Assignment

***Note:** default= Single Choice Questions, MSQ= Multiple Choice Questions, NAT: Numerical Answer Type*

Follow the glimpse for Q1-Q7

You're the data analyst for the "Blazing Bats," a rising cricket team preparing for a crucial T20 match. Captain Rohan "The Strategist" Sharma relies on you to decode pitch patterns, optimize player stats, and predict fan trends using a mix of Markov Chains and NumPy wizardry. Each question below is a mission-critical task—solve them to secure victory!

Question 1

Glimpse: Rohan suspects the pitch behaves like a "chain of states." He asks, "What's the core rule behind this pattern?" You need to define it to predict tomorrow's conditions.
Which of the following best describes a Markov Chain?

A) A deterministic process where future states depend on all past states

B) A random process where the future state depends only on the current state

C) A sequence of independent events with no memory

D) A continuous-time process with fixed transition rates

Correct Answer: B
Explanation:
A Markov Chain is a stochastic process where the probability of transitioning to a future state depends only on the current state, not on the sequence of past states. This is known as the "memoryless" property. Option A is incorrect because Markov Chains are not deterministic. Option C describes independent events, not a Markov Chain, and Option D refers to continuous-time processes, which are a specific type rather than a general definition.

Question 2

Glimpse: The pitch is in State A (Sticky) today and shifts to State B (Dry) tomorrow. Rohan wants to know the odds it stays Dry for the next over. Can you calculate it?
Given a Markov Chain with states {A, B}, the probability of moving from A to B is 0.7, and from B to A is 0.4. What is $P(X_2 = B \mid X_0 = A, X_1 = B)$, where X_n represent state at step n?

A) 0.3

B) 0.6

C) 0.7

D) 1.0

Correct Answer: B
Explanation:
In a Markov Chain, the future state depends only on the current state (Markov property). Here, X_2 depends only on $X_1 = B$, not on $X_0 = A$. Given the transition probability from B to A is 0.4, the probability of staying in B is $1 - 0.4 = 0.6$.

Question 3

Glimpse: Rohan's planning analytics for weather, fan recommendations, and speech coaching—but one task doesn't fit your pitch model. Which is it?
For which of the following cases an analyst would not use Markov Chains?

A) Weather prediction

B) Recommendation Systems

C) Solving systems of linear equations

D) Speech Recognition

Correct Answer: C
Explanation:
Solving systems of linear equations is typically a deterministic algebraic task, not a stochastic process like a Markov Chain, making C the odd one out. Markov Chains are widely used in other cases.

Question 4

Glimpse: Starting with a Sticky pitch (state 0), Rohan needs the odds it's Dry (state 1) in two days for his spin strategy. Crunch the numbers!
A Markov Chain has the transition matrix $P = \begin{bmatrix} 0.2 & 0.8 \\ 0.5 & 0.5 \end{bmatrix}$. What is the probability of being in state 1 after two steps, starting from state 0?

A) 0.44

B) 0.50

C) 0.56

D) 0.62

Correct Answer: C
Explanation:
The transition matrix is $P = \begin{bmatrix} 0.2 & 0.8 \\ 0.5 & 0.5 \end{bmatrix}$. To find the probability after two steps, compute P^2:
- $P^2[0,0] = (0.2)(0.2) + (0.8)(0.5) = 0.04 + 0.4 = 0.44$
- $P^2[0,1] = (0.2)(0.8) + (0.8)(0.5) = 0.16 + 0.4 = 0.56$
Starting from state 0, the probability of being in state 1 after two steps is $P^2[0,1] = 0.56$.

Question 5

Glimpse: Rohan quizzes you: "What's the golden rule that makes our pitch predictions work?" Pick the principle that keeps your model on track.
Which statement correctly reflects the Markov Property?

A) The probability of a state depends on the entire history of the chain

B) The process must be reversible to exhibit the Markov Property

C) The next state depends only on the current state, not prior states

D) All transition probabilities must be equal for the property to hold

Correct Answer: C
Explanation:
The Markov Property states that the probability distribution of the next state depends only on the current state, not on the sequence of states that preceded it. Option A contradicts this, Option B is unrelated (reversibility is not required), and Option D is false (transition probabilities can vary).

Question 6

Glimpse: You're adjusting bowler stats in NumPy. You copy a speed array and tweak one value—does the original lineup change? Test it out!
What happens when the following code is executed?

```
import numpy as np
a = np.array([1,2,3,4,5])
b = a.copy()
b[1] = 100
print(a)
```

(A) [1, 100, 3, 4, 5]

(B) [1, 2, 3, 4, 5]

(C) [1, 200, 3, 4, 5]

(D) [100, 2, 3, 4, 5]

Correct Answer: (B) [1, 2, 3, 4, 5]
Explanation: Since `b` is a copy of `a`, modifying `b` does not affect `a`.

