

Instituto Superior Técnico / University of Lisbon

Department of Bioengineering

Master on Biomedical Engineering

Signals and Systems in Bioengineering

1st Semester de 2014/2015

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Test 1

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Name :

Number:

The duration of the test is 1h30m. The score of each item is 2 when right and -0.5 if wrong. Only one option can be selected in each question.

1. Consider the complex signal $x(n) = [0; j; 1 + 3j; -1 - j; 0; 3; -2j; 1 - j]$. What is the value of $X_8(k)$ for $k = 8$?
 - a) 0.
 - b) 4.
 - c) $4 - j$.
 - d) None
2. Consider the signal $x(n) = [3; 2; 1; 0; 1; 2; 3; 4]$. What is the option where the 8-length DFT is real?
 - a) $x((n - 1)_8)$.
 - b) $x((n + 1)_8)$.
 - c) $x((n - 2)_8)$.
 - d) None
3. Consider the 4-length and 8-length sequences $x_4(n)$ and $y_8(n)$ respectively. Let also $w(n) = x(n) * y(n)$ and $z(n) = x(n) \star y(n)$ where $*$ and \star denote the linear and 8-length circular convolutions respectively. Select the right option.
 - a) $z(0) = w(0)$.
 - b) $z(1) = w(0)$.
 - c) $z(4) = w(4)$.
 - d) None

4. What is the frequency of the discrete signal $x(n) = \exp(j2n/7)$?

- a) $2/7$.
- b) $2/14$.
- c) $2\pi/14$.
- d) None

5. Consider the *Linear Time Invariant* (LTI) filter with the following transfer function

$$H(z) = \frac{1 - 0.1z^{-1}}{1 - 0.7z^{-1} + 0.1z^{-2}} \quad (1)$$

What is the corresponding time recursion that can be used to implement the filter?

- a) $y(n) = x(n) - 0.1x(n-1) + 0.7y(n-1) - 0.1y(n-2)$.
- b) $y(n) = x(n) - 0.1x(n-1) - 0.7y(n-1) + 0.1y(n-2)$.
- c) $y(n) = x(n) + 0.1x(n-1) + 0.7y(n-1) - 0.1y(n-2)$.
- d) None

6. Consider a 10 length signal $x = [0; 1; 2; 3; 4; 5; 6; 7; 8; 9]$. Sample the Fourier transform of x , $X(\omega)$, at 8 evenly spaced frequencies, $X_8(k)$, and compute $y(n) = DFT_8^{-1}(X)$, for $n = [0, 1, \dots, 7]$, where $DFT_8^{-1}()$ denotes a 8 length DFT inversion operator.

What is $y(n)$?

- a) $y(n) = [0; 1; 2; 3; 4; 5; 6; 7]$.
- b) $y(n) = [8; 9; 2; 3; 4; 5; 6; 7]$.
- c) $y(n) = [8; 10; 2; 3; 4; 5; 6; 7]$.
- d) None

7. Consider the following transfer function of a filter:

$$H(z) = \frac{1 - 0.5z^{-1}}{1 - (3/2)z^{-1} + (13/16)z^{-2}} \quad (2)$$

with poles $p_{1,2} = \frac{3}{4} \pm j\frac{1}{2}$. What is central frequency of this filter?

- a) $\omega_0 = 0$ rad/sample.
- b) $\omega_0 = 1$ rad/sample.
- c) $\omega_0 = \arctan(2/3)$.

- d) None
8. The goal is to filter, in real time, an audio signal from a microphone with a 25 length impulse response FIR filter. The signal should be processed with a 500 sample length blocks and the convolution is performed by using a 512 length FFT algorithm. What is the number of overlapped samples of the input blocks?
- a) 24.
 - b) 12.
 - c) 0.
 - d) None

Problem (4)

Let $X(k)$ and $Y(k)$ be the DFTs of the N -length $x(n)$ and $y(n)$ sequences respectively where

$$Y(k) = \begin{cases} -X(k) & \text{if } k \text{ is even} \\ X(k) & \text{otherwise} \end{cases} \quad (3)$$

1. What is the relation between $y(n)$ and $x(n)$
2. If $x(n) = [0; 1; 2; 3; 4; 5; 6; 7]$ what is $y(n)$?