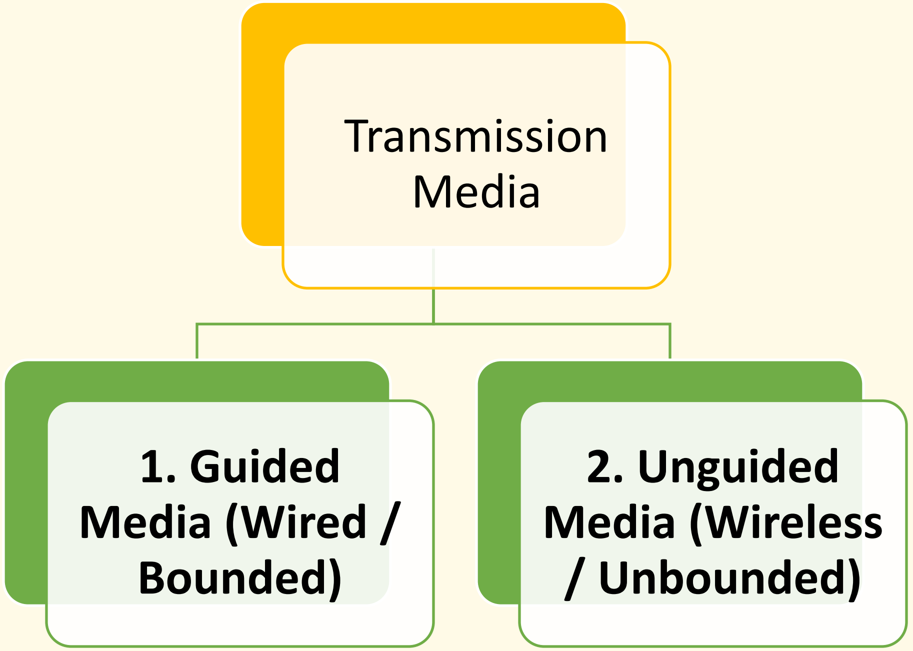
UNIT-II

Transmission Media:

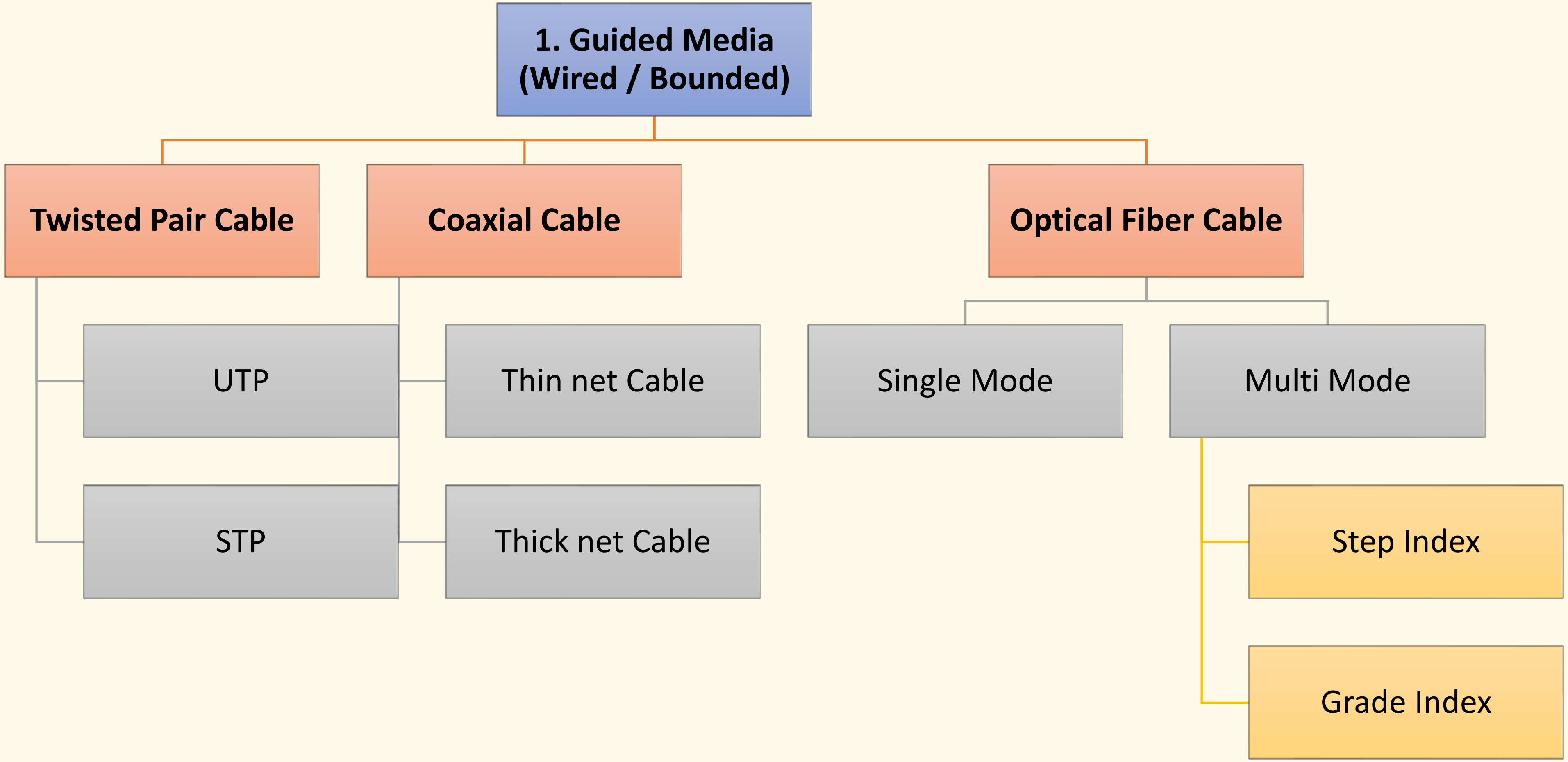
- Guided and unguided,
- Attenuation, distortion,
- noise, throughput,
- propagation speed and time, wavelength, Shannon capacity,
- comparison of media

Transmission Media

Transmission media = The **path** through which data travels from sender to receiver.
It is of **two main types**:



Unit – II Transmission Media:



- **1. Guided Media (Wired / Bounded)**
- Data travels through physical cables.
- **Twisted Pair Cable**
  - Copper wires twisted together.
  - Used in LAN, telephone lines.
  - Cheap but limited distance.
- **Advantages:**
- Cheap and easy to install.
- Widely available (used in LAN & telephone).
- ❌ **Disadvantages:**
- Short distance & low bandwidth compared to fiber.
- Easily affected by noise and interference.

Types of Twisted Pair Cable

1. Unshielded Twisted Pair (UTP)
No extra shielding.
Cheaper, easy to install.
Used in **LAN, telephone lines**.

2. Shielded Twisted Pair (STP)
Has a **metallic shield** around wires.
Less noise & interference.
More expensive than UTP.
Used in **industrial & high-speed networks**.

2. Coaxial Cable

Single copper wire with insulation & shielding.
Used in cable TV, broadband.
Better speed than twisted pair.

✅ **Advantages:**

1. Better bandwidth and less noise than twisted pair.
2. Can be used for both analog (TV) and digital (Internet).

❌ **Disadvantages:**

1. More expensive than twisted pair.
2. Thicker and harder to install over long distances.

These are two types of **coaxial cables**

1. Thin net (10Base2)

Thin coaxial cable (0.25 inch).
Flexible & easy to install.
Maximum length: **185 meters**.
Cheaper, but more prone to noise.

2. Thick net (10Base5)

Thick coaxial cable (0.5 inch).
Strong, supports long distance.
Maximum length: **500 meters**.
Costly & difficult to bend/install.

