



# Data Communications and Networking

Fourth Edition

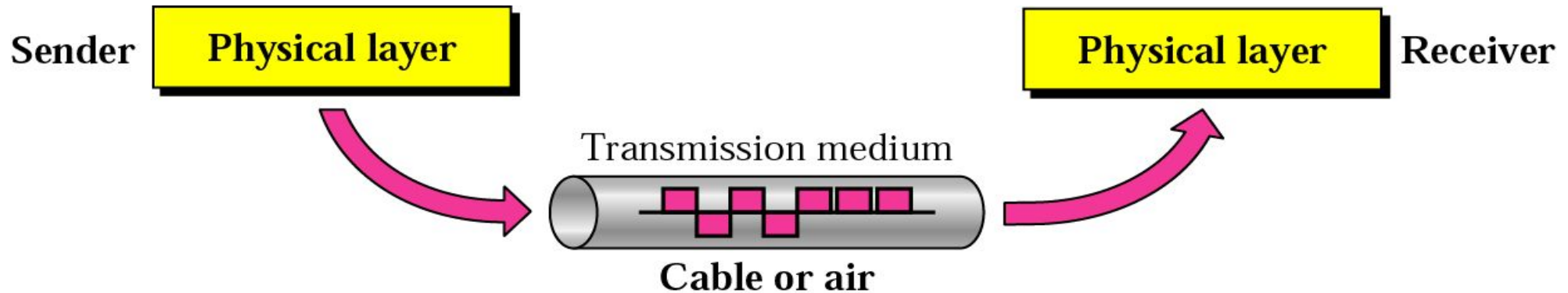
## Chapter 7

# Transmission Media



## 7. Transmission media

- Transmission medium and physical layer



# Transmission media

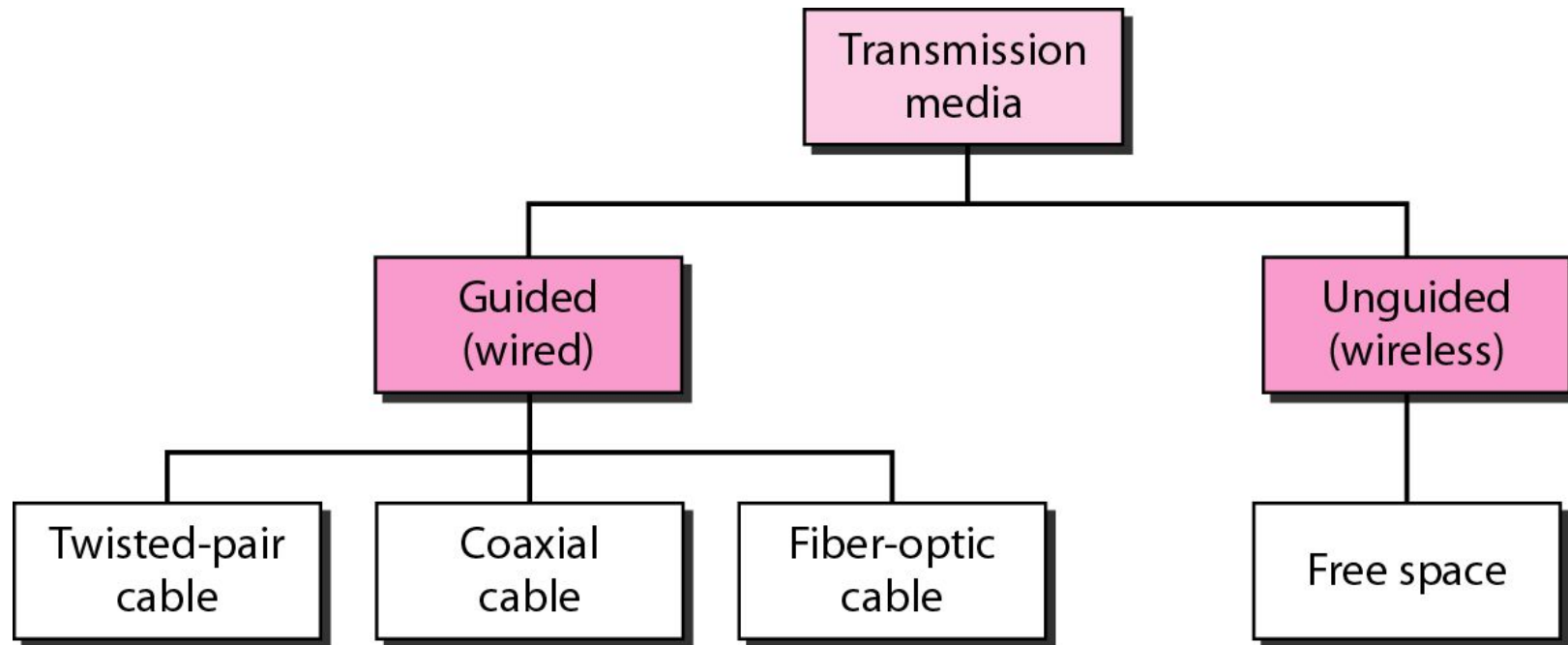
## 7.1 Guided Media

## 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**

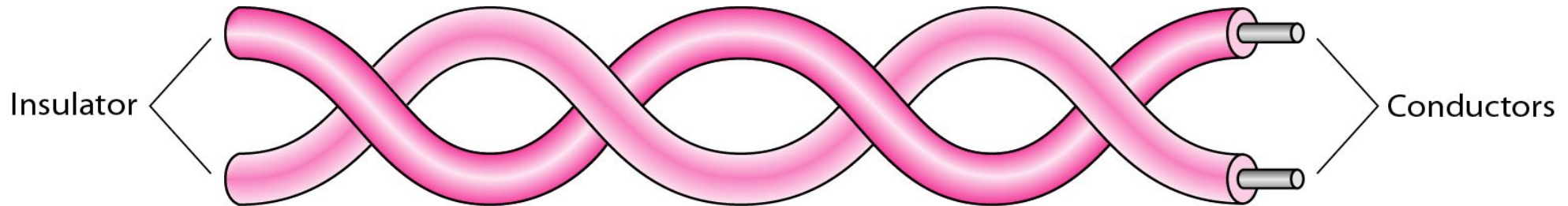
**Coaxial Cable**

**Fiber-Optic Cable**



# Twisted-Pair Cable

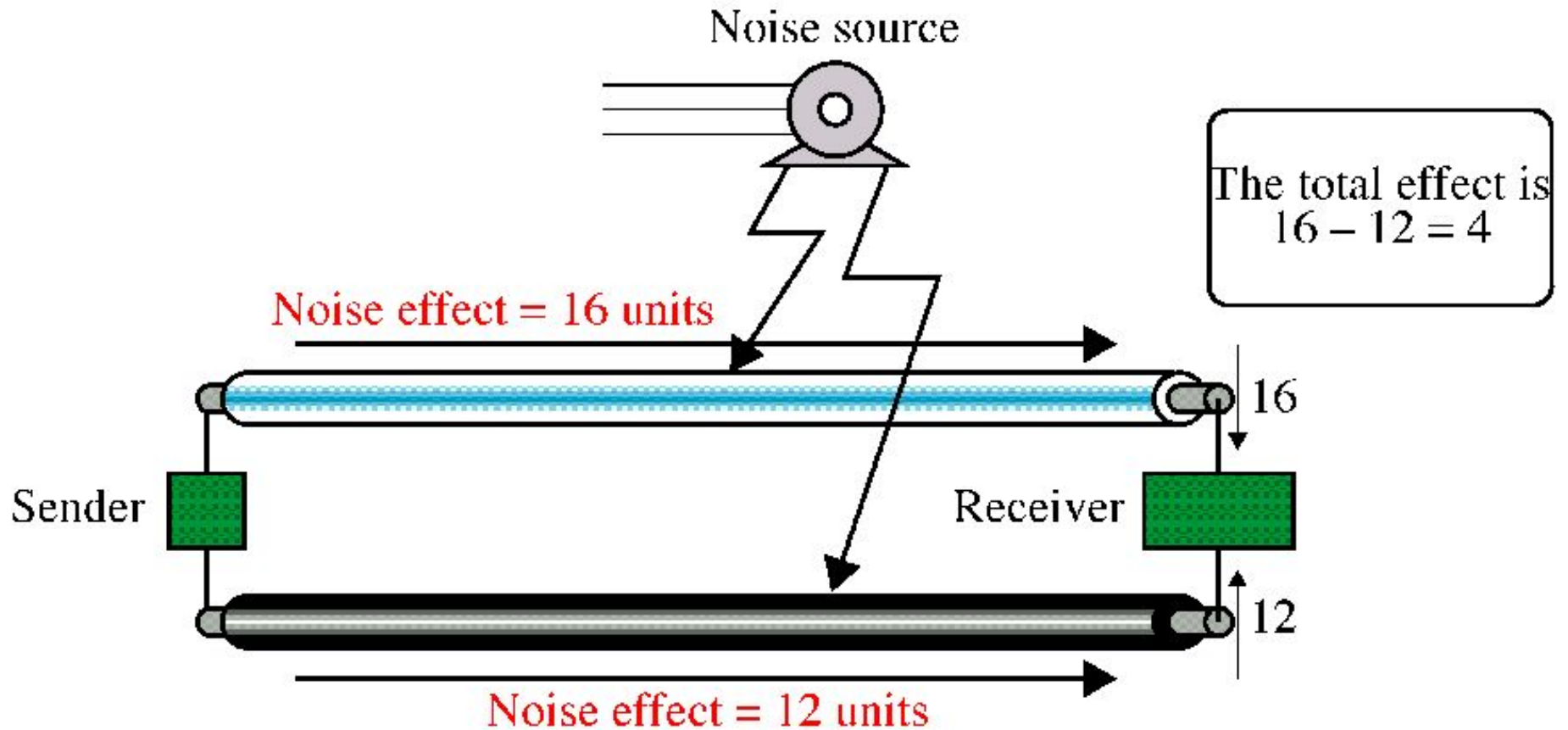
**Figure 7.3** *Twisted-pair cable*



- ❑ **Two copper conductors**
- ❑ **One carries 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**

