SYSC 4405: Practice Midterm Exam (#:1) October 17, 2008

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Background: You are designing a DSP system to control an infusion pump to inject controlled amounts of drugs into a patient in the intensive care unit. The pump is illustrated in the figure: saline solution is pumped into the patient at a constant rate (5 ml/min). The computer controls the injection of small amounts of drug input ($x(t)$) into a mixing chamber (with drug concentration, $w(t)$). The saline mixed with the drug then travels through a catheter (tube) and is injected into the patient (with drug concentration, $y(t)$).

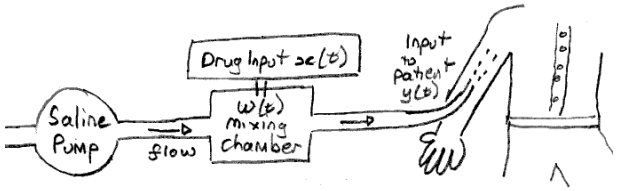

Illustration of infusion pump:

The goal of your work is to build a DSP system to measure the pump behaviour (this exam). In order to analyse it, you divide it into the following subsystems:

Subsystem	Input	Output	Impulse Response	Description
1	$x(t)$	$w(t)$	$h_1(t)$	Mixing chamber
2	$w(t)$	$y(t)$	$h_2(t)$	Flow in catheter

You use a sample rate of $T_s = 0.05$ s. The chemical sensors measure quantities so that a 1 molar concentration given 1 V.

1. (1 point) Your exam is exam number **1**. Write down this number.
2. (5 points) Subsystem #1 can be represented by the following difference equation:
   $$w[n] = 0.99y[n-1] + 0.01x[n]$$
   Calculate $h_1[n]$
3. (5 points) Subsystem #2 behaves as a delay of 5 s. **Show** $h_2(t)$ **and** $h_2[n]$**.**
4. (5 points) **Calculate the discrete time Fourier transform (DTFT) of system #2:** $H_2(e^{j\omega})$
5. (5 points) **Draw a block diagram of the entire system (with input** $x(t)$ **and output** $y(t)$**).** To show many delay elements in series, you may write: e.g. *Delay* $\times 15$.
6. (5 points) **Calculate the impulse response of the entire system from** $h_1[n]$ **and** $h_2[n]$**.**
7. (5 points) **Characterize the entire system in terms of the following properties: a) linear, b) memoryless, c) shift-invariant, d) LSI, e) stable, f) causal.** You only need to list *yes* or *no* for each property.
8. (5 points) Given an input $x(t) = 10u(t)$ V. **Calculate** $y[51]$ **and** $y[501]$**. Estimate** $y[5001]$ **(to within** $\pm 1\%$**).** Assume initial contitions are zero.
9. (5 points) A 10 bit A/D converter is used with $X_{min} = 0$ and $X_{max} = 0.5V$. Assume that the measured signal power is 10^{-4} V^2. **Calculate the SNR due to quantization (in dB).**
10. (5 points) As part of the control system, we wish to filter the control signal before it is input at $x[n]$. To do this, we use an FIR filter of length 200. This filter is implemented with a 512 point DFT using block processing and the overlap-add technique. **Sketch the block filter process and indicate:** L**,** M **and** N **and the length of each signal and any zero-padding.**