Data Communications

1. What signal-to-noise ratio is needed to put a T1 carrier on a 50-kHz line?
   The data rate of a T1 carrier is 1.544 Mbit/sec.
   The data rate of a noisy channel is given by $C=W * \log_2(1+S/N)$
   $C=1.544$, $W=50$ Hz, $S/N = 2^{(C/W)} + 1$

2. It is desired to send a sequence of computer screen images over a network. The screen is 480 x 640 pixels, each pixel being 24 bits. There are 60 screen images per second. How much bandwidth is needed, if the communication channel is noise free using 8 data levels? What if the channel is noisy with signal to noise ratio (SNR) of 20dB?
   Data rate is $C=480*640*24*60$ bits/sec
   Using a noiseless channel $C=2W\log_2(M)$
   $W=C/2\log_2(M)$
   Using noisy channel $C=W\log_2(1+S/N)$
   $SNR = 10\log_{10}(S/N)$ ➔ $10^{(20/10)}=S/N = 100$
   $W = C/\log_2(1+100)$

3. A simple telephone system consists of two end offices and a single toll office to which each end office is connected by a 1-MHz full-duplex trunk. The average telephone is used to make four calls per 8-hour workday. The mean call duration is 6 min. Ten percent of the calls are long-distance (i.e., pass through the toll office). What is the maximum number of telephones an end office can support? (Assume 4 kHz per circuit.)

   Each user makes 4 calls, 6 minutes each (24 minutes). 10% calls (2.4 minutes) are long distance. Each user has a 4KHz connection. This means each 1MHz/4KHz = 256 simultaneous calls can be made. The maximum number of telephones are supported if the long distance calls are distributed uniformly during the 8-hour workdays.
   Maximum number of supported telephones is : 256 * 8 * 60 / 2.4

4. A modem constellation diagram has data points at the following coordinates: (1, 1), (1, -1), (-1, 1), and (-1, -1). How many bps can a modem with these parameters achieve at 1200 baud?
   Since 4 coordinates are used, 2 bits are sent per baud.
   So data rate is 1200*2 bps

5. Consider the bit string 1001110100. Draw the encoding diagram for the following bit encoding methods:
   a. Manchester encoding
   b. Differential Manchester encoding
   c. NRZ
   d. NRZI
6. Assume a communication line has the bandwidth limit of 5000Hz. Also assume the average noise power is 10 mW. What should be the signal to noise ratio to reach a data rate of 20000 bps?

C=W log(1+S/N) ➔ 20000 = 5000log(1+S/10) ➔ 15 = S/10 ➔ S = 150 SNR = 10log10(15)

7. A data network consists of two segments with attenuation rates of 10 and 12 dB respectively. To keep the data rate in the minimum required level we should limit the attenuation by adding an amplifier so that the signal energy does not drop more than %25. What should be the gain of the amplifier?

   $P_{out} = 0.75 * P_{in}$ ➔ $X-10-12 = 10\log_{10}(P_{out}/P_{in})$ ➔ $X = 22-0.125$