

**ECSE-6961: Fundamentals of Wireless
Broadband Networks
Spring 2007, Exam 2**

Time: **75 min (strictly enforced)**

Points: **50**

YOUR NAME:

Be brief, but DO NOT omit necessary detail

{Note: Simply copying text directly from the slides or notes will not earn (partial) credit. Brief, clear and consistent explanation will.}

1. [4 pts] Basics: Nyquist Sampling & Nyquist pulse

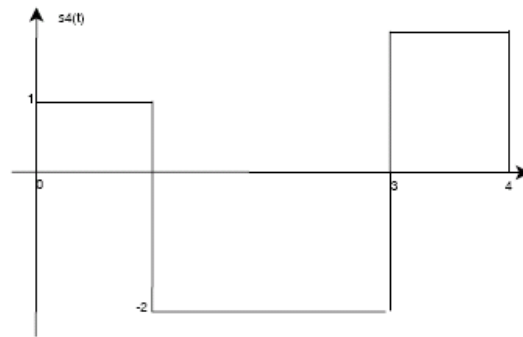
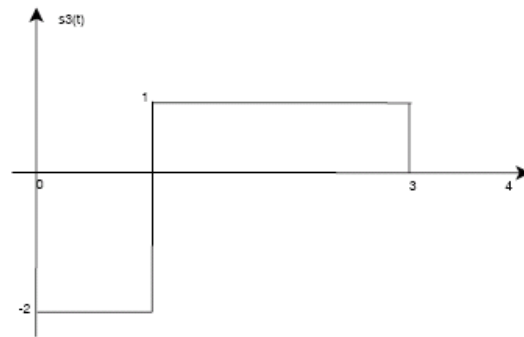
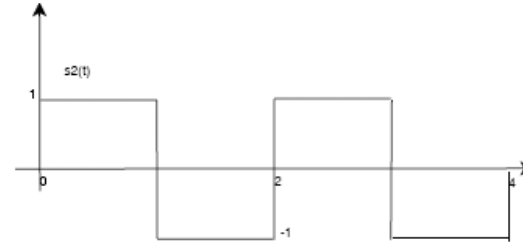
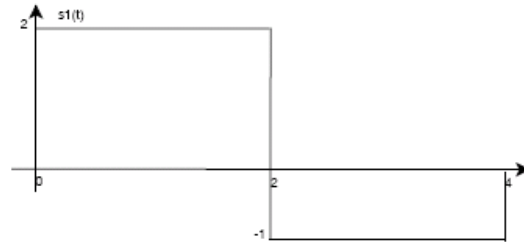
Explain why and how a sampling rate of $2W$ samples allows a band-limited analog signal to be perfectly reconstructed. What is a Nyquist pulse?

2. [4 pts] Basics: Modulation Briefly explain the difference between PCM vs PAM vs PSK?

3. [8 pts] Matched Filter vs Equalizer, Correlator, MRC, Rake, Beamforming

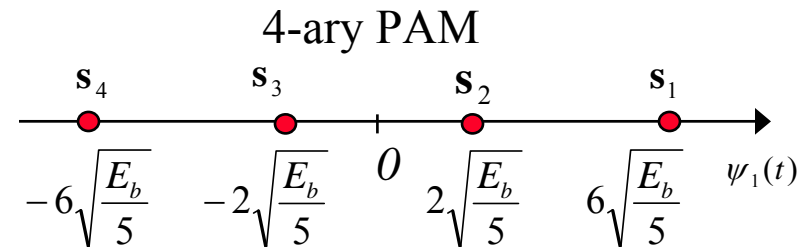
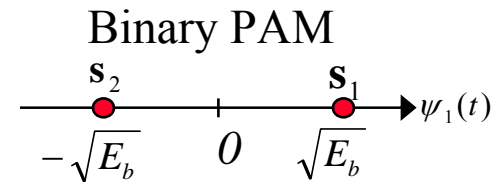
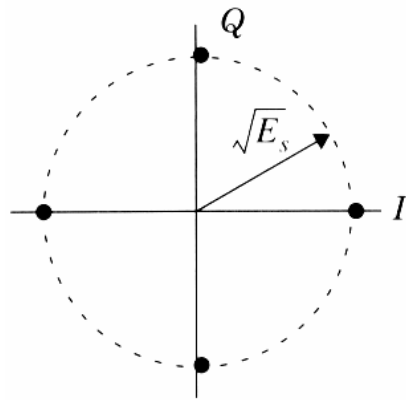
What is a matched filter (1.5 pts)? How is it different from an equalizer (1.5 pts)? How is the matched filter related to a correlator (1.5 pts)? Explain how it is essentially equivalent to Maximal-ratio-combining (MRC), Rake receiver and (transmit/receive) Beamforming (2 pts)? Under what circumstances is MRC significantly better than selection combining (1 pt) ?

4. [6 pts] **Orthogonality & Distance**: Show that these four signals are orthogonal (3 pts). What is the distance between the signal pairs (s_1, s_4) and the signal pairs (s_2, s_3) ? {3 pts}



5. [6 pts] Eb/No vs SNR & Shannon Limit: What is the relationship between E_b/N_0 vs SNR (2 pts)? Why is the former used in plots vs P_b (bit error rate) (1 pt)? How is E_b/N_0 related to spectral efficiency (ρ) (1 pt)? What is the minimum E_b/N_0 possible (ultimate Shannon limit) given a spectral efficiency (ρ) constraint of 4 bits/Hz? (2 pts)?

6. [8 pts] Modulation & Signal Space: Below we have the figure of 2-PAM vs 4-PAM. Draw a rough figure for 8-PAM with the appropriate energy values at the constellation points (5 pts). 4-PSK provides a gain over 4-PAM by using the extra degree of freedom. How much is this gain (in dB) (3 pts)? Show your calculations.



7. [8 pts] Interference: There are several sources of interference in wireless networks: *inter-symbol interference* (AWGN channels due to poor pulse-shaping; multi-path frequency-selective channels), *inter-cell interference*, *intra-cell interference* (CDMA), and *inter-carrier interference* (in OFDM). Briefly explain why each of these interference phenomena arise (4 pts)? How do techniques like pulse-shaping, spread spectrum/Rake, equalizers and OFDM deal with the ISI problem (4 pts)?

8. [6 pts] Code Design & MIMO: Explain the product distance and determinant criteria for time-only and space-time code design (3 pts). Explain why the Alamouti code does not use the degrees of freedom of a MIMO channel, but is able to do so for a MISO channel (even without channel knowledge at the sender) (3 pts).