U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**
Branch: Artificial Intelligence and Machine Learning **Duration: 3 hrs.**
Course Code: 24AM6HSSMM **Max Marks: 100**
Course: Stochastic Modelling for Machine Learning

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

<table>
<tr><th></th><th></th><th>UNIT - I</th><th>CO</th><th>PO</th><th>Marks</th></tr>
<tr><td>1</td><td>a)</td><td>Describe a stochastic process. Give one example for the following:
i. Discrete state and Continuous time stochastic processes
ii. Continuous state and discrete time stochastic processes</td><td>CO1</td><td>PO1</td><td>05</td></tr>
<tr><td></td><td>b)</td><td>Stock price cannot be modelled using Brownian motion, Justify the statement with relevant reasons.</td><td>CO2</td><td>PO2</td><td>05</td></tr>
<tr><td></td><td>c)</td><td>For the closing price dataset,
<table><tr><td>Day</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>Closing price in $</td><td>100</td><td>102</td><td>101</td><td>105</td><td>107</td></tr></table>Compute the following for each day from Day 2 to Day 5
i. Simple return
ii. Gross return
iii. Log return</td><td>CO3</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>a)</td><td>Explain any three types of stochastic process classified on the basis of relationship among the random variables.</td><td>CO1</td><td>PO1</td><td>05</td></tr>
<tr><td></td><td>b)</td><td>Discuss the reasons for modelling returns rather than prices in investment analysis. Highlight the advantages of using returns for evaluating investment performance and assessing risk.</td><td>CO2</td><td>PO2</td><td>05</td></tr>
<tr><td></td><td>c)</td><td>Find the rate of return from an investment that, for an initial payment of 100, yields return 60 at the end of the two periods.</td><td>CO3</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>UNIT - II</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>a)</td><td>Define Markov Chain. Give any three properties of transition probability matrix.</td><td>CO1</td><td>PO1</td><td>05</td></tr>
<tr><td></td><td>b)</td><td>A gambler has $2. He bets $1 at a time and wins $1 with probability 0.4. He stops playing if he loses all his money or wins $4.
i. Summarize the given concept in the form of transition probability matrix.
ii. Calculate the probability that he has lost his money at the end of 3 plays.</td><td>CO3</td><td>PO4</td><td>09</td></tr>
</table>

			iii. Calculate the probability that the game lasts for more than 4 plays.			
		c)	Derive the Chapman-Kolmogorov equation for a Markov Chain process. Also explain the same in detail.	*CO2*	*PO2*	**06**
			OR			
	4	a)	A Reinforcement learning agent navigates a grid with three states: State A, State B, and State C. The transition probabilities are: State A: 0.6 to stay in State A, 0.4 to move to State B. State B: 0.5 to move to State A, 0.5 to move to State C. State C: 0.7 to move to State B, 0.3 to stay in State C. i. Construct the transition probability Matrix (TPM) for the system. ii. Calculate the 2-step transition probability from State A to State C using the TPM. Given the initial state distribution as [1, 0, 0] (starting in State A), calculate the state distribution after 3 steps. Interpret the result.	*CO3*	*PO3*	**10**
		b)	Differentiate between a first-order Markov process and a higher-order Markov process, and explain how a higher- order Markov process can be transformed into an equivalent first-order Markov process.	*CO1*	*PO1*	**05**
		c)	Verify the process $X(t) = \frac{A}{\pi}\cos(\omega t + \varphi), \quad 0 \leq \varphi \leq \pi$ is weak sense stationary or not.	*CO2*	*PO3*	**05**
			UNIT - III			
	5	a)	Explain the following with examples: i. Absorbing State. ii. Irreducible Markov chain. iii. Classification of States.	*CO1*	*PO2*	**08**
		b)	For the given transition probability matrix with the states 1,2,3,4 and 5 $P = \begin{pmatrix} 1/2 & 0 & 1/2 & 0 & 0 \\ 1/2 & 0 & 0 & 1/2 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1/2 & 1/2 & 0 \end{pmatrix}.$ i. Identify and classify the states as either recurrent or transient. ii. Is the Markov Chain Ergodic?	*CO2*	*PO2*	**08**
		c)	Obtain the mean recurrence times for the given transition probability matrix, $M = \begin{pmatrix} 1.0 & 0.0 & 0.0 & 0.0 \\ 0.1 & 0.2 & 0.5 & 0.2 \\ 0.1 & 0.2 & 0.6 & 0.1 \\ 0.0 & 0.0 & 0.0 & 1.0 \end{pmatrix}$	*CO1*	*PO1*	**04**
			OR			
	6	a)	A coffee shop has three types of daily customer volume patterns: Low (L), Medium (M), and High (H). The transition probabilities between these patterns form a Markov chain with the transition probability matrix:	*CO3*	*PO2*	**06**

