Problem 4.1  PAM vs. QAM.
   For this problem, please make the following assumptions:

   • The noise is additive white Gaussian noise with variance $\sigma^2$ in both the in-phase and quadrature components.
   • 0’s and 1’s appear with equal probability.
   • The symbol period $T$ is equal to 1.
   • The shortest distance between two constellation points is $2d$.

(a) Derive the symbol error probability formula for 16-QAM, also known as Quadrature Phase Shift Keying (QPSK).

(b) Calculate the average power of the 16-QAM signal.
(c) Write the probability of symbol error for 16-PAM and 16-QAM as functions of the signal-to-noise ratio (SNR). Superimposed on the same plot, plot the probability of symbol error for 16-PAM and 16-QAM as a function of SNR. For the horizontal axis, let the SNR take on values from 0 dB to 20 dB. Comment on the difference in the symbol error rate vs. SNR curves.

**Problem 4.2** Carrier Phase Recovery via Phase Locked Loop

**Problem 4.3** Carrier Phase Recovery via the Costas Loop
Johnson & Sethares, problem 10.17.

**Problem 4.4** Timing Recovery Using Output Power Maximization
Johnson & Sethares, problem 12.9.

**Problem 4.5** Linear Least-Squares Equalization
Johnson & Sethares, problem 13.1.