

Transmission Media

□ Guided:

- Twisted Pair
- Coaxial cable
- Optical fiber

□ Unguided:

- Microwave
- Satellite
- Wireless

Twisted Pair (TP)

- Separately insulated
- Twisted together
- Often "bundled" into cables
- Usually installed in building during construction



(a) Twisted pair

- ❑ Twists decrease the cross-talk
- ❑ Neighboring pairs have different twist length
- ❑ Most of telephone and network wiring in homes and offices is TP.

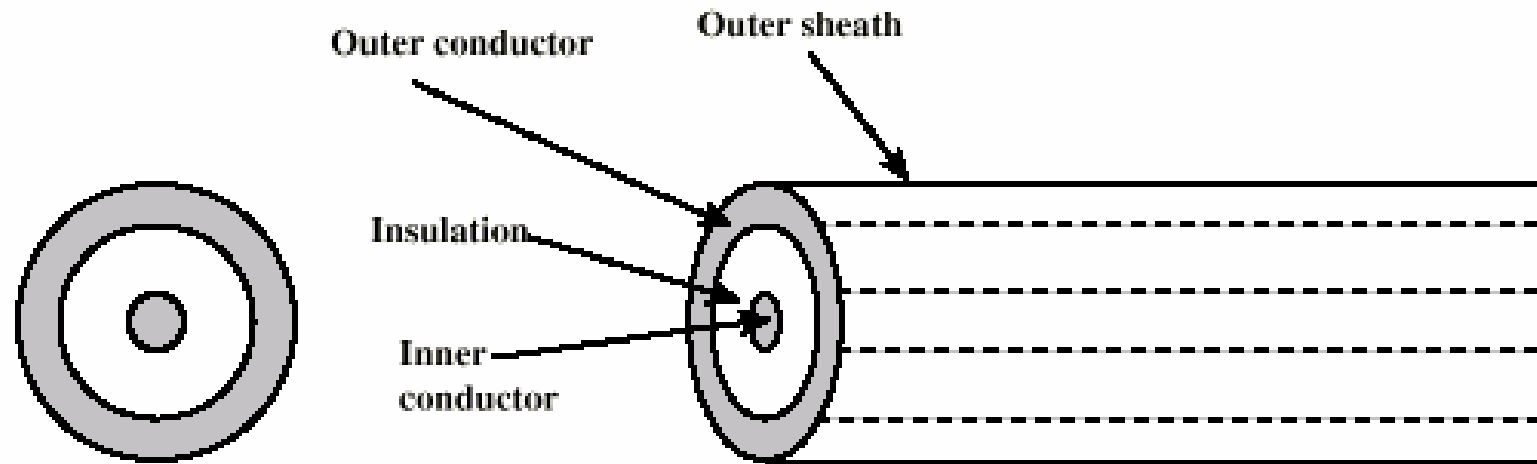
Unshielded and Shielded TP

- ❑ Unshielded Twisted Pair (UTP)
 - ❑ Ordinary telephone wire
 - ❑ Cheap, Flexible \Rightarrow Easiest to install
 - ❑ No shielding \Rightarrow Suffers from external EM interference
 - ❑ Used in Telephone and Ethernet
- ❑ Shielded Twisted Pair (STP)
 - ❑ Metal braid or sheathing that reduces interference
 - ❑ More expensive
 - ❑ Harder to handle (thick, heavy)
 - ❑ Used in token rings

UTP Categories

- ❑ Cat 3
 - ❑ Up to 16MHz
 - ❑ Voice grade found in most offices
 - ❑ Twist length of 7.5 cm to 10 cm
- ❑ Cat 4
 - ❑ Up to 20 MHz. Not used much in practice.
- ❑ Cat 5
 - ❑ Up to 100MHz
 - ❑ Used in 10 Mbps and 100 Mbps Ethernet
 - ❑ Twist length 0.6 cm to 0.85 cm
- ❑ Cat 5E (Enhanced), Cat 6, Cat 7

