EECS 206 — PROBLEM SET #7 — Winter 2006

ASSIGNED: Mar. 06, 2006. **READ:** Part 5 of Official Lecture Notes (available on-line).
DUE DATE: Mar. 10, 2006. **TOPICS:** Linear Time-Invariant (LTI); impulse response.

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

---

[30] 1. For each of these systems, is it (answer Y or N in a table; show no work):
[2] (i) linear; [2] (ii) time-invariant; [1] (iii) causal; [1] (iv) BIBO-stable?

[6] (a) $y[n] = x[n] + 2x[n-1] + 3x[n-2] + 4x[n-3]$. [6] (b) $y[n] = 2x[n+1] + 3x[n-1]$.
[6] (c) $y[n] = nx[n]$. [6] (d) $y[n] = x[n] + 1$. [6] (e) $y[n] - 2y[n-1] = x[n]$.

---

[20] 2. $y[n] = x[n] + 4x[n-1] - 2x[n-2]$=weighted average of the 3 most recent inputs.

[5] (a) Compute $y[n]$ for $x[n] = \{\underline{1}, 2, 3, 4, 5\}$ by plugging into the system.
[5] (b) Determine the impulse response $h[n]$ of this system by reading it off of it.
[5] (c) Compute $y[n]$ for $x[n] = \{\underline{1}, 2, 3, 4, 5\}$ by convolving with $h[n]$.
[5] (d) Compute $y[n]$ for $x[n] = \cos(\frac{\pi}{2}n)$ using phasors (remember them?)

---

[20] 3. *Cascade and series connections of systems:*
Compute a description $y[n] = ax[n] + bx[n-1] + cx[n-2] + \ldots$ for the two LTI systems $y[n] = 2x[n] + 3x[n-1]$ and $y[n] = 4x[n] - 5x[n-2]$ when they are connected together:
[10] (a) In series. [10] (b) In parallel. **Hint:** Look at the second system carefully.

---

[20] 4. *Exploiting linearity and time-invariance properties:*
Same LTI system: $\{\underline{1}, 2\} \rightarrow \boxed{\text{LTI}} \rightarrow \{\underline{1}, 5, 6\}$ and $\{\underline{0}, 1, 4\} \rightarrow \boxed{\text{LTI}} \rightarrow \{\underline{0}, 1, 7, 12\}$.
Using *only* the properties of linearity and time-invariance (all you need):

[05] (a) Compute the response $y[n]$: $\{\underline{2}, 5, 4\} \rightarrow \boxed{\text{LTI}} \rightarrow y[n]$
[05] (b) Compute the response $y[n]$: $\{\underline{0}, 0, 2\} \rightarrow \boxed{\text{LTI}} \rightarrow y[n]$
[10] (c) Compute the response $y[n]$: $\cos(\frac{\pi}{2}n) \rightarrow \boxed{\text{LTI}} \rightarrow y[n]$

---

[10] 5. *Dereverberation:*
Run the following Matlab program, which adds 31 echoes (reverberations) to `gong`. Each reverberation is attenuated by a factor of 0.8 over the previous reverberation.

```
clear;load gong;N=[1:32768];X=(y(N))';Y=X;Y(65536)=0;for I=1:31;
Y=Y+[zeros(1,1024*I) (0.8∧I)*X zeros(1,1024*(32-I))];end; %fill in B
subplot(221),plot(N,X);subplot(222),plot(N,Y(N));Z=filter(B,[1],Y);
subplot(223),plot(N,Z(N));subplot(224),plot(N,Z(N)-X); %vertical scale
```

Fill in the missing *vector* `B` in `filter` so the 1^{st} 32768 values of Z and X agree. This recovers original `gong` signal from signal+reverberations. Explain why it works. You need a total of 2 nonzero coefficients in B. How do you do this? Try thinking!

"A cynic is someone who, when he smells roses, looks around for a coffin"-Oscar Wilde