26. An input signal $x(t) = 2 + 5\sin(100\pi t)$ is sampled with a sampling frequency of 400 Hz and applied to the system whose transfer function is represented by $H(z) = \frac{1}{N}\left[\frac{1-z^{-N}}{1-z^{-1}}\right]$ where N represents the number of samples per cycle. The output $y(n)$ of the system under steady state is ________.

(a) 0

(b) 1

(c) 2

(d) 5

GATE 2m

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$x(t) = 2 + 5\sin 100\pi t$

$f_s = 400\text{Hz} \Rightarrow T_s = \frac{1}{400}$

$x(nT_s) = 2 + 5\sin 100\pi \frac{n}{400}$

$x(n) = 2 + 5\sin \frac{\pi}{4} n$

$N = \frac{2\pi}{\omega_0} \cdot m = \frac{2\pi}{\pi/4} \cdot m$

$= 8m$

$N = 8$

$H(z) = \frac{1}{8}\left[\frac{1-z^{-8}}{1-z^{-1}}\right]$

$H(e^{j\omega}) = \frac{1}{8}\left[\frac{1-e^{-j8\omega}}{1-e^{-j\omega}}\right]$

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$$H(e^{j0}) = \frac{1}{8}\left(\frac{1-e^{0}}{1-e^{0}}\right) = \frac{0}{0}$$

$$= \lim_{\omega \to 0} \frac{1}{8} \; \frac{0 - e^{-j8\omega}(-j8)}{0 - e^{-j\omega}(-j)}$$

$$= 1$$

$$H(e^{j0}) = 1$$

$$H(e^{j\pi/4}) = \frac{1}{8}\left(\frac{1-e^{-j8\cdot\frac{\pi}{4}}}{1-e^{-j\pi/4}}\right)$$

$$= \frac{1}{8}\,\frac{(1-1)}{(\quad)} = 0$$

$$y(n) = 1\cdot(2) + 0\cdot\left(5\sin\frac{\pi}{4}n\right)$$

$$y(n) = 2$$

Ans = 2

28. A ~~casual~~ Causal LTI system is described by the D.E $2y(n) = \alpha y[n-2] - 2x[n] + \beta x[n-1]$

The system is stable only if

(a) $|\alpha| = 2, |\beta| < 2$ (b) $|\alpha| > 2, |\beta| > 2$

(c) $|\alpha| < 2$, any β (d) $|\beta| < 2$, any α

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$$2y(n) = \alpha y(n-2) - 2x(n) + \beta x(n-1)$$

$$2Y(z) = \alpha z^{-2} Y(z) - 2X(z) + \beta z^{-1} X(z)$$

$$Y(z)(2 - \alpha z^{-2}) = X(z)(-2 + \beta z^{-1})$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{-2 + \beta z^{-1}}{2 - \alpha z^{-2}}$$

$$2 - \alpha z^{-2} = 0$$

$$2z^2 - \alpha = 0$$

$$z = \pm\sqrt{\frac{\alpha}{2}}$$

$$\left|\sqrt{\frac{\alpha}{2}}\right| < 1$$

$$\left|\frac{\alpha}{2}\right| < 1$$

$$|\alpha| < 2$$

(c)

For a causal and stable sys all the poles must lie inside unit circle.

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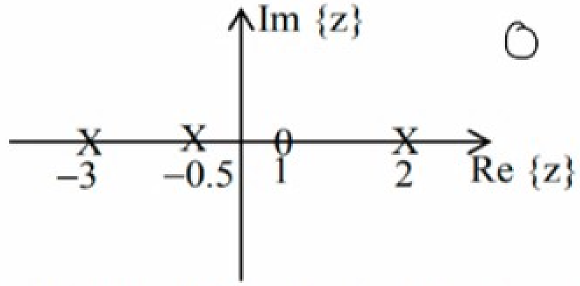
29. Consider an LTI system whose pole-zero pattern is shown in figure

