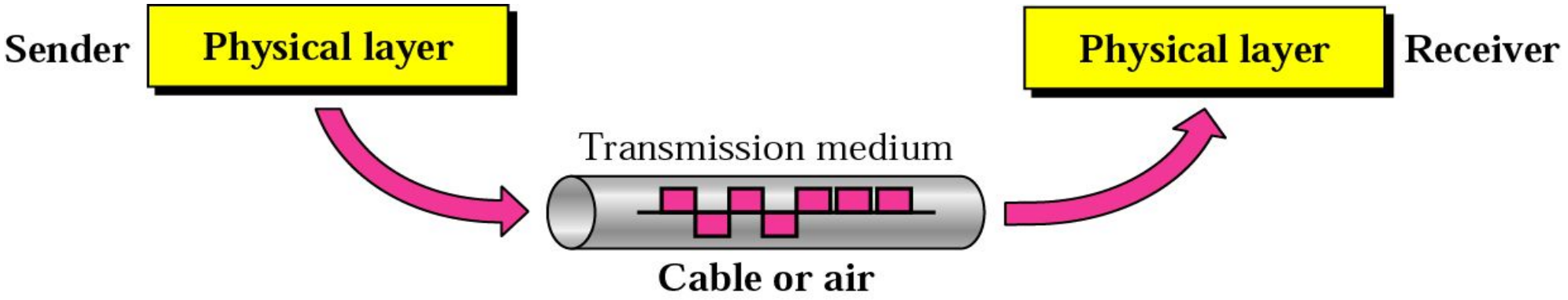
Data Communications and Networking Fourth Edition

# Chapter 7

# Transmission Media

# 7. Transmission media

- **Transmission medium and physical layer**



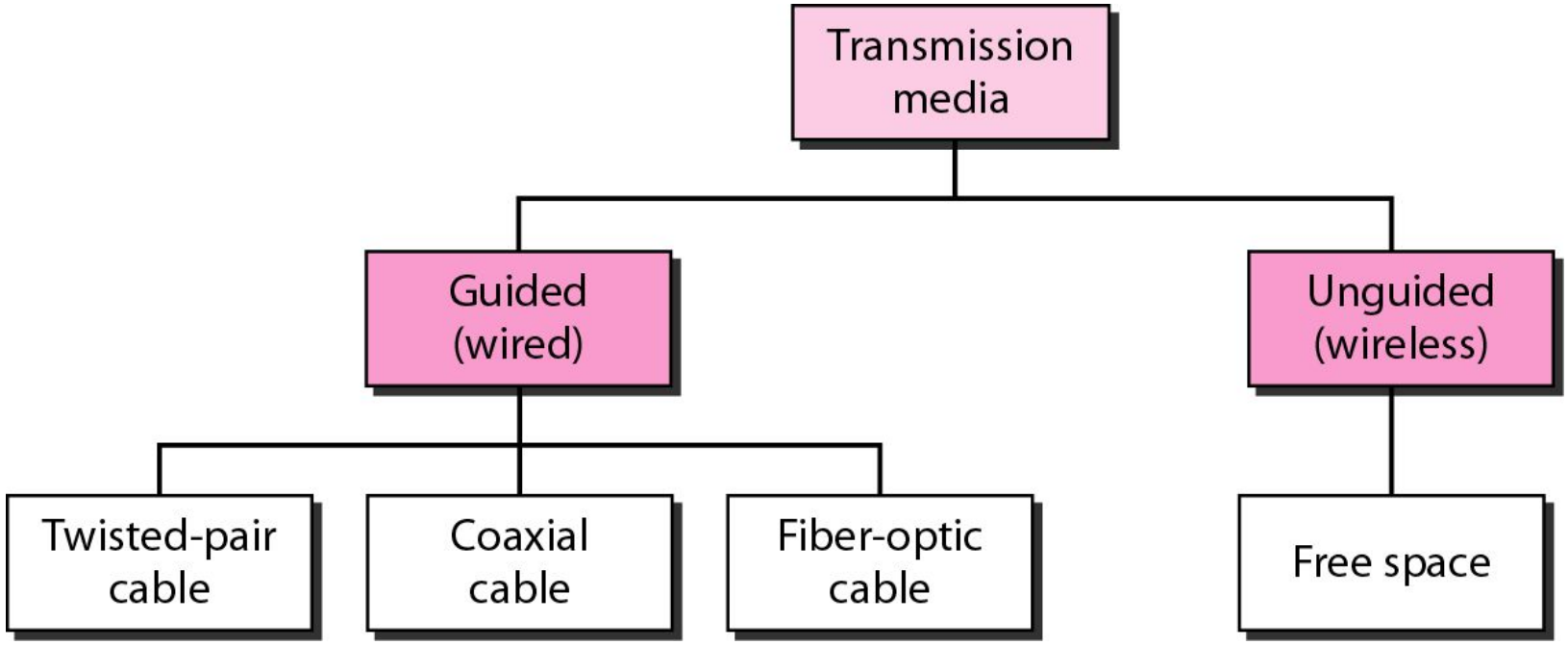
# Transmission media

## 7.1 Guided Media

## 7.2 Unguided media: Wireless

# Transmission Media(cont'd)

- **Classes of transmission media**



# 7-1 GUIDED MEDIA

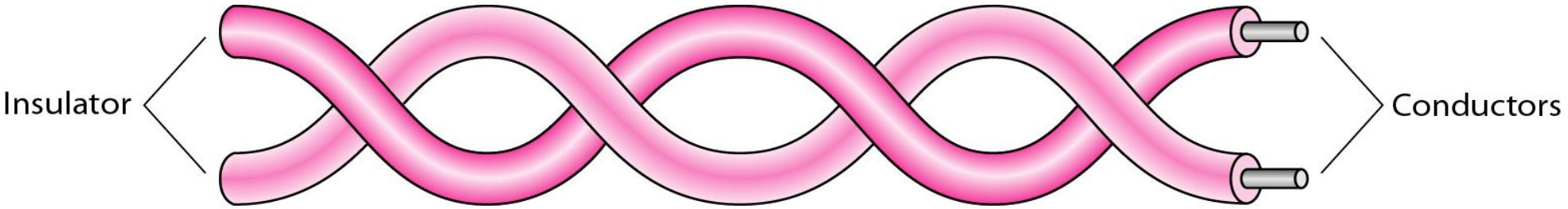
**Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable.**

***Topics discussed in this section:***

**Twisted-Pair Cable**
**Coaxial Cable**
**Fiber-Optic Cable**

# Twisted-Pair Cable

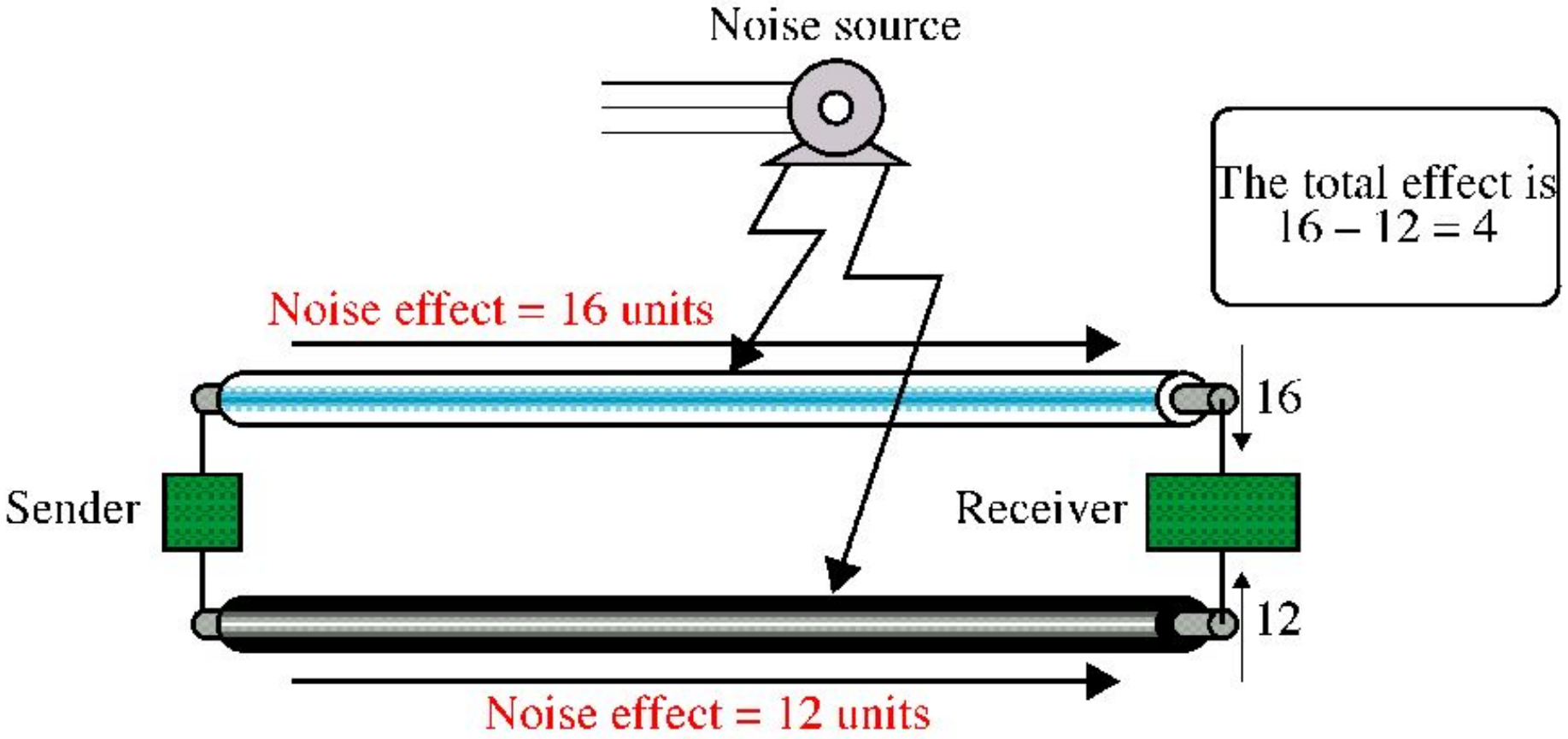
**Figure 7.3** *Twisted-pair cable*




- Two copper conductors
- One carriers signals, the other is the ground reference
- Receiver operates on the difference between the signals.
- This is why they are twisted, to maintain balance
- More twists mean better quality

