DATA VISUALIZATION USING PYTHON PROGRAMMING

Matplotlib is a popular Python library for creating static, interactive, and animated visualizations.
It provides a MATLAB-like interface and is used widely in AI, data analysis, and machine learning.

BACKGROUND: What are the differences between these **Function-Module-Packeage-Library**?

Function: A function is a block of reusable code designed to perform a specific task. It helps in organizing programs and avoiding repetition.

```
def greet(name):
    return f"Hello, {name}!"

print(greet("Students"))
print("x")
```

```
Hello, Students!
x
```

Module: A module is a Python file (.py) that contains a collection of related functions, variables, and classes. It allows you to organize your code logically and reuse it in multiple programs.

To make a module create a file, write the following add and subtract function and then save it with a name. Ex: abc.py

```
# abc.py
def add(a, b):
    return a + b

def subtract(a, b):
    return a - b
```

Create another python file in the same folder and then import the previous file [abc.py]. Call add/subtract functions by using the following code

```
# make sure that abc.py is saved in the local folder
import abc
print(abc.add(5, 6))
```

```
11
```

A package A package is a directory (folder) that contains multiple modules and an *_init_*.py file (which can be empty). It helps organize large projects by grouping related modules together.

Must have an *_init_*.py file (which can be empty).

```
my_package/
│
├── __init__.py
├── math_utils.py
└── string_utils.py
```

Library: A library is a collection of packages and modules that provide tools for performing specific types of tasks such as data analysis, visualization, or machine learning.

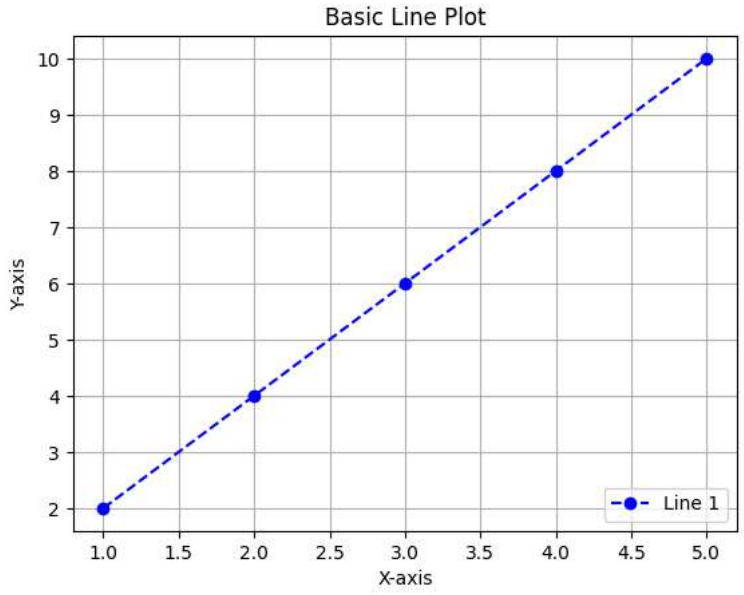
Mathematical Plots

using Matplotlib library

Line Graph

```
# ------------------------------------------
# Program: Basic Line Plot using Matplotlib
# Objective: To visualize a simple linear relationship between X and Y
# ------------------------------------------

# Importing the matplotlib library for data visualization
import matplotlib.pyplot as plt
```

