# Spring 2021 - ECE 1150

# ASSIGNMENT 3

**Show all steps in answering the following questions. Make sure to put units of measurements (if applicable) in your answers.**

1. Compare between the different wired physical transmission medium (twisted pair cable, coaxial cable, multimode optical fiber, single mode optical fiber) in terms of noise susceptibility and capacity. Comment on the relation between noise susceptibility and capacity (Hint: use Shannon's Theorem).

2. What is meant by attenuation of a signal? What is the impact of the distance of the link on the attenuation? How is it different in wired and wireless links?

3. Consider the signal received by a device from a wired access point.
    a. If the access point sends a signal at a power level of 50 watts, what is the signal strength in dBm?
    b. The signal attenuates 10 dB every 1 km. What is the received power after 15 km?
    c. If the receiver sensitivity is -65dBm, could the receiver detect the signal? If yes, why? If no, what can we change in the network to have the receiver detects the signal. Validate your answer
    d. If the noise power at the laptop is -85 dBm, what is the received signal power to noise ratio (SNR) in dB?

4. Consider a phone network that uses a channel with bandwidth of 4 kHz and operates at an SNR of 75dB. What is the capacity of the channel?

5. If the channel capacity is 20Mbps, and bandwidth is 5MHz, what is SNR of the channel?

6. a) The transmit power of a TV satellite is 80 W and the diameter of the reflector of the transmit antenna is 160 cm. The diameter of the receive antenna is on 240 cm. Distance from the satellite to Pittsburgh is 40 000 km, frequency is 11.5 GHz. How many dBm is the signal received by the receive antenna? $\eta = 0.7$.

b) A satellite link has a frequency of 12 GHz. The satellite antenna reflector size is 2 m, the ground station has a 3 m antenna. The aperture efficiency of each antenna is 70% (η = 0.7). The power received by the ground station (i.e. the input signal power to the receiver) must be -75 dBm. What must be the transmit power of the satellite transmitter?

**Hint:** An antenna gain (G) can be obtained from wavelength (λ ), aperture efficiency (η) and its diameter (D) as follows: G= 10 $log_{10}\left(\eta\left(\frac{\pi D}{\lambda}\right)^2\right)$
(D is the antenna diameter and λ the wavelength)

7. A floor with a rectangular layout has area 20x30 meter$^2$. IoT devices are spread out in the area, each has a sensitivity of -90dBm. We need to connect all devices in this floor to the wireless LAN using access points. Each access point can transmit at a power of 1mW and operate at 2.4GHz. The path loss exponent in the environment is 5. Can we use a single access point to connect the devices? Justify your answer.

8. Simulation using Matlab

   In this question you will simulate a simple communication system. You will simulate a signal that has only two values of the amplitude to represent bits. The signal is transmitted over a channel that adds noise to the signal. The noise is modeled as AWGN (additive white Gaussian noise). In this question, we will get the bit error rate (BER) at different values for SNR. Please follow the steps below:

   a) Generate stream of bits representing data. This can can be a vector of N bits (you can set N = 100 bits)
   b) Generate a rectangular signal from the bits to represent the transmitted signal. The signal takes value of V for bit 1 and value of -V for bit 0. Let each bit be represented by Ns samples in the signal. Meaning that, if Ns =3 and we send bit '1', the transmitted signal will have values represented by [V V V]. If bit '0' is sent, then the corresponding samples in signal will be [-V -V -V].
      You can set Ns =3 and V =1.
   c) Simulate a received signal by passing the transmitted pass signal over AWGN channel. You can use "awgn" Matlab function. We will use different values for SNR from -10 to 10 dB (you will need a for loop).
   d) Plot the received signal at SNR = -10 dB and SNR = 10 dB.
   e) Simulate a simple receiver that recovers back the bits from the received signal. The receiver will basically check every Ns sample from the received signal, then get the average of each Ns samples. The average is then compared with a

threshold of 0. If the average of any Ns samples is less than 0, the received decides that the recovered bit is 0. Otherwise, the receiver decide that the recovered bit is 1. At this point you should get back the transmitted bits generated in the first step, but errors may occur due to noise.

f) Repeat the above process for each SNR value from (-10 to 10 dB) and calculate BER at each SNR value by comparing recovered bits with the generated bits. Plot BER versus SNR.

Comment on your observed results.