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ECE 300
Signals and Systems

Exam 3
10 November, 2009

This exam is closed-book in nature. You are not to use a calculator or computer during the exam. Do not write on the back of any page, use the extra pages at the end of the exam. ***<u>You must show your work to receive credit for a problem.</u>***

Problem 1	________	/ 35
Problem 2	________	/30
Problem 3	________	/ 20
Problem 4	________	/ 15

Exam 3 Total Score: _______ / 100

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1. (35 points) Assume $x(t) = 4\,\text{sinc}\left[\frac{1}{\pi}(t-2)\right]\cos(4(t-2))$ is the input to an LTI system with transfer function

$$H(\omega) = \begin{cases} \frac{1}{\pi} e^{-j\omega 3} & |\omega| > 4 \\ 0 & else \end{cases}$$

a) Determine the Fourier transform $X(\omega)$ of $x(t)$

b) Accurately sketch the magnitude and phase of $X(\omega)$

c) Determine the energy in $x(t)$

d) Sketch the magnitude and phase of $Y(\omega)$

e) Determine the system output $y(t)$

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2. (30 points) Fill in the following table, show all your work

$x(t)$	$X(\omega)$
	$\left[rect\left(\frac{\omega+2}{3}\right)+rect\left(\frac{\omega-2}{3}\right)\right]e^{j\omega 3}$
	$\frac{3}{2+j\left(\frac{\omega}{5}+2\right)}$
$\frac{4}{4+(2t-4)^2}$	

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3. (20 points) Consider the signal $x(t) = \cos(4t) + \cos(6t)$

a) Sketch the spectrum of $X(\omega)$

b) $x(t)$ is the input to an ideal sampler sampling at rate $f_s = \frac{5}{2\pi} = \frac{1}{T}$ seconds. Sketch the spectrum of the sampled signal $X_s(\omega)$.

c) Assume $x_s(t)$ is the input to an ideal lowpass filter with a cutoff frequency of 7 rad/sec and passband gain of T. Determine the output signal $x_r(t)$ and write it in terms of the original signal $x(t)$ plus any aliased terms.

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4) (15 points) The periodic signal $x(t)$ has the Fourier series representation

$$x(t) = 2 + \sum_{k=-\infty}^{k=\infty} \frac{1}{1+kj} e^{jk3t}$$

$x(t)$ is the input to an LTI system (a high pass filter filter) with the transfer function

$$H(j\omega) = \begin{cases} 0 & |\omega| < 2 \\ 4e^{-j2\omega} & |\omega| > 2 \end{cases}$$

The steady state output of the system can be written as

$$y(t) = ax(t-b) + c + d\cos(e(t-b) + f)\ .$$

Determine the output, writing it in as simple a form (like that above) as you can.

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Some Potentially Useful Relationships

$$E_\infty = \lim_{T\to\infty} \int_{-T}^{T} |x(t)|^2 dt = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

$$P_\infty = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 dt$$

$$e^{jx} = \cos(x) + j\sin(x) \qquad j = \sqrt{-1}$$

$$\cos(x) = \frac{1}{2}\left[e^{jx} + e^{-jx}\right] \qquad \sin(x) = \frac{1}{2j}\left[e^{jx} - e^{-jx}\right]$$

$$\cos^2(x) = \frac{1}{2} + \frac{1}{2}\cos(2x) \qquad \sin^2(x) = \frac{1}{2} - \frac{1}{2}\cos(2x)$$

$$\text{rect}\left(\frac{t - t_0}{T}\right) = u\left(t - t_0 + \frac{T}{2}\right) - u\left(t - t_0 - \frac{T}{2}\right)$$