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Important Questions *for* GATE 2022

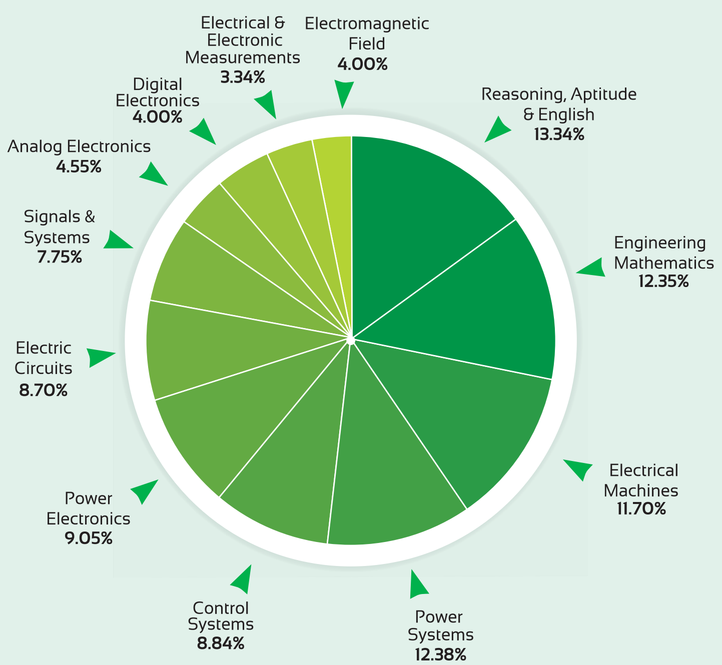
ELECTRICAL ENGINEERING

Day 3 of 8

Q.51 - Q.75 (Out of 200 Questions)

Signals & Systems, Electrical & Electronic Measurements

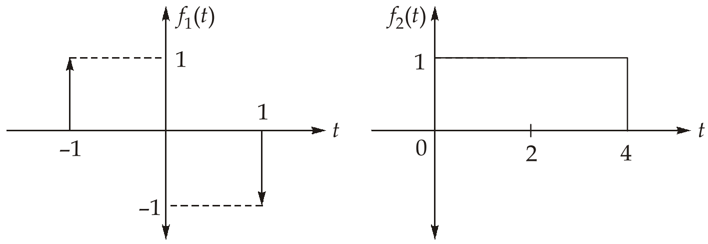
SUBJECT-WISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS

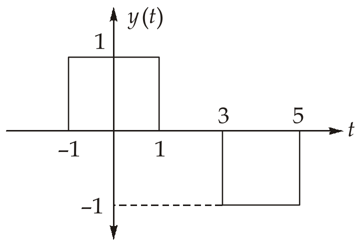


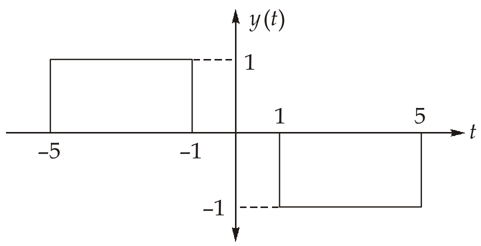
Subject	Average % (last 5 yrs)
Reasoning, Aptitude & English	13.34%
Engineering Mathematics	12.35%
Electrical Machines	11.70%
Power Systems	12.38%
Control Systems	8.84%
Power Electronics	9.05%
Electric Circuits	8.70%
Signals & Systems	7.75%
Analog Electronics	4.55%
Digital Electronics	4.00%
Electrical & Electronic Measurements	3.34%
Electromagnetic Fields	4.00%
Total	**100%**

Signals & Systems, Electrical & Electronic Measurements

Q.51 The signals $f_1(t)$ and $f_2(t)$ are as shown below. The convolution of $f_1(t)$, $f_2(t)$ i.e., $y(t)$ = $f_1(t) * f_2(t)$ will be represented as which of the given below option



(a)


(b)


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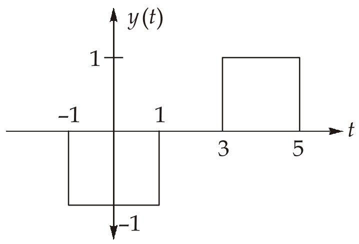
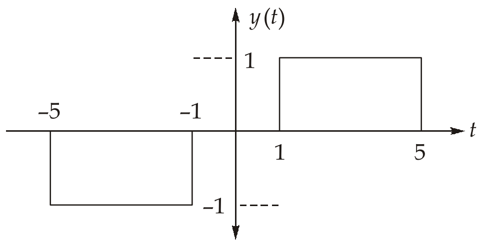


(d)


Q.52 A time domain energy signal is defined as $x(t)$ with energy equal to 10 J, then the energy of the signal $2x(5t - 6)$ is equal to ________ J.

