

# Transmission Media

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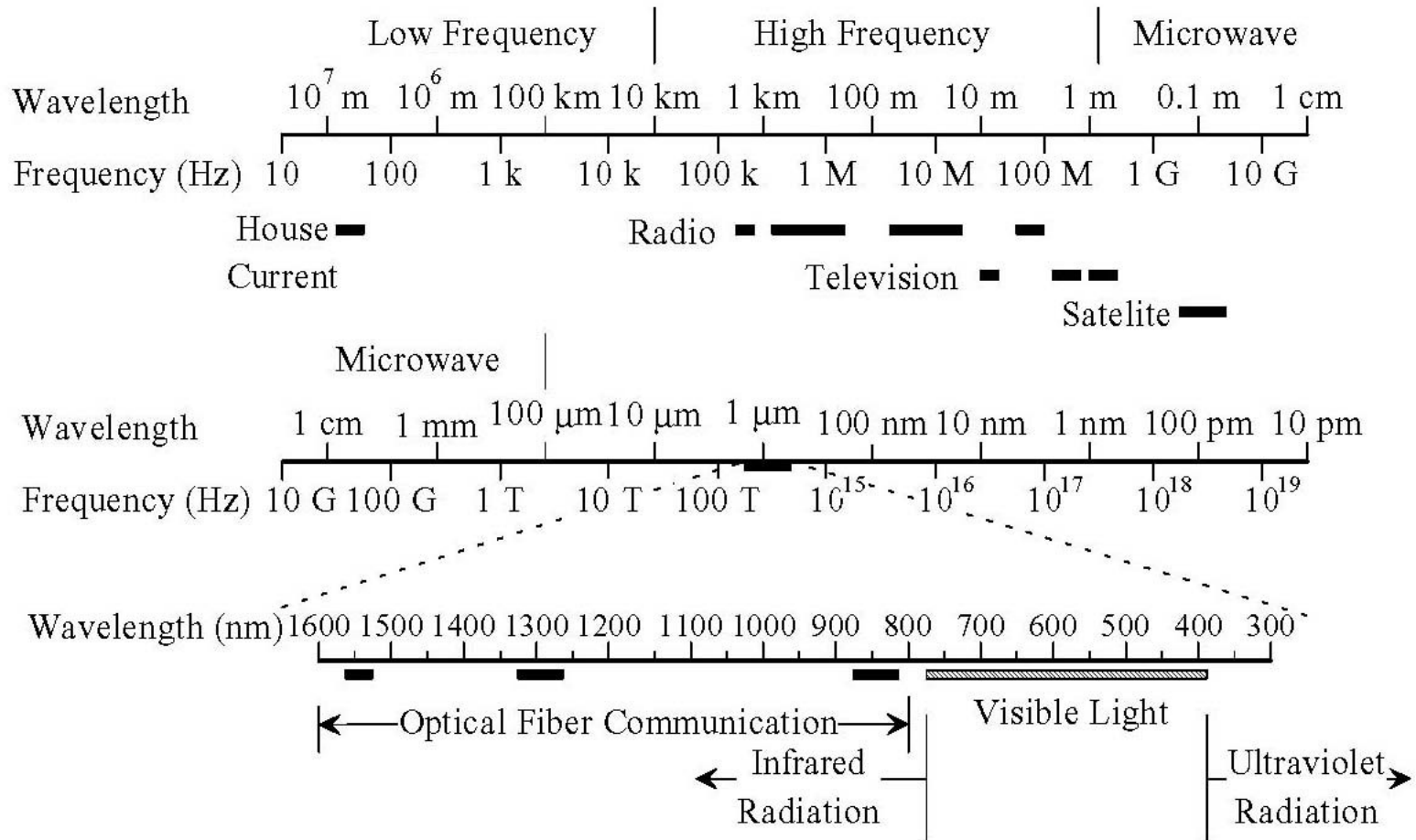
These slides are available on-line at:

<http://www.cse.wustl.edu/~jain/cse473-05/>



- ❑ Electromagnetic Spectrum
- ❑ Transmission Media: Twisted Pair, Coax, fiber, wireless
- ❑ Unshielded Twisted Pair (UTP) categories
- ❑ Reflection and Refraction
- ❑ Antennas: Isotropic, directional, omni-directional
- ❑ Terrestrial and Satellite Microwave

