U.S.N.										

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

Autonomous Institute Affiliated to VTU

June 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>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>Prove that Brownian Motion is a martingale. And also consider a particle undergoing Brownian motion in a one-dimensional space. Let X_t denote the position of the particle at time t, where $t \geq 0$. Assume that X_t follows a Standard Brownian Motion process. Calculate the joint probability distribution for the particle's position at these three time points, i.e. $P(X_1=0.5, X_2=1.2, X_3=-0.8)$</td><td>CO3</td><td>PO4</td><td>10</td></tr>
<tr><td></td><td>c)</td><td>Prove that the mean and variance of conditional distribution $E[X(S)|X(t)=A]=\frac{x}{y}*A$, where $x<y$.</td><td>CO2</td><td>PO3</td><td>05</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>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>CO1</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td>b)</td><td>For the given stock 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>Stock Price($)</td><td>150</td><td>155</td><td>153</td><td>160</td><td>165</td></tr>
</table>
Calculate the following for each day from Day 2 to Day 5:
i. Percentage Change in Price.
ii. Daily Log Return.</td><td>CO1</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td>c)</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>06</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>Verify the process $X(t)=\frac{A}{\pi}\cos(\omega t+\varphi), \quad 0 \leq \varphi \leq \pi$ is weak sense stationary or not.</td><td>CO2</td><td>PO3</td><td>05</td></tr>
<tr><td></td><td>b)</td><td>A Company is considering Markov Theory to analyse brand switching between 3 different brands (brand A, brand B, brand C)</td><td>CO3</td><td>PO3</td><td>07</td></tr>
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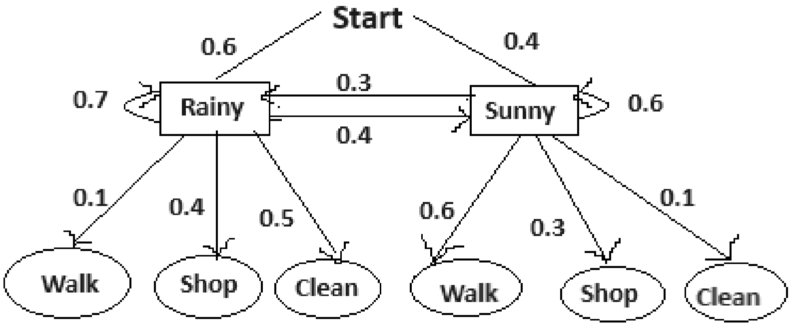
			of storage devices. Survey data has been collected and shown below in the form of transition probability matrix. $P = \begin{pmatrix} 0.1 & 0.2 & 0.7 \\ 0.2 & 0.4 & 0.4 \\ 0.1 & 0.3 & 0.6 \end{pmatrix}$ i. Draw the digraph. ii. Assume that currently brand A is in use. Compute the probability for the company in brand B, followed by next time the company may use brand A again.			
		c)	Three boys A, B, C are throwing ball to each other, A always throws the ball to B and B always throws the ball to C. C is just as likely to throw the ball B as to A. If C was the first person to throw the ball find the probabilities that after three throws. i. A has the ball ii. B has the ball iii. C has the ball	*CO2*	*PO4*	**08**
			OR			
	4	a)	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**
		b)	Derive the Chapman-Kolmogorov equation for a Markov Chain process. Also explain the same in detail.	*CO2*	*PO2*	**06**
		c)	A Reinforcement learning agent navigates a grid with three states: State P, State Q, and State R. The transition probabilities are: State P: 0.3 to stay in State P, 0.7 to move to State Q. State Q: 0.4 to move to State P, 0.6 to move to State R. State R: 0.8 to move to State Q, 0.2 to stay in State R. i. Construct the transition probability Matrix (TPM) for the system. ii. Calculate the 2-step transition probability from State P to State R using the TPM. Given the initial state distribution as [0, 1, 0] (starting in State P), calculate the state distribution after 2 steps. Interpret the result.	*CO3*	*PO3*	**09**
			UNIT - III			
	5	a)	Illustrate the Markov decision process with suitable example.	*CO2*	*PO2*	**05**
		b)	If the state space S={0,1,2,3,…….} and the transition probability matrix is given by p_r, $p_{r+1}=1/4=p_{r,0}$ for all r belong to S i. Construct the transition probability matrix ii. Analyse whether the Markov chain is ergodic. iii. Calculate the mean time spent on transient state.	*CO2*	*PO3*	**10**
		c)	What are the limitations of Markov chain model? How to determine limiting distribution of Markov chain?	*CO1*	*PO1*	**05**
			OR			
	6	a)	For the given digraph shown in the Figure 4a.	*CO2*	*PO3*	**10**