Q.53 Consider a causal LTI system with frequency response $H(j\omega) = \dfrac{1}{3 + j\omega}$ for a particular input $x(t)$, this system is observed to produce the output as $y(t) = e^{-3t}\,u(t) - e^{-4t}\,u(t)$. Then the input $x(t)$ is

(a) $e^{-3t}\,u(t)$
(b) $e^{-t}\,u(t)$
(c) $e^{-4t}\,u(t)$
(d) $e^{4t}\,u(t)$

Q.54 Let $x(t) = \dfrac{\sin(10\pi t)}{\pi t}$ be the continuous time signal, the condition on the sampling interval 'T_s' so that $x(t)$ is uniquely represented by the discrete-time sequence $x[n] = x[nT_s]$ is

(a) $T_s > \dfrac{1}{10}$
(b) $T_s < \dfrac{1}{10}$
(c) $T_s > 10\pi$
(d) $T_s < \dfrac{1}{5\pi}$

Q.55 The region of convergence of a signal $x[n]$ whose z-transform is represented as $X(z)$, where

$$x[n] = \begin{cases} 1; & -5 \le n \le 5 \\ 0; & \text{otherwise} \end{cases}$$

(a) $|z| > 0.2$
(b) $|z| > 5$
(c) $0.2 < |z| < 5$
(d) entire z-plane except $z = 0$ and $z = \infty$

Q.56 The inverse Laplace transform of the signal $X(s) = \log(s + 2) - \log(s + 3)$. Then $x(t)$ is equal to (Assume all initial conditions are zero).

(a) $\left(\dfrac{e^{3t} - e^{-2t}}{t}\right)u(t)$
(b) $\left(\dfrac{e^{-3t} - e^{-2t}}{t}\right)u(t)$
(c) $\left(\dfrac{e^{-3t} - e^{2t}}{t}\right)u(t)$
(d) $\left(\dfrac{e^{3t} - e^{2t}}{t}\right)u(t)$

Q.57 The unit step response of a system with transfer function $\dfrac{b(s+a)}{(s+b)}$ is $c(t)$. If initial value $c(0) = 2$ and final value $c(\infty) = 8$. Then the ratio of $\left(\dfrac{a}{b}\right)$ is ________.

(a) 1
(b) 2
(c) 3
(d) 4

Q.58 For $x(n) = \left(\dfrac{1}{3}\right)^{nu(n)} + \left(\sqrt{3} + j\right)^{-n} u(n)$;

If ROC: $a < |z| < 1$, then the value of a will be

Q.59 Let $y(t) = e^{-t} \cdot u(t) * \sum_{K=-\infty}^{\infty} \delta(t - 3k)$. If $y(t) = A \cdot e^{-t}$ for $3 \le t < 6$, then the value of A is ________ .

(Answer upto two decimal places)

Q.60 Consider a continuous time LTI system whose frequency response is

$$H(j\omega) = \int_{-\infty}^{\infty} h(t)e^{-j\omega t} \cdot dt = \frac{\sin 4\omega}{\omega}$$

If the input to this system is a periodic signal

$$x(t) = \begin{cases} 1; & 0 \le t < 4 \\ -1; & 4 \le t < 8 \end{cases}$$

with period $T = 8$, and the corresponding system output $y(t)$ has Fourier series coefficient b_k. Which one of the following option is correct?

