



# Computer Networks: Physical layer



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# Maximum data rate of a channel

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- Depends on
  - The bandwidth available
  - The level of the signals we use
  - The quality of the channel (the level of noise)
- Noiseless channel
  - Nyquist formula
    - $\text{bitrate} = 2.B.\log_2 L$
- Noisy channel
  - Shannon formula
    - $\text{capacity} = B.\log_2(1+\text{SNR})$

# Example



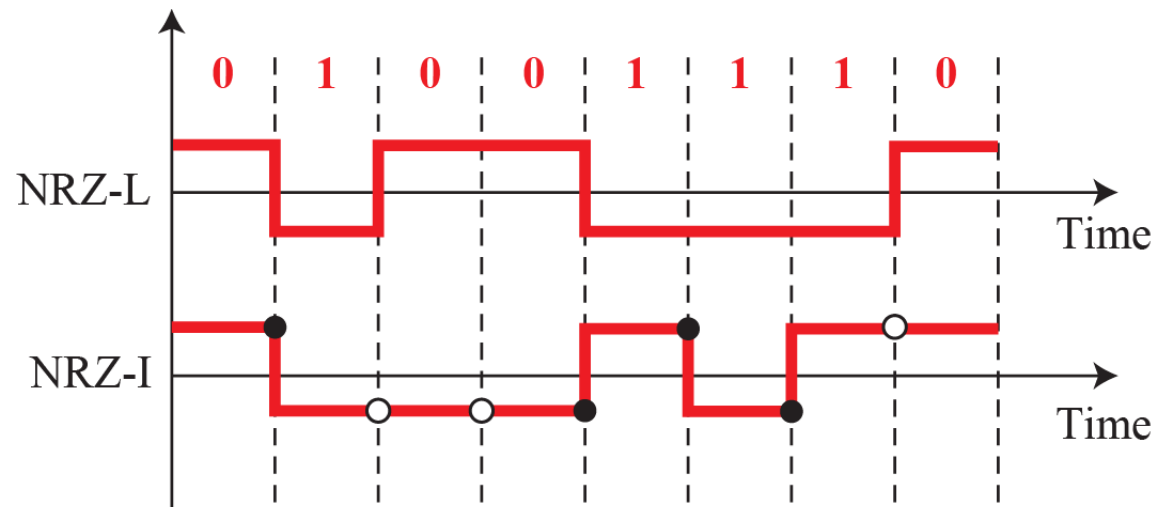
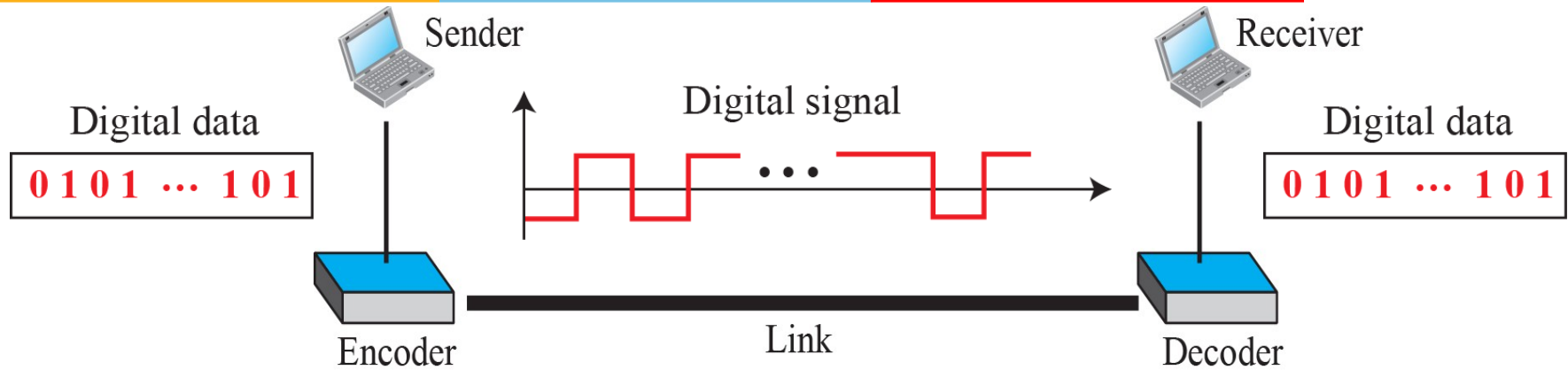
We need to send 265 kbps over a noiseless (ideal) channel with a bandwidth of 20 kHz. How many signal levels do we need?

