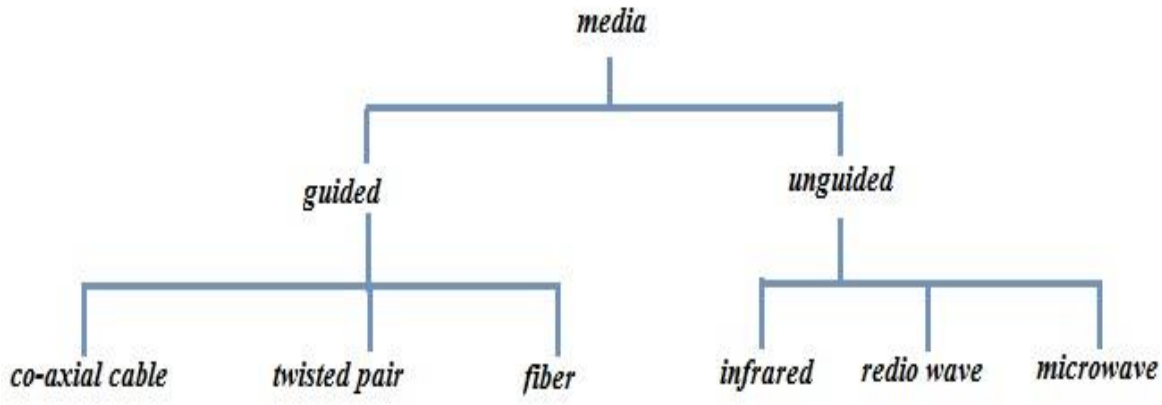
Chapter No: 2

TRANSMISSION MEDIA

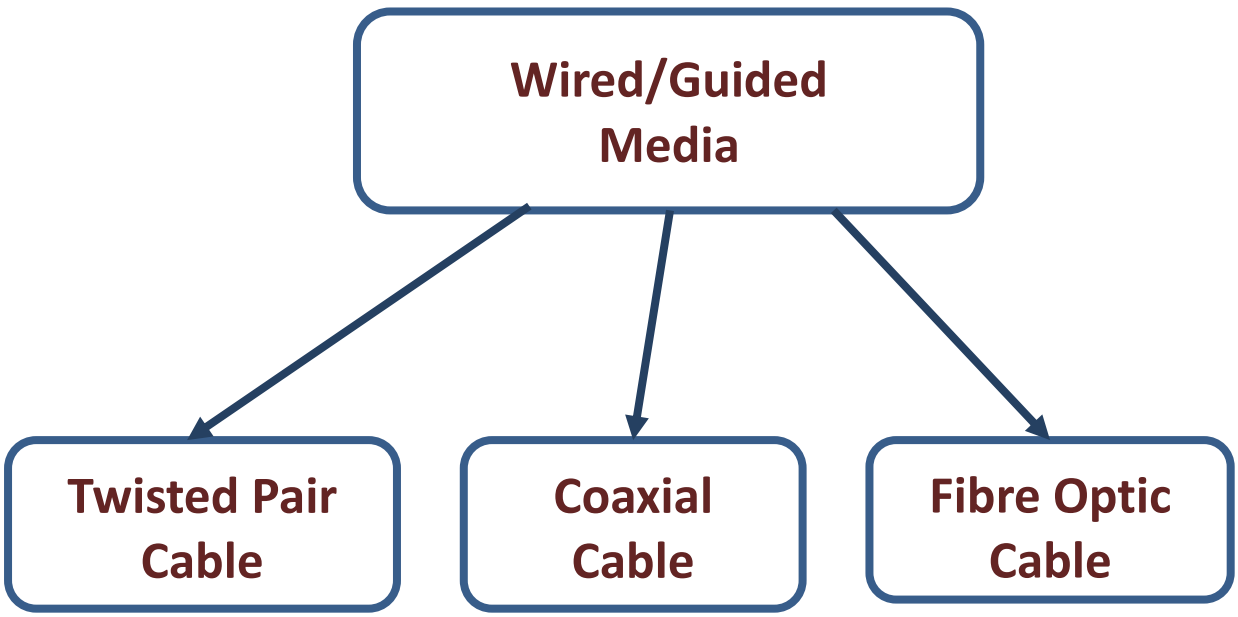
Transmission Media

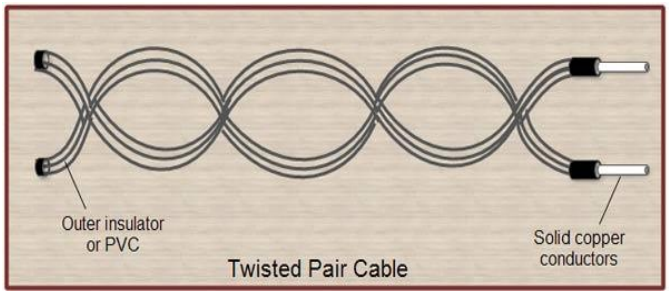
- Transmission medium is the way in which data is transmitted from one place to another.
- It provide a pathway over which the message can travel from sender-to-receiver.
- Each of the message can be sent in the form of data by converting them into binary digits.
- These binary digits are then encoded into a signal that can be transmitted over the appropriate medium.