# Electromagnetic Spectrum



□ Infrared light is used for optical communication

# 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.

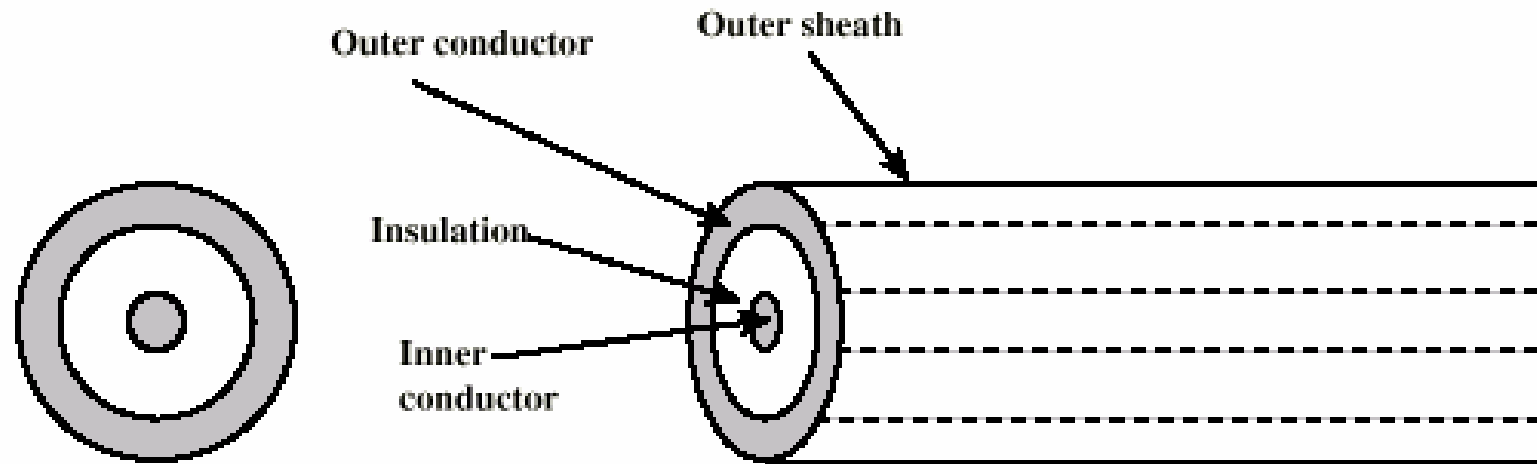
# Unshielded and Shielded TP

- ❑ 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



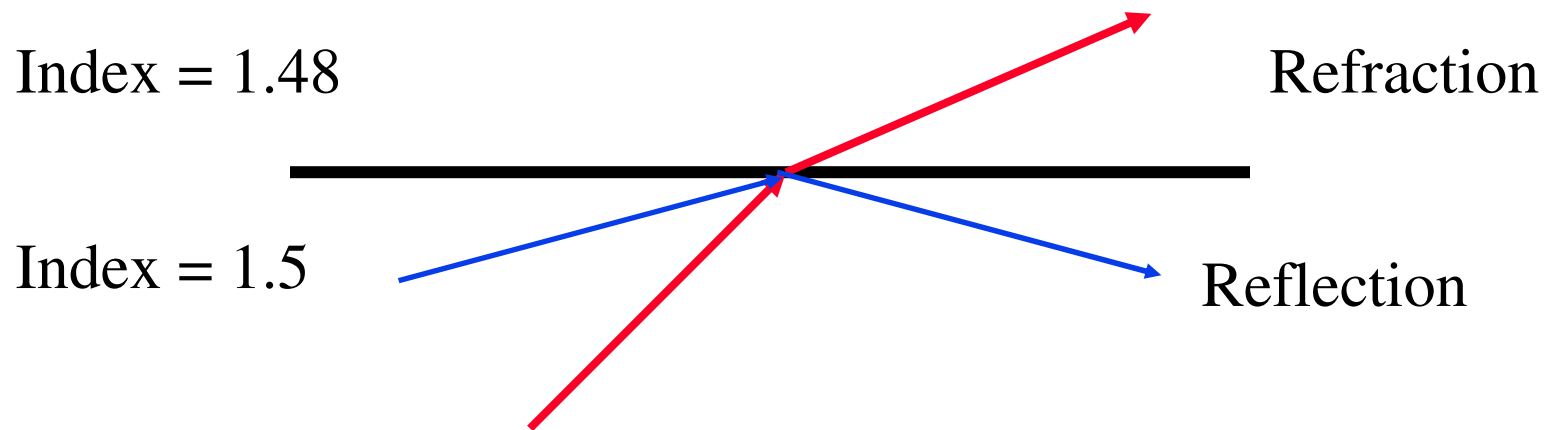
- Outer conductor is braided shield
- Inner conductor is solid metal
- Separated by insulating material
- Covered by padding

