ASSIGNED: Jan. 06, 2006. **READ:** Part 1 of Official Lecture Notes (available on-line).
DUE DATE: Jan. 13, 2006. **TOPICS:** Mean, energy, histograms, translation, plotting.

Show work on separate sheets of paper. Include all hand and Matlab plots and code.

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[20] 1. For each of these 4 signals, compute the mean[2], energy[2], rms value[1]:

(a) $\begin{cases} 4t & \text{for } 0 < t < 2; \\ 0 & \text{for otherwise} \end{cases}$; (b) $\begin{cases} 1-|t-1| & \text{for } |t-1| < 1; \\ 0 & \text{for otherwise} \end{cases}$; (c) $3 + 4\cos(2\pi t + 1)$ (d) $x[n] = \{3, 1, 4, 1, 5, 9\}$

Hint: If you need to, *draw a sketch* for (a) and (b); this helps visualize the functions.

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[20] 2. *Translation and time scaling of signals:*

[05] (a) For the signal $x(t)$ in #1a, sketch **by hand** $y(t) = x(2t - 1)$.

[05] (b) For the signal $x(t)$ in #1b, sketch **by hand** $y(t) = x(1 - 2t)$.

[10] (c) If a signal $x(t)$ has support $[a, b]$, compute a general formula for the support of the signal $y(t) = x(ct - d)$ in terms of constants a, b, c, d.

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[20] 3. *Histograms and computation of mean from histograms:*

[10] (a) Sketch **by hand** the histogram of one period of $5 + 5\cos(\frac{\pi}{5}n)$. Use 10 bins.

[10] (b) Compute the mean and mean square of this signal *directly from its histogram.* Compare your answers to the *actual* mean and mean square of this signal.

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[20] 4. *Using Matlab and sum of sinusoids at the same frequency:*

[05] (a) Using Matlab, plot $3\cos(t)+4\sin(t)$ for $0 \le t \le 20$. Use `t=linspace(0,20,1000)`. (What would happen if you used `t=[1:20]`? Why doesn't this work well?)

[05] (b) From your plot in #4a, read off the amplitude, frequency, and phase of $x(t)$.

[10] (c) Derive a general formula for simplifying $A\cos(\omega t) + B\sin(\omega t)$ by applying the cosine addition formula to $C\cos(\omega t - \theta)$.
(i) Compute C and θ from A and B; (ii) Compute A and B from C and θ.

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[20] 5. *Time delay estimation using correlation with delayed signal:*

Air traffic control uses radar to determine the distance d from an airport to a plane. The airport sends a radar pulse $s(t)$, which reflects off the plane back to the airport. The airport receives radar signal $y(t) = s(t - D) + n(t)$ where $n(t)$ is random "noise" and *unknown* time delay $D = \frac{2d}{c}$ where c=the speed of light (distance=rate×time).

The goal is to determine the unknown delay D from the noisy received signal $y(t)$.

A crude 1-D version of this problem is simulated by the line of Matlab code below:

```
S=randn(1,100);N=randn(1,1000);D=round(200+600*rand);Y=[zeros(1,D) S zeros(1,900-D)]+N;
```

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[10] (a) Run this line of code and plot Y. *Using only this plot*, where's the plane?

[10] (b) Run the following line of code, which correlates Y with delayed versions of S:

`for I=1:899;Z(I)=Y*[zeros(1,I) S zeros(1,900-I)]';end` Plot Z. Where's the plane?
Check your answer using `D`. Try this 3 times and turn in 6 plots of Y,Z (use `subplot`).
This works since correlation of two random signals is small unless they're the *same.*

"Never let your schooling interfere with your education"–Mark Twain