$$265,000 = 2 \times 20,000 \times \log_2 L \rightarrow \log_2 L = 6.625 \quad L = 2^{6.625} = 98.7 \text{ levels}$$

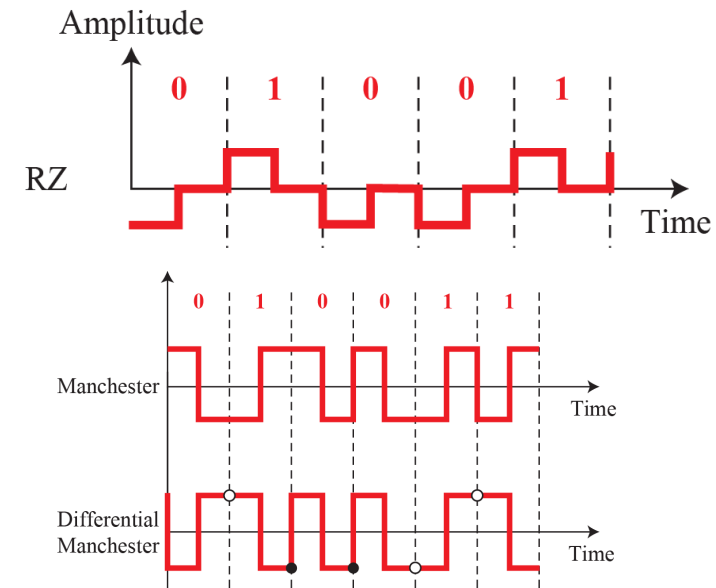
A telephone line normally has a bandwidth of 3000 Hz assigned for data communications. The signal-to-noise ratio is usually 3162. Find out the capacity.

