ECEN 621 - HW#2: Please answer the following questions:

1) **What are the differences between analog and digital signals?**
   Analog signal:
   - Signal intensity varies in a smooth fashion over time
   - No breaks or discontinuities in the signal

   Digital signal:
   - Signal intensity maintains a constant level for some period of time and then changes to another constant level

2) **What are three important characteristics of a periodic signal?**
   Frequency (Period), Amplitude, Phase

3) **What are the relationships between a signal’s spectrum and its bandwidth?**
   Usually, wider spectrum can support higher bandwidth, depending on the specific modulation schemes. Spectrum is the width of the physical radio band. Bandwidth is the achievable data transmission rate.

4) **Define the channel capacity.**
   Theoretical maximum that can be achieved through this channel.

5) **Differentiate between guided media and unguided media.**
   Guided Media:
   - Waves are guided along a solid medium

   Unguided Media:
   - Provides means of transmission but does not guide electromagnetic signals.
     Usually referred to as wireless transmission

6) **How is interference avoided by using FDM?**
   Takes advantage of the fact that the useful bandwidth of the medium exceeds the required bandwidth of a given signal. Split the entire spectrum into a number of non-overlapped bands, thus avoiding interferences.

7) **What is attenuation?**
   The variation of the signal power during the transmissions.

8) **If a signal has a fundamental frequency of 1000 Hz, then what’s its period?**
   Period = 1 / 1000 Hz = 1 ms

9) **What is the channel capacity for a telephone channel with a 300 Hz bandwidth and a signal-to-noise ratio of 3 dB?**
   \[
   \text{channel capacity} = B \log_2(1 + SNR) \\
   = 300 \times \log_2 \left(1 + 10^{\frac{3}{10}}\right) = 474.8 \text{ bit/s}
   \]
10) A digital signaling system is required to operate at 9600 bps.
   a. If a signal element encodes a 4-bit word, what is the minimum required bandwidth for the channel?
   b. Repeat a) for the case of 8-bit words.
   
   a.
   Signal Element Rate (symbol rate): $C = \frac{9600}{4} = 2400$ symbol/sec
   Required bandwidth $B = \frac{C}{2} = 1200$ Hz
   
   b.
   Signal Element Rate (symbol rate): $C = \frac{9600}{8} = 1200$ symbol/sec
   Required bandwidth $B = \frac{C}{2} = 600$ Hz

11) Given a channel with an intended capacity of 20 Mbps, the bandwidth of the channel is 3 MHz. What SNR is required to achieve this capacity?
   In order to satisfy $B \log_2(1 + SNR) = 20 \times 10^6$ bps, we need to have
   
   $SNR = 2^{\frac{20 \times 10^6}{B}} - 1 = 100.6 = 20$ dB