CLASS TEST

S.No.: 01SKECEE_H+I_20052024

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SIGNAL & SYSTEM

EC-EE

Date of Test : 20/05/2024

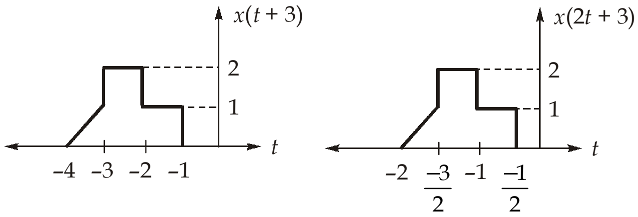
ANSWER KEY

1.	(c)	7.	(c)	13.	(b)	19.	(c)	25.	(d)
2.	(b)	8.	(a)	14.	(b)	20.	(d)	26.	(b)
3.	(a)	9.	(a)	15.	(d)	21.	(a)	27.	(b)
4.	(c)	10.	(c)	16.	(c)	22.	(d)	28.	(a)
5.	(c)	11.	(b)	17.	(c)	23.	(b)	29.	(c)
6.	(b)	12.	(b)	18.	(c)	24.	(a)	30.	(b)

DETAILED EXPLANATIONS

1. (c)

The signal $x(2t + 3)$ can be obtained by first shifting $x(t)$ to the left by 3 units and then scaling by 2 units.



2. (b)

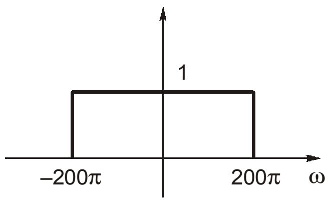
$$e^{-(2t-2)}\,u(t-1) = e^{-2(t-1)}\,u(t-1)$$

Now,
$$e^{-2t}\,u(t) \leftrightarrow \frac{1}{2+j\omega}$$

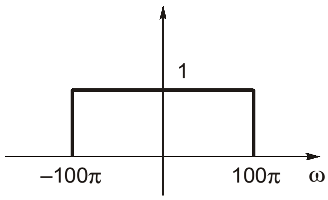
$$e^{-2(t-1)}\,u(t-1) \leftrightarrow \frac{e^{-j\omega}}{2+j\omega}$$

3. (a)

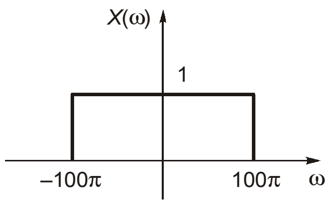
$$\frac{\sin(200\pi t)}{\pi t} \longleftrightarrow$$



$$\frac{\sin(100\pi t)}{\pi t} \longleftrightarrow$$



$$x(t) = \frac{\sin(200\pi t)}{\pi t} * \left(\frac{\sin(100\pi t)}{\pi t}\right) \longleftrightarrow$$



$$E = \int_{-\infty}^{\infty} |x(t)|^2\,dt = \frac{1}{2\pi}\int_{-\infty}^{\infty} |X(\omega)|^2\,d\omega = \frac{1}{2\pi}\int_{-100\pi}^{100\pi} (1)\,d\omega = \frac{200\pi}{2\pi} = 100$$

4. (c)

Given, $x(n) \xleftrightarrow{z} X(z)$

by the definition of z-transform,

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

$$= \sum_{n=-\infty}^{\infty} \sum_{k=0}^{\infty} a^k \delta[n-5k] z^{-n}$$

The term $\delta[n - 5k]$ is equal 1 if $n = 5k$ and equal to zero otherwise.

$$\therefore \quad X(z) = \sum_{k=0}^{\infty} a^k z^{-5k} \quad [\because n = 5k]$$

$$= \frac{1}{1 - az^{-5}}$$

or
$$X(z) = \frac{z^5}{z^5 - a}$$

5. (c)

$$(1 + \cos 300\pi t)^2 \rightarrow f_{1\,max} = 300 \text{ Hz}$$
$$(\sin 4000\pi t)^2 \rightarrow f_{2\,max} = 4000 \text{ Hz}$$
$$f_{max} = f_{1\,max} + f_{2\,max} = 4300 \text{ Hz}$$
$$f_s = 2f_{max} = 8.6 \text{ kHz}$$

