Roll No											

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF

MID TERM EXAMINATION

Winter Semester: 2021 - 22

Course Code: ECE 2003

Course Name: Signals and Systems

Program & Sem: B.Tech, II Sem

Date: 12/May/2022

Time: 10:00 AM – 11:30 AM

Max Marks: 50

Weightage: 25%

Instructions:

(i) Calculators NOT allowed.

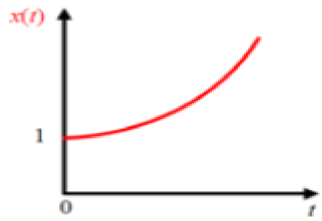
(ii) You must show ALL work or explain answer for each problem to receive full credits

---

Part A [Memory Recall Questions]

Answer all the questions. Each question carries ONE mark. (10Qx 1M= 10M)

1. A signal $x(t)$ is given as in figure below. What is the Fourier transform of this signal?



(C.O.1)[Knowledge]

2. An everlasting signal exists over the entire interval $-\infty < t < \infty$. Is a periodic signal, by its definition, an everlasting signal? Is it also causal?
(C.O.1)[Comprehension]

3. Statement 1: All causal systems are systems with memory.

Statement 2: All systems with memory are causal.

Are the above statements true?
(C.O.1)[Knowledge]

4. Identify if the system $y(t) = tx(t) + x(t-1)$ is static(memoryless) or dynamic(memory)?

(C.O.1)[Knowledge]

5. $x(t-T)$ represents $x(t)$ time-shifted by T seconds. If T is negative, the shift is to the _______________ side of the time axis, called as “advance”. Else, it is “delay”.

(C.O.1)[Comprehension]

6. The implication of truncated Fourier series approximation of a discontinuous signal is that it will in general exhibit high-frequency ripples and overshoot near the discontinuities. This phenomenon is called as ___________________.
[1M](C.O.2)[Knowledge]

7. Check whether the system $y(t) = \cos(3t)x(t)$ is time variant or not.
[1M](C.O.1)[Knowledge]

8. Find the conjugate of $x[n] = [-4 - j5, 6 + j4]$.
[1M](C.O.1)[Knowledge]

9. What is the Fourier Transform of $x(t) = A$?
[1M](C.O.2)[Knowledge]

10. The derivative of a signal $x(t)$ is found to be an impulse signal. Identify $x(t)$.

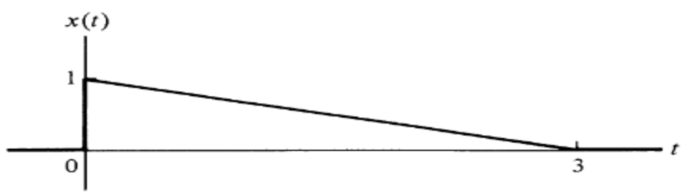
(C.O.1)[Knowledge]

Part B [Thought Provoking Questions]

Answer all the questions. Each question carries FOUR mark. (4Qx4M=16M)

11. John needs to perform convolution graphically for which he needs to perform some basic operations on signals. His teacher advised him to practice the basic operations on signal $x(t)$ given below before using it for convolution. Help him to identify the below given operations and sketch the following:

a. $x(-t)$
b. $x(t+2)$
c. $x(2t+2)$
d. $x(1-3t)$

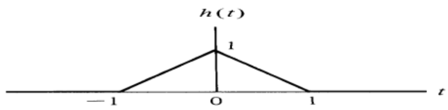


[4M](C.O.1)[Comprehension]

12. *One of the important properties of convolution is the sifting property by which convolution of a function with a shifted impulse yields a shifted version of that function. i.e.,* $f(t) * \delta(t - t_0) = f(t_0)$. If $x(t)$ is an impulse train, i.e., $x(t) = \sum_{k=-\infty}^{+\infty} \delta(t - kT)$ and $h(t)$ is as shown below, then

a. Sketch $x(t)$

b. Assuming $T = 2$, determine and sketch $y(t) = x(t) * h(t)$.