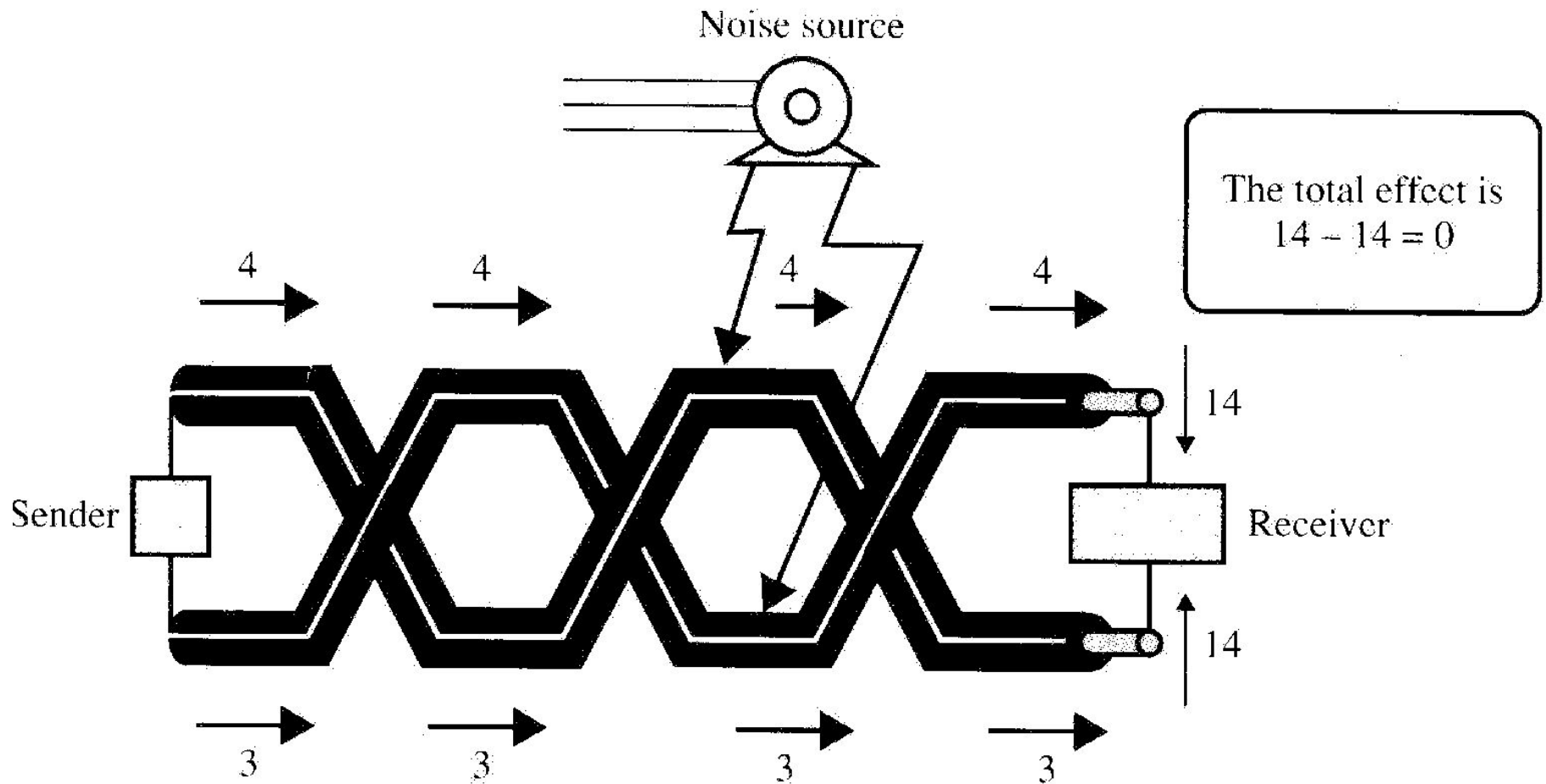
# Twisted-Pair Cable

- Effect of noise on parallel lines



# Twisted-Pair Cable

- Effect of noise on twisted-pair lines

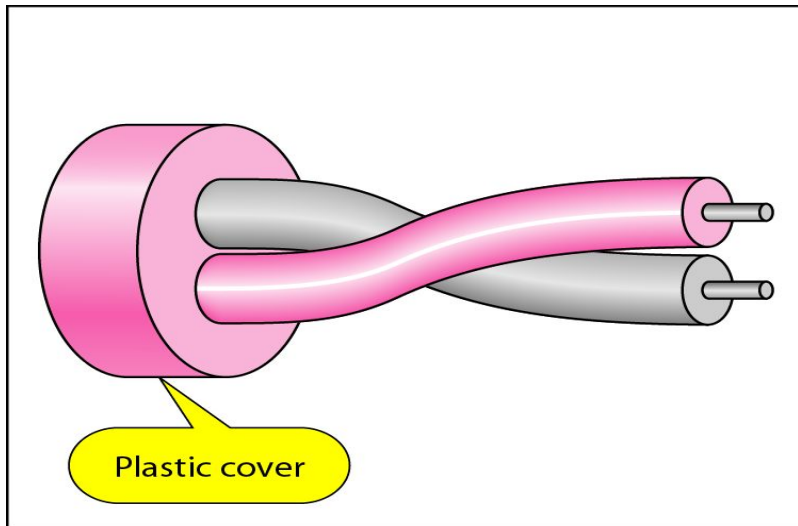




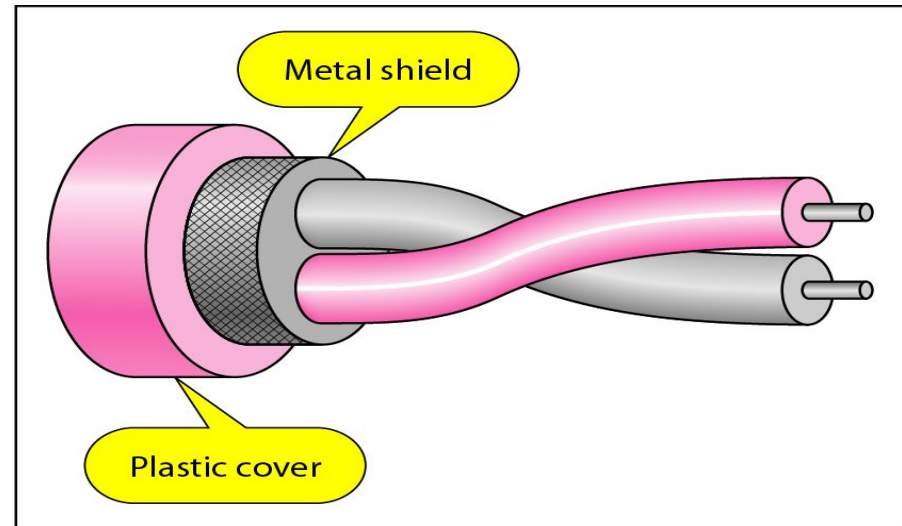
# Twisted-Pair Cable

Twisted-Pair Cable comes in two forms

- Unshielded twisted pair cable
- Shielded twisted pair cable



a. UTP



b. STP



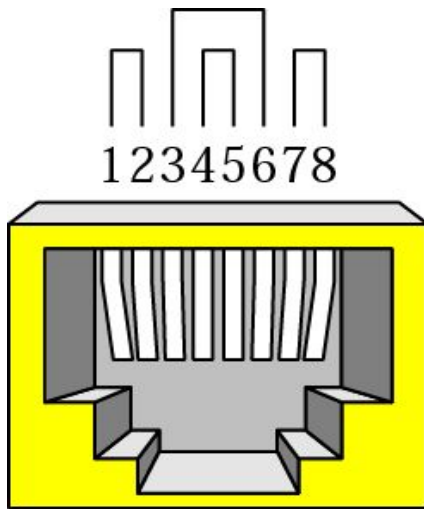
**Table 7.1** *Categories of unshielded twisted-pair cables*

<i>Category</i>	<i>Specification</i>	<i>Data Rate (Mbps)</i>	<i>Use</i>
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

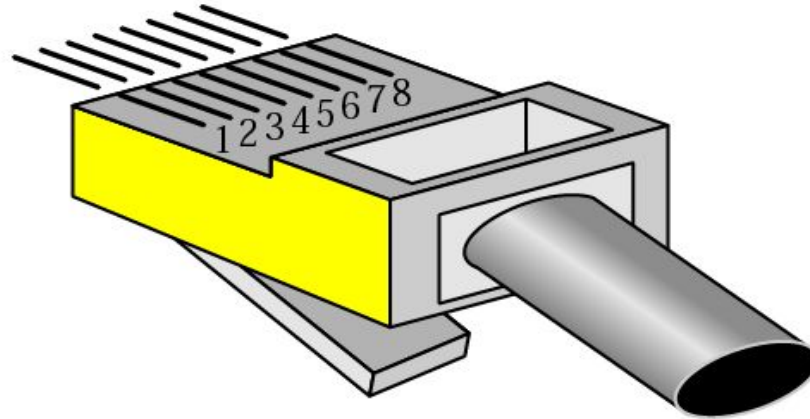


# Twisted-Pair Cable

- **UTP connectors**



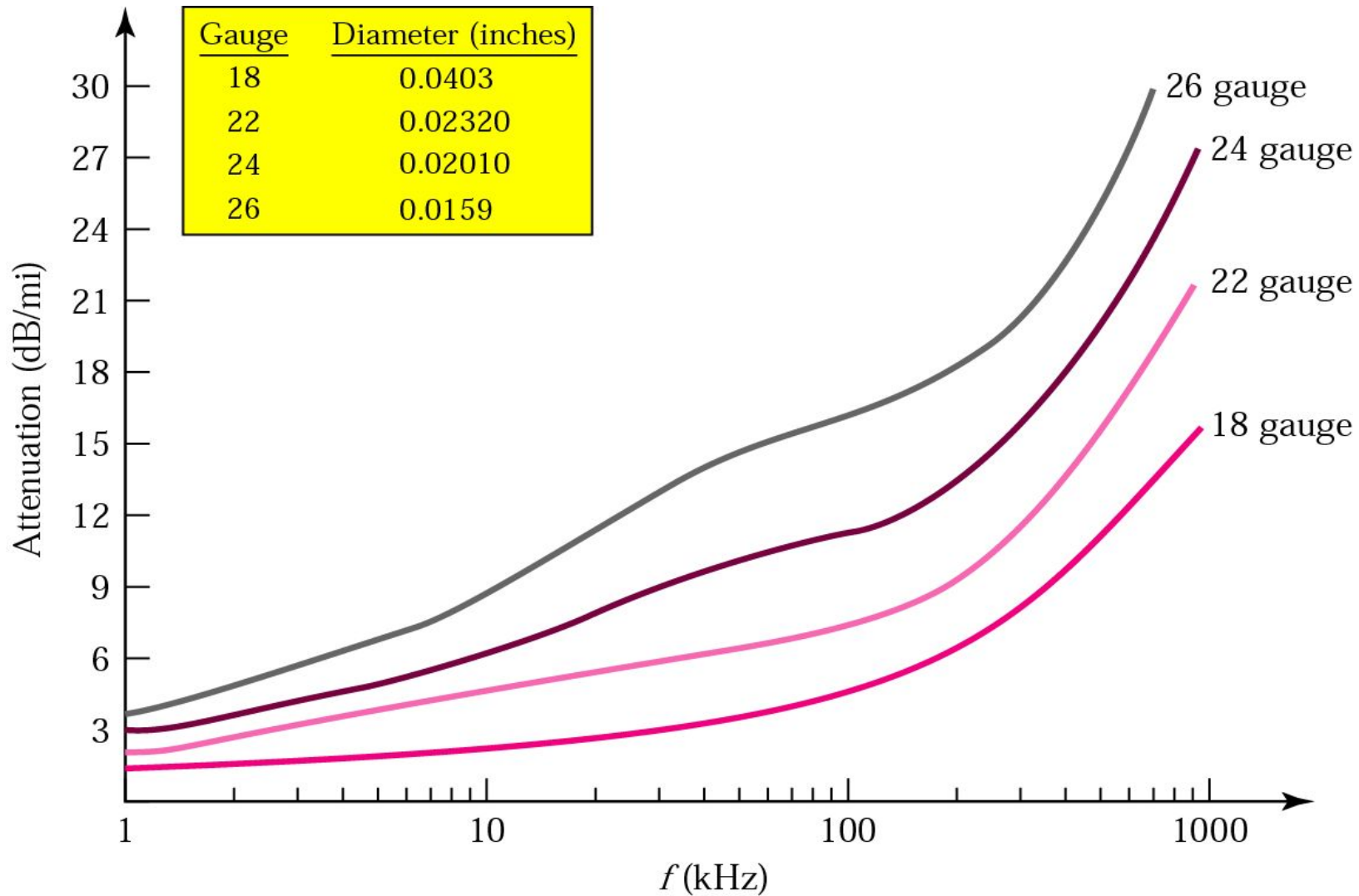
RJ-45 Female



RJ-45 Male

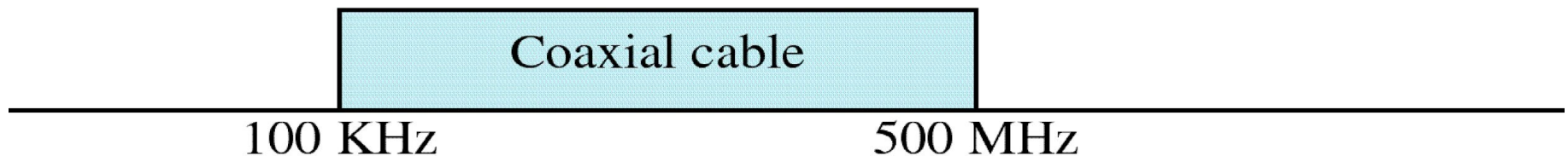
- **RJ – Registered Jack**
- **keyed connector, can be inserted one way**

