
- Sending and receiving antennas do not have to be aligned
- Propagate in the sky mode (Susceptible to interference)
- Suitable for long-distance broadcasting
- Penetrate walls
- Used for multicast communications, such as AM radio and television, and paging systems.

2.33 MICROWAVE

- frequencies between 1 and 300 GHz
- unidirectional
- sending and receiving antennas need to be aligned
- propagation - line-of-sight
- Very high-frequency microwaves cannot penetrate walls.
- microwave band is relatively wide, almost 299 GHz.
- wider subbands can be assigned, and a high data rate is possible.

- ***Physical Description:***
  - Transmitter is a parabolic dish, mounted as high as possible (10 feet in diameter).
  - Requires unobstructed line of sight between source and receiver.

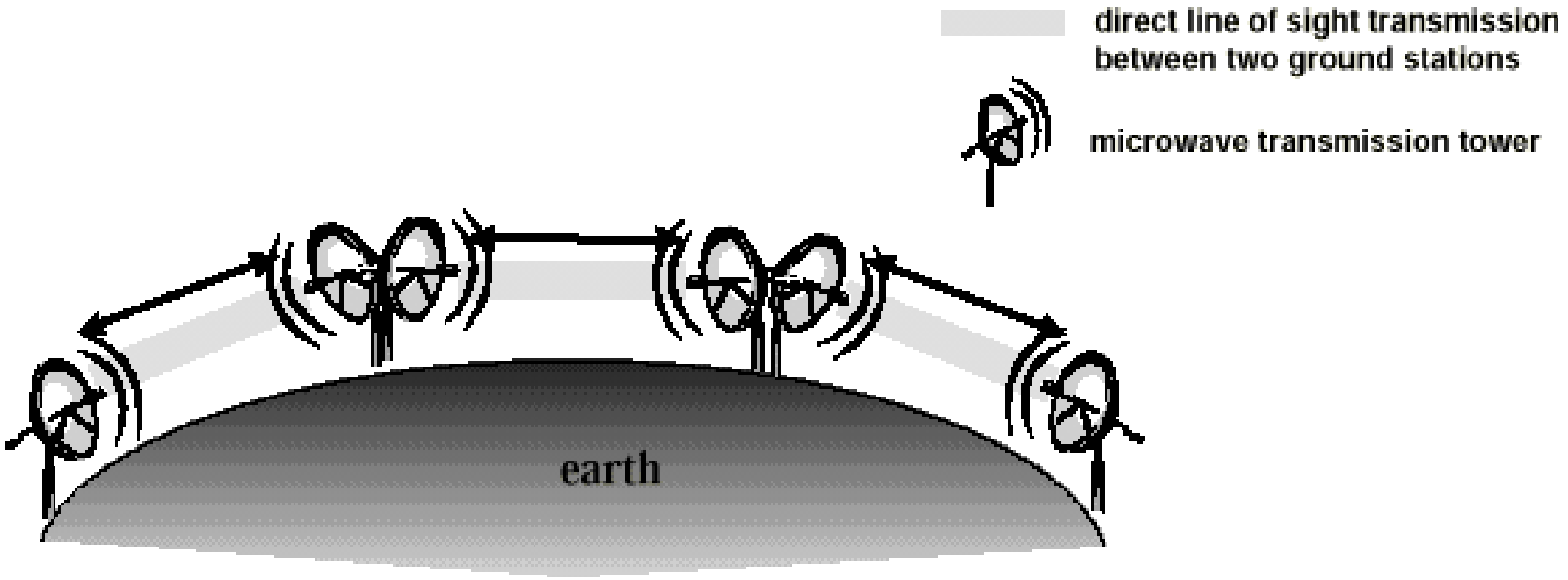


Figure 2.11 : **Microwave Transmission**

- Microwaves need unidirectional antennas that send out signals in one direction.
- Two types of antennas are used for microwave communications: the parabolic dish and the horn.