(C.O.1) [Comprehension]

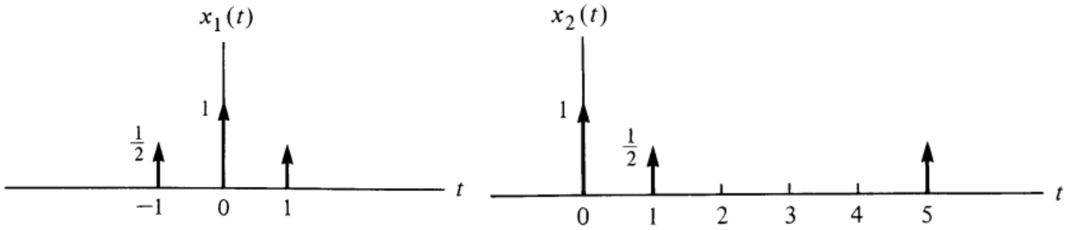
13. Let $x(t)$ be a periodic signal, with fundamental period T_0 and Fourier series coefficientsa_k. Consider the following signals. Express the Fourier series coefficients for each signal

a. $x(t - t_0)$

b. $x(t) = [1 + \cos(2\pi t)][\sin(10\pi t + \frac{\pi}{6})]$

Hint: $\cos\theta = \frac{e^{j\theta}+e^{-j\theta}}{2}$ *and* $\sin\theta = \frac{e^{j\theta}-e^{-j\theta}}{2j}$.
(C.O.2)[Comprehension]

14. Find the Fourier transforms $X_1(j\omega)$ and $X_2(j\omega)$ of the below two signals $x_1(t)$ and $x_2(t)$ respectively



[4M](C.O.2)[Comprehension]

Part C [Problem Solving Questions]

Answer all the questions. Each question carries EIGHT mark. (3Qx8M=24M)

15. *Our development of the convolution sum representation for discrete-time LTI systems was based on using the unit sample function as a building block for the representation of arbitrary input signals. This representation, together with knowledge of the response to* $\delta(t)$ *and the property of superposition, allowed us to represent the system response to an arbitrary input in terms of a convolution.* If a system has an impulse response $h(t) = 2\delta(t) - \delta(t-1) - \delta(t+1)$, then graphically determine the response $y(t)$, for an arbitrary input $x(t) = \delta(t) + \delta(t-1)$. You should divide your work as follows:

a. Sketch $h(t)$ and $x(t)$.

b. Write down the relationship between $y(t)$, $x(t)$ and $h(t)$.

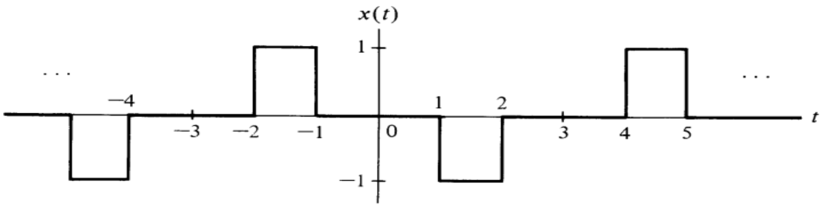
c. Flip $h(t)$ in the above relationship and shift it to get $h(t-\tau)$. Determine by what amount of t should you shift it to start the convolution. Sketch this shifted impulse-response.

d. Now slide the shifted impulse response across the entire stretch of the given input step-by-step. Sketch the shifted impulse-responses at each step that will result in a non-zero output.

e. Sketch the response of the system for each shifted impulse-response you showed above.

f. Finally, sketch the total response $y(t)$.
(C.O.1)[Comprehension]

16. *The purpose of this problem is to show that the representation of an arbitrary periodic signal by a Fourier series, or more generally by a linear combination of any set of orthogonal functions, is computationally efficient and in fact is very useful for obtaining good approximations of signals.* By evaluating the Fourier series analysis equation, determine the Fourier series for the below signal $x(t)$.