x pole

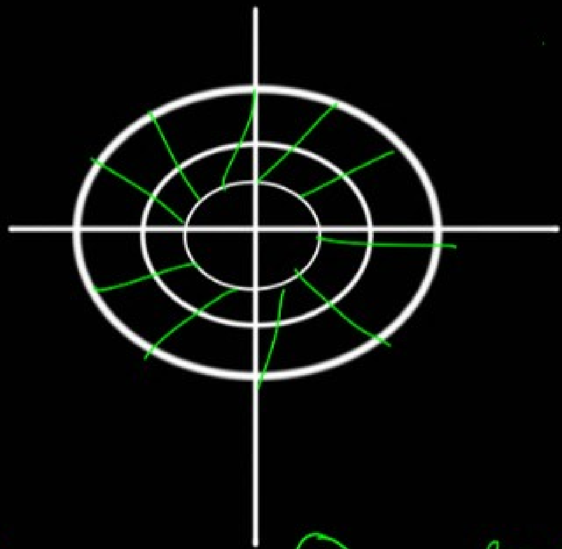
O zero



(a) Find the ROC of system function, if it is known to be stable?

(b) Is it possible for the given pole-zero plot to be a causal & stable system?

(c) How many possible ROC's are there?



(a)

$0.5 < |z| < 2 \Rightarrow$ ROC includes unit circle

(b) Not possible to have both causal and stable

(c) $|z| > 3$, $|z| < 0.5$

$0.5 < |z| < 2$, $2 < |z| < 3$

$0.5 < |z| < 3$ is invalid as this is including pole at $z = 2$

30. The impulse response h(n) of a LTI system is real. The transfer function H(z) of the system has only one pole and it is at z = 4/3. The zeros of H(z) are non-real and located at |z| = 3/4. The system is

(a) stable & causal (b) unstable & anticausal

(c) unstable & causal (d) stable & anticausal

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If h(n) is real and if at all H(z) has complex zeros and complex poles then they always occur in conjugate pairs.

$$H(z) = \frac{(z - \frac{3}{4}e^{j\theta})(z - \frac{3}{4}e^{-j\theta})}{z - 4/3} = \frac{z^2 + \cdots}{z - 4/3}$$

$$= z + \cdots$$

$$h(n) = \delta(n+1) + \cdot \quad h(n) \neq 0 \quad n < 0$$

System is Anti Causal $\Rightarrow |z| < \frac{4}{3}$ ✓ ROC includes unit circle

$|z| < 1.33$

System is stable

32. Consider the system with transfer function, $H(z) = \frac{z^{-1}}{1-2z^{-1}}$. Then the corresponding stable impulse response is

(a) $-0.5\,\delta(n) - 0.5\,(2)^n\,u[-n-1]$

(b) $2^{n-1}\,u[n-1]$

(c) $0.5\,\delta(n) + 0.5\,(2)^{n-1}\,u[n-1]$

(d) $0.5\,\delta(n) + 2^n\,u[-n-1]$

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$-a^n u(-n-1) \to \frac{z}{z-a}$

$|z| < |a|$

$H(z) = \frac{1}{z-2}$

$\cancel{|z| > 2}$, $|z| < 2$ ✓ → ROC is including unit circle

$= \frac{1}{2} \frac{2}{z-2}$

$= \frac{1}{2}\left(\frac{2 - z + z}{z-2}\right)$

$= \frac{1}{2}\left(-1 + \frac{z}{z-2}\right)$

$h(n) = -0.5\,\delta(n) - 0.5\,2^n u(-n-1)$

Ans (a)

33. Suppose $x[n]$ is an absolutely summable discrete-time signal. Its z-transform is a rational function with two poles and two zeros. The poles are at $z = \pm 2j$. Which one of the following statements is TRUE for the signal $x[n]$?

GATE - 2015

(a) It is a finite duration signal.

(b) It is a causal signal.

(c) It is a non-causal signal.

(d) It is a periodic signal.

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$$X(z) = \frac{\quad}{(z+2j)(z-2j)}$$

ROC should include unit circle

$|z| > 2$, $|z| < 2$ ✓ Non-causal signal.