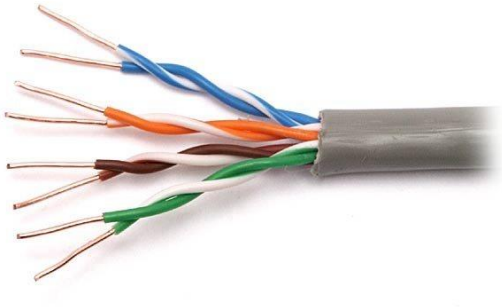


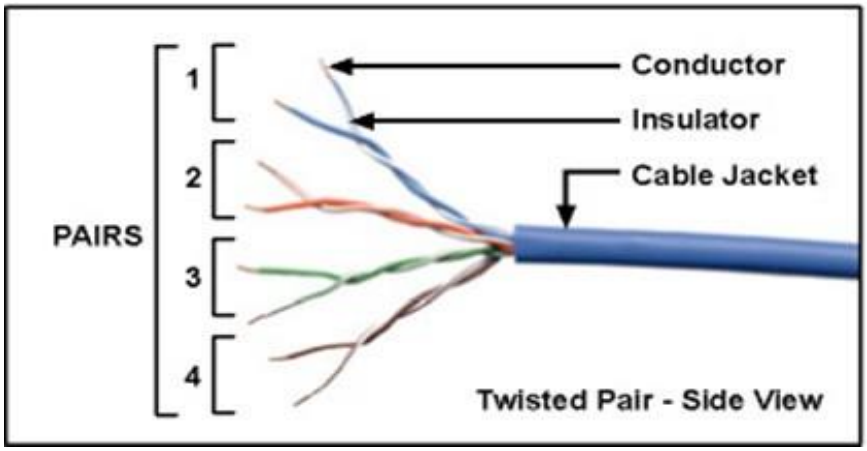
I. Wired/Guided Transmission Media

- Guided transmission media are the cables that are tangible or have physical existence.
- Bounded transmission means having connectivity between a source and destination using cables or wires. The signals have to travel through this channel i.e. physical media









- A twisted pair cable is a pair of copper wires.
- Copper wires are the most common wires used for transmitting signals because of good performance at low costs.
- A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together to form a single media.
- Out of these two wires, only one carries actual signal and another is used for ground reference.
- To identify every cable, these cables are colour coated.
- The twists between wires are helpful in reducing noise (electro-magnetic interference) and crosstalk.
- This type of cable is used in telephone lines to provide voice and data channels.

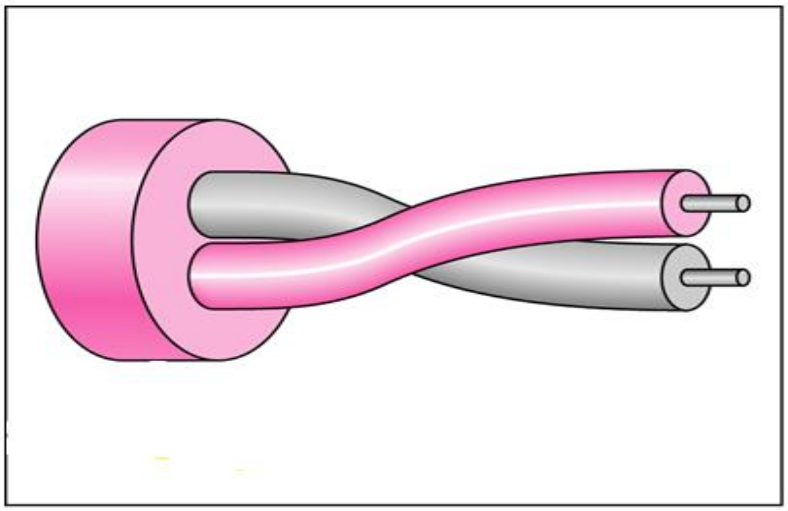
Types of Twisted Pair

The two types of twisted pairs are:

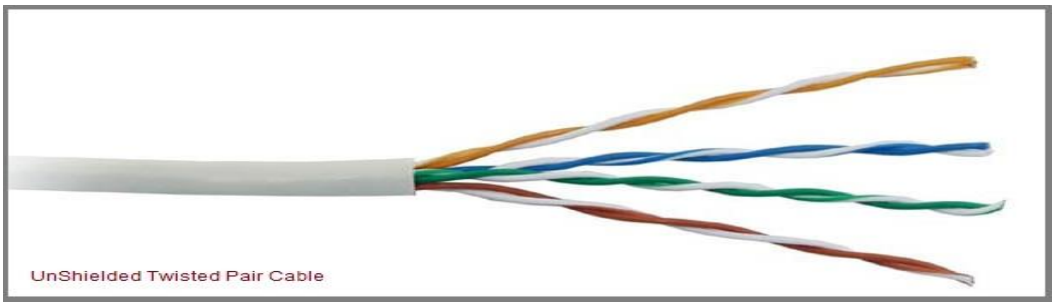
1. Unshielded twisted pair (UTP)

2. Shielded twisted pair (STP)

1. **Unshielded twisted pair (UTP):-**



- UTP is more common.
- UTP cost less than STP and easily available due to its many use.
- Due to its low cost, UTP cabling is used extensively for local-area networks (LANs) and telephone connections.
- UTP cables consist of 2 or 4 pairs of twisted cable.
- Cable with 2 pair use RJ-11 connector and 4 pair cable use RJ-45 connector.



Advantages of UTP:

- Easy installation and setup.
- Capable of high speed for LAN.
- Low cost.
- UTP is very flexible.

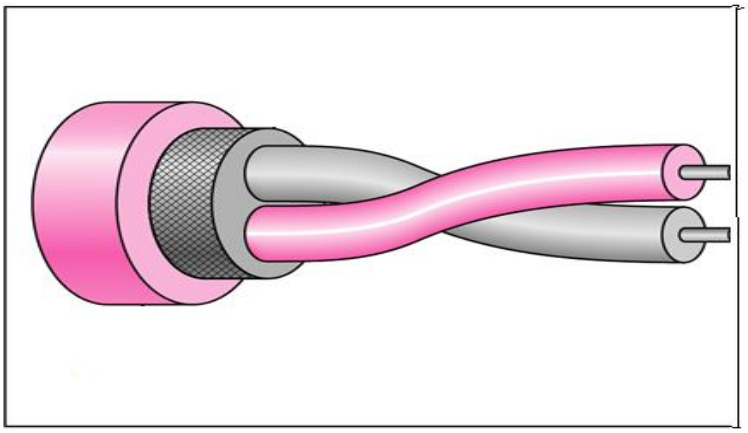
Disadvantages of UTP:

- Short distance due to attenuation.
- Limited bandwidth.