# Twisted-Pair Cable



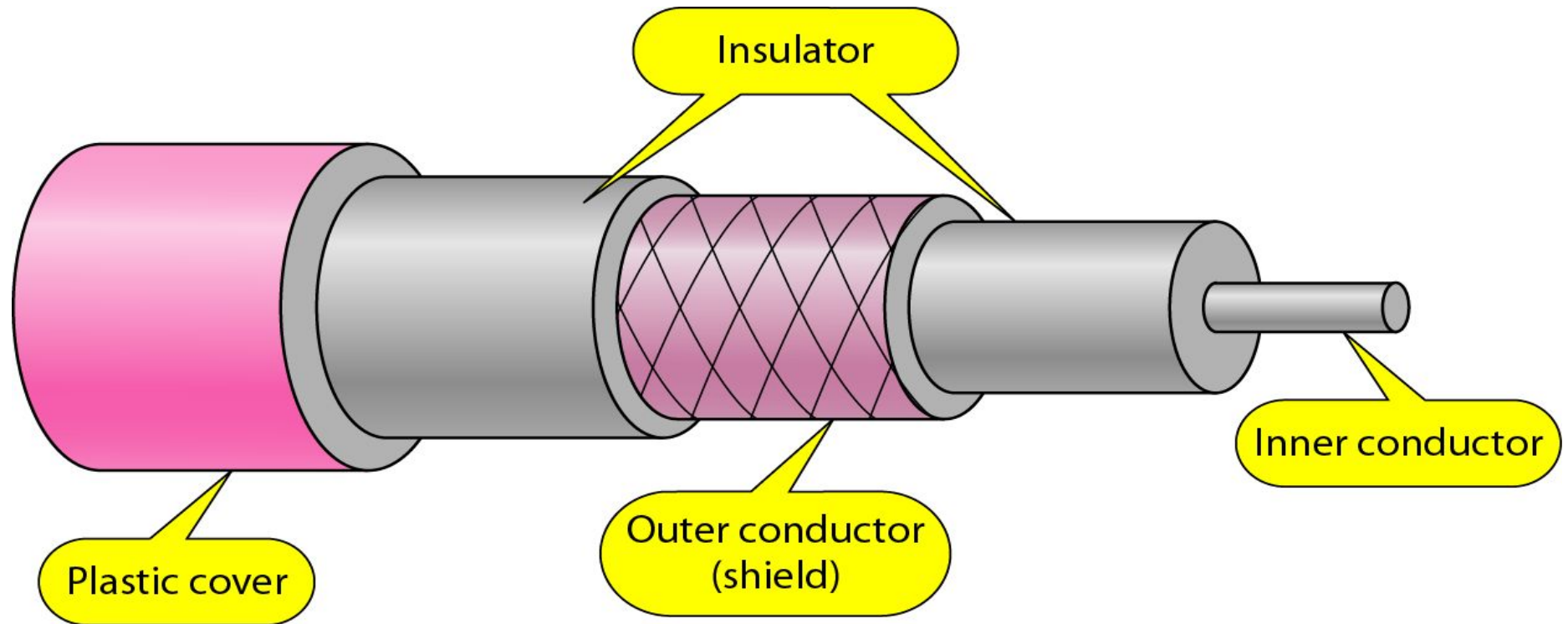
# Coaxial Cable

- **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

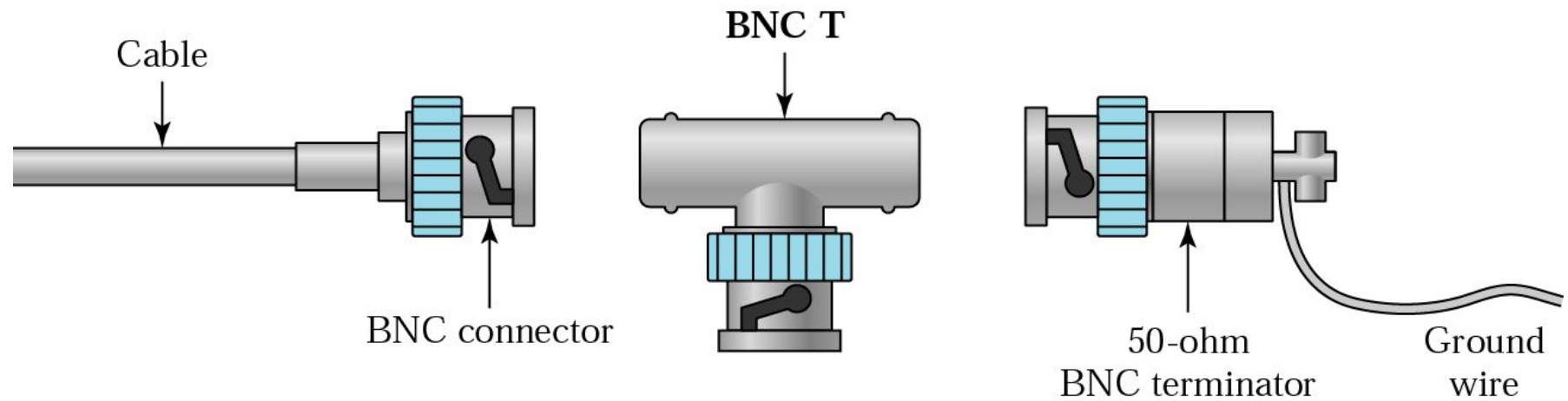
**Table 7.2** *Categories of coaxial cables*

<i>Category</i>	<i>Impedance</i>	<i>Use</i>
RG-59	75 $\Omega$	Cable TV
RG-58	50 $\Omega$	Thin Ethernet
RG-11	50 $\Omega$	Thick Ethernet



# Coaxial Cable

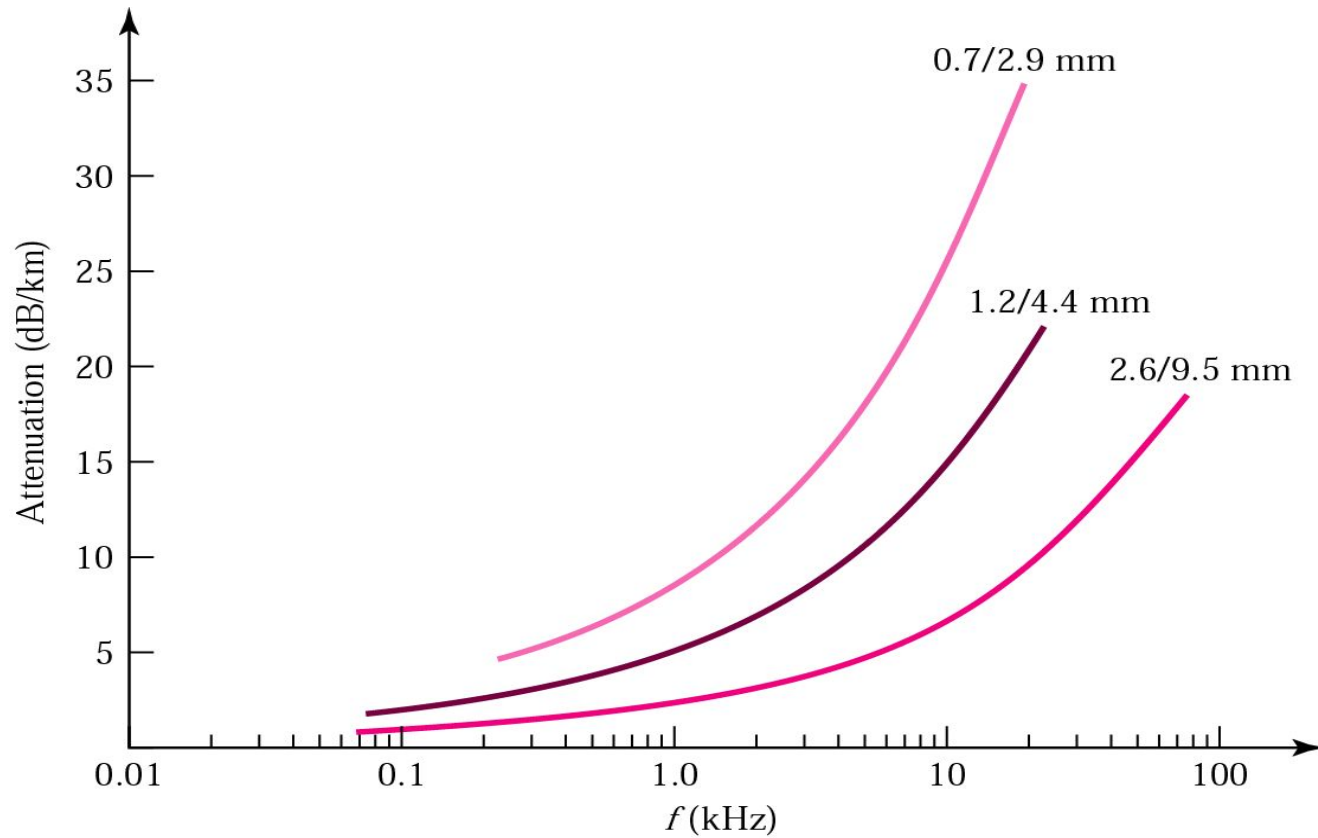
- Coaxial Cable Connectors





# Coaxial Cable

- Performance



# Optical Fiber Cable

- **Optical Fiber**

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

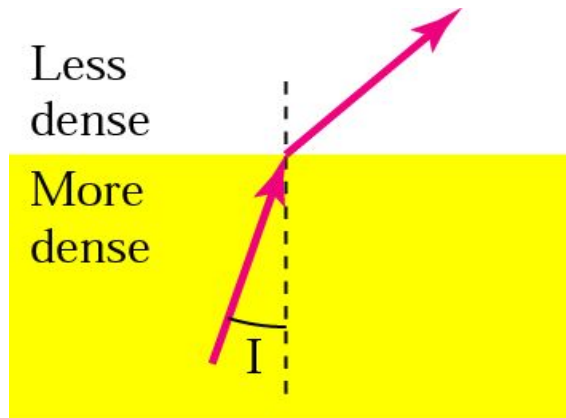
- **Nature of Light**

- ~ 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.