(a) $b_k = 0$; for even values of k
$b_k \neq 0$; for odd values of k

(b) $b_k \neq 0$; for even values of k
$b_k \neq 0$; for odd values of k

(c) $b_k \neq 0$; for even values of k
$b_k = 0$; for odd values of k

(d) $b_k = 0$; for even values of k
$b_k = 0$; for odd values of k

Q.61 Consider a continuous-time system with input-output relation:

$$y(t) = \frac{1}{T}\int_{t-T/2}^{t+T/2} x(\tau)\,d\tau$$

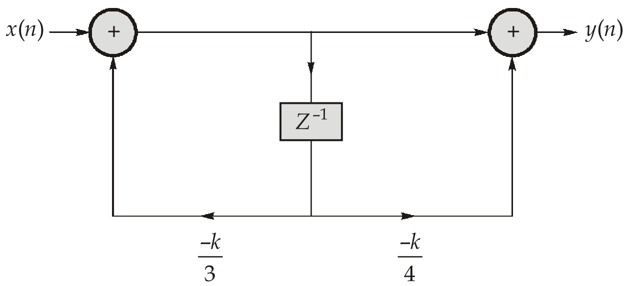
Select the correct option given below,

(a) Linear, time variant, causal
(b) Non-linear, time invariant, causal
(c) Linear, time invariant, non casual
(d) Linear, time invariant, causal

Q.62 Fourier transform of $e^{-2|t-1|}$ is

(a) $\frac{4e^{j\omega}}{4+\omega^2}$
(b) $\frac{4e^{-j\omega}}{4+\omega^2}$
(c) $\frac{4e^{-j\omega}}{(2+\omega)^2}$
(d) $\frac{4e^{j\omega}}{(2+\omega)^2}$

Q.63 Consider the causal digital filter shown in below figure:



The values of k for which system is stable.

(a) $|k| < 3$
(b) $|k| > 3$
(c) $|k| < \frac{1}{3}$
(d) $|k| > \frac{1}{3}$

Q.64 A Wattmeter has a current coil of 0.03 Ω resistance and a pressure coil of 6000 Ω resistance connected such that the current coil is on the load side. If the load take 20 A at a voltage of 220 V and 0.6 power factor then the percentage error in the reading of wattmeter is

(a) 0.45%
(b) 0.30%
(c) 0.15%
(d) 0.90%

Q.65 If the distance of screen from a CRT to centre of deflection plates is 20 cm. The length of deflection plate is 2 cm. The distance between the plate is 1 cm and the accelerating voltage is 500 V, the deflection sensitivity is____________ cm/V.

Q.66 An ac bridge has the following constants:

Arm *AB* - Capacitor of 0.5 μF in parallel with 1 kΩ resistance.

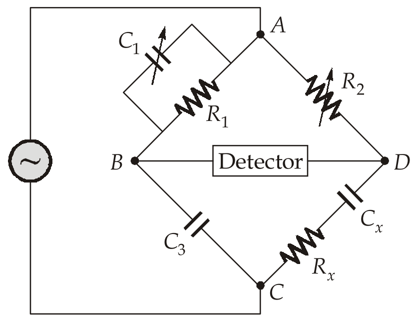
Arm *AD* - Resistance of 2 kΩ.

Arm *BC* - Capacitor of 0.5 μF

Arm *CD* - Unknown capacitor of C_x and resistance R_x in series.

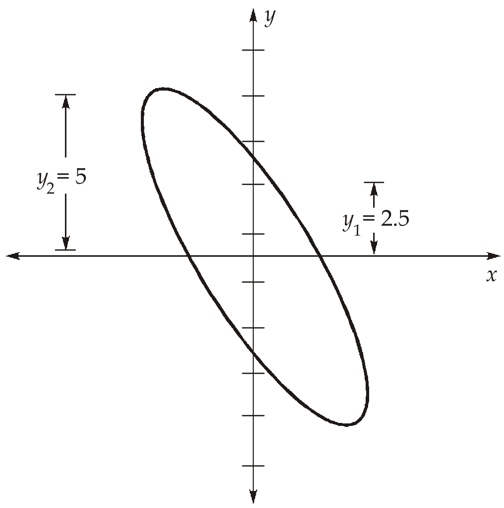
Frequency - 1 kHz

The dissipation factor is



(a) 3.14
(b) 1.05
(c) 6.28
(d) 0.57

Q.67 When two voltages of same frequency out of different phase are connected to Y and X plates of the oscilloscope, Lissojous pattern displayed on the CRO screen in shown in the figure below. Phase difference between these two signals is ________ degree.