Question 7

Glimpse: Fan energy's key to morale. You've got tempo data (X) and cheer ratings (Y)—does a louder beat mean quieter fans? Find the correlation!
Given two NumPy arrays $X = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$ and $Y = \begin{bmatrix} 4 & 2 & 0 \end{bmatrix}$, what is the Pearson correlation coefficient computed using $np.corrcoef(X, Y)$?

Correct Answer: -1.0
Explanation:
Using $np.corrcoef(X, Y)$:
- Mean of X: $\bar{X} = \frac{1+2+3}{3} = 2$
- Mean of Y: $\bar{Y} = \frac{4+2+0}{3} = 2$
- Covariance: $\text{cov}(X, Y) = \frac{1}{2}[(1-2)(4-2) + (2-2)(2-2) + (3-2)(0-2)] = \frac{1}{2}[-2+0-2] = -2$
- Variance of X: $\sigma_X^2 = \frac{1}{2}[1+0+1] = 1$, $\sigma_X = 1$
- Variance of Y: $\sigma_Y^2 = \frac{1}{2}[4+0+4] = 4$, $\sigma_Y = 2$
- $\rho = \frac{\text{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{-2}{1 \cdot 2} = -1.0$.
The perfect negative linear relationship ($Y = 4 - 2X$) yields $\rho = -1.0$, matching NumPy's output.

Question 8

What will be the shape of the array after executing the following code?

```
import numpy as np
arr = np.array([1, 2, 3, 4, 5, 6, 7, 8])
reshaped = arr.reshape(2, -1, 2)
print(reshaped.shape)
```

(A) (2, 4)

(B) (2, 2, 2)

(C) (2, 3, 2)

(D) (4, 2)

Correct Answer: (B) (2, 2, 2)
Explanation: The reshape function `arr.reshape(2,-1,2)` automatically determines the middle dimension based on the total elements (8), resulting in shape (2,2,2).

Question 9(MSQ)

Given the following matrix:

$$\begin{bmatrix} 4 & 5 \\ 7 & 8 \end{bmatrix}$$

Which of the following code snippets will produce this matrix as output?

(A)
```
import numpy as np
np2 = np.array([[1, 2, 3],
                [4, 5, 6],
                [7, 8, 9]])
print(np2[1:, :2])
```

(B)
```
import numpy as np
np2 = np.array([[4, 5],
                [7, 8]])
print(np2)
```

(C)
```
import numpy as np
np2 = np.array([[1, 2, 3],
                [4, 5, 6],
                [7, 8, 9]])
print(np2[:2, 1:])
```

(D)
```
import numpy as np
np2 = np.array([[1, 2, 3],
                [4, 5, 6],
                [7, 8, 9]])
np2[0, :2] = [4, 5]
print(np2[1:, :2])
```

Correct Answers: A, B, D

$$\begin{bmatrix} 4 & 5 \\ 7 & 8 \end{bmatrix}$$

Explanation:

- **Option (A):** Starts with

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

and uses `np2[1:, :2]` to select all rows from index 1 onward (second and third rows) and columns up to index 2 (first two columns), resulting in $\begin{bmatrix} 4 & 5 \\ 7 & 8 \end{bmatrix}$.

- **Option (B):** Directly defines the array as

$$\begin{bmatrix} 4 & 5 \\ 7 & 8 \end{bmatrix}$$

and prints it, which matches the target matrix.

- **Option (C):** Starts with the same 3x3 array and uses `np2[:2, 1:]` to select rows up to index 2 (first two rows) and columns from index 1 onward, yielding

$$\begin{bmatrix} 2 & 3 \\ 5 & 6 \end{bmatrix}$$

which does not match.

- **Option (D):** Starts with the same 3x3 array, modifies the first row's first two elements to `[4, 5]`, making the array

$$\begin{bmatrix} 4 & 5 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

Then, `np2[1:, :2]` selects rows 1 and 2, columns 0 and 1, resulting in

$$\begin{bmatrix} 4 & 5 \\ 7 & 8 \end{bmatrix}$$

Question 10

If $X = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ and $Y = \begin{bmatrix} 5 & 6 \end{bmatrix}$ are NumPy arrays, what is the result of $X + Y$?

A) $\begin{bmatrix} 6 & 8 \\ 8 & 10 \end{bmatrix}$

B) $\begin{bmatrix} 6 & 7 \\ 8 & 9 \end{bmatrix}$

C) Error: shapes incompatible

D) $\begin{bmatrix} 1 & 2 & 5 & 6 \\ 3 & 4 & 5 & 6 \end{bmatrix}$

Correct Answer: A

Explanation:

NumPy broadcasting allows operations on arrays of different shapes by stretching the smaller array. Here, X is 2×2 and Y is 1×2. Y is broadcasted to 2×2 as $\begin{bmatrix} 5 & 6 \\ 5 & 6 \end{bmatrix}$. Then:

- $X + Y = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} + \begin{bmatrix} 5 & 6 \\ 5 & 6 \end{bmatrix} = \begin{bmatrix} 1+5 & 2+6 \\ 3+5 & 4+6 \end{bmatrix} = \begin{bmatrix} 6 & 8 \\ 8 & 10 \end{bmatrix}$.

