National University of Computer and Emerging Sciences

DL-2001: Introduction to Data Science
Lab Manual 06

Department of Data Science

FAST-NU, Lahore, Pakistan

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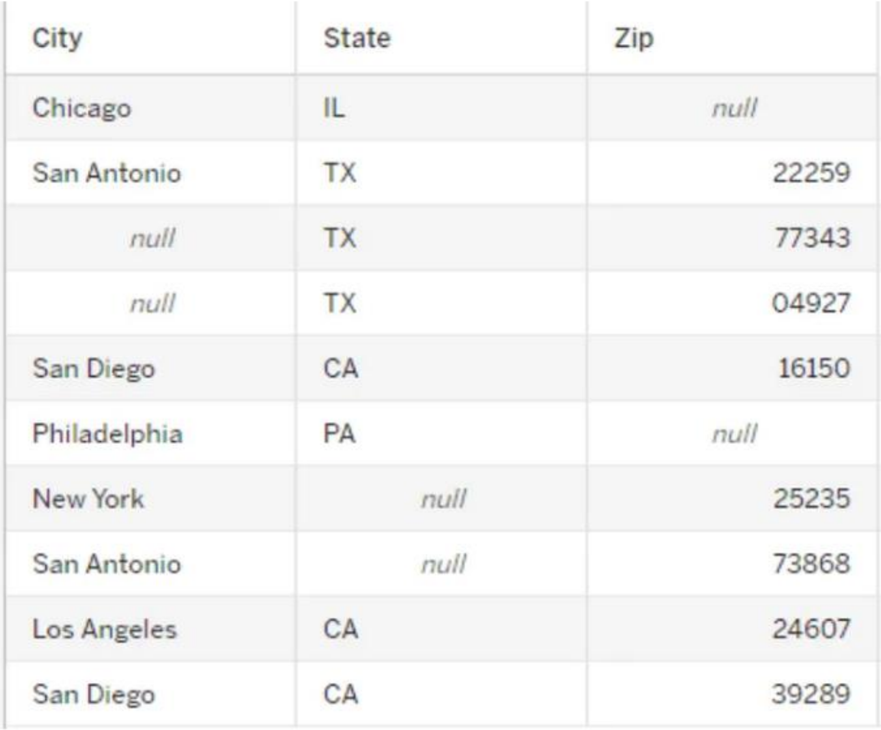
Objectives

After performing this lab, students shall be able to understand the following data science concepts and applications:

- ✓ Handling Missing/Duplicate Values, Outliers
- ✓ Data Visualization

1 Handling Missing Values

Missing values occur when no data is recorded for certain entries in a dataset. This can happen due to data collection errors, incomplete surveys, or system failures.



City	State	Zip
Chicago	IL	*null*
San Antonio	TX	22259
null	TX	77343
null	TX	04927
San Diego	CA	16150
Philadelphia	PA	*null*
New York	*null*	25235
San Antonio	*null*	73868
Los Angeles	CA	24607
San Diego	CA	39289

Missing data can introduce bias, lead to incorrect conclusions, and cause errors in computations.

1.1 Detecting Missing Values

```
import pandas as pd

df = pd.read_csv("data.csv")  # Load dataset
print(df.isnull().sum())  # Count missing values in each column
print(df.info())  # Check data types and missing values
```

1.2 Handling Missing Values

1.2.1 Remove rows/columns

Remove rows/columns with too many missing values:

```
df.dropna(inplace=True)  # Remove rows with missing values
df.dropna(axis=1, inplace=True)  # Remove columns with missing values
```

1.2.2 Imputation

Impute missing values (Mean/Median/Mode)

```
df['Age'].fillna(df['Age'].median(), inplace=True)  # Fill missing values with median
df['City'].fillna(df['City'].mode()[0], inplace=True)  # Fill missing values with mode
```

2 Removing Duplicate Data

Duplicates can inflate dataset size and lead to incorrect insights.

```
df.duplicated().sum()  # Check for duplicate rows
df = df.drop_duplicates()  # Remove duplicate rows
```

3 Handling Outliers

Outliers are data points that are significantly different from other observations. They can be caused by errors, rare events, or natural variations in data.