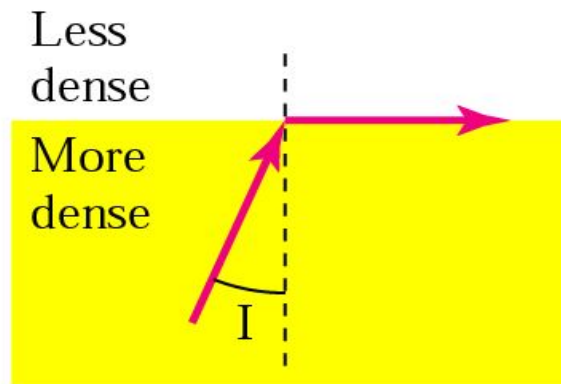


# Optical Fiber Cable

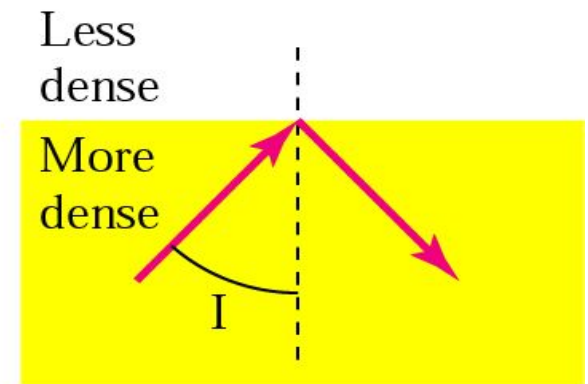
## ● Refraction



$I < \text{critical angle,}$   
refraction



$I = \text{critical angle,}$   
refraction



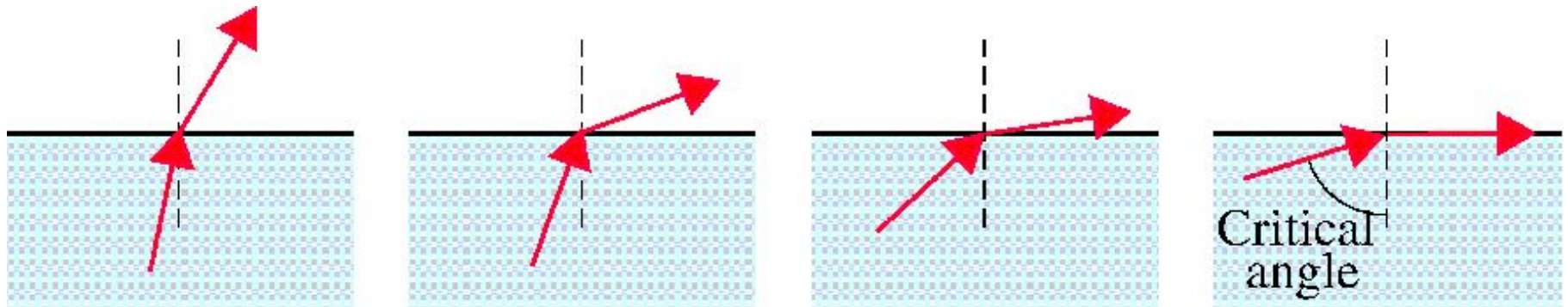
$I > \text{critical angle,}$   
reflection



# Optical Fiber Cable

- critical angle

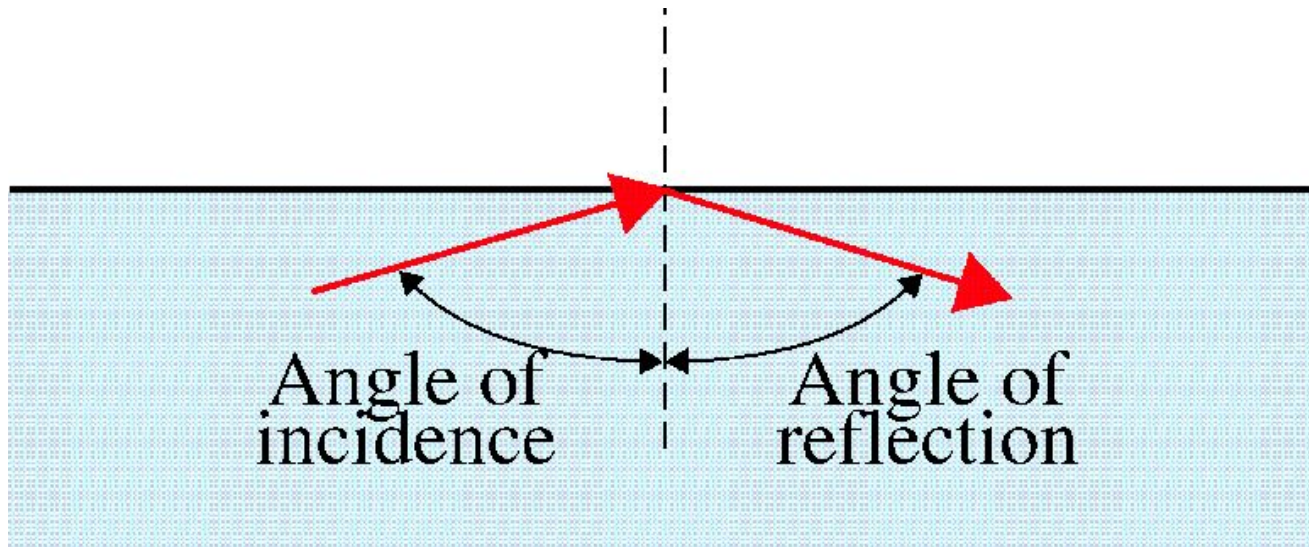
- ◆ As the angle of incidence increases, it moves away from vertical and closer to the horizontal.



# Optical Fiber Cable

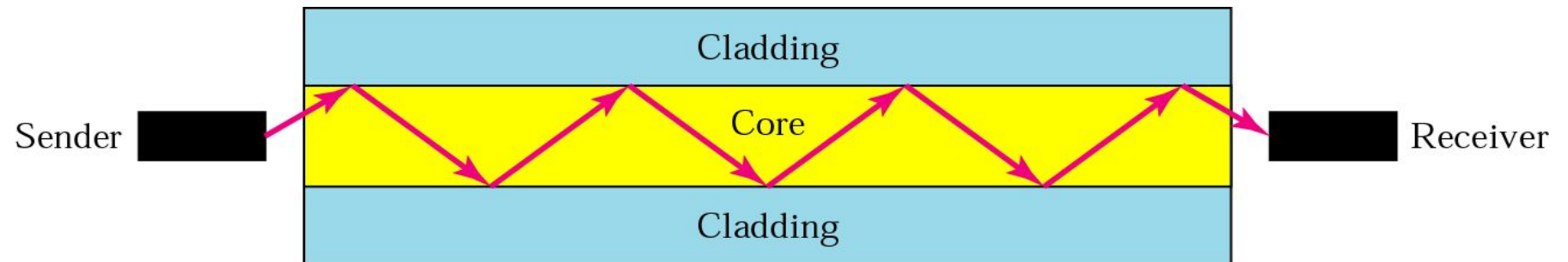
- **Reflection**

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



# Optical Fiber Cable

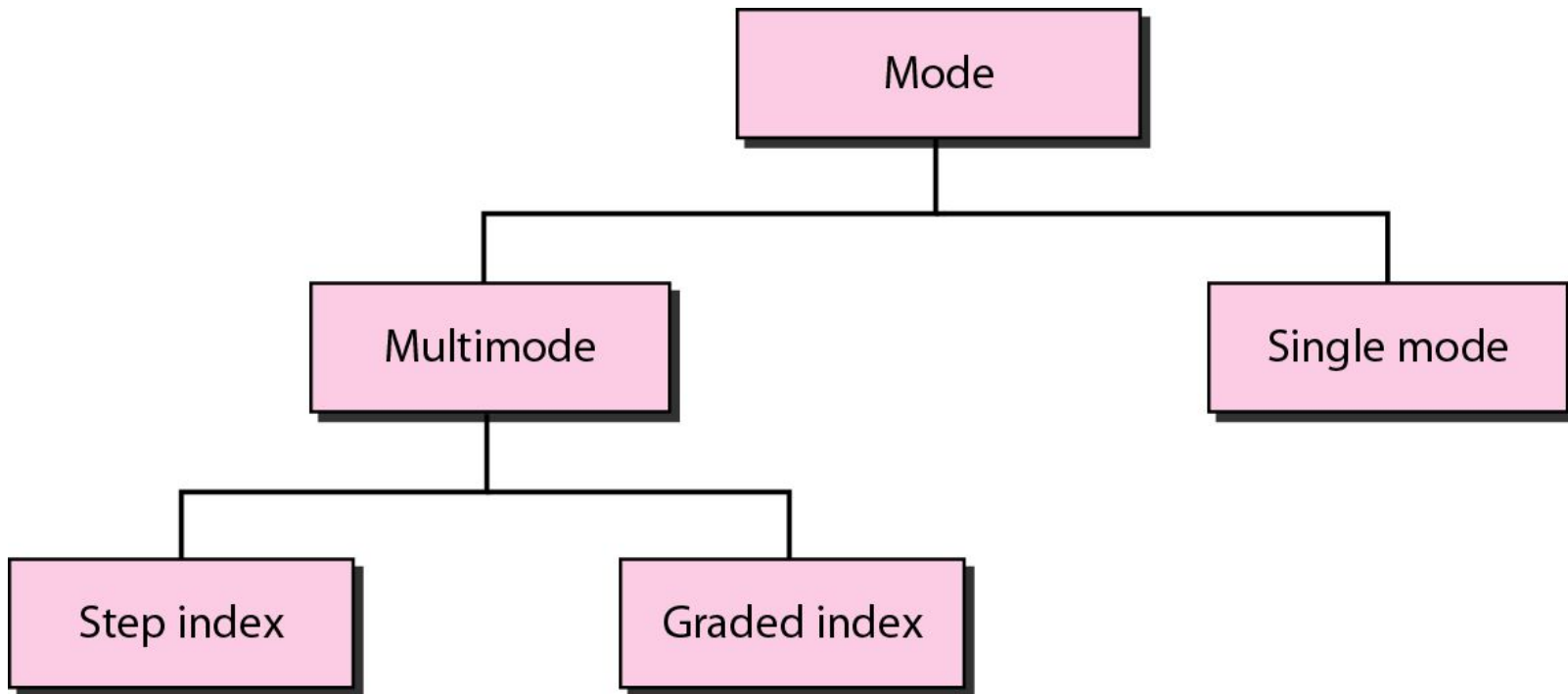
- Optical Fiber



# Optical Fiber Cable

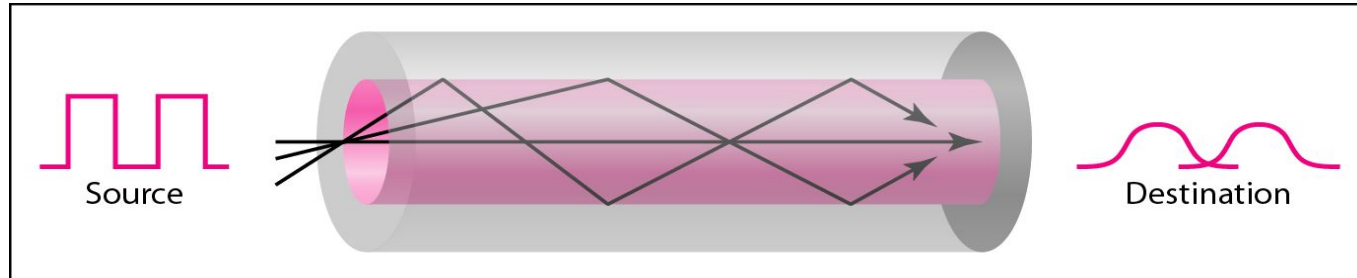
- **Propagation Models**

◆ **current technology supports two models for propagating light along optical channel.**

