



**POSTAL  
BOOK PACKAGE**

**2025**

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**Objective Practice Sets**

## **Communication Systems**

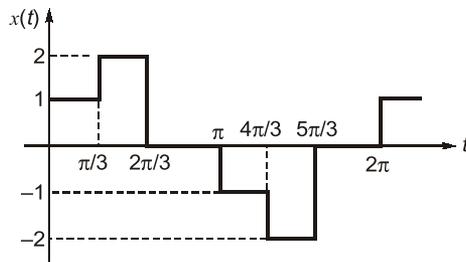
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# Fourier Analysis of Signal Energy and Power Signals

## MCQ and NAT Questions

- Q.1** If  $G(f)$  represents the Fourier transform of a signal  $g(t)$  which is real and odd symmetric in time then
- $G(f)$  is complex
  - $G(f)$  is imaginary
  - $G(f)$  is real
  - $G(f)$  is real and non-negative

- Q.2** Compute the amplitude of the fundamental component of the waveform given in figure.



- 0
- 1.00
- 1.603
- 1.712

- Q.3** Let  $x(t)$  be a signal with its Fourier transform  $X(j\omega)$  suppose we are given the following facts.

- $x(t)$  is real.
- $x(t) = 0$  for  $t \leq 0$ .
- $\frac{1}{2\pi} \int_{-\infty}^{\infty} \text{Re}\{X(j\omega)\} e^{j\omega t} d\omega = 2|t|e^{-|t|}$ .

then a closed form expression for  $x(t)$  is

- $2e^{-t} u(t)$
- $e^{-|t|}$
- $te^{-2t} u(t)$
- $2te^{-t} u(t)$

- Q.4 Assertion (A):** If two signals are orthogonal they will also be orthonormal.

**Reason (R):** If two signals are orthonormal they also will be orthogonal.

- Both A and R are true, and R is the correct explanation of A.
- Both A and R are true, but R is not a correct explanation of A.
- A is true, but R is false.
- A is false, but R is true.

- Q.5** Consider the following statements:  
The normalized power,  $S \equiv v^2(t)$  can be defined as the
- instantaneous power divided by the maximum power in the circuit.
  - time average power that appears in a one ohm resistor.
  - Total power consumed by the circuit divided by the average power consumed in that circuit.
  - the mean square value of  $v(t)$ .

Which of the above statements is/are correct?

- 2 only
- 1 and 2
- 2 and 3
- 2 and 4

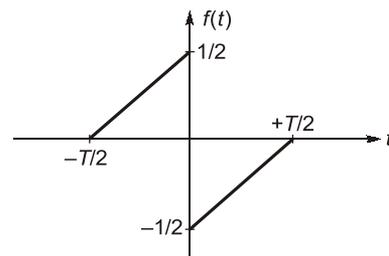
- Q.6** The auto correlation function of a rectangular pulse of duration  $T$  is

- A rectangular pulse of duration  $T$
- A rectangular pulse of duration  $2T$
- A triangular pulse of duration  $T$
- A triangular pulse of duration  $2T$

- Q.7** The amplitude spectrum of Gaussian pulse is

- uniform
- a sine function
- gaussian
- an impulse function

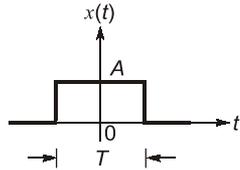
- Q.8** A function  $f(t)$  is shown in figure.



The Fourier transform  $F(\omega)$  of  $f(t)$  is

- real and even function of  $\omega$
- real and odd function of  $\omega$
- imaginary and odd function of  $\omega$
- imaginary and even function of  $\omega$

**Q.9** What is the total energy of the rectangular pulse shown in the figure below?



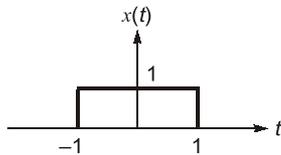
- (a)  $AT$  (b)  $A^2T$   
(c)  $A^2T^2$  (d)  $AT^2$

