Homework for Chapter 2

1. Is an oil pipeline a simplex system, a half-duplex system, a full-duplex system, or none of the above? What about a river or a walkie-talkie-style communication?

2. How much bandwidth is there in 0.1 microns of spectrum at a wavelength of 1 micron?

3. Compute the Fourier coefficients for the function $f(t) = t$ $(0 \le t \le 1)$.

4. A noiseless 3-kHz channel is sampled every 1 msec. (i) What is the maximum data rate? (ii) How does the maximum data rate change if the channel is noisy, with a signal-to-noise ratio of 30 dB?

5. If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate?

6. What is the minimum bandwidth needed to achieve a data rate of B bits/sec if the signal is transmitted using NRZ, MLT-3, and Manchester encoding? Explain your answer.

7. Prove that in 4B/5B mapped data with the NRZI encoding, a signal transition will occur at least every four bit times.

8. In the discussion about orthogonality of CDMA chip sequences, it was stated that if $\mathbf{S} \cdot \mathbf{T} = 0$ then $\mathbf{S} \cdot \overline{\mathbf{T}}$ is also 0. Prove this.

9. A CDMA receiver gets the following chips: $(-1\ +1\ -3\ +1\ -1\ -3\ +1\ +1)$. Assuming the chip sequences defined in Fig. 2-22(a), which stations transmitted, and which bits did each one send?

10. A regional telephone company has 15 million subscribers. Each of their telephones is connected to a central office by a copper twisted pair. The average length of these twisted pairs is 10 km. How much is the copper in the local loops worth? Assume that the cross section of each strand is a circle 1 mm in diameter, the density of copper is 9.0grams/cm^3, and that copper sells for \$6 per kilogram.

11. If a T1 carrier system slips and loses track of where it is, it tries to resynchronize using the first bit in each frame. How many frames will have to be inspected on average to resynchronize with a probability of 0.001 of being wrong?

12. What is the available user bandwidth in an OC-12c connection?

13. Suppose that x bits of user data are to be transmitted over a k-hop path in a packet-switched network as a series of packets, each containing p data bits and h header bits, with $x \gg p + h$. The bit rate of the lines is b bps and the propagation delay is negligible. What value of p minimizes the total delay?

14. How fast can a cable user receive data if the network is otherwise idle? Assume that the downstream cable channel works at 27 Mbps and that the user interface is

    (a) 10 Mbps Ethernet

    (b) 100 Mbps Ethernet

    (c) 54 Mbps Wireless.

15. Calculate the transmit time in the previous problem if packet switching is used instead. Assume that the packet size is 64 KB, the switching delay in the satellite and hub is 10 microseconds, and the packet header size is 32 bytes.