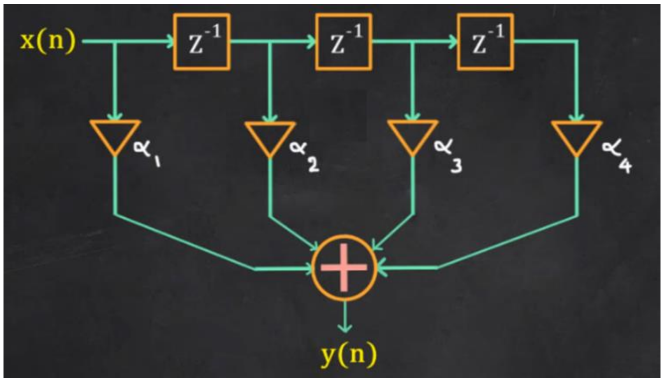
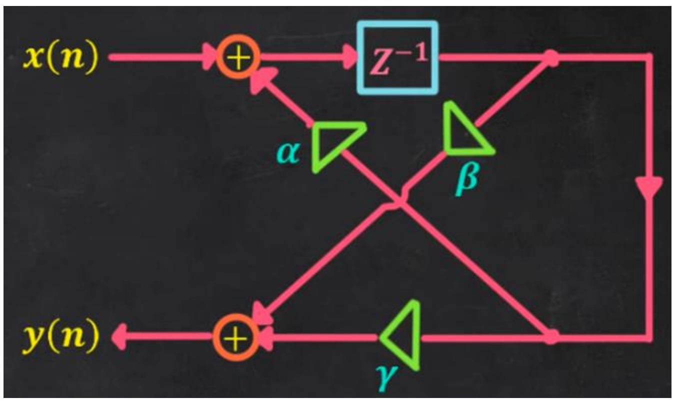
Q1: Find y(n) expression in the following block diagrams, **(a)** and **(b)**. In **(a)**, assume that α's are scalar values. In **(b)**, assume α, β, γ are all scalar values.

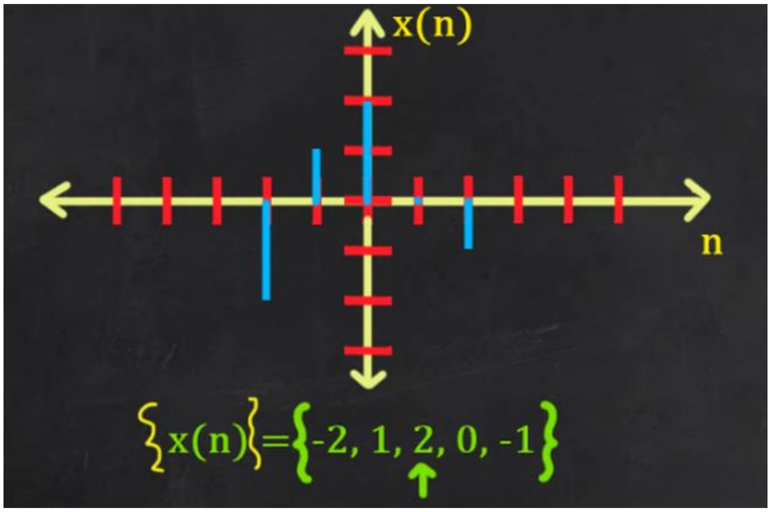
(a)



(b)



Q2: Find the expressions for the even digital sequence/signal, x_e (n), and the odd digital sequence/signal, x_o(n), for the given digital sequence/signal, x (n). Plot each sequence/signal.



Q3: Determine which of the following signals are energy signals or power signals.

$x(n) = 4\,,\ n > 0$	$x(n) = \left(\frac{1}{4}\right)^n u(n)$	$x(n) = \begin{cases} 3(-1)^n, & n \geq 0 \\ 0 & , n < 0 \end{cases}$

Use the following hints:

	CT Signals	DT Signals
Instantaneous Power	$P(t) = \lvert x(t)\rvert^2$	$P(n) = \lvert x(n)\rvert^2$
Total Energy	$E = \int_{-\infty}^{\infty} \lvert x(t)\rvert^2\, dt$	$E = \sum_{n=-\infty}^{\infty} \lvert x(n)\rvert^2$
Average Power	$P = \lim_{T\to\infty}\left[\frac{\int_{-T}^{T}\lvert x(t)\rvert^2\, dt}{2T}\right]$	$P = \lim_{N\to\infty}\left[\frac{\sum_{n=-N}^{N}\lvert x(n)\rvert^2}{2N+1}\right]$

Energy Signal & Power Signal

Energy Signal : $0 < E < \infty$ (Finite Total Energy) and $P = 0$ (Zero Average Power)

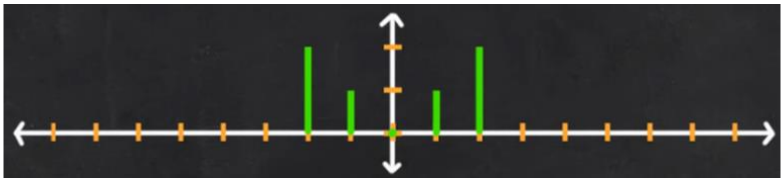
Power Signal : $0 < P < \infty$ (Finite Average Power) and $E = \infty$ (Infinite Total Energy)

A signal cannot be both an energy signal and a power signal

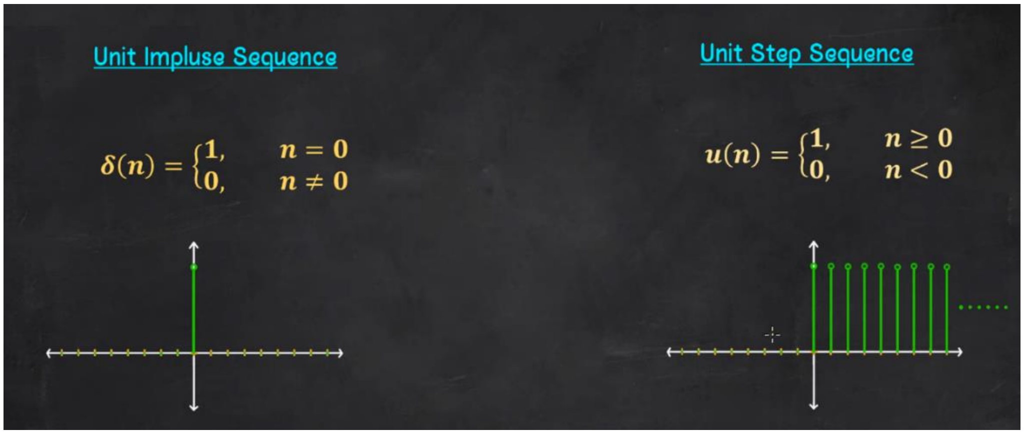
There can be signals that are neither an energy signal nor a power signal

No physical signal can have infinite energy or infinite average power

Q4: Express the following signal in terms of **(a)** unit impulse signal, and **(b)** unit step signal.



Use the mathematical definitions of unit impulse sequence and unit step sequence given below.



Q5: Find the fundamental period for the following digital signals:

$$\bar{x}_1(n) = 4\cos\left(\frac{2\pi n}{5}\right) \qquad \bar{x}_2(n) = \sin(0.6\pi n + 0.6\pi)$$

Note that a sinusoidal discrete signal is periodic if 2π/ω equals a rational number, as shown below:

$$\omega N = 2\pi r \quad , \quad r \rightarrow +\text{ve integer}$$

$$\frac{2\pi}{\omega} = \frac{N}{r}$$

In the above, both N and r are positive integers, where N is the period of the digital signal.

Q6: Find the fundamental period for the following digital signal:

$$\bar{x}(n) = \cos(1.2\pi n + 0.65\pi) - 4\sin(0.9\pi n) + 5\cos(0.5\pi n)$$

Use the following hint, where LCM is the Least Common Multiple. Note that the LCM is the smallest positive integer that is evenly divisible by two or more given numbers.

$$\bar{x}_1(n) \qquad \bar{x}_2(n) \qquad \bar{x}_3(n)$$

$$N_1 \qquad N_2 \qquad N_3$$

$$\bar{x}_4(n) = \alpha\bar{x}_1(n) + \beta\bar{x}_2(n) + \gamma\bar{x}_3(n)$$

$$N_4 = LCM(N_1, N_2, N_3)$$

You need to show the graphs of each digital signal using MATLAB. Also, plot the graph of the overall signal of $x_4(n)$.

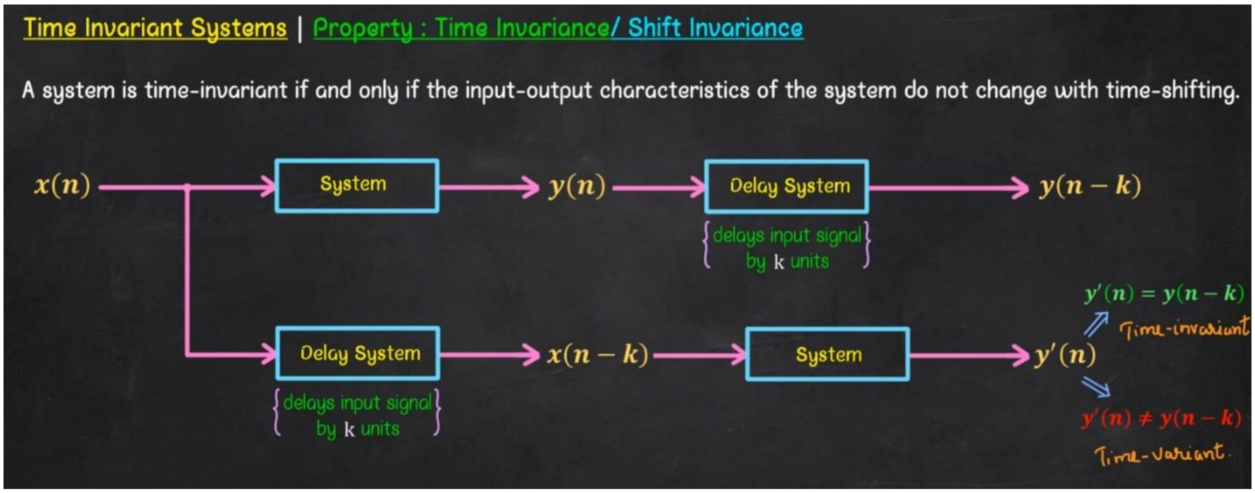
Q7: Show whether the given digital signals are time-variant or time-invariant.

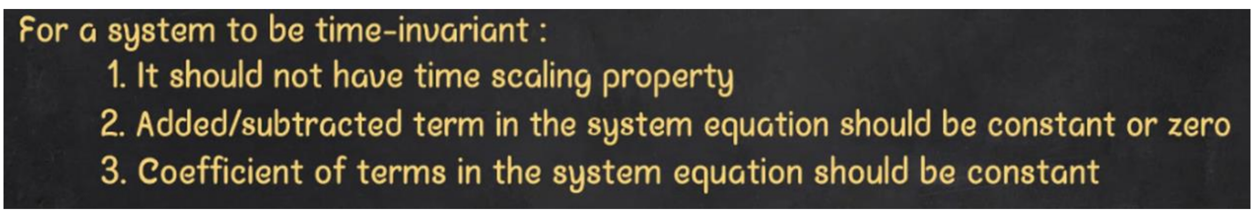
Part 1: y(n) = x(2n).

Part 2: y(n) = 2n + x(n).

Part 3: y(n) = n.x(n).

Use the given hints.





Q8: Show whether the given digital signals are causal or non-casual.

Part 1: $y(n) = x(n) – x(n-1)$.

Part 2: $y(n) = a.x(n)$.

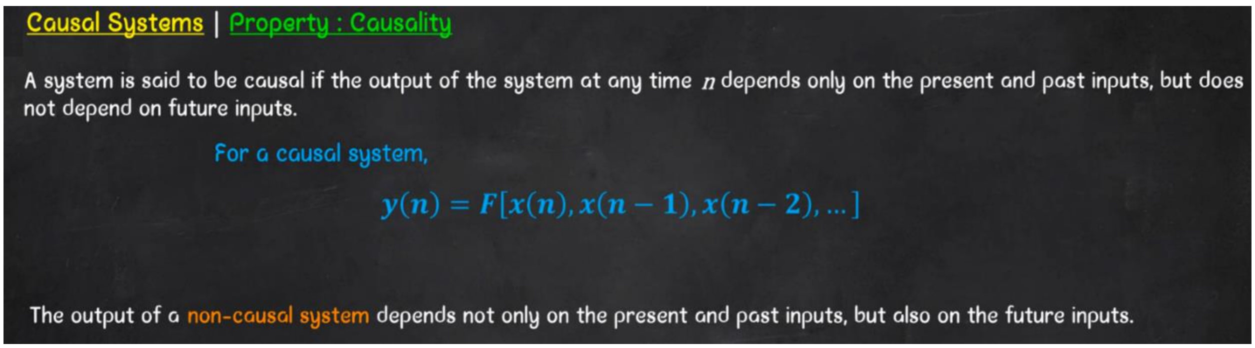
Part 3: $y(n) = \sum_{k=-\infty}^{n} x(k)$.

Part 4: $y(n) = x(n) + 3x(n + 4)$.

Part 5: $y(n) = x(n^2)$.

Part 6: $y(n) = x(-n)$.

Use the given hints.



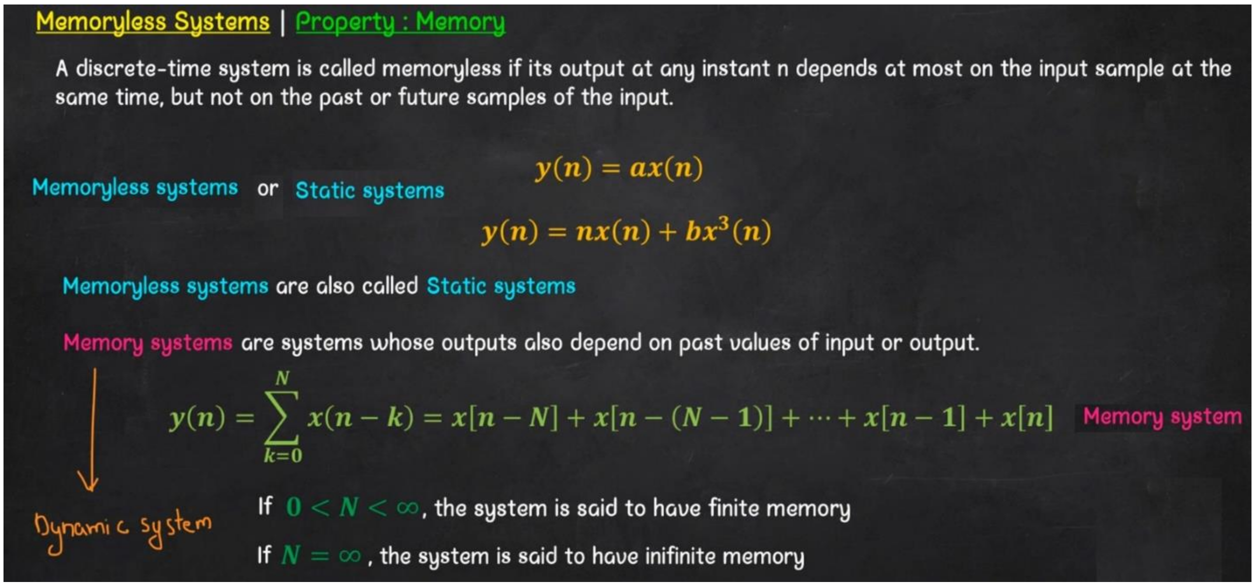
Q9: Show whether the given digital systems are static system (memoryless) or dynamic (memory) system.

Part 1: y(n) = = [2 + sin (n - 1)].x(n)

Part 2: y(n) = max[x(n), x(n - 1), ..., x(−∞)]

Part 3: y(n) = x(-n).