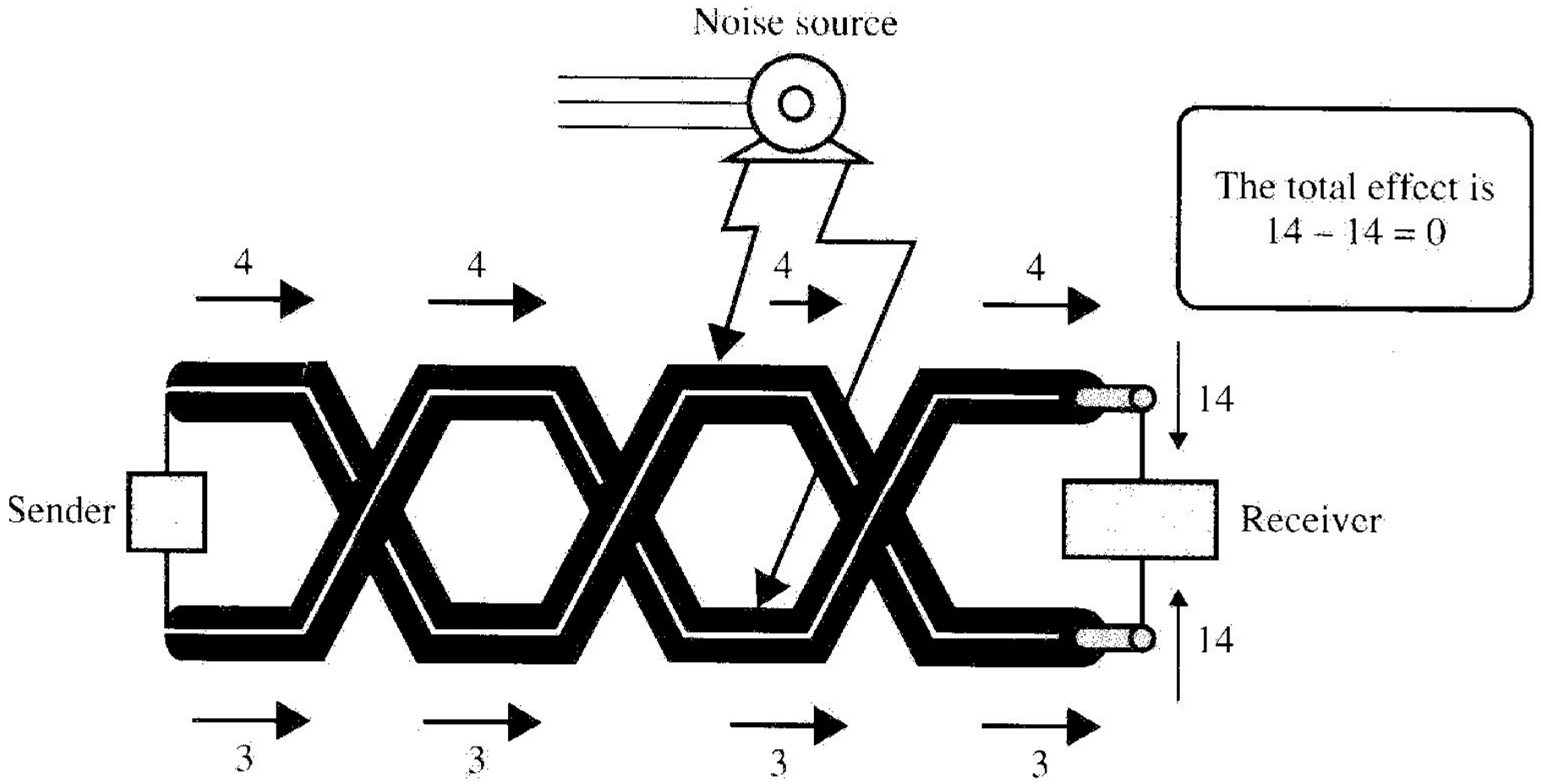
# Twisted-Pair Cable

- **Effect of noise on parallel lines**



# Twisted-Pair Cable

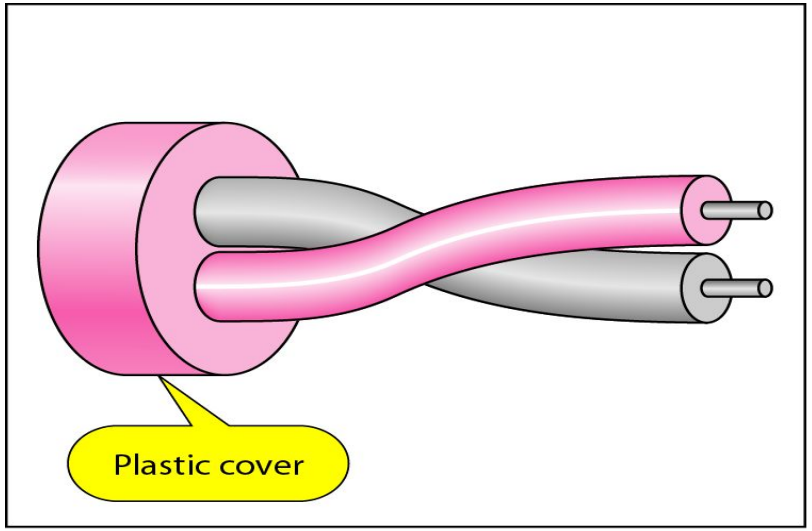
- **Effect of noise on twisted-pair lines**



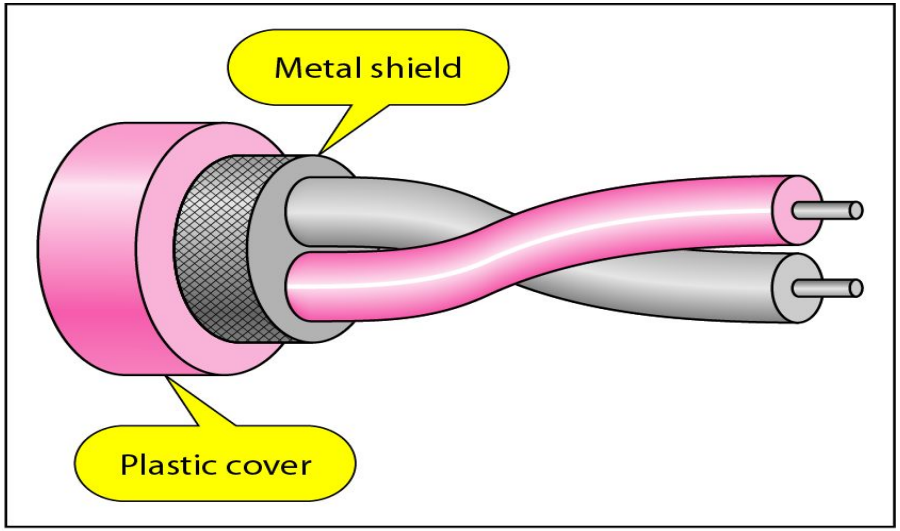
# Twisted-Pair Cable

## Twisted-Pair Cable comes in two forms

- Unshielded twisted pair cable
- Shielded twisted pair cable




a. UTP



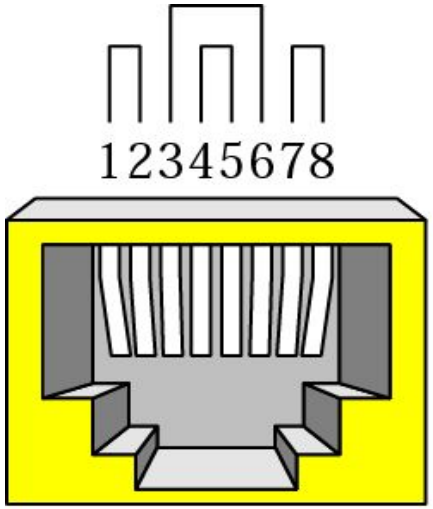

b. STP

## Table 7.1 *Categories of unshielded twisted-pair cables*

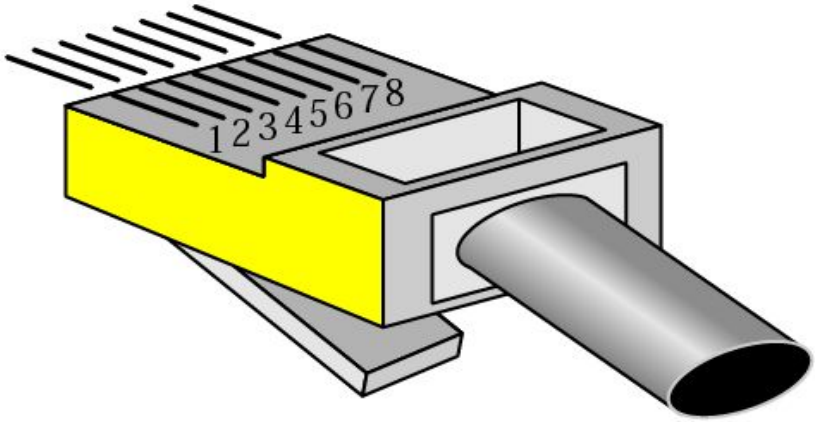
| *Category* | *Specification* | *Data Rate (Mbps)* | *Use* |
|---|---|---|---|
| 1 | Unshielded twisted-pair used in telephone | < 0.1 | Telephone |
| 2 | Unshielded twisted-pair originally used in T-lines | 2 | T-1 lines |
| 3 | Improved CAT 2 used in LANs | 10 | LANs |
| 4 | Improved CAT 3 used in 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 |