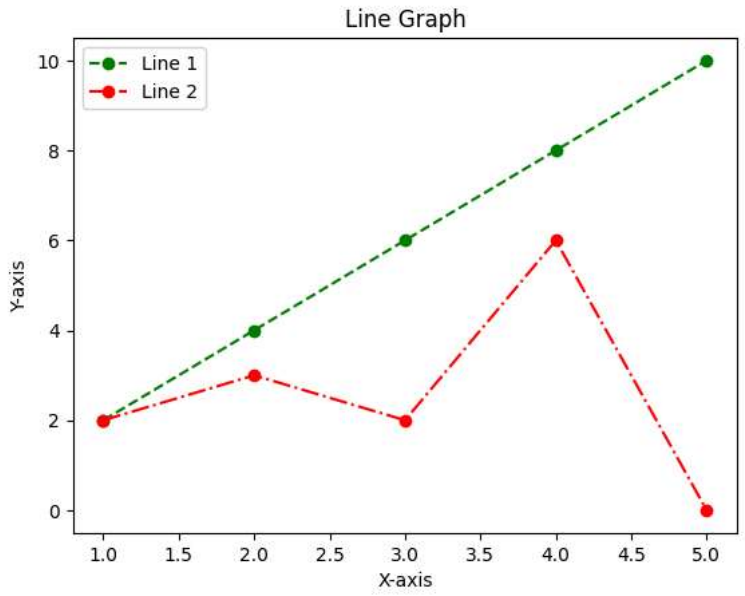
```
# Defining the data points for the X and Y axes
x = [1, 2, 3, 4, 5]          # X-axis values
y = [2, 4, 6, 8, 10]        # Corresponding Y-axis values (linear relation)

# Creating a line plot
# color     : defines the line color
# marker    : 'o' places circular markers on each data point
# linestyle : '--' makes the line dashed
plt.plot(x, y, color='blue', marker='o', linestyle='--')

# Adding a descriptive title to the graph
# loc = 'center' positions the title in the center (default)
plt.title("Basic Line Plot", loc='center')

# Labeling the X and Y axes
plt.xlabel("X-axis")
plt.ylabel("Y-axis")

# Displaying a grid to make it easier to read the graph
plt.grid(True)

# Adding a legend to describe the plotted line
# loc = 'lower right' positions it at the bottom-right corner
plt.legend(["Line 1"], loc='lower right')

# Displaying the final plotted graph
plt.show()
```



Line Plot: More than two variables

```
# ------------------------------------------------------------
# Program: Multiple Line Plot using Matplotlib
# Objective: To plot two different line graphs on the same axes
# ------------------------------------------------------------

# Importing the matplotlib library for plotting
import matplotlib.pyplot as plt

# Defining the data values for the X-axis
x = [1, 2, 3, 4, 5]

# Defining the Y values for the first line (Line 1)
y = [2, 4, 6, 8, 10]      # This shows a linear increasing trend

# Defining the Y values for the second line (Line 2)
z = [2, 3, 2, 6, 0]       # This shows a fluctuating pattern

# Plotting Line 1
# color     → sets the line color
# marker    → 'o' adds circular markers at each point
# linestyle → '--' makes a dashed line
plt.plot(x, y, color='green', marker='o', linestyle='--')

# Plotting Line 2 with different styling
```

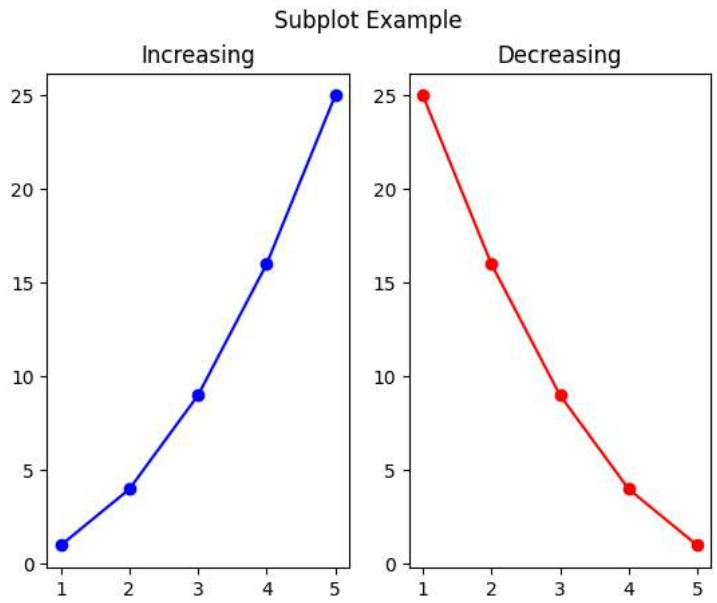
```
# linestyle '-.' is a dash-dot style
plt.plot(x, z, color='red', marker='o', linestyle='-.')

# Adding labels to the axes
plt.xlabel('X-axis')
plt.ylabel('Y-axis')

# Adding a title to the graph
plt.title('Line Graph')

# Adding a legend to differentiate the two lines
# loc='upper left' places the legend at the top-left corner
plt.legend(['Line 1', 'Line 2'], loc='upper left')

# Displaying the final graph
plt.show()
```