Q.68 A digital voltmeter uses a 10 MHz clock and has a voltage controlled generator which provides a width of 10 μs/volt. A 10 V input signal will corresponds to pulse count of ____________

Q.69 An angular deflection of 15° was observed by a PMMC galvanometer, carry a current *I* through its moving coil with controlling torque provided by spring. If a meter is replaced with another PMMC meter having same specification but with doubled magnetic flux density and current in the coil also becomes twice, then, new deflection (in degree) will be

(a) 30°
(b) 60°
(c) 90°
(d) 15°

Q.70 A single phase 230 V induction watt hour meter is connected to a load which draws 16 A current at 0.8 p.f. If the speed of rotation of the energy disc was 20 rpm, then the value of meter constant in revolution per kWhr will be

(a) 560.8
(b) 407.6
(c) 480.4
(d) 503.2

Q.71 Two wattmeter method is used to measure power in circuit supplied by a 3-ϕ , 440 V, 50 Hz feeding a balanced 3-ϕ load. The readings obtained from the wattmeter 1 and wattmeter 2 were 4 kW and 1 kW respectively. It was found that while taking second reading (1 kW) the current coil of second wattmeter were interchanged. The value of power factor will be ________ (upto 3 decimal places)

Q.72 A dynamometer type wattmeter with pressure coil angle of 2° measure 400 W for 1 - ϕ inductive load supplied by 230 V. If this wattermeter is replaced by another wattmeter with pressure coil angle 1° reading obtained is 320 W. The value of current drawn by load is

(a) 10.45 A
(b) 12.42 A
(c) 19.99 A
(d) 16.32 A

Q.73 A digital to analog converter has full scale output of 4.2 V. The converter has resolution close to 18 mV, then bit size of digital to analog converter will be

(a) 8
(b) 10
(c) 6
(d) 12

Multiple Select Questions (MSQ)

Q.74 A periodic signal with period T_0 is real. The signal $x(t)$ has even and odd part shown as $x_e(t)$ and $x_0(t)$, also C_k is the k^{th} exponential Fourier series coefficient of $x(t)$.

$$\text{If } C_k = \begin{cases} \left(\dfrac{10}{3|k|} + \dfrac{3}{k}j\right) & k \neq 0 \text{ and } |k| < 3 \\ 10 & k = 0 \end{cases}$$

Then which of the following is/are correct?

(a) The power of even part of $x(t)$ is 127.76 W
(b) The power of odd part of $x(t)$ is 25.50 W
(c) The power of even part of $x(t)$ is 120.46 W
(d) The power of odd part of $x(t)$ is 28.50 W

Q.75 The equations under balance conditions for a bridge are

$$R_1 = \frac{R_2 R_3^2}{R_4^2} \text{ and } L_1 = \frac{C_4 R_3^3}{R_2},$$

where R_1 and L_1 are respectively unknown resistance and inductance.
In order to achieve converging balance

(a) R_3 should be chosen as variable
(b) R_4 should be chosen as variable
(c) C_4 should be chosen as variable
(d) R_2 and C_4 should be chosen as variable

■■■■

Detailed Explanations

51. **(a)**

Given, $f_1(t) = \delta(t+1) - \delta(t-1)$

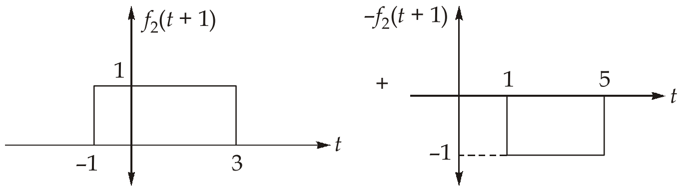
and $y(t) = f_1(t) * f_2(t)$

Using convolution property of impulse,

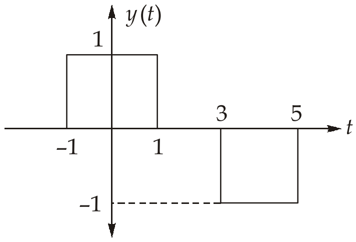
$$x(t) * \delta(t - t_0) = x(t - t_0)$$

$$y(t) = f_2(t+1) - f_2(t-1)$$

Drawing $f_2(t+1)$ and $-f_2(t-1)$



$\Rightarrow$



Hence option (a) is correct.