6. (b)

Given,
$$x(t) = \frac{\sin(10\pi t)}{\pi t}$$

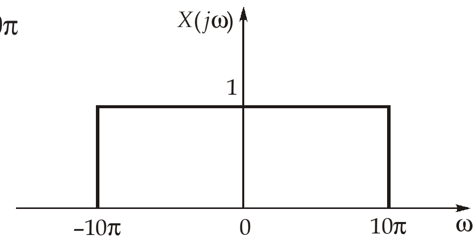
Taking Fourier transform

$$X(j\omega) = \begin{cases} 1 \; ; & |\omega| \le 10\pi \\ 0 \; ; & |\omega| > 10\pi \end{cases}$$

or

$\therefore$ The maximum frequency 'ω_m' present in $x(t)$ is $\omega_m = 10\pi$

Hence we require,



$$\frac{2\pi}{T_s} > 2\omega_m$$

$$\frac{2\pi}{T_s} > 20\pi$$

$$\therefore \quad T_s < \frac{1}{10}$$

7. (c)

Conjugate anti-symmetric part of $x[n]$ is $\frac{x[n] - x^*[-n]}{2}$.

$$x^*[-n] = [2, 1 + j, -2 + j5]$$

$$\therefore \quad \frac{x[n] - x^*[-n]}{2} = \frac{[-2 - j5, 1 - j, 2] - [2, (1 + j), -2 + j5]}{2} = [-2 - j2.5, -\underset{\uparrow}{j}, 2 - j2.5]$$

8. (a)

$$X(e^{j\omega}) = e^{j\omega} + e^{-j\omega} + 2(e^{2j\omega} - e^{-2j\omega}) + 3(e^{3j\omega} + e^{-3j\omega})$$
$$= 2\cos\omega + 4j\sin(2\omega) + 2\cos 3\omega = 2\cos(\pi) + 4j\sin(2\pi) + 6\cos(3\pi)$$
$$= -2 + 0 - 6 = -8$$
$$|Xe^{j\pi}| = 8$$

9. (a)

$$Re\{x(t)\} = \frac{x(t)+x^*(t)}{2}$$

$\therefore$ The Fourier coefficient of $x^*(t)$ are

$$b_K = \frac{1}{T}\int_T x^*(t)e^{-jK\frac{2\pi}{T}t}\,dt$$

Taking conjugate on both sides

$$b_K^* = \frac{1}{T}\int_T x(t)e^{-j(-K)\frac{2\pi}{T}t}\,dt$$

$\therefore$ $$a_{-K} = b_K^*$$

$\therefore$ Fourier series Coefficient of $Re\{x(t)\} = \dfrac{a_K + a_{-K}^*}{2}$

10. (c)

Given, $$H(z) = \frac{z}{z-0.2} = \frac{1}{1-0.2z^{-1}} \quad \text{ROC}: |z| > 0.2$$

Since the ROC : $|z| > 0.2$, which includes unit circle.

$\therefore$ The impulse response will be stable.

11. (b)

Given, $$y(t) = e^{-t}u(t) * \sum_{k=-\infty}^{\infty}\delta(t-2k)$$

$$= e^{-t}u(t) * (\ldots\ldots + \delta(t+4)+\delta(t+2)+\delta(t)+\delta(t-2)+\delta(t-4)+\ldots\ldots)$$

Using convolution property of impulse response,

i.e., $$x(t) * \delta(t-t_0) = x(t-t_0)$$

$$y(t) = \ldots + e^{-(t+4)}u(t+4) + e^{-(t+2)}u(t+2) + e^{-t}u(t) + e^{-(t-2)}u(t-2) + e^{-(t-4)}u(t-4)$$
$+ \ldots$

In the range $0 \le t < 2$, we may write $y(t)$ as,

$y(t) = [\ldots + e^{-(t+4)}u(t+4) + e^{-(t+2)}u(t+2) + e^{-t}u(t) + e^{-(t-2)}u(t-2) + e^{-(t-4)}u(t-4) + \ldots]\,(u(t) - u(t-2))$

$$= \left(e^{-t} + e^{-(t+2)} + e^{-(t+4)} + \ldots\ldots\right);\quad 0 \le t < 2$$

$$= e^{-t}\left(1 + e^{-2} + e^{-4} + \ldots\ldots\right);\quad 0 \le t < 2$$

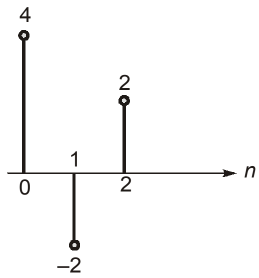
$$= e^{-t}\left[\frac{1}{1-e^{-2}}\right];\quad 0 \le t < 2$$

