RUTGERS

School of Engineering
Department of Electrical and Computer Engineering

332:421 **Wireless Communications Systems** **Fall 2010**

Quizlette 1

Write all answers on the printed sheet

USEFUL:

$$\sin(a \pm b) = \sin(a)\cos(b) \pm \cos(a)\sin(b) \qquad \cos(a \pm b) = \cos(a)\cos(b) \mp \sin(a)\sin(b)$$

$$\cos\tfrac{\pi}{4} = \tfrac{1}{\sqrt{2}} \qquad \sin\tfrac{\pi}{4} = \tfrac{1}{\sqrt{2}}$$

$$\sin^2 t = \tfrac{1-\cos 2t}{2} \qquad \cos^2 t = \tfrac{1+\cos 2t}{2}$$

1. $s_1(t) = \cos 2\pi t$, $s_2(t) = \sin 2\pi t$ and $s_3(t) = \sin(2\pi t + \frac{\pi}{4})$, all for $t \in [0, 1]$.

   (a) Carefully verify that $\phi_1(t) = \sqrt{2}\cos 2\pi t$ and $\phi_2(t) = \sqrt{2}\sin 2\pi t$ form an orthonormal basis set.

   (b) Derive the vector representations $\underline{s}_i$ for each of the $s_i(t)$ using the $\phi_i(t)$ in the previous part. Evaluate any integrals you obtain and sketch your results in signal space.

2. Assume you are given orthonormal signals $\phi_1(t)$ and $\phi_2(t)$ and you are also given two information signals $s_1(t) = \phi_1(t)$ and $s_2(t) = \phi_2(t)$. The received signal is $r(t) = s_i(t) + n(t)$ where $n(t)$ is zero mean stationary white Gaussian noise with spectral height 1. You may assume that the $s_i(t)$ are equally likely.

   (a) Sketch $s_1(t)$ and $s_2(t)$ in signal space. What is the total average energy used by the signals?

   (b) A single value governs the probability of error for this system. What is that single value called and what is its numerical value. (BE CAREFUL!)

   (c) Please derive signals $s_3(t)$ and $s_4(t)$ that achieve the same probability of error as $s_1(t)$ and $s_2(t)$ but use less average energy. Sketch your $s_3(t)$ and $s_4(t)$ in the signal space.