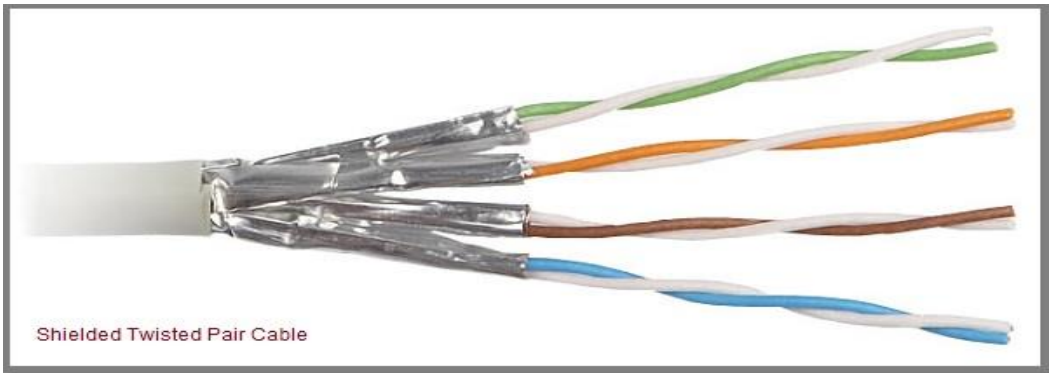
Application

- Commonly used in telephone lines.

2. **Shielded twisted pair (STP):-**



- This type of cable has a metal foil covering which encases each pair of insulator conductors.
- Electromagnetic noise penetration is prevented by metal casing. Shielding also eliminates crosstalk.
- It is similar to UTP but has a mesh shielding that's protects it from EMI which allows for higher transmission rate.
- It is more expensive than coaxial and unshielded twisted pair.



Advantages of STP:

- STP reduces interference.
- Faster than UTP and coaxial cable.
- Better performance at higher data rates.

Disadvantages of STP:

- More expensive than UTP and coaxial cable.
- More difficult installation and setup.
- High attenuation rate.
- High cost.

Question: Explain the construction of Shielded Twisted Pair Cable.

- STP is similar to UTP but with each pair covered by an additional copper braid jacket or foil wrapping. This shielding helps to protect the signals on the cables from external interference.

- Shielding provides a means to reflect or absorb electric fields that are present around cables. Shielding comes in a variety of forms from copper braiding or copper meshes to aluminized.
- STP is more expensive than UTP but has the benefit of being able to support higher transmission rates over longer distances.
- STP is heavier and more difficult to manufacture, but it can greatly improve the signaling rate in a given transmission scheme Twisting provides cancellation of magnetically induced fields and currents on a pair of conductors.
- Magnetic fields arise around other heavy current-carrying conductors and around large electric motors. Various grades of copper cables are available, with Grade 5 being the best and most expensive.
- STP is used in IBM token ring networks.

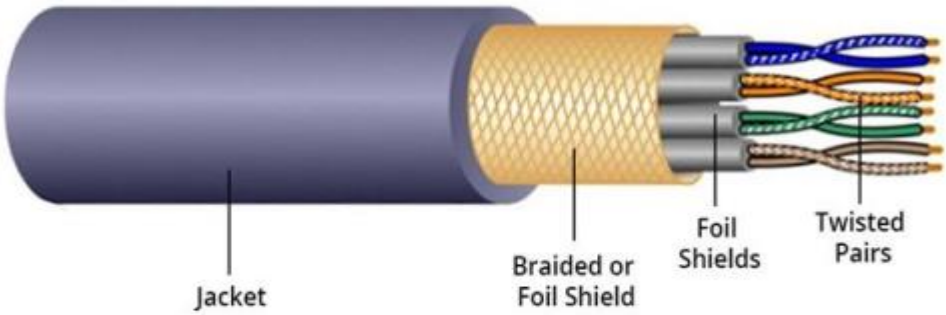
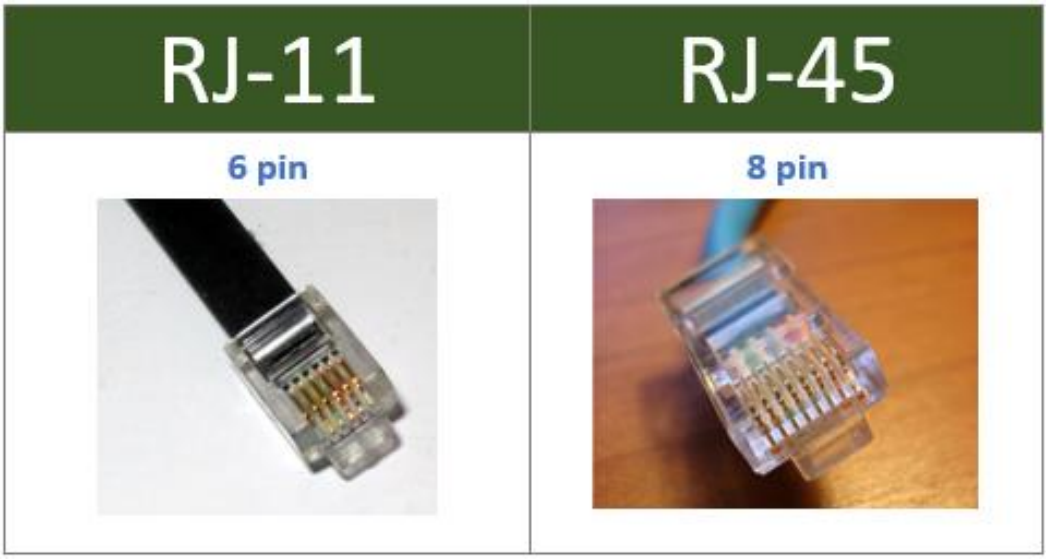
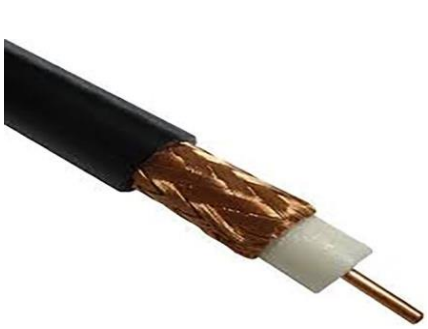