**Q.10** Which one of the following is not a property of auto correlation function ( $R(\tau)$ )?

- (a)  $R(0) \leq R(\tau)$   
(b)  $R(\tau) = R(-\tau)$   
(c)  $R(0) = s =$  average power of the waveform  
(d) Power spectral density is Fourier transform of auto correlation function for a periodic waveform

**Q.11**  $x(t)$  is a positive rectangular pulse from  $t = -1$  to  $t = +1$  with unit height as shown in figure.

The value of  $\int_{-\infty}^{\infty} |X(\omega)|^2 d\omega$  (where  $X(\omega)$  is Fourier transform of  $x(t)$ ) is



- (a) 2 (b)  $2\pi$   
(c)  $4\pi$  (d) 4

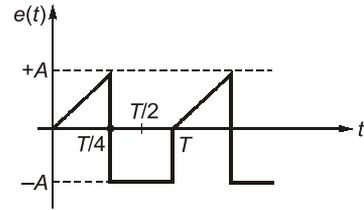
**Q.12** The Fourier transform of  $x(t) = \frac{2a}{a^2 + t^2}$  is

- (a)  $2\pi e^{-a|\omega|}$  (b)  $\pi e^{-2a|\omega|}$   
(c)  $\pi e^{-a\omega}$  (d)  $\pi e^{-2a\omega}$

**Q.13** Out of the four signal waveforms-sinusoid, rectangular, triangular and saw-tooth, all of them having the same periodicity, the minimum bandwidth corresponds to which one of the following?

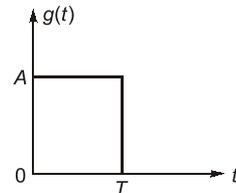
- (a) Sinusoidal (b) Rectangular  
(c) Triangular (d) Saw-tooth

**Q.14** The rms value of the periodic waveform  $e(t)$  shown in figure is



- (a)  $\sqrt{\frac{3}{2}} A$  (b)  $\sqrt{\frac{2}{3}} A$   
(c)  $\sqrt{\frac{1}{3}} A$  (d)  $\sqrt{\frac{5}{6}} A$

**Q.15** The energy density spectrum  $|G(f)|^2$  of a rectangular pulse shown in the given figure is



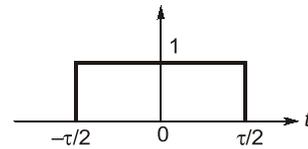
- (a)  $AT \left( \frac{\sin \pi f T}{\pi f T} \right)$  (b)  $(AT)^2 \left( \frac{\sin \pi f T}{\pi f T} \right)^2$   
(c)  $(AT)^2 \left( \frac{\sin \pi f T}{\pi f T} \right)$  (d)  $A^2 \left( \frac{\sin \pi f T}{\pi f T} \right)$

**Q.16** Fourier transform of the gate function as shown below is

$$f(t) = 1 \text{ for } -\tau/2 \leq t < \tau/2$$

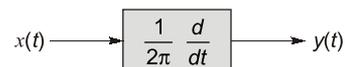
$$= 0 \text{ otherwise}$$

(where  $\tau$  is the width of the gate function).  
The value of  $F(\omega)$  is



- (a)  $\frac{\tau \sin(\omega\tau)}{\omega\tau}$  (b)  $\frac{\tau \sin(2\omega\tau)}{2\omega\tau}$   
(c)  $\frac{\tau \sin(\omega\tau/2)}{(\omega\tau/2)}$  (d)  $\frac{\tau}{2} \cdot \frac{\sin(\omega\tau/2)}{(\omega\tau/2)}$

**Q.17** A deterministic signal  $x(t) = \cos 2\pi t$  is passed through a differentiator as shown in figure.



what is its power spectral density  $S_{yy}(f)$ ?

(a)  $\frac{1}{4}[\delta(f-1) + \delta(f+1)]$  (b)  $\frac{1}{2}[\delta(f-1) + \delta(f+1)]$

(c)  $\frac{1}{4}[\delta(f) + \delta(f+1)]$  (d) None of the above

**Q.18** A signal is represented by

$$x(t) = \begin{cases} 1 & |t| < 1 \\ 0 & |t| > 1 \end{cases}$$

The Fourier transform of the convolved signal  $y(t) = x(2t) * x(t/2)$ .

