Reg. No.																

Question Paper Code	14656

M.E. / M.Tech. - DEGREE EXAMINATIONS, APRIL / MAY 2026

Second Semester

M.E. - Communication Systems

24PCOPC204 - ADVANCED DIGITAL SIGNAL PROCESSING

Regulations - 2024

Duration: 3 Hours | Max. Marks: 100

PART – A (i) (MCQ)
(16 × 1 = 16 Marks)
Answer ALL Questions

		Marks	*K – Level*	*CO*
1.	Spectral factorization is primarily used in a) Designing Wiener filters b) Computing autocorrelation from PSD c) Estimating mean of a process d) Determining ergodicity	*1*	*K1*	*CO1*
2.	With finite data records, an over determined least squares problem occurs when: a) Number of equations > number of unknowns b) Number of unknowns > number of equations c) Data length = model order d) Noise power = signal power	*1*	*K1*	*CO1*
3.	A key difference between stochastic and deterministic signal models is a) Stochastic models involve probability distributions for noise/uncertainty b) Deterministic models cannot be implemented digitally c) Stochastic models always have zero mean d) Deterministic models require Gaussian assumptions	*1*	*K2*	*CO1*
4.	For a WSS process, the periodogram is a) Unbiased and consistent b) Asymptotically unbiased but inconsistent c) Biased and consistent d) Unbiased only for Gaussian processes	*1*	*K1*	*CO2*
5.	Which specific technique does Welch's method add to Bartlett's to reduce spectral leakage? a) Data Windowing b) Phase Shifting c) Matrix Inversion d) Linear Prediction	*1*	*K2*	*CO2*
6.	Increasing segment overlap in Welch's method generally: a) Increases variance and decreases bias b) Decreases variance and increases bias c) Increases number of segments averaged, reducing variance d) Has no effect on bias or variance	*1*	*K2*	*CO2*
7.	Levinson recursion is used to solve a) Prony all pole normal equations b) Periodogram c) LMS Algorithm d) Modified Periodogram	*1*	*K1*	*CO3*
8.	Lattice realization is mainly used in a) Adaptive filters b) Linear prediction filters c) Spectrum estimation d) Kalman filtering	*1*	*K2*	*CO3*
9.	In linear prediction analysis, the predictor coefficients are chosen such that a) Signal bandwidth is maximized b) Prediction error energy is minimized c) Autocorrelation becomes zero d) FFT computation becomes simpler	*1*	*K3*	*CO3*

10.	In Kalman filtering, the system is described by a) $x[n]=Ax[n-1]+w[n-1]$, $z[n]=Hx[n]+v[n]$ b) Only ARMA models c) Only MA models d) Deterministic difference equations only	*1*	*K3*	*CO4*
11.	A key advantage of lattice realization for linear prediction is a) It is always stable b) It is always stable c) It requires matrix inversion d) It requires matrix inversion	*1*	*K1*	*CO4*
12.	For a p×p Toeplitz system, Levinson recursion has computational complexity a) O(p) b) O(p) c) O(p3) d) O(p3)	*1*	*K3*	*CO4*
13.	The Widrow–Hoff LMS weight update is a) $w(n+1)=w(n)+\mu e(n)x(n)$ b) $w(n+1)=w(n)-\mu e(n)x(n)$ c) $w(n+1)=\mu e(n)x(n)$ d) $w(n+1)=w(n)+\mu x(n)$	*1*	*K3*	*CO5*
14.	RLS adaptive filter typically converges: a) Slower than LMS b) Faster than LMS but with higher complexity c) At same speed as LMS d) Only for stationary signals	*1*	*K2*	*CO5*
15.	For decimation by D, the anti-aliasing filter should have cutoff: a) π/D (normalized rad/sample) b) π c) $D\pi/2$ d) $D\pi$	*1*	*K3*	*CO6*
16.	During interpolation by a factor L=3L=3L=3, the number of zero-valued samples inserted between consecutive input samples is a) 1 b) 2 c) 3 d) 4	*1*	*K3*	*CO6*