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



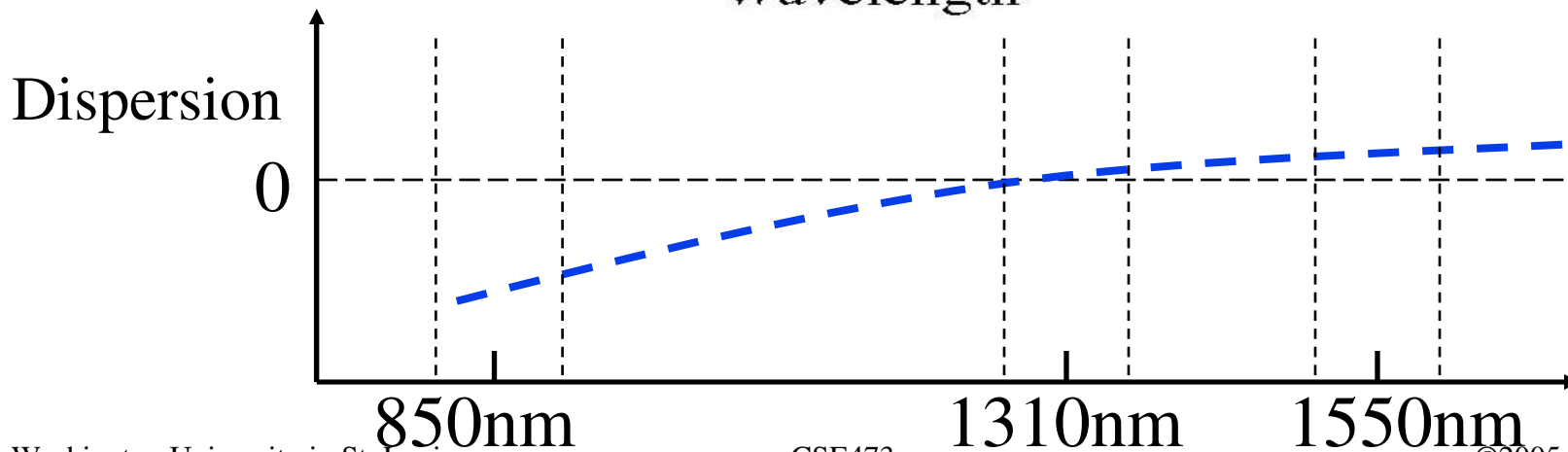
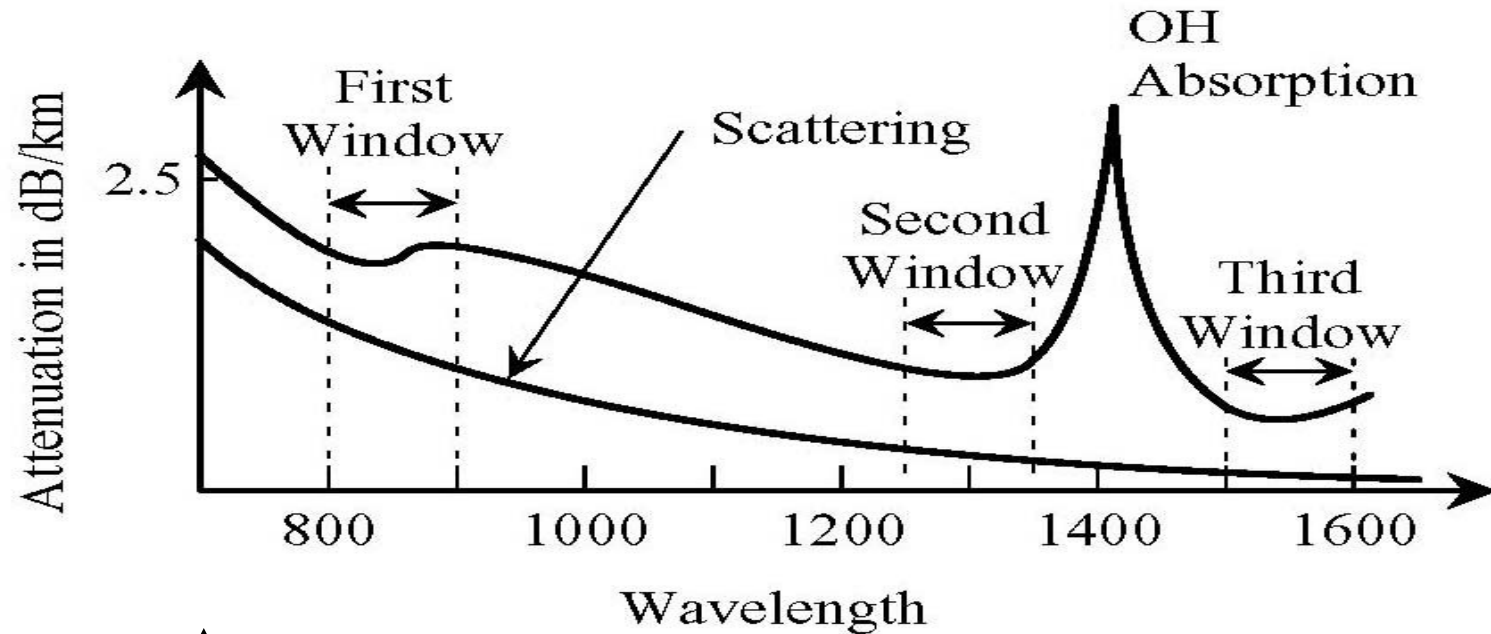
# Reflection and Refraction

