Work Sheet 5: NumPy, Scipy and Matplotlib

Q1. Write a NumPy program that creates a NumPy array of random numbers and uses SciPy to compute the statistical properties (mean, median, variance) of the array.

Q2. Write a NumPy program to generate a 2D array and performs a discrete Fourier transform using SciPy's fftpack module.

Q3. Write a NumPy program that creates a NumPy array and uses SciPy to solve a linear algebra problem. For example, finding the determinant, inverse, and eigenvalues of a matrix.

Q4. Write a NumPy program to generate a set of data points using NumPy and perform interpolation using SciPy's interpolate module.

Q5. Write a NumPy program to create a time series dataset and apply SciPy's signal processing functions to filter the data.

Q6. You will simulate sales data for a small retail store for 12 months and for 4 products, analyze the data, and perform basic statistical operations like total sales, average sales, maximum sales, etc. You will also determine the best and worst performing months based on the sales data.

Q7. This project involves analysing the marks of students across multiple subjects. The goal is to generate and analyse data, including calculating total marks, average marks, subject-wise performance, and identifying top and bottom performers. You will also determine the passing percentage and generate insights based on students' performance.

Student Name	Math	Physics	Chemistry	English
Arin	85	78	92	88
Aditya	79	82	74	90
Chirag	90	85	89	92
Gurleen	66	75	80	78
Kunal	70	68	75	85

Q8. You are provided with the following data for the velocity of an object over time. The velocity data is modelled by a quadratic function of the form $v(t)=at^2+bt+c$, where v(t) is the velocity at time t, and a, b, and c are constants to be determined using curve fitting. (Using SciPy's Curve fitting)

Time (Seconds)	0	1	2	3	4	5
Velocity (m/s)	2	3.1	7.9	18.2	34.3	56.2

Q9. This project involves analysing the marks of students across multiple subjects. The goal is to generate and analyse data, including calculating total marks, average marks, subject-wise performance, and identifying top and bottom performers. You will also determine the passing percentage and **generate insights based on students' performance using plots**.

Student Name	Math	Physics	Chemistry	English
Arin	85	78	92	88
Aditya	79	82	74	90
Chirag	90	85	89	92
Gurleen	66	75	80	78
Kunal	70	68	75	85

Q10. You are provided with the following data for the velocity of an object over time. The velocity data is modelled by a quadratic function of the form $v(t)=at^2+bt+c$, where v(t) is the velocity at time t, and a, b, and c are constants to be determined using curve fitting. (Using SciPy's Curve fitting). **Plot the original data and curve obtained in one plot with all the features of plot.**

Time (Seconds)	0	1	2	3	4	5
Velocity (m/s)	2	3.1	7.9	18.2	34.3	56.2

Q11. You are given the following data representing the population of a town in various years,

Table 1

S. No.	Year	Population (in thousands)
1	2000	50
2	2005	55
3	2010	70
4	2015	80
5	2020	90

What is the Pearson's correlation coefficient for the above data? Estimate the population of the town in the year 2008 using linear interpolation/regression equation based on Table 1 data. **Write Python code to perform the interpolation using Scipy functions and plot it**.

Q12. Consider the polynomial equation $p(x)=3x^3-5x^2+2x-8$

1. Use SciPy to find the roots of the polynomial.
2. Plot the polynomial function p(x) for the range of x from -3 to 3 and mark the roots on the plot.

Q13. Compare the performance (time taken) of Python programs.

1. Convert 200MB, 400 MB, 600 MB, 800 MB, and 1000MB text files to upper case.
2. Generate a file with random text of all the MBs and convert it into upper case and check time and plot.

Q14. Consider the function $f(x) = x^4 - 3x^3 + 2$.

1. Use SciPy to find the local minima of the function.
2. Plot the function f(x) over the range $x = [-2,3]$ and mark the local minima on the plot.

Q15. A robotic arm joint is modeled as a **damped oscillatory system**. The displacement of the joint angle θ(t) over time can be represented by the second-order differential equation:

$$\frac{d^2\theta}{dt^2} + 0.2\frac{d\theta}{dt} + \theta = 0$$

with initial conditions:

- $\theta(0) = 1$ rad
- $\theta'(0) = 0$ rad/s

Tasks

1. Use **SciPy's `odeint`** to solve the system of equations for $t = 0 \rightarrow 20$ sec.
2. Use **NumPy** arrays to handle the time vector and solutions.
3. Plot the solution θ(t) using **Matplotlib**.
4. Find the **maximum displacement** and the **time at which it occurs** using **NumPy functions**.
5. Comment: What does the damping coefficient 0.2 imply for robotic joint motion?