Figure: Construction of Shielded Twisted Pair

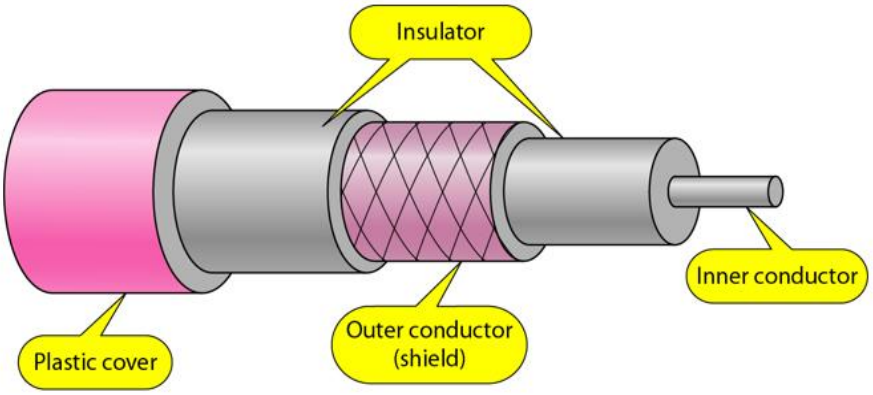
- RJ-45 connectors is used with Ethernet cables in computer networking.
- RJ-11 connectors is used in connecting telephone units.



Coaxial Cable



- **Coaxial cables** are copper cables with better shielding than twisted pair cables, so that transmitted signals may travel longer distances at higher speeds.
- The shield minimizes electrical and radio frequency interference.
- Coaxial cabling is the primary type of cabling used by the cable television industry and is also widely used for computer networks, such as Ethernet.



- Coaxial cable has two wires of copper.
- The core/inner copper wire in centre and is made of solid conductor. It is enclosed in an insulating sheath.
- The second/outer copper wire is wrapped around, and is used to protect from external electromagnetic interference (Noise).
- This all is covered by plastic cover used to protect the inner layers from physical damage such as fire or water.

Coaxial Cable Standards

- Coaxial cables are categorized by their Radio Government (RG) ratings. Each RG number denotes a unique set of physical specifications
    - 50-Ohm RG-7 or RG-11 : used with thick Ethernet.
    - 50-Ohm RG-58 : used with thin Ethernet
    - 75-Ohm RG-59 : used with cable television

Advantages of Co-axial Cable:

- Low cost due to less total footage of cable, hubs not needed.
- Lower attenuation than twisted pair.
- Supports high bandwidths.
- Can support high data rates.

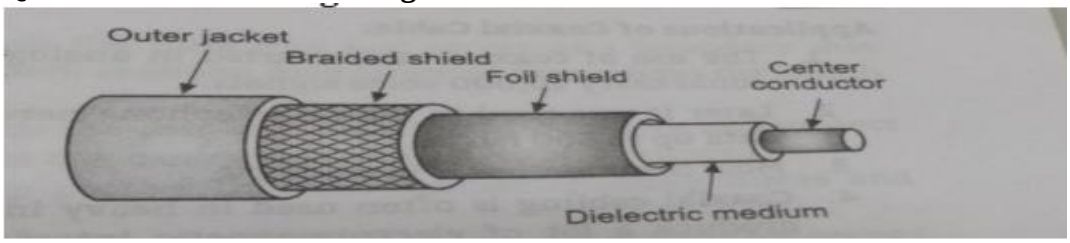
Disadvantages of Co-axial Cable:

- Limited in network speed.
- Limited in size of network.
- One bad connector can take down entire network.
- Coax is among the most expensive types of wire cables

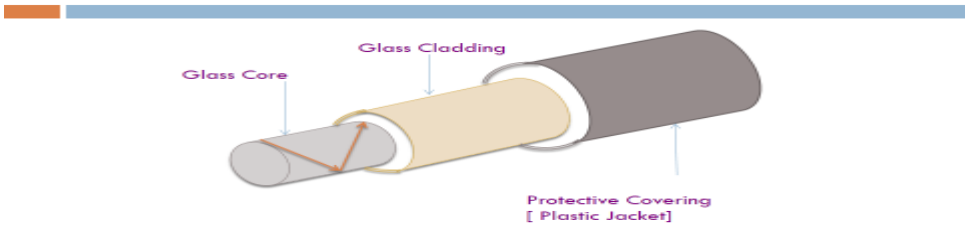
Applications of Co-axial Cable:

- Digit Analog telephone n/w.
- Analog telephone n/w.
- Cable TV.
- Ethernet LAN's – Thick and Thin.
- Digital transmission.
- Long distance telephone transmission– can carry 10,000 voice calls.

Question: Draw a labeled diagram of coaxial cable.

