COMMUNICATIONS TEST 3

Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

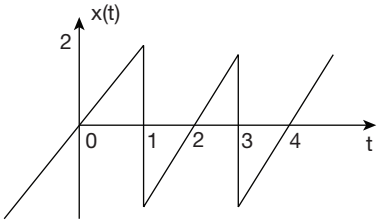
1. Statements on autocorrelation
(1) Auto correlation $R(\tau)$ of a periodic waveform is also periodic with same periods.
(2) PSD of auto correlation function of a power signal are Fourier Transform pair.
(3) Maximum value of auto correlation function $R(\tau)$ occurs at origin.
(4) The auto-correlation exhibits conjugate symmetry.
True statement is/are
(A) 1, 2 only (B) 1, 2 and 3 only
(C) 2 and 3 only (D) 1, 2, 3 and 4

2. Two independent random variables X and Y are uniformly distributed in the interval [–2, 2]. The probability that max[X, Y] is less than $\frac{1}{4}$ is

(A) $\frac{9}{16}$ (B) $\frac{81}{256}$
(C) $\frac{81}{16}$ (D) $\frac{9}{256}$

3. A modulated signal $y(t) = x(t) \cos 30000\ \pi t$, components the baseband signal $x(t)$ has frequency components less than 5kHz only x. The minimum required rate at which $y(t)$ should be sampled to recover $x(t)$.
(A) 10 kHz (B) 30 kHz
(C) 40 kHz (D) 50 kHz

4. A signal $m(t)$ as shown in figure is applied to both phase modulator (with k_p as a phase consonant) and a frequency modulator (with k_f as a frequency constant) having the same carrier frequency.



The ratio k_p/k_f (rad/Hz) for the same maximum frequency deviation is _____.
(A) 8π (B) 4π
(C) 2π (D) π

5. For an angle modulated signal $f(t) = 10 \cos. [2\pi 10^6 t + 2 \cos 2000\pi t + 3\sin 4000\pi t]$. The average power of $f(t)$ is
(A) 16W (B) 9W
(C) 50W (D) 100W

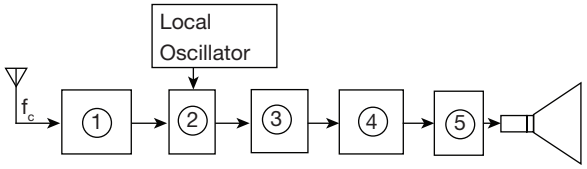
6. A PM signal is given as
$f(t) = \cos [2\pi fct + \alpha_1 \cos 2\pi f_1 t + \alpha_2 2\pi f_2 t]$
The maximum deviation of the instantaneous frequency from the carrier frequency f_c is
(A) $\alpha_2 2\pi f_1 + \alpha_1 2\pi f_1$ (B) $\alpha_2 2\pi f_2 - \alpha_1 2\pi f_1$
(C) $\alpha_2 f_2 + \alpha_1 f_1$ (D) $\alpha_2 f_2 - \alpha_1 f_1$

7. Non-linear distortion is expected to be maximum in
(A) AM (B) DSB-SC
(C) SSB – SC (D) None of these

8. Selective fading is more severe in
(A) AM only (B) DSB – SC
(C) SSDB – SC (D) None of these

9. In superheterodyne Receiver, AVC is used in (Automatic Volume Control)
(A) Local oscillator (B) RF Amplifier
(C) First detector (D) Second detector

10.



In a super heterodyne Receiver

(A)		(B)	
1.	RF Amplifier	1.	RF Amplifier
2.	Mixer	2.	Mixer
3.	Second Detector	3.	IF Amplifier
4.	IF Amplifier	4.	Second Detector
5.	Power Amplifier	5.	Power Amplifier

(C)		(D)	
1.	IF Amplifier	1.	RF Amplifier
2.	Mixer	2.	Mixer
3.	RF Amplifier	3.	Second Detector
4.	Power Amplifier	4.	IF Amplifier
5.	Second Detector	5.	Power Amplifier

11. Four voice signals having bandwidth 5 kHz are frequency division multiplexed. First voice signal is modulated with carrier 1 MHz. If Guard band is 2 MHz, then the carrier frequency for 2nd voice signal is _____
(A) 3000 kHz (B) 3010 kHz
(C) 2995 kHz (D) None of these

12. Positive *RF* peaks of an *AM* voltage rise to a maximum value of 8V and drop to a minimum value of 2V. The

modulation index assuming single tone modulation is _____.