(a)  $\frac{4}{\omega^2} \sin\left(\frac{\omega}{2}\right)$  (b)  $\frac{4}{\omega^2} \sin\left(\frac{\omega}{2}\right) \sin(2\omega)$

(c)  $\frac{4}{\omega^2} \sin 2\omega$  (d)  $\frac{4}{\omega^2} \sin^2 \omega$

**Q.19** A signal has Fourier series coefficients

$$C_n \Rightarrow C_{-1} = C_1 = 8, C_0 = 0, C_2 = C_{-2} = 2$$

its power is

(a) 0 (b) 136  
(c) 20 (d) 120

**Q.20** Consider the signal defined by

$$x(t) = \begin{cases} e^{j10t} & \text{for } |t| \leq 1 \\ 0 & \text{for } |t| > 1 \end{cases}$$

its Fourier transform is

(a)  $\frac{2 \sin(\omega - 10)}{\omega - 10}$  (b)  $2e^{j10} \frac{\sin(\omega - 10)}{\omega - 10}$

(c)  $\frac{2 \sin \omega}{\omega - 10}$  (d)  $e^{j10\omega} \frac{2 \sin \omega}{\omega}$

**Q.21** Suppose we have given following information about a signal  $x(t)$

- $x(t)$  is real odd
- $x(t)$  is periodic with  $T = 2$
- Fourier coefficients  $C_n = 0, |n| > 1$

4.  $\frac{1}{2} \int_0^2 |x(t)|^2 dt = 1$

The signal that satisfy these conditions

- (a)  $\sqrt{2} \sin \pi t$  and unique  
(b)  $\sqrt{2} \sin \pi t$  but not unique  
(c)  $2 \sin \pi t$  and unique  
(d)  $2 \sin \pi t$  but not unique

**Q.22** The Fourier series coefficients, of a periodic signal

$$x(t) \text{ expressed as } \sum_{k=-\infty}^{k=+\infty} a_k e^{j2\pi kt/T} \text{ are given by}$$

$$a_{-2} = 2 - j1; a_{-1} = 0.5 + j0.2; a_0 = j2; a_1 = 0.5 - j0.2$$

$$a_2 = 2 + j1; \text{ and } a_k = 0; \text{ for } |k| > 2$$

which of the following is true.

- (a)  $x(t)$  has finite energy because only finitely many coefficients are non-zero  
(b)  $x(t)$  has zero average value because it is periodic  
(c) the imaginary part of  $x(t)$  is constant  
(d) the real part of  $x(t)$  is even

**Q.23** If the energy of a signal  $X(t)$  is 9 unit, then the energy of signal  $X(2t)$  will be \_\_\_\_\_ unit.

**Q.24** If  $x(t) = \frac{1}{t}$ , then Hilbert transform of  $x(t)$  will be  $-K\delta(t)$ . Then the value of  $K$  will be \_\_\_\_\_.

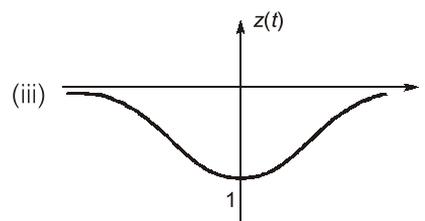
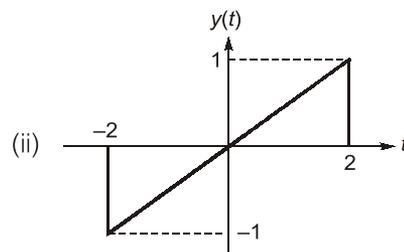
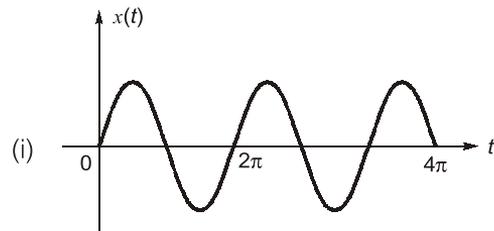
**Q.25** What will be the value of following integral \_\_\_\_\_?

$$\int_{-\infty}^{\infty} S_a^2(2t) dt$$

where  $S_a(t) = \text{Sampling function } S_a(t) = \frac{\sin t}{t}$

### Multiple Select Questions (MSQs)

**Q.26** Consider the real signals shown below:



Which of the below statements are correct?

