Ref. No.: Ex/IEBT/T/223/2018

B.TECH INSTRUMENTATION AND ELECTRONICS ENGINEERING
SECOND YEAR SECOND SEMESTER – 2018

Subject : DIGITAL SIGNAL PROCESSING **Time : Three hours** **Full Marks :100**

Answer *any* ten. All questions carry equal marks.

1. a) Determine the impulse response of a causal linear time invariant system which produces the output signal
$y(n) = 6\,\delta(n) + 10\,\delta(n-1) - 9\,\delta(n-2) - 14\,\delta(n-3) + 5\,\delta(n-4) - \delta(n-6)$
when excited by the input signal $x(n) = 3\,\delta(n) + 5\,\delta(n-1) - \delta(n-3)$
b) Consider a sinusoidal signal sampled at 8000 Hz. This signal is applied to a system which produces the following output signal
$y(n) = x(n)$ when n is even integer
$= 0$ otherwise.
What is the frequency of the output signal when the input signal is 400Hz?

2. a) Consider a causal LTI system whose output is
$y(n) - (3/4)\,y(n-1) + (1/8)y(n-2) = 2x(n)$
determine its impulse response.
If the input to this system is $x(n) = (1/4)^n\, u(n)$. What will be its output?
b) What is the stability criterion of a discrete time system?

3. a) Consider the finite sequence
$x(n) = 1$ for $-1 \le n \le 1$
$= 0$ otherwise
Determine its DTFT and DFT. Plot them.
b) Find the time domain signal x(n) given its Fourier series coefficients
$X(k) = j\,\delta(k-1) - j\,\delta(k+1) + \delta(k-3) + \delta(k+3)$ and $\omega_0 = \pi$.
Repeat the problem for $\omega_0 = 3\pi$.

4. Find out whether the system $y(n) = x^2(n)u(n)$ is
a) linear, b) causal, c) stable, d) time invariant, d) memory less.

5. a) Find the convolution of $x_1(n) = \{1\ 2\ 3\}$ with $x_2(n) = \{2\ 2\ 5\}$ graphically. Origin is at 2nd instant.
b) Express the following signal as weighted sum of time shifted impulses
$x(n) = 1$ for $n = \pm 1, \pm 3$
$= 2$ for $n = \pm 2$
$= 0$ otherwise.

6. a) Prove that $x(n) * \delta(n-m) = x(n-m)$.
b) Convolute $x(n) = n+1$ for $n = 0,1,2$
$= 0$ otherwise
with $h(n) = 2^n\, u(n)$.

7. Use the z-transform to perform the convolution of the following two sequences
$$h(n) = \begin{cases} (1/2)^n & 0 \le n \le 2 \\ 0 & \text{otherwise} \end{cases}$$
And $x(n) = \delta(n) + \delta(n-1) + 4\delta(n-2)$.

8. An FIR filter is given by the system function
$H(z) = 1 + 16.0625z^{-4} + z^{-8}$.
Draw the filter structure.

9. Design a digital Butterworth filter to meet the constraint

$$0.9 \leq |H(e^{j\omega})| \leq 1,\ 0 \leq \omega \leq \pi/2$$
$$|H(e^{j\omega})| \leq 0.2,\ 3\pi/4 \leq \omega \leq \pi$$

10. Design a single pole low pass digital filter with a 3-dB bandwidth of 0.2π, using the bilinear transformation applied to the analog filter

$$H(s) = \Omega_c/(s+\Omega_c)$$

where Ω_c is the 3dB bandwidth of the analog filter.

11. A low pass filter is to be designed with the following desired frequency response

$$H_d(e^{j\omega}) = e^{-2j\omega} \quad , \quad -\pi/4 \leq \omega \leq \pi/4$$
$$= 0 \quad , \quad \pi/4 < \omega \leq \pi$$

Determine the filter coefficient $h_d(n)$ if the window function is defined as

$$w(n) = 1 \quad , \quad 0 \leq n \leq 4$$
$$= 0 \quad , \quad \text{otherwise.}$$

12. Write short notes on: (any two)
    i) Merits and demerits of DFT method.
    ii) Process of Sampling an analog signal and its reconstruction
    iii) Comparison between linear convolution and circular convolution.
    iv) Phase delay and group delay.

Compare Fourier transform, Laplace Transform and Z-transform.