(A) 0.1 (B) 0.25
(C) 0.5 (D) 0.6

13. Match List-I (Type of Noise) and List-II (Its property) and select the correct answer using the code below

List-I		List-II	
(a)	Shot Noise	(1)	Noise generated in a resistor.
(b)	White Noise	(2)	PSD is independent of frequency.
(c)	Narrow Band Noise	(3)	Temperature limited code.
(d)	Thermal Noise	(4)	Noise at the output of a filter.

	a	*b*	*c*	*d*
(A)	2	1	3	4
(B)	3	2	4	1
(C)	1	2	4	3
(D)	4	2	3	1

14. Match List-I with List-II and select the correct answer using the code given below the lists:–

List-I		List-II	
(a)	If amplifier	(1)	Booster
(b)	Mixer	(2)	Variable gain Amplifier
(c)	Power Amplifier	(3)	Frequency conversion
(d)	Automatic gain control	(4)	Narrow band tuned Amplifier

	a	*b*	*c*	*d*
(A)	4	3	1	2
(B)	4	2	1	3
(C)	1	3	4	2
(D)	1	2	4	3

15. Anti-aliasing filter is used _____.

(A) before the signal is reconstructed
(B) before the signal is sampled
(C) after the signal is reconstructed
(D) after the signal is sampled

16. Bandwidth needed for *FM* signal that has a peak deviation of ± 5 kHz and audio signal ranges from 400 Hz to 4 kHz.

(A) 10 kHz (B) 18 kHz
(C) 8 kHz (D) 9 kHz

17. In an amplitude modulated system, if the total power is 900W and the power in carrier is 500W, then the modulation index is _____

(A) 0.26 (B) 1.26
(C) 1.6 (D) 0.5

18. Equalizers used in telephone systems to correct frequency distortion must have

(A) Flat-frequency response
(B) Complementary response to that of the medium
(C) A band pass filter type of response
(D) Similar frequency response as the medium to which they are connected.

19. A narrow band *FM* signal is transmitted through space. The probability distribution function for demodulated signal will be

(A) Poisson (B) Binomial
(C) Rician (D) Gaussian

20. In a Archery competition there are 10 chances given to each contestant. The probability distribution function for atleast 7 bows reach exactly at mid point will be ____.

(A) Binomial (B) Poisson
(C) Gamma (D) Rayleigh

21. As the number N increases the control limit theorem indicates that the probability density of sum of N independent random variables tends to approach

(A) Gaussian density (B) Poisson density
(C) Rayleigh density (D) Rician density

22. A wide sense stationary random process $X(t)$ with mean $E[X(t)] = m$. This is applied as input to an LTI system with impulse response $h(t) = e^{-2at}u(t)$. Mean of the output is _____.

(A) m (B) ma
(C) $2\,ma$ (D) zero

23. Let X be a real-valued random variable with $E[x]$. The false relation is, if C is a constant.

(i) $E[x + c] = E[x] + c$ (ii) $E[cx] = cE[x]$
(iii) $E[c] = c$ (iv) $E[x - c] = E[x] - c$
(A) (i) only (B) (i) and (ii)
(C) (ii) and (iii) (D) (iv) only

24. A band limited random process $X(t)$ has two sided PSD

$$S_x(f) = \begin{cases} 10^{-3}\left(5 - |f|\right) watts/Hz, & |f| \le 5kHz \\ 0, & otherwise \end{cases}$$

The signal $x(t)$ modulates a carrier Cos 20,000 πt and the resultant signal is pass through a band filter of unity gain with center frequency of 10 kHz and bandwidth of 2 kHz. The output power (in watts) is _____

(A) 4.5 watts (B) 4 watts
(C) 3.5 watts (D) 3 watts

25. Let X be a random variable which is uniformly chosen from the set of positive even numbers less than 200. The expectation, $E[x]$, is