- (a) The Fourier transform of  $y(t)$  and  $z(t)$  is real-valued.
- (b) The Fourier transform of  $x(t)$  is conjugate symmetric.
- (c)  $\int_{-\infty}^{\infty} X(j\omega) \cdot d\omega = 0$
- (d)  $\int_{-\infty}^{\infty} Z(j\omega) \cdot d\omega = 0$

**Q.27** Consider a continuous-time ideal low pass filter having the frequency response

$$H(j\omega) = \begin{cases} 1, & |\omega| \leq 80 \\ 0, & |\omega| > 80 \end{cases}$$

The input to this filter is a signal  $x(t)$  with fundamental frequency  $\omega_0 = 10$  rad/sec and Fourier series coefficients  $X[k]$ . If  $y(t)$  represents the output of the filter and it is given that

$Y[k] = X[k]$ , then the values of  $k$  for which  $X[k]$  is non-zero are:

- (a) 3
- (b) 7
- (c) 10
- (d) 12

**Q.28** For a periodic signal  $x(t)$ , the Fourier series coefficients are given as below:

$$X[k] = \begin{cases} 5, & k = 0 \\ j\left(\frac{1}{2}\right)^{|k|}, & \text{otherwise} \end{cases}$$

Which of the below statements are correct?

- (a)  $x(t)$  is real signal.
- (b)  $x(t)$  is an even signal.
- (c)  $\frac{dx(t)}{dt}$  is an odd signal.
- (d)  $x(t)$  is an energy signal.



**Answers Fourier Analysis of Signal Energy and Power Signals**

- 1. (b)      2. (a)      3. (d)      4. (d)      5. (d)      6. (d)      7. (c)
- 8. (c)      9. (b)      10. (a)      11. (c)      12. (a)      13. (a)      14. (d)
- 15. (b)      16. (c)      17. (b)      18. (b)      19. (b)      20. (a)      21. (b)
- 22. (a)      23. (4.5)      24. (3.14)      25. (1.57)      26. (b, c)      27. (a, b)      28. (b, c)

**Explanations Fourier Analysis of Signal Energy and Power Signals**

**1. (b)**

Function, $g(t)$	Fourier Transform, $G(f)$
Real and odd	Imaginary and odd
Real and even	Real and even
Imaginary and odd	Real and odd
Imaginary and even	Imaginary and even

**2. (a)**

$$a_0 = \frac{1}{T} \cdot \int_0^T f(t) dt$$

$$a_0 = \frac{1}{2\pi} \int_0^{2\pi} f(t) dt = \frac{1}{2\pi} \times \left[ \int_0^{2\pi/3} f(t) dt + \int_{\pi}^{5\pi/3} f(t) dt \right]$$

$$= \frac{2}{2\pi} \left[ 1 \cdot \frac{\pi}{3} + 2 \cdot \frac{\pi}{3} - 1 \cdot \frac{\pi}{3} - 2 \cdot \frac{\pi}{3} \right] = 0$$

**3. (d)**

$$x(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(j\omega) e^{j\omega t} d\omega$$

$$\Rightarrow \text{Real}(x(t)) = 2|t|e^{|t|}$$

- Since,  $x(t) = 0, \quad t \leq 0$
- $\Rightarrow x(t) = 2te^{-t} \quad t > 0$
- $\Rightarrow x(t) = 2te^{-t} u(t)$