$$C = B \log_2 (1 + \text{SNR}) = 3000 \log_2 (1 + 3162) = 34,881 \text{ bps}$$

# Digital data to Digital signal

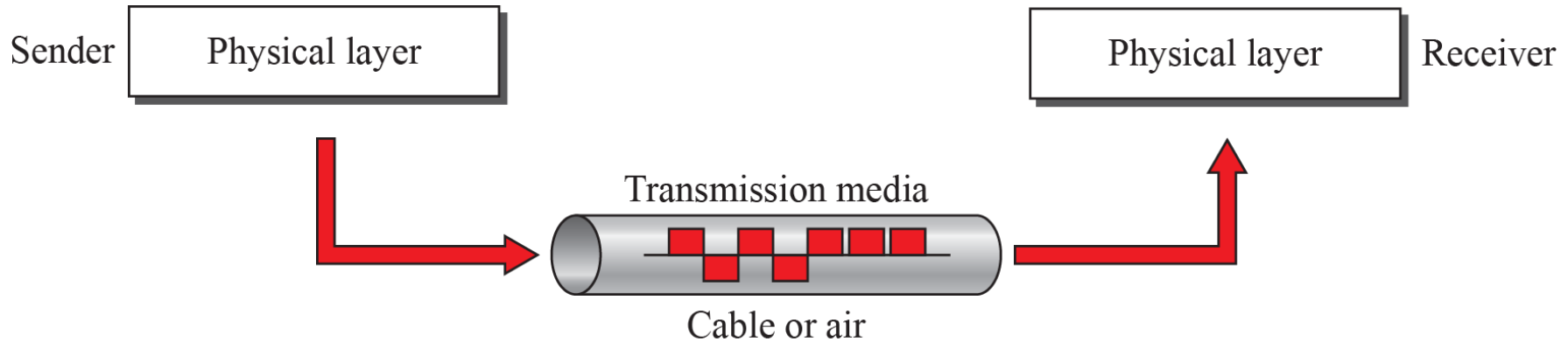


○ No inversion: Next bit is 0      ● Inversion: Next bit is 1

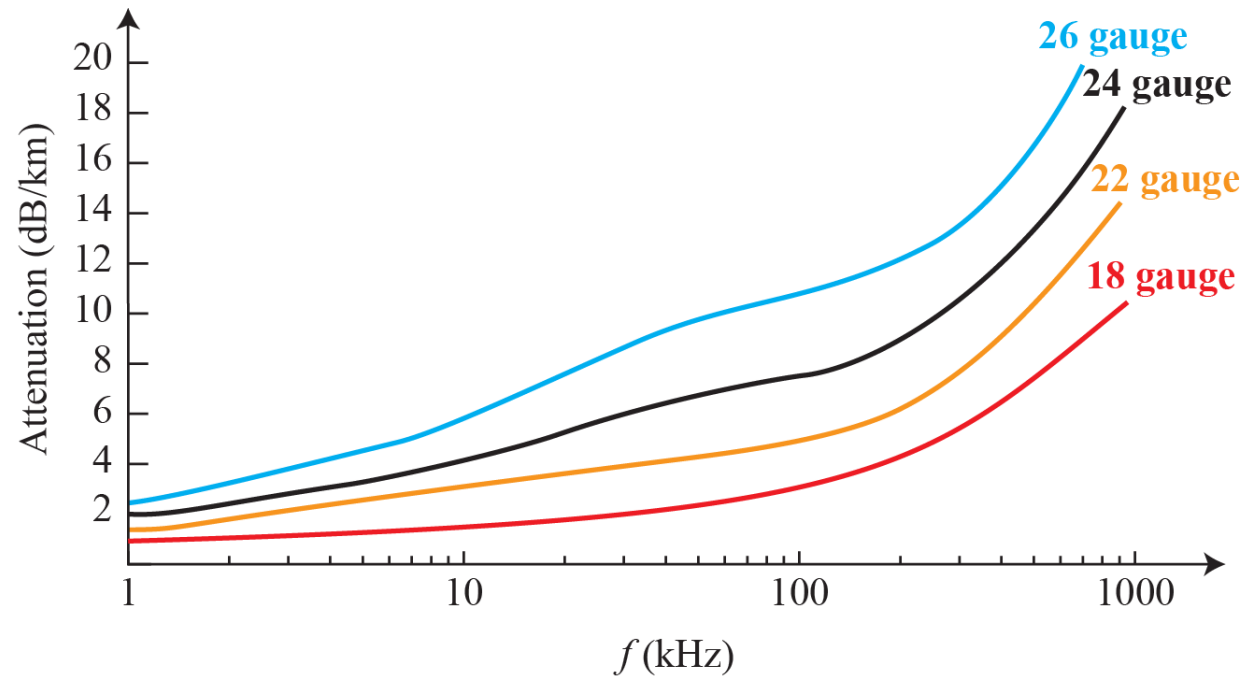
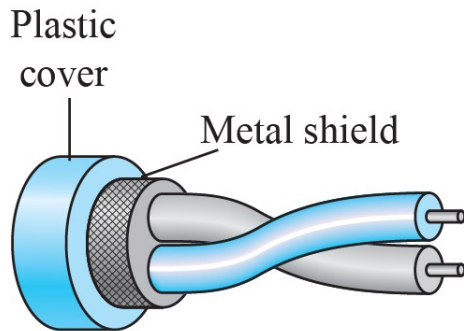
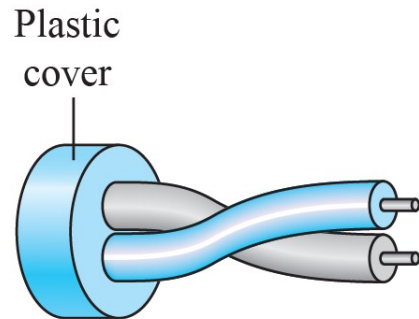