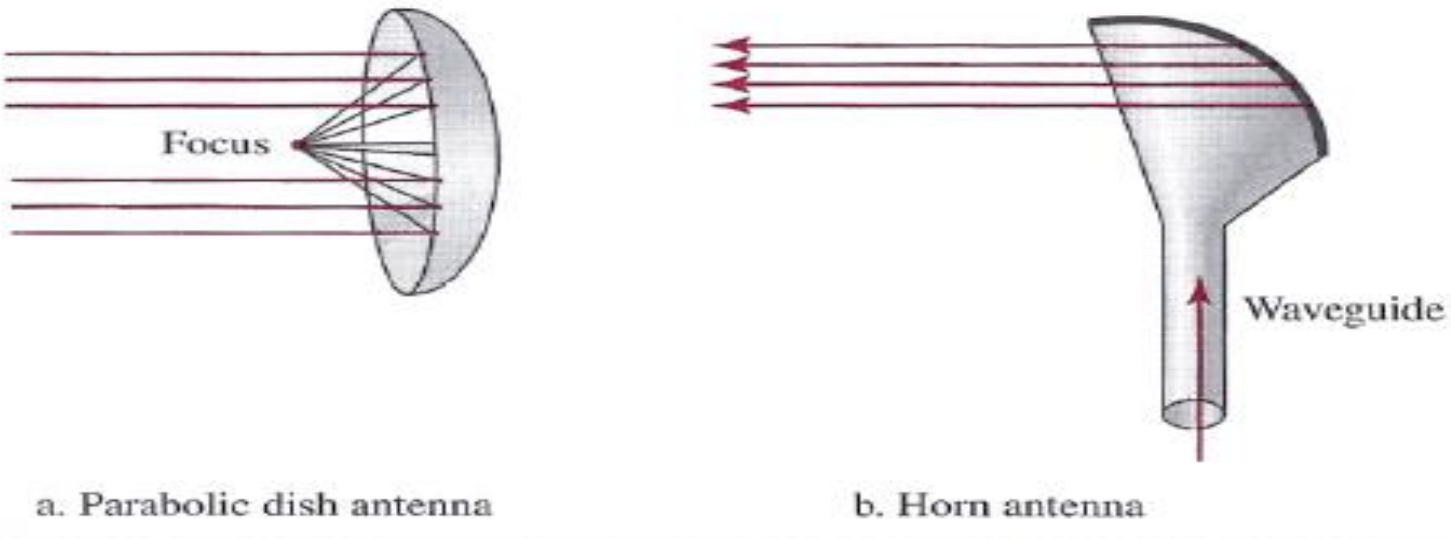


Figure 2.12 :Unidirectional Antenna

- ***Physical Description (continue):***
  - Microwaves antennas are usually located at substantial heights above ground level in order to extend range between antennas and to eliminate physical barrier
  - Curvature of the earth requires stations (called repeaters) to be ~30 –50 miles apart.