**4. (d)**

**Orthogonal:** Two vector are perpendicular i.e. their dot product is zero.

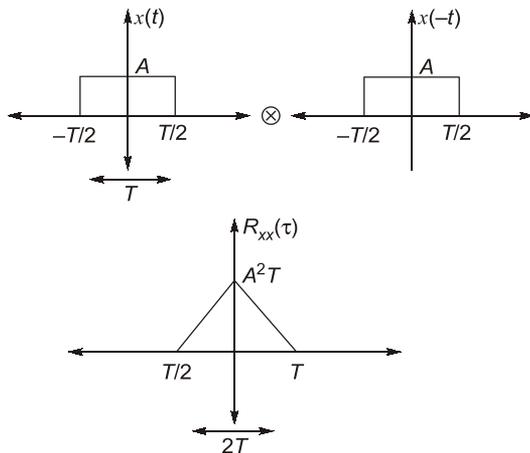
**Orthonormal:** Two vectors are perpendicular and are of unit length.

## 5. (d)

- Normalized power  $\rightarrow$  Power in  $1 \Omega$  resistor
- $P_N = V^2(t)$ , normalized power is average and mean of voltage required.
- $V_{rms} = \sqrt{P_N}$

## 6. (d)

ACF or Auto correlation function is nothing but convolution of  $x(t)$  with time reversed form of  $x(t)$ , i.e.  $x(t)$



ACF is a triangular pulse of duration  $2T$ .

## 7. (c)

Amplitude spectrum of Gaussian pulse is Gaussian.

## 8. (c)

Signal is odd,

$$x(t) = -x(-t)$$

Signal is half symmetric

$$x(t) = x\left(t + \frac{T_0}{2}\right)$$

$\therefore$  contains odd harmonic.

Signal  $f(t)$  is real and odd,

$\therefore F(\omega)$  is imaginary and odd.

## 9. (b)

$$x(t) = A; \quad -\frac{T}{2} \leq t \leq \frac{T}{2}$$

$$= 0; \quad \text{for all other } t$$

$$E = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

$$= \int_{-T/2}^{T/2} A^2 dt = [A^2 t]_{-T/2}^{T/2} = A^2 T$$

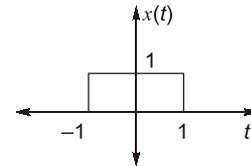
## 10. (a)

For autocorrelation function

$$R(0) \geq R(\tau)$$

$R(0) \rightarrow$  Maximum value of autocorrelation function.

## 11. (c)



From Parseval's theorem,

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

$$\Rightarrow 2\pi \int_{-\infty}^{\infty} |x(t)|^2 dt = \int_{-\infty}^{\infty} |X(\omega)|^2 d\omega$$

$$= 2\pi \int_{-1}^1 1^2 dt = 2\pi \times 2 = 4\pi$$

$$\int_{-\infty}^{\infty} |X(\omega)|^2 d\omega = 4\pi$$

## 12. (a)

$$e^{-a|t|} \longleftrightarrow \frac{2a}{a^2 + \omega^2}$$

$$\frac{2a}{a^2 + t^2} \longleftrightarrow 2\pi e^{-a|\omega|} = 2\pi e^{-a|\omega|}$$

As per duality property.

## 13. (a)

Fourier transform of a sinc wave is an impulse. So, it has infinitesimally narrow bandwidth and out of these, sinusoid have minimum BW.

## 14. (d)

$$V_{rms} = \sqrt{\frac{1}{T} \int_{-T/2}^{T/2} (f(t))^2 dt}$$

$$V_{rms}^2 = \frac{1}{T} \cdot \int_0^{T/4} \left(\frac{4A}{T} \cdot t\right)^2 dt + \int_{+T/4}^T (-A)^2 dt$$

$$V_{rms}^2 = \frac{1}{T} \cdot \left[ \frac{3A^2 T}{4} + \frac{16A^2}{T^2} \cdot \frac{1}{3} \frac{T^3}{16 \times 4} \right]$$

$$V_{rms}^2 = A^2 \left[ \frac{3}{4} + \frac{1}{12} \right] = A^2 \cdot \frac{10}{12}$$

$$V_{rms} = A \sqrt{\frac{5}{6}}$$