

**EE 5654 - Digital Communications - Spring 2004**  
**Homework 3**  
**Due Tuesday 2/22/05**

1. In this problem you will determine the impact of a constant phase offset to BPSK modulation. Specifically, derive the probability of the optimal receiver with equally likely symbols (i.e., the ML decision rule) when there is a constant phase offset  $\theta_0$ . The calculation should assume that the standard decision rule is applied to the received signal (i.e., the receiver does not take into account the constant phase offset).
2. Repeat problem #1 for QPSK modulation.
3. Repeat problem #1 for  $M$ -ary PSK modulation.
4. How would you adapt the receiver in problem #1 if the receiver knew the phase offset?
5. Derive the probability of error of the optimal coherent BPSK receiver in terms of  $E_b/N_0$  if white *Laplacian* noise is added to the signal. The Laplacian pdf is

$$f(x) = \frac{1}{\sigma} e^{-(2/\sigma)|x|}$$

where  $\sigma$  is the variance of the noise and assume that  $\sigma^2 = N_0/2$  at the output of the matched filter. Plot your result along with the probability of error for AWGN.