3. Optical Fiber Cable

Uses light signals.
Very high speed & long distance.
Expensive but secure.

✅ **Advantages:**

Very **high bandwidth & speed** (much faster than copper cables).
Immune to **electrical noise and interference**.

❌ **Disadvantages:**

Expensive compared to twisted pair & coaxial.
Fragile and difficult to install/repair.

Types of Optical Fiber

1.Single-Mode Fiber (SMF)

- Very thin core (≈ 8–10 microns).
- Carries **one light signal (mode)** at a time.
- Used for **long-distance, high-speed** communication (up to 100 km+).
- Example: Internet backbone, telecom.

2.Multi-Mode Fiber (MMF)

- Thicker core (≈ 50–62.5 microns).
- Carries **multiple light signals (modes)** at the same time.
- Suitable for **short distance** (up to 2 km).
- Example: LAN, campus networks.

Types of Multi-Mode Fiber (MMF)

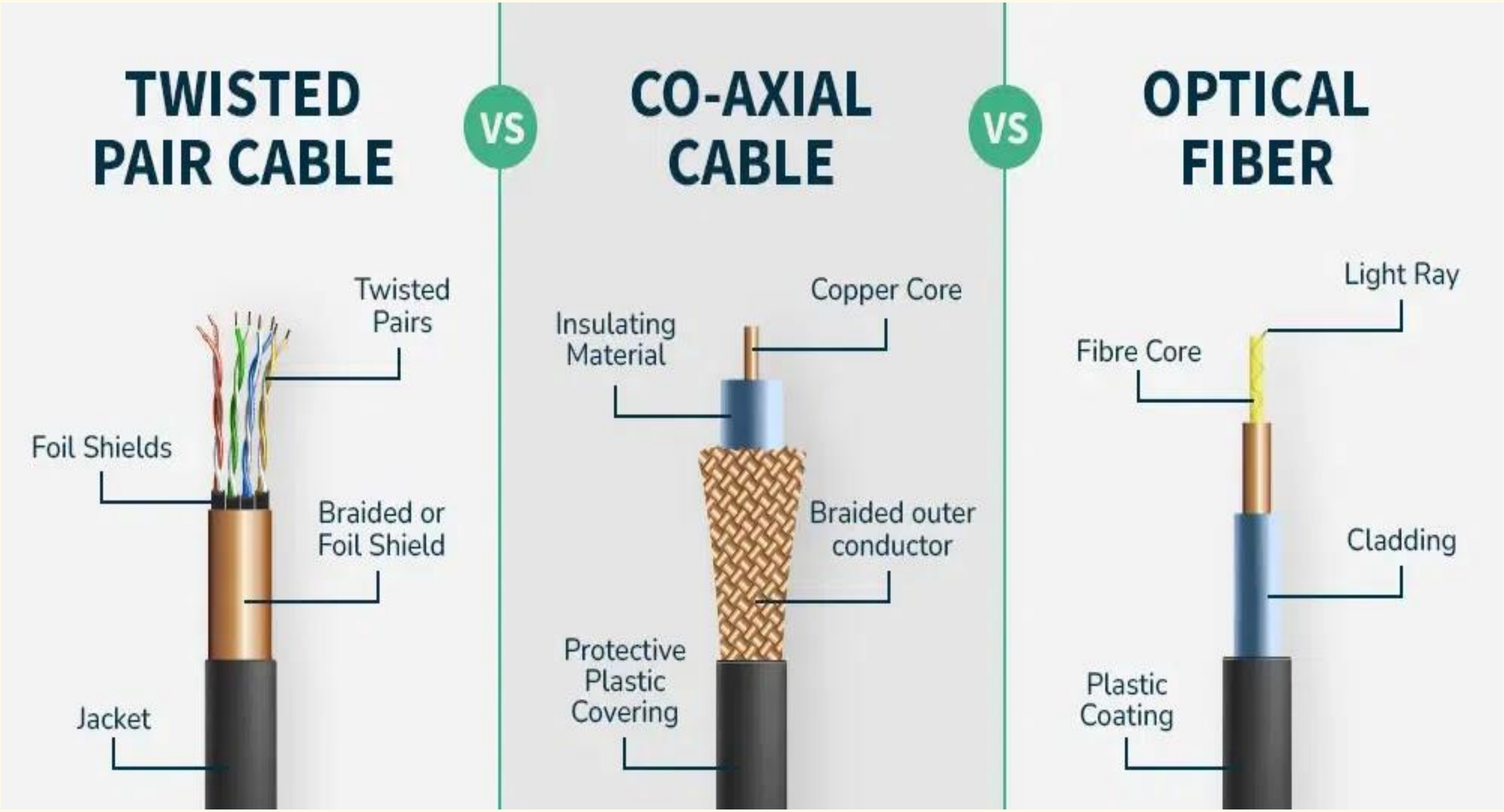
1. Step-Index Multi-Mode Fiber

- Core has a **uniform refractive index**.
- Light rays travel in a zig-zag pattern.
- Cheaper but **more signal distortion**.
- Suitable for **short distance** data transfer.

2. Graded-Index Multi-Mode Fiber

- Core has a **gradually changing refractive index** (higher in center, lower at edges).
- Light rays bend smoothly, reducing distortion.
- Better performance than step-index.
- Used in **LANs and campus networks** (medium distance).

Unit – II Transmission Media:



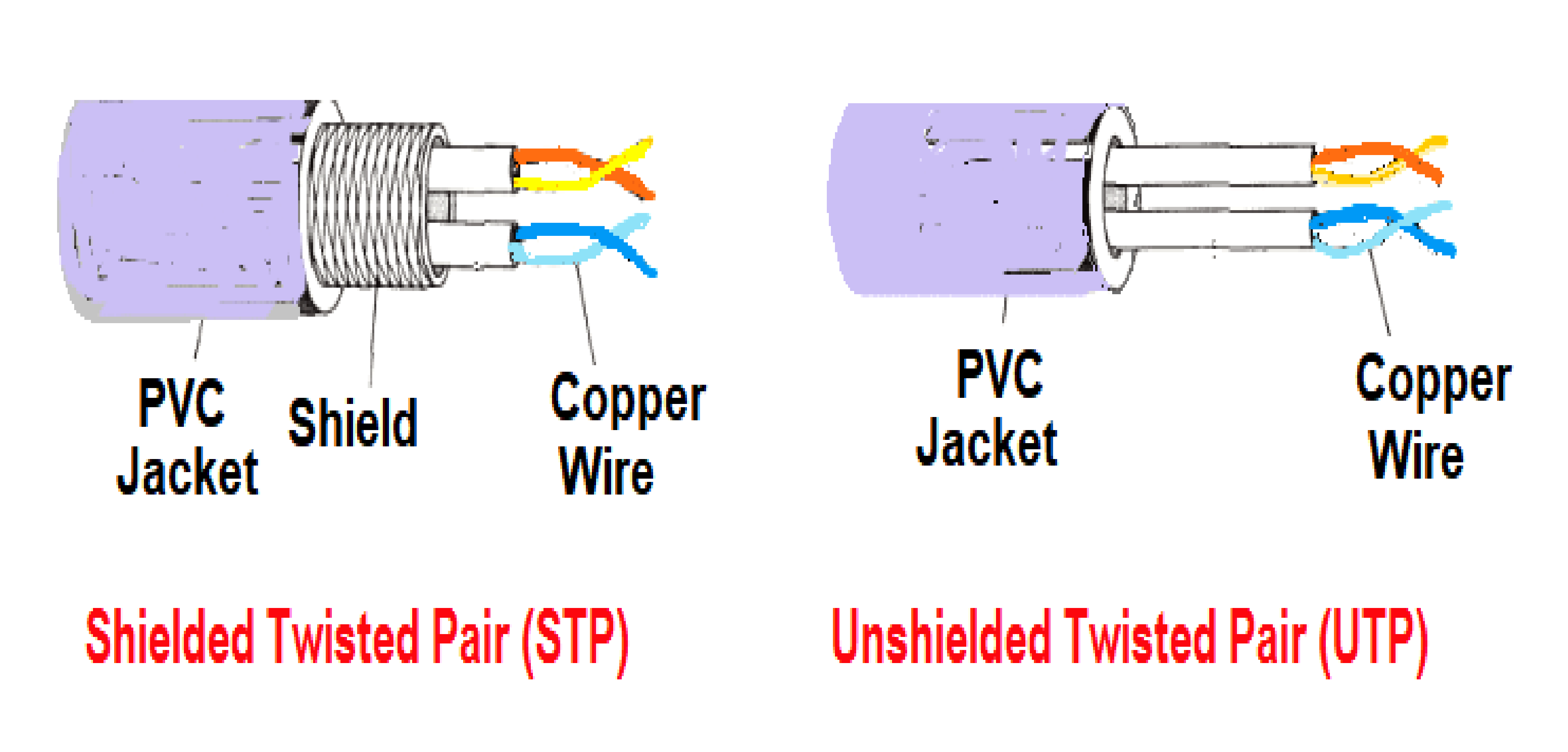
Fiber Optic Cable

10Base2 (Thin net)

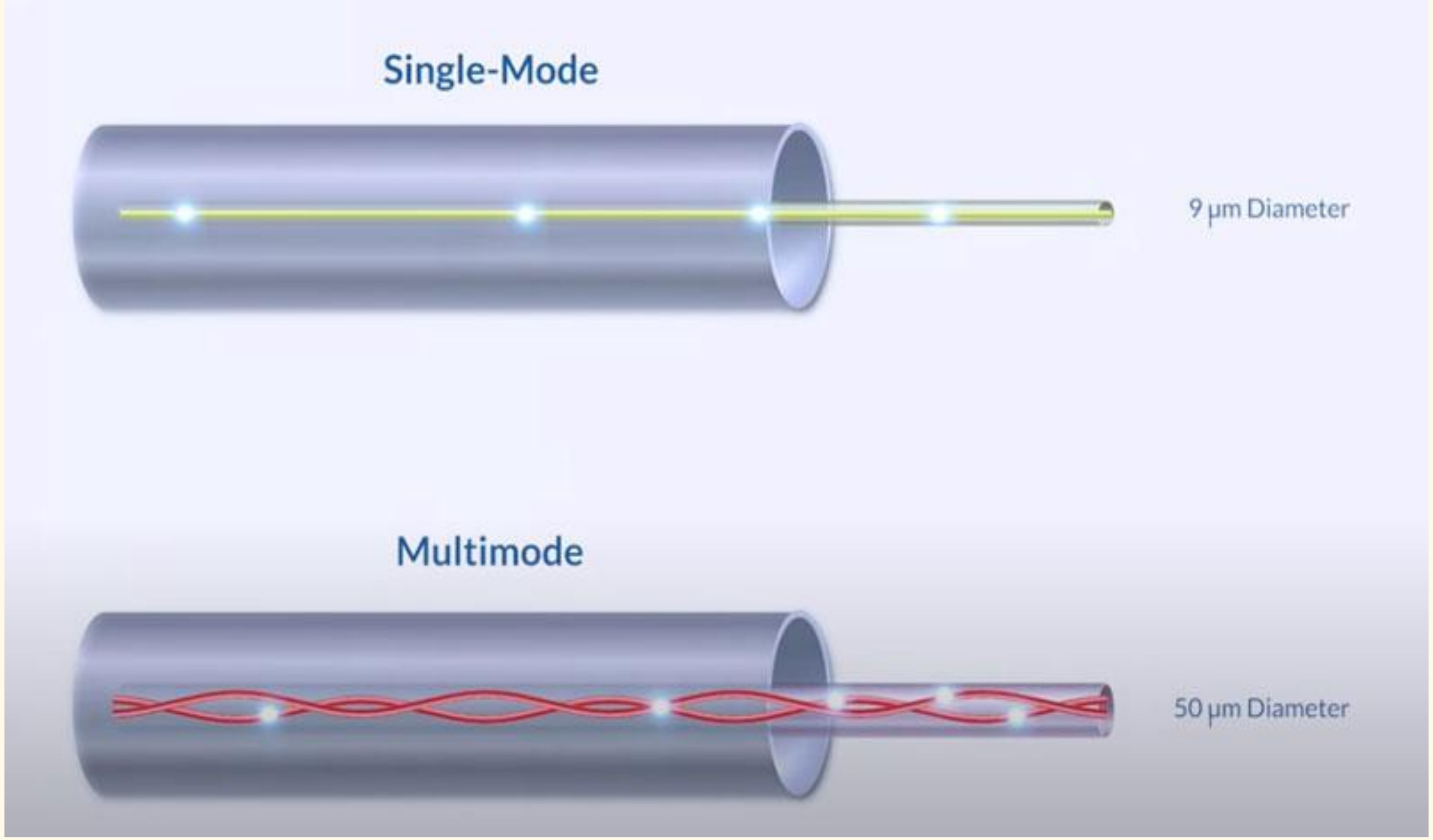
- **10** → Supports **10 Mbps** data transfer speed.
- **Base** → Uses **Baseband transmission** (only Ethernet signals on the cable, no multiplexing).
- **2** → Maximum length of the cable segment is **200 meters** (actually 185 meters, but rounded to 200, hence "2").

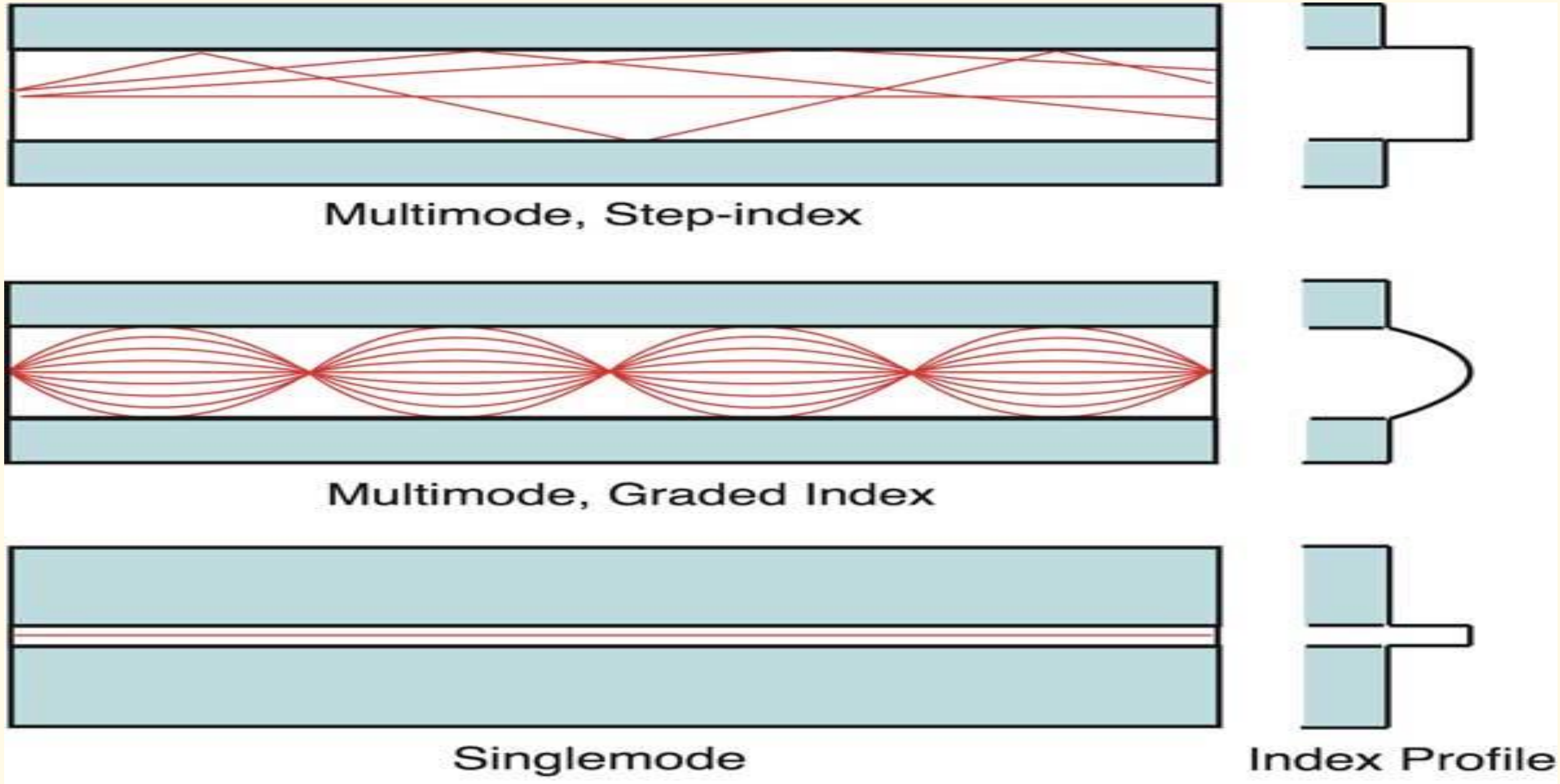
10Base5 (Thick net)