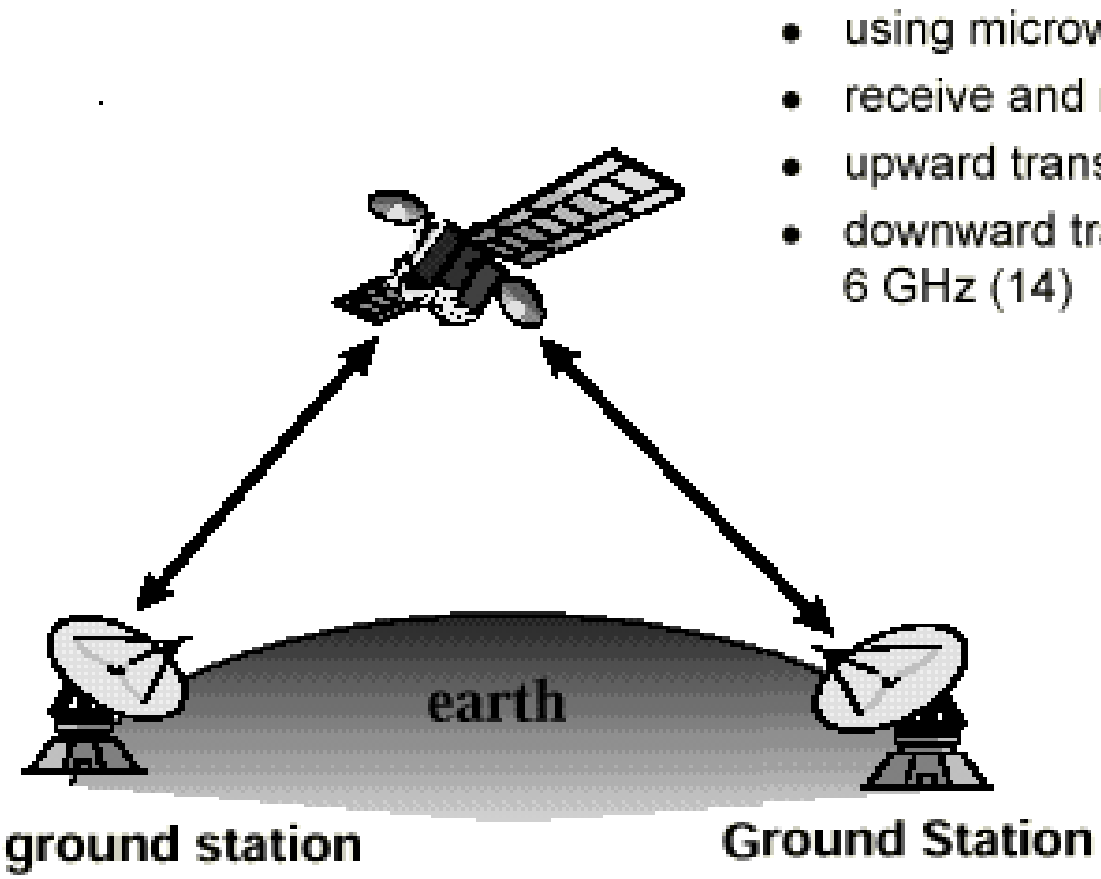
- ***Transmission Application:***

  RESEARCH by students

Example of Microwave application: SATELLITE COMMUNICATION

- ***Physical Description:***
  - A communication satellite is, in effect, a microwave relay station in space.
  - It uses to link two or more ground-based microwave transmitter or receiver.

- ***Physical Description (continue):***
  - Can relay signals over long distances.
  - Satellite Transmission Process:



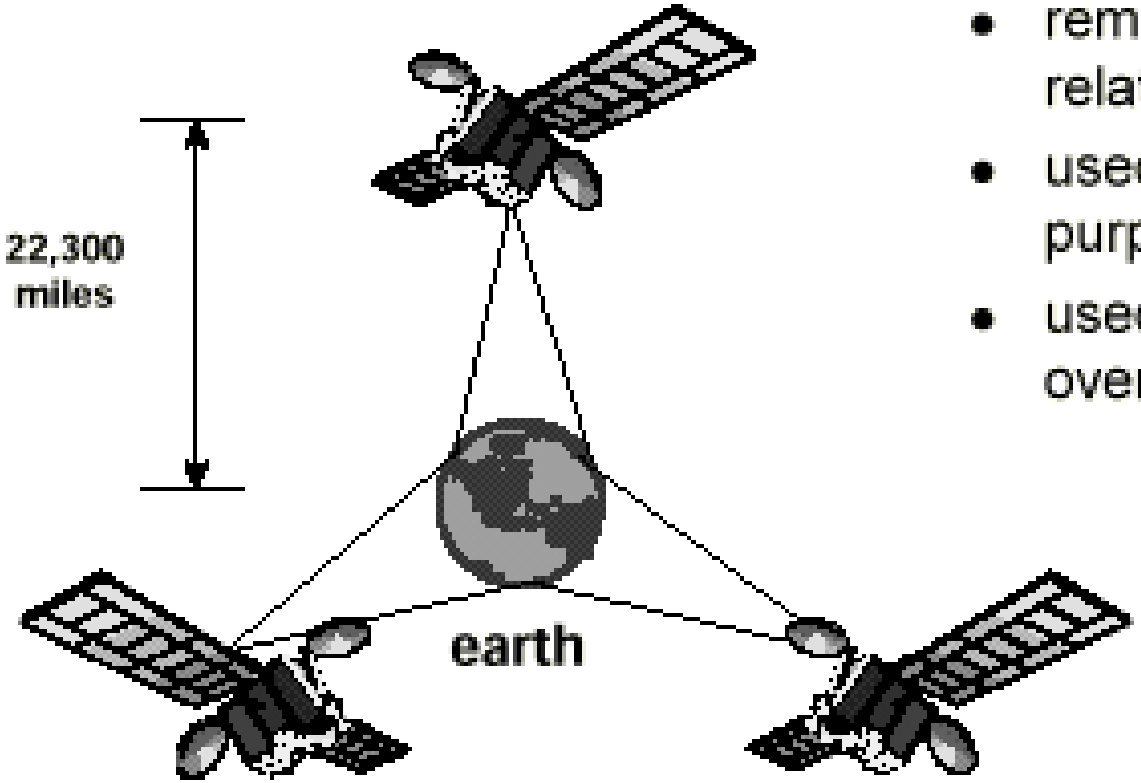
- ***Physical Description (continue):***
  - Earth stations communicate by sending signals to the satellite on uplink.
  - The satellite then repeats those signals on a downlink.
  - The broadcast nature of the downlink makes it attractive for services such as the distribution of television programming.