○ No inversion: Next bit is 1      ● Inversion: Next bit is 0

# Transmission media



# Guided media

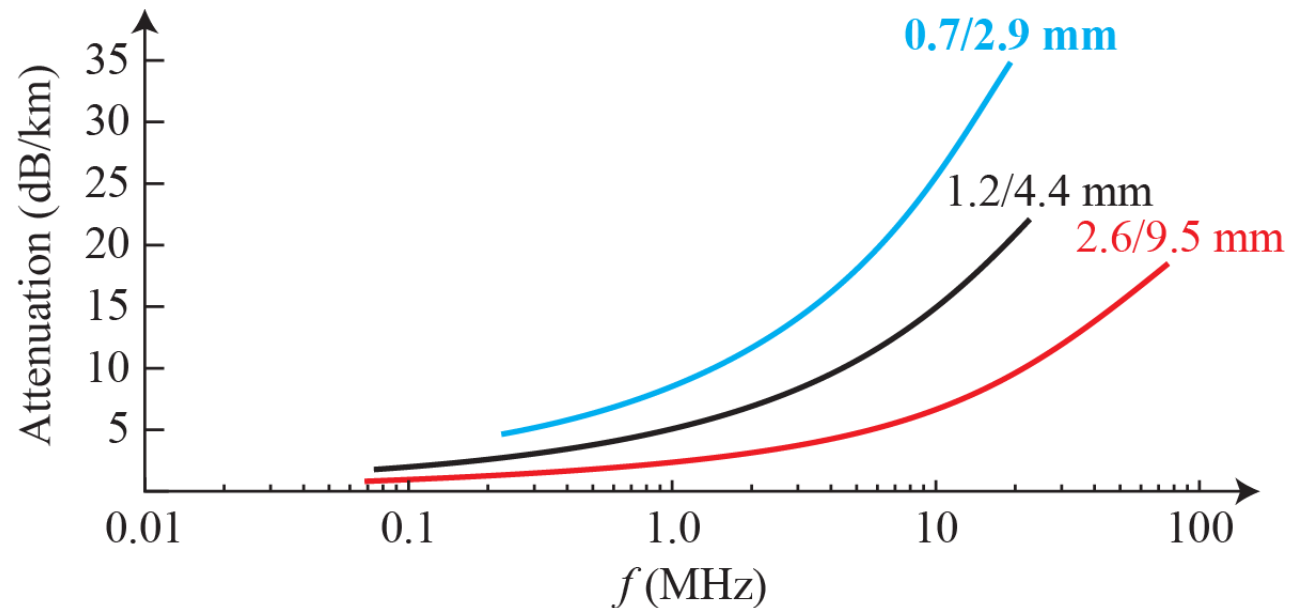
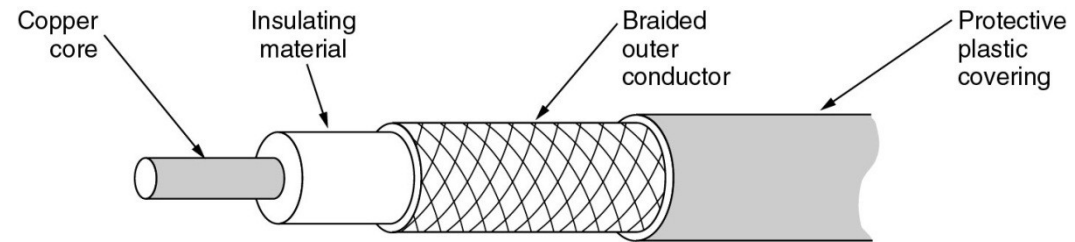
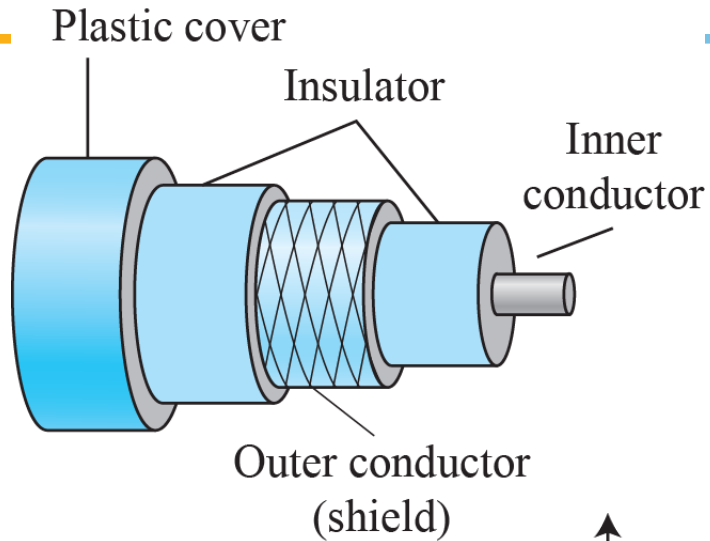


