[10:30am] Channel Impairments

- The channel (between transmitter and receiver) can degrade the signal
- Channel can be any medium in which waves propagate
    - Air (electromagnetic)
    - Underwater (acoustic)
    - Wire (electromagnetic, optical)
- In the same medium, different frequency bands have different channel properties
- Lower frequencies (and therefore larger wavelength) require larger antenna
    - Higher frequencies lead to smaller antennas that can be integrated into a device, e.g. smartphone.
- Many factors can lead to an overall loss in signal strength
    - Loss as a function of distance r
        - Spherical geometric spreading leads to $1/r^2$ loss in signal power
        - Cylindrical geometric spreading leads to $1/r$ loss in power
    - Loss due to physical barriers
        - Each door, window, and wall in a building causes 10 dB attenuation
    - Other forms of attenuation (other than geometric spreading) occur at higher frequencies
- Fading: attenuation may change over time. Many possible causes
    - Transmitter or receiver in motion
    - Multipath propagation
    - Weather
- Benefits of higher frequency bands
    - More availability of large uninterrupted bands
        - Example: WiGig (several GHz of bandwidth)
- Challenges of higher frequency bands
    - Ultimately limited by transistor switching speeds
    - Analog designs have additional design complexity

- Additive thermal noise
    - Random motion of electrons
    - Approximate as Gaussian (central limit theorem)
- (approximate) LTI effects
    - Resistance, capacitance, and inductance of wired channel
    - Multipath propagation of wireless channel
    - Approximate IIR response as FIR by truncating
    - Model as convolution with a channel impulse response
        - Distortion in frequency
        - Spreading in time