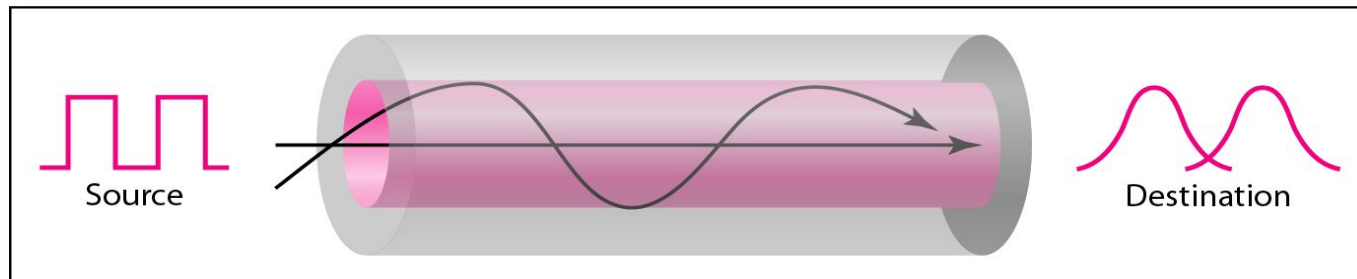


# Optical Fiber Cable

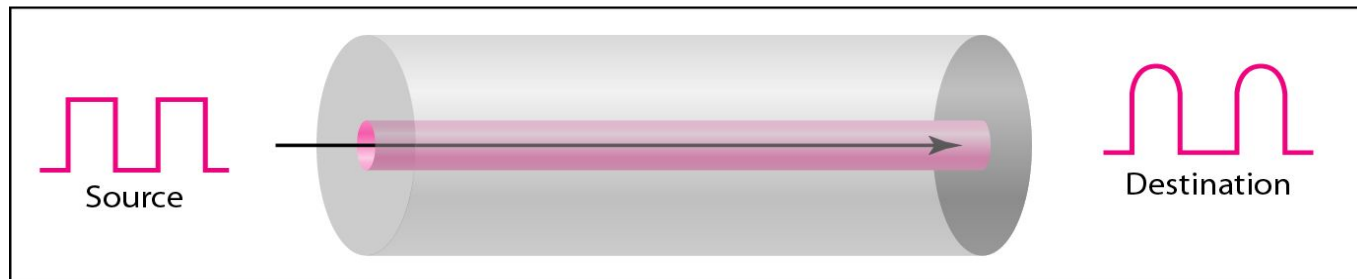
Figure 7.13 *Modes*



a. Multimode, step index



b. Multimode, graded index



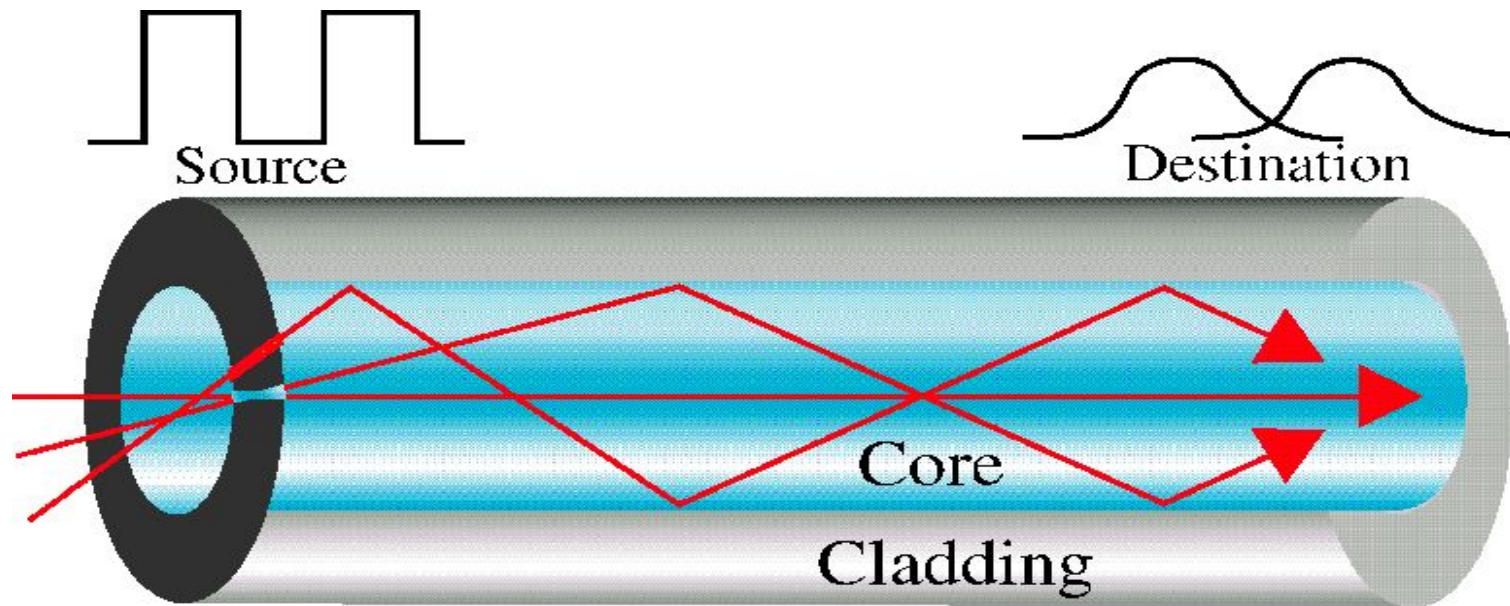
c. Single mode



# Optical Fiber Cable

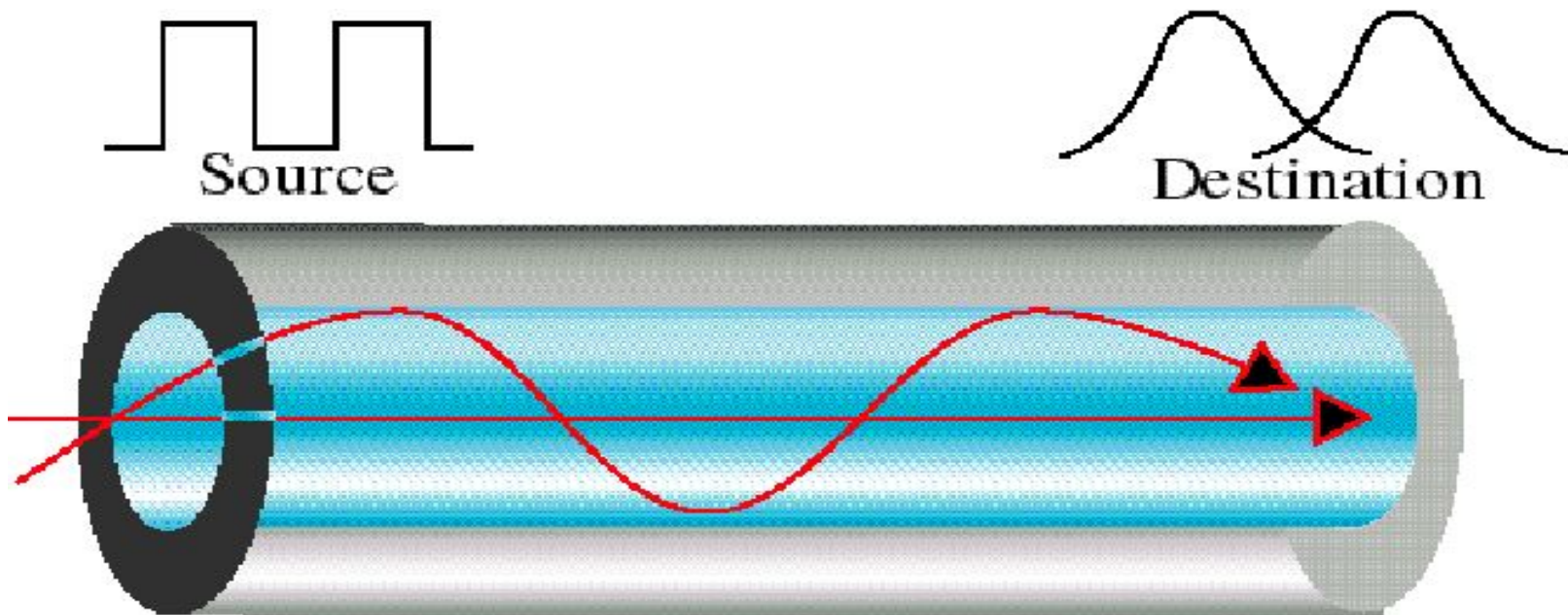
- **Multimode step-index**

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



## Optical Fiber Cable

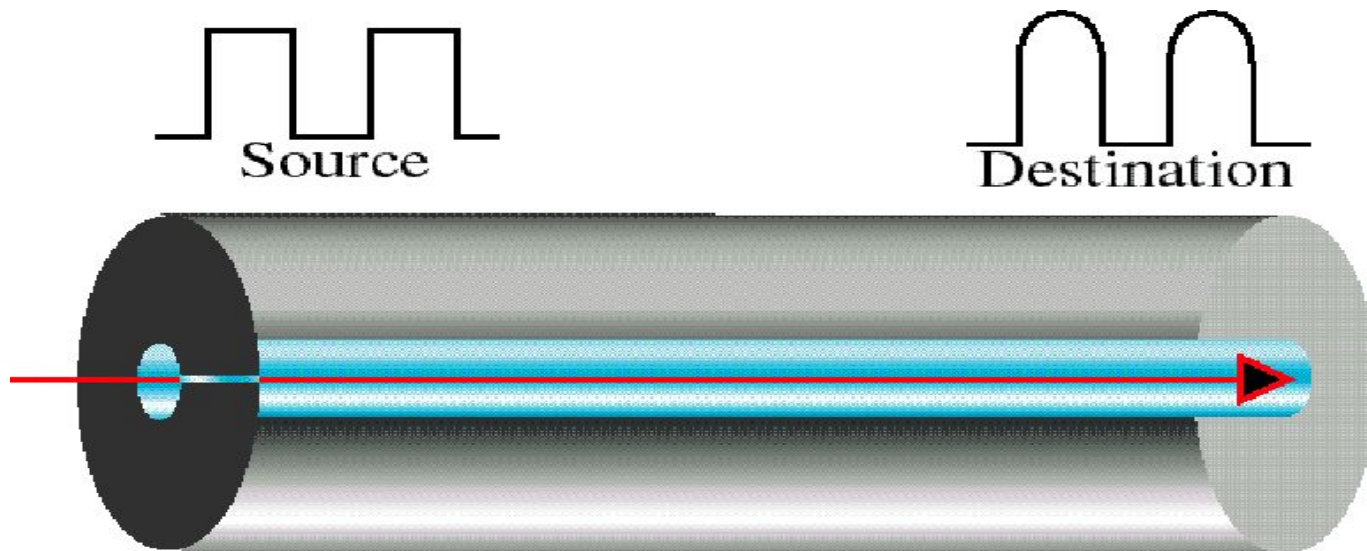
- **Multimode graded-index**
  - ◆ fiber with varying densities
  - ◆ highest density at the center of the core