$\because$ $$y(t) = Ae^{-t} \text{ for } 0 \le t < 2$$

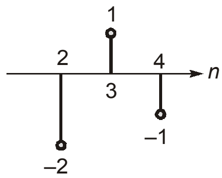
$\therefore$ $$A = \frac{1}{1-e^{-2}}$$

12. (b)

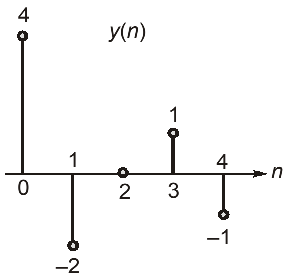
For $x_1[n] = 2\delta[n]$, $\quad y_1(n) = 2y(n) \Rightarrow$



For $x_2[n] = -\delta[n-2]$, $\quad y_2(n) = -y(n-2) \Rightarrow$



$y(n) = y_1(n) + y_2(n) \Rightarrow$



13. (b)

$$F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}\,dt$$

$$= \int_{-\infty}^{\infty} [f(t)\cos\omega t - jf(t)\sin\omega t]\,dt$$

$$= \int_{-\infty}^{\infty} f(t)\cos\omega t\,dt - j\int_{-\infty}^{\infty} f(t)\sin\omega t\,dt$$

$f(t) \Rightarrow$ even signal
$f(t)\ \cos\omega t \Rightarrow$ even signal
$f(t)\ \sin\omega t \Rightarrow$ odd signal

$$\int_{-\infty}^{\infty} f(t)\sin\omega t\,dt = 0$$

$$\int_{-\infty}^{\infty} f(t)\cos\omega t\,dt = 2\int_{0}^{\infty} f(t)\cos\omega t\,dt$$

$$\therefore \quad F(\omega) = 2\int_{0}^{\infty} f(t)\cos\omega t\,dt$$

14. (b)

Given, $\quad X(s) = \log(s+2) - \log(s+3)$

Differentiating both the sides with respect to s

$$\frac{d}{ds}X(s) = \frac{1}{s+2} - \frac{1}{s+3} \qquad \text{...(i)}$$

From the properties of Laplace transform, we know that,

$$tx(t) \longleftrightarrow -\frac{d}{ds}X(s)$$

Thus equation (i) can be written as,

$$-tx(t) = [e^{-2t} - e^{-3t}]u(t)$$

or,
$$x(t) = \left[\frac{e^{-3t} - e^{-2t}}{t}\right]u(t)$$

15. (d)

$$C_k = j\delta(k+2) - j\delta(k-2) + 2\delta(k+3) + 2\delta(k-3)$$

$$x(t) = \sum_{k=-\infty}^{\infty} C_k e^{jk\omega_0 t} = \sum_{k=-\infty}^{\infty} C_k e^{jk\pi t}$$

$$= je^{-j2\pi t} - je^{j2\pi t} + 2e^{-j3\pi t} + 2e^{j3\pi t}$$

$$= 4\cos(3\pi t) + 2\sin(2\pi t)$$

16. (c)

Given that,

Let,
$$y_1(t) = 2\pi X(-\omega)\big|_{\omega = t}$$

We have,
$$y_1(t) = 2\pi \int_{u=-\infty}^{\infty} x(u)e^{jut}du$$

Similarly, let $y_2(t)$ be the output due to passing $x(t)$ through 'F' twice.