Coaxial Cable

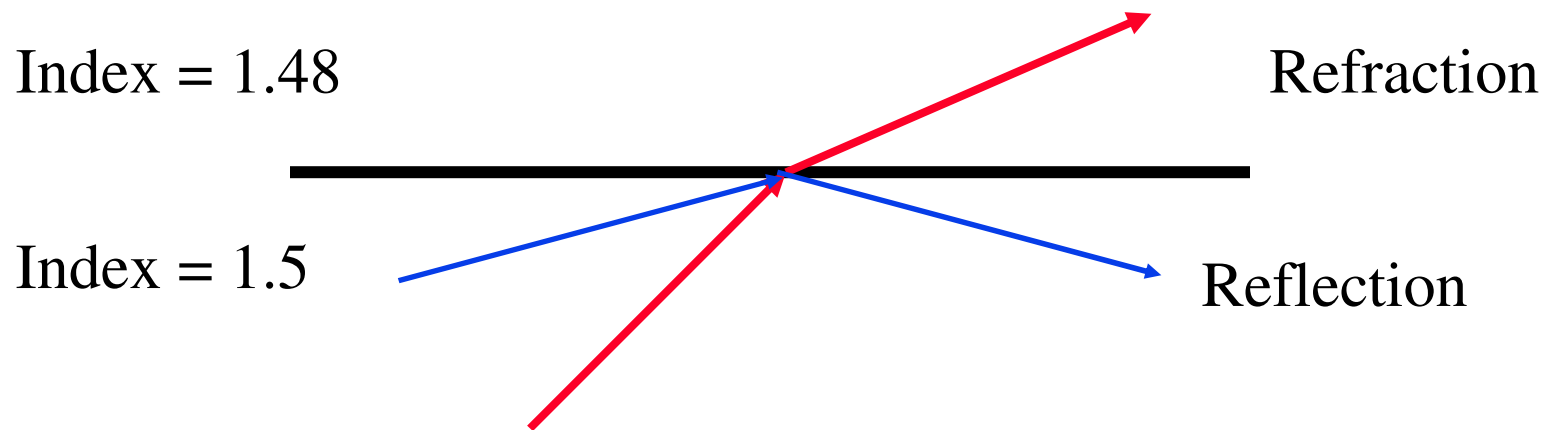


- Outer conductor is braided shield
- Inner conductor is solid metal
- Separated by insulating material
- Covered by padding