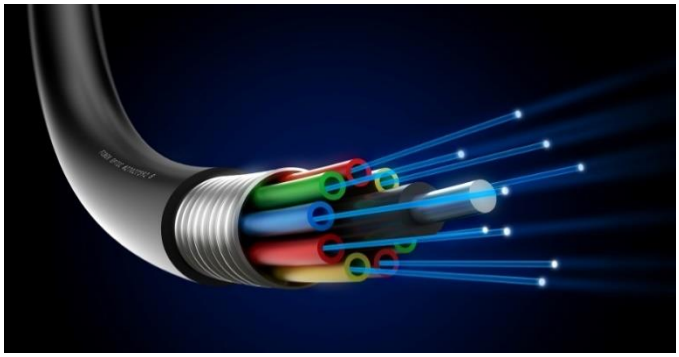


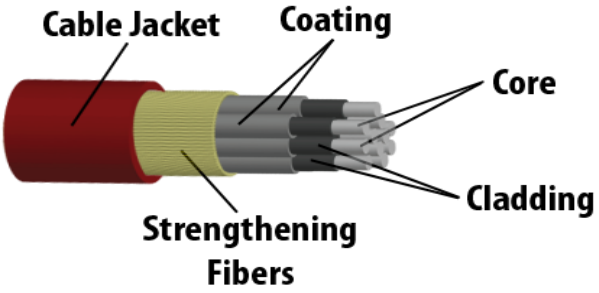
Fibre Optics Cable

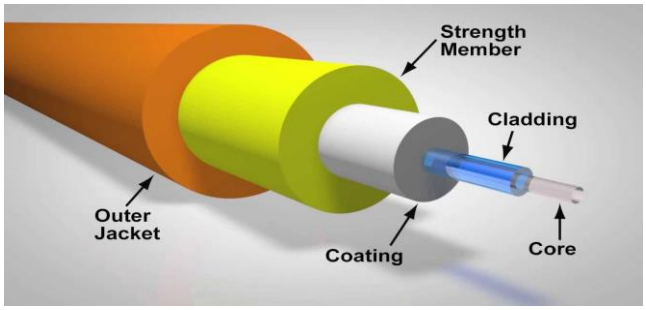


- A fibre optic cable is made of high quality of thin glass or plastic and is used to transfer digital data signals in the form of light up to distance of thousands of miles.
- Fibre optic cables are not affected by electromagnetic interference, so noise and distortion is very less.
- Fibre optic cables carry communication signals using pulses of light generated by small lasers or light-emitting diodes (LEDs).

- The cable consists of one or more strands of glass, each only slightly thicker than a human hair. The centre of each strand is called the core, which provides the pathway for light to travel. The core is surrounded by a layer of glass called cladding that reflects light inward to avoid loss of signal and allow the light to pass through bends in the cable. No light escapes the glass core because of this reflective **cladding.**







Advantages of Optical Fibre:-

- Fibre optic cables have a much High bandwidth than metal cables. This means that they can carry more data.
- Smaller Size and Lighter weight.
- low attenuation
- Not affected electromagnetic interference (No EMI interference)
- Signals carrying data can travel long distances without weakening
- Suitable for industrial and noisy areas

Disadvantages of Optical Fibre:-

- Optical fibre cables are expensive
- Difficult to install
- Maintenance is expensive and difficult

Question:Explain propagation modes in fiber optic cable with neat diagram.

The different propagation modes in fiber optic cable are as follows:

- **Multimode step index fiber**: In multimode step index fiber, the core has one density and the cladding has another density.

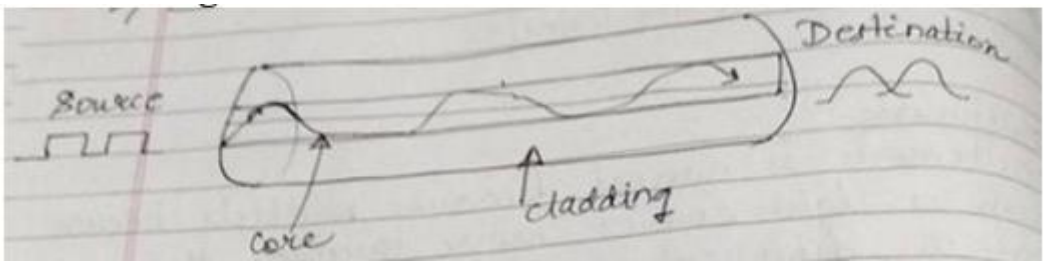
- Therefore at the interface, there is a sudden change that is why it is called step index. Multiple beams take different paths on reflection as shown in figure.
- The beam that strikes core at a smaller angle that has to be reflected many more times than the beam that shifted the core at a larger angle to reach other end. This means that at the destination, all beams do not reach simultaneously. It is used for short distances.

➢ **Multimode graded-index fiber:**

In this, core itself is made of a material of varying densities.

• The density is the highest at the core and gradually decreases towards the edge.

• Therefore, a beam gas through gradual refraction giving rise to a curve except that the horizontal beam travels unchanged.

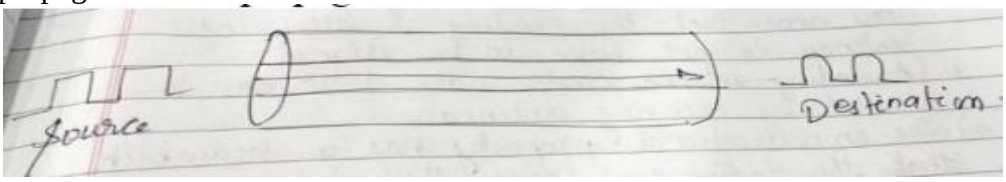


➢ **Single-mode:**

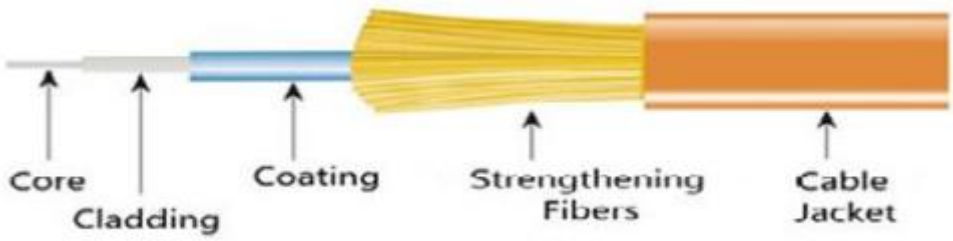
• It uses step-index fiber and a highly focused source of light that limits beam to a small range of angles, all close to horizontal.

