ASSIGNED: Mar. 17, 2006. **READ:** Part 6 of Official Lecture Notes (available on-line).
DUE DATE: Mar. 24, 2006. **TOPICS:** Frequency response (response to sinusoidal input).

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

[40] 1. For the system $y[n] = x[n] + 3x[n-1] - 3x[n-2]$:

[05] (a) Determine the impulse response $h[n]$.

[05] (b) Determine the frequency response function $H(e^{j\omega})$.

[05] (c) If $x[n] = 3\cos(\frac{\pi}{2}n)$, compute the response $y[n]$.

[15] (d) If $x[n] = 1 + 2\cos(\frac{\pi}{3}n + 1) + 3\cos(\frac{2\pi}{3}n - 1) + 4\cos(\pi n)$, compute $y[n]$.

[10] (e) If $x[n] = 2\cos(\frac{\pi}{2}n + 1) + 1 + 3\delta[n-1]$, compute $y[n]$.
Hint: Compute the response to the impulse separately, then use linearity.

[25] 2. *Frequency response functions–what they look like:*

[05] (a) If $H(e^{j\omega}) = 1 + 2e^{-j2\omega} - 3e^{-j3\omega}$, determine impulse response $h[n]$.

[10] (b) If $H(e^{j\omega}) = 1 + 2e^{-j2\omega} - 3e^{-j3\omega}$, compute the 4-point DFT of $h[n]$ **without using your answer to (a)**. (I promised no more by-hand DFTs!)

[10] (c) If gain $|H(e^{j\omega})| = \sqrt{(1 + 4\cos(\omega))^2 + (2\sin(\omega))^2}$, compute $h[n]$.
Hint: What are real and imag parts? $\cos\theta = (\frac{1}{2})(e^{j\theta} + e^{-j\theta})$. Delay by one.

[15] 3. *Simple notch filtering to remove sinusoidal interference:*

[05] (a) Run the line of Matlab code below. This adds 2000 Hz interference to `Handel`.
`clear;load handel;X=y(27001:35192)'+10*cos(pi*4000*[1:8192]/8192);`
Listen to X using `sound(X)`. Describe what you hear in words. Is this annoying?

[10] (b) Run the line of Matlab code below. Insert a number '?' so 2000 Hz is eliminated.
`Y=filter([1 ?  1],[1],X);` YOU have to fill in a number for '?'
Listen to `Y` using `sound(Y)`. Describe what you hear in words. Is this better?
Adjust the amplitude of the 2000 Hz sinusoid if necessary for best results.

[20] 4. *Power supply ripple: Continuous-time frequency response*
A simple power supply (like your calculator AC adapter) uses a transformer and diodes to generate a rectified sinusoidal voltage $x(t) = 19.7|\sin(377t)|$ (period=$\frac{1}{120}$ sec).

Fourier series: $x(t) = 12.54 - 25.08\sum_{k=1}^{\infty} \frac{\cos(754kt)}{4k^2-1}$ where $\frac{2(19.7)}{\pi} = 12.54$.

$x(t) \rightarrow \boxed{\text{RC CIRCUIT}} \rightarrow y(t)$. The frequency response of $\boxed{\text{RC CIRCUIT}}$ is:

Gain=$|H(f)|$=$1/\sqrt{1 + (f/12)^2}$. Phase=$\angle H(f)$=$-\tan^{-1}(f/12)$. **Note:** f is in Hertz.

(10) (a) Compute the Fourier series of $y(t)$ from the Fourier series of $x(t)$.
by modifying the amplitude and phase of each sinusoid in $x(t)$ according to $H(f)$.
Explicitly write out the first 5 terms@[2] of the Fourier series expansion of $y(t)$.

(05) (b) Using Matlab, plot both $x(t)$ and $y(t)$ on the same plot for $0 \leq t \leq 0.1$.

(05) (c) How big is the *ripple* (this will be evident) in the power supply output $y(t)$?

"Diplomacy is the art of saying 'nice doggie' until you can find a stick."