52. **(8)**

Given, signal $x(t)$ has energy 'E'

for $ax(t) \xleftrightarrow{E} a^2E$

$\therefore$ $ax(bt + c) \xleftrightarrow{E} \dfrac{a^2E}{b}$

From the given signal $a = 2$, $b = 5$ and hence

$\therefore$ The energy of signal $2x(5t - 6)$ is

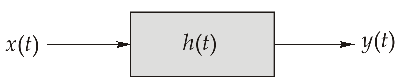
$$E = \frac{(2)^2 \times 10}{5} = 8 \text{ J}$$

53. **(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,

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

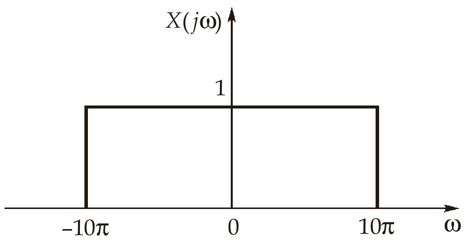
54. **(b)**

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,

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

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

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

55. **(d)**

The given sequence of $x[n]$ is finite duration. Hence, the region of convergence is $0 < |z| < \infty$.

56. **(b)**

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

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,

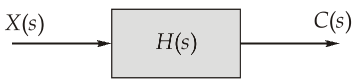
$$-tx(t) = [e^{-2t} - e^{-3t}]\,u(t)$$

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

57. **(d)**

Let, the given transfer function,

$$H(s) = \frac{b(s+a)}{(s+b)}$$



where, $$X(s) = \frac{1}{s} \qquad (\because \text{ unit step response})$$

$$C(s) = X(s)H(s) = \frac{b(s+a)}{s(s+b)}$$

Given, $$c(0) = 2$$

$$\Rightarrow \quad \underset{s\to\infty}{Lt}\; s\cdot\frac{b(s+a)}{s(s+b)} = 2$$

$$b = 2$$

and $$c(\infty) = 8$$

$$\Rightarrow \quad \underset{s\to 0}{Lt}\; s\cdot\frac{b(s+a)}{s(s+b)} = 8$$

$$a = 8$$

now, $$\frac{a}{b} = \frac{8}{2} = 4$$

58. **(0.5)**

First part: $$\left(\frac{1}{3}\right)^{nu(n)} = \begin{cases} \left(\frac{1}{3}\right)^{n\times 0} & n<0 \\ \left(\frac{1}{3}\right)^{n\times 1} & n\geq 0 \end{cases} = \begin{cases} 1 & n<0 \\ \left(\frac{1}{3}\right)^{n}, & n\geq 0 \end{cases}$$

$$\left(\frac{1}{3}\right)^{nu(n)} = u(-n-1) + \left(\frac{1}{3}\right)^{n} u(n)$$

Second part:

$$\left(\sqrt{3}+j\right)^{-n} u(n) = \left(\frac{1}{\sqrt{3}+j}\right)^{n} u(n)$$

$$\therefore \quad |z| = \left|\frac{1}{\sqrt{3}+j}\right| = \frac{1}{2}$$

$$\therefore \quad \text{ROC: } |z| > \frac{1}{2}$$

Combining both ROC's

$$\frac{1}{3} < |z| < 1$$

$$|z| > \frac{1}{2}$$

Net ROC: $\frac{1}{2} < |z| < 1$

Comparing with given ROC: $a < |z| < 1$

$$\therefore \quad a = \frac{1}{2}$$

59. **21.13 (21.00 to 21.30)**

$$y(t) = e^{-t} \cdot u(t) * \sum_{K=-\infty}^{\infty} \delta(t-3k)$$

$$y(t) = e^{-t} \cdot u(t) * [....\delta(t+9) + \delta(t+6) + \delta(t+3) + \delta(t) + \delta(t-3) + \delta(t-6) + \delta(t-9) + ...]$$

$$y(t) = e^{-(t+9)} \cdot u(t+9) + e^{-(t+6)} \cdot u(t+6) + e^{-(t+3)} \cdot u(t+3) + e^{-t} \cdot u(t) + e^{-(t-3)} \cdot u(t-3) + e^{-(t-6)} \cdot u(t-6) + e^{-(t-9)} \cdot u(t-9) + ...$$

$$y(t) = e^{-(t-3)} \cdot u(t-3) + e^{-t} \cdot (t) + e^{-(t+3)} u(t+3) + e^{-(t+6)} u(t+6) + e^{-(t+9)} u(t+9) + ... \; 3 \le t < 6$$

$$y(t) = e^{-(t-3)} + e^{-t} + e^{-(t+3)} + e^{-(t+6)} + e^{-(t+9)} + ... \; 3 \le t < 6$$

$$y(t) = e^{-t}[e^{3} + 1 + e^{-3} + e^{-6} + e^{-9} + ...] \; 3 \le t < 6$$

$$y(t) = e^{-t}\left[\frac{e^3}{1-\frac{1}{e^3}}\right]; 3 \le t < 6 = e^{-t}\left[\frac{e^6}{e^3-1}\right]; 3 \le t < 6$$

$$\therefore \quad A = \frac{e^6}{e^3-1} = 21.13$$

60. **(d)**

Let us first evaluate the Fourier series coefficients of $x(t)$ clearly, since $x(t)$ is real and odd, a_k is purely imaginary and odd.