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

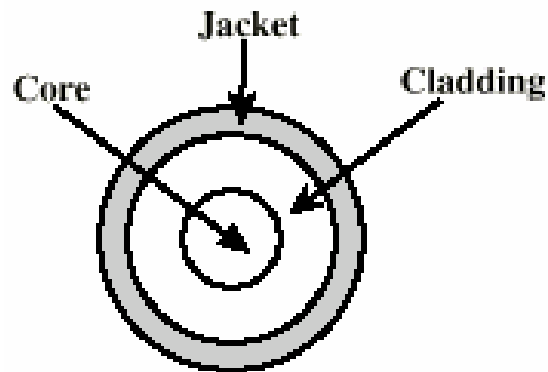


- Refracted light bends towards the higher index medium

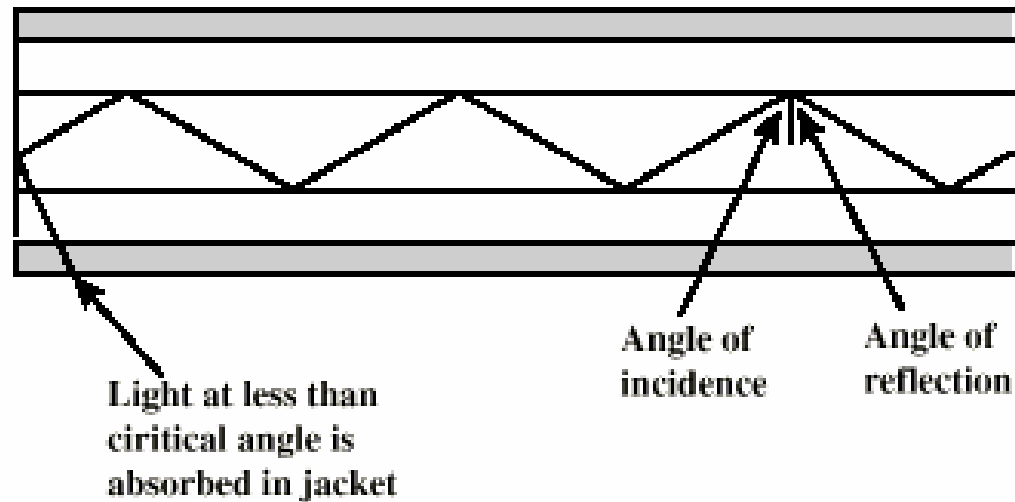
# Attenuation and Dispersion



# Optical Fiber



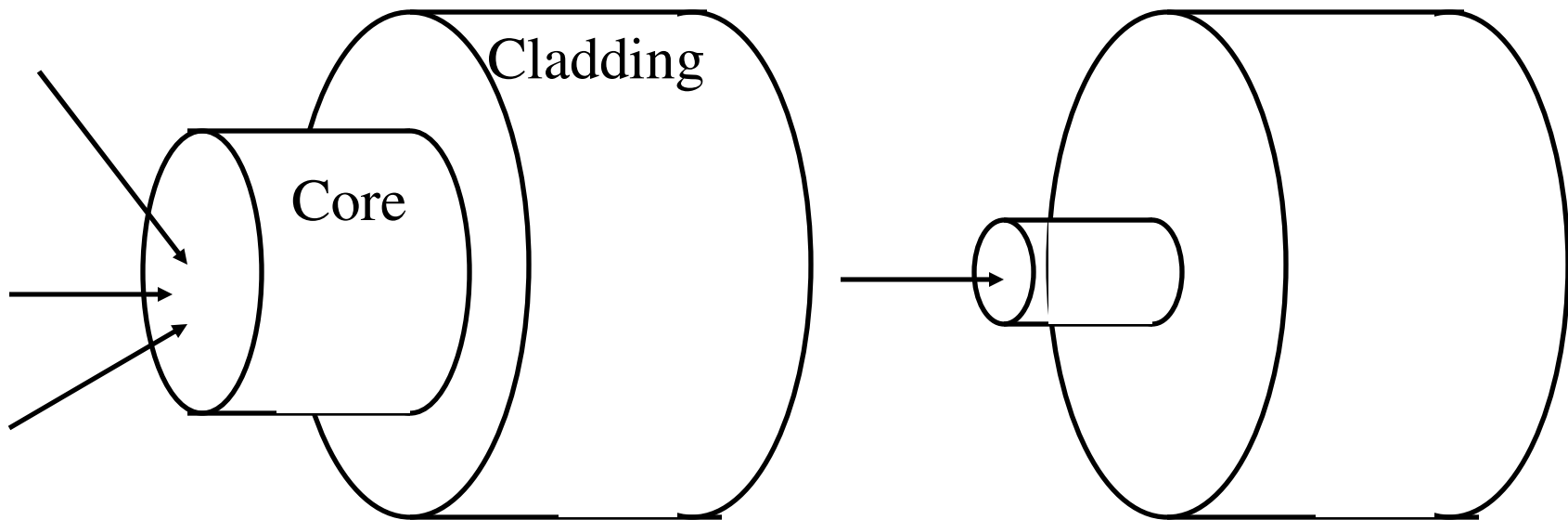
- Glass or plastic core
- Laser or light emitting diode
- Specially designed jacket
- Small size and weight