- ❑ Higher bandwidth than UTP. Up to 500 MHz.
- ❑ Used in cable TV

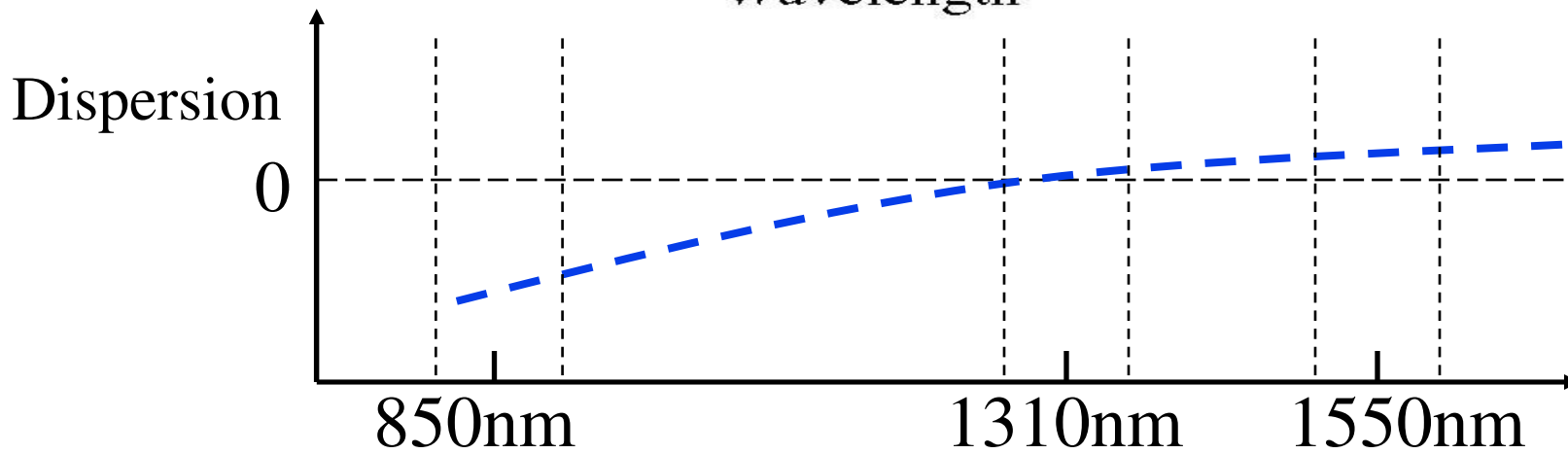
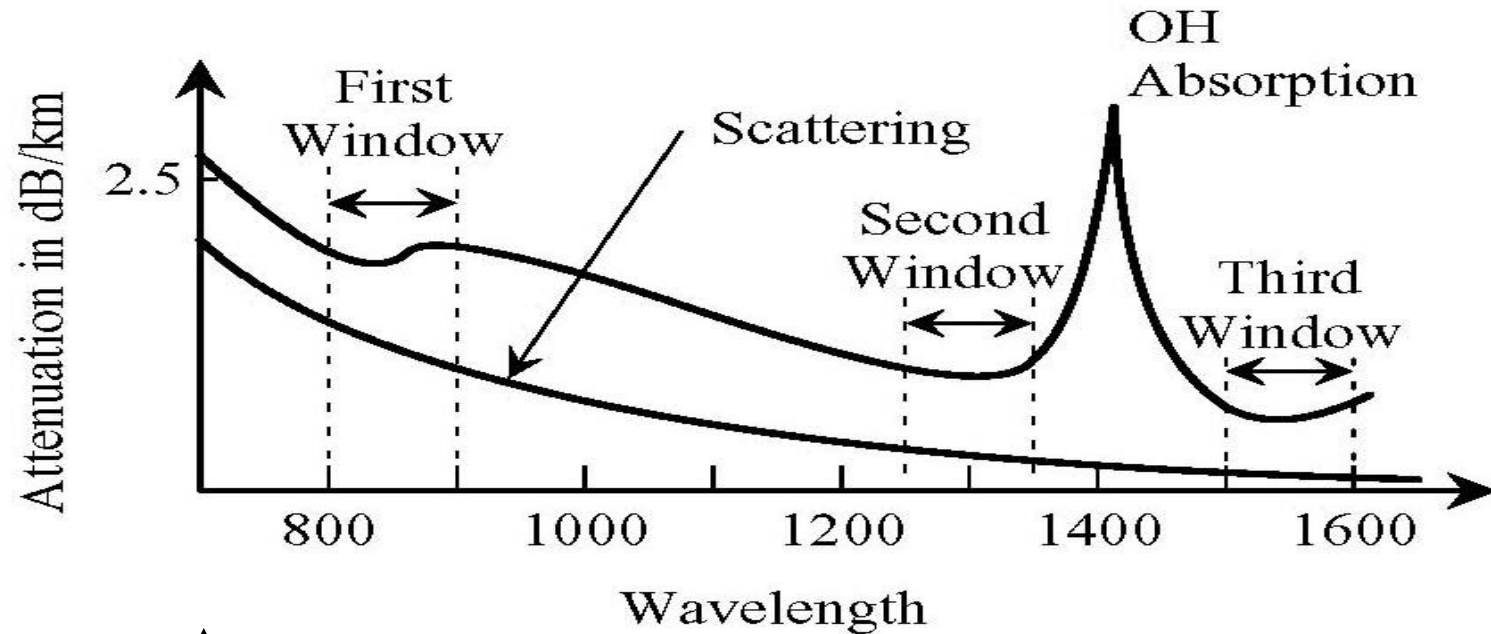
Reflection and Refraction