		 Figure 4a. i. Identify the Hidden, observable states and initial probabilities. ii. Obtain Transition Probability Matrix T and Emission probability matrix E. iii. Identify most likely hidden states corresponding to observed sequence {walk, shop, walk}.			
	b)	Explain the following: i. Absorbing state ii. Reducible and Irreducible state	*CO1*	*PO1*	**05**
	c)	The transition matrix of the Markov chain $\{x_{n,} n>=0\}$ is $T = \begin{pmatrix} 0.1 & 0.2 & 0.7 \\ 0.3 & 0.4 & 0.3 \\ 0.5 & 0.4 & 0.1 \end{pmatrix}$ The initial distribution is given by: $P(X_0=1)=0.6; P(X_0=2)=0.3; P(X_0=3)=0.1$. Compute the distribution of X_1 andprobabilities of the following: i. $P(X_2=1)$ ii. $P(X_1=1, X_2=2, X_3=3 \mid X_0=1)$	*CO3*	*PO3*	**05**
		UNIT - IV			
7	a)	Explain the following with suitable equations: i. Monte-Carlo Reinforcement learning ii. Action-value functions	*CO2*	*PO3*	**06**
	b)	For the given reward matrix R, construct the Q-table by applying the Q-learning algorithm. $R = \begin{pmatrix} -1 & 0 & -1 & 0 & -1 & -1 \\ 0 & -1 & 100 & -1 & 0 & -1 \\ -1 & -1 & 0 & -1 & -1 & -1 \\ 0 & -1 & 0 & -1 & -1 & -1 \\ -1 & 0 & -1 & 0 & -1 & 0 \\ -1 & -1 & 100 & -1 & 0 & -1 \end{pmatrix}$	*CO3*	*PO3*	**10**
	c)	Differentiate between on-policy and off-policy methods.	*CO2*	*PO2*	**04**
		OR			
8	a)	Illustrate the Reinforcement learning method with suitable example. And also give the Q-learning algorithm with respect to reinforcement learning.	*CO2*	*PO2*	**10**
	b)	Derive mathematical equation for bellman's value function.	*CO2*	*PO3*	**05**

		c)	Analyze how ε-greedy method different from SoftMax action selection method.	*CO3*	*PO3*	**05**
			UNIT - V			
	9	a)	Write and explain Actor Critic Algorithm (ACA).	*CO2*	*PO2*	**10**
		b)	Illustrate the actor-critic method with an example.	*CO2*	*PO2*	**05**
		c)	An engineer working on a drone navigation project with a goal to train an autonomous drone to navigate in a complex environment with obstacles and checkpoints. Explain how policy gradient method is more suitable if the action space for the drone is continuous.	*CO2*	*PO1*	**05**
			OR			
	10	a)	Explain scenarios where Policy Gradient methods are preferred over value-based methods like Q-Learning.	*CO1*	*PO1*	**06**
		b)	Discuss the advantages of employing policy-gradient technique	*CO1*	*PO1*	**04**
		c)	Explain the following: i. Architecture of Actor-Critic Algorithm (ACA) Update rules for ACA.	*CO2*	*PO2*	**10**

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