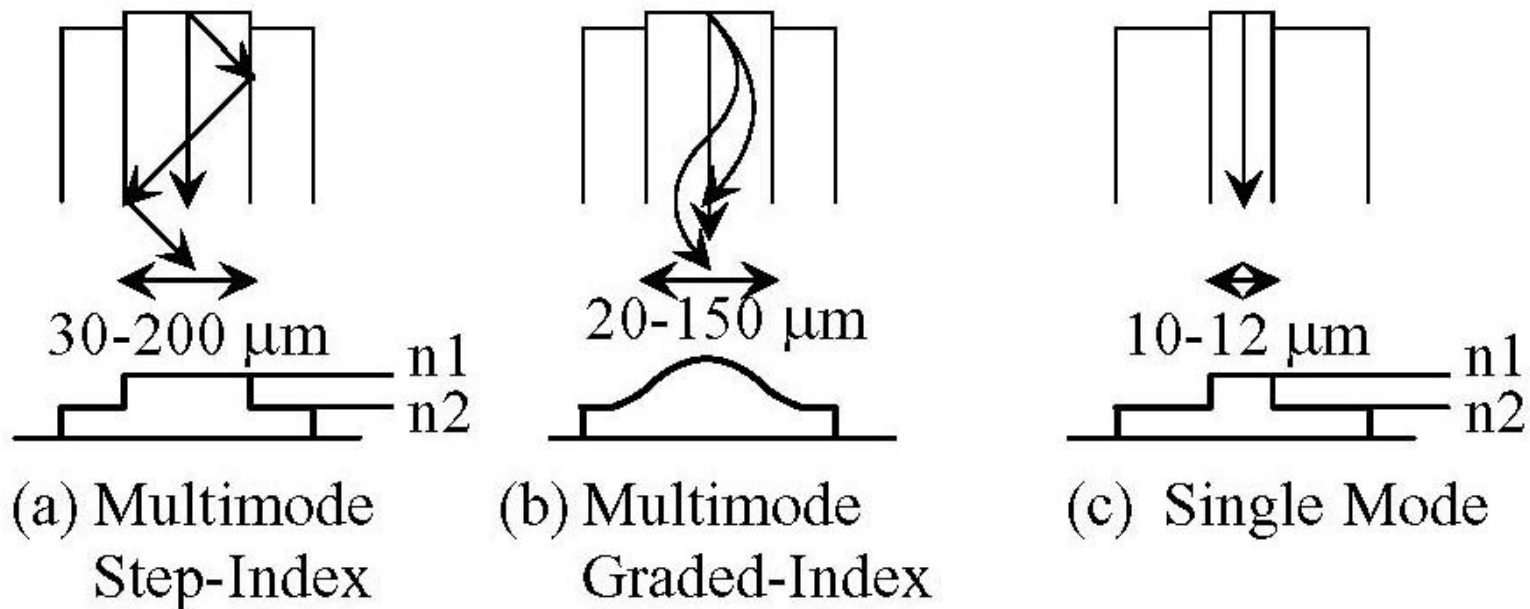
- ❑ A cylindrical mirror is formed by the cladding
- ❑ The light wave propagate by continuous reflection in the fiber
- ❑ Not affected by external interference  $\Rightarrow$  low bit error rate
- ❑ Fiber is used in all long-haul or high-speed communication
- ❑ Infrared light is used in communication

