SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
ACADEMIC YEAR 2019-2020 SEMESTER 1
DIGITAL SIGNAL PROCESSING
TUTORIAL 3

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1. Consider the following sequences:

$$x[n] = \{2, 0, -1, 6, -3, 2, 0\}, \qquad -3 \le n \le 3,$$
$$y[n] = \{8, 2, -7, -3, 0, 1, 1\}, \qquad -5 \le n \le 1,$$
$$w[n] = \{3, 6, -1, 2, 6, 6, 1\}, \qquad -2 \le n \le 4.$$

   Determine the following sequence by a linear convolution of the sequences given above:
   (a) $u[n] = x[n] \circledast y[n]$;
   (b) $v[n] = x[n] \circledast w[n]$;
   (c) $g[n] = w[n] \circledast y[n]$.

2. Let $y[n] = x_1[n] \circledast x_2[n]$, and $v[n] = x_1[n-N_1] \circledast x_2[n-N_2]$. Express $v[n]$ in terms of $y[n]$.

3. Consider the following finite-length sequences:
   (i) $\{h[n]\}, -M \le n \le N$,
   (ii) $\{g[n]\}, K \le n \le N$,
   (iii) $\{w[n]\}, -L \le n \le -R$,
   where M, N, K, L and R are positive integers with $K < N$ and $L > R$. Define
   (a) $y_1[n] = h[n] \circledast h[n]$,
   (b) $y_2[n] = g[n] \circledast g[n]$,
   (c) $y_3[n] = h[n] \circledast g[n]$,
   (d) $y_4[n] = h[n] \circledast w[n]$,
   What is the length of each of the convolved sequences? What is the range of the index n for which each of the above convolved sequences is defined?

4. Develop a closed-form expression for the convolution: $a^n\mu[n] \circledast \mu[n]$.

5. Consider two complex-valued sequences $h[n]$ and $g[n]$ expressed as a sum of their respective conjugate symmetric and conjugate anti-symmetric parts, i.e., $h[n]= h_{cs}[n]+ h_{ca}[n]$, and $g[n]= g_{cs}[n]+ g_{ca}[n]$. For each of the following sequences, determine if it is conjugate symmetric or conjugate antisymmetric.
   (a) $h_{cs}[n] \circledast g_{cs}[n]$ (b) $h_{ca}[n] \circledast g_{cs}[n]$ (c) $h_{ca}[n] \circledast g_{ca}[n]$

6. Show that the following sequences are absolutely summable, where $|\alpha|<1$
   (a) $x_1[n]= \alpha^n\mu[n-1]$ for $|\alpha|<1$, (b) $x_2[n]= n\alpha^n\mu[n-1]$ for $|\alpha|<1$, and (c) $x_3[n]= \mu[n]/((n+2)(n+3))$

7. An LTI discrete-time system is characterized by a left-side impulse response given by $h[n] = \alpha^n\mu[-n-1]$. Determine the range of the value of the constant α for which the system is BIBO stable.

8. Develop a general expression for the output $y[n]$ of an LTI discrete-time system in terms of its input $x[n]$ and the unit step response $s[n]$ of the system.

9. Determine the step response of an LTI discrete-time system characterized by an impulse response $h[n] = (-\alpha)^n \mu[n]$, $0 < \alpha < 1$.

10. Determine the expression for the impulse response of following LTI system.