# 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.

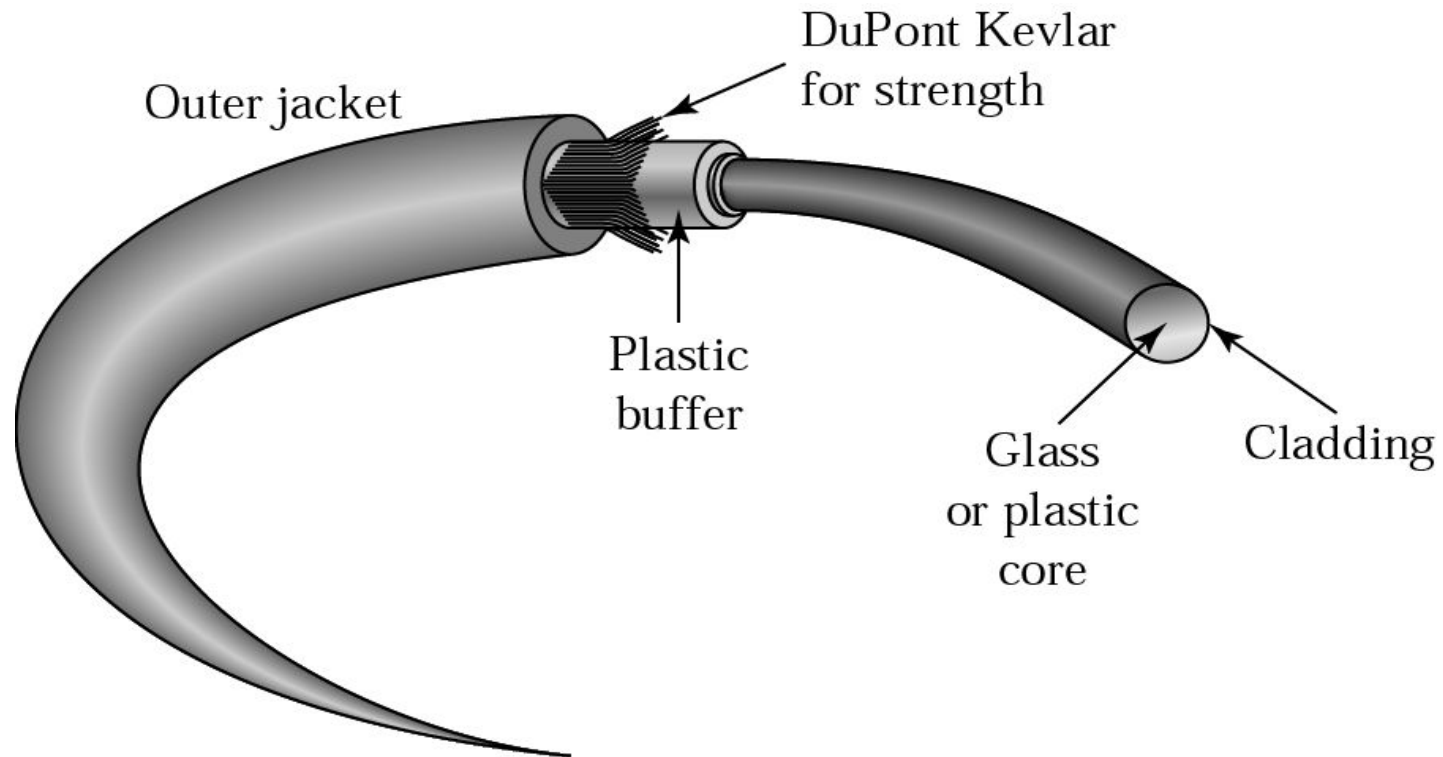
**Table 7.3** *Fiber types*

Type	Core ( $\mu\text{m}$ )	Cladding ( $\mu\text{m}$ )	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