# Types of Fibers I

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



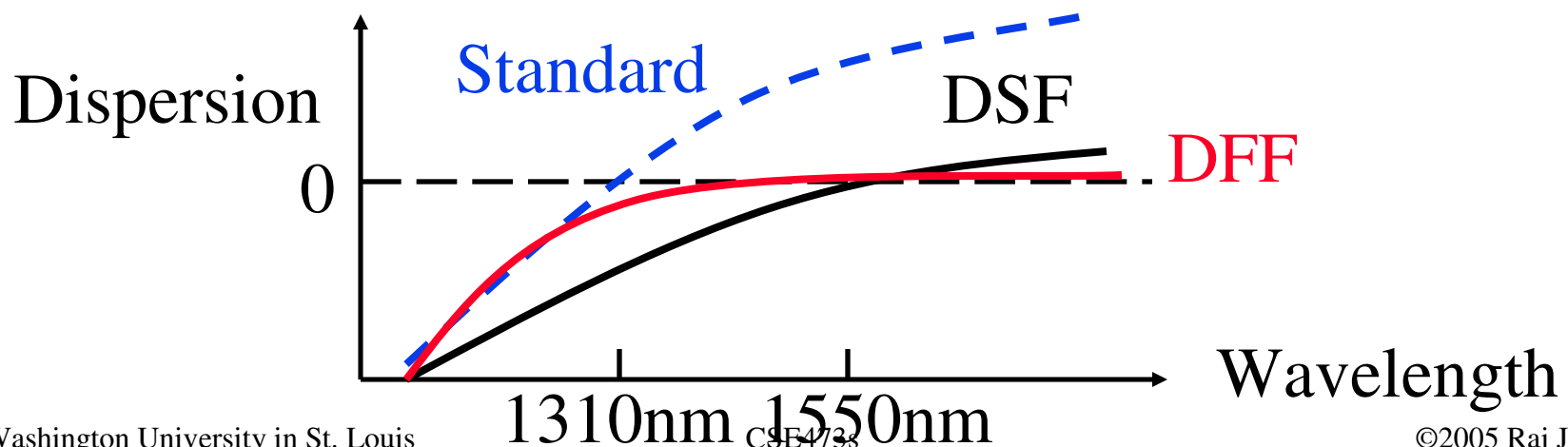
# Reducing Modal Dispersion



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

## Types of Fibers II

- **Dispersion-Shifted Fiber:** Zero dispersion at 1310nm  
EDFAs/DWDM systems operate at 1550 nm  
Special core profile  $\Rightarrow$  zero dispersion at 1550 nm
- **Dispersion Flattened Fiber:** 3 ps/nm/km 1300-1700nm  
Use 1300 nm now and 1550 in future  
Low dispersion causes four-wave mixing  
 $\Rightarrow$  DSF/DFF not used in multi-wavelength systems

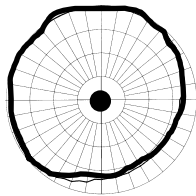


# Wireless Transmission Frequencies

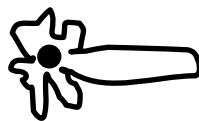
- ❑ 2GHz to 60GHz
  - ❑ Terrestrial Microwave, Satellite Microwave
  - ❑ Highly directional
  - ❑ Point to point
