ECE230X Lecture 4 Supplementary Slides

Data and Computer Communications Eighth Edition
By William Stallings
Section 4.1 – Guided Transmission Media

D. Richard Brown III
Worcester Polytechnic Institute
Electrical and Computer Engineering Department

Adapted from Prentice Hall instructor resources

Guided Transmission Media

- Establishes a physical path through which communication signals efficiently propagate
- Lots of choices but almost all can be categorized into three types:
  - Twisted pair cable (copper)
    - Category 3, 5, 5e, 6, …
  - Coaxial cable (copper)
    - RG-6, RG-58, RG-59, …
  - Fiber optic cable (plastic/glass)
    - Multimode, singlemode, …

Twisted Pair

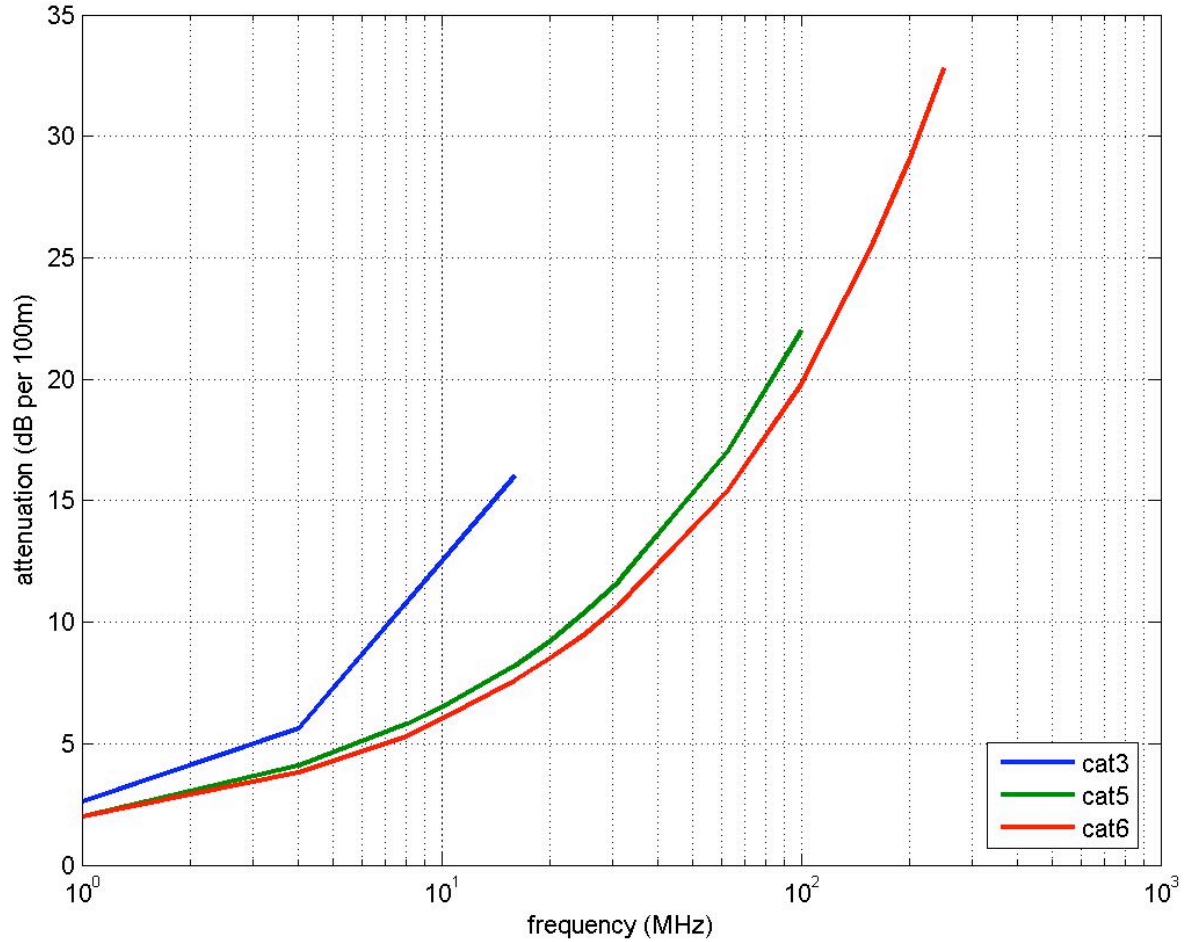
—Separately insulated
—Twisted together
—Often "bundled" into cables
—Usually installed in building during construction