Therefore, $a_0 = 0$

Now,

$$a_k = \frac{1}{8}\int_0^8 x(t) \cdot e^{-j\left(\frac{2\pi}{8}\right)kt} \cdot dt$$

$$= \frac{1}{8}\int_0^4 e^{-j\left(\frac{2\pi}{8}\right)kt} \cdot dt - \frac{1}{8}\int_4^8 e^{-j\left(\frac{2\pi}{8}\right)kt} \cdot dt$$

$$= \frac{1}{8}\left(\frac{e^{-j\frac{\pi kt}{4}}}{-j\frac{\pi}{4}k}\right)_0^4 - \frac{1}{8}\left(\frac{e^{-j\frac{\pi kt}{4}}}{-j\frac{\pi}{4}k}\right)_4^8$$

$$= \frac{1}{2}\frac{\left(1-e^{-j\pi k}\right)}{j\pi k} - \frac{1}{2}\frac{\left(e^{-j\pi k}-e^{-j2\pi k}\right)}{j\pi k}$$

$$= \frac{1}{j2\pi k}\left(1-e^{-j\pi k}-e^{-j\pi k}+1\right)$$

$$a_k = \begin{cases} 0; & K = 0, \pm 2, \pm 4, \pm 6, ... \\ \dfrac{2}{j\pi k}; & K = \pm 1, \pm 3, \pm 5, ... \end{cases}$$

Input of LTI system does not contain even harmonics

∴ Output also does not contain even harmonics,

$$b_k = 0; \text{ for even value of } k$$

When $x(t)$ is passed through an LTI system with frequency response $H(j\omega)$, the output $y(t)$ is given by,

$$y(t) = \sum_{K=-\infty}^{\infty} a_k \cdot H(jk\omega_0) \cdot e^{jk\omega_0 t}$$

Where, $\omega_0 = \frac{2\pi}{8} = \frac{\pi}{4}$

Since a_k is non-zero only for odd values of k, we need to evaluate the above summation only for odd k.

$$H(jK\omega_0) = H\left(jk\frac{\pi}{4}\right) = \frac{\sin(k\pi)}{\frac{k\pi}{4}}$$

$H(jk\omega_0)$ is always zero for odd values of k

∴ $y(t) = 0$

∴ $b_k = 0$ for odd values of k

61. **(c)**

Integration is linear system

Time-variant (or) time invariant system:

Delay input by t_o units

$$= \frac{1}{T}\int_{t-T/2}^{t+T/2} x(\tau - t_0)\,d\tau \quad ...(i)$$

Delay output by t_o units (or) substitute $(t - t_0)$ in the place of t.

$$y(t - t_0) = \frac{1}{T}\int_{t-t_0-T/2}^{t-t_0+T/2} x(\tau)\,d\tau \quad ...(ii)$$

From equation (i) and (ii), we can say equation (i) = equation (ii),

∴ The given system is time invariant.

Causal (or) Non-causal system:

$$y(t) = \frac{1}{T}\int_{t-T/2}^{t+T/2} x(\tau)\,d\tau$$

Let, $T = 4$

$$y(0) = \frac{1}{4}\int_{-2}^{2} x(\tau)\,d\tau$$

Here, $y(0)$ depends on future value $x(2)$.

$\therefore$ The given system is non-causal system.

62. **(b)**

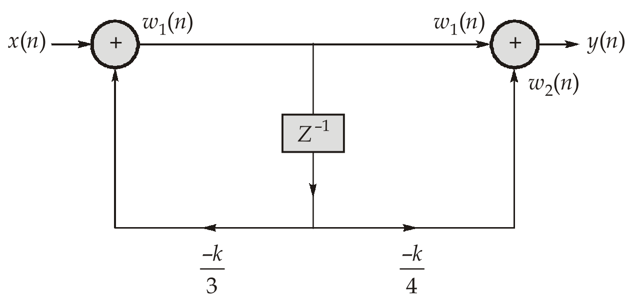
We know that,

$$e^{-a|t|} \xleftrightarrow{\text{F.T.}} \frac{2a}{a^2+\omega^2}$$

$$\therefore \quad e^{-2|t|} \xleftrightarrow{\text{F.T.}} \frac{4}{4+\omega^2}$$

$$\therefore \quad e^{-2|t-1|} \xleftrightarrow{\text{F.T.}} \frac{4\cdot e^{-j\omega}}{4+\omega^2}$$