Option C would occur if shapes were truly incompatible (e.g., 2×3 vs 1×2).

Question 11(MSQ)

Given the following matrix:

$$\begin{bmatrix} 1 & 2 & 3 \\ 10 & 20 & 30 \\ 7 & 8 & 9 \end{bmatrix}$$

Which of the following code snippets will produce this matrix?

1.
```
import numpy as np
matrix = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])
matrix[1, :] = [10, 20, 30]
print(matrix)
```

2.
```
import numpy as np
matrix = np.array([[1, 2, 3], [10, 20, 30], [7, 8, 9]])
print(matrix)
```

3.
```
import numpy as np
matrix = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])
matrix[0, :] = [10, 20, 30]
print(matrix)
```

4.
```
import numpy as np
matrix = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])
matrix[1] = np.array([10, 20, 30])
print(matrix)
```

Correct Answers: (A), (B), and (D) produce

$$\begin{bmatrix} 1 & 2 & 3 \\ 10 & 20 & 30 \\ 7 & 8 & 9 \end{bmatrix}$$

Explanation:

- **Option (A):** Starts with
$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$
and replaces row index `1` (second row) with `[10, 20, 30]` using `matrix[1, :] = [10, 20, 30]`, resulting in the target matrix.

- **Option (B):** Directly defines the matrix as
$$\begin{bmatrix} 1 & 2 & 3 \\ 10 & 20 & 30 \\ 7 & 8 & 9 \end{bmatrix},$$
which matches the target matrix without modification.

- **Option (C):** Starts with the same initial matrix but replaces row index `0` (first row) with `[10, 20, 30]`, resulting in
$$\begin{bmatrix} 10 & 20 & 30 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix},$$
which does not match.

- **Option (D):** Starts with the same initial matrix and replaces row index `1` with `np.array([10, 20, 30])`, which is equivalent to (A) since `matrix[1]` is shorthand for `matrix[1, :]` in this context, producing the target matrix.

Thus, (A), (B), and (D) all correctly produce the given matrix.

Question 12(NAT)

In the weather example from the class, if it is raining today, the probability of rain tomorrow is 0.4, and no rain tomorrow is 0.6. If it is not raining today, the probability of rain tomorrow is 0.2, and no rain is 0.8. What is the probability of no rain two days from now, given it is raining today?

(Answer up to 2 decimal points)

Correct Answer: 0.72

Explanation:

Transition matrix: $P = \begin{bmatrix} 0.4 & 0.6 \\ 0.2 & 0.8 \end{bmatrix}$. Compute P^2:

- $P^2[0,1] = (0.4)(0.6) + (0.6)(0.8) = 0.24 + 0.48 = 0.72$

Question 13

What will be the output of the following code?

```
import numpy as np
arr = np.ones((3,3))
arr[1, 1] = 5
print(arr)
```

(A) $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 5 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

(B) $\begin{bmatrix} 5 & 5 & 5 \\ 5 & 5 & 5 \\ 5 & 5 & 5 \end{bmatrix}$

(C) $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 5 & 1 \end{bmatrix}$

(D) $\begin{bmatrix} 1 & 1 & 1 \\ 5 & 5 & 5 \\ 1 & 1 & 1 \end{bmatrix}$

Correct Answer: (A) $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 5 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

Explanation: The code initializes a 3×3 array of ones and replaces the center element (row 1, column 1) with 5.

Question 14

What will be the output of the following code?

```
import numpy as np
np1 = np.array([10, 20, 30, 40, 50, 60])
print(np1[1:-1:2])
```

Options:

(A) [20, 40]

(B) [10, 30, 50]

(C) [20, 30, 40, 50]

(D) [30, 50]

Correct Answer: (A) [20, 40]

Explanation: The slicing `np1[1:-1:2]` starts at index 1 (value 20), stops at index -1 (value 60, which is excluded), and moves with a step of 2, selecting indices 1 and 3, which correspond to [20, 40].

Question 15(NAT)

In the Coke and Pepsi example, the transition matrix is $P = \begin{bmatrix} 0.9 & 0.1 \\ 0.2 & 0.8 \end{bmatrix}$. If a person currently purchases Pepsi, what is the probability they will purchase Coke two purchases from now?

(Answer up to 2 decimal points)

Correct Answer: 0.34

Explanation:

From Pepsi (state 1), compute P^2:

- $P^2[1,0] = (0.2)(0.9) + (0.8)(0.2) = 0.18 + 0.16 = 0.34$

Matches transcript calculation (54:18-54:24), confirming 0.34.