• It is manufactured with much smaller diameter than that of multimode fiber and with substantially lower density.

• The decrease in density results in a critical angle i.e. close enough to 90 to make propagation of beams almost horizontal.



Question:Draw a labeled diagram of fiber optic cable and state its advantages.



Advantages of fiber optic cable:

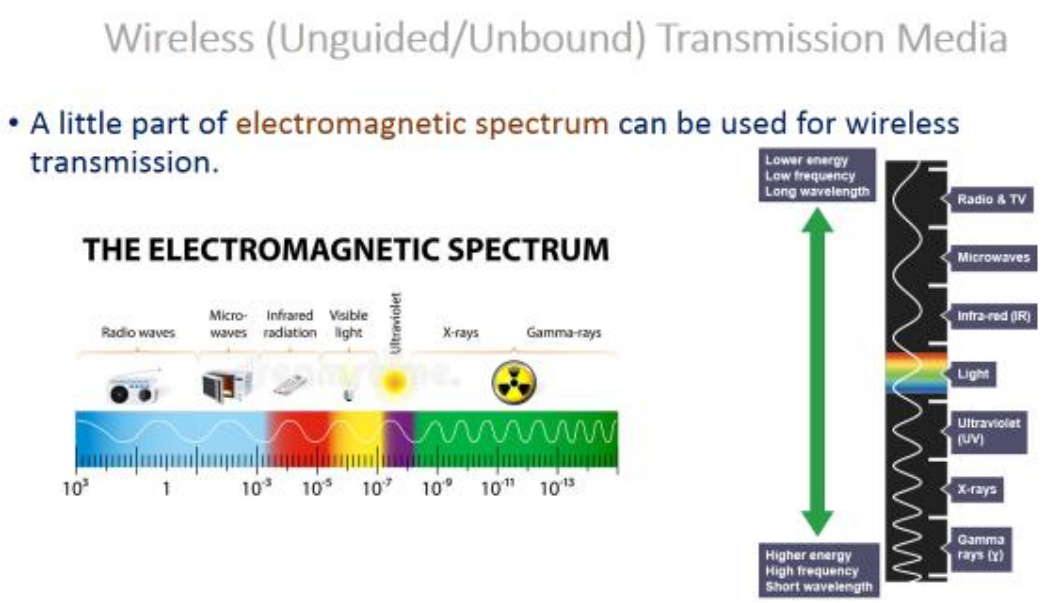
1.Higher data rate
2.Large Bandwidth
3.Less signal attenuation
4.Light weight.
5.More reliability
6.Long distance.
7.Higher security.

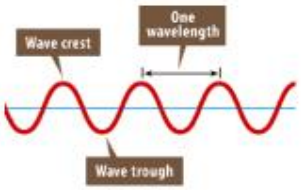
Question: Differentiate between twisted pair coaxial cable and fiber optic cable (any 4 points).

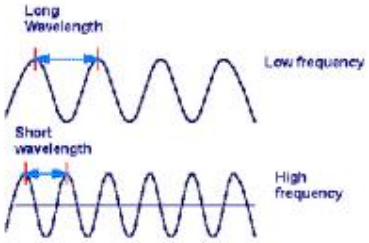
Sr. No.	Twisted pair cable	Coaxial cable	Fiber optic cable
1	Transmission of signals of takes place in the electrical form over the metallic conducting wires.	Transmission of signals takes place in the electrical form over the inner conductor of the cable.	Signal transmission takes place in an optical form over a glass fiber.
2	In this medium the noise immunity is low.	Coaxial having higher noise immunity than twisted pair cable.	Optical fiber has highest noise immunity as the light rays are unaffected by the electrical noise.
3	Twisted pair cable can be affected due to external magnetic field.	Coaxial cable is less affected due to external magnetic field.	Not affected by the external magnetic field.
4	Cheapest medium	Moderate Expensive	Expensive
5	Low Bandwidth	Moderately high bandwidth	Very high bandwidth
6	Attenuation is very high	Attenuation is low	Attenuation is very low
7	Installation is easy	Installation is fairly easy	Installation is difficult

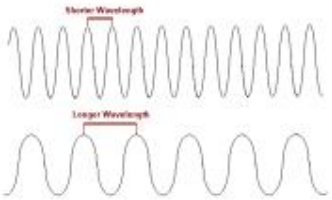
II. Wireless (Unguided/Unbound) Transmission Media

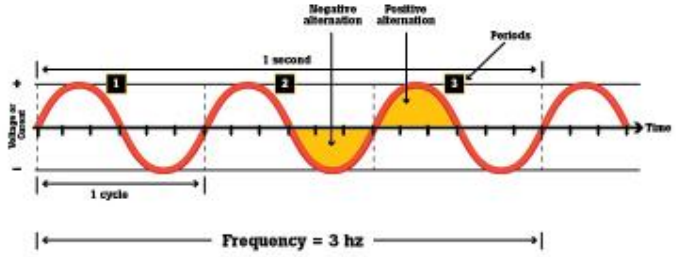
- A wave can be described as a disturbance that travels through a medium from one location to another location.
- A **wave** is a transfer of energy, usually through a form of matter called a **medium**.
- There are a special type of wave that can travel without a medium, called **electromagnetic waves (**also called **EM** waves)**,** which are waves like radio waves and microwaves.
- Unlike sound waves and water waves, electromagnetic waves don't need a fluid, or a solid, or even air to help them travel from one place to another. EM waves can travel across the great vacuum of space, which is why we see light from distant stars and planets.
- Electromagnetic waves are formed when an electric field comes in contact with a magnetic field. They are hence known as 'electromagnetic' waves.
- Electromagnetic (EM) radiation is a form of energy that is all around us and takes many forms, such as radio waves, microwaves, X-rays and gamma rays.
- Sunlight is also a form of EM energy. Electromagnetic energy from the sun comes to Earth in the form of radiation.
- The Electromagnetic Spectrum describes a wide range of different electromagnetic waves.