(a) Twisted pair

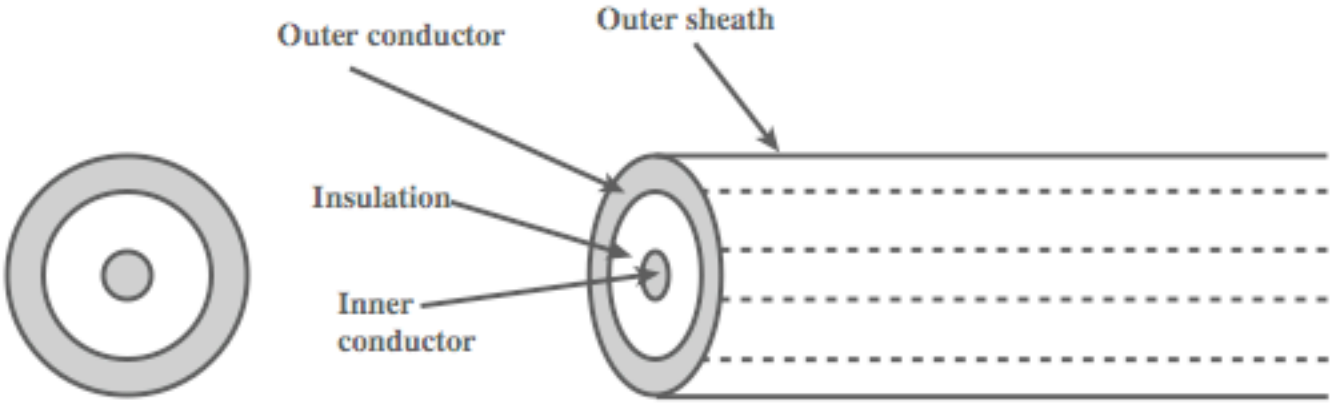
Characteristics of Twisted Pair Media

- Advantages
  - Inexpensive
  - Easy to bundle multiple pairs into a single cable
  - Relatively easy to add connectors
- Disadvantages
  - Relatively high attenuation
    - Ok for short links
    - Longer links require repeaters
  - Limited frequency window
    - Cat 3: 0–16MHz
    - Cat 5 and 5e: 0–100MHz
    - Cat 6: 0–250MHz
  - Relatively susceptible to interference and noise
    - Can be overcome somewhat with shielding (more expensive)

Attenuation of common UTP



Coaxial Cable



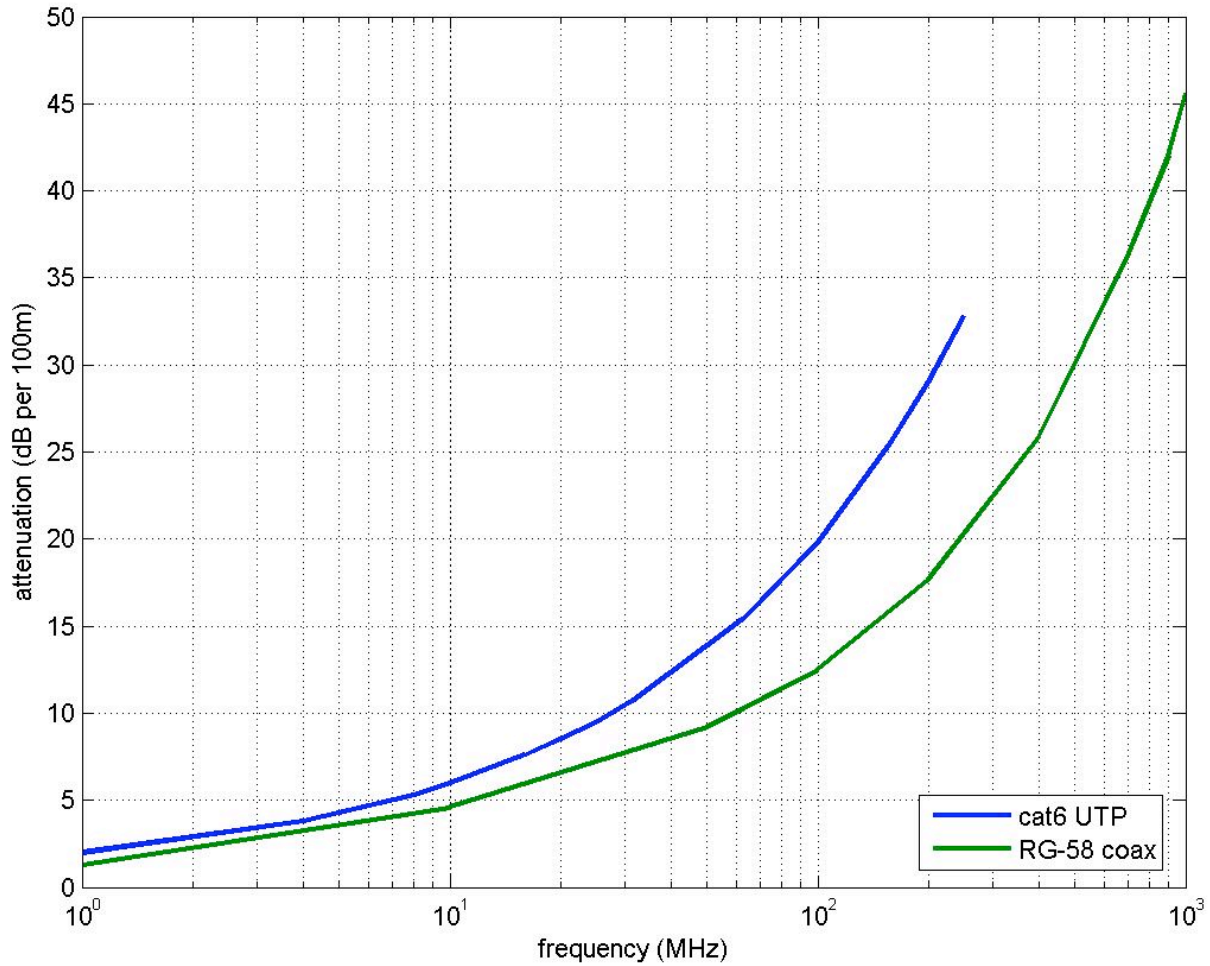
—Outer conductor is braided shield
—Inner conductor is solid metal
—Separated by insulating material
—Covered by padding