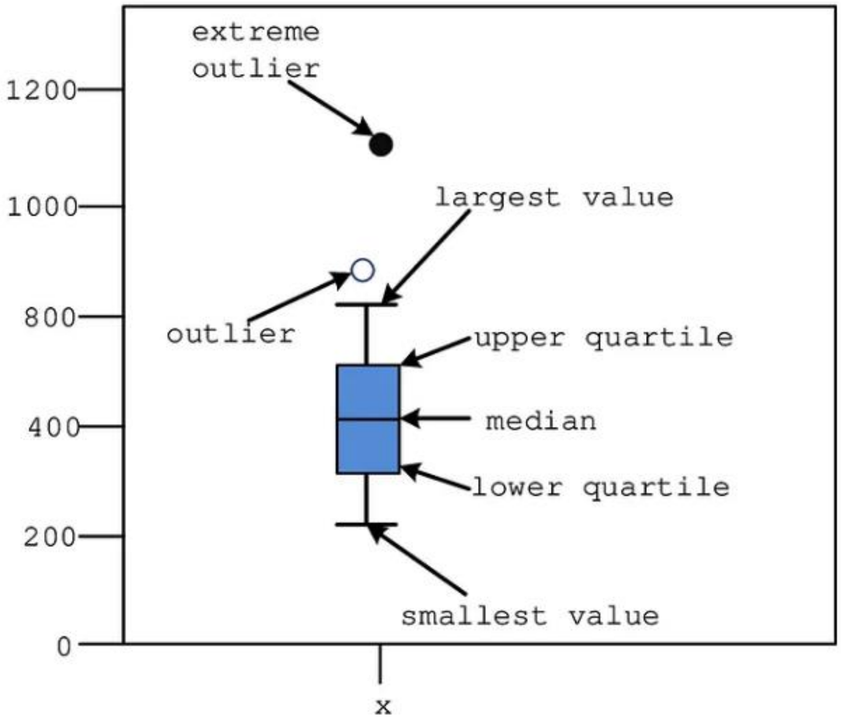
Outliers can distort statistical summaries and machine learning models.

3.1 Detecting Outliers

3.1.1 Boxplots

A boxplot is a visual representation that helps identify outliers by showing the distribution of data, including quartiles and extreme values.

```
import seaborn as sns
sns.boxplot(df['Salary'])
```



3.1.2 Z-score Method

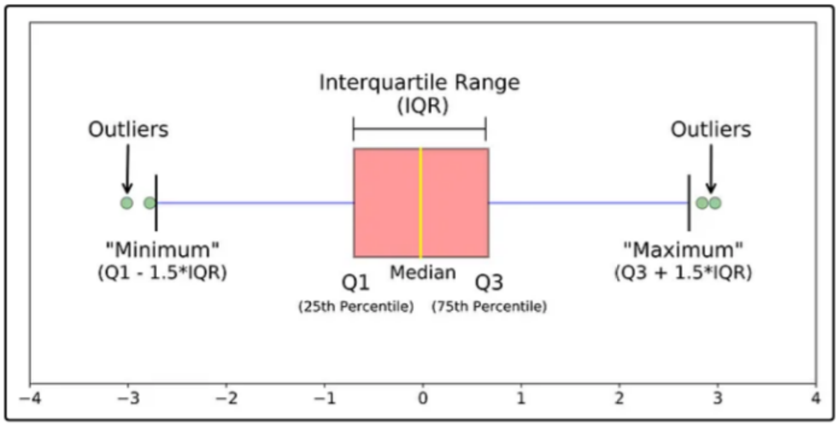
Z-score measures how many standard deviations a data point is from the mean. A value above 3 or below -3 is often considered an outlier.

```
from scipy import stats
df = df[(stats.zscore(df['Salary']) < 3)]  # Keep values within 3 standard deviations
```

3.1.3 IQR (Interquartile Range) Method

The interquartile range (IQR) is the difference between the 75th percentile (Q3) and 25th percentile (Q1) of the data. Outliers fall outside the range of Q1 − 1.5 × IQR to Q3 + 1.5 × IQR.

```
Q1 = df['Salary'].quantile(0.25)
Q3 = df['Salary'].quantile(0.75)
IQR = Q3 - Q1
df_clean = df[(df['Salary'] >= (Q1 - 1.5 * IQR)) & (df['Salary'] <= (Q3 + 1.5 * IQR))]
```



Matplotlib

Matplotlib is a low-level graph plotting library in python that serves as a visualization utility. Matplotlib was created by John D. Hunter. Matplotlib is open source and we can use it freely. Matplotlib is mostly written in python, a few segments are written in C, Objective-C and JavaScript for Platform compatibility.

