T-61.140 Signal Processing Systems

1st mid term exam, Monday 7.3.2004 15-18, hall M.
You are NOT allowed to use any math formulae book and **NO any calculator**. Formulae paper is delivered by assistants. **Write down all necessary steps to your solutions. Begin** a new problem **from a new page.**

1) (2-4 p) Compute the fundamental period N_0 of the sequence $x[n]$. **Choose one and only one of the following**:

   A) (max 2 p) $x[n] = \cos((\pi/9)n)$

   B) (max 3 p) $x[n] = \cos((\pi/9)n) + 2\sin((\pi/2)n + \pi/7)$

   C) (max 4 p) $x[n] = \cos((\pi/9)n^3) + 2\sin((\pi/2)n + \pi/7)$,
   hint $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$.

2) (6p) See the block diagram in Figure 1

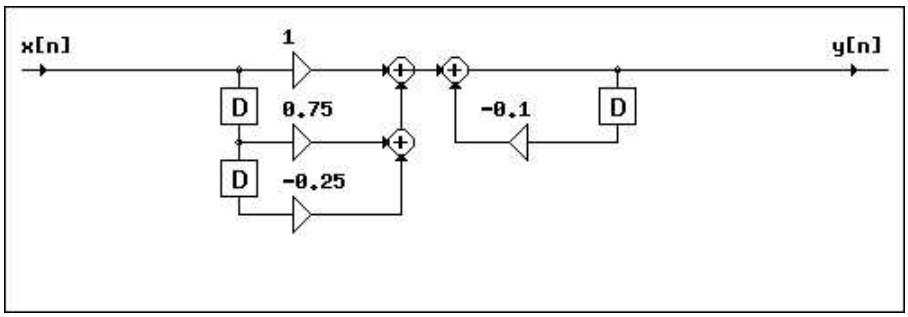

Figure 1: Filter of Problem 2. All memory registers are initially zero.

   a) What is the difference equation of the filter? $y[n] = \ldots$

   b) Compute the first five non-zero values of the impulse response.

   c) What is the output value at $n = 4$, i.e. $y[4]$, if the input is

$$x[n] = \sum_{k=0}^{+\infty} 10^{3-k}\delta[n-k]$$

   d) Modify two filter coefficients so that the new impulse response will be

$$h_2[n] = \{\underline{2}, -0.25, -0.125, 0.0625, -0.03125, \ldots\}$$

   where the underlined value represents index $n = 0$. Draw the block diagram of the modified filter.

3) (6p) Consider a LTI system, which consists of three subsystems $h_1[n]$ in cascade. The impulse response of each subsystem is $h_1[n] = \delta[n] + \delta[n-1]$.

   a) What is the impulse response of the cascade system $h_c[n] = (h_1[n] * h_1[n]) * h_1[n]$?

   b) If the output for a cascade system is

$$y[n] = \delta[n+3] + 10\delta[n] + 15\delta[n-1] + 6\delta[n-2]$$

   what was the input $x[n]$?

   c) Is the system causal? Explain.

   d) Is the system stable? Explain.

4) (4 x 2p = 8p) Choose **at most four topics**, and write down briefly but in sufficient details. Use figures and examples.

A) "What do these impulse and impulse response mean **in practice**?" (student question, spring 2005)

B) Which things make an automatic speech recognition problem tough or not?

C) How can you blur (= get rid of) details in digital gray-scale pictures?

D) Fourier-series representation of periodic continuous-time rectangular pulse, use example in Figuere 2, where signal $x(t)$, whose fundamental period is $T_0 = 7$.

E) What are the similarities and differences between discrete-time (LTI) FIR and IIR filters?

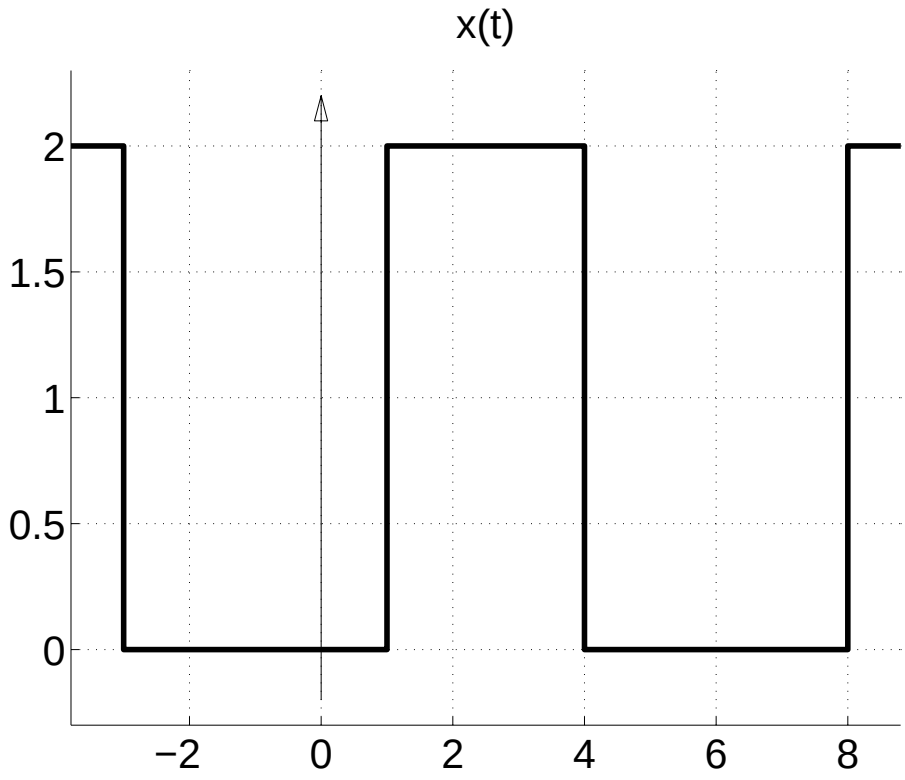

Figure 2: Periodic signal $x(t)$ in Problem 4D.