(b) Coaxial cable

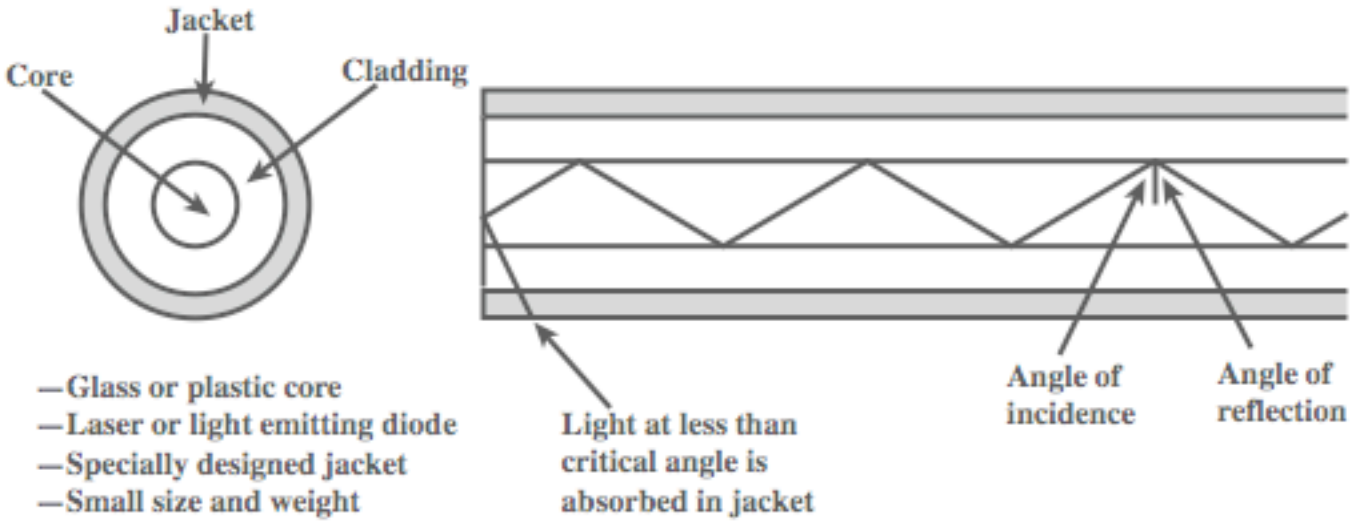
Characteristics of Coaxial Cable Media

- Advantages
  - Larger frequency window than twisted pair
  - Lower attenuation than twisted pair
    - Can have longer links without repeaters
  - Less susceptible to interference and noise
  - Easy to add connectors
- Disadvantages
  - More expensive than twisted pair
  - Not easy to bundle multiple pairs into a single cable
  - Relatively bulky
- Often being replaced by optical fiber in long-distance applications