- Index of Refraction = Speed of light in Vacuum/Speed in glass
= $300 \text{ m}/\mu\text{s} / 200 \text{ m}/\mu\text{s} = 1.5$

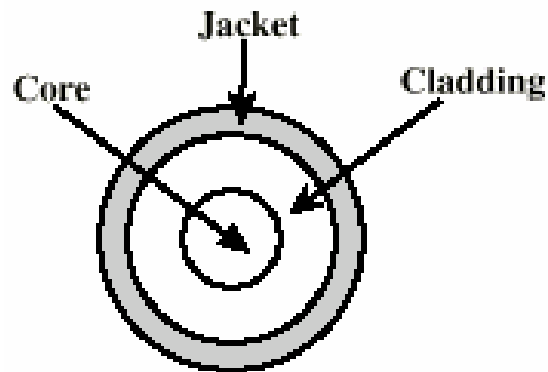


- Refracted light bends towards the higher index medium

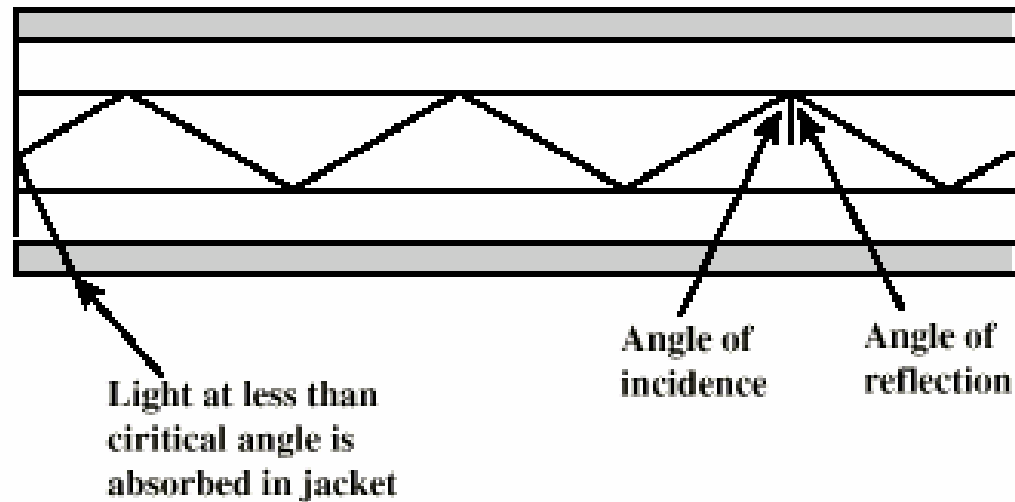
Attenuation and Dispersion



Optical Fiber



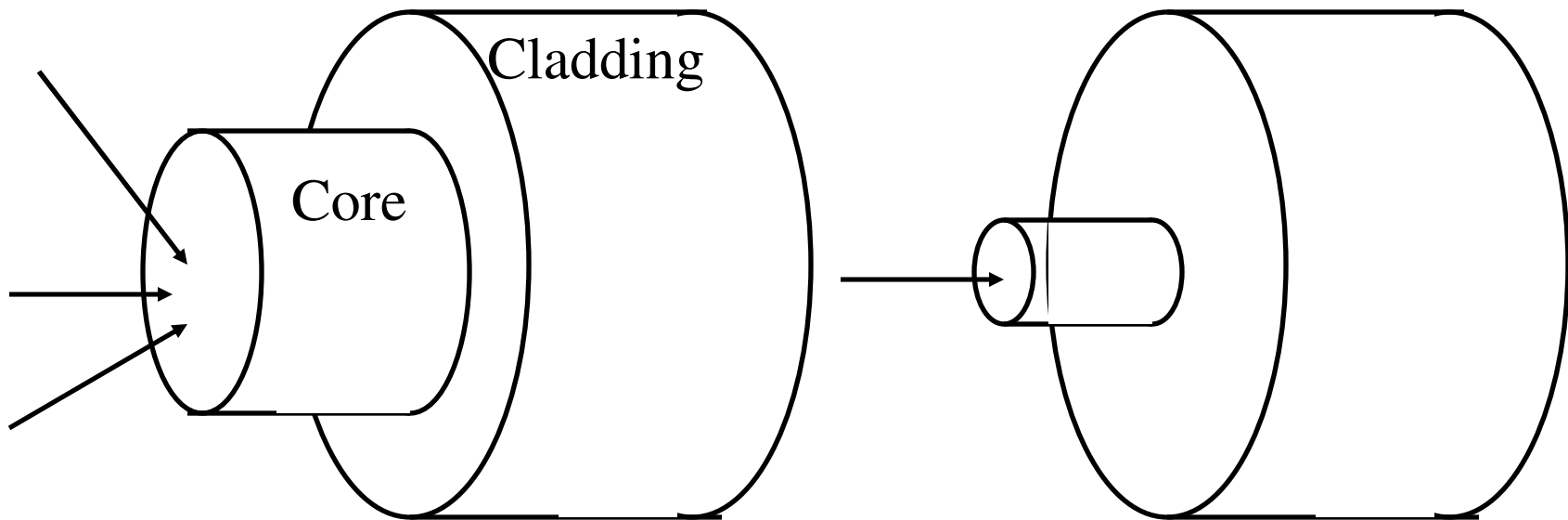
- Glass or plastic core
- Laser or light emitting diode