1.1 Installation of Matplotlib

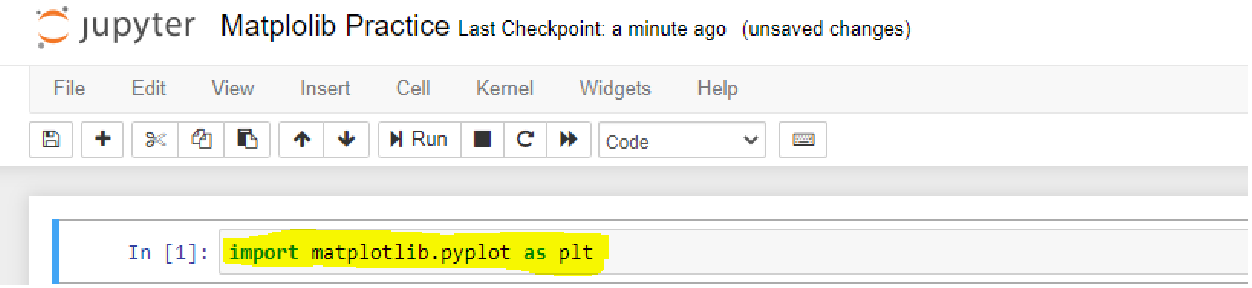
If you have Python and PIP already installed on a system, then installation of Matplotlib is very easy.

pip install matplotlib

But mostly distribution like Anaconda, Spyder have pre-installed matplotlib.

1.2 Pyplot

Most of the Matplotlib utilities lies under the pyplot submodule, and are usually imported under the plt alias:


jupyter
Matplolib Practice Last Checkpoint: a minute ago (unsaved changes)
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Run
Code

```
In [1]: import matplotlib.pyplot as plt
```

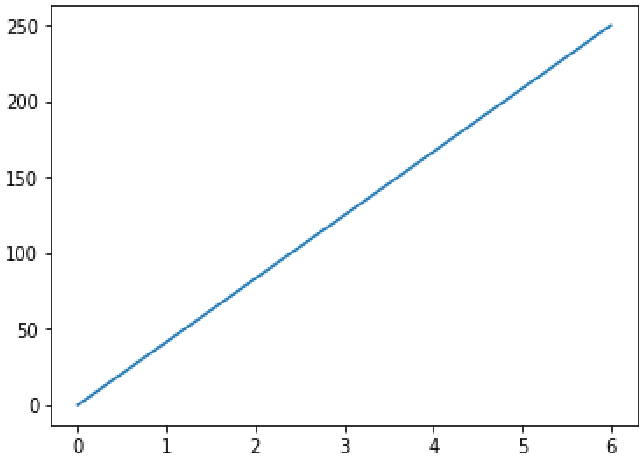
import matplotlib.pyplot as plt

Now the Pyplot package can be referred to as plt.

Example

Draw a line in a diagram from position (0,0) to position (6,250):

Code	Output

import matplotlib.pyplot as plt
import numpy as np
 	
xpoints=np.array([0, 6])
ypoints=np.array([0, 250])
 	
plt.plot(xpoints, ypoints)
plt.show()
	

1.3 Plotting x and y points

The plot() function is used to draw points (markers) in a diagram.

By default, the plot() function draws a line from point to point.

The function takes parameters for specifying points in the diagram.

Parameter 1 is an array containing the points on the **x-axis**.

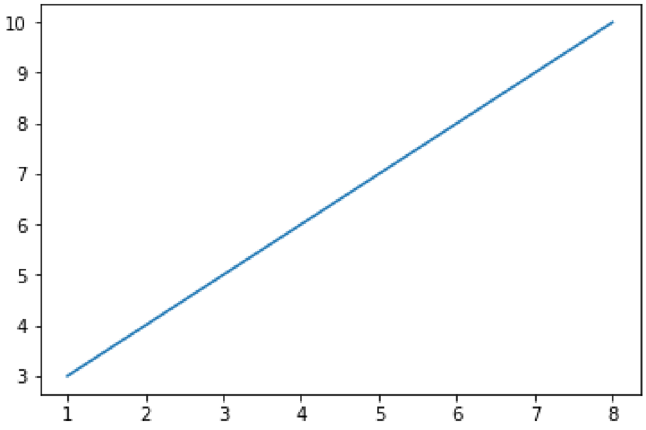
Parameter 2 is an array containing the points on the **y-axis**.