(A) 50 (B) 51
(C) 100 (D) 101

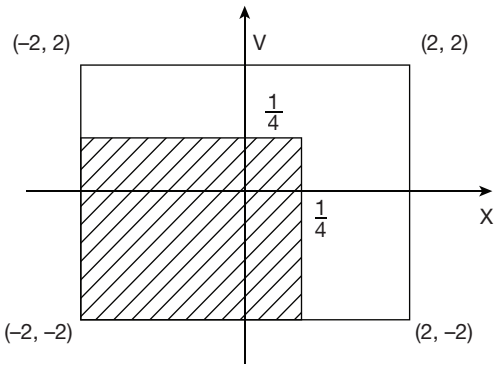
Answer Keys

1. D	**2.** B	**3.** A	**4.** C	**5.** C	**6.** D	**7.** A	**8.** A	**9.** D	**10.** B
11. B	**12.** D	**13.** B	**14.** A	**15.** B	**16.** B	**17.** B	**18.** B	**19.** C	**20.** A
21. A	**22.** C	**23.** D	**24.** A	**25.** D					

Hints and Explanations

1. All are the properties of auto-correlation function. Choice (D)

2.



$-2 \le X \le 2$ and $-2 \le Y \le 2$ is the entire rectangle.

The region in which maximum of $\{x, y\}$ is less than $\frac{1}{4}$ is shown below as shades region inside this rectangle.

$$P\left\{\max\{x,y\} < \frac{1}{4}\right\} = \frac{\text{Area of shaded region}}{\text{Area of entire rectangle}}$$

$$= \frac{\frac{9}{4}\times\frac{9}{4}}{4\times 4} = \frac{81}{256}$$ Choice (B)

3. $x(t)$ have maximum frequency component 5 kHz, So
$f_S = 2 \times 5 = 10$ kHz Choice (A)

4. For phase modulation $\omega_i t = 2\pi f_c t + k_p x(t)$

Frequency deviation $= K_P \left|\frac{d}{dt}x(t)\right|_{\max}$

$= K_p [2]_0^1 = K_P[2] = 2K_P$

For frequency modulation:

Frequency deviation $= 2\pi |k_f x(t)|_{\max}$

$= 2\pi k_f \left|[t]\right|_{\max} = 2\pi k_f[2]$

So $\frac{k_P}{k_f} = 2\pi$ Choice (C)

5. Average power of f(t) is $\frac{10^2}{2} = 50\text{W}$ Choice (C)

6. $\omega it = 2\pi f_c t + \alpha_1 \cos 2\pi f_1 t + \alpha_2 2\pi f_2 t$ after differentiation

$\omega i = 2\pi f_c - \alpha_1 . 2\pi f_1 \sin 2\pi f_1 t + \alpha_2 2\pi f_2$

Maximum deviation $\Delta f = \alpha_2 f_2 - \alpha_1 f_1$ Choice (D)

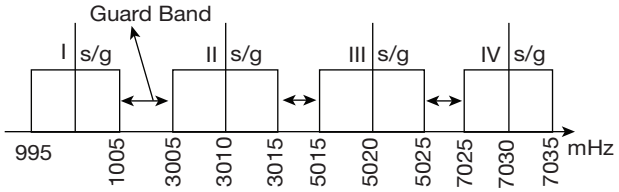
7. Non-linear distortion is expected to be maximum in AM and minimum in SSB – SC systems. Choice (A)

8. At high frequencies, *AM* is inferior to suppressed carrier systems. Choice (A)

9. AVC bias keeps receiver output substantially constant with time for any variations in receiver input voltage and used in second detector in superheteroclyne receiver. Choice (D)

10. Choice (B)

11. Bandwidth of voice signals 5 kHz



So carrier frequency for II *S/g* is 3010 kHz.