Attenuation comparison between Cat 6 UTP and RG-58 Coaxial cable



Optical Fiber

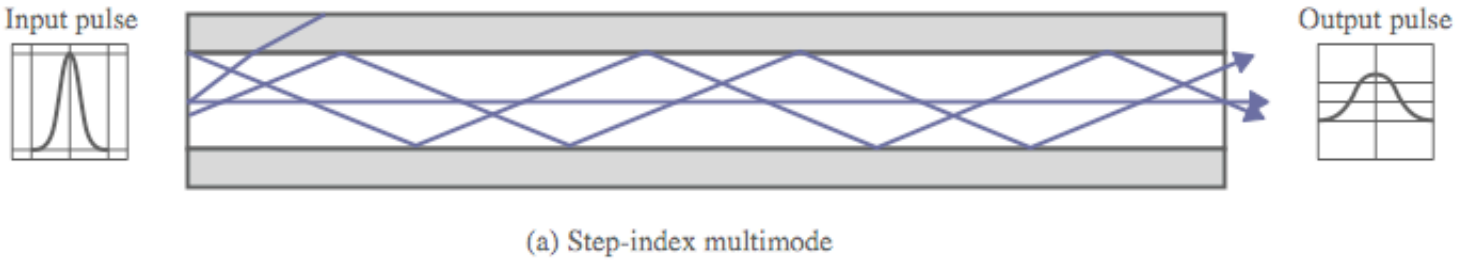


(c) Optical fiber

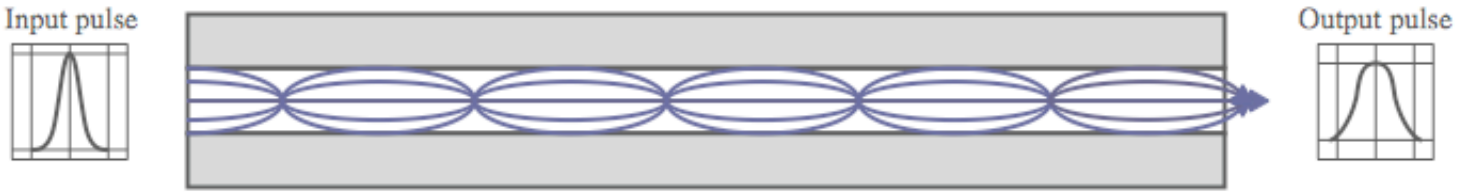
Characteristics of Optical Fiber

- Advantages
  - Huge frequency windows [1THz = 10^{12} Hz]
    - 185–192 THz (1561–1620nm wavelength)
    - 192–196 THz (1528–1561nm wavelength)
    - 222–234 THz (1280–1350nm wavelength)
    - 333–366 THz (820–900nm wavelength)
  - Very low attenuation (as low as 0.2dB/km at 1550nm!)
  - Relatively small size and weight
  - Can easily bundle multiple fibers into a single cable
  - Electromagnetic isolation
- Disadvantages
  - Relatively difficult to add connectors
  - Requires specialized optical hardware
  - Relatively expensive (and overkill?) for short links

Optical Fiber Transmission Modes



(a) Step-index multimode



(b) Graded-index multimode

(c) Single mode

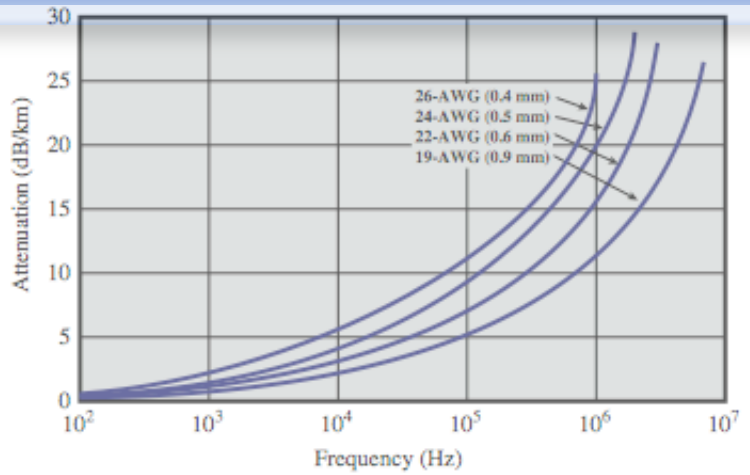
Frequency Utilization for Fiber Applications

Wavelength (in vacuum) range (nm)	Frequency Range (THz)	Band Label	Fiber Type	Application
820 to 900	366 to 333		Multimode	LAN
1280 to 1350	234 to 222	S	Single mode	Various
1528 to 1561	196 to 192	C	Single mode	WDM
1561 to 1620	192 to 185	L	Single mode	WDM