# Twisted-Pair Cable

- **UTP connectors**



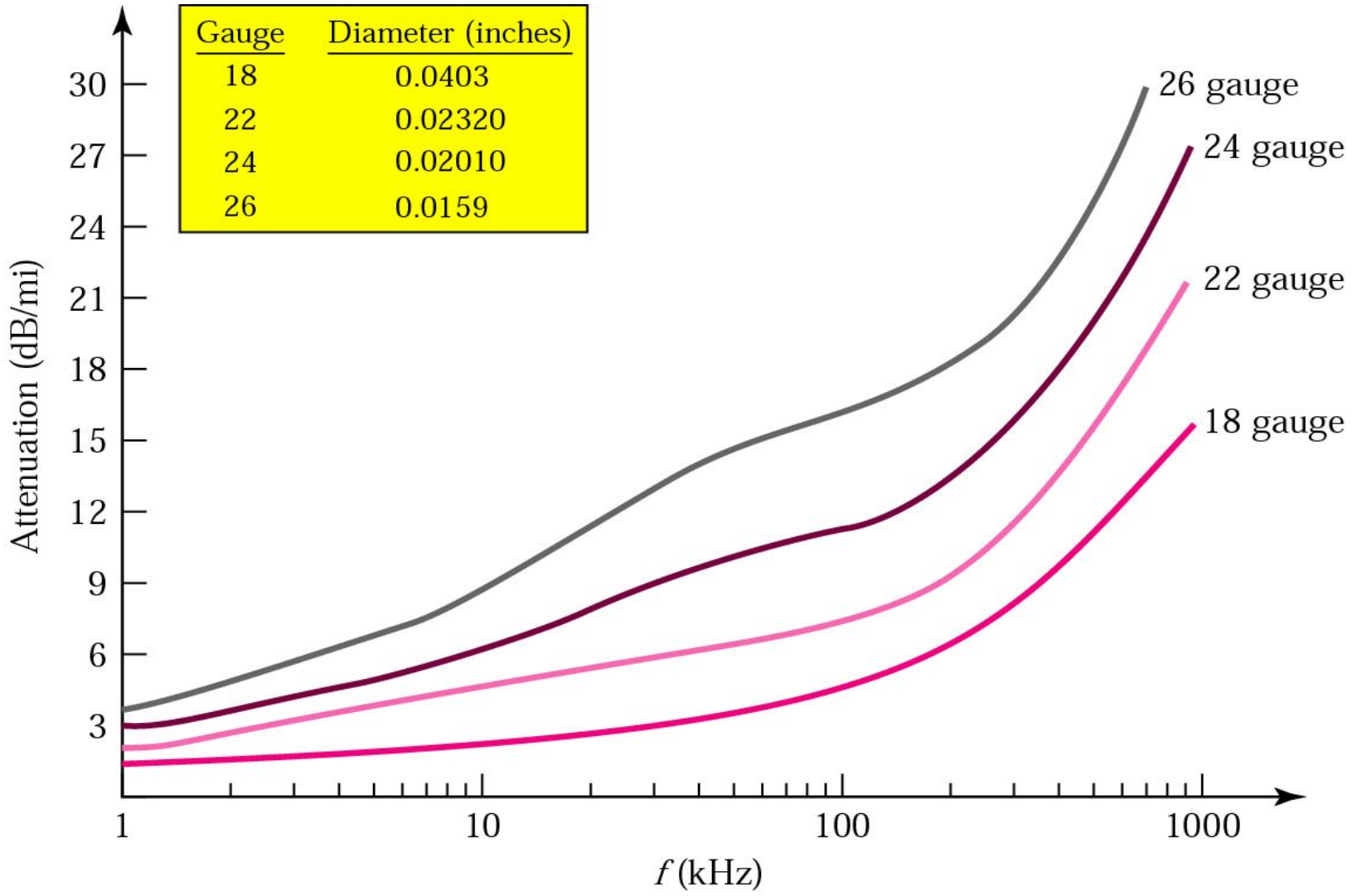

RJ-45 Female




RJ-45 Male

- **RJ – Registered Jack**
- **keyed connector, can be inserted one way**

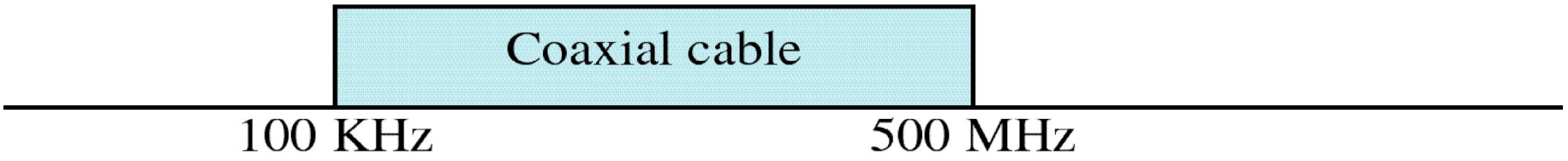
# Twisted-Pair Cable



# Coaxial Cable

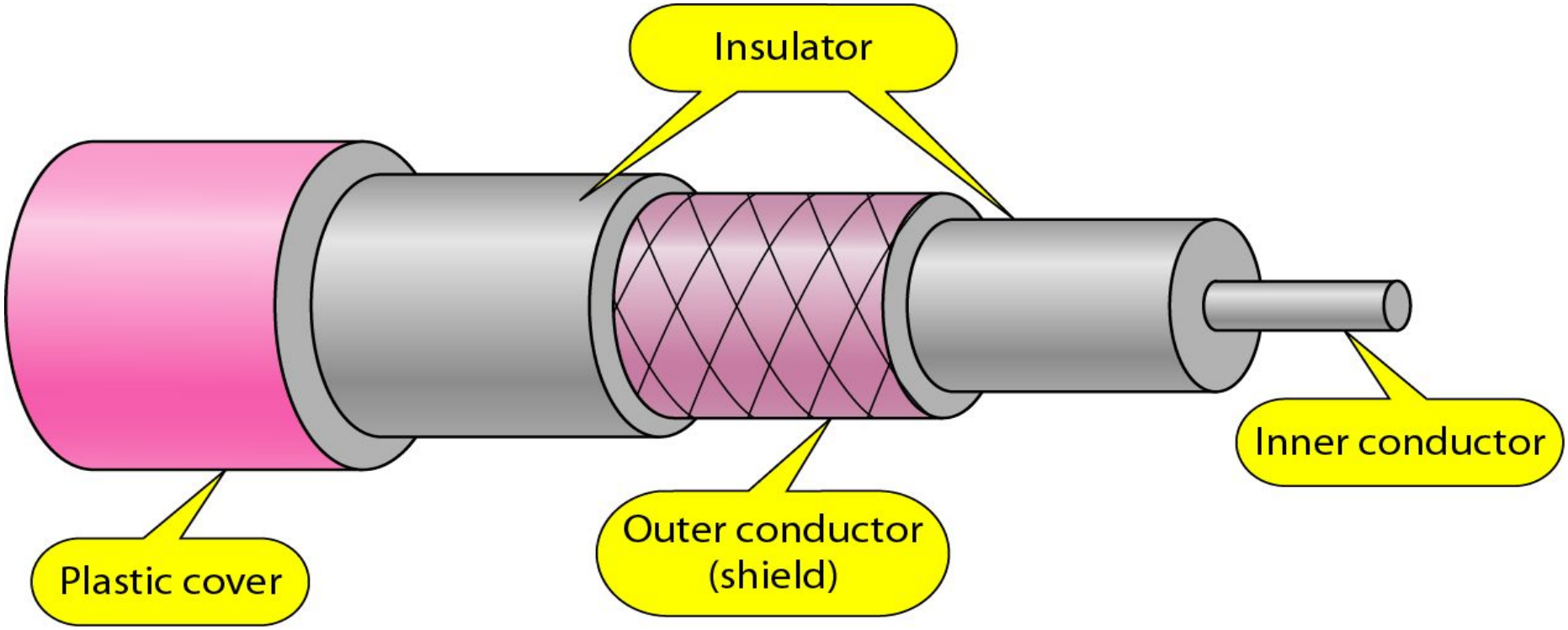
- **Coaxial Cable**
  - **carries signals of higher frequency ranges**

- **Frequency range of coaxial cable**



# Coaxial Cable

**Figure 7.7** *Coaxial cable*



# Coaxial Cable

- **Coaxial Cable Standards**

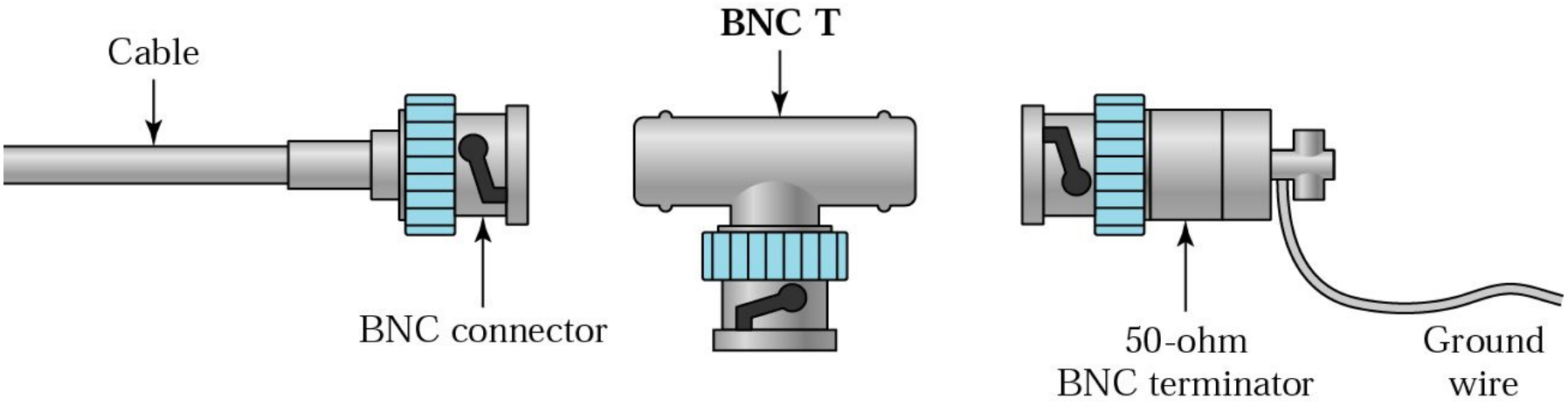
  **~ are categorized by RG(radio government) rating**

**Table 7.2** *Categories of coaxial cables*

| *Category* | *Impedance* | *Use* |
|---|---|---|
| RG-59 | 75 Ω | Cable TV |
| RG-58 | 50 Ω | Thin Ethernet |
| RG-11 | 50 Ω | Thick Ethernet |

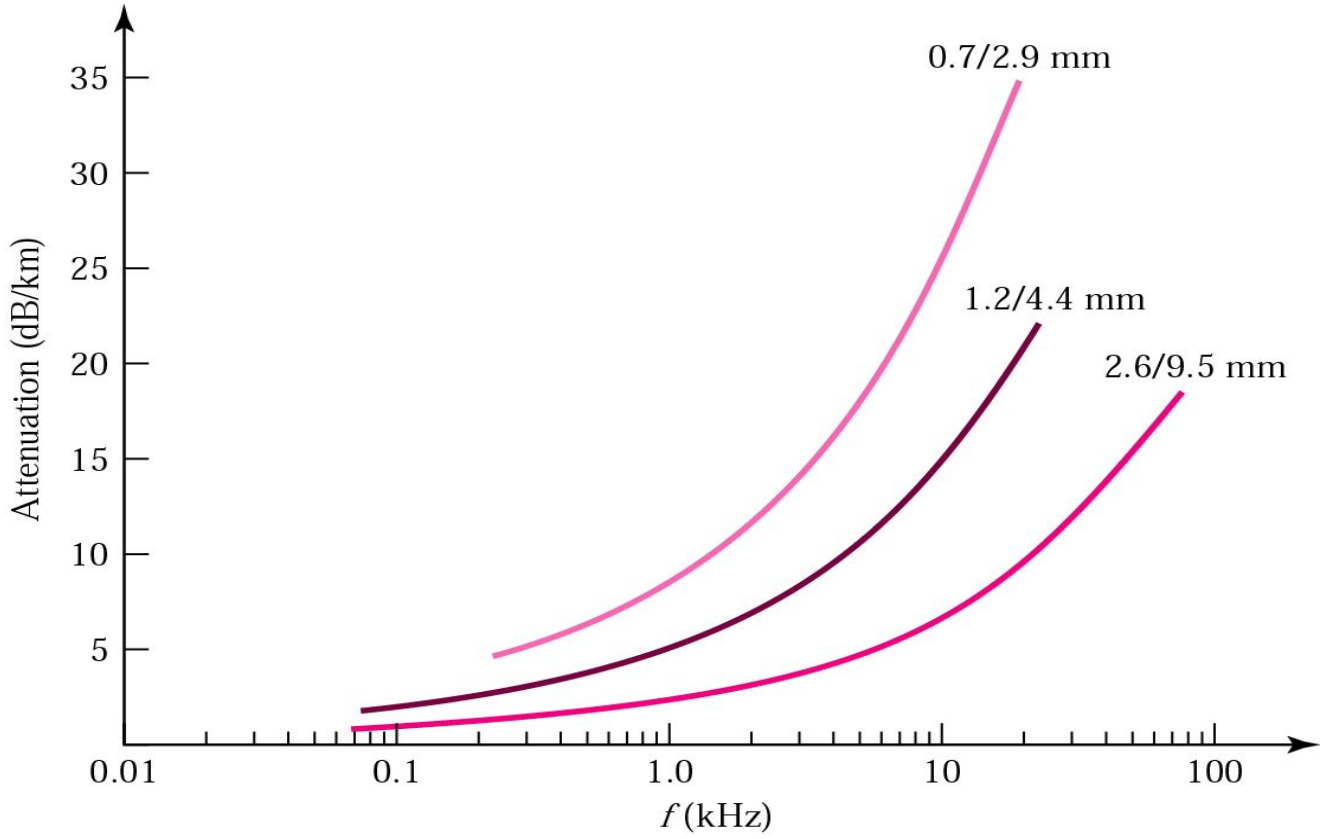
# Coaxial Cable

- **Coaxial Cable Connectors**



# Coaxial Cable

- **Performance**



# Optical Fiber Cable

- **Optical Fiber**

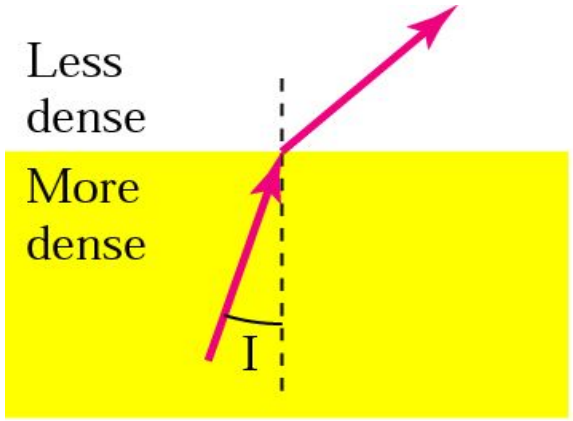
  **~ is made of glass or plastic and transmits signals in the form of light**

- **Nature of Light**

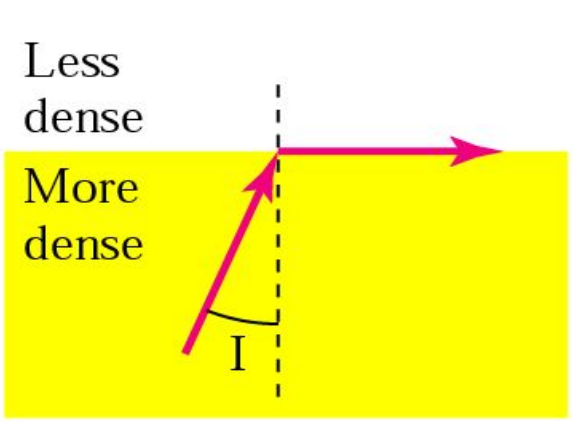
  **~ is a form of electromagnetic energy. It travels at its fastest in a vacuum : 300,000km/s. This speed decreases as the medium through which the light travels become denser.**