(C.O.2)[Comprehension]

17. Consider a signal $x(t)$, which consists of a single rectangular pulse of unit height, is symmetric about the origin and has a total width T_1.

a. Sketch $x(t)$

b. Sketch $\tilde{x}(t)$, which is periodic repetition of $x(t)$ with period $T_0 = 3T_1/2$

c. Compute a_k, the Fourier series coefficients of $\tilde{x}(t)$. Sketch a_k for $k = 0, \pm 1, \pm 2, \pm 3$.

d. Compute $X(j\omega)$, the Fourier transform of $x(t)$. Try to sketch $|X(j\omega)|$ for $|\omega| \leq 6\pi/T_1$

Hint: Try to recall how Fourier series coefficients act as samples and form the spectrum of Fourier transform as $T_0 \rightarrow \infty$
(C.O.2)[Comprehension]

Roll No												

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF

MID TERM EXAMINATION

Winter Semester: 2021 - 22

Course Code: ECE 2003

Course Name: Signals and Systems

Program & Sem: B.Tech, II Sem

Date: 12/May/2022

Time: 10:00 AM – 11:30 AM

Max Marks: 50

Weightage: 25%

Instructions:

(iii) Calculators NOT allowed.

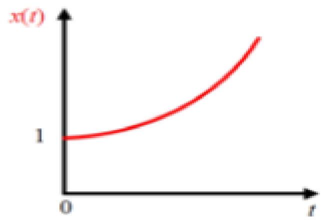
(iv) You must show ALL work or explain answer for each problem to receive full credits

---

Part A [Memory Recall Questions]

Answer all the questions. Each question carries ONE mark. (10Qx 1M= 10M)

1. A signal $x(t)$ is given as in figure below. What is the Fourier transform of this signal?



(C.O.1)[Knowledge]

2. An everlasting signal exists over the entire interval $-\infty < t < \infty$. Is a periodic signal, by its definition, an everlasting signal? Is it also causal?
(C.O.1)[Comprehension]

3. Statement 1: All causal systems are systems with memory.

Statement 2: All systems with memory are causal.

Are the above statements true?
(C.O.1)[Knowledge]

4. Identify if the system $y(t) = tx(t) + x(t-1)$ is static(memoryless) or dynamic(memory)?

(C.O.1)[Knowledge]

5. $x(t-T)$ represents $x(t)$ time-shifted by T seconds. If T is negative, the shift is to the _______________ side of the time axis, called as "advance". Else, it is "delay".

(C.O.1)[Comprehension]

6. The implication of truncated Fourier series approximation of a discontinuous signal is that it will in general exhibit high-frequency ripples and overshoot near the discontinuities. This phenomenon is called as ____________________.
[1M](C.O.2)[Knowledge]

7. Check whether the system $y(t) = \cos(3t)x(t)$ is time variant or not.
[1M](C.O.1)[Knowledge]

8. Find the conjugate of $x[n] = [-4 - j5, 6 + j4]$.
[1M](C.O.1)[Knowledge]

9. What is the Fourier Transform of $x(t) = A$?
[1M](C.O.2)[Knowledge]

10. The derivative of a signal $x(t)$ is found to be an impulse signal. Identify $x(t)$.

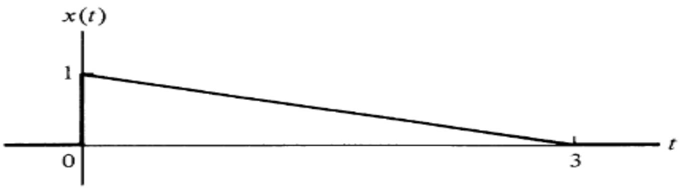
(C.O.1)[Knowledge]

Part B [Thought Provoking Questions]

Answer all the questions. Each question carries FOUR mark. (4Qx4M=16M)