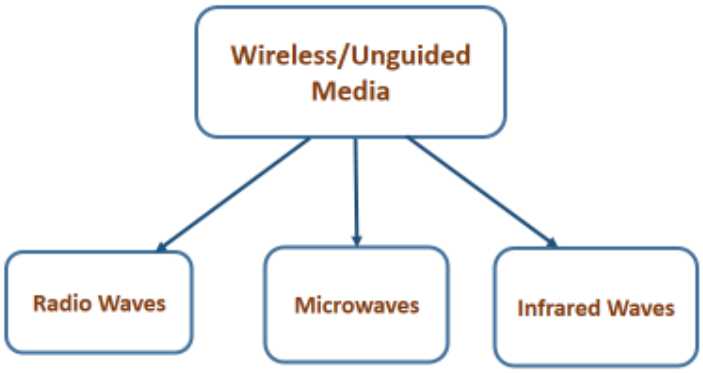








Band	Frequency range	Wavelength range
Extremely Low Frequency (ELF)	<3 kHz	>100 km
Very Low Frequency (VLF)	3 to 30 kHz	10 to 100 km
Low Frequency (LF)	30 to 300 kHz	1 m to 10 km
Medium Frequency (MF)	300 kHz to 3 MHz	100 m to 1 km
High Frequency (HF)	3 to 30 MHz	10 to 100 m
Very High Frequency (VHF)	30 to 300 MHz	1 to 10 m
Ultra High Frequency (UHF)	300 MHz to 3 GHz	10 cm to 1 m
Super High Frequency (SHF)	3 to 30 GHz	1 to 1 cm
Extremely High Frequency (EHF)	30 to 300 GHz	1 mm to 1 cm



Radio Waves Transmission

- Radio waves are EM (Electromagnetic) waves that have wavelengths between 1 millimetre and 100 kilometres (or 300 GHz and 3 kHz in frequency).
- Radio frequency is easy to generate because it has large wavelength and can travel long distance.
- Radio waves are generated by radio transmitters and received by radio receivers.
- Radio stations transmit radio waves using transmitters, which are received by the receiver installed in our devices. Both transmitters and receivers use antennas to radiate or capture radio signals
- It can penetrate walls easily, so these waves are widely used for communication both indoors and outdoors.
- Radio waves are omnidirectional means they travel in all the directions from the source.
- When an antenna transmits radio waves, they are propagated in all directions.
- A sending antenna send waves that can be received by any receiving antenna. The omnidirectional property has disadvantage, too. The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signal using the same frequency or band.

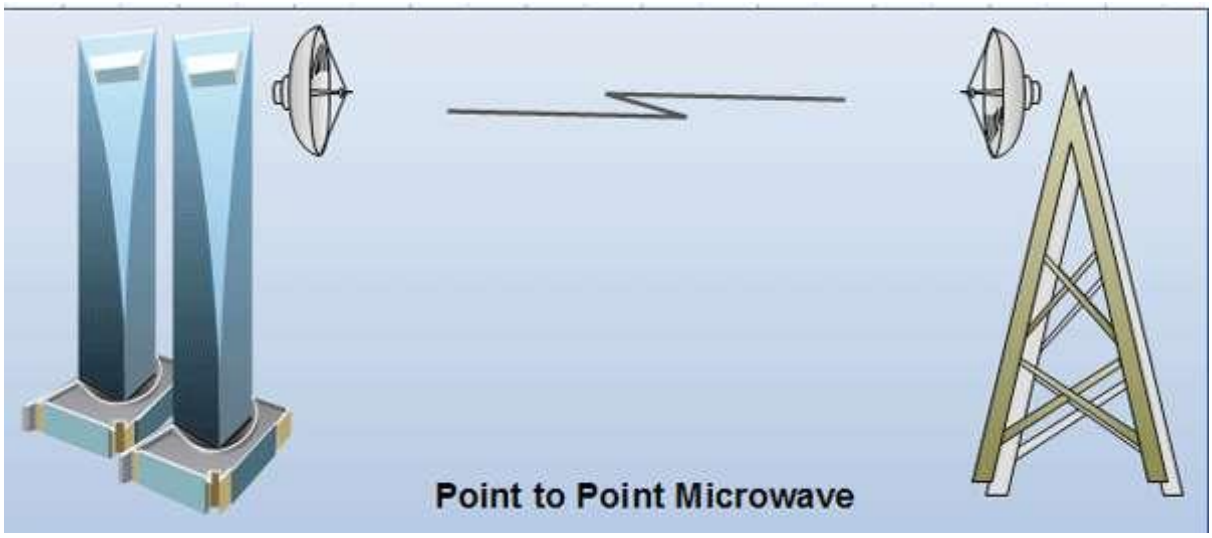
- It is Used Mobile, AM/FM radio, television