- ❑ 30MHz to 1GHz
  - ❑ Omni-directional
  - ❑ Broadcast radio
- ❑  $3 \times 10^{11}$  to  $2 \times 10^{14}$ 
  - ❑ Infrared
  - ❑ Short distance

# Antenna

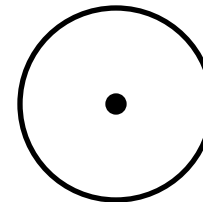
- ❑ Transmitter converts electrical energy to electromagnetic waves
- ❑ Receiver converts electromagnetic waves to electrical energy
- ❑ Same antenna is used for transmission and reception
- ❑ Omni-Directional: Power radiated in all directions
- ❑ Directional: Most power in the desired direction
- ❑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



Omni-Directional



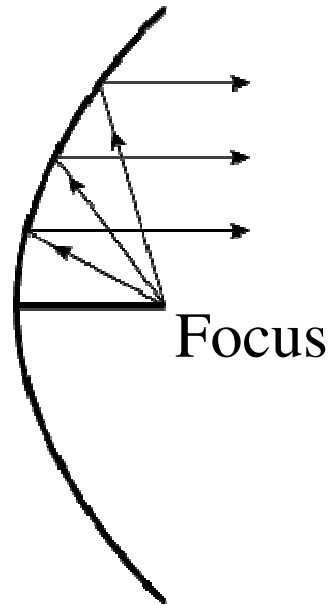
Directional



Isotropic



# Parabolic Antenna



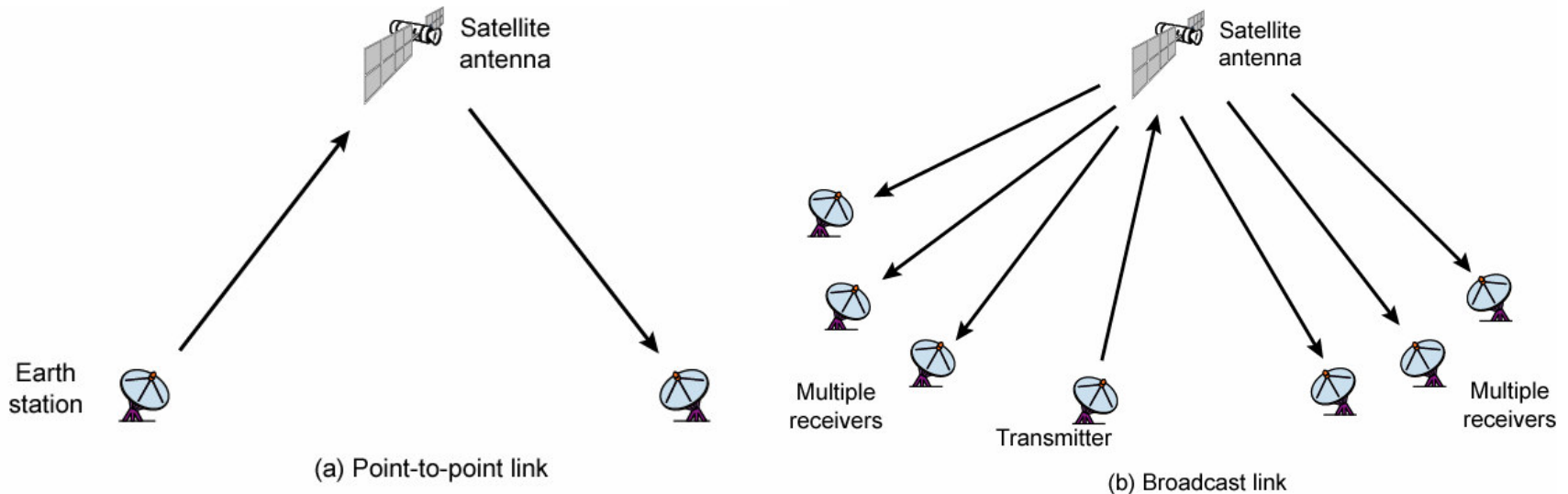
- ❑ Used in Terrestrial microwaves
- ❑ Line of sight communication
- ❑ 10-60 GHz
- ❑ Higher frequencies for higher data rates