LINE PLOT: Multiple line plot using different subplots

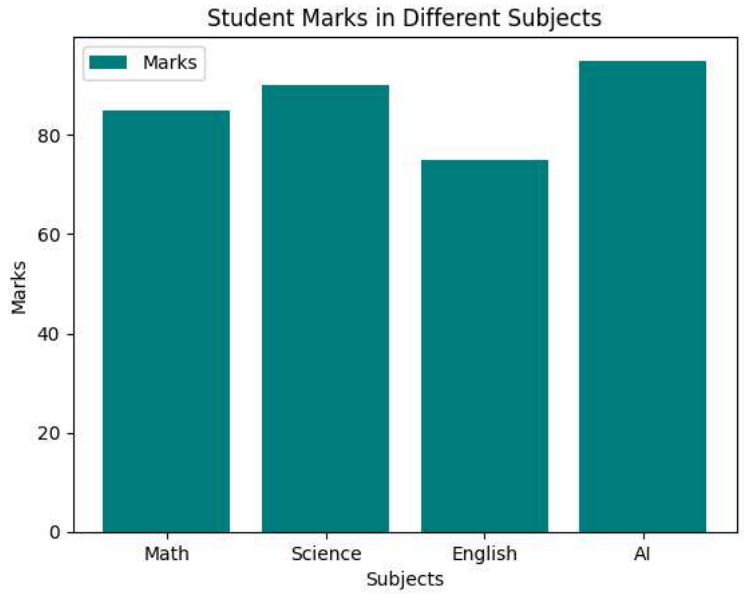
```
# ------------------------------------------------------------
# Program: Subplot Example (Two Graphs in One Figure)
# Objective: To display two line plots side-by-side using subplots
# ------------------------------------------------------------

# Importing matplotlib for plotting
import matplotlib.pyplot as plt

# Defining X values (common for both graphs)
x = [1, 2, 3, 4, 5]

# Y values for the first graph (increasing pattern)
y = [1, 4, 9, 16, 25]

# Y values for the second graph (decreasing pattern)
z = [25, 16, 9, 4, 1]

# ----------------------------
# First Subplot (1 row, 2 columns, position 1)
# ----------------------------
plt.subplot(1, 2, 1)           # Layout: 1 row × 2 columns, this is subplot 1
plt.plot(x, y, color='blue', marker='o')
plt.title("Increasing")        # Title for first graph

# ----------------------------
# Second Subplot (same layout, position 2)
# ----------------------------
plt.subplot(1, 2, 2)           # Subplot position 2
plt.plot(x, z, color='red', marker='o')
plt.title("Decreasing")        # Title for second graph

# Adding a main title for the entire figure
plt.suptitle("Subplot Example")

# Displaying both subplots together
```

```
plt.show()
```

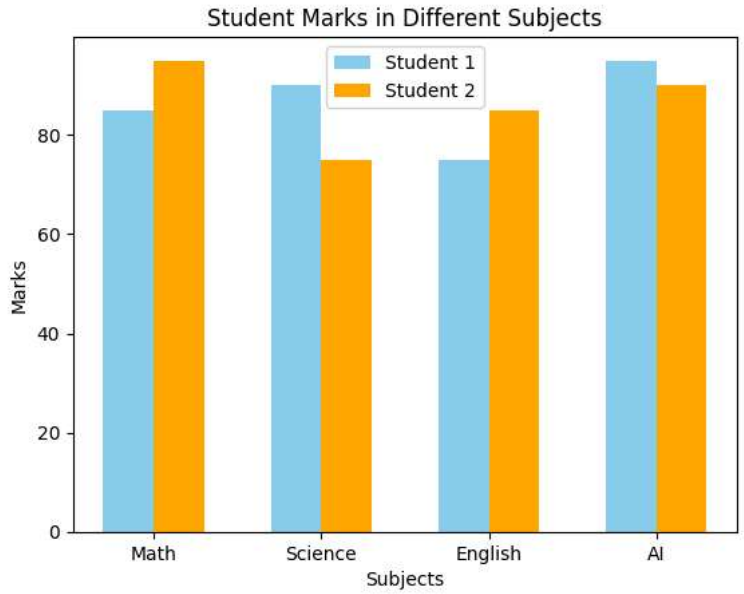


BAR GRAPH:

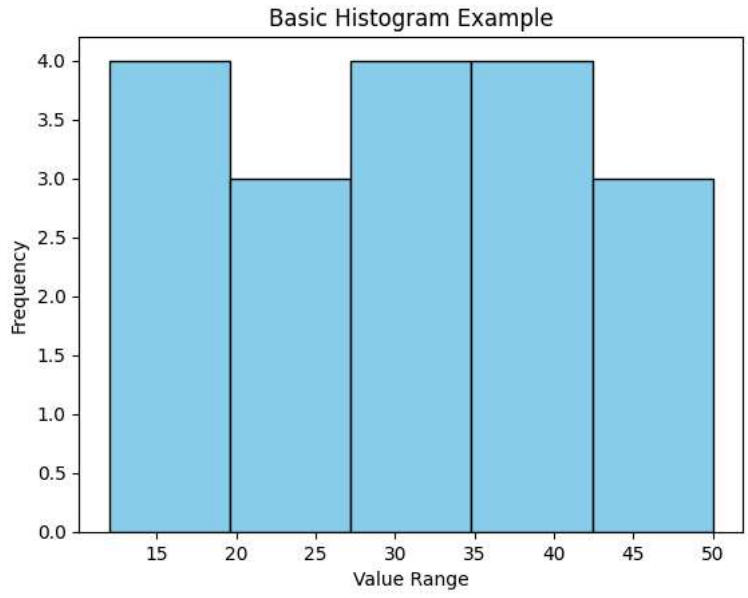
```
# ------------------------------------------------------------
# Program: Bar Graph of Student Marks
# Objective: To visualize marks scored by a student in different subjects
# ------------------------------------------------------------

# Importing matplotlib for creating the bar graph
import matplotlib.pyplot as plt

# Defining the categories (subjects) for the X-axis
subjects = ['Math', 'Science', 'English', 'AI']

# Marks scored by Student 1
marks = [85, 90, 75, 95]

# Creating the bar graph
# subjects → X-axis labels
# marks    → heights of bars
# color    → sets the bar color
plt.bar(subjects, marks, color='teal')

# Adding the graph title
plt.title("Student Marks in Different Subjects")

# Labeling X and Y axes
plt.xlabel("Subjects")
plt.ylabel("Marks")

# Adding a legend to describe the data
plt.legend(["Marks"])

# Displaying the bar graph
plt.show()
```




```
# ------------------------------------------------------------------------
# Program: Side-by-Side Bar Chart (Grouped Bar Chart)
# Objective: Compare marks of two students across different subjects
# ------------------------------------------------------------------------

import matplotlib.pyplot as plt

# Subjects (categories on X-axis)
subs = ['Math', 'Science', 'English', 'AI']

# Marks of two different students
marks = [85, 90, 75, 95]     # Student 1
marks2 = [95, 75, 85, 90]    # Student 2

# Numeric positions for bars on X-axis
x = [1, 2, 3, 4]

# Width of each bar in the grouped bar chart
width = 0.30

# Adjusting positions for the two sets of bars
# x1: left positions for Student 1
# x2: right positions for Student 2
x1 = [item - width/2 for item in x]
x2 = [item + width/2 for item in x]

# Plotting Student 1's marks
plt.bar(x1, marks, width, label='Student 1', color='skyblue')

# Plotting Student 2's marks
plt.bar(x2, marks2, width, label='Student 2', color='orange')

# Adding title and labels
plt.title("Student Marks in Different Subjects")
plt.xlabel("Subjects")
plt.ylabel("Marks")

# Setting the X-axis tick labels to subject names
plt.xticks(x, subs)

# Adding legend to identify the bars
plt.legend()

# Displaying the final chart
plt.show()

# NOTE:
# An alternative method for positioning bars:
# x = np.arange(len(subs))  # Example: array([0, 1, 2, 3])
```




```
# ------------------------------------------------------------
# Program: Histogram Example
# Objective: To visualize the frequency distribution of numerical data
# ------------------------------------------------------------

import matplotlib.pyplot as plt

# Sample numerical data
data = [12, 15, 18, 19, 22, 24, 25, 29, 30, 32, 33, 35, 38, 40, 42, 45, 47, 50]

# Creating the histogram
# data  → numerical values to group into bins
# bins  → number of intervals (groups)
# color → bar color
# edgecolor → outline color for bars
plt.hist(data, bins=5, color='skyblue', edgecolor='black')

# Adding title and axis labels
plt.title("Basic Histogram Example")
plt.xlabel("Value Range")
plt.ylabel("Frequency")

# Displaying the histogram
plt.show()
```

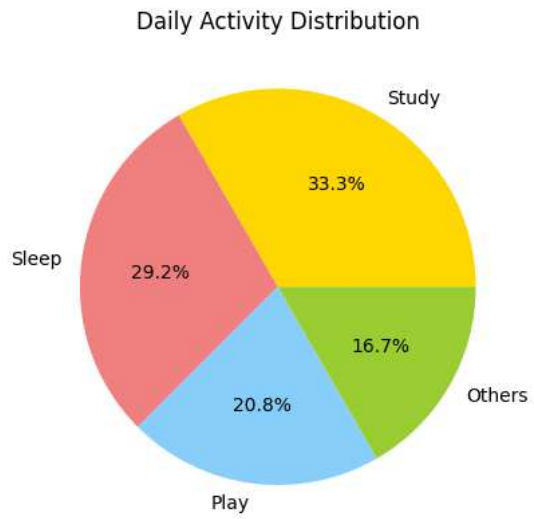


Explanation

plt.hist(data, bins=5, ...) → divides the data into 5 bins (groups) and shows how many values fall in each.