63. **(a)**



We have,

$$W_1(z) = X(z) - \frac{k}{3}z^{-1}W_1(z)$$

$$W_1(z) = \frac{X(z)}{1+\frac{k}{3}z^{-1}}$$

Also, $$W_2(z) = -\frac{k}{4}z^{-1}W_1(z)$$

$$W_2(z) = -\frac{X(z)\frac{k}{4}z^{-1}}{1+\frac{k}{3}z^{-1}}$$

Therefore, $Y(z) = W_1(z) + W_2(z)$ will be

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

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1-\frac{k}{4}z^{-1}}{1+\frac{k}{3}z^{-1}}$$

Since $H(z)$ corresponds to a causal filter, the ROC will be $|z| > \frac{|k|}{3}$. For the system to be stable, the ROC of $H(z)$ must include the unit circle. This is possible only if $\frac{|k|}{3} < 1$.

$\therefore \quad |k| < 3$

64. (a)

Power consumed by load,

$$P_T = VI\cos\phi = 220 \times 20 \times 0.6 = 2640 \text{ W}$$

Now given that,

$$R_C = 0.03\ \Omega,\ R_P = 6000\ \Omega$$

Power indicated by wattmeter,

$$P_W = \text{Power consumed by load + power loss in current coil}$$
$$= P_T + I^2R_C = 2640 + (20)^2\,(0.03) = 2652 \text{ W}$$

$$\%\text{Error} = \frac{P_W - P_T}{P_T}\times 100 = \frac{2652-2640}{2640}\times 100$$

$$\%\text{Error} = 0.45\%$$

65. 0.04 (0.038 to 0.042)

In case of CRO deflection sensitivity

$$S = \frac{Ll_d}{2dV_a}$$

$L = 20$ cm

$l_d = 2$ cm

$d = 1$ cm

$V_a = 500\ V$

$$\therefore \quad S = \frac{20\times 2}{2\times 1\times 500} = 0.04\,\text{cm/V}$$

66. (a)

$$R_x = \frac{C_1}{C_3}R_2 = \frac{0.5\mu\text{F}}{0.5\mu\text{F}}\times 2k = 2\text{ k}\Omega$$

$$C_x = \frac{R_1}{R_2}\times C_3 = \frac{1k}{2k}\times 0.5\mu\text{F} = 0.25\ \mu\text{F}$$

The dissipation factor is given by,

$$D = \omega R_x C_x$$
$$= 2 \times 3.142 \times 1000 \times 2 \times 1000 \times 0.25 \times 10^{-6}$$
$$= 3.142$$

67. (150)

$\because$ $$\sin\phi = \frac{y_1}{y_2} = \frac{2.5}{5} = 0.5$$

$\because$ As the major axis is in 2nd and 4th quadrants

$\therefore$ $$\phi = 180° - \sin^{-1}(0.5)$$
$$= 180° - 30°$$
$$= 150°$$

68. (1000)

$$\text{Time for one count} = \frac{1}{10 \times 10^6} = 10^{-7} \text{ sec}$$
$$\text{Total Time} = 10 \times 10 \times 10^{-6} = 100 \times 10^{-6} \text{ sec}$$
$$\text{Count} = \frac{100 \times 10^{-6}}{10^{-7}} = 1000$$

69. (b)

$$T_d = BINA$$

Controlling torque, $T_c = K\theta$

At balance, $T_c = T_d$

$$K\theta = BINA$$

Deflection, $\theta \propto BI$

Given, magnetic flux density is being doubled i.e. 2 B

Current in the coil also becomes twice = $2I$

New deflecting torque, $\theta' \propto (2B)\ (2I)$

$$\theta' \propto 4\ BI$$

New deflection torque is 4 times of initial deflection torque

New deflection also becomes 4 times

$$= 4 \times 15° = 60°$$

70. (b)

$$\text{Power absorbed by load} = VI\cos\phi$$
$$= 230 \times 16 \times 0.8$$
$$= 2.944 \text{ kW}$$