Radio Spectrum

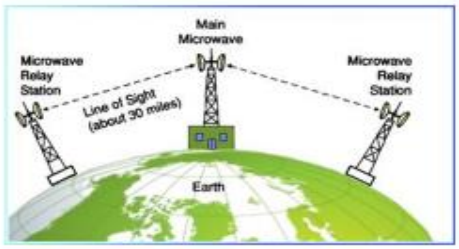
Radio Band	Frequency	Some Applications
Very Low Frequency VLF	3 KHZ to 30 KHz	Radio Navigation
Low Frequency LF	30 KHz to 300 KHz	Long Wave Radio
Medium Frequency MF	30 KHz to 3 MHz	AM Radio
High Frequency HF	3 MHz to 30 MHz	CB Radio (HAM) Point to Point Radio Search and Rescue Services
Very High Frequency VHF	30 MHz to 300 MHz	FM radio 88-108 MHz VHF Broadcast TV
Ultra High Frequency UHF	300 MHz to 3 GHz	UHF Broadcast TV Cellular Phones Microwave Links Wi-Fi in 2.4 Band Satellite Communications
Super High Frequency SHF	3 GHz to 30 GHz	Microwave Links Wi-Fi in 5 GHz Band Satellite Communications
Extra High Frequency EHF	30 GHz to 300 GHz	Microwave Links

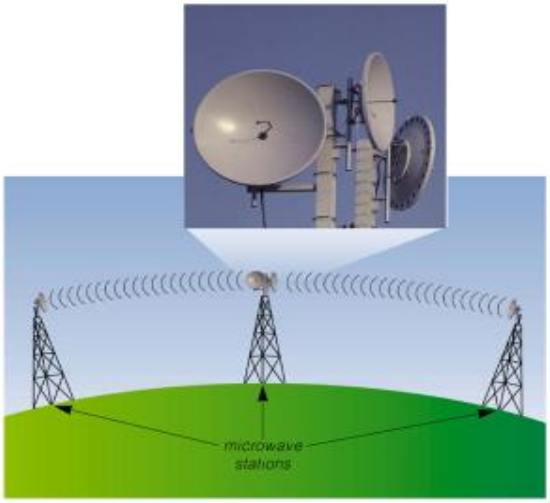
Micro Waves Transmission

- Microwaves are a type of radio waves with high frequencies. It can be classified as a subclass of radio waves. The frequency of microwaves lies in the 300 MHz to 300 GHz.
- Unlike radio waves, microwaves are unidirectional, in which the sending and receiving antennas need to be aligned.
- Microwaves are widely used for point-to-point communications because their small wavelength, which means that the signal is focused into a narrow beam. Additionally, each antenna must be within line of sight of the next antenna.



- Electromagnetic waves above 100 MHz tend to travel in a straight line and signals over them can be sent by beaming those waves towards one particular station. Because Microwaves travels in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.





- Microwaves have higher frequencies and do not penetrate wall like obstacles.
- It is used for satellite communication, navigation, radar, remote sensing and other short distance communication systems.\

Question: Explain the reason for using different frequency bands for uplink and downlink in satellite communication.

➢ The **uplink** frequency is the frequency which is used for transmission of signals from earth station transmitter to the satellite.
The **downlink** frequency is the frequency which is used for transmission of signals from the satellite to the earth station receiver

➢ Uplink frequency is different from downlink frequency for following reason:

- The satellite transmitter generates a signal that would jam its own receiver; if both uplink and downlink shared the same frequency.
- Trying to receive and transmit an amplified version of the same uplink waveform at same satellite will cause unwanted feedback or ring around from the downlink antenna back into the receiver.
- Frequency band separation allows the same antenna to be used for both receiving and transmitting, simplifying the satellite hardware.

➢ To overcome the above-mention difficulties satellite repeaters must involve some form of frequency translation before power amplification.
So, Uplink frequency is different from downlink frequency.

Question: Explain Microwave transmission with its advantages and disadvantages.

- **Microwave:**
  Electromagnetic waves having frequencies between 1 and 300GHz are called microwaves.
- Microwaves are unidirectional. When an antenna transmits microwave waves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned.
- The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.

The following describes some characteristics of microwave propagation:

- Microwave propagation is line-of-sight.
- Very high-frequency microwaves cannot penetrate walls. This characteristics can be a disadvantage if receivers are inside buildings.
- The microwave band is relatively wide, almost 299 GHz. Therefore wider sub bands can be assigned, and a high data rate is possible.
- Use of certain portions of the band requires permission from authorities

Applications:

Microwaves, due to their unidirectional properties, are very useful when unicast (one-to-one) communication is needed between the sender and the receiver. They are used in cellular phones, satellite networks, and wireless LANs.

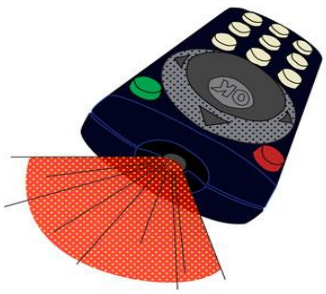
Advantages:

- Installation of towers and associated equipment's is cheaper than laying down a cable of 100KM length.
- Less maintenance as compared to cables.
- Repeaters can be used. So effect of noise is reduced.
- No adverse effects such as cable breakage.
- Due to the use of highly directional antenna no interference is there.
- Size of transmitter and receiver reduces due to the use of high frequency.

Disadvantages:

- Signal strength at the receiving antenna reduces due to multipath reception.

Infrared Waves Transmission



- Infrared signals have frequencies between 300 GHz to 400 THz. They are used for short-range communication.
- Infrared waves are used for very short distance communication like TV remote, wireless speakers, automatic doors, hand held devices etc.
- Infrared waves having high frequencies prevents interference b/w one system to another.

- Infrared signals have high frequencies and cannot penetrate walls. Due to its short-range communication system, the use of an infrared communication system in one room will not be affected by the use of another system in the next room. This is why using an infrared TV remote control in our home will not interfere with the use of our neighbour's infrared TV remote control.

THE DISADVANTAGES OF USING INFRARED

- Infrared signals cannot be used for long distance communication. In addition, we cannot use infrared waves outside a building because sun's rays contain infrared waves that can interfere with communication.