Uplink: The communication going from ground to a satellite

Downlink: The communication going from a satellite to ground

- ***Physical Description (continue):***

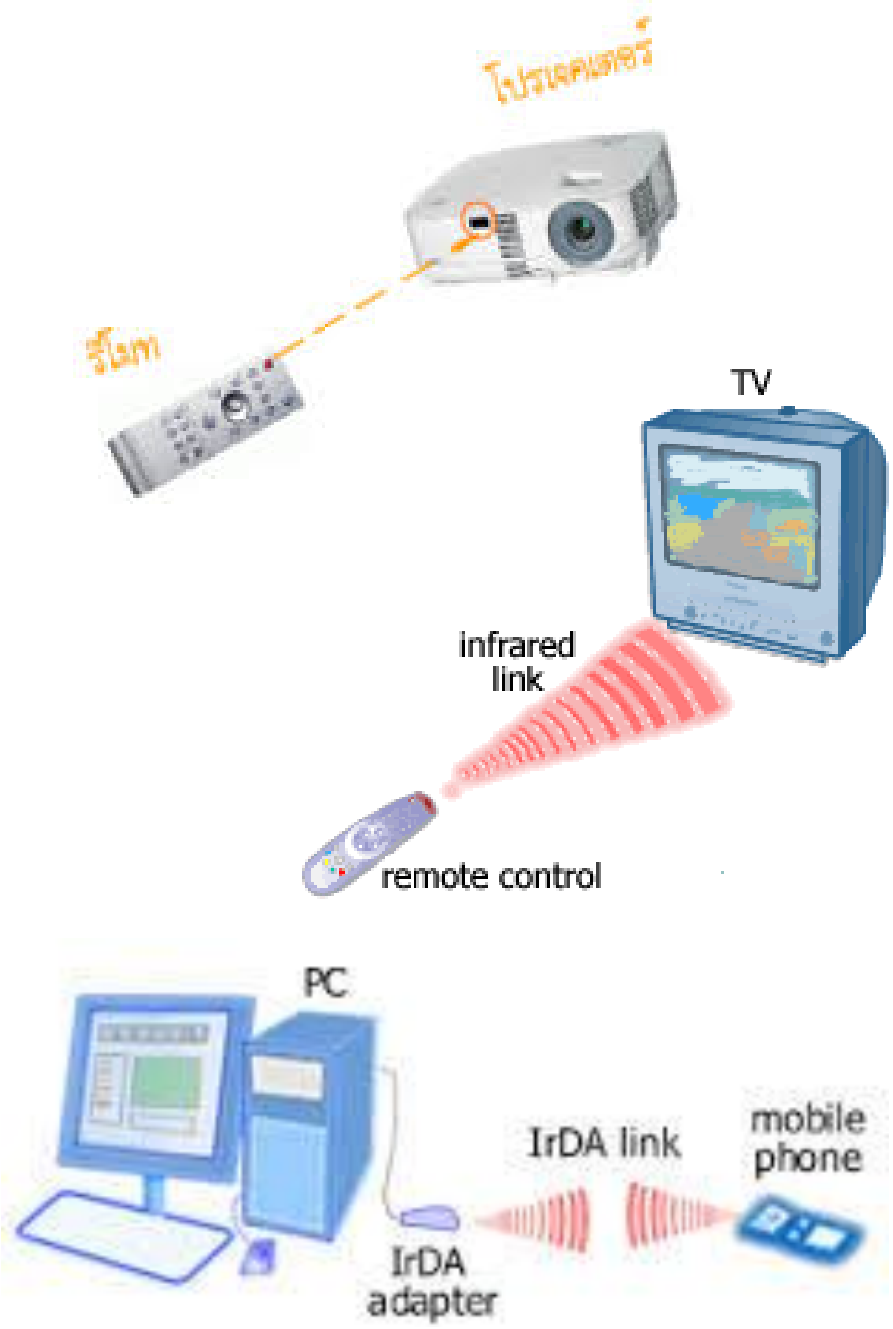
- **Geostationary satellites**: Remain above the equator at a height of 22,300 miles (geosynchronous orbit) which travel around the earth in exactly the time the earth takes to rotate.