$$y_2(t) = 2\pi \int_{v=-\infty}^{\infty} 2\pi \int_{u=-\infty}^{\infty} x(u)e^{juv}du\, e^{jtv}dv$$

$$= (2\pi)^2 \int_{u=-\infty}^{\infty} x(u) \int_{v=-\infty}^{\infty} e^{j(t+u)v}dv\, du$$

$$= (2\pi)^2 \int_{u=-\infty}^{\infty} x(u)(2\pi)\delta(t+u)du$$

$$= (2\pi)^3 X(-t)$$

Finally, let $y_3(t)$ be the output due to passing $x(t)$ through F three times

$$y_3(t) = 2\pi \int_{u=-\infty}^{\infty} (2\pi)^3 x(-u)e^{jtu}du$$

$$= (2\pi)^4 \int_{-\infty}^{\infty} e^{-jtu}x(u)du = (2\pi)^4 X(t)$$

17. (c)

The fourier transform of $x(t)$ can be written

$$X_1(j\omega) = |X_1(j\omega)|e^{j\angle X_1(j\omega)}$$

Let, $$X_{1a}(j\omega) = \begin{cases} 1; & |\omega| < 3\pi \\ 0; & \text{otherwise} \end{cases}$$

Note that, given $X_1(j\omega)$ is "$3jw$" times $X_{1a}(j\omega)$

$$\therefore \quad X_1(j\omega) = \begin{cases} 3j\omega; & |\omega| < 3\pi \\ 0; & \text{otherwise} \end{cases}$$

Since, at $$\omega = 3\pi, \ |X_1(j\omega)| = 9\pi \text{ and } \angle X_1(j\omega) = \frac{\pi}{2}$$

$$\omega = -3\pi, \ |X_1(j\omega)| = 9\pi \text{ and } \angle X_1(j\omega) = -\frac{\pi}{2}$$

By taking inverse fourier transform,

Thus, $$x_1(t) = 3\frac{d}{dt}x_{1a}(t)$$ [By using differential property]

also we can express $$x_{1a}(t) = \frac{\sin 3\pi t}{\pi t}$$

Thus, $$x_1(t) = 3\frac{d}{dt}\left[\frac{\sin 3\pi t}{\pi t}\right]$$

$$= \frac{3}{\pi} \times \frac{1}{t^2}[3\pi t \cos 3\pi t - \sin 3\pi t]$$

$$\therefore \quad x_1(t) = \frac{3}{\pi t^2}[3\pi t \cos 3\pi t - \sin 3\pi t]$$

18. (c)

We know that the Laplace transform of

$$\cos(at)u(t) = \frac{s}{s^2 + a^2}$$

$$\therefore \quad \cos(\pi t)u(t) = \frac{s}{s^2 + \pi^2}$$

now, the given function $x(t)$ can be written as,

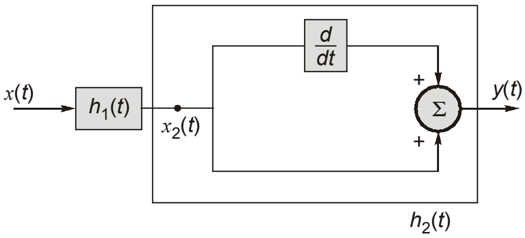
$$x(t) = \cos(\pi t)u(t) - \cos \pi t\, u(t-1)$$
$$= \cos(\pi t)u(t) - \cos \pi(t - 1 + 1)\, u(t-1)$$
$$= \cos(\pi t)u(t) - \cos[\pi(t-1) + \pi]\, u(t-1)$$
$$= \cos \pi\, tu(t) - [\cos \pi(t-1)(-1) - 0]\, u(t-1)$$
$$= \cos \pi\, tu(t) + \cos \pi(t-1)\, u(t-1)$$

By taking Laplace transform,

$$X(s) = \frac{s}{s^2 + \pi^2} + \frac{s e^{-s}}{s^2 + \pi^2}$$ $[\because x(t - t_0) = X(s) \cdot e^{-st_0}$, by shifting property]

$$X(s) = \frac{s[1 + e^{-s}]}{s^2 + \pi^2}$$

19. (c)