- Specially designed jacket
- Small size and weight



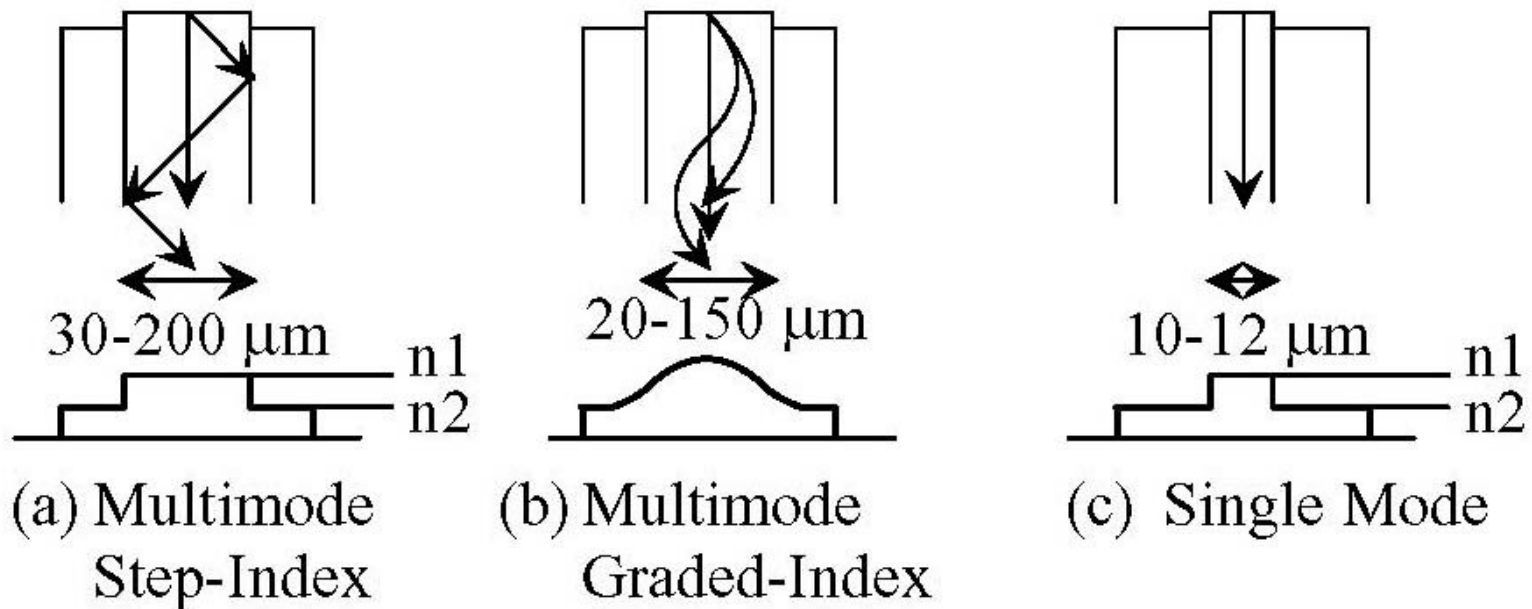
- ❑ A cylindrical mirror is formed by the cladding
- ❑ The light wave propagate by continuous reflection in the fiber
- ❑ Not affected by external interference \Rightarrow low bit error rate
- ❑ Fiber is used in all long-haul or high-speed communication
- ❑ Infrared light is used in communication