			$P = \begin{pmatrix} 0.5 & 0.3 & 0.2 \\ 0.2 & 0.5 & 0.3 \\ 0.3 & 0.4 & 0.3 \end{pmatrix}$. Find the steady state distribution			
		b)	Consider a Hidden Markov Model with three hidden states {A, B, C} and two observable states {X, Y}. Given the following transition(T) and emission probabilities(E): $T = \begin{pmatrix} 0.6 & 0.2 & 0.2 \\ 0.5 & 0.3 & 0.2 \\ 0.1 & 0.4 & 0.5 \end{pmatrix} E = \begin{pmatrix} 0.6 & 0.4 \\ 0.3 & 0.7 \\ 0.5 & 0.5 \end{pmatrix}$ The initial distribution is given by (0.4, 0.2,0.4) Analyze the hidden states corresponding to the observed sequence {X, Y}.	*CO3*	*PO4*	**10**
		c)	Illustrate the Markov decision process with recycling robot example.	*CO2*	*PO1*	**04**
			UNIT - IV			
	7	a)	Describe how the ε- greedy approach can be used to balance exploration and exploitation.	*CO2*	*PO2*	**04**
		b)	With respect to reinforcement learning, explain the following: i. Provide the Temporal Difference (TD) algorithm and also analyze how bootstrapping is utilized within it. ii. Give the Q-learning algorithm.	*CO2*	*PO3*	**10**
		c)	Analyze how reinforcement learning method differ from supervised and unsupervised learning methods with suitable examples	*CO2*	*PO2*	**06**
			OR			
	8	a)	Consider a simple 2×3 grid world environment where an agent can move up, down, left, or right. The goal state is located at the top-right corner. The agent starts at the bottom-left corner. The agent receives a reward of +10 for reaching the goal state and 0 for all other transitions. The episode ends when the agent reaches the goal state. Assuming $\gamma = 0.8$, i. Construct the Q-table ii. Identify the optimal policy, corresponding to actions with maximal Q Values.	*CO3*	*PO4*	**10**
		b)	Derive mathematical expression for Bellman's value function.	*CO2*	*PO3*	**06**
		c)	Differentiate between on-policy and off-policy methods based on Reinforcement learning.	*CO2*	*PO1*	**04**
			UNIT - V			
	9	a)	Differentiate between actor-critic, value-based, and policy-based approaches.	*CO2*	*PO2*	**06**
		b)	Discuss the advantages of employing policy-gradient technique	*CO1*	*PO1*	**04**
		c)	Explain the following: i. Architecture of Actor-Critic Algorithm (ACA) ii. Update rules for ACA.	*CO2*	*PO2*	**10**
			OR			
	10	a)	Design an example problem where the Actor-Critic algorithm can be applied. i. Define the state space, action space, and reward function.	*CO2*	*PO2*	**10**

			ii. Explain how the critic's value function and the actor's policy are updated during training.			
		b)	Elaborate on Applications of Actor-Critic Algorithm.	*CO1*	*PO1*	**05**
		c)	Explain scenarios where Policy Gradient methods are preferred over value-based methods like Q-Learning.	*CO1*	*PO1*	**05**

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