Let

$$x_2(t) = \delta(t)$$

$$h_2(t) = \left(\delta(t) + \frac{d}{dt}\delta(t)\right)$$

$$h_1(t) = e^{-t}u(t)$$

$$h(t) = e^{-t}u(t) * \left(\delta(t) + \frac{d}{dt}\delta(t)\right)$$

$$h(t) = e^{-t}u(t) * \delta(t) + e^{-t}u(t) * \frac{d}{dt}\delta(t)$$

$$= e^{-t}u(t) + \frac{d}{dt}\left(e^{-t}u(t)\right) * \delta(t)$$

$$= e^{-t}u(t) + \frac{d}{dt}\left(e^{-t}u(t)\right)$$

$$= e^{-t}u(t) - e^{-t}u(t) + e^{-t}\delta(t)$$

$$h(t) = \delta(t) \qquad \because \; e^{-t}\delta(t) = e^{0}\delta(t) = \delta(t)$$

20. (d)

$$H(j\omega) = \frac{1+2e^{-j\omega}}{1+\dfrac{1}{2e^{-j\omega}}} = \frac{1+2e^{-j\omega}}{2e^{-j\omega}+1}\cdot 2e^{-j\omega}$$

$$|H(j\omega)| = 2$$

21. (a)

Given,

$$X(e^{j\omega}) = \frac{\sin\dfrac{3\omega}{2}}{\sin\dfrac{\omega}{2}} = \frac{e^{j3\omega/2} - e^{-j3\omega/2}}{e^{j\omega/2} - e^{-j\omega/2}} = \frac{e^{j3\omega/2}\left[1-e^{-j3\omega}\right]}{e^{j\omega/2}\left[1-e^{-j\omega}\right]}$$

$$= e^{j\omega}\left[\frac{1-e^{-j3\omega}}{1-e^{-j\omega}}\right]$$

$$X(e^{j\omega}) = \frac{e^{j\omega}}{1-e^{-j\omega}} - \frac{e^{-j2\omega}}{1-e^{-j\omega}}$$

by taking inverse DTFT,

$$x[n] = u[n+1] - u[n-2]$$

$$= \begin{cases} 1; & -1 \le n < 2 \\ 0; & \text{otherwise} \end{cases}$$

From parseval's theorem,

$$\sum_{n=-\infty}^{\infty} |nx[n]|^2 = \frac{1}{2\pi}\int_{-\pi}^{\pi}\left|\left[\frac{d}{d\omega}X(e^{j\omega})\right]\right|^2 d\omega$$

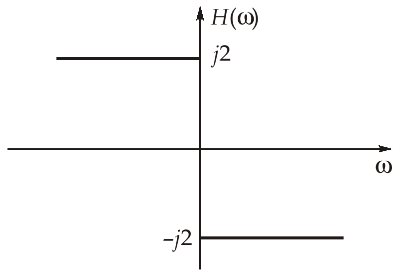
$$\therefore \quad \frac{1}{\pi}\int_{-\pi}^{\pi}\left|\left[\frac{d}{d\omega}X(e^{j\omega})\right]\right|^2 d\omega = 2\sum_{n=-\infty}^{\infty}|nx[n]|^2 d\omega$$

$$= 2\sum_{n=-1}^{1}|n|^2 = 2[1+0+1] = 4$$

$$\frac{1}{\pi}\int_{-\pi}^{\pi}\left|\left[\frac{d}{d\omega}X(e^{j\omega})\right]\right|^2 d\omega = 4$$

22. (d)

By redrawing the given frequency response, we get,



We can write $H(\omega) = -j2\,\text{sgn}(\omega)$

We know that,

For $\quad \text{sgn}(t) \xleftrightarrow{\text{FT}} \dfrac{2}{j\omega}$

By duality property

$$\frac{2}{jt} \xleftrightarrow{\text{FT}} 2\pi\,\text{sgn}(-\omega)$$

$$\frac{2}{jt} \xleftrightarrow{\text{FT}} -2\pi\,\text{sgn}(\omega)$$

$$\frac{2}{\pi t} \xleftrightarrow{\text{FT}} -j2\,\text{sgn}(\omega)$$

or $\quad = 2(\pi t)^{-1}$

23. (b)

$$X[k] = \sum_{n=0}^{N-1} x[n]e^{-j\frac{2\pi}{N}nK}$$

$$g[n] = x[n-2]_{\text{mod N}}$$

$$G[k] = e^{-j\frac{2\pi}{N}(2)k}X[k]$$

$$G[1] = e^{-j\frac{2\pi}{4}(2)1}X[1] = e^{-j\pi}X[1]$$

$$G[1] = -X[1] = -7$$

24. (a)