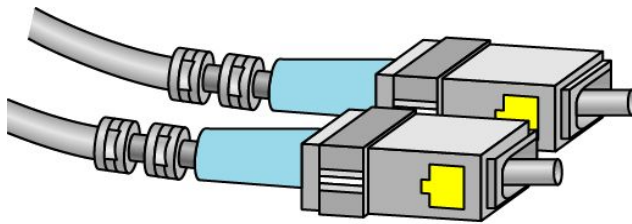
# Optical Fiber Cable

- **Cable Composition**

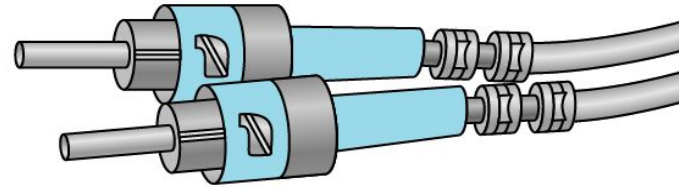


# Optical Fiber Cable

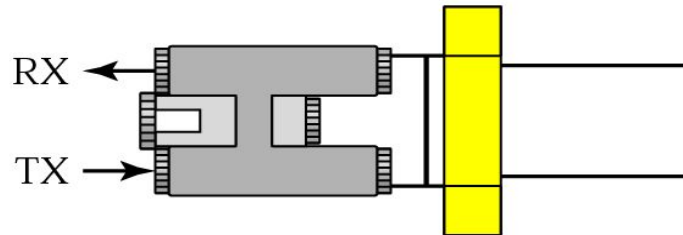
- **Fiber-optic Cable Composition**



SC connector



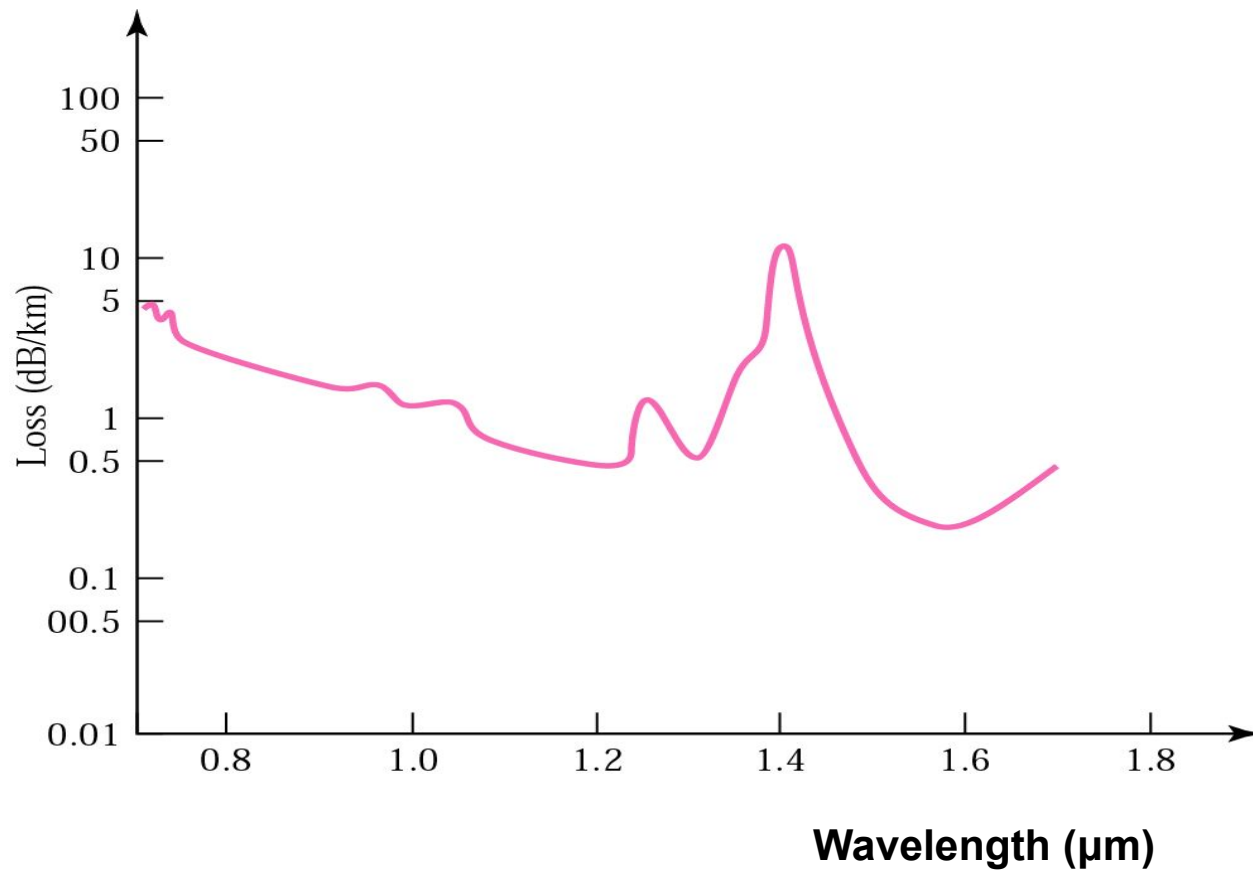
ST connector



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

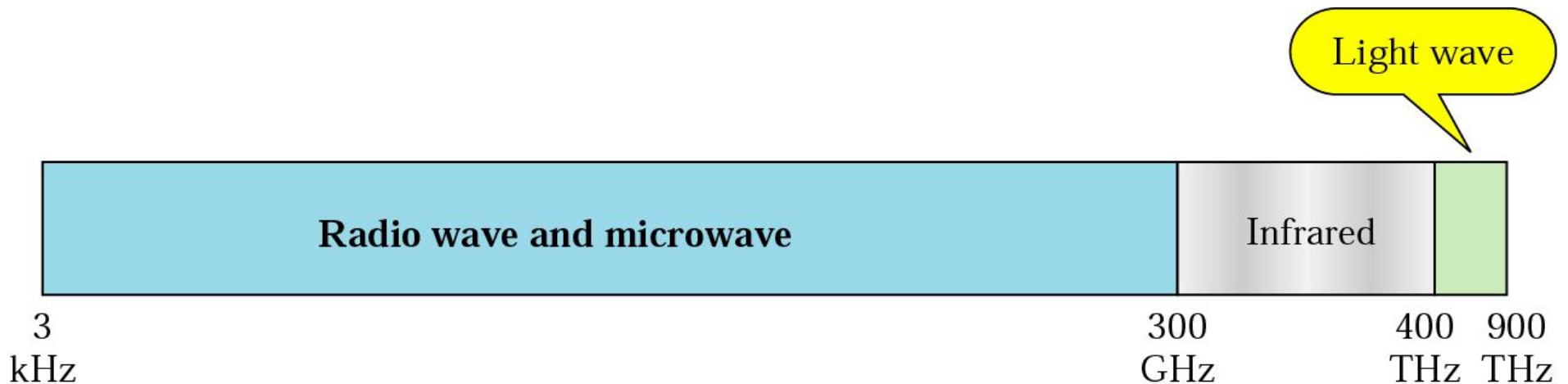
Infrared



# Unguided media

- wireless
- signals are broadcasted through air

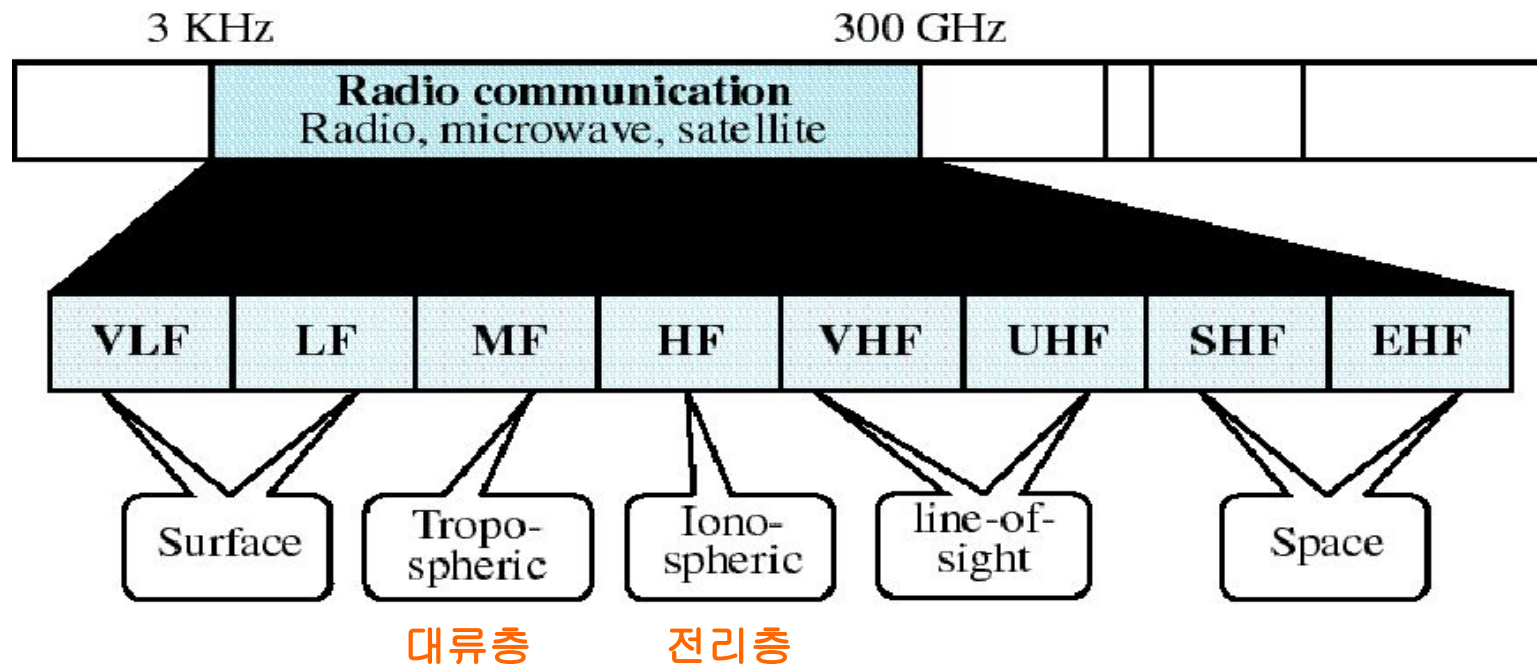
**Figure 7.17** *Electromagnetic spectrum for wireless communication*