- **10** → Provides **10 Mbps** data transmission speed.
- **Base** → Uses **Baseband transmission** (only Ethernet signals on the cable).
- **5** → Maximum segment length of **500 meters** (hence the "5").


PVC Jacket
Shield
Copper Wire
PVC Jacket
Copper Wire
Shielded Twisted Pair (STP)
Unshielded Twisted Pair (UTP)

Unit – II Transmission Media:

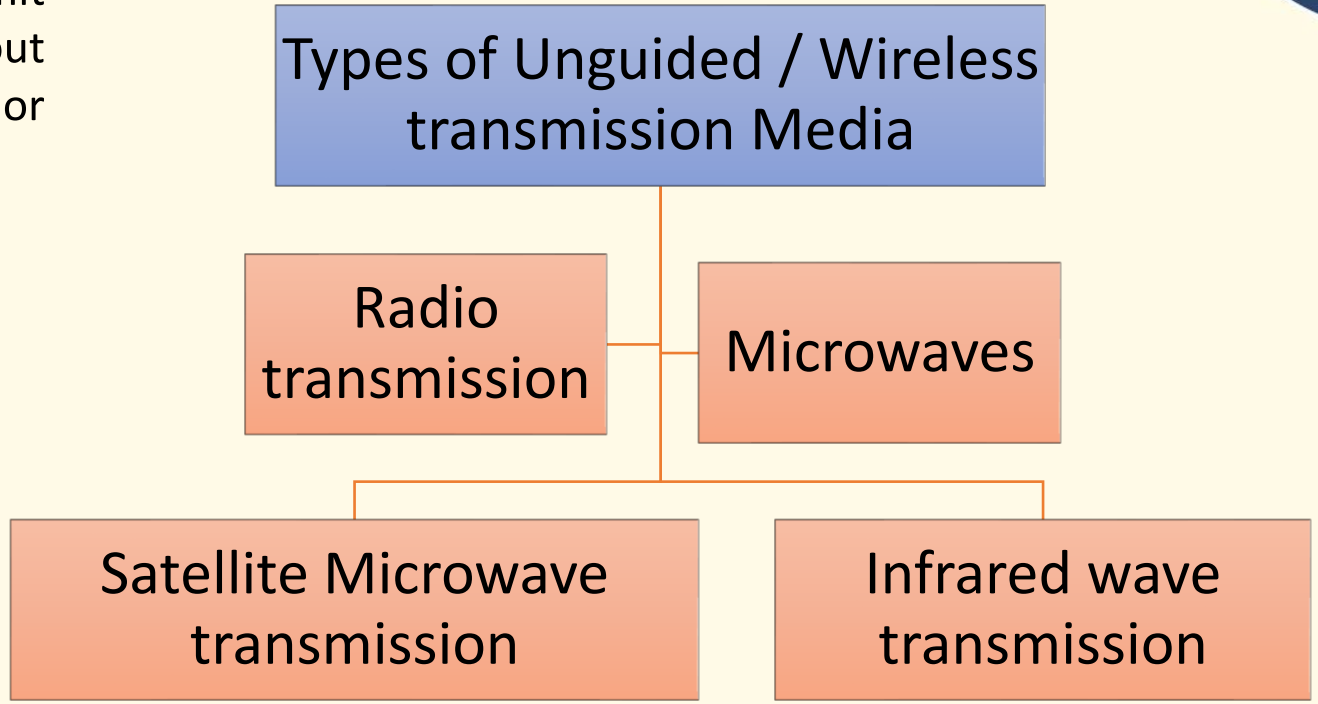



Multimode, Step-index
Multimode, Graded Index
Singlemode
Index Profile

Feature	**Twisted Pair**	**Coaxial Cable**	**Fiber Optic**
Material	Copper wires (twisted)	Single copper core + shield	Glass or plastic fiber
Speed	Low–Medium (up to 1–10 Gbps)	Medium	Very High (Tbps)
Distance	Short (up to 100 m)	Few km	Very Long (100s of km)
Cost	Cheapest	Moderate	Expensive
Noise protection	Low	Medium (shielded)	Very High (immune to interference)
Uses	LAN, telephone lines	Cable TV, internet (cable modem)	Broadband, backbone, long-distance comm

Unguided Transmission

Unguided transmission media transmit signals **through the air (or space)** without using any physical conductor like cables or wires.



TEMPL GROUP OF INSTITUTIONS
EDUCATING | GROOMING | SUCCEEDING
AFFILIATED TO CCS UNIVERSITY
APPROVED BY
AICTE I UGC I NCTE I SCERT
BAR COUNCIL OF INDIA

Types of Unguided Transmission Media

1.Radio Waves

1. Frequency: 3 kHz – 1 GHz
2. Can travel **long distances**, even through walls.
3. Used in **AM/FM radio, TV, mobile phones**.

2.Microwaves

1. Frequency: 1 GHz – 300 GHz
2. Travel in **straight line (line of sight)**.
3. Used in **satellite communication, Wi-Fi, Bluetooth**.