34. y(n) – 0.8y(n–1) = x(n) + 1.25x(n+1). Its right sided impulse response is ______

(a) Causal (b) Unbounded

(c) Periodic (d) Non-negative

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$$Y(z) - 0.8z^{-1}Y(z) = X(z) + 1.25z^{1}X(z)$$

$$Y(z)(1 - 0.8z^{-1}) = X(z)(1 + 1.25z)$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1 + 1.25z}{1 - 0.8z^{-1}}$$

$$= \frac{1}{1-0.8z^{-1}} + 1.25\frac{z}{1-0.8z^{-1}}$$

$$= \frac{z}{z-0.8} + 1.25z\frac{z}{z-0.8}$$

$$h(n) = (0.8)^n u(n) + 1.25(0.8)^{n+1}u(n+1)$$

$h(n) \neq 0 \quad n < 0$

$\Rightarrow$ Not causal

Ans (d)

35. Consider the following statements regarding a linear discrete - time system

$$H(z) = \frac{z^2 + 1}{(z+0.5)(z-0.5)}$$

1. The system is stable.
2. The initial value h(0) of the impulse response is - 4.
3. The steady-state output is zero for a sinusoidal discrete time input of frequency equal to one-fourth the sampling frequency.

Which of these statements are correct?

(a) 1, 2 and 3
(b) 1 and 2
(c) 1 and 3
(d) 2 and 3

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Poles = ± 0.5

poles are inside unit circle $\Rightarrow$ stable

$$h(0) = \lim_{z\to\infty} H(z)$$

$$= \lim_{z\to\infty} \frac{\cancel{z^2}(1+1/z^2)}{\cancel{z^2}\left(1+\frac{0.5}{z}\right)\left(1-\frac{0.5}{z}\right)}$$

$$= \frac{1}{(1+0)(1-0)}$$

$$= \underline{1}$$

2 is False

35. Consider the following statements regarding a linear discrete - time system

$$H(z) = \frac{z^2+1}{(z+0.5)(z-0.5)}$$

1. The system is stable.
2. The initial value h(0) of the impulse response is - 4.
3. The steady-state output is zero for a sinusoidal discrete time input of frequency equal to one-fourth the sampling frequency.

Which of these statements are correct?

(a) 1, 2 and 3 (b) 1 and 2

(c) 1 and 3 (d) 2 and 3

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$$x(t) = A \sin \omega_0 t$$

$$\omega_0 = \frac{\omega_s}{4}$$

$$x(nT_s) = A \sin \frac{\omega_s}{4} \cdot nT_s$$

$$= A \sin \frac{2\pi}{4} n$$

$$x(n) = A \sin \frac{\pi}{2} n$$

$$H(e^{j\omega}) = \frac{e^{j2\omega}+1}{(e^{j\omega}+0.5)(e^{j\omega}-0.5)}$$

$$\Rightarrow H(e^{j\pi/2}) = \frac{e^{j2\cdot\frac{\pi}{2}}+1}{(\quad)(\quad)}$$

$$H(e^{j\pi/2}) = 0$$

$$y(n) = 0\left(A \sin \frac{\pi}{2} n\right) = 0$$

3 is correct.

(C)

36. **Assertion (A):** The stability of the system is assured if the Region of Convergence (ROC) includes the unit circle in the Z-plane.

Reason (R): For a causal stable system all the poles should be outside the unit circle in the Z-plane.

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A : True

R : False

37. **Statement (I):** The system function

$$H(z)=\frac{z^3-2z^2+z}{z^2+\frac{1}{4}z+\frac{1}{8}}$$ is not causal.

Statement (II): If the numerator of H(z) is of lower order than the denominator, the system may be causal.

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$$H(z) = \frac{-1}{2} + \frac{1}{2}\frac{z}{z-2}$$

$$h(n) = -\frac{1}{2}\delta(n) - \frac{1}{2}2^n u(-n-1)$$

$$h(n) \neq 0 \quad n<0$$

I $H(z) = z + (\quad)$

$h(n) = \delta(n+1) + (\quad) \neq 0 \quad n<0 \Rightarrow$ Not causal

$\Rightarrow$ Not causal

II $H(z) = \frac{1}{z-2} \quad |z|<2$

$$= \frac{2}{2(z-2)} = \frac{1}{2}\frac{(2-z+z)}{z-2}$$

whenever the numerator of H(z) is of lower order than the denominator, the sys may or may be causal.