By the definition of Fourier series,

We can write $C_{N_0/2}$ for N_0 is even,

$$C_{N_0/2} = \frac{1}{N_0}\sum_{n=0}^{N-1} x[n]\,e^{-j\left(\frac{N_0}{2}\right)\left(\frac{2\pi}{N_0}\right)n}$$

$$= \frac{1}{N_0}\sum_{n=0}^{N-1} x[n]\, e^{-j\pi n} = \frac{1}{N_0}\sum_{n=0}^{N-1} (-1)^n\, x[n] = \text{real}$$

25. (d)

Given, $x(t) = 2 + \cos(50\pi t)$

Frequency of signal $\omega_{sig} = 50\pi$

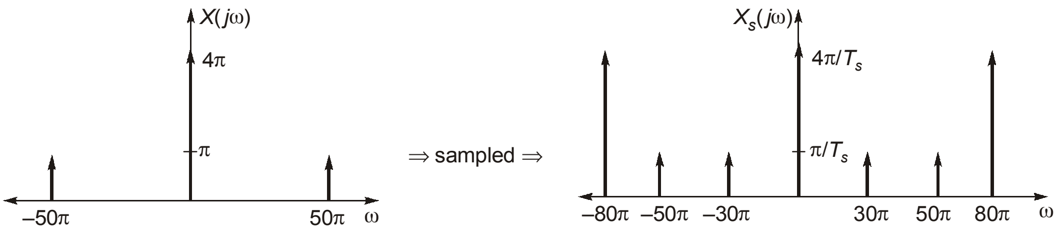
$T_s = 0.025$ sec

$\therefore$ sampling frequency $\omega_s = \frac{2\pi}{T_s} = 80\,\pi$ rad/sec

then, $X(j\omega) = 4\,\pi\delta(\omega) + \pi[\delta(\omega + 50\pi) + \delta(\omega - 50\pi)]$

Let the sampled signal be represented as $X_s(j\omega)$, where $X_s(j\omega)$ is given as

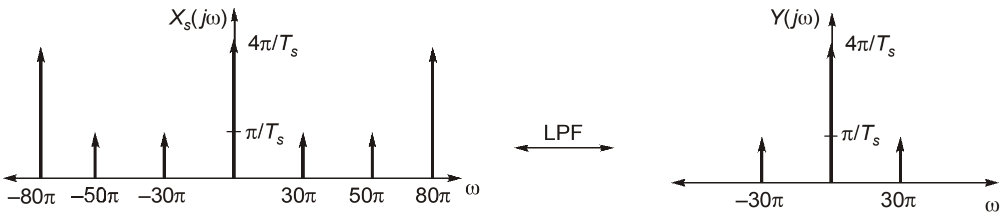
$$X_s(j\omega) = \frac{1}{T_s}\sum_{m=-\infty}^{\infty} X(j(\omega - n\omega_s))$$



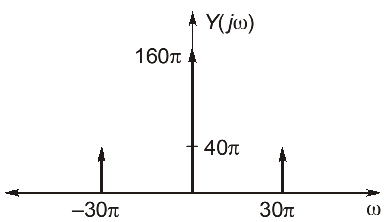
$$X_s(j\omega) = 40\sum_{m=-\infty}^{\infty} [4\pi\delta(\omega - 80\pi)] + \pi\delta(\omega - 50\pi - 80\pi n) - \pi\delta(\omega + 50\pi - 80\pi n)]$$

now, the sampled input $X_s(j\omega)$ is passed through a low passed filter having cut-off frequency at $\omega = 40\pi$.

Therefore the output $Y(j\omega)$ will contain only the components which are less than $\omega = 40\,\pi$.