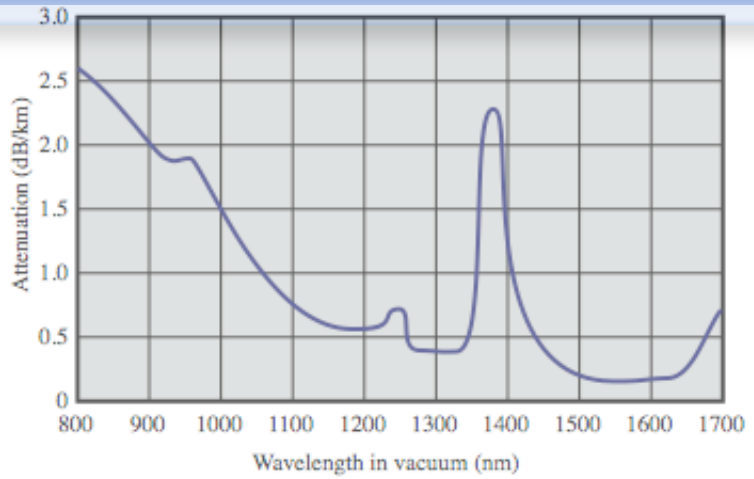
LAN = local area network
(typically short links and lower data rates)

WDM = wavelength division multiplexing (see Chap 8)
(typically long links and very high data rates)

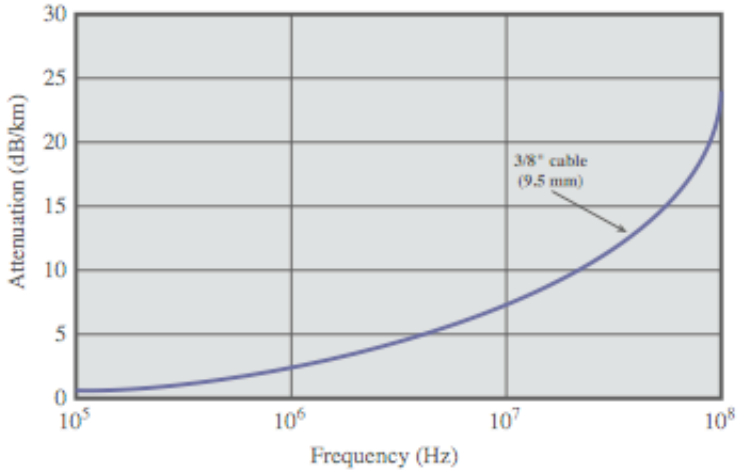
Attenuation in Guided Media



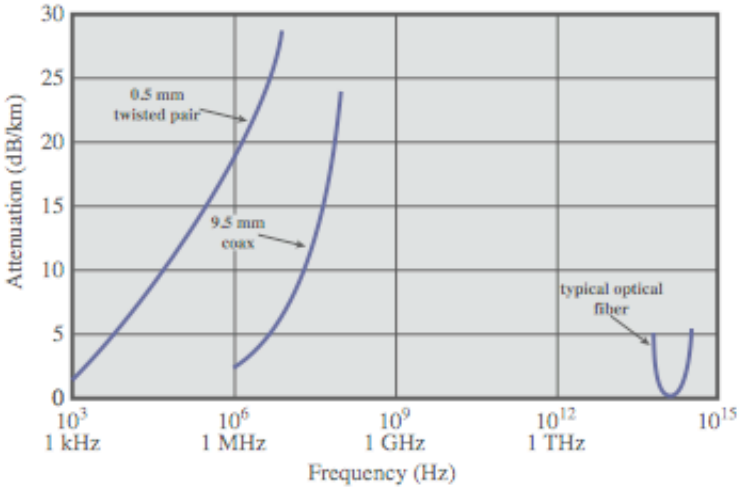
(a) Twisted pair (based on [REEV95])



(c) Optical fiber (based on [FREE02])



(b) Coaxial cable (based on [BELL90])



(d) Composite graph

Summary

- Three main types of guided media
  - Twisted pair cable
  - Coaxial cable
  - Fiber optic cable
- Unshielded twisted pair (UTP) is the cheapest and most convenient medium
  - Smallest frequency window
  - Often used for LANs (even gigabit Ethernet)
- Fiber optic cable: huge frequency windows and very low attenuation
  - Often used for high-capacity, long distance trunks
  - Replacing many applications of coaxial cable
  - Becoming feasible for high-speed LANs and shorter links
  - Trend: Fiber to the home, e.g. Verizon FiOS