38. **Statement (I):**

Z-transform approach is used to analyze the discrete time systems and is also called as pulse transfer function approach.

Statement (II):

The sampled signal is assumed to be a train of impulses whose strengths, or areas, are equal to the continuous time signal at the sampling instants.

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H(z) is the ratio of Z-Transform of sampled output to the Z-Transform of sampled input

$$H(z) = \frac{Y(z)}{X(z)} = \frac{Z.T\{y(n)\}}{Z.T\{x(n)\}}$$

Both I and II are true and II is the correct explanation for I

Continuous	$\omega \to 0$ $s \to 0$	$\omega \to \infty$ $s \to \infty$	
Discrete	$\omega \to 0$ $z \to 1$	$\omega \to \pi$ $z \to -1$	$\omega = \omega_c$
LPF	1	0	$1/\sqrt{2}$
HPF	0	1	$1/\sqrt{2}$
BPF	0	0	1
BRF	1	1	0
APF	1	1	1

$z = e^{j\omega}$

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Identify the nature of the filter $H(s) = \frac{s}{s^2+3s+3}$

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$$H(0) = \frac{0}{0+0+3} = 0$$

$$H(\infty) = \lim_{s\to\infty} \frac{s}{s^2\left(1+\frac{3}{s}+\frac{3}{s^2}\right)}$$

$$= \frac{1}{s\left(1+\frac{3}{s}+\frac{3}{s^2}\right)}$$

$$= \frac{1}{\infty(1+0+0)} = 0$$

Ans BPF

$$H(s) = \frac{s^2}{s^2+3s+3}$$

$$H(0) = \frac{0}{3} = 0$$

$$H(\infty) = \lim_{s\to\infty} \frac{s^2}{s^2\left(1+\frac{3}{s}+\frac{3}{s^2}\right)}$$

$$= \lim_{s\to\infty} \frac{1}{1+0+0}$$

$$= 1$$

Ans : HPF

Identify the nature of the filter with Impulse response $h(n) = (-0.8)^n u(n)$

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$$H(z) = \frac{z}{z+0.8}$$

$\omega = 0$

$$H(1) = \frac{1}{1+0.8} = \frac{1}{1.8} = 0.555$$

$\omega = \pi$

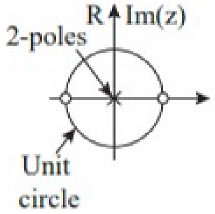
$$H(-1) = \frac{-1}{-1+0.8} = \frac{-1}{-0.2} = 5$$

HPF

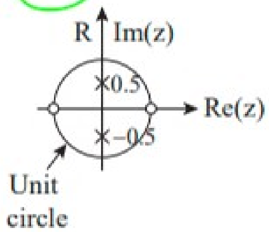
The pole-zero plots of three discrete-time systems P, Q and R on the z-plane are shown below.

[GATE-17 S2]

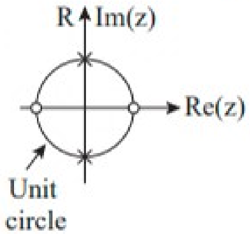
1



2



3



Which one of the following is TRUE about the frequency selectivity of these systems?

(a) All three are high-pass filters

(b) All three are band-pass filters ✓

(c) All three are low-pass filters

(d) P is a low-pass filter, Q is a band-pass filter and R is a high-pass filter.