PART – A (ii) (Short Answer Questions)
(6 × 3 = 18 Marks)
Answer ALL Questions

17.	Select the mean square value of a random process in terms of its PSD.	*3*	*K3*	*CO1*
18.	Derive AR model with appropriate difference equations.	*3*	*K3*	*CO2*
19.	Apply the lattice structure relations to determine the reflection coefficient for a first-order predictor.	*3*	*K3*	*CO3*
20.	Analyze the effectiveness of the Wiener filter in noise reduction applications and justify its limitations.	*3*	*K4*	*CO4*
21.	Evaluate the trade-off between convergence speed and computational complexity in the RLS algorithm.	*3*	*K4*	*CO5*
22.	Given $x[n]=\cos(0.3\pi n)$, decimate by D=3.Plot the spectrum of x[n].	*3*	*K4*	*CO6*

PART - B (Descriptive Answer Questions)
(6 × 11 = 66 Marks)
Answer ALL Questions

23.	a)	The power spectral density of a WSS process is given by $\mathbf{S_{XX}(\omega) = 1/9+\omega^2}$ (i) Find the auto-correlation function $R_{XX}(\tau)$. (ii) Calculate the mean square value $E[X^2(t)]$ of the process.	*11*	*K3*	*CO1*
		OR			
	b)	Derive the relationship between mean and autocorrelation of input process and mean and autocorrelation of output process.	*11*	*K3*	*CO1*

24.	a)	Construct the relationship between autocorrelation and power spectrum and prove the Wiener-Khinchin theorem.	*11*	*K3*	*CO2*
		OR			
	b)	Derive the Yule-Walker equations for an AR(p) process. Explain how they are used to estimate AR parameters and power spectral density.	*11*	*K3*	*CO2*
25.	a)	Given the autocorrelation sequence $r_x(k) = [2, 0.5(1+j), 0.5]^T$ and determine the coefficients of the second-order all-pole model using the Levinson–Durbin recursion algorithm.	*11*	*K5*	*CO3*
	b)	Given 3-stage lattice filter with reflection coefficients $k_1 = 1/4$, $k_2 = 1/2$, $k_3 = 1/3$, and determine the corresponding FIR filter coefficients in the direct form structure.	*11*	*K5*	*CO3*
26.	a)	A wide-sense stationary signal has autocorrelation values: $R_{xx}(0) = 1, R_{xx}(1) = 0.5, R_{xx}(2) = 0.25$ Design a second-order causal linear predictor: $\hat{x}(n) = a_1 x(n-1) + a_2 x(n-2)$ Determine a_1 and a_2 using Wiener–Hopf equations. Evaluate the performance by computing the minimum mean square prediction error (MMSE).	*11*	*K5*	*CO4*
		OR			
	b)	Evaluate the performance of the Maximum Likelihood criterion in estimating unknown signal parameters under noisy conditions.	*11*	*K5*	*CO4*
27.	a)	Derive the LMS algorithm from steepest descent by approximating the gradient and write the complete algorithm with its computational complexity.	*11*	*K4*	*CO5*
		OR			
	b)	An adaptive FIR filter of order 2 uses the Recursive Least Squares (RLS) algorithm. Given: • Input vector: $x(n) = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$ • Desired response $d(n) = 2$ • Initial weight vector: $w(0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$ • Initial inverse correlation matrix: $P(0) = I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ • Forgetting factor: $\lambda = 0.9$ Apply one iteration of the RLS algorithm to compute the updated weight vector. Analyze the estimation error obtained after the update.	*11*	*K4*	*CO5*
28.	a)	A signal sampled at 6 kHz is interpolated by a factor of 3. Apply the interpolation process and find the new sampling rate.	*11*	*K3*	*CO6*
		OR			
	b) (i)	Given $\mathbf{H(z)=1+0.5z^{-1}+0.25z^{-2}+0.125z^{-3}}$, decimation by D=2.Find poly phase components $E_0(z)$ and $E_1(z)$ and depict the poly phase decimation structure.	*6*	*K3*	*CO6*
	(ii)	Draw the two-channel sub-band coding system and how the bit rate reduced in sub-band coding.	*5*	*K3*	*CO6*