Signals and Systems I (2016506)
Faculty of Engineering
Department of Electrical and Electronics Engineering

Lecture 3 - Systems (During Lecture)

1. **Consider the systems described by the following input-output relationships. Notice that S1 and S2 were the systems you had to implement in the "Before lecture" activity of this week**

$$\begin{aligned} &\text{S1} \quad y[n] = \cos[0.2\pi n]\, x[n] \\ &\text{S2} \quad y[n] = x[n] + 3x[n-1] \\ &\text{S3} \quad y[n] = x[n] + 3x[n-1]\, x[n-2] \end{aligned} \tag{1}$$

   a) **Write a subfunction within the .m file for system S3. Use the same archive in which you implemented S1 and S2**

   b) **Consider the test signals**

$$\begin{aligned} x_1[n] &= ne^{-0.2n}\left(u[n] - u[n-20]\right) \\ x_2[n] &= \cos[0.05\pi n]\left(u[n] - u[n-20]\right) \end{aligned} \tag{2}$$

   and the inputs

$$\begin{aligned} x[n] &= x_1[n] \\ x[n] &= x_2[n] \\ x[n] &= x_1[n] + x_2[n] \\ x[n] &= 5x_1[n] - 3x_2[n] \end{aligned} \tag{3}$$

   Compute and graph the response of the systems to each input. You must open three figure windows (one per system). In each window, there should be two subplots with four graphs:

   - <u>**First subplot:**</u>
     - **Graph 1:** $\text{Sys}\{x_1[n]\}$
     - **Graph 2:** $\text{Sys}\{x_2[n]\}$
     - **Graph 3:** $\text{Sys}\{x_1[n] + x_2[n]\}$
     - **Graph 4:** the sum of the responses to $x_1[n]$ and $x_2[n]$, labeled as $\text{Sys}\{x_1[n]\} + \text{Sys}\{x_2[n]\}$
   - <u>**Second subplot:**</u>
     - **Graph 1:** $\text{Sys}\{5x_1[n]\}$
     - **Graph 2:** $\text{Sys}\{3x_2[n]\}$
     - **Graph 3:** $\text{Sys}\{5x_1 - 3x_2[n]\}$
     - **Graph 4:** $5\,\text{Sys}\{x_1[n]\} - 3\,\text{Sys}\{x_2[n]\}$

   Conclude about the linearity of the systems

   c) **Compute and graph the output of each system to the inputs**

$$\begin{aligned} x[n] &= x_1[n-1] \\ x[n] &= x_2[n-3] \end{aligned} \tag{4}$$

   and compare them to the responses to the inputs $x_1[n]$ and $x_2[n]$, respectively. Open three figure windows (one per system). In each window, there should be two subplots with two graphs:

- **First subplot:**
  - **Graph 1:** $\text{Sys}\left\{x_1\left[n\right]\right\}$
  - **Graph 2:** $\text{Sys}\left\{x_1\left[n-1\right]\right\}$
- **Second subplot:**
  - **Graph 1:** $\text{Sys}\left\{x_2\left[n\right]\right\}$
  - **Graph 2:** $\text{Sys}\left\{x_2\left[n-3\right]\right\}$

Identify the time-variant systems from the set {S1, S2, S3}

d) **Based on the conclusions of the simulations above, fill the following table**

	Linear	**Time-invariant**
S1		
S2		
S3		

Intermezzo: a ***block diagram*** is a graphical representation of a system in which its components are represented by blocks connected by lines. These lines show the existing relationships between blocks. Block diagrams are broadly applied in controls, signal processing, communication and mechatronics. Loosely speaking, a block diagram can be used to provide a graphical representation of the interaction between signals through systems in a particular engineering process of interest.

2. **For this exercise, you will require to use Simulink.**

a) **Download the file** `L3.slx` **from the Google Classroom.**

b) **In these document, you will find three different systems. Only the input and output terminals of the systems will be used**

Using blocks from the Simulink Library Browser (under "Sources"), construct the following test signals

$$\begin{aligned}
x_1\left(t\right) &= u\left(t\right)\\
x_2\left(t\right) &= 2u\left(t\right)\\
x_3\left(t\right) &= 7\sin\left(\frac{2\pi}{10}t\right)\\
x_4\left(t\right) &= 7\sin\left(\frac{2\pi}{10}t-30^\circ\right)\\
x_5\left(t\right) &= u\left(t-1\right)
\end{aligned}$$

c) **Using the test signals, conclude about linearity and time-invariance of each system and fill the following table**

	Linear	**Time-invariant**
S1		
S2		
S3		

Hint: try signals x_1, x_2 and x_5 in systems 1 and 3, and signals x_3 and x_4 in system 2