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1 $H(z) = \dfrac{(z-1)(z+1)}{z^2}$

$H(1) = 0 \qquad H(-1) = 0$

BPF

2 $H(z) = \dfrac{z^2-1}{(z-j0.5)(z+j0.5)}$

$= \dfrac{z^2-1}{z^2+0.25}$ BPF

3 $H(z) = \dfrac{z^2-1}{(z+j)(z-j)} = \dfrac{z^2-1}{z^2+1}$ BPF

A discrete real allpass system has a pole at $z = 2\angle 30°$: it, therefore, **[GATE-06]**

(a) also has a pole at $1/2\angle 30°$

(b) has a constant phase response over the z-plane: $\arg|H(z)| = \text{const}$

(c) is stable only if it is anticausal

(d) has a constant phase response over the unit circle: $\arg|H(e^{j\Omega})| = \text{const}$

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For real all pass system, poles occur in conjugate pairs

$$z = 2\angle 30° = 2e^{j\pi/6}$$

The other pole is $2e^{-j\pi/6}$

$|z| < |2e^{j\pi/6}|$

$|z| < 2$ or $|z| > 2$

Anticausal $|z| < 2$

$\Rightarrow$ ROC is including unit circle. $\Rightarrow$ stable

Ans (c)

A discrete-time all-pass system has two of its poles at $0.25\angle 0^\circ$ and $2\angle 30^\circ$. Which one of the following statements about the system is TRUE?

(GATE -18)

(a) It has two more poles at $0.5\angle 30^\circ$ and $4\angle 0^\circ$.

(b) It is stable only when the impulse response is two-sided.

(c) It has constant phase response over all frequencies.

(d) It has constant phase response over the entire z-plane.

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(b) $0.25 < |z| < 2$

ROC includes unit circle

$\Rightarrow$ System is stable.

Ans (b)

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$$H(z) = \frac{\alpha + z^{-1}}{1+\alpha z^{-1}}, \text{ find } |H(e^{jw})|, \angle H(e^{jw})$$

$$H(e^{jw}) = \frac{\alpha + e^{-jw}}{1+\alpha e^{-jw}} = \frac{\alpha + \cos w - j\sin w}{1+\alpha\cos w - j\alpha\sin w}$$

$$|H(e^{jw})| = \sqrt{\frac{(\alpha+\cos w)^2 + (\sin w)^2}{(1+\alpha\cos w)^2 + (\alpha\sin w)^2}} = \sqrt{\frac{\alpha^2 + \cos^2 w + 2\alpha\cos w + \sin^2 w}{1+\alpha^2\cos^2 w + 2\alpha\cos w + \alpha^2\sin^2 w}}$$

$$= \sqrt{\frac{\alpha^2 + 1 + 2\alpha\cos w}{1+\alpha^2 + 2\alpha\cos w}}$$

$$= \underline{1}$$

$$|H(e^{jw})| = \underline{1} \;\; \forall \; w$$

$$\angle H(e^{jw}) = \tan^{-1}\left(\frac{-\sin w}{\alpha + \cos w}\right) - \tan^{-1}\left(\frac{-\alpha\sin w}{1+\alpha\cos w}\right)$$

Let $X(z) = \frac{1}{1 - z^{-3}}$ be the Z - transform of a causal signal x[n]. Then, the value of x[2] and x[3] are

[GATE-14-S1]

(a) 0 and 0 (b) 0 and 1

(c) 1 and 0 (d) 1 and 1

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$$u(n) \longrightarrow \frac{z}{z-1}$$

$$u(n|3) \longrightarrow \frac{z^3}{z^3-1}$$

$$X(z) = \frac{z^3}{z^3-1}$$

$$x(n) = u(n|3) = \{\underset{\uparrow}{1}, 0, 0, 1, 0, 0, 1, 0, 0 \ldots\}$$

$$x(2) = 0, \quad x(3) = 1 \qquad (b)$$

$$\frac{1}{1-r} = 1 + r + r^2 + r^3 + \ldots \qquad |r| < 1$$

$$\frac{1}{1-z^{-3}} = 1 + z^{-3} + z^{-6} + z^{-9} + \ldots$$

$$|z^{-3}| < 1 \qquad \frac{1}{|z|^3} < 1 \Rightarrow |z| > 1$$

The z-Transform of a sequence x[n] is given as $X(z) = 2z + 4 - 4/z + 3/z^2$. If y[n] is the first difference of x[n], then Y(z) is given by

[GATE-15 S2]