Types of Fibers I

- ❑ Multimode Fiber: Core Diameter 50 or 62.5 μm
Wide core \Rightarrow Several rays (mode) enter the fiber
Each mode travels a different distance
- ❑ Single Mode Fiber: 10- μm core. Lower dispersion.



Reducing Modal Dispersion



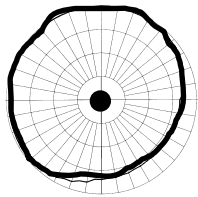
- ❑ Step Index: Index takes a step jump
- ❑ Graded Index: Core index decreases parabolically

Wireless Transmission Frequencies

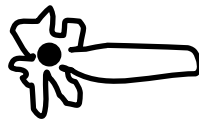
- ❑ 2GHz to 60GHz
 - ❑ Terrestrial Microwave, Satellite Microwave
 - ❑ Highly directional
 - ❑ Point to point
- ❑ 30MHz to 1GHz
 - ❑ Omni-directional
 - ❑ Broadcast radio
- ❑ 3×10^{11} to 2×10^{14}
 - ❑ Infrared
 - ❑ Short distance

Antenna

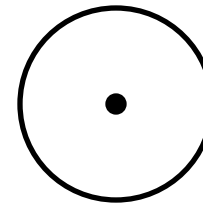
- ❑ Transmitter converts electrical energy to electromagnetic waves
- ❑ Receiver converts electromagnetic waves to electrical energy
- ❑ Same antenna is used for transmission and reception
- ❑ Omni-Directional: Power radiated in all directions
- ❑ Directional: Most power in the desired direction
- ❑ Isotropic antenna: Radiates in all directions equally
- ❑ Antenna Gain = Power at particular point/Power with Isotropic
Expressed in dBi