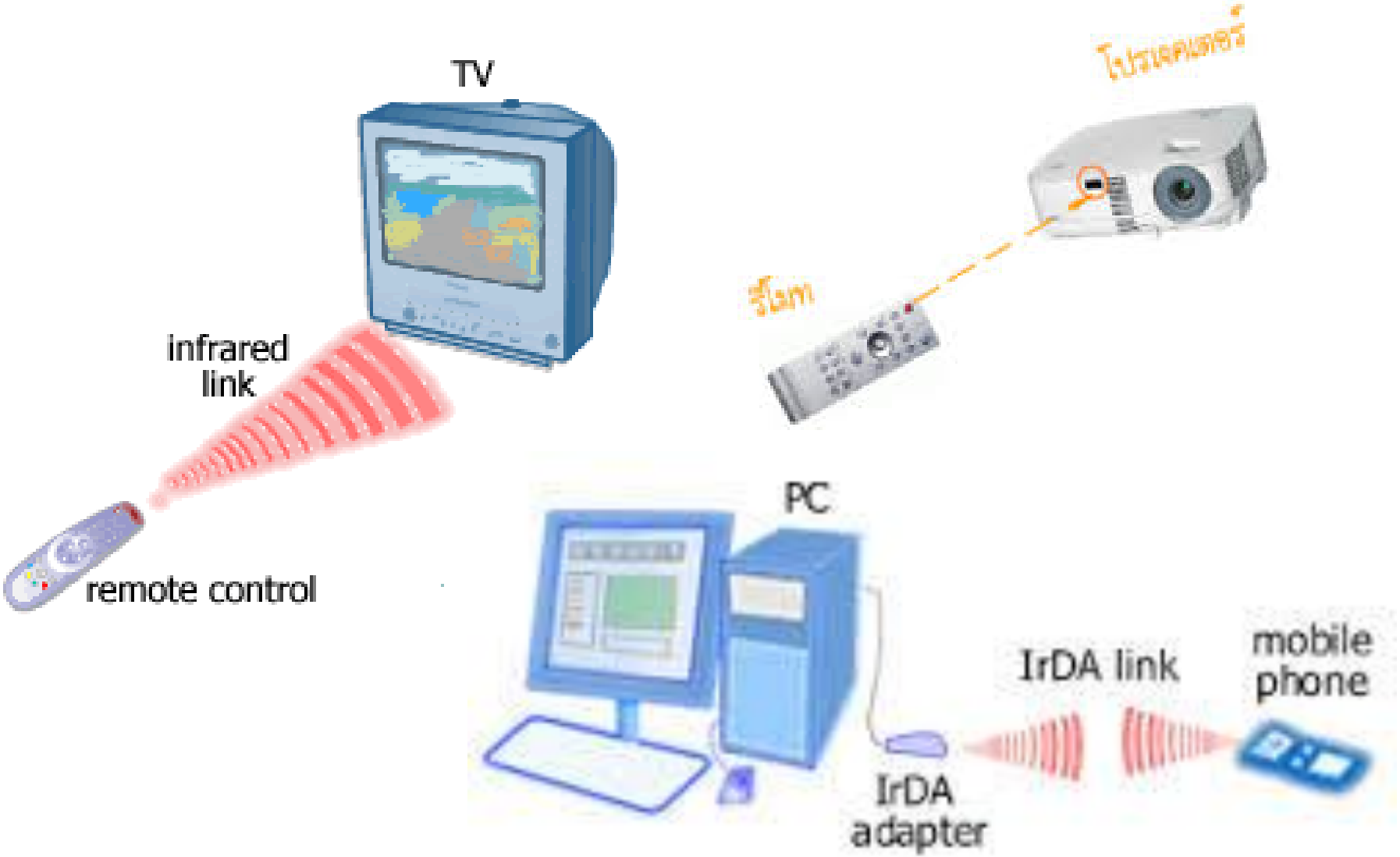
- remains in a fixed position relative to ground station.
- used for communication purposed.
- used 3 satellites to cover all over the earth.

2.34 INFRARED

- Infrared communication is achieved using transmitter/receiver (transceiver) that modulate non-coherent infrared light.
- used for short-range communication.
- having high frequencies, cannot penetrate walls
- interference between one system and another.
- Transceiver must be in line of sight of each other, either directly or reflection from light colored surface.
- the sun's rays contain infrared waves that can interfere with the communication.