(a) $2z + 2 - \frac{8}{z} + \frac{7}{z^2} - \frac{3}{z^3}$

(b) $-2z + 2 - \frac{6}{z} + \frac{1}{z^2} - \frac{3}{z^3}$

(c) $-2z - 2 + \frac{8}{z} - \frac{7}{z^2} + \frac{3}{z^3}$

(d) $4z - 2 - \frac{8}{z} - \frac{1}{z^2} + \frac{3}{z^3}$

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$y(n) = x(n) - x(n-1)$

$Y(z) = X(z) - z^{-1}X(z)$

$Y(z) = 2z + 4 - 4z^{-1} + 3z^{-2}$

$-2 - 4z^{-1} + 4z^{-2} - 3z^{-3}$

$Y(z) = 2z + 2 - 8z^{-1} + 7z^{-2} - 3z^{-3}$

(a)

The z – transform of a signal x[n] is given by $4z^{-3} + 3z^{-1} + 2 - 6z^2 + 2z^3$. It is applied to a system, with a transfer function $H(z) = 3z^{-1} - 2$. Let the output be y(n). Which of the following is true?

[GATE-09]

(a) y(n) is non causal with finite support

(b) y(n) is causal with infinite support

(c) $y(n) = 0; |n| > 3$

(d) $\mathrm{Re}[Y(z)]_{z=e^{j\theta}} = -\mathrm{Re}[Y(z)]_{z=e^{-j\theta}}$

$\mathrm{Im}[Y(z)]_{z=e^{j\theta}} = \mathrm{Im}[y(z)]_{z=e^{-j\theta}}; -\pi \le \theta < \pi$

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$Y(z) = X(z) \cdot H(z)$

$= 12z^{-4} + 9z^{-2} + \cancel{6z^{-1}} - 18z^{1} + 6z^{2}$

$- 8z^{-3} - \cancel{6z^{-1}} - 4 + 12z^{2} - 4z^{3}$

$= -4z^{3} + 18z^{2} - 18z - 4$

$+ 9z^{-2} - 8z^{-3} + 12z^{-4}$

$y(n) = \{-4, 18, -18, \underset{\uparrow}{-4}, 0, 9, -8, 12\}$

n=0

Ans (a)

A cascade system having the impulse responses $h_1(n) = \{\underset{\uparrow}{1}, -1\}$ and $h_2(n) = \{\underset{\uparrow}{1}, 1\}$ is shown in the figure below, where symbol $\uparrow$ denotes the time origin. **[GATE-17-S2]**

$$x(n) \longrightarrow \boxed{h_1(n)} \longrightarrow \boxed{h_2(n)} \longrightarrow y(n)$$

The input sequence $x(n)$ for which the cascade system produces an output sequence $y(n) = \{\underset{\uparrow}{1}, 2, 1, -1, -2, -1\}$ is

(a) $x(n) = \{\underset{\uparrow}{1}, 2, 1, 1\}$

(b) $x(n) = \{\underset{\uparrow}{1}, 1, 2, 2\}$

(c) $x(n) = \{\underset{\uparrow}{1}, 1, 1\}$

(d) $x(n) = \{\underset{\uparrow}{1}, 2, 2, 1\}$

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Overal I.R $= h_1(n) * h_2(n)$

$$\begin{array}{cccc} & 1 & -1 & \\ & 1 & 1 & \\ \hline & 1 & -1 & \\ \times & & 1 & -1 \\ \hline \end{array}$$

$h(n) = \{\underset{\uparrow}{1} \quad 0 \quad -1\}$

$y(n) = x(n) * h(n)$

$Y(z) = X(z)\,H(z) \Rightarrow X(z) = \dfrac{Y(z)}{H(z)}$

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$$X(z) = \frac{1 + 2z^{-1} + 1z^{-2} - 1z^{-3} - 2z^{-4} - z^{-5}}{1 - z^{-2}}$$

