Interview Practice Questions - Python, Pandas, NumPy

# Python - Logic & Problem Solving

1. 1. Write a function to find the longest substring without repeating characters.
2. 2. Detect if a linked list has a cycle (without using external libraries).
3. 3. Given a list of integers, return all combinations of numbers that sum to a target.
4. 4. Write a function to flatten an arbitrarily nested list.
5. 5. Implement a rate limiter (max 3 calls per 10 seconds).
6. 6. Check if a string has balanced parentheses (e.g., ({[]})).
7. 7. Build a simple LRU Cache class.
8. 8. Find the first non-repeating character in a string.
9. 9. Simulate a multi-threaded counter (safe increment).
10. 10. Write a custom iterable class that mimics range with step logic.

# Python - OOP & System Design

1. 1. Design a class to represent a bank account (deposit, withdraw, overdraft).
2. 2. Create a Restaurant Booking System (classes for table, customer, reservation).
3. 3. Use inheritance and polymorphism to create a shape class hierarchy (Shape → Circle, Rectangle).
4. 4. Override the \_\_str\_\_ and \_\_repr\_\_ of a class to display it nicely.
5. 5. Build a plugin system where you can register new modules dynamically.

# Pandas - Data Analysis & Manipulation

1. 1. Find all duplicate rows in a DataFrame, drop them, and keep only the last occurrence.
2. 2. Fill missing time series data by forward-filling and extrapolation.
3. 3. Group a DataFrame by category and find the row with the max value per group.
4. 4. Parse a messy date column with multiple formats (e.g., '2021/03/05', 'March 5, 2021').
5. 5. Pivot a DataFrame with multiple value columns and calculate percentages by row.
6. 6. Convert a column of strings like '1,200', '3,500' into integers.
7. 7. Create a rolling weighted average (custom weights).
8. 8. Optimize memory usage of a DataFrame with millions of rows.
9. 9. Find the first and last visit per customer in a visit log DataFrame.
10. 10. Compute a new column: % change between current and previous rows, grouped by another column.

# NumPy - Array Manipulation & Math

1. 1. Implement k-means clustering from scratch using only NumPy.
2. 2. Rotate a 2D array 90 degrees clockwise without using loops.
3. 3. Use broadcasting to normalize each row independently.
4. 4. Implement a function to calculate the cosine similarity between two vectors.
5. 5. Create a 3D Gaussian filter manually (without scipy).
6. 6. Replace each element in a matrix with the average of its neighbors.
7. 7. Efficiently calculate the pairwise distance matrix for N points in 2D space.
8. 8. One-hot encode a vector of integers using NumPy only.
9. 9. Simulate a random walk in 2D for N steps.
10. 10. Build a simple convolution operation using sliding window and matrix dot products.

# Combo - Python + Pandas/NumPy

1. 1. Use Pandas to read a CSV, clean the data, and use NumPy to apply a model formula row-wise.
2. 2. Given a CSV of logs with timestamps, find the time window with the highest activity.
3. 3. Implement a class that loads a CSV file and exposes methods like mean(col), describe(col), etc., using Pandas internally.
4. 4. Parse a Pandas column with embedded JSON strings and extract nested fields into new columns.
5. 5. Use NumPy to create a large dataset and Pandas to summarize it with custom aggregation functions.