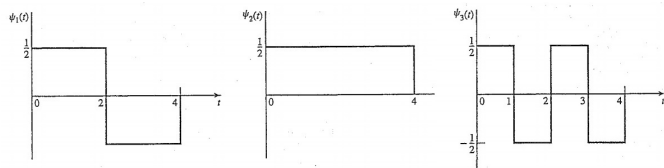


ECE (435/535a) Spring 2016 Midterm 2
April 5

Name: _____ Signature: _____

Instructions: Answer all questions and show all work. Answers which are not justified with appropriate work will receive 0 points. Students who cheat will receive zero points on the exam and will be subject to the university's disciplinary procedure for academic dishonesty. Cheating includes, but is not limited to, collaborating or conferring in any way with anyone. Use of the internet is strictly forbidden. Your signature above attests that you are in compliance with these rules.

1. Use the orthonormal waveforms shown in the figure below to approximate the function $x(t) = \cos(\frac{\pi t}{4})$, over the interval $0 \leq t \leq 4$ by the linear combination $\hat{x}(t) = \sum_{n=1}^3 c_n \psi_n(t)$.



- (a) (15 points) Determine the expansion coefficients $\{c_n\}$ that minimize the mean-square approximation error $\mathcal{E} = \int_0^4 (x(t) - \hat{x}(t))^2 dt$.
 (Hints: $\int \sin(x) dx = -\cos(x)$, $\int \cos(x) dx = \sin(x)$ and $\cos^2(x) = \frac{1+\cos(2x)}{2}$.)

(b) (10 points) Determine the residual mean square error \mathcal{E}_{\min} .

Problem	Points	Student's Score
1	25	
2	40	
3	35	
Total:	100	

2. (PSK Modulation)

(a) (5 points) Write an expression for a set of M-ary PSK signal waveforms assuming that the $g(t)$ is a baseband pulse shape, ω_c is the carrier frequency and T is the symbol period.

(b) (5 points) Write an expression for the signal-space representation of the above waveforms.

(c) (10 points) What are the orthonormal basis functions? How many of them are there?

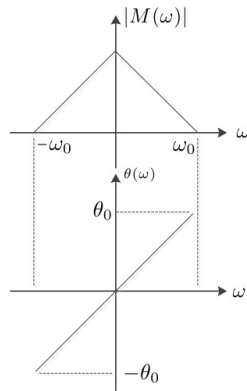
(d) (15 points) Find the Euclidean distance between any two signal points in the constellation.

(e) (5 points) Find the minimum Euclidean distance.

3. (Hilbert Transform)

(a) (10 points) Define the Hilbert transform of a signal $m(t)$.

(b) (25 points) The spectrum ($M(\omega) = |M(\omega)|e^{j\theta(\omega)}$) of the signal $m(t)$ is shown below.



Plot the spectrum of the signal $\hat{m}(t)$ which is equal to the Hilbert transform of $m(t)$.