- **kHz** = **Kilohertz** → 1 kHz = 1,000 Hertz (cycles per second)
- **GHz** = **Gigahertz** → 1 GHz =1 billion Hertz (1×10^9 Hz)
- 1,000,000,000 Hertz (cycles per second)
- **THz** = **Terahertz** → 1 THz = 1 trillion Hertz (1×10^{12} Hz)
- = 1,000,000,000,000

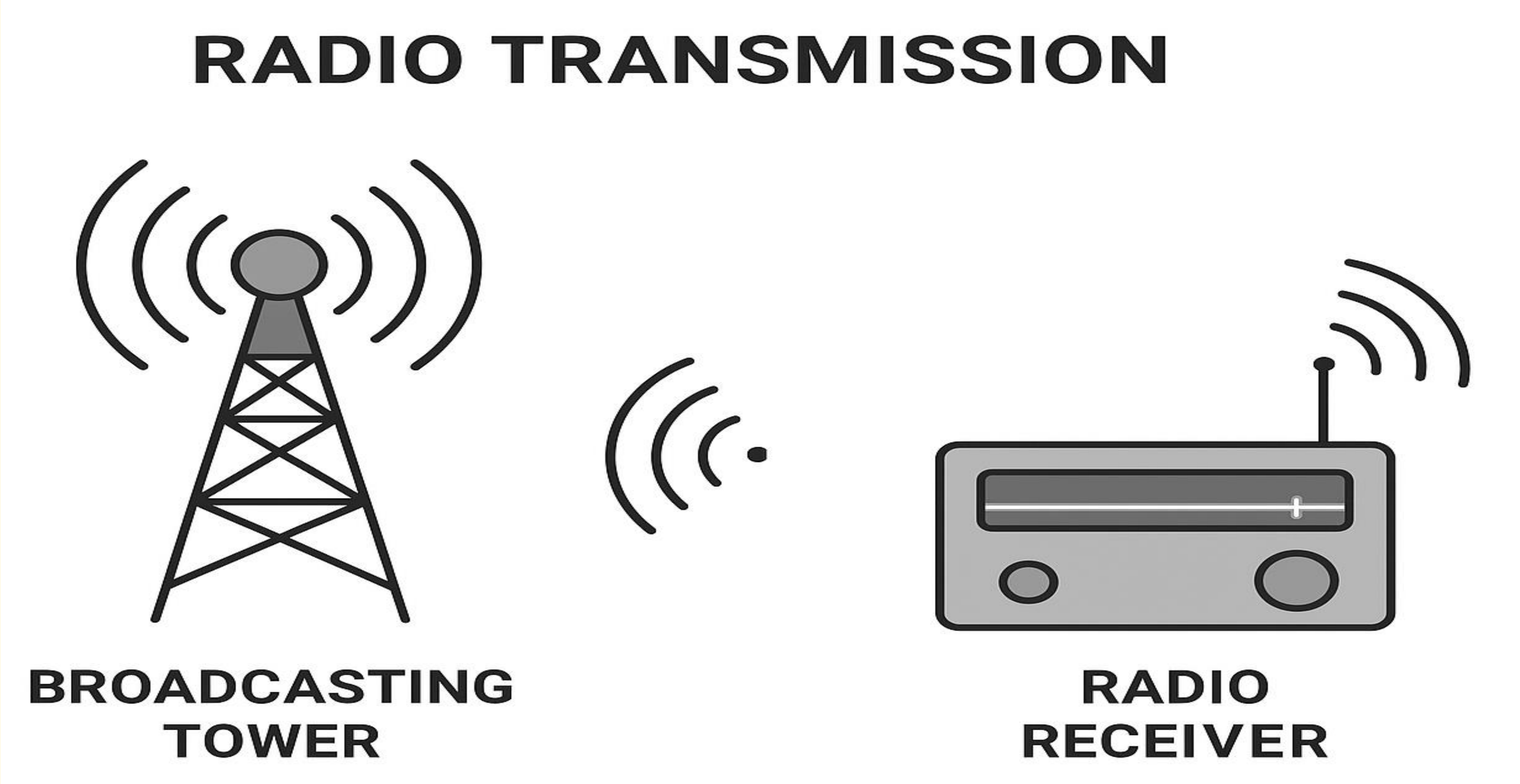
3.Infrared (IR)

1. Frequency: 300 GHz – 400 THz
2. Short range, Infrared light is widely used for short-range
3. Used in **remote controls, short-range devices**.

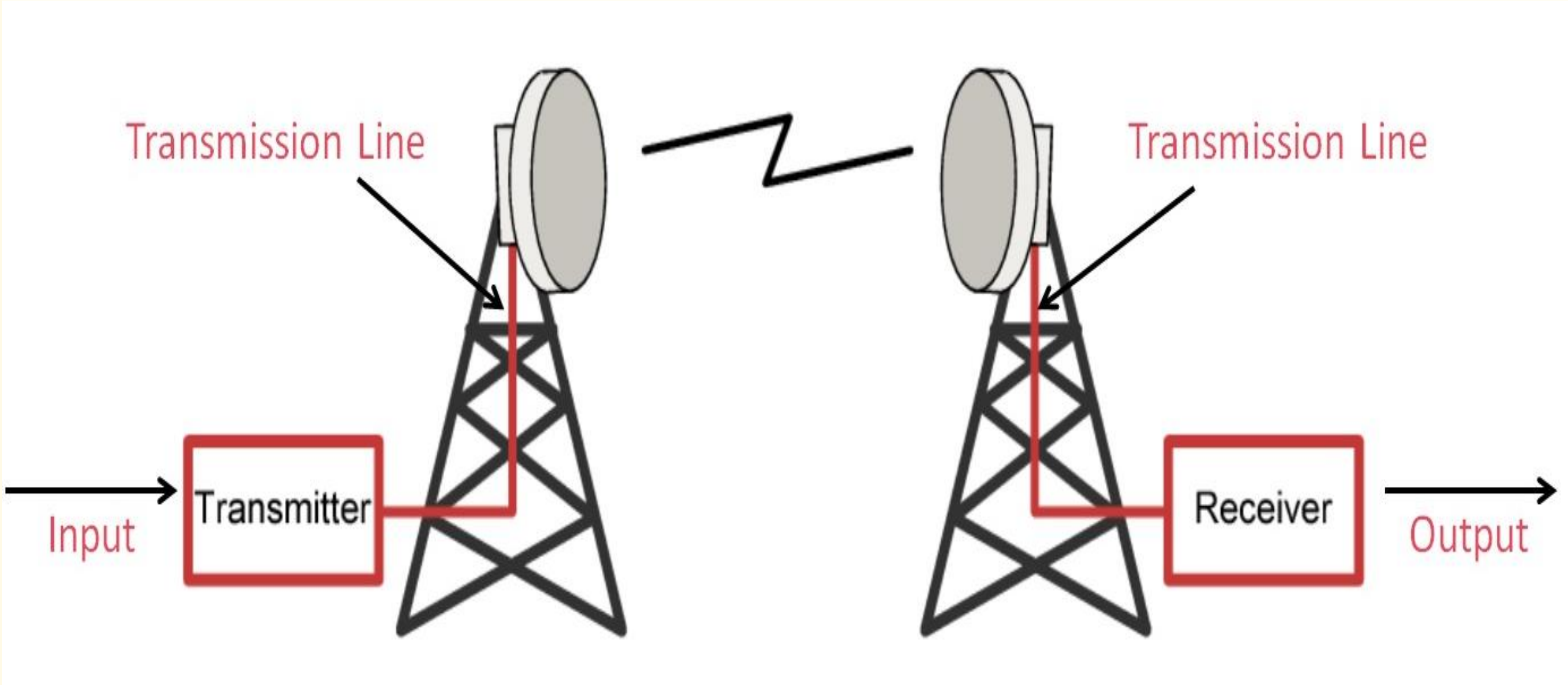
4.Satellite Communication

1. Uses **microwaves** sent to satellites and back to earth.
2. Used in **TV broadcast, GPS, weather forecasting, global communication**.

