# T-61.140 Signal Processing Systems

1st mid term exam, Monday 10.3.2003 15-18, hall M.
You are not allowed to use a math reference book nor any calculator. Formulae given in a separate paper.

1. (6p) Statements, reply either TRUE (T) or FALSE (F). A correct answer +1 points, a wrong -1 points. Reply to as many statements as you want. However, the maximum number of points is six and minimum zero.

   a) The complex conjugate of the complex number $e^{-13\pi j/4}$ is $-0.7071 - 0.7071j$ (with the precision given in the formulae paper).

   b) Signal $x(t) = \cos(10\pi t) + \cos(10t)$ is periodic.

   c) Sequences $x_1[n] = e^{3\pi jn/8} + e^{-3\pi jn/8}$ and $x_2[n] = \sin(3\pi n/8 + \pi/16)$ have the same fundamental period.

   d) The output $y[n]$ of a causal LTI system is zero for all $n < 0$.

   e) The impulse response of a moving average filter with four points is given by $h[n] = 0.25\delta[n] + 0.25\delta[n-1]$.

   f) Convolution of sequences $x_1[n] = 3\delta[n] + 2\delta[n-1]$ and $x_2[n] = -\delta[n] + 2\delta[n-1]$ is $x[n] = x_1[n] * x_2[n] = -3\delta[n] + 4\delta[n-1] + 4\delta[n-2]$.

   g) The Fourier transform of the convolution of the signal $x(t) = e^{-t}u(t)$ and the impulse response $h(t) = e^{-5t}u(t)$ is $Y(j\omega) = 1/(5 + 6j\omega - \omega^2)$

   h) The inverse transform of the spectrum $Y(j\omega) = e^{-2j\omega}/(1 + 0.3j\omega)$ is $y(t) = e^{-0.3(t-2)}u(t-2)$

   j) The Fourier transform $H(j\omega)$ of the impulse response $h(t)$ is computed by multiplying impulse response by $e^{-j\omega t}$.

2. (6p) Consider a discrete-time system, whose input-output-relationship is $y[n] = 0.5x[n+2] + 0.5x[n+1]$.

   a) Is the system linear? Is it time-invariant? Is it causal? Explain briefly.

   b) If the input is $x[n] = 3\delta[n+1] - 2\delta[n]$, what is the output $y[n]$?

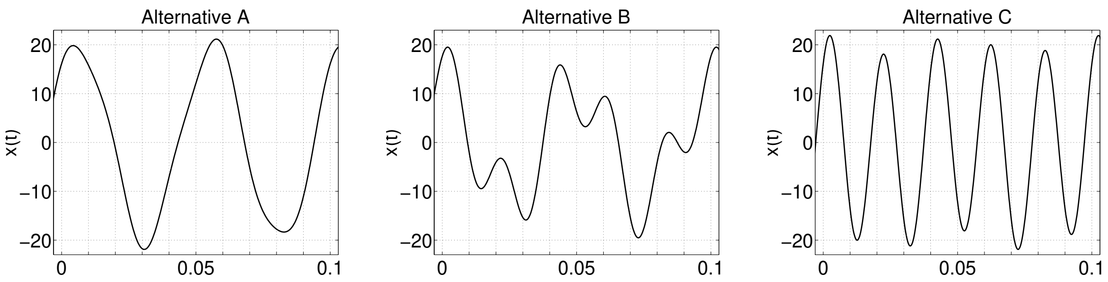
   c) If the output is $y[n] = \delta[n] - \delta[n-2]$, what is the input $x[n]$?

3. (6p) Non-zero Fourier-series coefficients of a periodic continuous-time signal are $a_{-5} = -10j,\ a_{-2} = 1,\ a_2 = 1,\ a_5 = 10j$. The fundamental angular frequency is $\omega_0 = 20\pi$ (rad/s).

   a) What is the fundamental period of the signal?

   b) What is the representation of the signal $x(t)$ using cosine/sine functions?

   c) Which figure below does represent the signal mostly? Explain briefly. In the x-axis there is time in the interval $-0.003$ s $\ldots 0.103$ s .




4. (6p) The number of students attending exercises weekly during this spring is given in the table below.

| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Week 6 |
|---|---|---|---|---|---|---|
| The number of students weekly: | 141 | 114 | 93 | 59 | 62 | 47 |

   Design a simple (as simple as possible), causal LTI system, which computes weekly differences of the amount of students in exercises.

   a) Write down the difference equation.

   b) Sketch the block (flow) diagram of the system.

   c) What is the impulse response of the system?

   d) What is the output sequence for an input given in the table above?