Omni-Directional

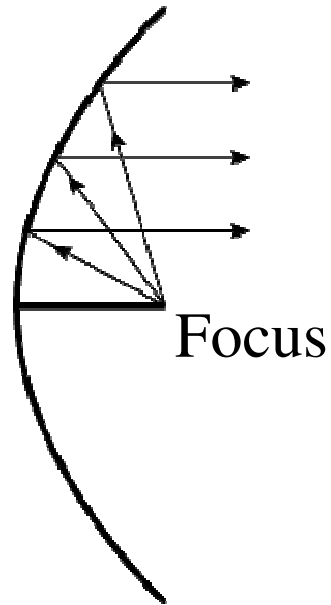


Directional



Isotropic

Parabolic Antenna



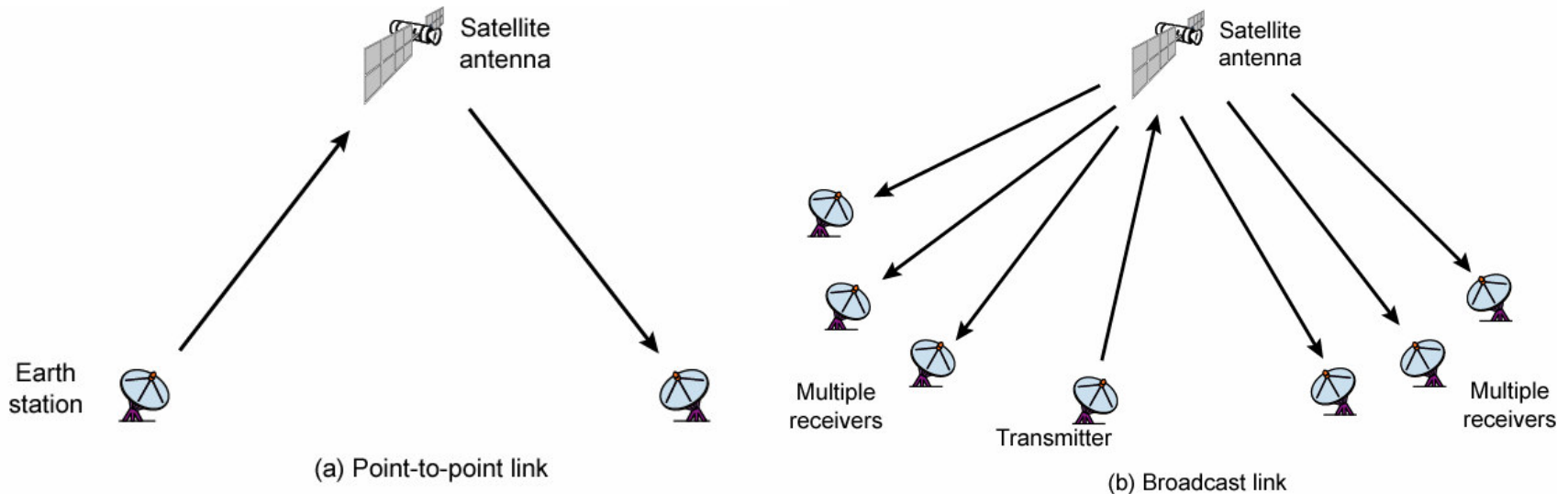
- ❑ Used in Terrestrial microwaves
- ❑ Line of sight communication
- ❑ 10-60 GHz
- ❑ Higher frequencies for higher data rates

Terrestrial Microwave

- ❑ Parabolic dish
- ❑ Focused beam
- ❑ Line of sight
- ❑ Long haul telecommunications
- ❑ Higher frequencies give higher data rates



Satellite Microwave



- ❑ Relay station \Rightarrow Satellite receives on one frequency, amplifies or repeats signal and transmits on another frequency
- ❑ Geo-stationary orbit: Height of 35,784km
- ❑ Point to Point or Direct broadcast satellite

Broadcast Radio

- ❑ Omni-directional
- ❑ FM radio, UHF and VHF television
- ❑ Line of sight
- ❑ Suffers from multi-path interference (Reflections)



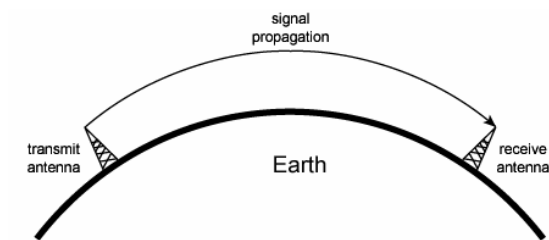
Infrared

- ❑ Used in TV remote control
IRD port of computers
- ❑ Modulate infrared light
- ❑ Line of sight (or reflection)
- ❑ Blocked by walls