Type	Frequency Range	Distance / Feature	Examples / Uses
Radio Waves	3 kHz – 1 GHz	Long range, can pass through walls	AM/FM radio, TV, mobile phones
Microwaves	1 GHz – 300 GHz	Line-of-sight, medium distance	Satellite, Wi-Fi, Bluetooth, radar
Infrared (IR)	300 GHz – 400 THz	Short range, cannot pass through walls	Remote controls, short-range devices
Satellite	Uses microwaves	Very long distance (global)	TV broadcast, GPS, weather, global comm


RADIO TRANSMISSION
BROADCASTING TOWER
RADIO RECEIVER

Microwaves

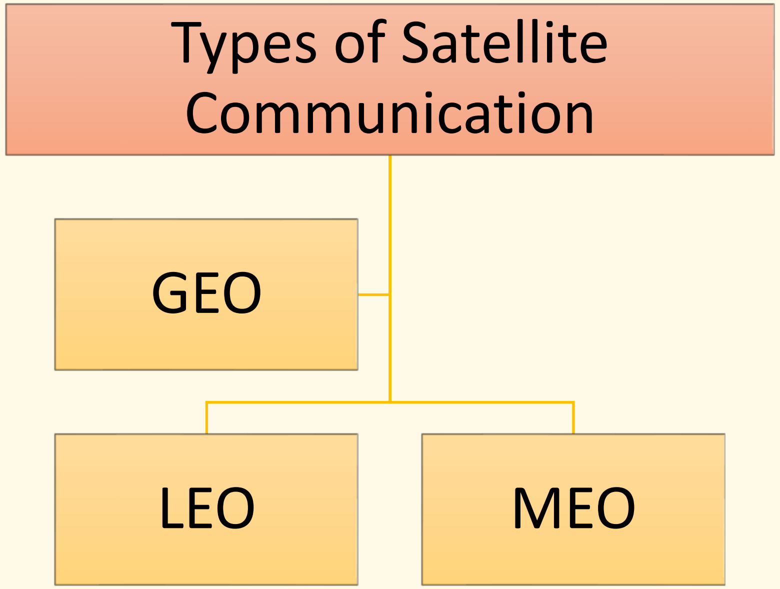


Infrared (IR)

Satellite Communication

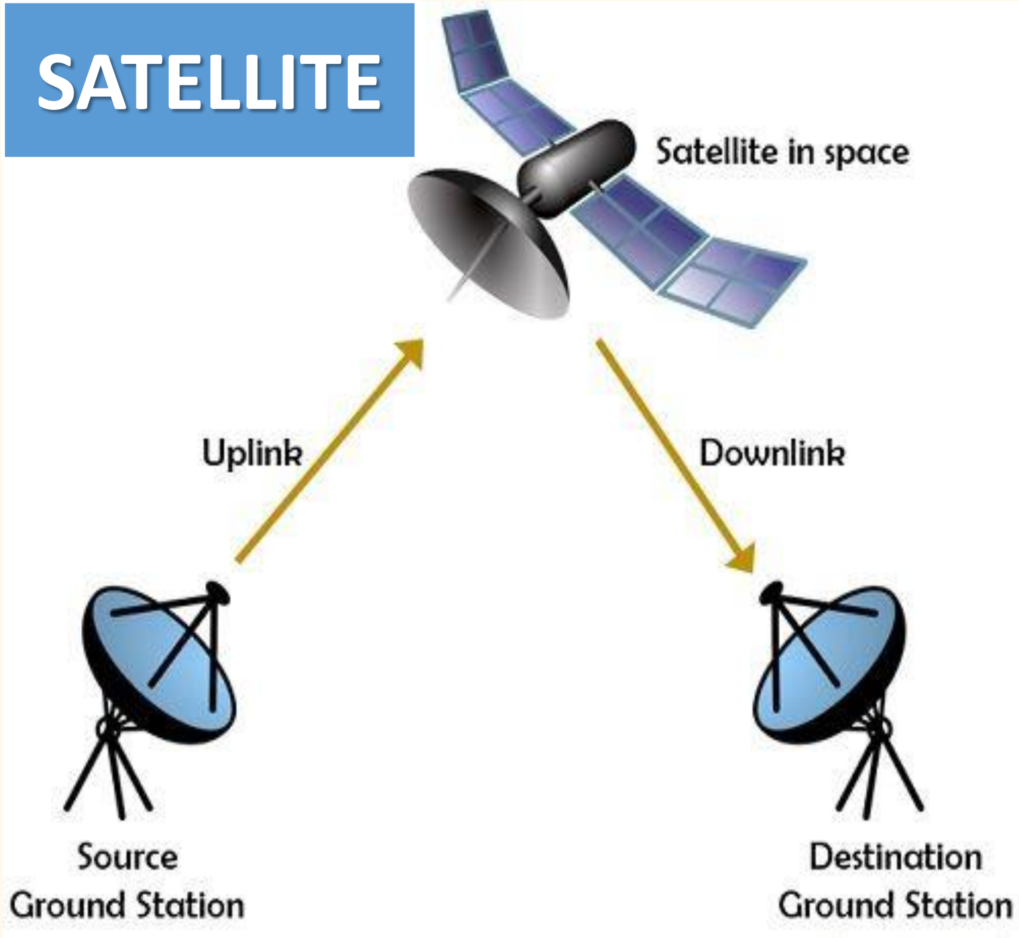
•Satellite communication is the **use of artificial satellites** to send and receive signals (voice, data, video) between two or more locations on Earth.

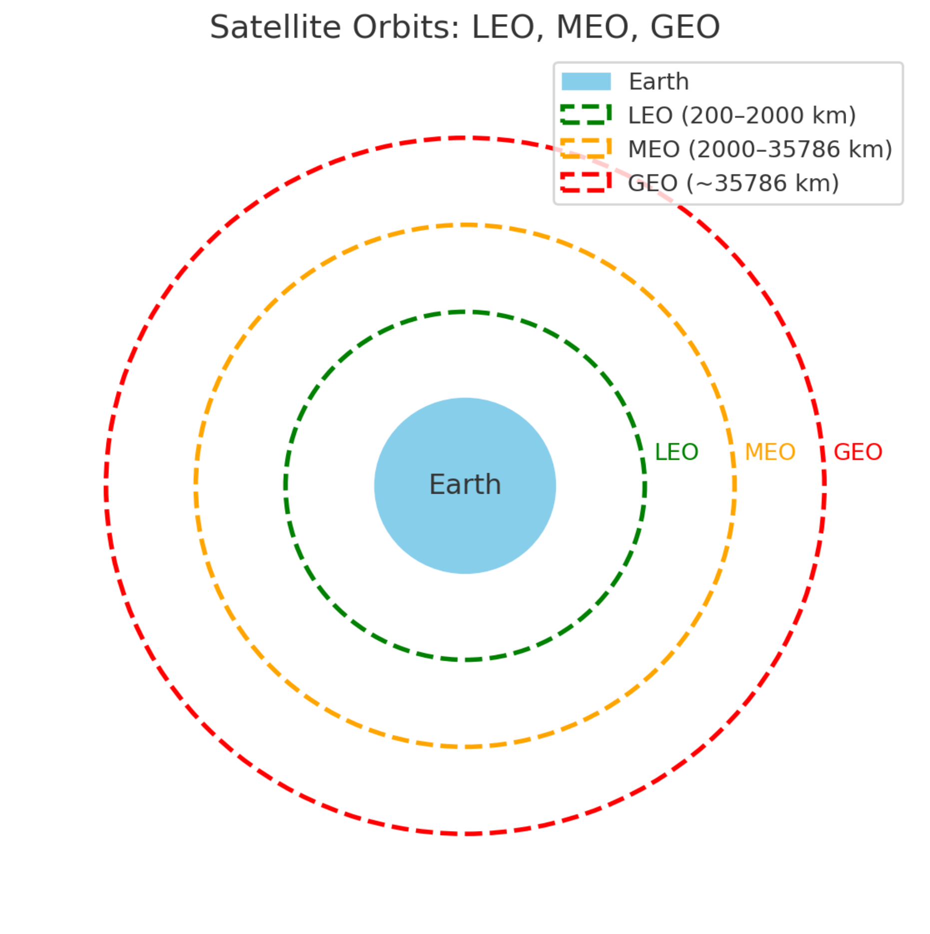
•Works mainly using **microwaves** (1–40 GHz frequency).