$$= \frac{(1 + 2z^{-1} + z^{-2}) - z^{-3}(1 + 2z^{-1} + z^{-2})}{1 - z^{-2}}$$

$$a^3 - b^3 = (a-b)(a^2 + ab + b^2)$$

$$a^2 - b^2 = (a+b)(a-b)$$

$$= \frac{(1 + 2z^{-1} + z^{-2})(1 - z^{-3})}{1 - z^{-2}}$$

$$= \frac{\cancel{(1+z^{-1})}^2 \cancel{(1 - z^{-1})}(1 + z^{-1} + z^{-2})}{\cancel{(1 - z^{-1})}\cancel{(1+z^{-1})}} = (1+z^{-1})(1+z^{-1}+z^{-2})$$

$$= 1 + z^{-1} + z^{-2} + z^{-1} + z^{-2} + z^{-3}$$

$$= 1 + 2z^{-1} + 2z^{-2} + z^{-3}$$

$$x(n) = \{\underset{\uparrow}{1}, 2, 2, 1\}$$

(d)

The causal signal with z-transform $z^2(z-a)^{-2}$ is ($u[n]$ is the unit step signal) **[GATE-21]**

(a) $a^{2n}u[n]$
(b) $(n+1)a^n u[n]$
(c) $n^{-1}a^n u[n]$
(d) $n^2 a^n u[n]$

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$$a^n u(n) \rightarrow \frac{z}{z-a}$$

$$n u(n) \rightarrow \frac{z}{(z-1)^2}$$

$$a^n n u(n) \rightarrow \frac{z/a}{\left(\frac{z}{a}-1\right)^2} = \frac{az}{(z-a)^2}$$

$$a^n x(n) \rightarrow X(z/a)$$

$$X(z) = \frac{z^2}{(z-a)^2} = \frac{z^2 - az + az}{(z-a)^2}$$

$$= \frac{z(z-a)}{(z-a)^2} + \frac{az}{(z-a)^2}$$

$$= \frac{z}{z-a} + \frac{az}{(z-a)^2}$$

$a^n u(n) + a^n n u(n)$

$(n+1)a^n u(n)$ //

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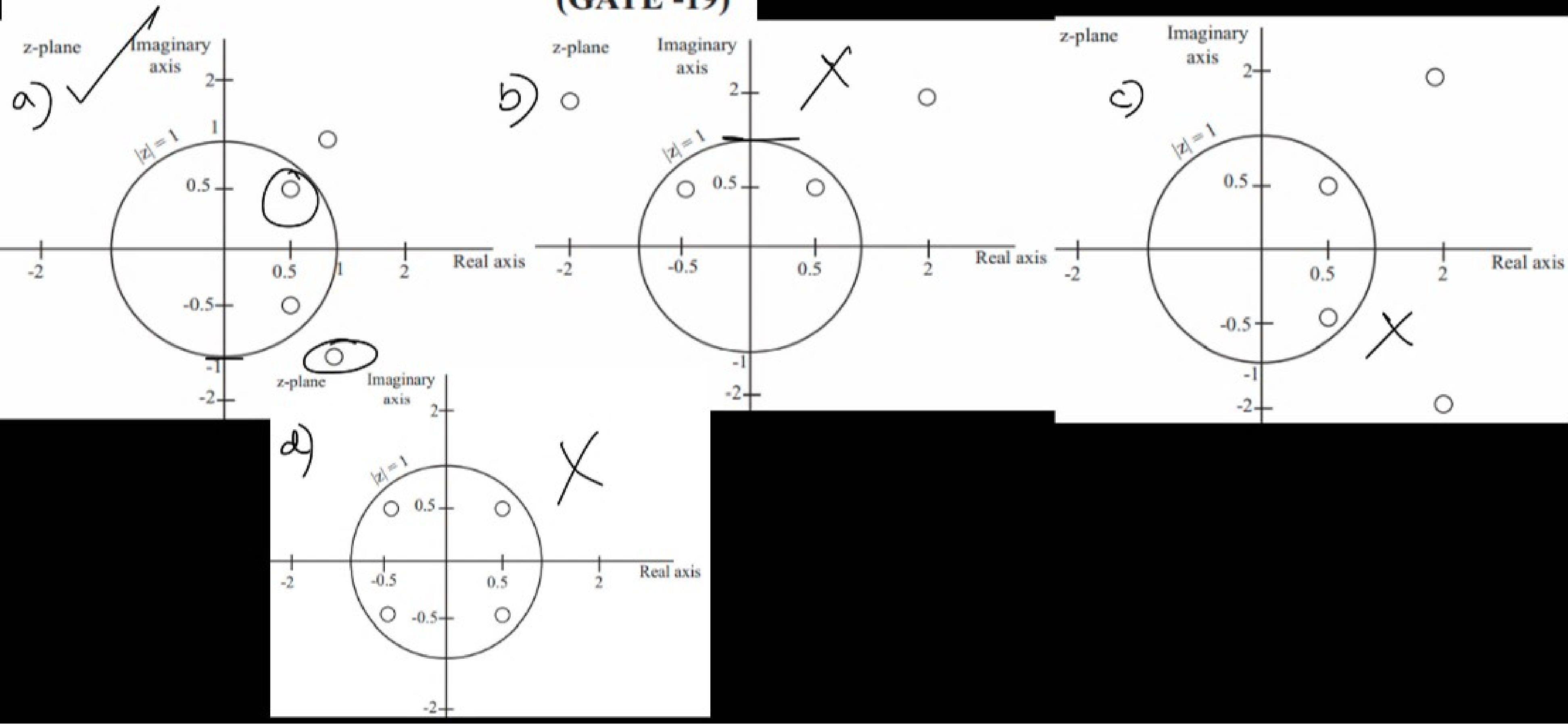
Let H(z) be the z-transform of a real-valued discrete-time signal h[n]. If $P(z) = H(z)\ H\left(\frac{1}{z}\right)$ has a zero at $z = \frac{1}{2} + \frac{1}{2}j$, and P(z) has a total of four zeros, which one of the following plots represents all the zeros correctly?