# Optical Fiber Cable

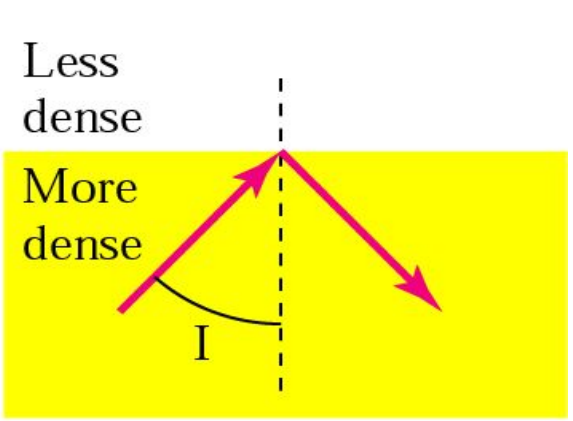
- **Refraction**




I < critical angle,
refraction




I = critical angle,
refraction

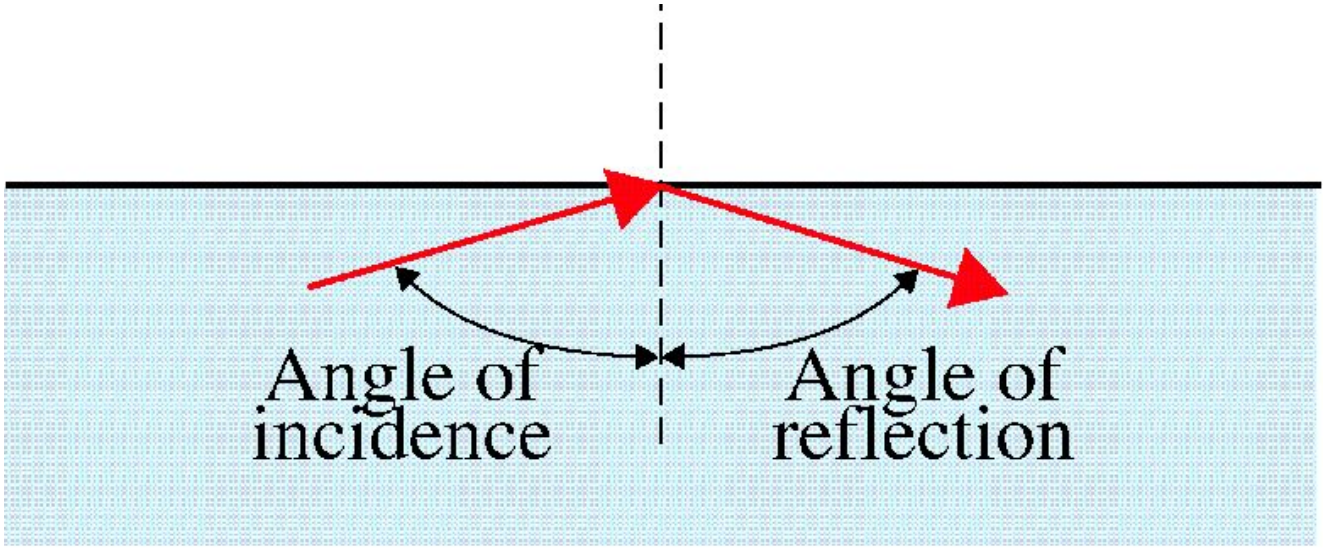



I > critical angle,
reflection

# Optical Fiber Cable

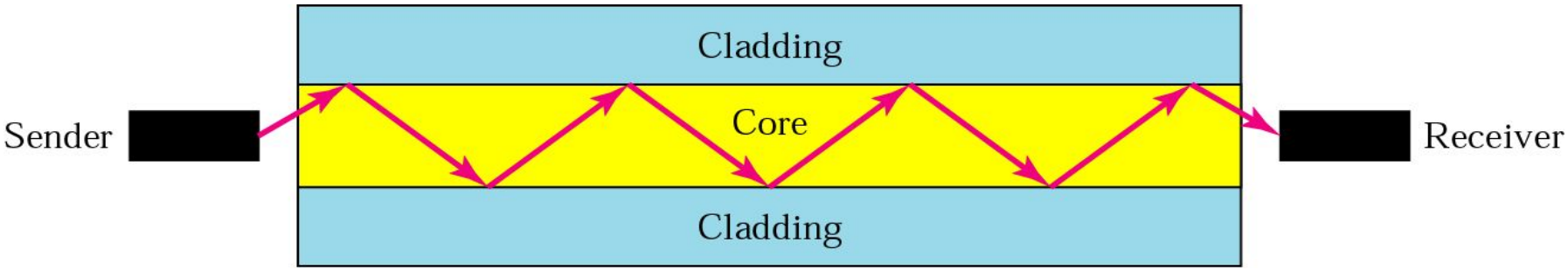
- **critical angle**
  - **As the angle of incidence increases, it moves away from vertical and closer to the horizontal.**

- **Reflection**
  - **When the angle of incidence becomes greater than the critical angle, a new phenomenon occurs called reflection**

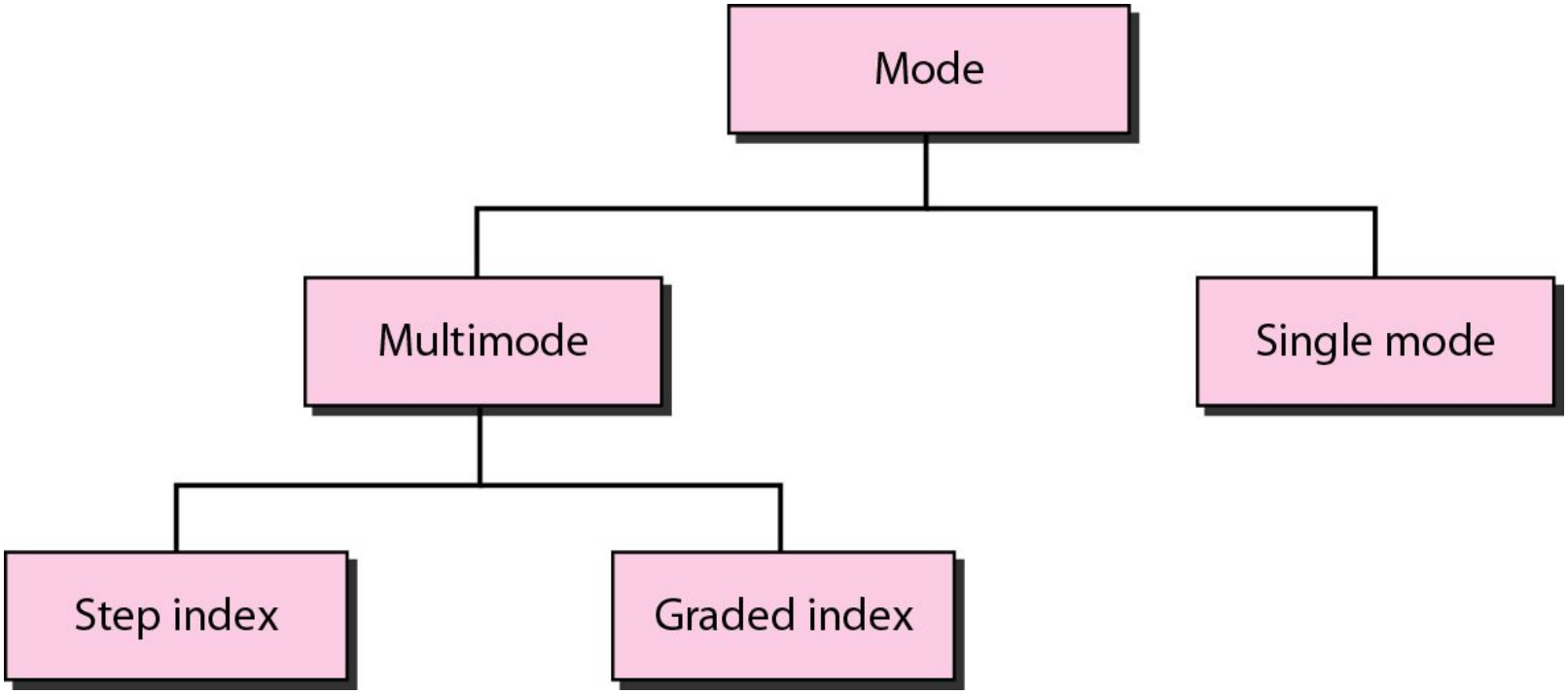


# Optical Fiber Cable

- **Optical Fiber**

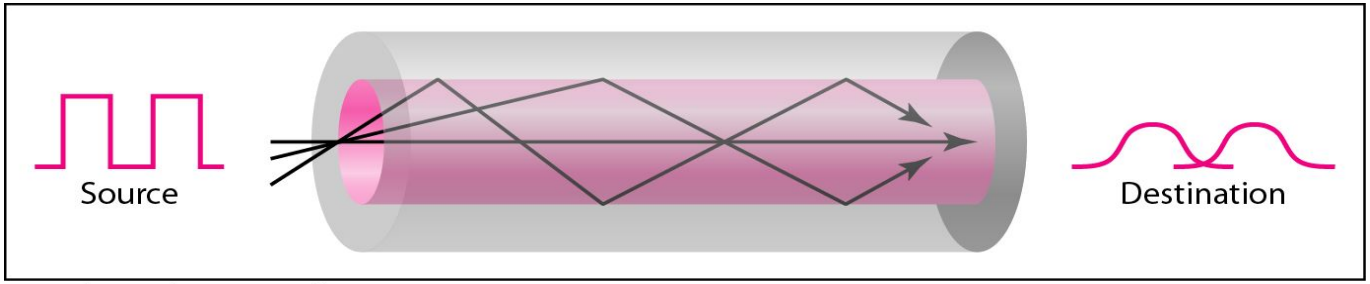


- **Propagation Models**
  - **current technology supports two models for propagating light along optical channel.**

