TASK 1 – GENERATION OF ELEMENTARY SIGNALS AND SYSTEM ANALYSIS

1. Generate the elementary signals that are employed for characterization of random signals. Also, generate a sinusoidal signal and subject the same to the following basic signal processing operations
   a. Time Shifting / Delaying (TD)
   b. Folding / Reflection (FD)
   c. Verify, whether TD[FD]=FD[TD]
   d. Convolution
   e. Correlation

   Illustrate the above operations with relevant waveforms.

2. Also, graphically verify whether the following system is linear / non-linear, Stable / unstable:
   $\boldsymbol{y(n) = y^2(n-1) + x(n)}$, for the bounded input $\boldsymbol{x(n) = u(n) + u(n-2)}$

3. Generate and plot each of the following sequences over the indicated interval.

a. $x(n) = 2\delta(n+2) - \delta(n-4)$, $-5 \le n \le 5$

b. $x(n) = n[u(n) - u(n-10)] + 10e^{-0.3(n-10)}[u(n-10) - u(n-20)]$

c. $x(n) = \cos(0.04\pi n) + 0.2w(n)$, $0 \le n \le 50$, where $w(n)$ is a Gaussian random sequence with zero mean and unit variance.

4. Given the following difference equation
   $y(n) - y(n-1) + 0.9y(n-2) = x(n)$; for all n

   a. Calculate and plot the impulse response $h(n)$ at $n = -20,\ldots,100$.

   b. Calculate and plot the unit step response $s(n)$ at $n = -20,\ldots,100$.

   c. Is the system specified by $h(n)$ stable?

5. A particular linear and time-invariant system is described by the difference equation
   $$y(n) - 0.5y(n-1) + 0.25y(n-2) = x(n) + 2x(n-1) + x(n-3)$$
   a. Determine the stability of the system.
   b. Determine and plot the impulse response of the system over $0 \le n \le 100$. Determine the stability from this impulse response.

6. A simple digital differentiator is given by
   $$y(n) = x(n) - x(n-1)$$
   which computes a backward first-order difference of the input sequence. Implement this differentiator on the following sequences and plot the results. Comment on the appropriateness of this simple differentiator.

   a. $x(n) = 5\,[u(n) - u(n-20)]$: a rectangular pulse

   b. $x(n) = n[u(n) - u(n-10)] + (20-n)[u(n-10) - u(n-20)]$: a triangular pulse

   c. $x(n) = \sin\left(\dfrac{\pi n}{25}\right)[u(n) - u(n-100)]$: a sinusoidal pulse