Number of revolutions in one minute = 20

Number of revolutions in one hour = 20 × 60 = 1200

Energy consumed in kWhr = 2.944 kWhr

$$\text{No. of revolutions per kWhr} = \text{Meter constant} = \frac{1200}{2.944} = 407.61$$

71. 0.327 (0.320 to 0.332)

Wattmeter -1 reading, $P_1 = 4$ kW

Wattmeter -2 reading, $P_2 = 1$ kW

For second reading as the terminals current coil were reversed

∴ Actual reading = –1 kW

$$\text{Power factor} = \cos\phi = \cos\left[\tan^{-1}\sqrt{3}\frac{(P_1 - P_2)}{P_1 + P_2}\right]$$

$$= \cos\left[\tan^{-1}\sqrt{3}\frac{(4-(-1))}{(4-1)}\right]$$

$$= \cos\left[\tan^{-1}\sqrt{3}\left(\frac{5}{3}\right)\right] = \cos(70.893°) = 0.327$$

72. (c)

Given, Supply voltage, $V = 230$ V

Reading of dynamometer type wattmeter

$$P = VI\cos(\phi - \beta)\cos\beta$$

If $\beta = 2°$ $\quad 400 = 230 \times I \times \cos(\phi - 2°)\cos 2°$ ...(i)

If $\beta = 1°$ $\quad 320 = 230 \times I \times \cos(\phi - 1°)\cos 1°$ ...(ii)

Using (i) and (ii), we get

$$\frac{VI\cos(\phi - 2°)\cos 2°}{VI\cos(\phi - 1°)\cos 1°} = \frac{400}{320}$$

$$[\cos\phi\cos 2° + \sin\phi\sin 2°] = 1.25 \times [\cos 1°\cos\phi + \sin\phi\sin 1°]$$

$$\sin\phi[\sin 2° - 1.25 \times \sin 1°] = \cos\phi[1.25\cos 1° - \cos 2°]$$

$$\tan\phi = \left\{\frac{1.25\cos 1° - \cos 2°}{\sin 2° - 1.25\sin 1°}\right\}$$

$$\phi = 87.01°$$

Using power relation $= VI\cos(\phi - 1°)\cdot\cos 1° = 320$

$$230 \times I\cos(87.01° - 1°)\cos 1° = 320$$

$$I = \frac{320}{230 \times \cos(86.01)\cos 1°}$$

$$I = 19.99 \text{ A}$$

73. (a)

$$\text{Resolution, } R = \frac{V_0}{2^N - 1} = 18 \text{ mV}$$

Where, V_0 = Full scale output voltage

= 4.2 V

N = bit size

So, $$\frac{V_0}{2^N} = 18 \text{ mV}$$

$\therefore$ $$\frac{4.2}{18\times10^{-3}} = 2^N - 1 = 233.33$$

$\therefore$ $$N = 8$$

74. (a)

If $x(t)$ is real then Fourier coefficient of even part of $x(t)$ i.e. $x_e(t)$ is Re $\{C_k\}$

So, $$B_k = \begin{cases} \dfrac{10}{3|k|} & |k| < 3 \\ 10 & k = 0 \end{cases}$$

So, $$B_k = \begin{cases} 10 & k = 0 \\ \dfrac{10}{3} & k = 1, -1 \\ \dfrac{10}{6} & k = 2, -2 \end{cases}$$

So power of $$x_e(t) = \sum_{k=-\infty}^{\infty} |B_k|^2 = 100 + 2\left(\frac{100}{9} + \frac{100}{36}\right)$$
$$= 127.76$$

If $x(t)$ is real, the Fourier coefficient of odd part of $x(t)$ i.e., $x_0(t)$ is img $\{c_k\}$

So, $$D_K = \begin{cases} \dfrac{3}{K}, & \text{for } k \neq 0 \text{ and } |k| < 3 \\ 0, & \text{for } k = 0 \end{cases}$$

So, Power of $$x_0(t) = \sum_{k=-\infty}^{\infty} |D_K|^2 = \left[\left(\frac{3}{-2}\right)^2 + \left(\frac{3}{-1}\right)^2 + (3)^2 + \left(\frac{3}{2}\right)^2\right]$$

$$= \frac{9}{4} + 9 + 9 + \frac{9}{4} = 22.5 \text{ W}$$

75. (b), (c)

In order to achieve converging balance, the elements not common to R_1 and L_1 are chosen as variables.

So, R_4 and C_4 should be chosen as variables.

■■■■