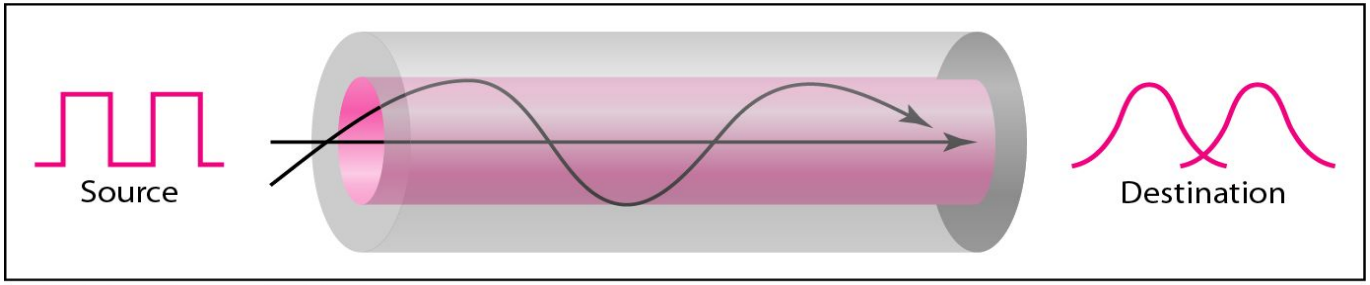


# Optical Fiber Cable

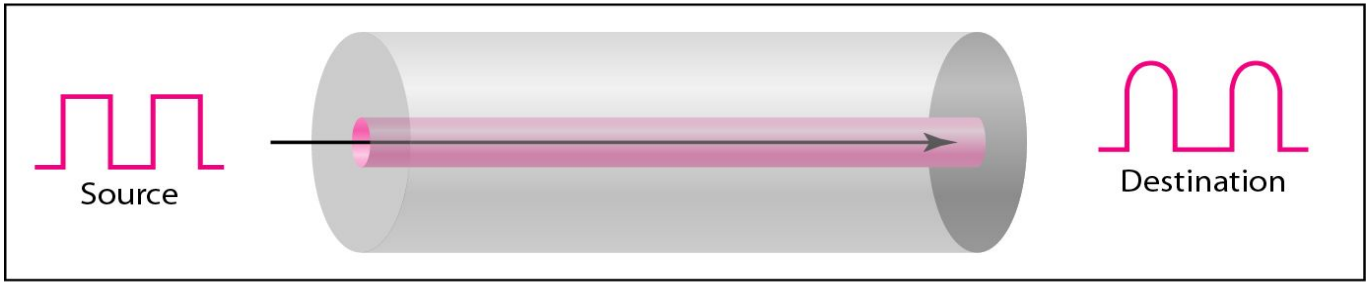
## Figure 7.13 *Modes*




a. Multimode, step index




b. Multimode, graded index

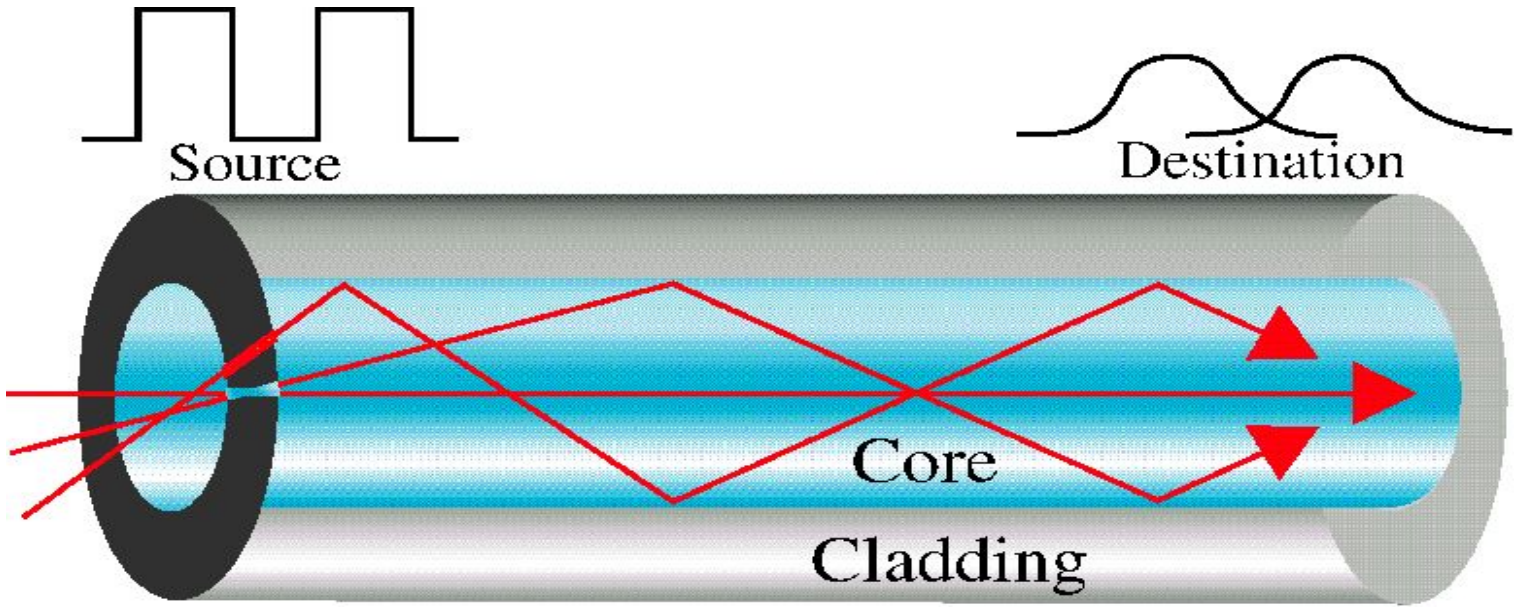



c. Single mode

# Optical Fiber Cable

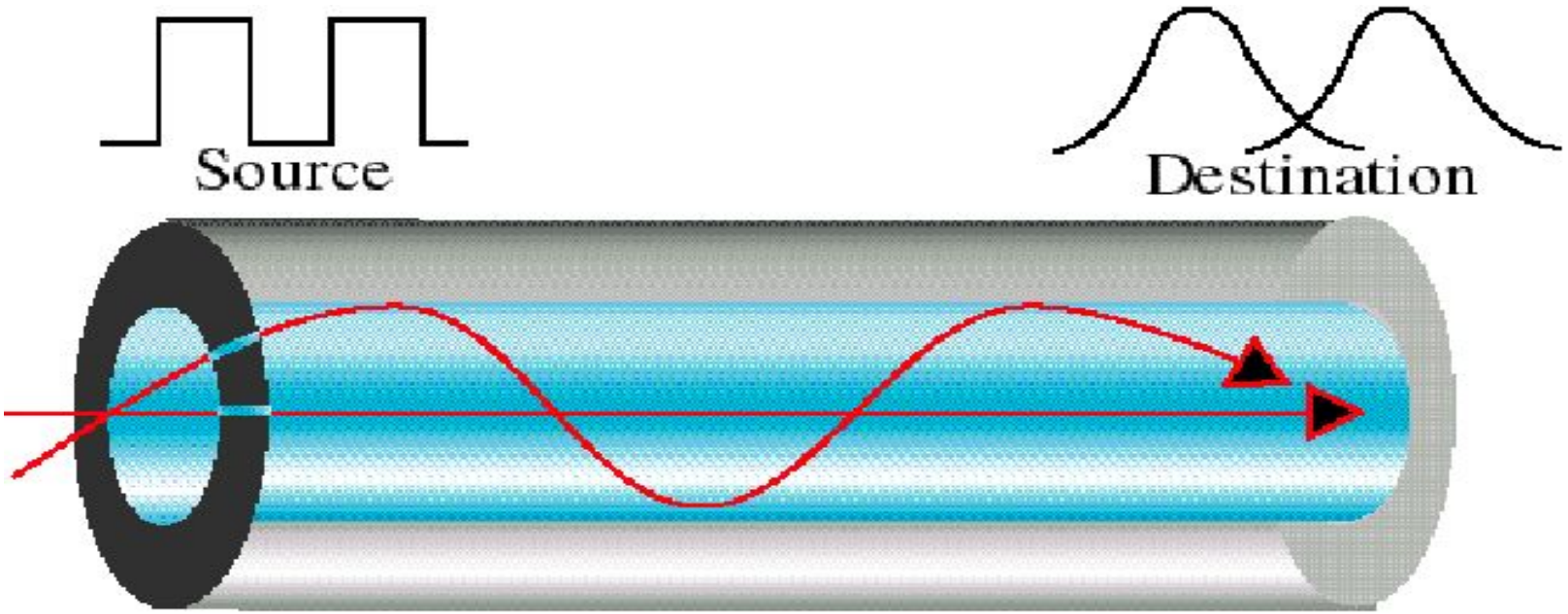
- **Multimode step-index**

  **~ multiple beams from a light source move through the core in different paths.**



# Optical Fiber Cable

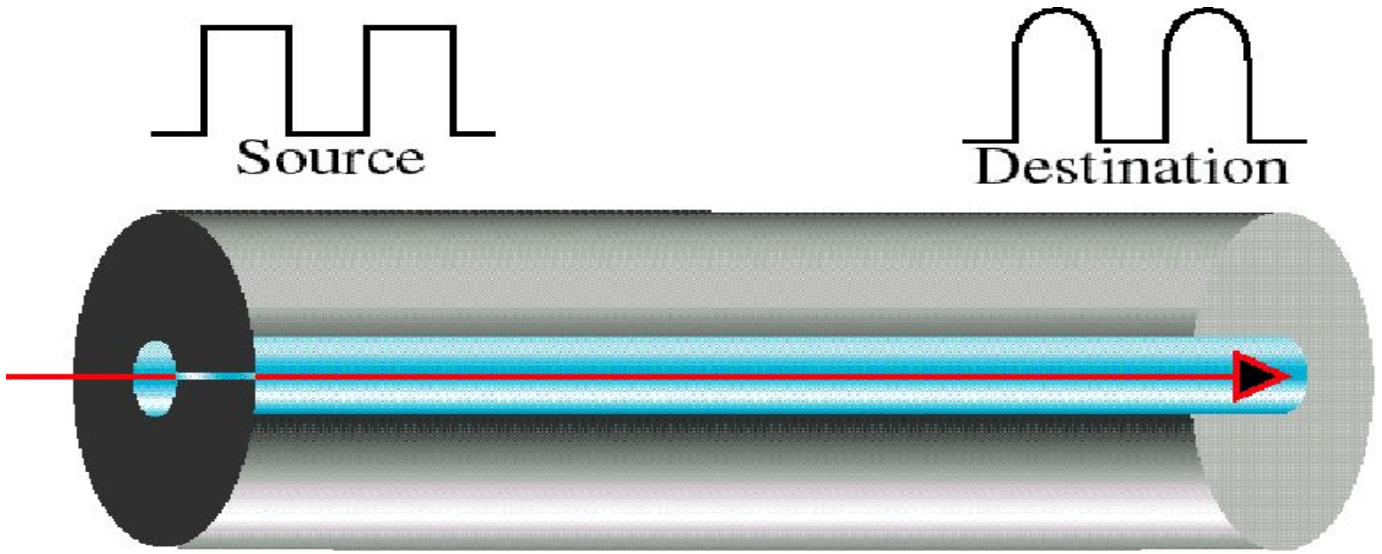
- **Multimode graded-index**
  - **fiber with varying densities**
  - **highest density at the center of the core**



# Optical Fiber Cable

- **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.**



# Optical Fiber Cable

- **Fiber sizes**

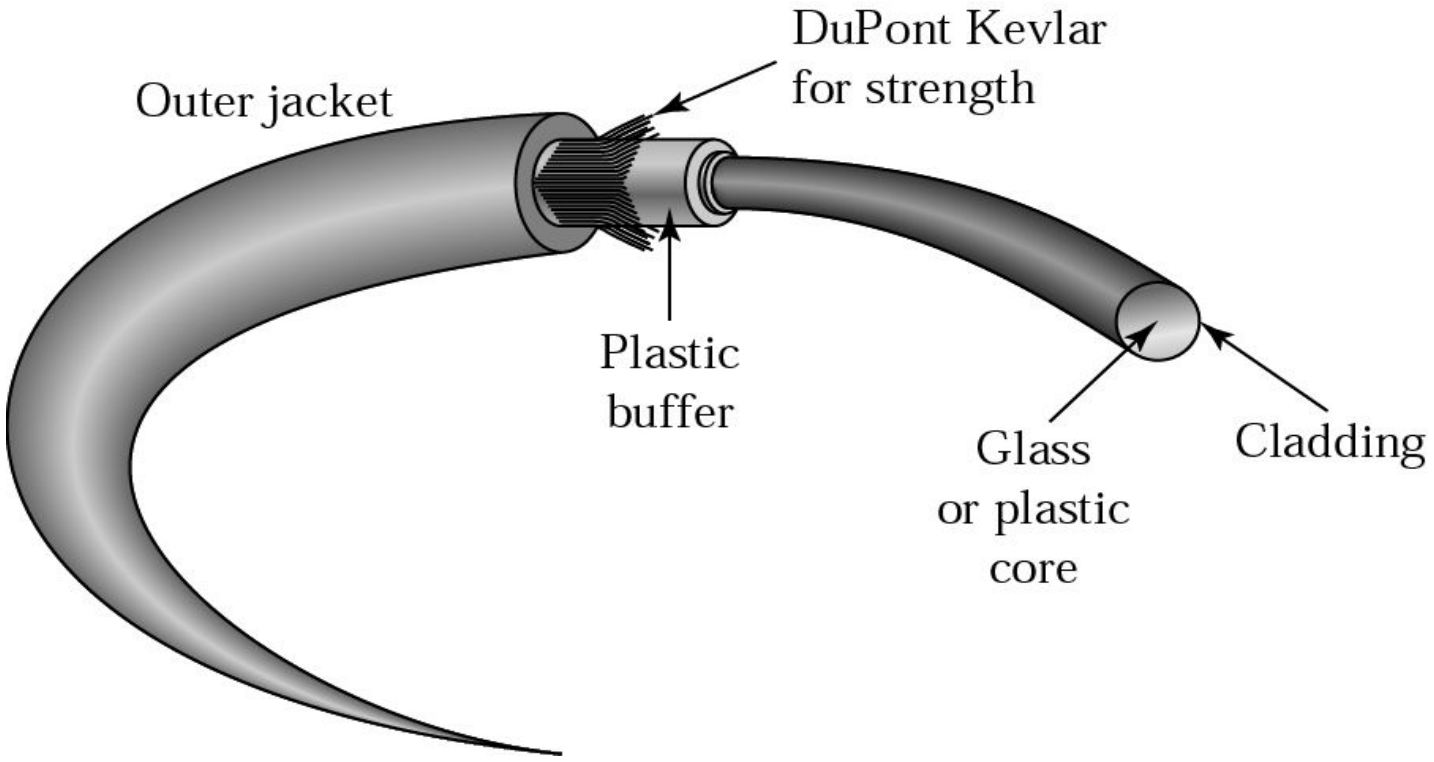
  **~ are defined by the ratio of the diameter of their core to the diameter of their cladding.**

**Table 7.3** *Fiber types*

| *Type* | *Core (μm)* | *Cladding (μm)* | *Mode* |
|---|---|---|---|
| 50/125 | 50.0 | 125 | Multimode, graded index |
| 62.5/125 | 62.5 | 125 | Multimode, graded index |
| 100/125 | 100.0 | 125 | Multimode, graded index |
| 7/125 | 7.0 | 125 | Single mode |