Pie Chart

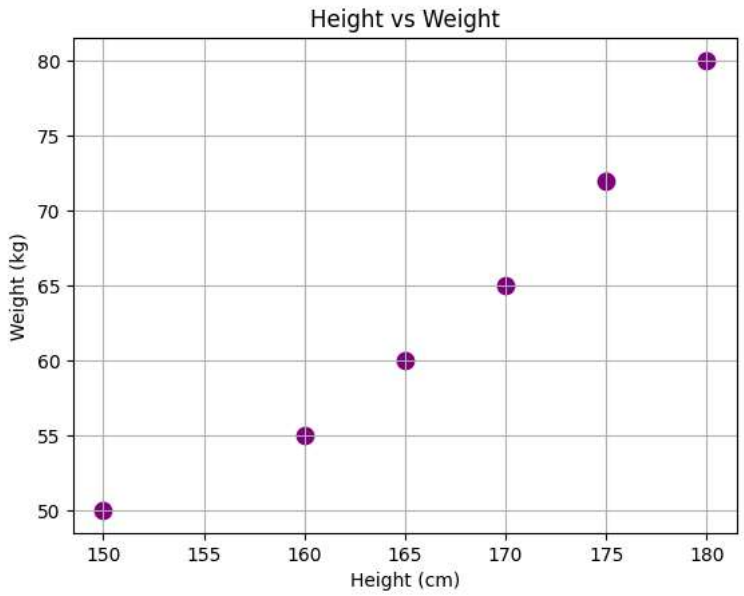
```
# ------------------------------------------------------------
# Program: Pie Chart - Daily Activity Distribution
# Objective: To show how many hours are spent on different daily activities
# ------------------------------------------------------------

import matplotlib.pyplot as plt

# Categories of daily activities
activities = ['Study', 'Sleep', 'Play', 'Others']

# Number of hours spent on each activity; numerical values that determine the size of each slice.
hours = [8, 7, 5, 4]

# Colors for each section of the pie chart
colors = ['gold', 'lightcoral', 'lightskyblue', 'yellowgreen']

# Creating the pie chart
# labels   → names of each activity
# colors   → assigns custom colors to each activity slice
# autopct  → display the percentage value on each slice
plt.pie(hours, labels=activities, colors=colors, autopct='%1.1f%%')

# Adding a title
plt.title("Daily Activity Distribution")

# Displaying the final pie chart
plt.show()
```



Scatter Plot:

```
# ------------------------------------------------------------
# Program: Scatter Plot - Height vs Weight
# Objective: To visualize the relationship between height and weight
# ------------------------------------------------------------

# Importing matplotlib for plotting
import matplotlib.pyplot as plt

# List of heights (in centimeters)
height = [150, 160, 165, 170, 175, 180]

# Corresponding list of weights (in kilograms)
weight = [50, 55, 60, 65, 72, 80]

# Creating a scatter plot
# color = 'purple' sets the dot color
# s = 80 sets the marker size (size of each dot)
plt.scatter(height, weight, color='purple', s=80)

# Adding a title to the graph
plt.title("Height vs Weight")

# Labeling the X and Y axes
plt.xlabel("Height (cm)")
```

```
plt.ylabel("Weight (kg)")

# Adding a grid for clearer visibility
plt.grid(True)

# Displaying the scatter plot
plt.show()
```



Histogram

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```
import matplotlib.pyplot as plt

subjects = ['Math', 'Science', 'English', 'AI']
marks = [85, 90, 75, 95]
marks2 = [95, 75, 85, 90]
width=0.3
plt.bar(subjects, marks, width, color='teal')
plt.bar(subjects, marks2, width, color='red')
plt.title("Student Marks in Different Subjects")
plt.xlabel("Subjects")
plt.ylabel("Marks")
plt.legend(["Per 1", "Per 2"])
plt.show()
```