Roll No.												

PRESIDENCY UNIVERSITY

BENGALURU

End - Term Examinations – December 2025

Date: 10- 12- 2025 **Time:** 1.00pm to 04.00pm

School: SOE	**Program:** B.Tech	
Course Code : ECE3033	**Course Name:** Adaptive Signal Processing	
Semester: V	**Max Marks**: 100	**Weightage**: 50%

CO - Levels	CO1	CO2	CO3	CO4	CO5
Marks	14	14	26	22	24

Instructions:

(i) Read all questions carefully and answer accordingly.

(ii) Do not write anything on the question paper other than roll number.

Part A

Answer ALL the Questions. Each question carries 2marks. **10Q x 2M=20M**

1.	An adaptive filter is a filter whose parameters (coefficients) automatically adjust themselves to minimize an error signal based on an optimization algorithm. Draw the adaptive filter block diagram	**2 Marks**	**L2**	**CO1**
2.	Describe the relationship between the learning rate (μ) and the stability condition of the LMS adaptive algorithm. What happens when μ is too small or too large?	**2 Marks**	**L2**	**CO1**
3.	What is the fundamental difference between time averaging and ensemble averaging in the analysis of random signals?	**2 Marks**	**L2**	**CO2**
4.	State the stationarity condition for an AR (1) process	**2 Marks**	**L2**	**CO2**
5.	Where can the Wiener filter be applied? Mention any two practical applications.	**2 Marks**	**L2**	**CO3**
6.	State the Principle of Orthogonality used in Wiener filter design and explain its significance.	**2 Marks**	**L2**	**CO3**
7.	Under what conditions does an AR (Auto-Regressive) process become asymptotically stationary?	**2 Marks**	**L2**	**CO3**

8.	Discuss the stability of the Method of Steepest Descent. How does the choice of step-size influence the convergence of the algorithm?	**2 Marks**	**L2**	**CO4**
9.	What is multipath channel modeling, and why is it important in wireless communication systems?	**2 Marks**	**L2**	**CO5**
10.	What is inverse modelling in adaptive signal processing? State its basic purpose.	**2 Marks**	**L2**	**CO5**

Part B

Answer the Questions. **Total Marks 80M**

11.	**a.**	Plant h= [0.6, −0.4] ^{T}. Use M=2, forgetting factor λ=1, regularizer δ=0.01. Initialize w (0) =0, P (0) =δ^{-1}I=100I. Given: x (1) = [1,0] ^{T}, d (1) =0.6. Compute k (1), e (1), w (1), P (1).	**10 Marks**	**L3**	**CO1**
		Or			
12.	**a.**	Obtain the cascade form realizations of the LTI system governed by the equation, $H(z) = \frac{1+3z^{-1}+2z^{-2}}{1+\frac{3}{8}z^{-1}-\frac{3}{32}z^{-2}-\frac{1}{64}z^{-3}}$	**10 Marks**	**L3**	**CO1**
13.	**a.**	Suppose the autocorrelation sequence $\boldsymbol{R(k)}$ of a stationary process is: $\boldsymbol{R(0)=4,\ R(1)=2.5,\ R(2)=1.4.}$ Estimate AR (2) process coefficients $\boldsymbol{\phi_1, \phi_2}$ using Yule-Walker equations.	**10 Marks**	**L3**	**CO2**
		Or			
14.	**a.**	Consider a discrete-time signal: $X[n]=\sin(2\pi f_0 n)+W[n], n=0,1,\ldots,N-1,$ where: $f_0 = 0.05$ (normalized frequency), $W[n]$ is zero-mean white Gaussian noise with variance $\sigma^2 = 0.25$, $N = 10{,}000$ is the number of samples. Check whether this is ergodicity or not.	**10 Marks**	**L3**	**CO2**
15.	**a.**	Channel impulse response (length 3): $\mathbf{h} = [0.5\ 0.3\ 0.1]$ Transmitted symbols $\boldsymbol{s(n)}$ are uncorrelated with zero mean and unit variance: $\boldsymbol{E[s(n)s(m)] = \delta(n-m)}$ Additive white Gaussian noise $\boldsymbol{v(n)}$ with variance $\boldsymbol{\sigma_v^2 = 0.01}$. Received signal: $\boldsymbol{x(n) = h_0 s(n) + h_1 s(n-1) + h_2 s(n-2) + v(n)}$ Wiener filter length chosen as $\boldsymbol{M = 3}$: $\mathbf{w} = [\boldsymbol{w_0, w_1 w_2}]^{T}$,	**20 Marks**	**L3**	**CO3**
		Or			
16.	**a.**	In speech enhancement, the current speech sample $\mathbf{x[n]}$ is predicted from the previous two samples. The autocovariance values estimated from clean speech are: Given: $\mathbf{r0 = 5}$,	**20 Marks**	**L3**	**CO3**

		$\mathbf{r1 = 3}$, $\mathbf{r2 = 1}$, Compute $p = 2$ order predictor coefficients using Levinson-Durbin algorithm.			

17.	**a.**	Analyze the stability of the discrete-time system with characteristic polynomial $$\boldsymbol{A(z) = 1 - 0.5z^{-1} + 0.2z^{-2}}$$ using the Schur–Cohn stability test. Clearly justify whether the system is stable or unstable.	**20 Marks**	**L4**	**CO4**
		Or			
18.	**a.**	Minimize the quadratic function $$f(x_1, x_2) = 2x_1^2 + x_2^2 - 2x_1x_2 - 2x_1$$ using the steepest descent algorithm, starting from $x^{(0)} = [0\ 0]^T$**.** Check the stability condition for the algorithm by finding the range of step size α for guaranteed convergence, and perform the first iteration.	**20 Marks**	**L4**	**CO4**

19.	**a.**	Apply the concept of adaptive modeling to a multi-path communication channel and develop an adaptive filter structure that can estimate and track the channel variations. Explain the modeling steps, derive the adaptive update equations, and illustrate how LMS/RLS-based adaptation improves channel equalization performance in practical wireless fading environments.	**20 Marks**	**L3**	**CO5**
		Or			
20.	**a.**	Apply adaptive signal processing techniques to the problem of geophysical exploration. Construct an adaptive model for seismic signal analysis and demonstrate how adaptive filtering helps in identifying underground layers, removing reverberations, and enhancing reflections. Include required block diagrams, mathematical modeling steps, and real-data application examples.	**20 Marks**	**L3**	**CO5**