# Wireless Transmission

## ● 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

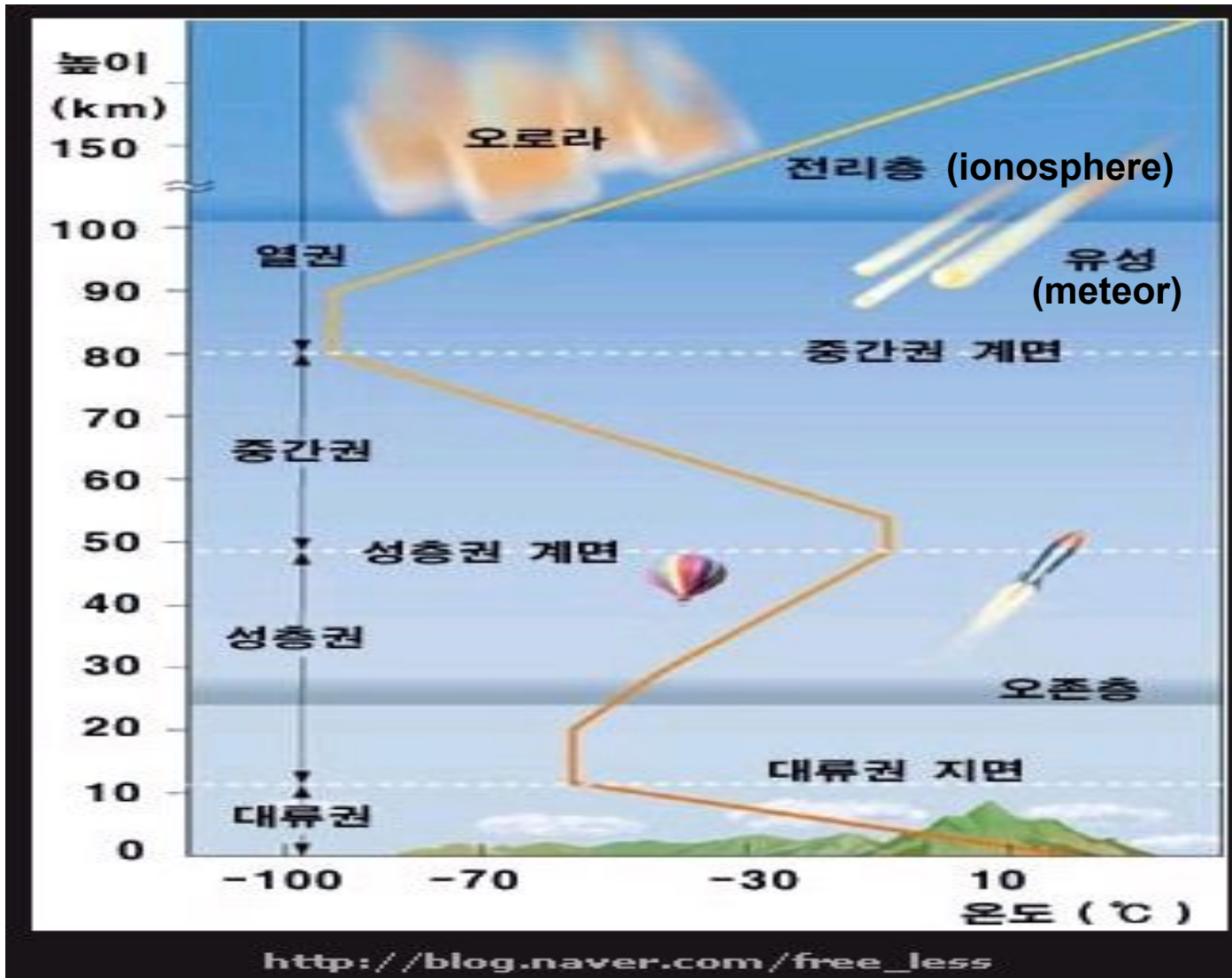
- **Line of sight Propagation**

- Very high-frequency signals in straight lines
- Directional antenna



# Earth's Atmosphere

외기권



열권

중간권

성층권

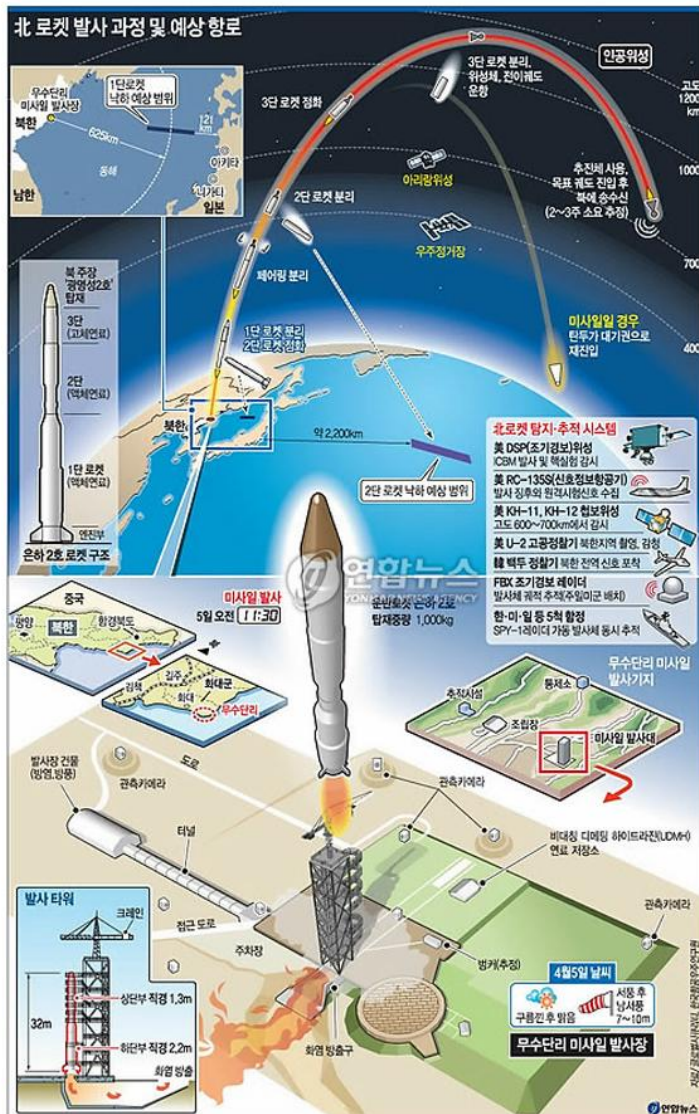
대류권



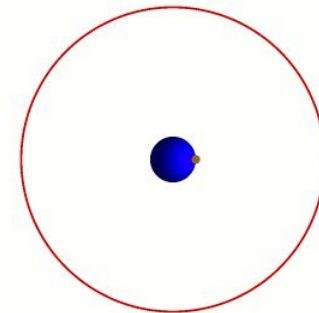
Kyung Hee  
University



## 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

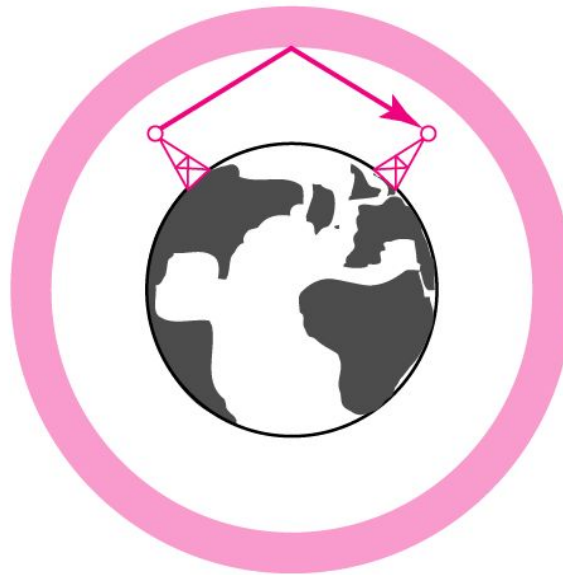
- ◆ Types of propagation

Ionosphere



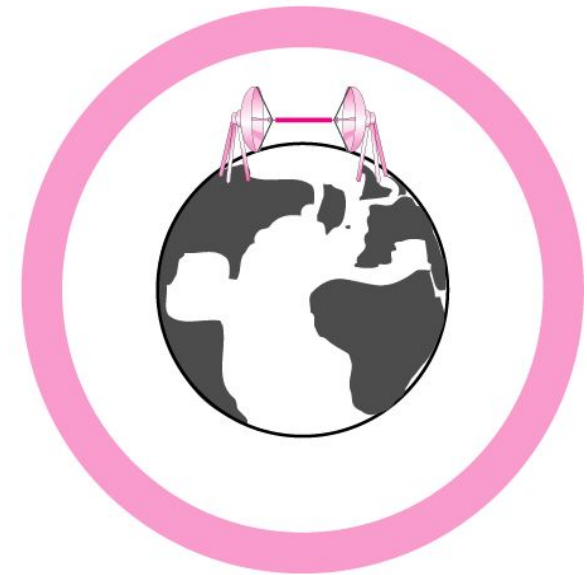
Ground propagation  
(below 2 MHz)

Ionosphere



Sky propagation  
(2–30 MHz)

Ionosphere



Line-of-sight propagation  
(above 30 MHz)



# Wireless Transmission

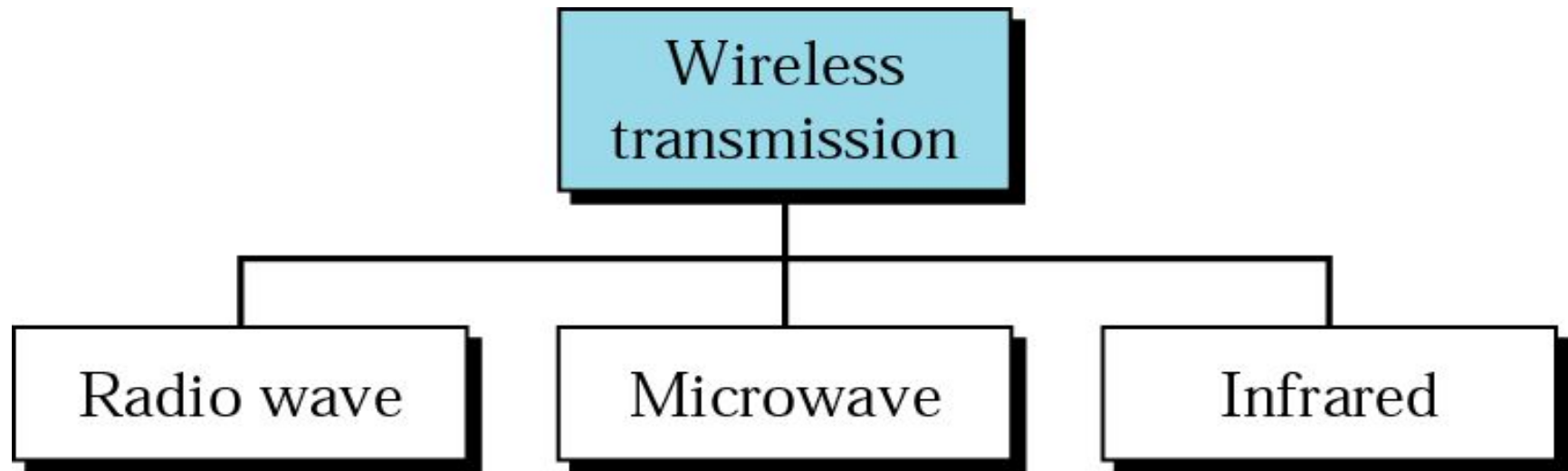
**Table 7.4** *Bands*

<i>Band</i>	<i>Range</i>	<i>Propagation</i>	<i>Application</i>
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



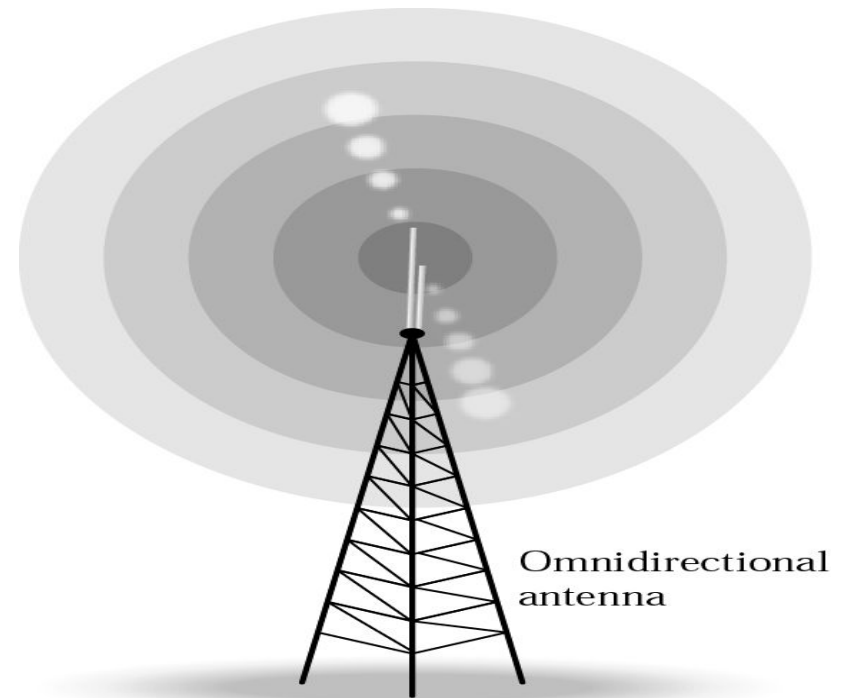
# Wireless Transmission

- **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.**



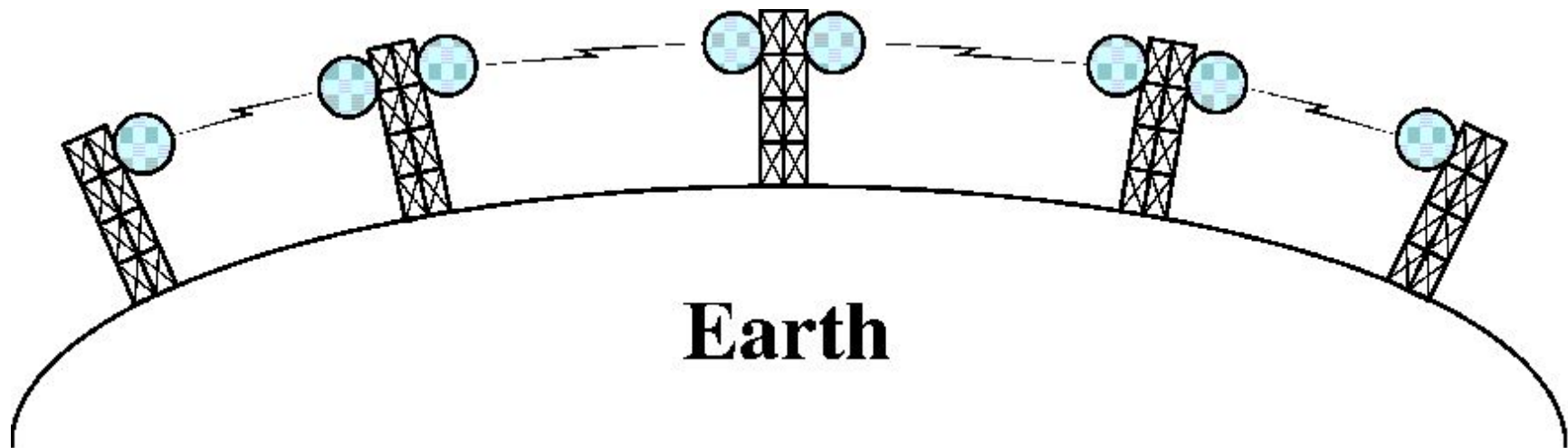
# MICRO WAVES

- **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

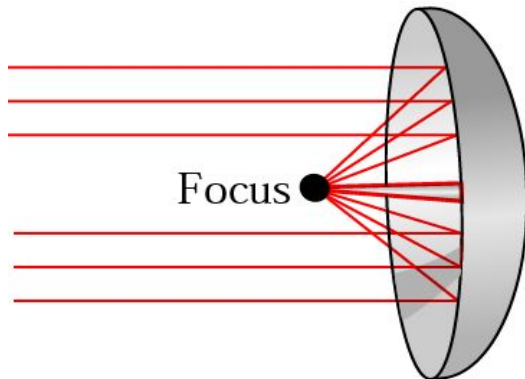
- **Repeaters**
  - ◆ To increase the distance served by terrestrial microwave, a system of repeaters can be installed with each antenna.



# MICRO WAVE

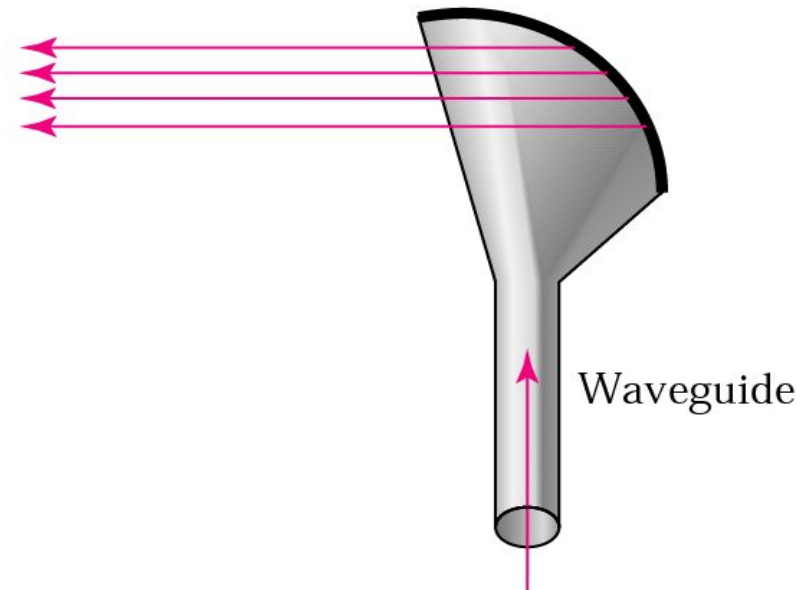
## ❖ Antenna – need unidirectional antenna that send out signals in one direction

- parabolic dish antenna



a. Dish antenna

- horn 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