11. John needs to perform convolution graphically for which he needs to perform some basic operations on signals. His teacher advised him to practice the basic operations on signal $x(t)$ given below before using it for convolution. Help him to identify the below given operations and sketch the following:

e. $x(-t)$
f. $x(t+2)$
g. $x(2t+2)$
h. $x(1-3t)$

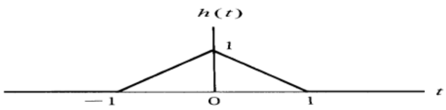


[4M](C.O.1)[Comprehension]

12. *One of the important properties of convolution is the sifting property by which convolution of a function with a shifted impulse yields a shifted version of that function. i.e.,* $f(t) * \delta(t - t_0) = f(t_0)$. If $x(t)$ is an impulse train, i.e., $x(t) = \sum_{k=-\infty}^{+\infty} \delta(t - kT)$ and $h(t)$ is as shown below, then

a. Sketch $x(t)$

b. Assuming $T = 2$, determine and sketch $y(t) = x(t) * h(t)$.



(C.O.1) [Comprehension]

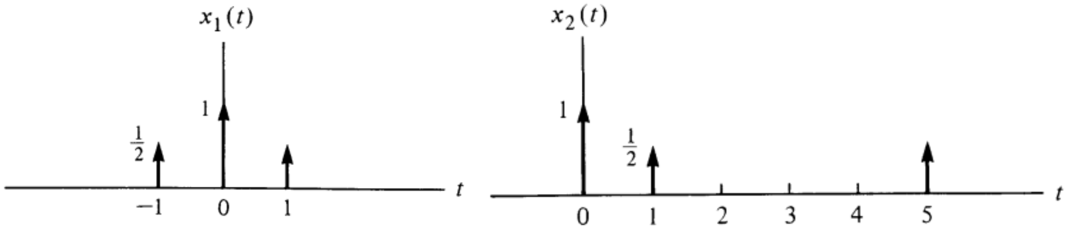
13. Let $x(t)$ be a periodic signal, with fundamental period T_0 and Fourier series coefficientsa_k. Consider the following signals. Express the Fourier series coefficients for each signal

a. $x(t - t_0)$

b. $x(t) = [1 + \cos(2\pi t)][\sin(10\pi t + \frac{\pi}{6})]$

Hint: $\cos\theta = \frac{e^{j\theta}+e^{-j\theta}}{2}$ *and* $\sin\theta = \frac{e^{j\theta}-e^{-j\theta}}{2j}$.
(C.O.2)[Comprehension]

14. Find the Fourier transforms $X_1(j\omega)$ and $X_2(j\omega)$ of the below two signals $x_1(t)$ and $x_2(t)$ respectively



[4M](C.O.2)[Comprehension]

Part C [Problem Solving Questions]

Answer all the questions. Each question carries EIGHT mark. (3Qx8M=24M)

15. *Our development of the convolution sum representation for discrete-time LTI systems was based on using the unit sample function as a building block for the representation of arbitrary input signals. This representation, together with knowledge of the response to $\delta(t)$ and the property of superposition, allowed us to represent the system response to an arbitrary input in terms of a convolution.* If a system has an impulse response $h(t) = 2\delta(t) - \delta(t-1) - \delta(t+1)$, then graphically determine the response $y(t)$, for an arbitrary input $x(t) = \delta(t) + \delta(t-1)$. You should divide your work as follows:

a. Sketch $h(t)$ and $x(t)$.

b. Write down the relationship between $y(t)$, $x(t)$ and $h(t)$.