Unit – II Transmission Media:

SATELLITE





LEO (Low Earth Orbit)

- Satellites orbit **close to the Earth**, at about **200–2,000 km** altitude.
- **Orbit time:** Around **90 to 120 minutes**.
- **Used for:** Mobile communication, Earth observation, remote sensing
- **Advantages:** Low delay, clear signals.
- **Disadvantages:** Covers small area, so many satellites are needed.

MEO (Medium Earth Orbit)

- Satellites orbit **higher**, at about **2,000–35,000 km** altitude.
- **Orbit time:** Around **6 to 12 hours**.
- **Used for:** GPS (navigation) and communication systems.
- **Advantages:** Fewer satellites needed than LEO.
- **Disadvantages:** Slightly higher delay than LEO.

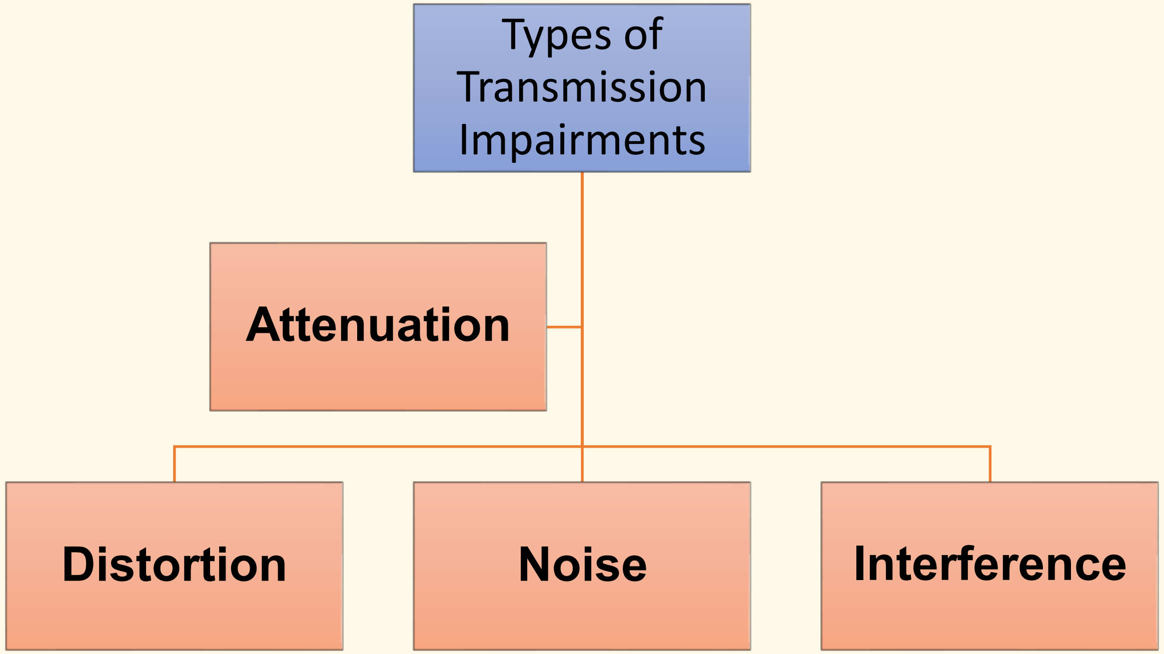
GEO (Geostationary Earth Orbit)

- Satellite orbits at **35,786 km** above Earth.
- The satellite **always stays above the same place on Earth.**
- **Orbit time:** 24 hours (same as Earth's rotation).
- **Used for:** TV broadcasting, weather forecast, and communication.
- **Advantages:** Large coverage area, fixed position.
- **Disadvantages:** High delay, costly, weak signals near poles.

Orbit	Altitude	Period	Coverage	Uses
LEO	200 – 2,000 km	90–120 min	Small	Earth observation, remote sensing
MEO	2,000 – 35,786 km	6–12 hrs	Medium	Navigation (GPS)
GEO	~36,000 km	24 hrs	Very Large (fixed point)	Communication, TV, Weather

Transmission Impairments

When data (signal) travels through a medium (like cable, air, fiber), the signal gets **weakened or distorted**. These problems are called **Transmission Impairments**.



GROUP OF INSTITUTIONS
EDUCATING | GROOMING | SUCCEEDING
AFFILIATED TO CCS UNIVERSITY
APPROVED BY
AICTE I UGC I NCTE I SCERT
BAR COUNCIL OF INDIA

Types of Transmission Impairments

1.Attenuation

Loss of signal strength as it travels through a medium (like cable, air).

- **Example:** A weak Wi-Fi signal far from the router.

2.Distortion

Change in the shape or form of the original signal.

- **Example:** Voice on a call sounding garbled.

TEMPL GROUP OF INSTITUTIONS
EDUCATING | GROOMING | SUCCEEDING
AFFILIATED TO CCS UNIVERSITY
APPROVED BY
AICTE I UGC I NCTE I SCERT
BAR COUNCIL OF INDIA

3. Noise

Unwanted random signals added to the original signal.

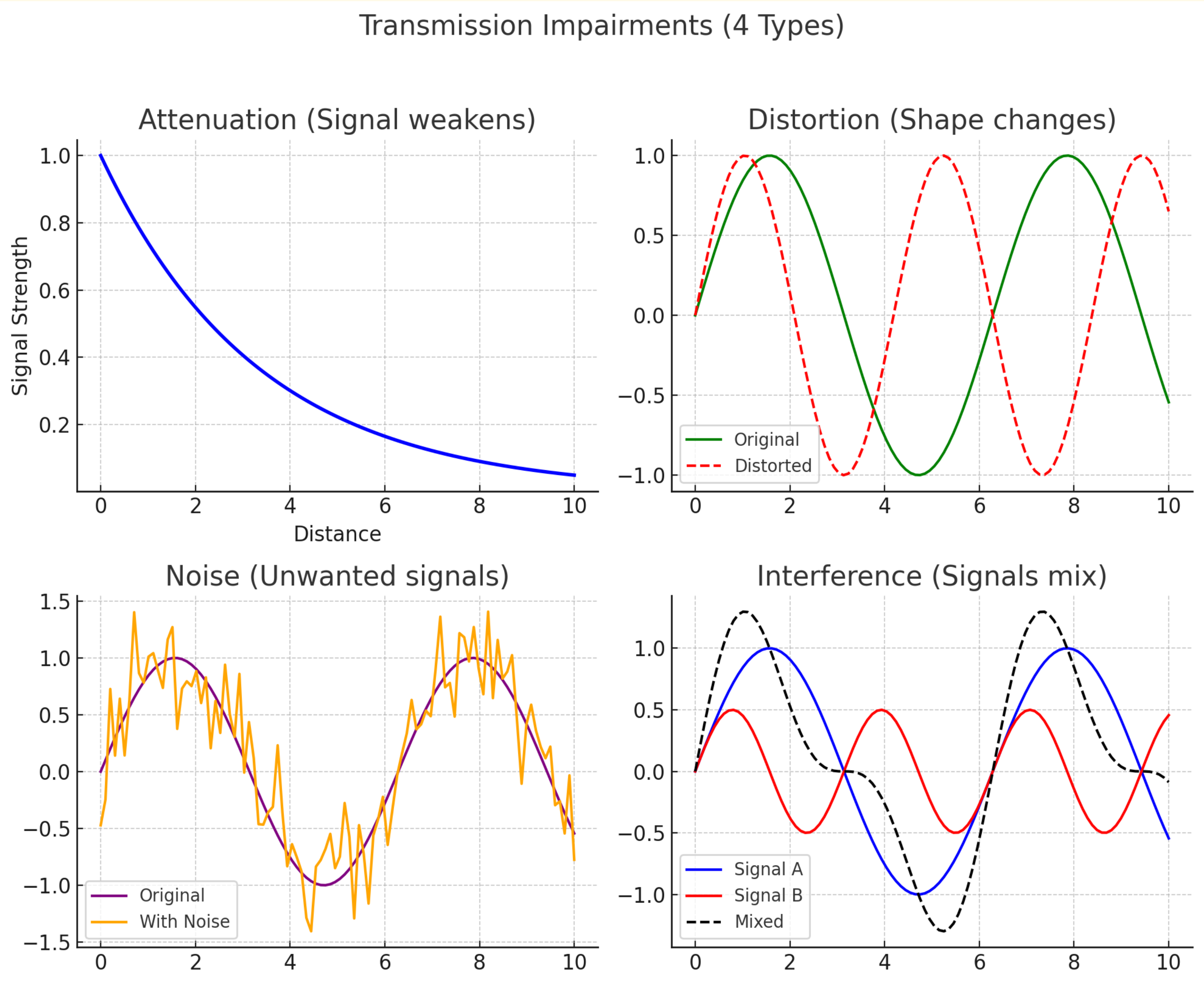
Example: Hiss in radio or static in a phone call.