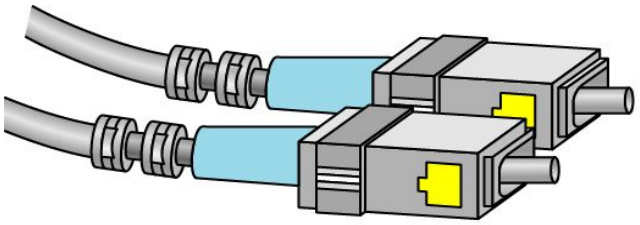
# Optical Fiber Cable

- **Cable Composition**

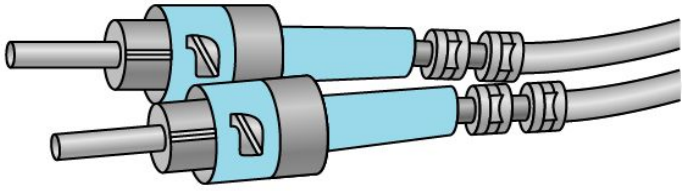


# Optical Fiber Cable

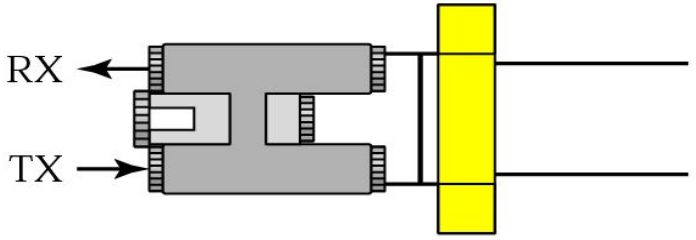
- **Fiber-optic Cable Composition**



SC connector



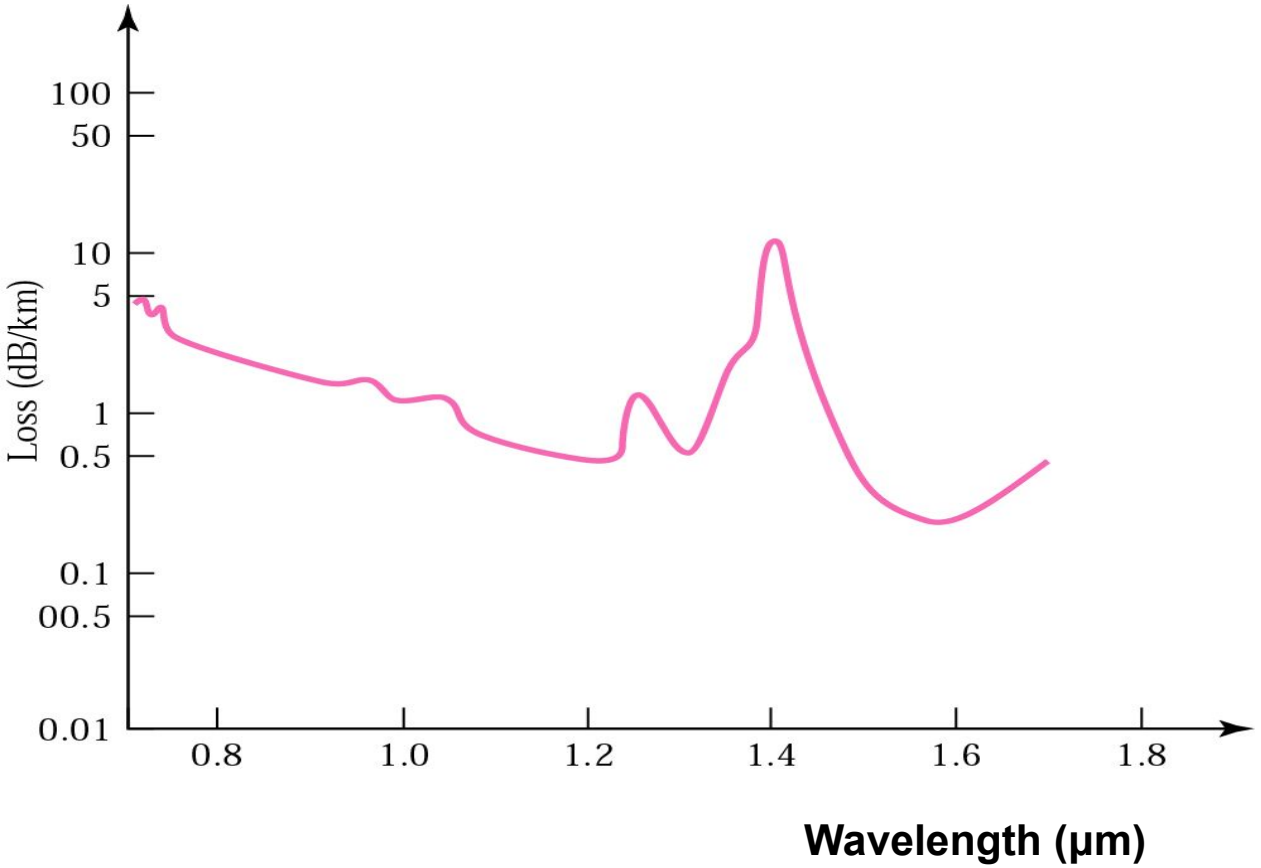
ST connector




MT-RJ connector

# Optical Fiber Cable

- **Optical Fiber Performance**



# Optical Fiber Cable

- **Advantages of Optical Fiber**
  - **Noise resistance**
  - **Less signal attenuation**
  - **Higher bandwidth**
- **Disadvantages of Optical Fiber Cost**
  - **Installation/maintenance**
  - **Fragility**

# 7.2 UNGUIDED MEDIA: WIRELESS

**Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.**

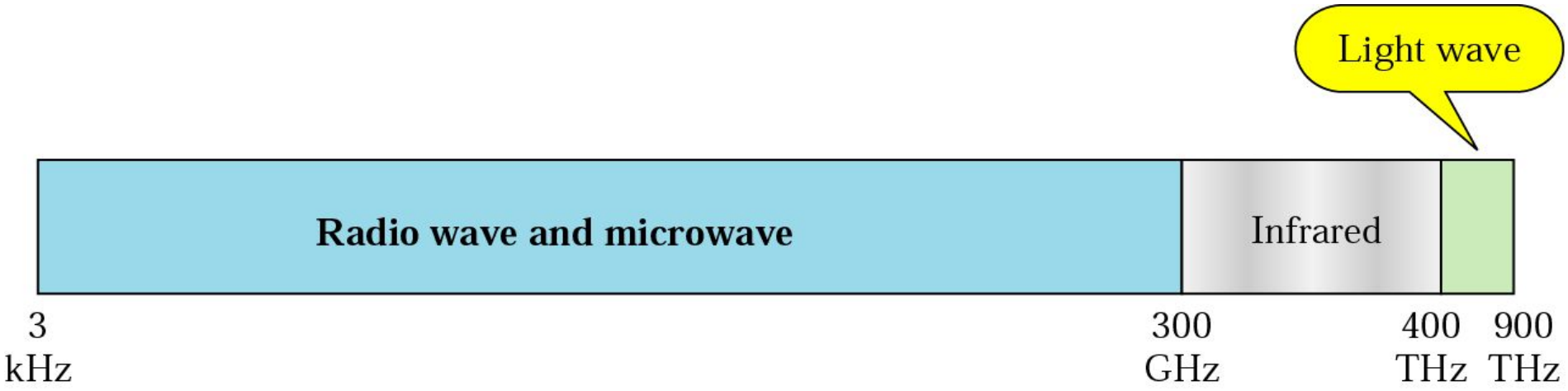
***Topics discussed in this section:***

**Radio Waves**
**Microwaves**
**Infrared**

# Unguided media

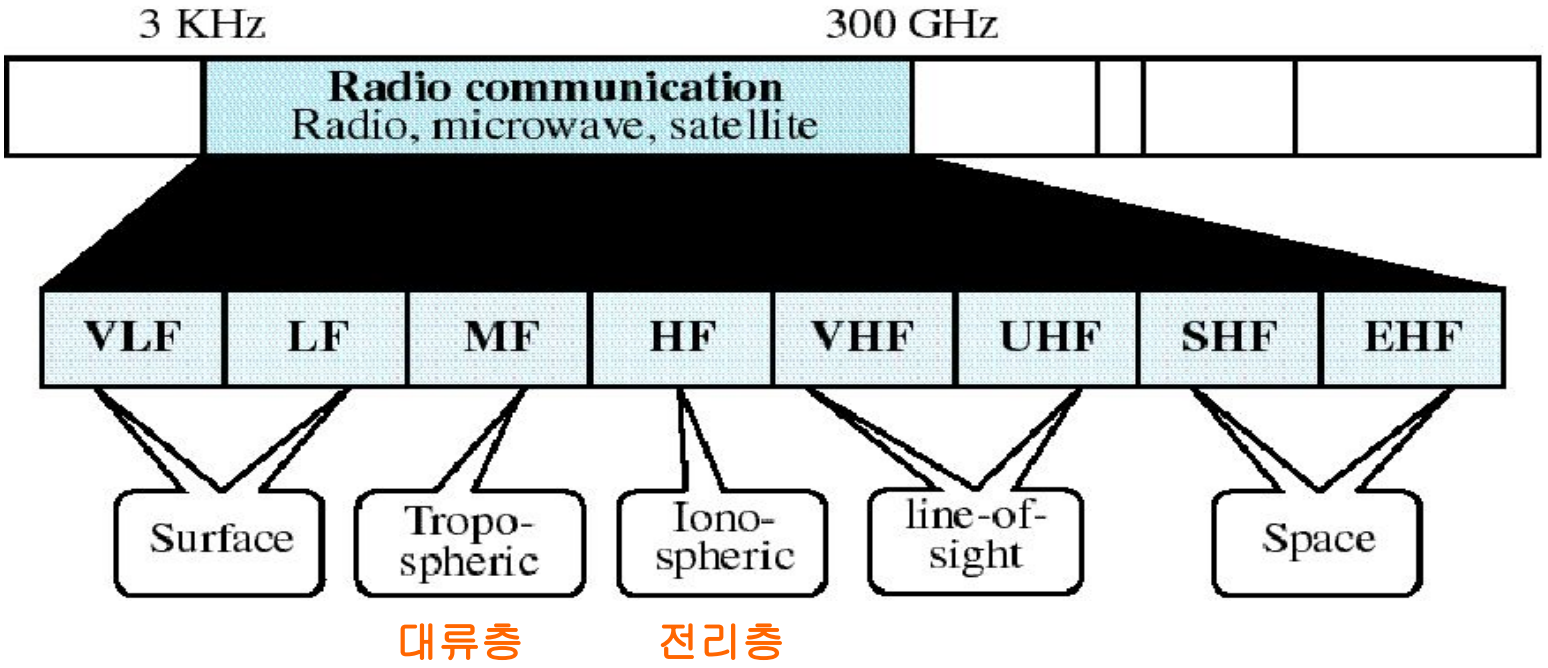
- wireless
- signals are broadcasted through air

**Figure 7.17** *Electromagnetic spectrum for wireless communication*



# Radio Frequency Allocation

| | | | |
|---|---|---|---|
| VLF | Very low frequency | VHF | Very high frequency |
| LF | Low frequency | UHF | Ultra high frequency |
| MF | Middle frequency | SHF | Super high frequency |
| HF | High frequency | EHF | Extremely high frequency |