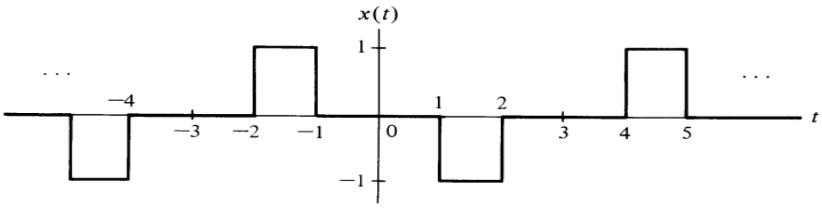
c. Flip $h(t)$ in the above relationship and shift it to get $h(t-\tau)$. Determine by what amount of t should you shift it to start the convolution. Sketch this shifted impulse-response.

d. Now slide the shifted impulse response across the entire stretch of the given input step-by-step. Sketch the shifted impulse-responses at each step that will result in a non-zero output.

e. Sketch the response of the system for each shifted impulse-response you showed above.

f. Finally, sketch the total response $y(t)$.
(C.O.1)[Comprehension]

16. *The purpose of this problem is to show that the representation of an arbitrary periodic signal by a Fourier series, or more generally by a linear combination of any set of orthogonal functions, is computationally efficient and in fact is very useful for obtaining good approximations of signals.* By evaluating the Fourier series analysis equation, determine the Fourier series for the below signal $x(t)$.



(C.O.2)[Comprehension]

17. Consider a signal $x(t)$, which consists of a single rectangular pulse of unit height, is symmetric about the origin and has a total width T_1.

a. Sketch $x(t)$

b. Sketch $\tilde{x}(t)$, which is periodic repetition of $x(t)$ with period $T_0 = 3T_1/2$

c. Compute a_k, the Fourier series coefficients of $\tilde{x}(t)$. Sketch a_k for $k = 0, \pm 1, \pm 2, \pm 3$.

d. Compute $X(j\omega)$, the Fourier transform of $x(t)$. Try to sketch $|X(j\omega)|$ for $|\omega| \leq 6\pi/T_1$

Hint: Try to recall how Fourier series coefficients act as samples and form the spectrum of Fourier transform as $T_0 \to \infty$

(C.O.2)[Comprehension]

Roll No												

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM EXAMINATION

Winter Semester: 2021 - 22

Course Code: ECE 2003

Course Name: SIGNALS AND SYSTEMS

Program & Sem: B Tech – II Sem

Date: 8th July 2022

Time: 01:00 PM to 04:00 PM

Max Marks: 100

Weightage: 50%

Instructions:

(v) Calculators NOT allowed.

(vi) You must show ALL work or explain answer for each problem to receive full credits

---

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries ONE mark. (15Qx 1M= 15M)

1. Laplace Transform of a signal exists only in the region of convergence of the signal. Name any signal for which the ROC is entire s-plane. (C.O.No.3) [Knowledge]

2. Check if the following function is memoryless or not: $y(t) = Rx(t)$. (C.O.No.1) [Knowledge]

3. Sampling theorem is followed strictly in modulation systems so as to reconstruct back the original signal from the samples. What is the relationship between f_s, sampling frequency and the message frequency, f_m according to sampling theorem? (C.O.No.3) [Knowledge]

4. Check whether the system $y(t) = (3t + 5)x(t)$ is causal or not. (C.O.No.1) [Knowledge]

5. Fourier transform of a signal exists if it is absolutely integrable. Does the Fourier transform exist for e^{at} for $a > 1$? (C.O.No.2) [Knowledge]

6. If the examination procedure at University is considered as an LTI system where the input is the answers written in the answer script and output is the number of marks received, what will be the total marks of a student who fails to take the test? (C.O.No.1) [Knowledge]

7. What is the expression for continuous-time Fourier Transform of $x(t - 3)$? (C.O.No.2) [Knowledge]

8. The minimum sampling frequency required to reconstruct the original signal from its samples using an ideal low pass filter is called the Nyquist rate. For a signal $x(t) = cos(100\pi t)$, What will be the Nyquist rate in Hertz? (C.O.No.3) [Knowledge]

9. What is the Laplace Transform ROC for a left sided continuous-time signal?

(C.O.No.3) [Knowledge]

10. The impulse signal is a signal whose value is equal to unity at $n = 0$, and at all other values of n, the signal value is zero. The z-transform of impulse signal is ____. (C.O.No.3) [Knowledge]

11. Four different transforms have been introduced thus far:

I. Continuous-time Fourier series
II. Discrete-time Fourier series
III. Continuous-time Fourier transform
IV. Discrete-time Fourier transform

In the following table, fill in the blanks with I, II, III, or IV depending on which transform(s) can be used to represent the signal described on the left. Finite duration means that the signal is guaranteed to be nonzero over only a finite interval.

