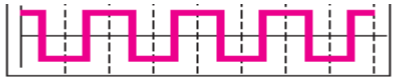
Data Communication Quiz #1 (2016. 10. 13) **Solutions**

Student ID: _____ Name: _____

1. A line has a SNR of 2000 and a bandwidth of 1 MHz. What is the maximum data rate supported by this line? Use necessary approximations, e.g. $log_2 1000 \approx 10$, in your calculation.
   - Shannon's capacity = $10^6 * \log_2(1+2000) \approx 10^6 * \log_2(2*1000) = 10^6 * 11 = 11$Mbps.
2. A signal travels from point A to point B. At point A, the signal power is 100 W. At point B, the power is 5 W. What is the attenuation in decibels?
   - 100 → 10: 10 dB, 10 → 5: 3 dB. So, the total attenuation is 13 dB.
3. What is the maximum data rate of a channel with a bandwidth of 200 KHz if we use 4 levels of digital signaling?
   - Nyquist capacity = $2 * 200 * 10^3 * \log_2 4 = 4*10^5*2 = 8*10^5$ bps (or 800 Kbps).
4. What is the Nyquist sampling rate for a band-pass signal with bandwidth of 300 KHz if the lowest frequency is 100 KHz?
   - The right end of the band is at 400 KHz. So the Nyquist sampling rate is 2 * 400 KHz = 800 KHz.
5. We have sampled a low-pass signal with a bandwidth of 300 KHz using 1024 levels of quantization.
   A. Calculate the bit rate of the digitized signal.
   - $2*300*10^3*\log_2 1024 = 6*10^6$ bps (or 6 Mbps).

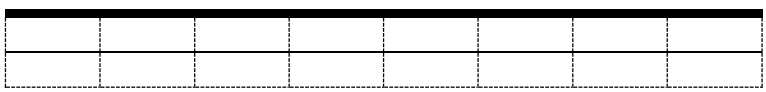
   B. Calculate the SNR_{dB} for this signal. (Hint: SNR_{dB} due to quantization error is $6.02n_b+1.76$ dB)
   - $n_b = \log_2 L = \log_2 1024 = 10$. So $SNR_{dB} = 6.02*10 + 1.76 = 61.96$ dB.

   C. Calculate the PCM bandwidth of this signal.
   - The PCM bandwidth is $n_b * B_{analog.}$ It is 10*300 KHz = 3 MHz.
6. In each of the following Differential Manchester encodings, what are the encoded bits? (from left to right)

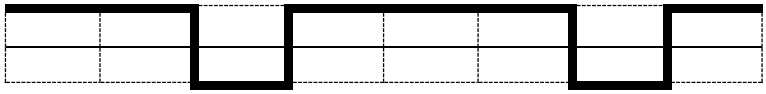
   A.  ?1111111 (The first bit cannot be decoded in the absence of the first signal level information)

   B.  00110011
7. Draw the NRZ-I signals using each of the following data streams, assuming that the last signal level has been positive.

   A. 00000000



   B. 00110011


8. A cable company uses a cable TV channel with a bandwidth of 6 MHz to provide digital communication. What is the available data rate if the company uses a 64-QAM? Let d=0. (Hint: QAM has the same bandwidth requirement as ASK and PSK.)
   - We can use the formula: $N = [1/(1 + d)] \times r \times B = 1 \times 6 \times 6$ MHz = 36 Mbps.

9. The telephone line has 4 KHz bandwidth. What is the maximum number of bits we can send using each of the following techniques? Let d=0.

   A. ASK : $r = 1 \rightarrow N = [1/(1 + 0)] \times 1 \times (4\ KHz) = 4\ kbps$

   B. QPSK : $r = 2 \rightarrow N = [1/(1 + 0)] \times 2 \times (4\ KHz) = 8\ kbps$

   C. 16-QAM: $r = 4 \rightarrow N = [1/(1 + 0)] \times 4 \times (4\ KHz) = 16\ kbps$

   D. 64-QAM: $r = 6 \rightarrow N = [1/(1 + 0)] \times 6 \times (4\ KHz) = 24\ kbps$

10. Draw the constellation diagram of 8-QAM with two amplitudes 1 and 3, and four different phases $\pi/4$, $3\pi/4$, $-\pi/4$, and $-3\pi/4$.