If we need to plot a line from (1, 3) to (8, 10), we have to pass two arrays [1, 8] and [3, 10] to the plot function.

Example

Draw a line in a diagram from position (1, 3) to position (8, 10):

Code	**Output**

import matplotlib.pyplot as plt
import numpy as np
 	
xpoints = np.array([1, 8])
ypoints = np.array([3, 10])
 	
plt.plot(xpoints, ypoints)
plt.show()
	

There are many types of single lines/multiple lines that can be drawn, explore other types at: https://www.w3schools.com/python/matplotlib_line.asp

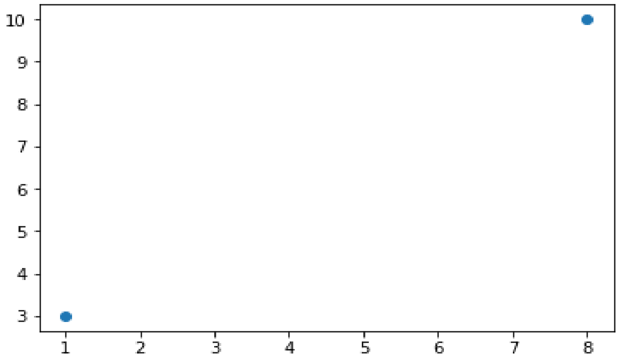
1.4 Plotting Without Line

To plot only the markers, you can use *shortcut string notation* parameter 'o', which means 'rings'.

Example

Draw two points in the diagram, one at position (1, 3) and one in position (8, 10):

Code	**Output**

import matplotlib.pyplot as plt
import numpy as np
 	
xpoints = np.array([1, 8])
ypoints = np.array([3, 10])
 	
plt.plot(xpoints, ypoints, 'o')
plt.show()
	

There can be different type of markers, you can explore at: https://www.w3schools.com/python/matplotlib_markers.asp

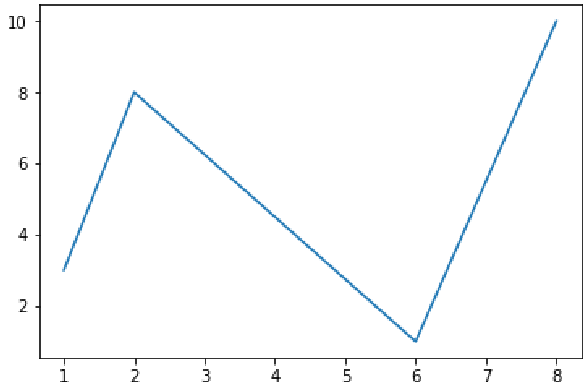
1.5 Multiple Points

You can plot as many points as you like, just make sure you have the same number of points in both axis.

Example

Draw a line in a diagram from position (1, 3) to (2, 8) then to (6, 1) and finally to position (8, 10):

Code	**Output**

import matplotlib.pyplot as plt
import numpy as np
 	
xpoints = np.array([1, 2, 6, 8])
ypoints = np.array([3, 8, 1, 10])
 	
plt.plot(xpoints, ypoints)
plt.show()
	

1.6 Default X-Points

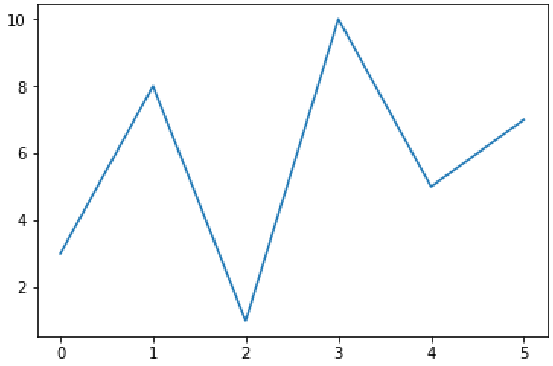
If we do not specify the points in the x-axis, they will get the default values 0, 1, 2, 3, (etc. depending on the length of the y-points.

So, if we take the same example as above, and leave out the x-points, the diagram will look like this:

Example

Plotting without x-points:

Code	Output

import matplotlib.pyplot as plt
import numpy as np
 	
ypoints = np.array([3, 8, 1, 10, 5, 7])
 	
plt.plot(ypoints)
plt.show()
	

The x-points in the example above are [0, 1, 2, 3, 4, 5] by default.