[5M]

Q. No	Signal Description			Transform
11.1	a. Continuous time	Infinite duration	Periodic	
11.2	b. Continuous time	Infinite duration	Aperiodic	
11.3	c. Continuous time	Finite duration	Aperiodic	
11.4	d. Discrete time	Infinite duration	Periodic	
11.5	e. Discrete time	Infinite duration	Aperiodic	

(C.O.No.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries NINE marks. (5Qx9M=45M)

12. A discrete time LTI system input-output relation is shown by a linear constant coefficient difference equation. Consider the linear constant coefficient difference equation for an LTI system initially at rest, $y[n] - \frac{1}{2}y[n-1] = x[n]$

a. What is the system function that describes $Y(e^{j\Omega})$ in terms of $X(e^{j\Omega})$?
b. For the above system, evaluate $y[n]$ if $x[n]$ is
   i. $\delta(n)$
   ii. $\left(\frac{3}{4}\right)^n u(n)$

(C.O.No.2) [Comprehension]

13. *According to time differentiation property* $\frac{dx(t)}{dt} \overset{FT}{\leftrightarrow} j\omega.X(\omega)$. A causal LTI filter has the frequency response $H(\omega) = -2j\omega$. For each of the following input signals, determine the filtered output signal $y(t)$.

(a) $x(t) = e^{jt}$ (b) $X(\omega) = \frac{1}{j\omega+2}$ (C.O.No.2) [Application]

14. *Sampling is the process in which the multiplication of a signal with impulse train takes place. Multiplication in time domain is convolution in frequency domain.* Consider the system in Fig. 14.1.

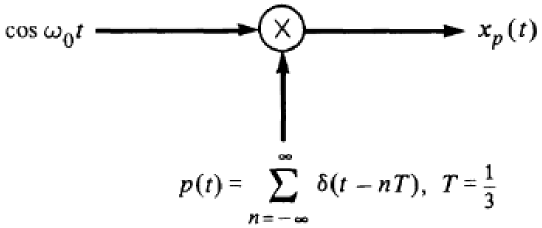


Fig. 14.1

Sketch $X_p(w)$for $-9\pi \leq \omega \leq 9\pi$ for the following values of ω_0.

(i) $\omega_0 = \pi$ (ii) $\omega_0 = 2\pi$ (iii) $\omega_0 = 3\pi$ (iv) $\omega_0 = 5\pi$

(C.O.No.3) [Comprehension]

15. For different signals, same expression for Laplace transform exists but with different ROC. Draw the ROC and determine $x(t)$ for the following conditions if $X(s)$ is given by $X(s) = \frac{1}{(s+1)(s+2)}$

(a) $x(t)$ is right-sided (b) $x(t)$ is left-sided (c) $x(t)$ is two-sided (C.O.No.3)[Comprehension]

16. The pole-zero plot for the z-transform $X(z)$ of a sequence $x[n]$ is shown in Fig.16.1.

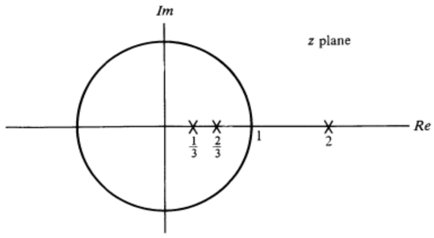


Fig.16.1

Determine what can be inferred about the associated region of convergence from each of the following statements.