Choice (B)

12. $m_a = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}} = \frac{8-2}{8+2} = \frac{6}{10} = 0.6$ Choice (D)

13. Choice (B)

14. Choice (A)

15. Choice (B)

16. $\Delta f = 5$ kHz

$f_m = 4$ kHz

$B.W = 2f_m + 2\Delta f$

$= (5 + 4) \times 2 = 18$ kHz Choice (B)

17. $P_T = P_C\left(1 + \frac{m_a^2}{2}\right)$

$900 = 500\left(1 + \frac{m_a^2}{2}\right)$

$\left(1 + \frac{m_a^2}{2}\right) = \frac{9}{5}$

$\frac{m_a^2}{2} = \frac{9}{5} - 1 = \frac{4}{5}$

$m_a^2 = \frac{8}{5}$

$m_a = 1.26$ Choice (B)

18. Choice (B)

19. Rician distribution is useful in analysis of carrier sinusoidal signal passing through narrow band noisy channel or in a single fading model. Choice (C)

20. Out of n attempts the probability of message reaching correctly for k times is given by binomial distribution.

Choice (A)

21. Choice (A)

22. $H(\omega) = \dfrac{1}{2a + j\omega}$

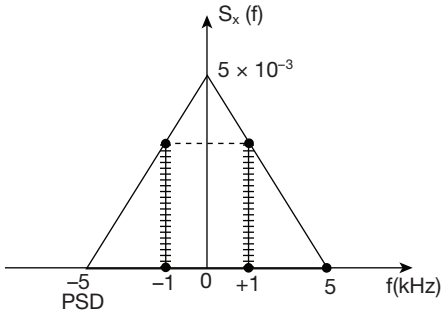
If $y(t)$ is the output of the LTI system then required mean at the output of the filter is $mH(0) = m.2a$

$= 2$ ma Choice (C)

23. (iv) relation is false

$E[X - C] = E[X] + C$ Choice (D)

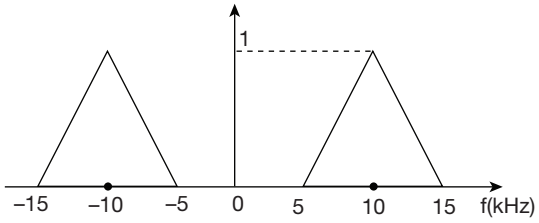
24.



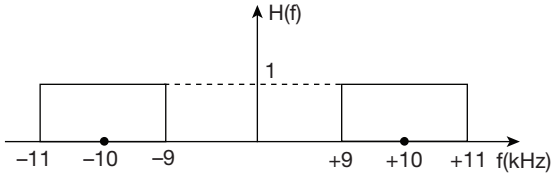
If $x(t) \overset{PSD}{\leftrightarrow} S_x(f)$

Then $x(t)\ \text{Cos}2\pi f_c t \overset{PSD}{\leftrightarrow} \dfrac{S_x(f - f_c) + S_x(f + f_c)}{4}$

$\therefore$ PSD of $x(t)$ cos $2\pi \times 10000t$



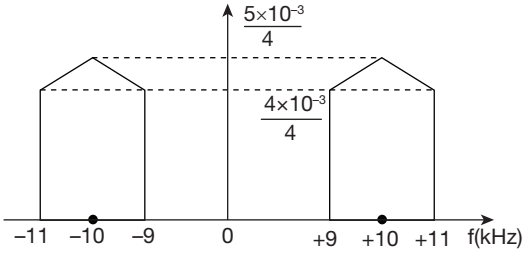
Now, BPF is given by



We know that

$S_x(f) \rightarrow \boxed{[H(f)]} \rightarrow |H(f)|^2\, S_x(f)$

$\therefore$ PSD of BPF output



Output Power = total area of output PSD

$$= 2\left[2000\left(\frac{4\times10^{-3}}{4}\right) + 2\left(\frac{1}{2}\times1000\times\frac{10^{-3}}{4}\right)\right]$$

$$= 2\left[2 + \frac{1}{4}\right] = 4.5 \text{ watts}$$ Choice (A)

25. $E[x] = \dfrac{2 + 4 ..... + 200}{100}$

$$= \frac{2(1 + 2 + 3 ..... + 100)}{100}$$

$$= \frac{\frac{2.n(n+1)}{2}}{100} = \frac{100(100+1)}{100} = 101$$ Choice (D)