# 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)



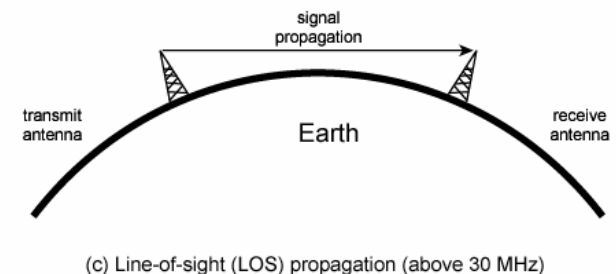
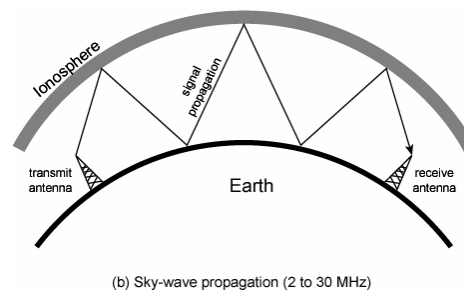
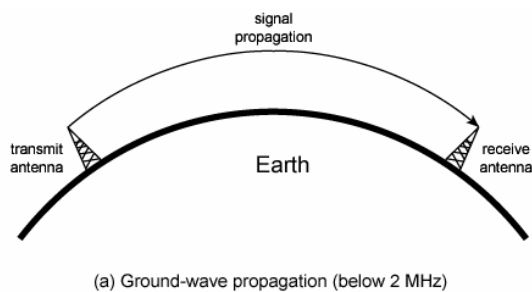
# Infrared

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



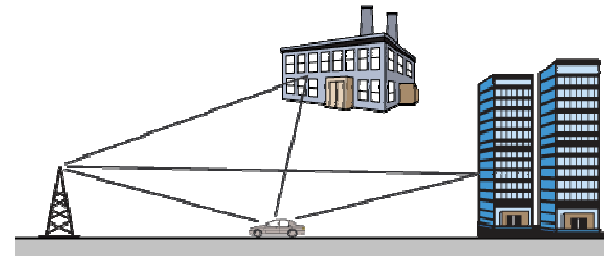
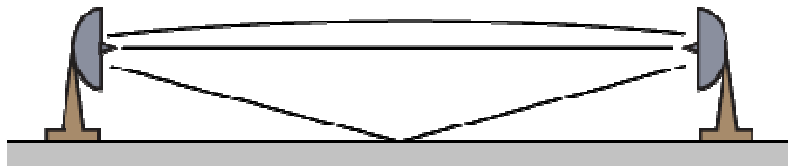
# Wireless Propagation

- ❑ **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



# 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



# Reading Assignment

- ❑ Read Chapter 4 of Stallings 7th edition.

# Homework

- Submit answer to exercise 4.3 (length of transmission media) of 7<sup>th</sup> edition by Stallings.