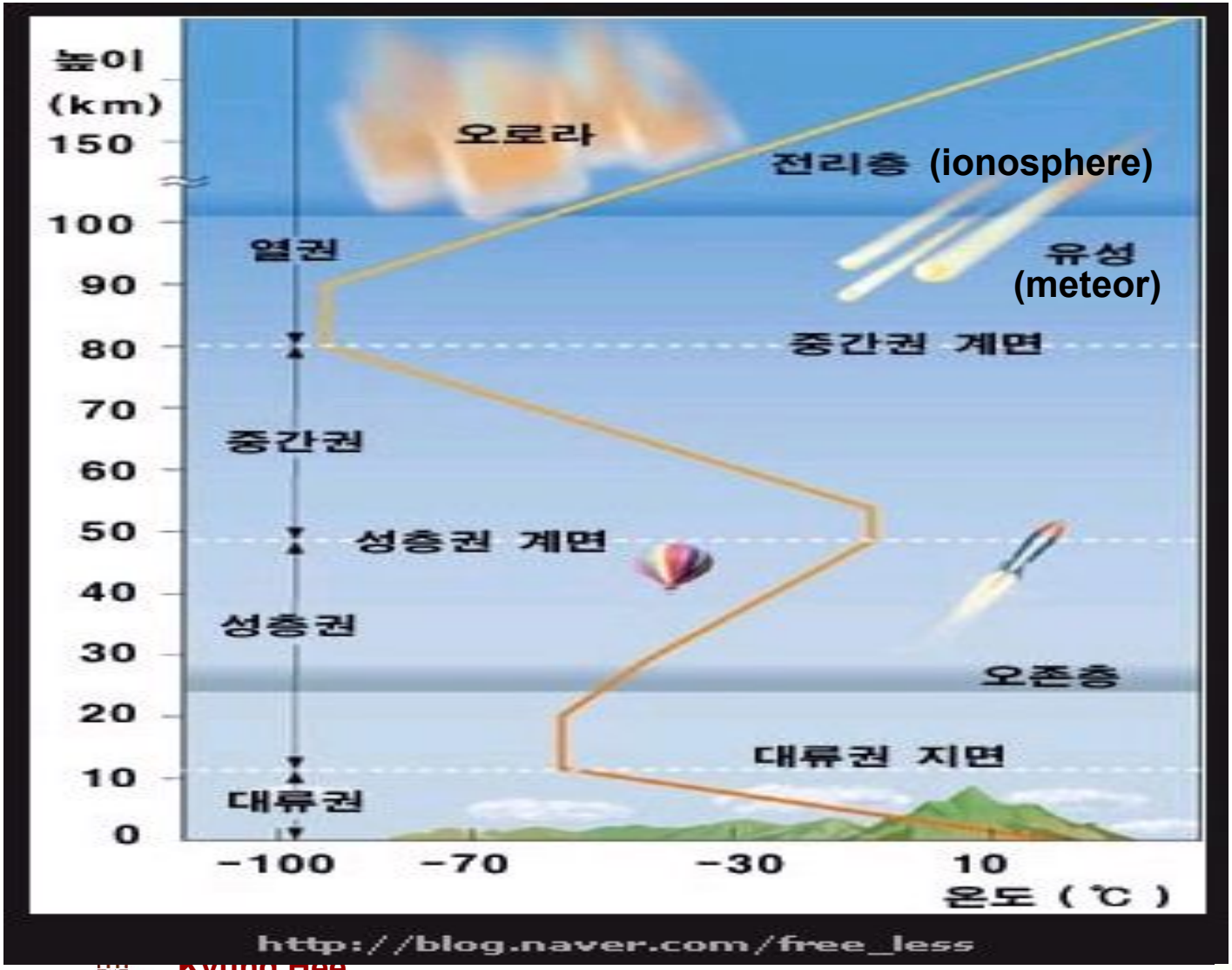
# Unguided media

| Band | Range | Propagation | Application |
|---|---|---|---|
| VLF | 3–30 KHz | Ground | Long-range radio navigation |
| LF | 30–300 KHz | Ground | Radio beacons and navigational locators |
| MF | 300 KHz–3 MHz | Sky | AM radio |
| HF | 3–30 MHz | Sky | Citizens band (CB), ship/aircraft communication |
| VHF | 30–300 MHz | Sky and line-of-sight | VHF TV, FM radio |
| UHF | 300 MHz–3 GHz | Line-of-sight | UHF TV, cellular phones, paging, satellite |
| SHF | 3–30 GHz | Line-of-sight | Satellite communication |
| EHF | 30–300 GHz | Line-of-sight | Long-range radio navigation |

# Travel of Radio Wave

- **Ground Propagation**
  - **traveling through the lowest portion of the atmosphere, hugging the earth**
  - **Emanating in all directions from the transmitting antenna and following the curvature of the planet**
- **Sky Propagation**
  - **High-frequency radio waves radiate upward into the ionosphere**
  - **Allowing for greater distances with lower output power**
- **Line of sight Propagation**
  - Very high-frequency signals in straight lines
  - Directional antenna

# Earth's Atmosphere



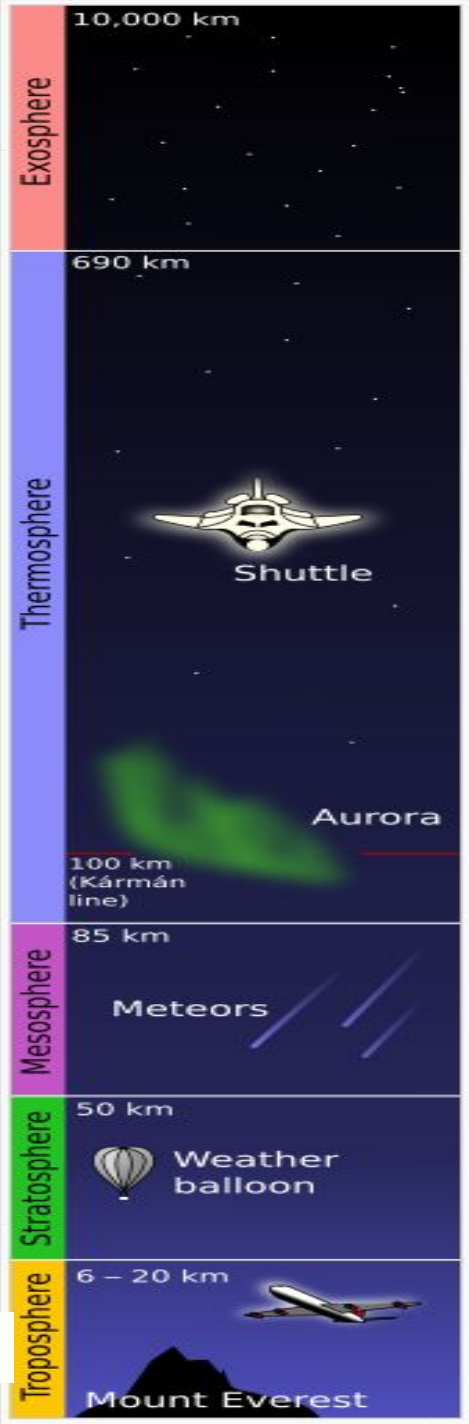

외기권

열권

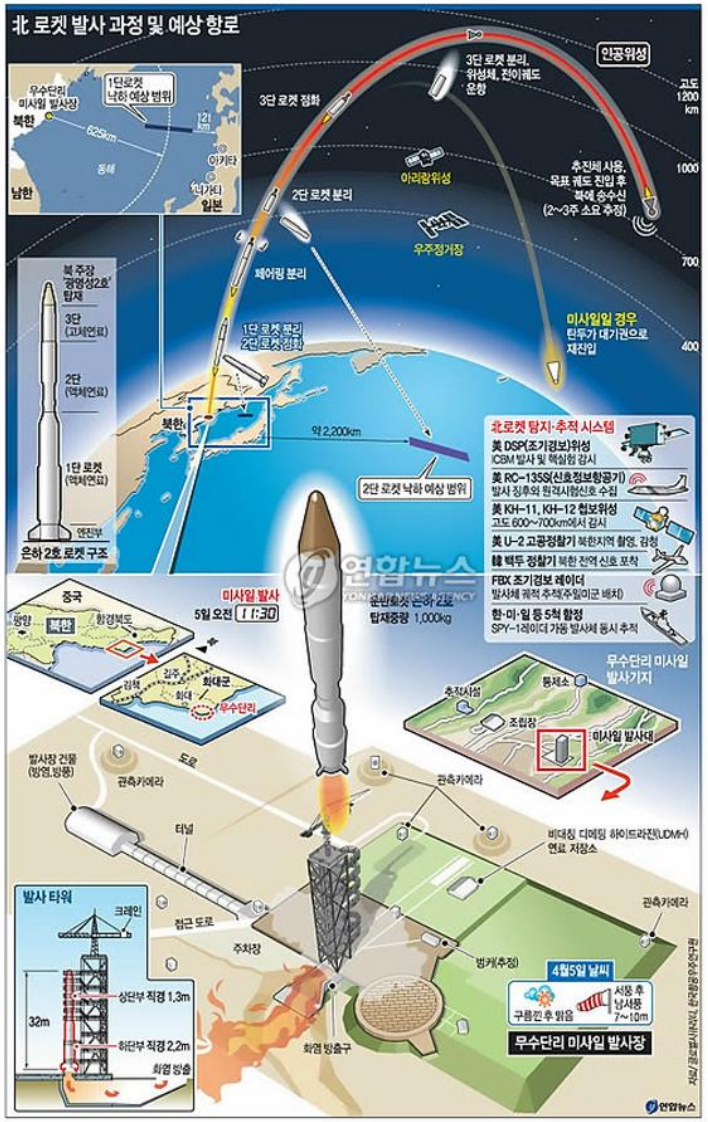
중간권

성층권

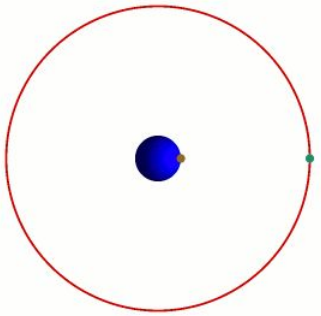
대류권



# An Example: Satellite



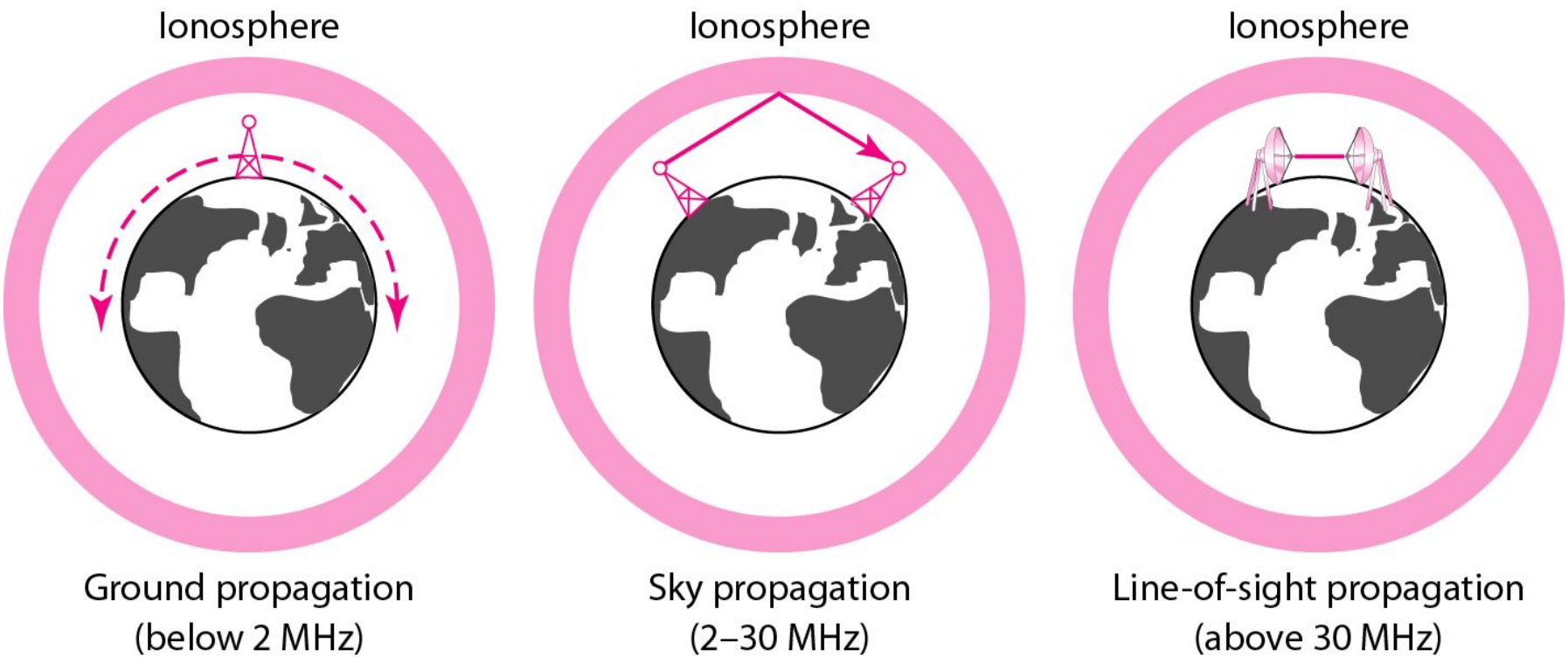

| English | Distance above earth (km) |
|---|---|
| Earth | 0 |
| Low Earth Orbit (LEO) | 160 to 2,000 |
| Medium Earth Orbit (MEO) | 2,000 to 34,780 |
| International Space Station (ISS) | 500 |
| Global Positioning System (GPS) satellites | 20,230 |
| Geostationary Orbit (GEO) | 35,794 |



