**SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY**
**DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING**
**ACADEMIC YEAR 2019-2020 SEMESTER 1**
**DIGITAL SIGNAL PROCESSING**
**TUTORIAL 2**

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1. For each of the following discrete-time systems, where $y[n]$ and $x[n]$ are, respectively, the output and input sequences, determine whether or not the system is (1) linear, (2) causal, (3)BIBO bounded, and (4) time-invariant. Show the necessary derivation.
   (a) $y[n] = x[n+3]$;
   (b) $y[n] = x[2-n]+\alpha$, where $\alpha$ is a nonzero constant;
   (c) $y[n] = \ln(1-|x[n]|)$;
   (d) $y[n] = \beta+\sum_{l=-1}^{3} x[n-l]$, where $\beta$ is a nonzero constant.

2. Determine if the median filter defined by $y[n]= \text{med}\{x[n-k], \ldots, x[n-1], x[n], x[n+1], \ldots, x[n+k]\}$ for a window length-$(2k+1)$ is a time-invariant system? Is it a causal system?

3. The second derivative $y[n]$ of a sequence $x[n]$ at time instant $n$ is usually approximated by $y[n] = x[n+1]-2x[n]+x[n-1]$. If $y[n]$ and $x[n]$ denote the output and input of a discrete-time system, is the system linear? Is it time invariant? Is it causal?

4. Consider a causal discrete-time system characterized by a first-order linear, constant-coefficient difference equation given by
   $$y[n] = ay[n-1]+bx[n], \quad \text{for } n \geq 0$$
   where $y[n]$ and $x[n]$ are, respectively, the output and input sequences. Compute the expression for the output sample $y[n]$ in terms of the initial condition $y[-1]$ and the input samples.
   (a) Is the system time-invariant if $y[-1] = 1$? Is the system linear if $y[-1] = 1$?
   (b) Repeat part (a) if $y[-1] = 0$.