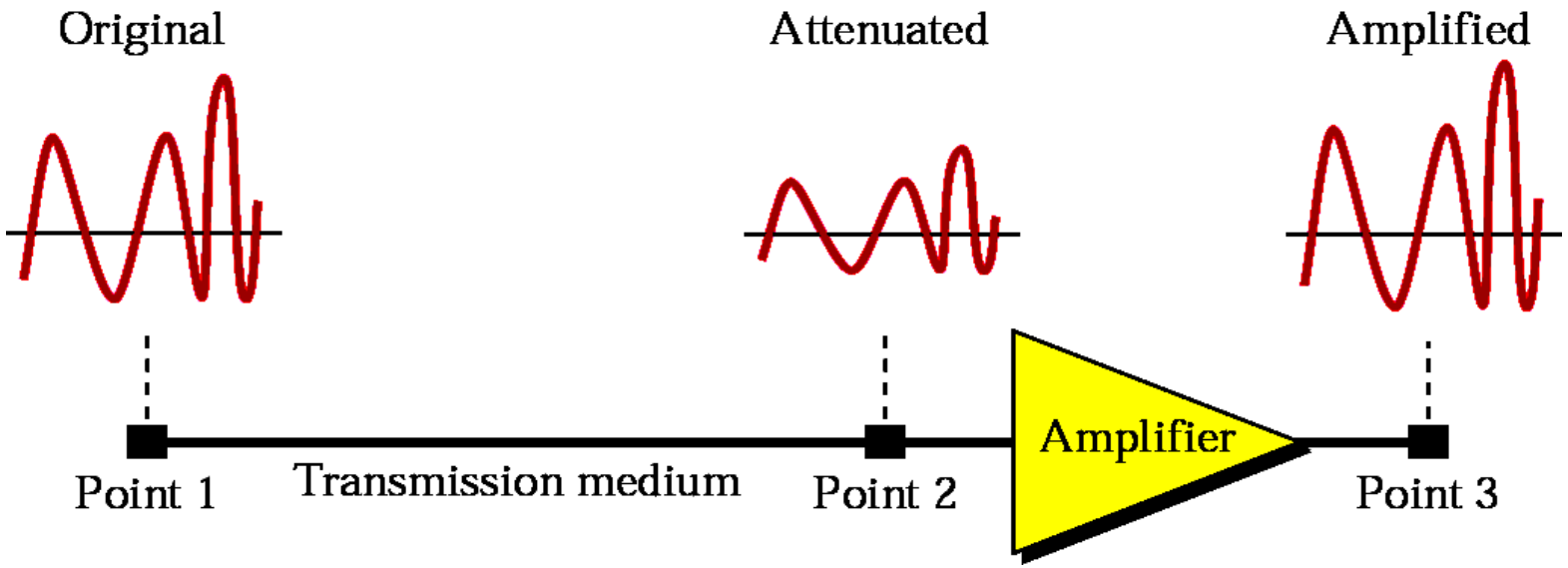


Infrared

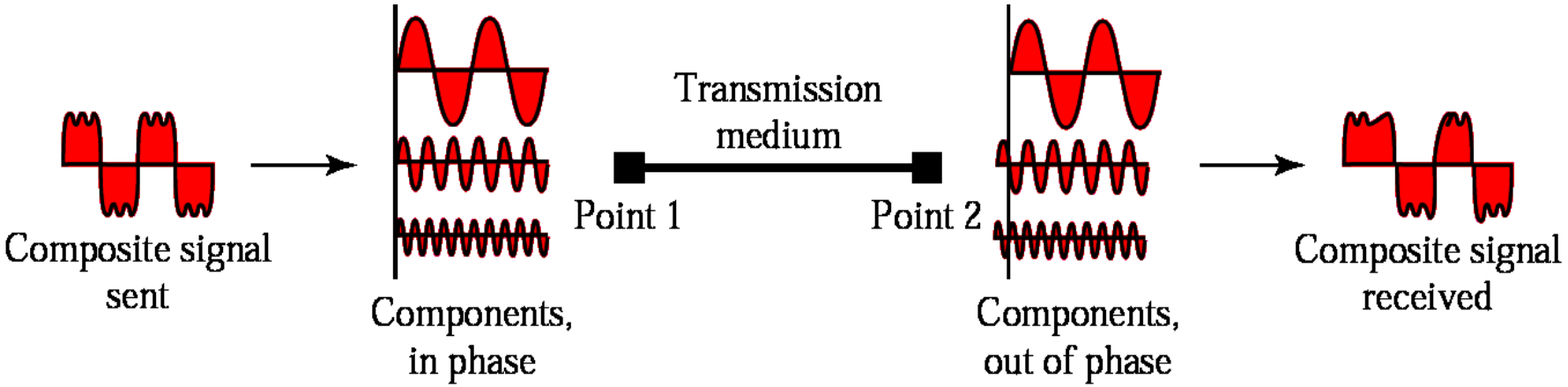

TV
infrared
link
remote control
PC
IrDA link
mobile
phone
IrDA
adapter

2.3.1 GUIDED MEDIA IMPAIRMENTS

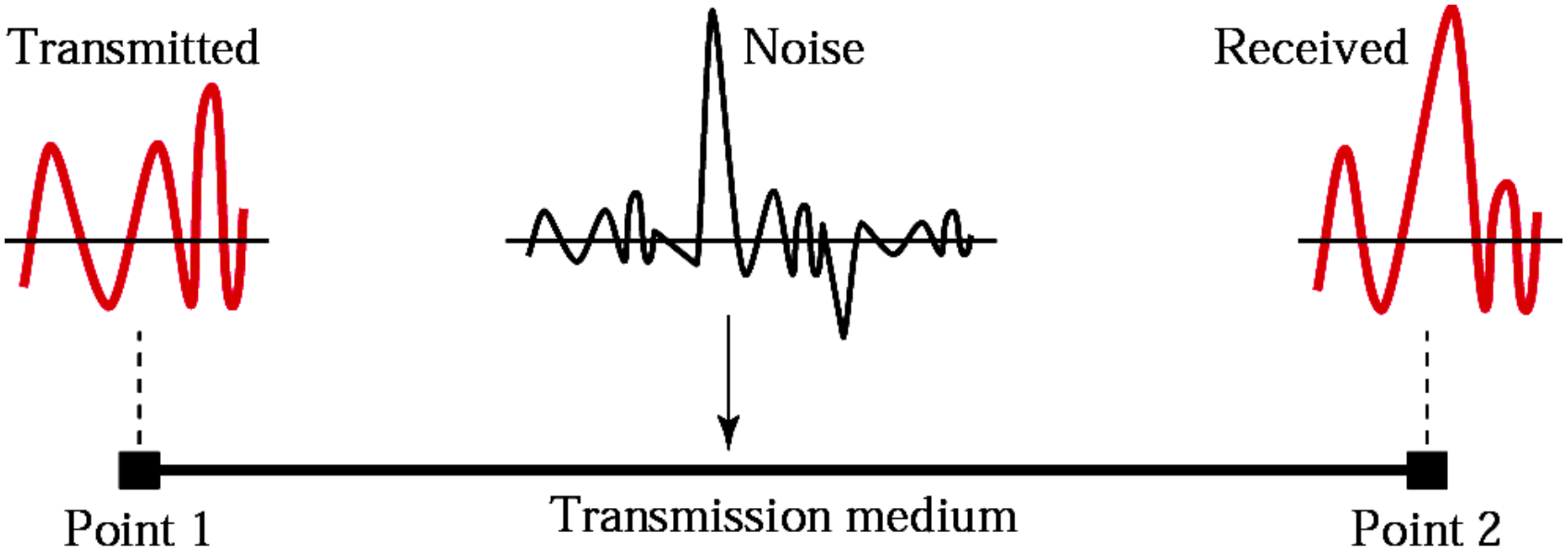
- ***Attenuation:***
  - Refers to loss of signal strength (amplitude decreases) as signal travels along the transmission medium.



- ***Distortion:***
  - Signal changes its form or shape.



- ***Noise:***
  - Unwanted electromagnetic energy inserted somewhere between transmission and reception.



- ***Noise:***

  Categories of noise:

  i. Thermal noise

  - Due to thermal as in electron movement in a conductor.
  - Cannot be avoided.

  ii. Crosstalk

  - Caused by unwanted electrical coupling between adjacent line.

iii. Impulse noise

- Caused by impulses of high electrical energy associated with external activities in short period.
- *Example:* lightning discharge.

iv. Induced noise

- Comes from sources such as motors and appliances.

2.3.2 UNGUIDED MEDIA IMPAIRMENTS

- ***Free-Space Loss:***
  - Signal disperse with distance. Therefore will receive less signal power from the transmitting antenna.

- ***Atmospheric Absorption:***
  - Atmospheric absorption [water vapor (rain, fog) and oxygen contributes to most attenuation].

- ***Refraction:***
  - Radio wave refracted when they propagate through atmosphere.

- ***Multipath:***
  - Multiple copies of signal are received by the receiver as signal may propagate through several paths with delays from reflected signal waves.

- ***Thermal noise:***
  - Thermal activities of devices and media.