Geostationary orbit
(geosynchronous orbit)

# Wireless Transmission

- **Propagation of radio waves**
  - **Types of propagation**



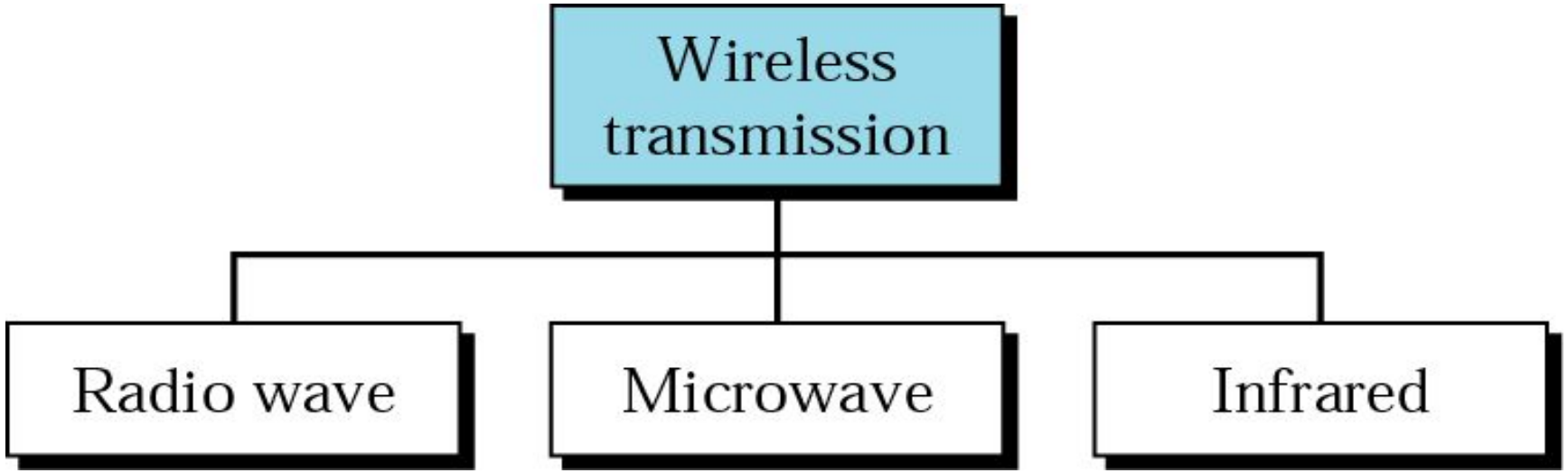
# Wireless Transmission

## Table 7.4 *Bands*

| *Band* | *Range* | *Propagation* | *Application* |
|---|---|---|---|
| VLF (very low frequency) | 3–30 kHz | Ground | Long-range radio navigation |
| LF (low frequency) | 30–300 kHz | Ground | Radio beacons and navigational locators |
| MF (middle frequency) | 300 kHz–3 MHz | Sky | AM radio |
| HF (high frequency) | 3–30 MHz | Sky | Citizens band (CB), ship/aircraft communication |
| VHF (very high frequency) | 30–300 MHz | Sky and line-of-sight | VHF TV, FM radio |
| UHF (ultrahigh frequency) | 300 MHz–3 GHz | Line-of-sight | UHF TV, cellular phones, paging, satellite |
| SHF (superhigh frequency) | 3–30 GHz | Line-of-sight | Satellite communication |
| EHF (extremely high frequency) | 30–300 GHz | Line-of-sight | Radar, satellite |

# Wireless Transmission

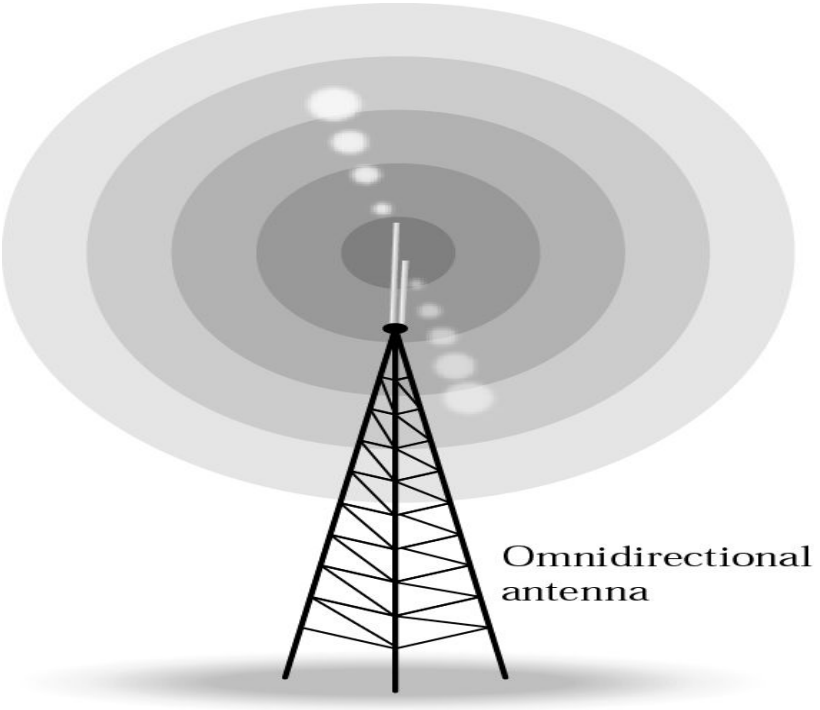
- **Wireless Transmission Waves**



# RADIO WAVE

- Electromagnetic waves ranging in frequencies between 3khz and 1Ghz are called Radio wave.

- Radio waves are Omni-directional, they are propagated in all directions.
- Radio waves are propagated in sky mode, can travel long distance.



# RADIO WAVE

*Note*

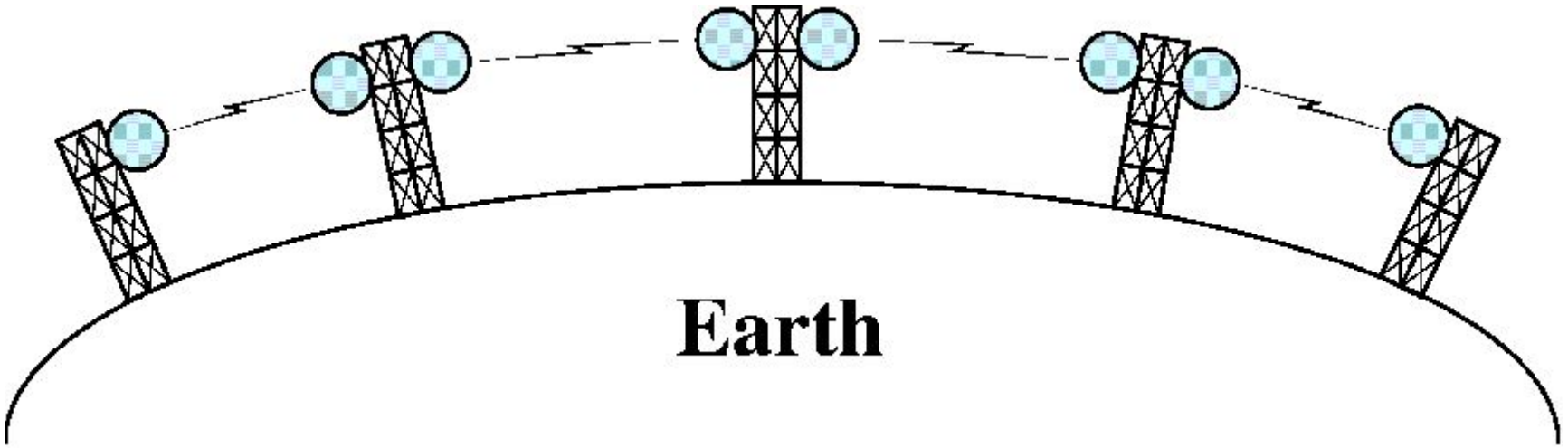
**Radio waves are used for multicast communications, such as radio and television, and paging systems.**

# MICRO WAVES

- Electromagnetic waves having frequencies between 1 and 300Ghz are called Microwaves.
- Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other.
- Very high-frequency M/W cannot penetrate walls.
- The M/W band is relatively wide, almost 299 Ghz.
  - Therefore wider subbands can be assigned, and a high data rate is possible.

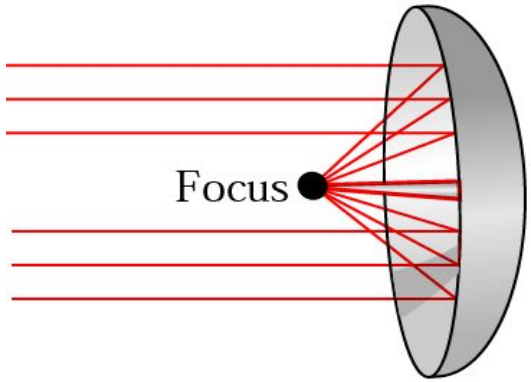
# MICRO WAVE

- **Repeaters**
  - **To increase the distance served by terrestrial microwave, a system of repeaters can be installed with each antenna.**

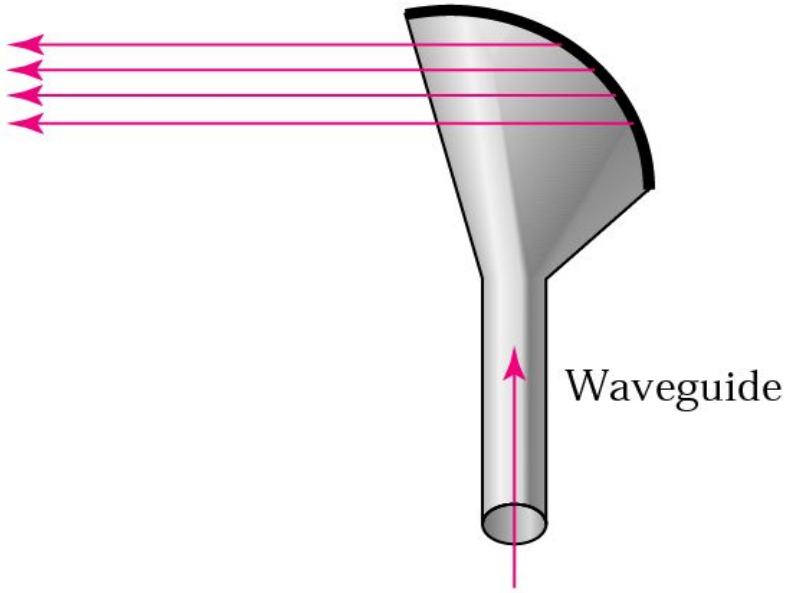


# MICRO WAVE

- **Antenna – need unidirectional antenna that send out signals in one direction**
  - **parabolic dish antenna**
  - **horn antenna**




a. Dish antenna




b. Horn antenna

# MICRO WAVE

**Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.**

# Infrared

- Infrared waves, with frequencies from 300 Ghz to 400 Thz, can be used for short-range communication.
- Infrared waves, having high frequencies, cannot penetrate walls.
  - this advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room.
- We cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication

# Infrared

**Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.**

# Summary (1)

- Transmission media lie below the physical layer.
- A guided medium provides a physical conduit from one device to another. Twisted-pair cable, coaxial cable, and optical fiber are the most popular types of guided media.
- Twisted-pair cable consists of two insulated copper wires twisted together. Twisted-pair cable is used for voice and data communication.
- Coaxial cable consists of a central conductor and a shield. Coaxial cable can carry signals of higher frequency ranges than twisted-pair cable. Coaxial cable is used in cable TV networks and traditional Ethernet LANs

# Summary (2)

- Fiber-optic cables are composed of a glass or plastic inner core surrounded by cladding, all encased in an outside jacket.
- Unguided media (free space) transport electromagnetic waves without the use of a physical conductor.
- Wireless data are transmitted through ground propagation, sky propagation, and line-of-sight propagation. Wireless waves can be classified as radio waves, microwaves, or infrared waves. Radio waves are omnidirectional; microwaves are unidirectional. Microwaves are used for cellular phone, satellite, and wireless LAN communications.
- Infrared waves are used for short-range communications such as those between a PC and a peripheral device. It can also be used for indoor LANs.

# Q & A