(a)

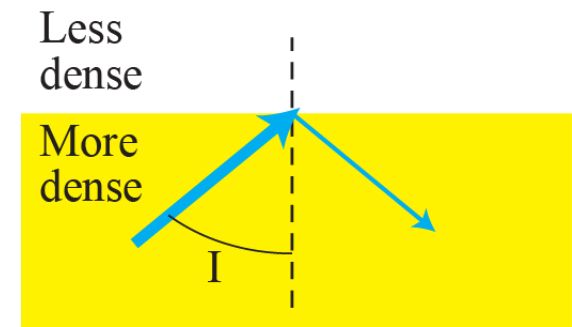
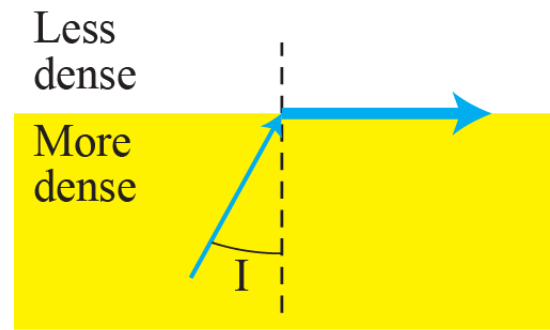
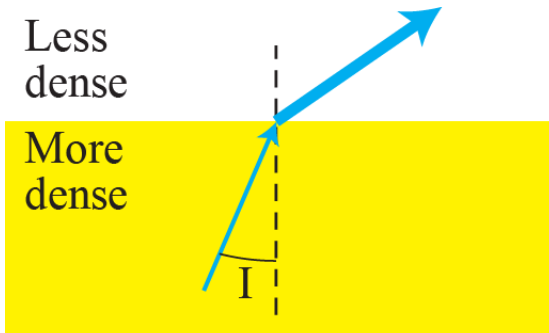


(b)