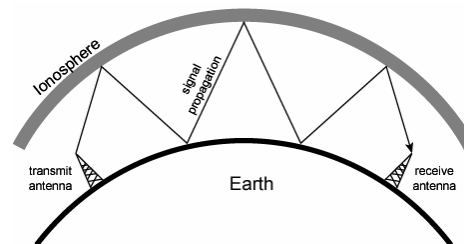


Wireless Propagation

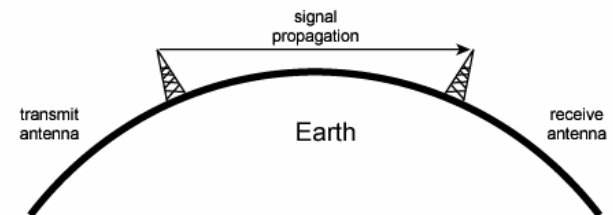
- ❑ **Ground wave:** Follows contour of earth. Up to 2MHz.
AM radio
- ❑ **Sky wave:** Signal reflected (Actually refracted) from ionosphere layer of upper atmosphere.
Amateur radio, BBC world service, Voice of America
- ❑ **Line of sight:** Above 30MHz. Density of atmosphere decreases with height. Results in radio waves bending towards earth



(a) Ground-wave propagation (below 2 MHz)



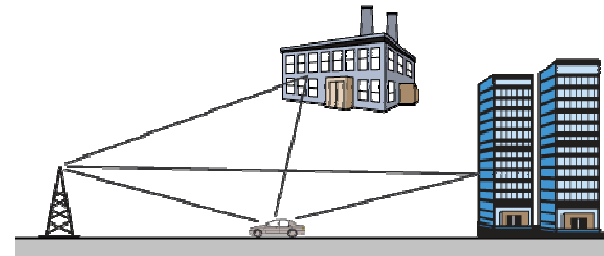
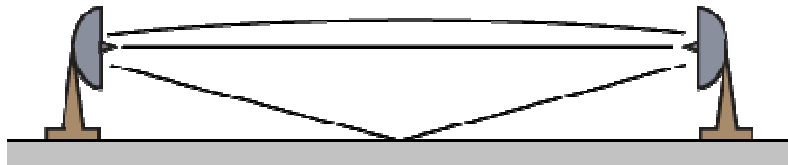
(b) Sky-wave propagation (2 to 30 MHz)



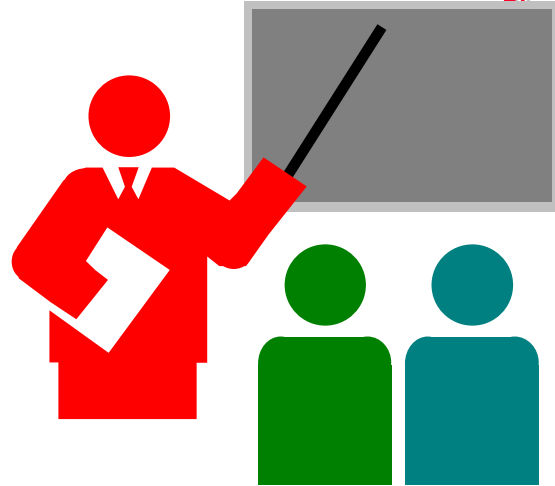
(c) Line-of-sight (LOS) propagation (above 30 MHz)

Line of Sight Transmission

- ❑ **Free space loss:** Signal disperses with distance
 - ❑ Greater for lower frequencies (longer wavelengths)
- ❑ **Atmospheric Absorption:** Water vapour and oxygen
 - ❑ Water greatest at 22GHz, less below 15GHz
 - ❑ Oxygen greater at 60GHz, less below 30GHz
 - ❑ Rain and fog scatter radio waves
- ❑ **Multipath:** Signal can be reflected causing multiple copies to be received. May be no direct signal at all. May reinforce or cancel direct signal



Summary



- ❑ Unshielded twisted-pair (UTP) vs STP
- ❑ Single mode and multimode optical fiber
- ❑ Optical communication wavelengths
- ❑ Isotropic vs omni directional vs directional antennas
- ❑ Parabolic antenna for microwave
- ❑ Ground wave, sky wave, line of sight