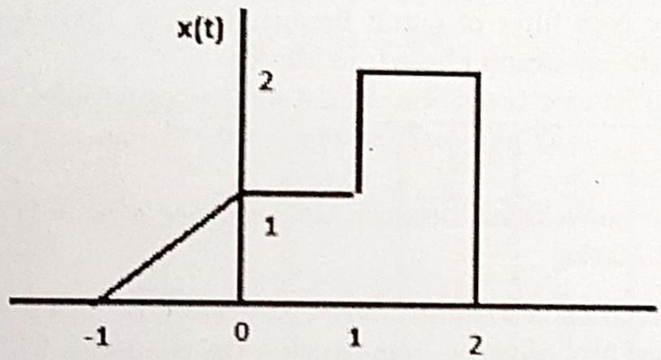
Indian Institute of Space Science and Technology
Signals and Systems AV223
Department of Avionics

End Examination May 2023

8th May 2023, Marks: 50, Time: 9.30 am to 12.30 am

Answer ALL questions

1. (i) A continuous time signal is shown in Figure.1, sketch the following: (a) $x(t)u(1-t)$ (b) $x(t)\delta(t-3/2)$ [2 Marks]



(ii) A continuous time periodic signal is given by $x(t) = 1+\frac{1}{2}cos2\pi t+cos4\pi t+\frac{2}{3}cos6\pi t$. Determine the fundamental frequency ω_0 and the Fourier series coefficients a_k such that $x(t) = \sum_{-\infty}^{\infty} a_k e^{j\omega_0 kt}$.[2 Marks]
(iii) Can the Fourier series representation of $x[n] = 2cos\sqrt{2}\pi n$ be determined. Justify your answer. [1 Marks]

2. (i) Compute and plot the convolution $y[n] = x[n+2] * h[n]$ if $x[n] = \delta[n]+2\delta[n-1]-\delta[n-3]$ and $h[n] = 2\delta[n+1]+2\delta[n-1]$. Also determine the correlation between $x[n]$ and $h[n]$ given by $r_{xh}(m)$. [3 Marks]
(ii) Find $h[n]$, the unit impulse response of the LTID system specified by $y[n]-5y[n-1]+6y[n-2] = 8x[n-1]-19x[n-2]$ using time domain analysis. [2.5 Marks]
(iii) Using classical approach solve $(D^2+4D-4)y(t) = (D+3)x(t)$ for the initial conditions $y(0^+) = 0$, $\dot{y}(0^+) = 2$ and input $x(t) = u(t)$. Is the system stable. [2.5 Marks]

3. (i) Consider a causal LTI sytem with frequency response $H(j\omega) = \frac{1}{j\omega+3}$, for a particular input $x(t)$, this system is observed to produce the output $y(t) = e^{-3t}u(t)-e^{-4t}u(t)$. Determine $x(t)$. [2.5 Marks]
(ii) Let $x[n]$ and $h[n]$ be signals with the following Fourier Transform $X(e^{j\omega}) = 3e^{j\omega}+$

$1-e^{-j\omega}+2e^{-3j\omega}$ and $H(e^{j\omega}) = -e^{-j\omega}+2e^{-2j\omega}+e^{4j\omega}$. Determine $y[n] = x[n] * h[n]$. [2 Marks]

(iii) Determine the signal $x[n]$ for the given Fourier transform $X(e^{j\omega}) = e^{j\omega}[1+cos\omega]$ [2 Marks]

(iv) Determine and sketch the magnitude and phase of the system given by $Y[n] = 1/3\{x[n]+x[n-1]+x[n-2]$ using FT.[2.5 Marks]

4. (i) Find the initial and final value of the signal given by $X(s) = \frac{s+3}{(s+3)^2+4}$. [2 Marks]
(ii) A CT signal is $h(t) = \delta(t-3)$ if $x(t) = cos4tu(t) + cos7tu(t)$ is given as input, what is the response $y(t)$ using Laplace transform? [3 Marks]
(iii) Draw the direct form II structure of the transfer function $H(s) = \frac{8s^3-4s^2+11s-2}{(s-1/4)(s^2-s+1/2)}$. [2 Marks]
(iv) Find the step response of the system described by $H(s) = \frac{10}{(s^2+6s+10)}$. [2.5 Marks].
(v) Determine the unilateral Laplace transform of $x(t) = \delta(t+1)+\delta(t)+e^{-2(t+3)}u(t+1)$. [1.5 Marks]

5. (i) Consider a CT signal $x(t) = 10cos(10\pi t)$. Draw the spectrum of the signal using FT. If it is sampled at 8 samples per second, draw the spectrum. If the signal is passed through a low pass filter of cutoff frequency $\omega_c = 15\pi$rad/sec, what is the output spectrum. Is the spectrum aliased. [3 Marks]
(ii) A signal $x(t)$ with Fourier transform $X(j\omega)$ undergoes impulse train sampling to generate $x_p(t) = \sum_{n=-\infty}^{\infty} x(nT)\delta(t-nT)$ where $T = 10^{-4}$, can $x(t)$ be recovered from $x_p(t)$, explain. [1 Mark]
(iii) Compute circular convolution between the sequence $x[n] = [1, 0.5]$ and $h[n] = [0.5, 1]$ using DFT. [2 Marks]

6. (i) The input output relation of a causal stable LTI is given by $y[n] = \alpha y[n-1]+\beta x[n]$. If the impulse response $h[n]$ of the system satisfies the condition $\sum_{n=0}^{\infty} h[n] = 2$, find the relation between α and β. [2 Marks]
(ii) For the given difference equation $3y[n] - 4y[n-1] + y[n-2] = x[n]$, associated input $x[n] = (1/2)^n u[n]$ and initial conditions $y[-1] = 1$ and $y[-2] = 2$, determine the output $y[n]$. [3 Marks]
(iii) A causal LTI system is shown in the Figure.2. Determine a difference equation relating $y[n]$ and $x[n]$. Is the system stable. [3 Marks]
(iv) A causal LTI system is described by $y[n] = y[n-1]+y[n-2]+x[n-1]$. Find the system function $H(z)$. Plot the poles and zeros and indicate the region of convergence. [3 Marks]