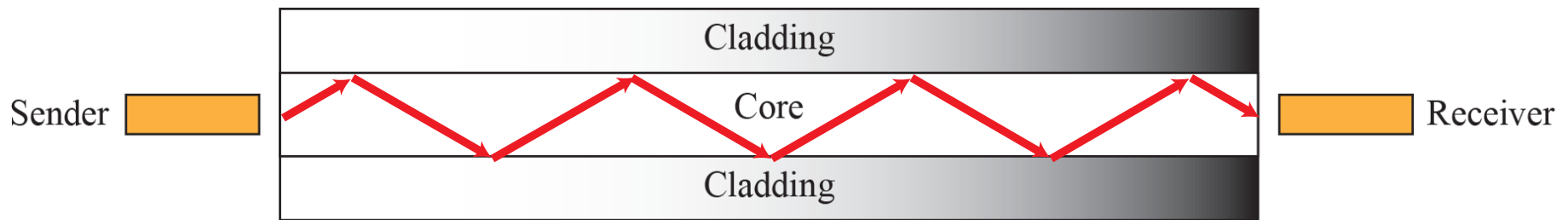
# Coaxial cable



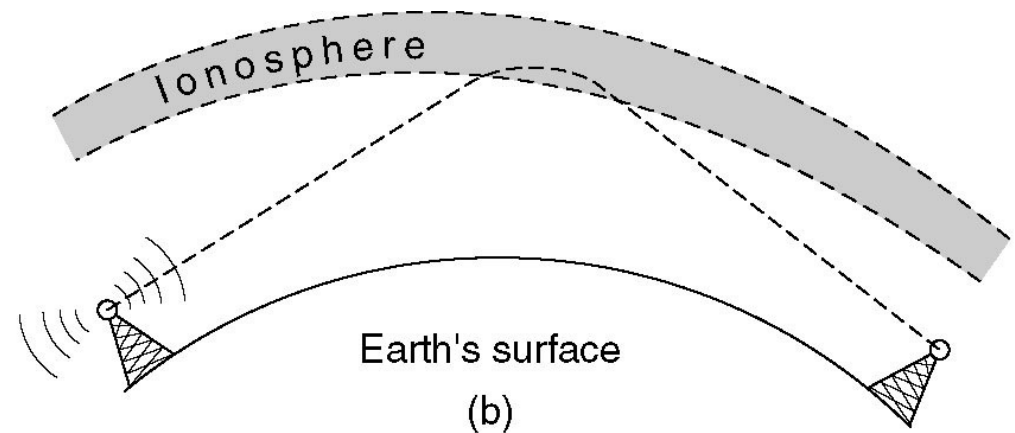
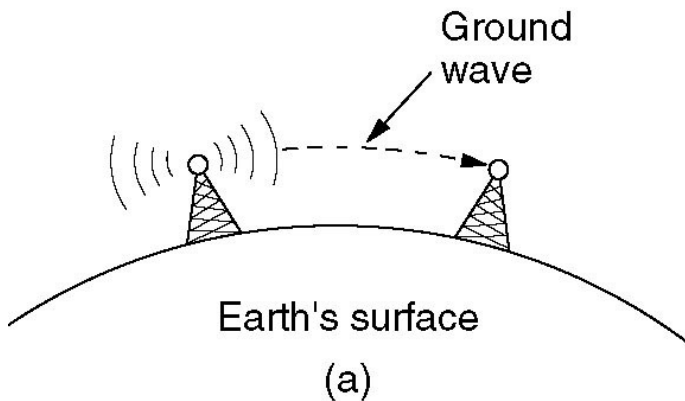
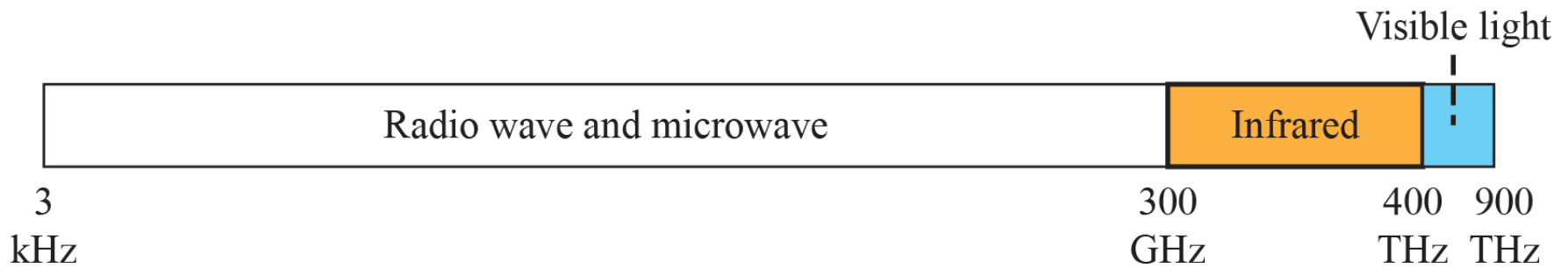
# Optical fiber



# Continued...



# Unguided media



# Bands



<i>Band</i>	<i>Range</i>	<i>Propagation</i>	<i>Application</i>
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio
LF (low frequency)	30–300 kHz	Ground	Radio beacons
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite