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2101600242

1 a) $x[n] = 2\delta[n+2] - \delta[n-4]; \quad -5 \le n \le 5$

```
n1 = -5:5;
delta = @(n,k) double(n==k);
x_a = 2*delta(n1,-2) - delta(n1,4);

stem(n1, x_a, 'filled');
title('Part (a) plot');
xlabel('n');
ylabel('x(n)');
grid on;
```

(b) ~~n2~~

~~n2 = 0:20;~~
~~u = @(n) double(n>=0);~~
~~function~~
~~x_b = n2~~

```
n_b = 0:20;
u_n = double(n_b>=0);
u_n_10 = double(n_b>=10);
u_n_20 = double(n_b>=20);

x_b = n_b .* (2*u_n - u_n_10) + 10*exp(-0.3*(n_b-10)) .* (u_n_10 - u_n_20);

% for ploting
figure;
stem(n_b, x_b, 'filled');
grid on;
xlabel('n');
ylabel('x[n]');
title('Sequence (b): x[n] computed for given expression');
```

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2.a) $T(x(n)) = e^{x(n)}$

(i) Testings for stability

$T(x(n)) = e^{x(n)}$

let $x(n) = \text{finite}$

$T[x(n)] = e^{\text{finite}} = \text{finite}$

Since for a bounded input, the system generates a bounded output, then the system is BIBO stable

(ii) Testing for causality

For $n=0$ $\quad T[x(0)] = e^{x(0)}$

since $x(n)$ only depends on the present inputs of n, then the system is causal

(iii) let $\quad T_1[x_1(n)] = e^{x_1(n)}$

$T_2[x_2(n)] = e^{x_2(n)}$

$T[a x_1(n) + b x_2(n)] = e^{[a x_1(n) + b x_2(n)]}$

$a T_1[x_1(n)] = e^{a x_1(n)}$

$b T_2[x_2(n)] = e^{b x_2(n)}$

$a T_1(x_1(n)) + b T_2(x_2(n)) = e^{a x_1(n)} + e^{b x_2(n)}$

$T[a x_1(n) + b x_2(n)] \neq a T_1(x_1(n)) + b T_2(x_2(n))$

The system is non-linear

(iv) For time-invariant systems;

$T(x(n-n_0)) = y(n-n_0)$

$y(n) = e^{x(n)}$

$y[n-n_0] = e^{x(n-n_0)}$

$T[x(n)] = e^{x(n)}$

$T[x[n-n_0]] = e^{x[n-n_0]}$

since $T[x[n-n_0]] = y[n-n_0]$, then the system is time-invariant

(v) Testing for memoryless

for $n=0$, $T[x(0)] = e^{x[0]}$

System is memoryless since it only depends on the present input of time, n at any instance

(b) $T(x[n]) = ax[n] + b$

(i) let $x[n]$ = any finite value
$T[x[n]] = a(\text{finite}) + b$
$T[x[n]]$ = finite value for as long as a and b are finite values.

The system is stable

(ii) Testing for causality
$n=0$, $T[x(0)] = ax(0) + b$

System is causal where it only depends on the present input of time, n for all values of n

(iii) let $T_1(x_1[n]) = ax_1[n] + b$
$T_2(x_2[n]) = ax_2[n] + b$

now: $T[C_1 ax_1[n] + C_2 ax_2[n] + 2b]$
$= a(C_1 a x_1[n] + C_2 a x_2[n] + 2b) + b$

Also

$C_1 T_1 (x_1(n)) = C_1 a x_1(n) + b$

$C_2 T_2 [x_2(n)] = C_2 a x_2 (n) + b$

$C_1 T_1 (x_1(n)] + C_2 T_2 (x_2(n)] = C_1 a x_1(n) + C_2 a x_2(n) + 2b$

Since the superposition is not satisfied, the system is non-linear

(iv) $T(x(n-n_0)] = a x[n-n_0] + b$

$y(n-n_0] = a x(n-n_0] + b$

Shift in the input leads to the same shift in the output

$T[x(n-n_0)] = y(n-n_0]$, then the system is Time-invariant

(v) For memoryless

for $n=0$ $T[x(0)] = a x(0] + b$

The system only depends on present values, then the system is memoryless

c) $T(x(n)] = x(n) + 3u(n+1]$

(i) $u(n+1] = 1$ for $n \geq -1$

let $x(n) =$ finite

$T[x(n)] =$ finite $+ 3 =$ finite

Since $T(x(n)] =$ finite, hence the system is stable

(ii) Testing for causality

Taking $n=0$ $T[x(0)] = x(0) + 3u[1]$

Therefore, the system is non-causal because it also depend on future input.

(iii) Testing for linearity

$T[c_1 x_1(n) + c_2 x_2(n)] = c_1 x_1(n) + c_2 x_2(n) + 3u(n+1]$

$c_1 T(x_1(n)) + c_2 T(x_2(n)] = c_1 x_1(n) + 3u(n+1] + c_2 x_2(n) +$
$3u(n+1]$

$\therefore T[c_1 x_1(n) + c_2 x_2(n)] \neq c_1 T(x_1(n)) + c_2 T(x_2(n)]$

the system is not linear

(iv) $T[x(n-n_0)] = x(n-n_0) + 3u(n+1]$

$y[n-n_0] = x[n-n_0] + 3u[n-n_0+1]$

since $T[x(n-n_0)) \neq y(n-n_0]$, then the system is time
variant

(v) Testing for memoryless

$n=0$, $T[x(0)] = x(0) + 3u(1]$

The system is memoryless since depends on the present input of time

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3 $h[n] = a^{-n} u[-n], \quad 0 < a < 1$

soln

$x[n] = u[n]$

$$u(n) = \begin{cases} 1, & n \geq 0 \\ 0 & n < 0 \end{cases}$$

$$y(n) = \sum_{k=-\infty}^{\infty} h(k)\, x(n-k]$$

$$y(n) = \sum_{k=-\infty}^{\infty} a^{-k} u(-k)\, x[n-k]$$

$$y(n) = \sum_{k=-\infty}^{\infty} a^{-k} u(-k)\, u[n-k]$$

for $n > 0$

$$y(n) = \sum_{k=-\infty}^{0} a^{-k} u(-k)\, u[-k]$$

$$y(n) = \sum_{k=-\infty}^{0} a^{-k} \quad [\text{letting } k = -k]$$

$$y[n] = \sum_{k=0}^{\infty} a^{k} = \frac{1}{1-a}$$

For $n \leq 0$

$$y(n) = \sum_{k=-\infty}^{\infty} a^{-k}$$

$$= \sum_{k=-n}^{\infty} a^{k} = \frac{a^{n}}{1-a}$$

$$y(n) = \begin{cases} \frac{1}{1-a} & n > 0 \\ \frac{a^{n}}{1-a} & n \leq 0 \end{cases}$$

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4a $y[n] - 5y[n-1] + 6y[n-2] = 2x[n-1]$

let $y_h(n) = z^n$

$z^n - 5z^{n-1} + 6z^{n-2} = 0$

$z^{n-2}[z^2 - 5z + 6] = 0$

$z^2 - 5z + 6 = 0$

$z_1 = 2$ and $z_2 = 3$

$y_h(n) = \cancel{x_1}\ A_1(2)^n + A_2(3)^n$

$y_h(n) = A_1(2)^n + A_2(3)^n$ is the homogenous solution

(b) Impulse response of the system

$$H(z) = \frac{Y(z)}{X(z)}$$

$y[n] - 5y[n-1] + 6y[n-2] = 2x[n-1]$

Taking the z-transform

$Y(z) - 5z^{-1}Y(z) + 6z^{-2}Y(z) = 2z^{-1}X(z)$

$$\frac{Y(z)}{X(z)} = H(z) = \frac{2z^{-1}}{6z^{-2} - 5z^{-1} + 1}$$

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

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

$2z^{-1} = A(1-3z^{-1}) + B(1-2z^{-1})$

for $z^{-1} = -1/3$

$2/3 = 1/3\, B$

$B = 2$

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

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

$A = -2$

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

$h[n] = IZT\{H(z)\}$

$h(n) = -2(2)^n u(n) + 2(3)^n u(n)$

$h(n) = 2(3^n - 2^n)u(n)$ is the impulse response of the system

(c) unit step response of the system

let $x(n) = u(n)$

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

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

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

$$Y(z) = \frac{A}{1-2z^{-1}} + \frac{B}{1-3z^{-1}} + \frac{C}{1-z^{-1}}$$

$$Y(z) = A(1-3z^{-1})(1-z^{-1}) + B(1-2z^{-1})(1-z^{-1}) + C(1-2z^{-1})(1-3z^{-1}) = 2z^{-1}$$

$z^{-1} = 1$	$z^{-1} = \frac{1}{3}$	$z^{-1} = \frac{1}{2}$
$2 = C = 1$	$B = 3$	$A = -4$

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

Taking the inverse z-transform

$$y(n) = -4\,(2^n]u(n] + 3(3^n]\,u(n] + u(n]$$
$$y(n) = [-4\,(2^n] + 3(3^n] + 1]\,u(n]$$

(d) (b)

```
n = -20:120;
a = [1 -5 6];
b = [0 2];
impulse_input = (n==0);
impulse_response = filter(b, a, impulse_input);
figure;
stem(n, impulse_response, 'filled');
grid on;
xlabel('n');
ylabel('h(n)');
title('Impulse Response of the system');
```

d (c)

```
n = -20:120;
a = [1 -5 6];
b = [0 2];
step_input = (n>=0);
step_response = filter(b, a, step_input);
figure;
stem(n, step_response, 'filled');
grid on;
xlabel('n');
ylabel('s[n]');
title('Step Response of the system');
```


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5 a) $y(n) = -2x(n) + 4x(n-1) - 2x(n-2)$

$h(n) = -2\delta(n) + 4\delta(n-1) - 2\delta(n-2)$

$h(n) = \{-2, 4, -2\}$

b) $h(n) = -2\delta(n) + 4\delta(n-1) - 2\delta(n-2)$

Taking the transforms

$H(e^{j\omega}) = -2 + 4e^{-j\omega} - 2e^{-2j\omega}$

$H(e^{j\omega}) = -2 + 4e^{-j\omega} - 2e^{-j\omega} \cdot e^{-j\omega}$

$= -2 + 2(2 - e^{-j\omega})e^{-j\omega}$

$H(e^{j\omega}) = -4e^{-j\omega}[e^{j\omega}/2 - 1 + \frac{1}{2}e^{-j\omega}]$

$H(e^{j\omega}) = -4e^{-j\omega}\left(\frac{e^{j\omega} + e^{-j\omega}}{2} - 1\right)$

But we know that $\frac{e^{j\omega} + e^{-j\omega}}{2} = \cos(\omega)$

$H(e^{j\omega}) = -4e^{-j\omega}(\cos\omega - 1]$

(c) from

$H(e^{j\omega}) = -4e^{-j\omega}(\cos\omega - 1)$

$\Rightarrow |H(e^{j\omega})| = \cancel{4e^{-j\omega}}\ 4(\cos\omega - 1)$

$|H(e^{j\omega})| = 4(\cos\omega - 1)$

$\angle H(e^{j\omega}) = -\omega$

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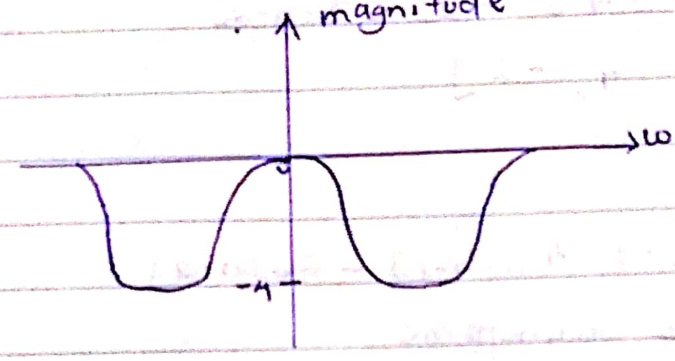
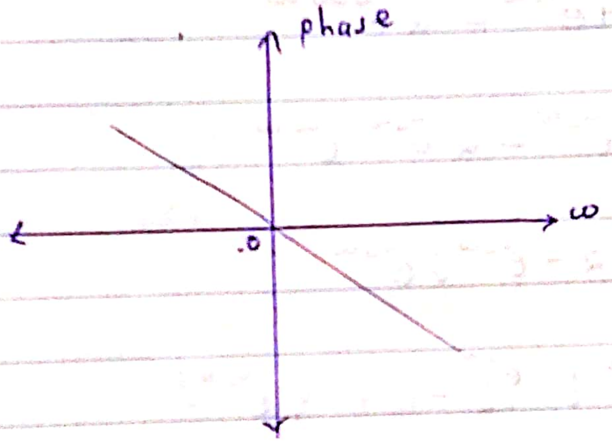
magnitude plot



Phase - Plot



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