Types:

- Thermal noise (due to heat in wires).
- Induced noise (from motors, devices).
- Crosstalk (mixing of signals from nearby wires).
- Impulse noise (spikes due to lightning, power faults).

4.Interference

- When **a signal from one channel disturbs another channel**.
- *Example*: Hearing other voices during a mobile call.
- Common in **wireless communication (radio, microwave, satellite)**.



- **Attenuation** → Blue curve getting weaker as distance increases.
- **Distortion** → Original vs distorted wave (shape change).
- **Noise** → Random disturbance added to the signal.
- **Interference** → Two signals mixing into one combined signal.

- The **performance of networks** means how well a computer network works to transfer data between devices. It is measured using different factors.

Performance factors of Networks

- Throughput
- Bandwidth
- Propagation Speed
- Propagation Time
- Wavelength
- Frequency

1. **Throughput**

Throughput is the **actual rate at which data is successfully transmitted over a network** (usually in bits per second, bps).

Example: Your 100 Mbps internet may give only 80 Mbps in real usage → **Throughput = 80 Mbps**..

2. Bandwidth

Bandwidth is the maximum amount of data that can be transmitted over a network connection in a given time.
Usually measured in **bits per second (bps)**
Example: A 100 Mbps internet connection can transfer up to 100 million bits per second.

3. Propagation Speed

Meaning: Speed at which a signal travels through the medium.

Unit: meters/second (m/s)

Formula:

$$\text{Propagation } speed = Distance/Propagation\ time$$

Example: In fiber optics, signal speed ≈ $2 \times 10^8\ m/s$)less than speed of light in vacuum).

4. Propagation Time

- **Meaning:** Time taken for a signal to travel from sender to receiver.
- **Unit:** seconds (s)
- **Formula:**

$$\text{Propagation } time = \frac{Distance}{Propagation\ speed}$$

- **Example:** For 3000 km distance over fiber ($v = 2 \times 10^8\ m/s$:(

$$t = \frac{3{,}000{,}000}{2 \times 10^8} = 0.015\ s = 15\ ms$$

5. Wavelength (λ)

Meaning: Physical length of one cycle of a wave.

Unit: meters (m)

Formula:

$$\lambda = \frac{v}{f}$$

where v= propagation speed, f= frequency.

Example: Radio wave, f = 100 MHz, v = 3×10^8m/s

$$\lambda = \frac{3 \times 10^8}{100 \times 10^6} = 3\,m$$

6. Frequency (f)

Meaning: Number of cycles a wave completes in 1 second.

Unit: Hertz (Hz)

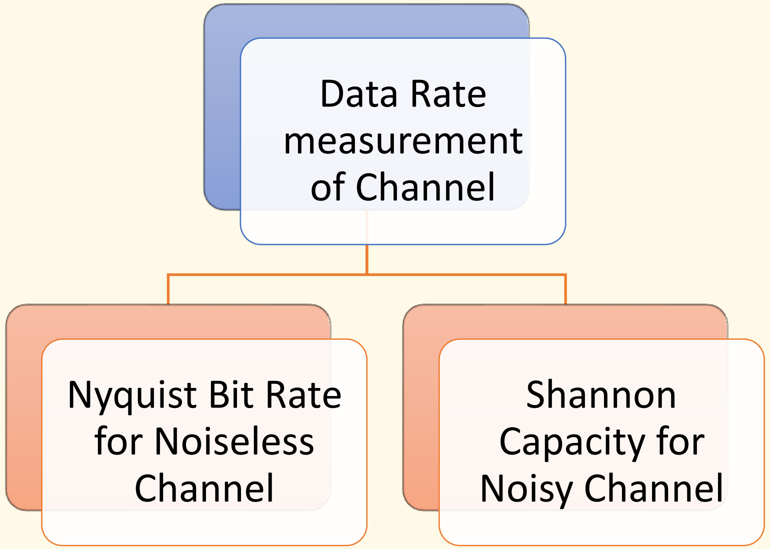
Relation with wavelength:

$$f = \frac{v}{\lambda}$$

Example: Light of wavelength 600 nm → $f = 5 \times 10^{14}\ Hz$

Factor	Meaning	Formula / Unit
Throughput	Actual data transfer rate	bps, Mbps, Gbps
Bandwidth	Max data carrying capacity	bps, Mbps, Gbps
Propagation Speed	Speed of signal in medium	~ 3×10^8 m/s (light speed)
Propagation Time	Time for signal to travel distance	Distance / Speed
Wavelength (λ)	Length of one cycle of signal	$\lambda = v / f$ (meters)
Frequency (f)	Cycles per second of signal	Hz, kHz, MHz, GHz

- **Data Rate of a Channel**
- The **data rate** means the speed at which data can be transmitted through a communication channel.
  It depends on **bandwidth**, **signal levels**, and **noise**.
- There are two famous formulas for measuring it:



1. Nyquist Bit Rate (Noiseless Channel)

Definition: Maximum data rate that can be transmitted over a noiseless channel.

Formula:

$$\text{Maximum } \textit{Bit Rate} = 2 \cdot B \cdot \log_2 M$$

Where:

B = Bandwidth of the channel (Hz)

M = Number of discrete signal levels (e.g., 2 for binary, 4 for 2 bits per symbol)

Special case (Binary signals, M = 2):

$$\text{Bit } \textit{Rate} = 2 \cdot B \; bps$$

Example : Bandwidth $B = 3\ kHz$ (3000), Binary signal $M = 2$ (0 or 1)

$$\text{Bit } \textit{Rate} = 2 \cdot 3000 \cdot \log_2 2 \quad (\log_2 2 = 1) = 6000\ bps$$

2. Shannon Capacity (Noisy Channel)

Definition: Maximum theoretical data rate of a channel **considering noise**.

Formula:

$$C = B \cdot \log_2(1 + SNR)$$

Where:

C= Channel capacity (bps)

B= Bandwidth (Hz)

SNR= Signal-to-Noise Ratio (as a **power ratio**, not in dB)

Example:

Bandwidth $B = 3000\ Hz$, SNR $= 30$(power ratio)

$$C = 3000 \cdot \log_2(1 + 30) = 3000 \cdot \log_2 31$$

$$\log_2 31 \approx 4.954$$

$C \approx 3000 \cdot 4.954 = 14{,}862\ bps$