Now by putting $T_s = 0.025$, we will get



26. (b)

$$X(z) = \frac{z}{z-1} \qquad |z| > 1$$

$$Y(z) = \frac{2z}{z-\frac{1}{3}} \qquad |z| > \frac{1}{3}$$

$$H(z) = \frac{2(z-1)}{z-\frac{1}{3}} \qquad |z| > \frac{1}{3}$$

$$X'(z) = \frac{z}{z-\frac{1}{2}} \qquad |z| > \frac{1}{2}$$

$$Y'(z) = \text{H(z)} \cdot X'(z)$$

$$= \frac{2z(z-1)}{\left(z-\frac{1}{2}\right)\left(z-\frac{1}{3}\right)} \qquad |z| > \frac{1}{2}$$

Taking inverse z transform

$$y[n] = \left[-6\left(\frac{1}{2}\right)^n + 8\left(\frac{1}{3}\right)^n\right]u[n]$$

$k_1 = -6, \quad k_2 = 8$

so, $\qquad k_1 + k_2 = 2$

27. (b)

If $x[n]$ is real

$$\text{odd}[x[n]] \xrightarrow{FT} jIm[X(e^{j\omega})]$$

$$\therefore \qquad \text{odd}[x[n]] = F^{-1}\left[\frac{1}{2}\left(e^{j\omega} - e^{-j\omega} - e^{2j\omega} + e^{-2j\omega}\right)\right]$$

$$= \frac{1}{2}\left[\delta[n+1] - \delta[n-1] - \delta[n+2] + \delta[n-2]\right]$$

$$\because \qquad \text{odd } [x[n]] = \frac{x[n] - x[-n]}{2}$$

Since, $\qquad x[n] = 0$ for $n > 0$

$x[n] = 2\ \text{odd}[x[n]]$

$= \delta[n + 1] - \delta[n + 2]$ for $n < 0$

using parshevel's theorem

$$\frac{1}{2\pi}\int_{-\infty}^{\infty}\left|X\left(e^{j\omega}\right)\right|^2 d\omega = \sum_{n=-\infty}^{\infty}|x[n]|^2$$

$$(x[0])^2 - 2 = 3$$
$$x[0] = \pm 1$$
$$\because \quad x[0] > 0$$
$$\therefore \quad x[n] = \delta[n] + \delta[n+1] - \delta[n+2]$$

28. (a)

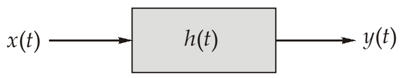
$$x[n] = \delta[n]$$
$$X(e^{j\omega}) = 1$$
$$\frac{dX(e^{j\omega})}{d\omega} = 0$$
$$\therefore \quad Y(e^{j\omega}) = e^{-j\omega}\, X(e^{j\omega})$$
$$h[n] = \frac{1}{2\pi}\int_{-\pi}^{\pi} e^{-j\omega}.e^{j\omega n} d\omega = \frac{\sin\pi(n-1)}{\pi(n-1)}$$

29. (c)

Given, the Causal LTI system,

$$H(j\omega) = \frac{1}{3+j\omega}$$

and output, $y(t) = e^{-3t}\,u(t) - e^{-4t}\,u(t)$



We know that, $H(j\omega) = \dfrac{Y(j\omega)}{X(j\omega)}$

$$Y(j\omega) = \frac{1}{3+j\omega} - \frac{1}{4+j\omega} = \frac{1}{(3+j\omega)(4+j\omega)}$$
$$\therefore \quad X(j\omega) = \frac{Y(j\omega)}{H(j\omega)} = \frac{1}{4+j\omega}$$

By inverse Fourier transform of $X(j\omega)$, we have,

$$x(t) = e^{-4t}\,u(t)$$

30. (b)

Given, $X(z) = \dfrac{1}{1-2.5z^{-1}+z^{-2}} = \dfrac{1}{(z^{-1}-2)\left(z^{-1}-\frac{1}{2}\right)}$

$$\frac{1}{(z^{-1}-2)\left(z^{-1}-\frac{1}{2}\right)} = \frac{A}{z^{-1}-2} + \frac{B}{z^{-1}-\frac{1}{2}}$$
$$\therefore \quad A = \frac{1}{2-\frac{1}{2}} = \frac{1}{3/2} = \frac{2}{3}$$
$$B = \frac{1}{\frac{1}{2}-2} = -\frac{2}{3}$$

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

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

Given $X(z)$ is a causal system, the ROC is right of the right most pole.

$\therefore\ |z| > 2$

hence, $$x[n] = -\frac{1}{3}\left(\frac{1}{2}\right)^n u[n] + \frac{4}{3}(2)^n u[n]$$

$$\therefore \qquad x(0) = -\frac{1}{3}+\frac{4}{3} = \frac{3}{3} = 1$$

■■■■