(GATE -19)

$$z = \frac{1}{2} + \frac{1}{2}j$$

$$z = \frac{1}{\frac{1}{2}+\frac{1}{2}j} = \frac{2}{1+j} = \frac{2(1-j)}{(1+j)(1-j)}$$

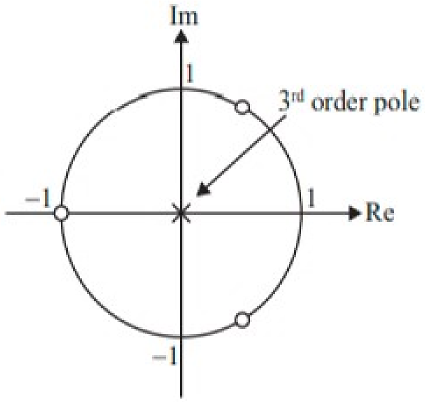
$$= 1-j$$



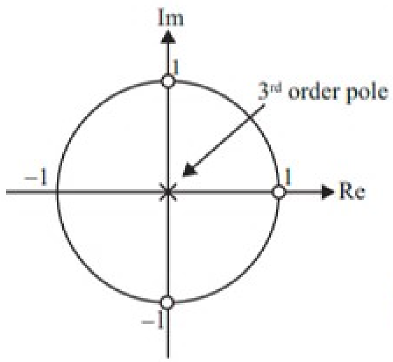
Which one of the following pole-zero plots corresponds to the transfer function of an LTI system characterized by the input-output difference equation given below?

$$y[n]=\sum_{k=0}^{3}(-1)^k x[n-k]$$ **(GATE -20)**

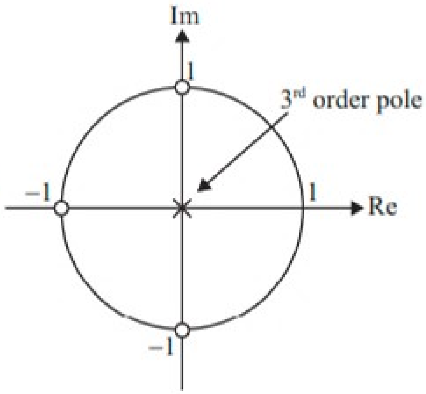
(a)



(c)



(b)



(d)