(a) $x[n]$ is right-sided.
(b) $x[n]$ is left-sided.
(c) The Fourier transform of $x[n]$ converges.
(d) The Fourier transform of $x[n]$ does not converge.

(C.O.No.3)[Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each question carries TEN marks.
(4Qx10M=40M)

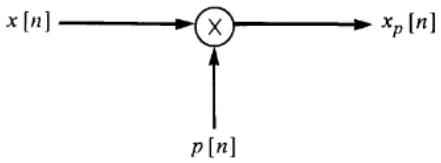
17. *Differential systems form the class of systems for which the input and output signals are related implicitly through a linear, constant coefficient ordinary differential equation.* If the output of a causal LTI system is related to the input $x(t)$ by the differential equation $\frac{dy(t)}{dt} + 2y(t) = x(t)$.

(a) Determine the frequency response $H(j\omega) = \frac{Y(j\omega)}{X(j\omega)}$ and sketch the phase and magnitude of $H(j\omega)$.

(b) If $x(t) = e^{-t}u(t)$, determine $Y(j\omega)$, the Fourier transform of the output.

(c) Find $y(t)$ for the input given in (b). (C.O.No. 2) [Comprehension]

18. Consider the system in Fig.18.1 and $p[n]$ as in Fig.18.2



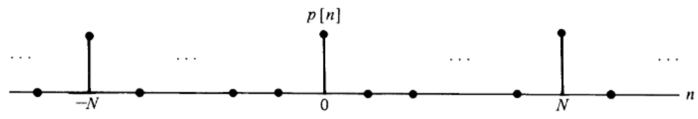
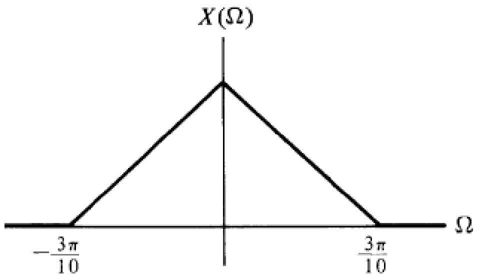


Fig.18.1 Fig.18.2

a. Sketch $P(e^{j\Omega})$ for $N = 1{,}2$.
b. For each of the discrete time spectra shown in Fig.18.3 and Fig.18.4 determine the maximum sampling period N such that $x[n]$ is re-constructible from its samples $x_p[n]$ using an ideal low-pass filter. In each case, specify the associated cut off frequencies for the low-pass filter.



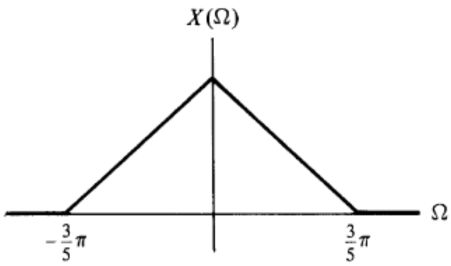


Fig.18.3 Fig.18.4

(C.O.No.2) [Comprehension]

19. The Laplace transform exists in s-plane except at poles. Determine the Laplace transform, pole and zero locations, and associated ROC for each of the following time functions.

(a) $e^{-at}u(t), a < 0$ (b) $-e^{-at}u(-t), a > 0$ (c) $e^{at}u(t), a > 0$
(d) $e^{-a|t|}, a > 0$ (e) $u(t)$ (f) $\delta(t - t_0)$

(C.O.No.3) [Comprehension]

20. An LTI system has an impulse response $h[n]$ for which the z-transform is $H(z) = \sum_{n=-\infty}^{\infty} h[n]z^{-n} = \frac{1}{1-\frac{1}{2}z^{-1}}, \quad |z| > \frac{1}{2}$

a. Plot the pole-zero pattern for $H(z)$.
b. Using the fact that signals of the form z^n are eigen functions of LTI systems, determine the system output for all n if the input is $x[n] = \left(\frac{3}{4}\right)^n + 3(2)^n$

(C.O.No.3) [Comprehension]