Use the given hints.



Q10: Consider the following LTI system, $y[k] - 0.8y[k-1] = x[k]$.

Part 1:

Find the frequency response of the system, i.e., both the amplitude response and the phase response. Only find the equations and no need to plot them.

Part 2:

Let $x[k] = 1$ be the input with the frequency response obtained in **Part 1**. Find the system response.

Part 3:

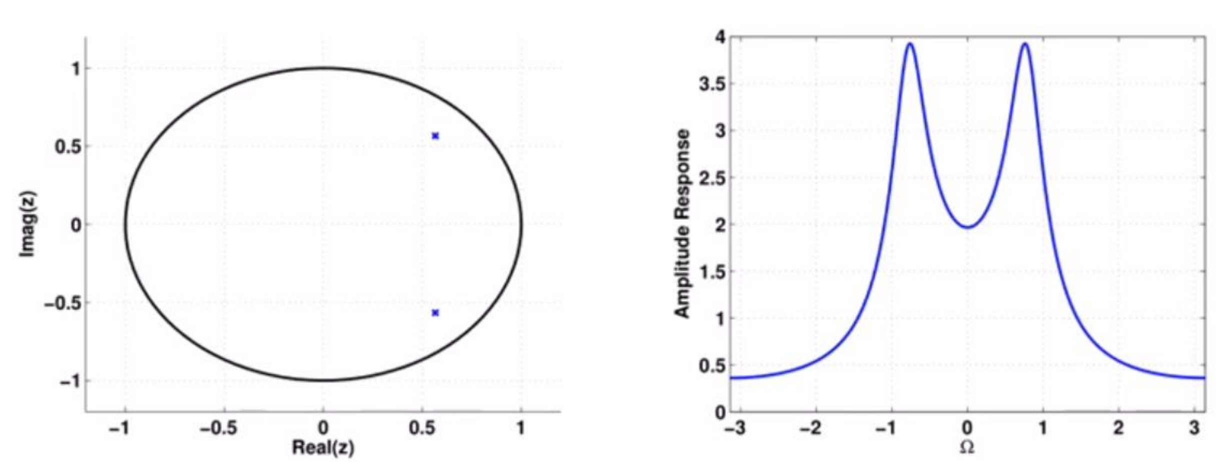
Let $x[k] = \cos\left(\frac{\pi}{6}k - 0.4\right)$ be the input with the frequency response obtained in **Part 1**. Find the system response.

Part 4:

Let $x(t) = \cos(1500t)$ be the ***continuous*** input with the frequency response obtained in **Part 1**. Find the system response if we sample the continuous signal every 0.001 seconds.

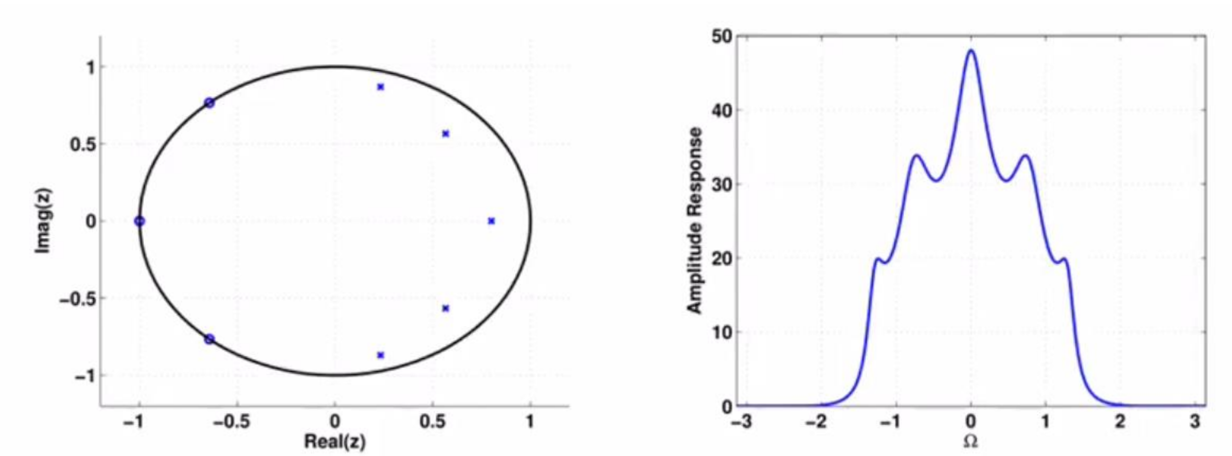
Q11: Explain the general shapes of the amplitude response using the given pole/zero plots.

