



POSTAL BOOK PACKAGE 2026

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Communication Systems

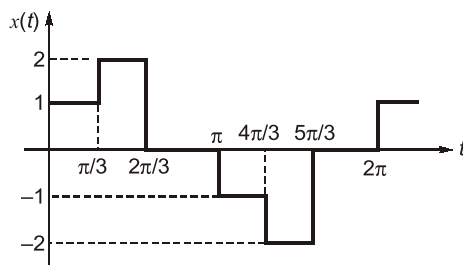
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Fourier Analysis of Signal Energy and Power Signals

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 $v(t)$.

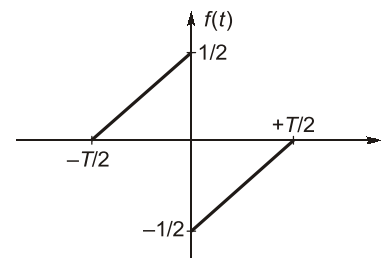
Which of the above statements is/are correct?

- 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

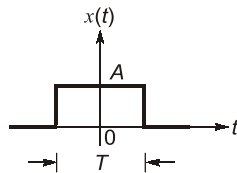
- Q.8** A function $f(t)$ is shown in figure.



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

- real and even function of ω
- real and odd function of ω
- imaginary and odd function of ω
- imaginary and even function of ω

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



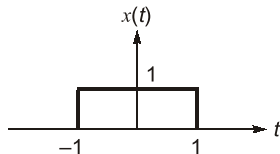
- (a) AT (b) A^2T
(c) A^2T^2 (d) AT^2

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) $R(0) = s = \text{average power of the waveform}$
(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) 2π
(c) 4π (d) 4

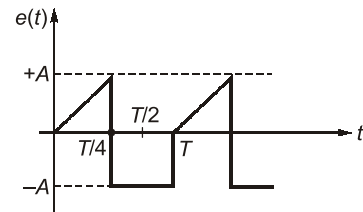
Q.12 The Fourier transform of $x(t) = \frac{2a}{a^2 + t^2}$ is

- (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?

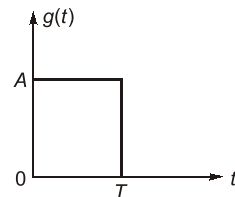
- (a) Sinusoidal (b) Rectangular
(c) Triangular (d) Saw-tooth

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

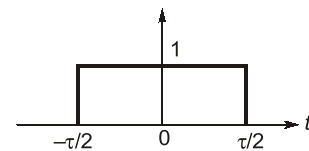


- (a) $AT \left(\frac{\sin \pi f T}{\pi f T} \right)$ (b) $(AT)^2 \left(\frac{\sin \pi f T}{\pi f T} \right)^2$
(c) $(AT)^2 \left(\frac{\sin \pi f T}{\pi f T} \right)$ (d) $A^2 \left(\frac{\sin \pi f T}{\pi f T} \right)$

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

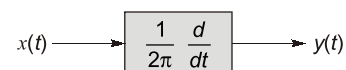
$$f(t) = 1 \text{ for } -\tau/2 \leq t < \tau/2 \\ = 0 \text{ otherwise}$$

(where τ 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 $x(t)$

1. $x(t)$ is real odd
2. $x(t)$ is periodic with $T = 2$
3. 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

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

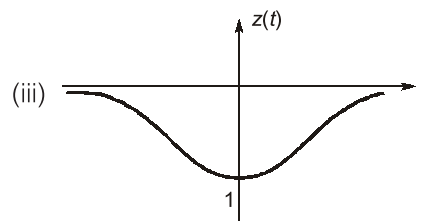
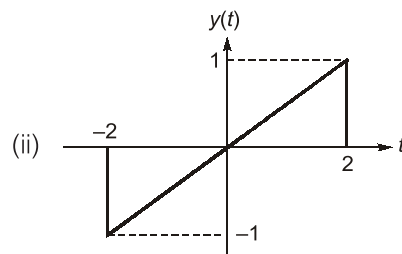
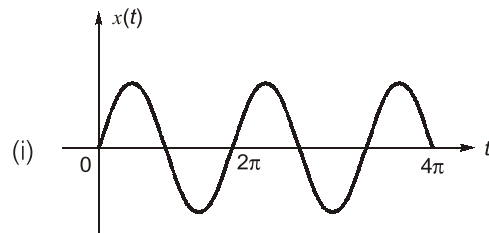
Q.25 What will be the value of following integral _____?

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

where $S_a(t)$ = 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)

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

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

$$\text{Since, } x(t) = 0, \quad t \leq 0$$

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

$$\Rightarrow x(t) = 2te^{-t} u(t)$$

4. (d)

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

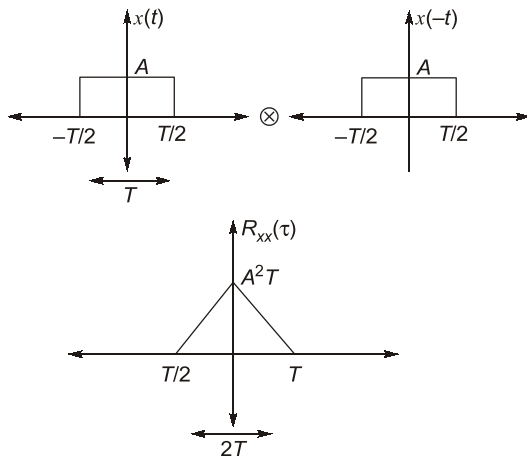
Orthonormal: Two vectors are perpendicular and are of unit length.

5. (d)

- Normalized power \rightarrow Power in 1Ω 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)

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

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

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

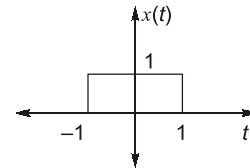
$$= \int_{-T/2}^{T/2} A^2 dt = [A^2 t]_{-T/2}^{T/2} = A^2 T$$

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)

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

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

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

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

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