Part 1:



(a) Pole/Zero Plot (b) Frequency Response

Part 2:



(c) Pole/Zero Plot (d) Frequency Response

Use the following hints:

- The Transfer Function Of A DT LTI System Can Be Written As

$$H(z) = K\frac{(z-z_1)(z-z_2)\cdots(z-z_n)}{(z-\gamma_1)(z-\gamma_2)\cdots(z-\gamma_n)}$$

where z_i and γ_i are Zeros and Poles of the System.

- Let $z = e^{j\Omega}$ (i.e evaluate $H(z)$ on the unit circle). This Gives The System Frequency Response

$$H(e^{j\Omega}) = H(\Omega) = K\frac{(e^{j\Omega}-z_1)(e^{j\Omega}-z_2)\cdots(e^{j\Omega}-z_n)}{(e^{j\Omega}-\gamma_1)(e^{j\Omega}-\gamma_2)\cdots(e^{j\Omega}-\gamma_n)}$$

- The Quantity $e^{j\Omega}$ Is A Point On the Unit Circle
- The Quantity $e^{j\Omega} - z_i$ Is A Vector From z_i to $e^{j\Omega}$
- The Quantity $e^{j\Omega} - \gamma_i$ Is A Vector From γ_i to $e^{j\Omega}$
- Use Polar Coordinates To Define

$$r_i e^{j\phi_i} = e^{j\Omega} - z_i$$

and

$$d_i e^{j\theta_i} = e^{j\Omega} - \gamma_i$$

- The Frequency Response Can Now Be Written As

$$\begin{aligned} H(\Omega) &= K\frac{(r_1e^{j\phi_1})(r_2e^{j\phi_2})\cdots(r_ne^{j\phi_n})}{(d_1e^{j\theta_1})(d_2e^{j\theta_2})\cdots(d_ne^{j\theta_n})} \\ &= K\frac{r_1r_2\cdots r_n}{d_1d_2\cdots d_n}e^{j[(\phi_1+\phi_2+\cdots+\phi_n)-(\theta_1+\theta_2+\cdots+\theta_n)]} \end{aligned}$$

- The Amplitude Response Is

$$\begin{aligned} |H(\Omega)| &= \left|K\frac{(r_1e^{j\phi_1})(r_2e^{j\phi_2})\cdots(r_ne^{j\phi_n})}{(d_1e^{j\theta_1})(d_2e^{j\theta_2})\cdots(d_ne^{j\theta_n})}\right| \\ &= K\frac{r_1r_2\cdots r_n}{d_1d_2\cdots d_n} \\ &= K\frac{\text{product of distances of zeros to } e^{j\Omega}}{\text{product of distances of poles to } e^{j\Omega}} \end{aligned}$$

- The Phase Response Is

$$\begin{aligned} \angle H(\Omega) &= \angle\left(K\frac{(r_1e^{j\phi_1})(r_2e^{j\phi_2})\cdots(r_ne^{j\phi_n})}{(d_1e^{j\theta_1})(d_2e^{j\theta_2})\cdots(d_ne^{j\theta_n})}\right) \\ &= (\phi_1+\phi_2+\cdots+\phi_n) \\ &- (\theta_1+\theta_2+\cdots+\theta_n) \\ &= \text{sum of zero angles to } e^{j\Omega} \\ &- \text{sum of pole angles to } e^{j\Omega} \end{aligned}$$

- The Amplitude and Phase Response Of A Filter Is Controlled By Its Pole and Zero Locations