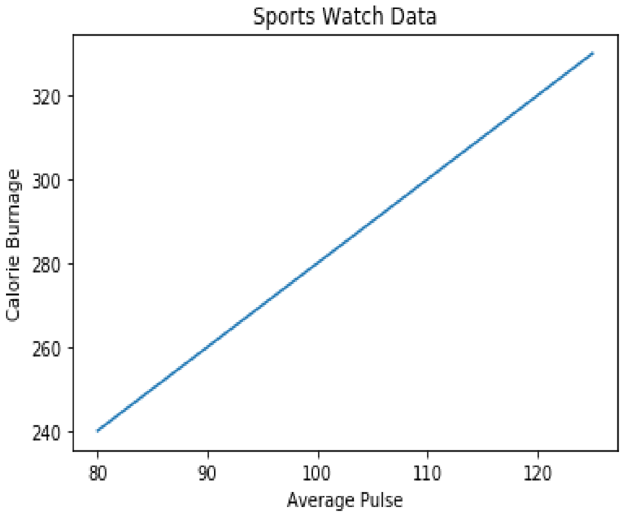
1.7 Create Labels and title for a Plot

With Pyplot, you can use the xlabel() and ylabel() functions to set a label for the x- and y-axis.

Example

Add labels to the x- and y-axis:

Code	Output

import numpy as np
import matplotlib.pyplot as plt
 	
x = np.array([80, 85, 90, 95,
 	
100, 105, 110, 115, 120, 125])
 	
y = np.array([240, 250, 260, 270,
 	
280, 290, 300, 310, 320, 330])
 	
plt.plot(x, y)
 	
plt.title("Sports Watch Data")
plt.xlabel("Average Pulse")
plt.ylabel("Calorie Burnage")
 	
plt.show()
	

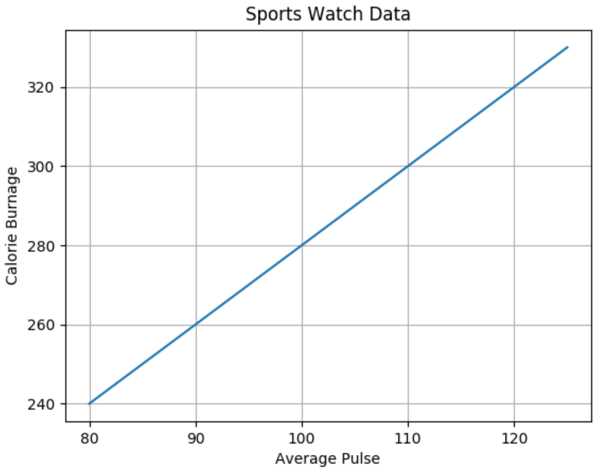
1.1 Add Grid Lines to a Plot

With Pyplot, you can use the grid() function to add grid lines to the plot.

Example

Add grid lines to the plot:

Code	Output

import numpy as np
import matplotlib.pyplot as plt
 	
x = np.array([80, 85, 90, 95, 100,
105, 110, 115, 120, 125])
 	
y = np.array([240, 250, 260, 270,
280, 290, 300, 310, 320, 330])
 	
plt.title("Sports Watch Data")
plt.xlabel("Average Pulse")
plt.ylabel("Calorie Burnage")
 	
plt.plot(x, y)
 	
plt.grid()
 	
plt.show()
	

Different type of grid can be generated, for more details see:
https://www.w3schools.com/python/matplotlib_grid.asp

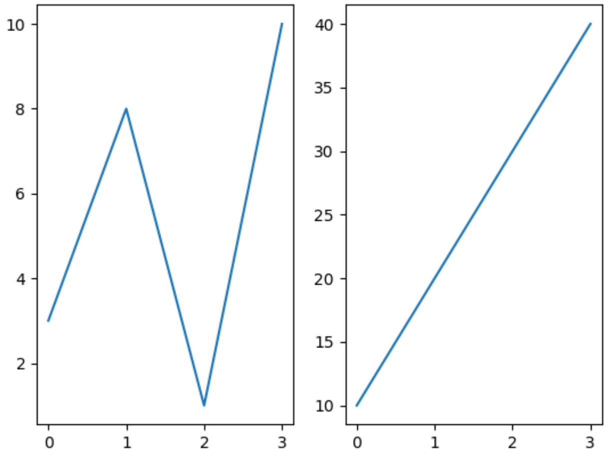
1.2 Display Multiple Plots

With the subplots() function you can draw multiple plots in one figure:

Example

Draw 2 plots:

Code	Output

import matplotlib.pyplot as plt
import numpy as np
 	
#plot 1:
x = np.array([0, 1, 2, 3])
y = np.array([3, 8, 1, 10])
 	
plt.subplot(1, 2, 1)
plt.plot(x,y)
 	
#plot 2:
x = np.array([0, 1, 2, 3])
y = np.array([10, 20, 30, 40])
 	
plt.subplot(1, 2, 2)
plt.plot(x,y)
 	
plt.show()
	

There different ways to plot multiple plots:
https://www.w3schools.com/python/matplotlib_subplots.asp

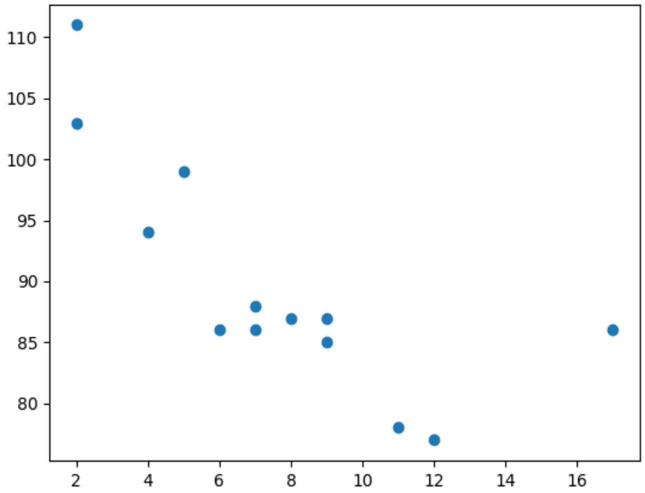
1.3 Creating Scatter Plots

With Pyplot, you can use the scatter() function to draw a scatter plot.

The scatter() function plots one dot for each observation. It needs two arrays of the same length, one for the values of the x-axis, and one for values on the y-axis:

Example:

Code	Output

import matplotlib.pyplot as plt
import numpy as np
 	
x=np.array([5,7,8,7,2,17,2,9,
 	
4,11,12,9,6])
 	
y=np.array([99,86,87,88,111,
 	
86,103,87,94,78,77,85,86])
 	
plt.scatter(x,y)
plt.show()
	

Explanation of above plot:

The observation in the example above is the result of 13 cars passing by. The X-axis shows how old the car is. The Y-axis shows the speed of the car when it passes. Are there any relationships between the observations? It seems that the newer the car, the faster it drives, but that could be a coincidence, after all we only registered 13 cars.

There are different type of scatter graphs that can be created (kindly see the link given, as all examples will make the manual lengthy):
https://www.w3schools.com/python/matplotlib_scatter.asp

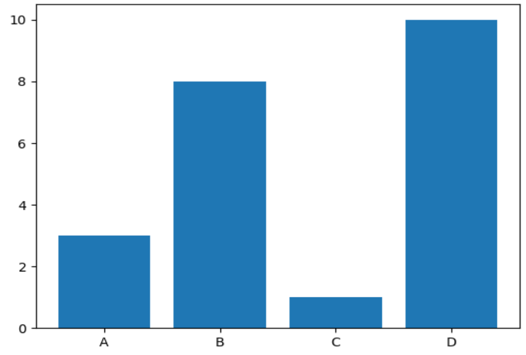
1.4 Creating Bars

With Pyplot, you can use the bar() function to draw bar graphs:

Example

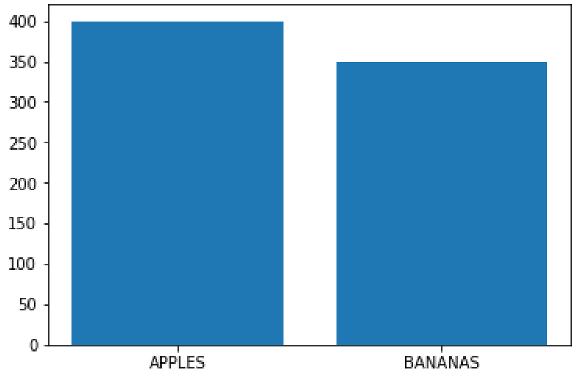
Draw 4 bars:

Code	Output

import matplotlib.pyplot as plt
import numpy as np
 	
x = np.array(["A", "B", "C", "D"])
y = np.array([3, 8, 1, 10])
 	
plt.bar(x,y)
plt.show()
	

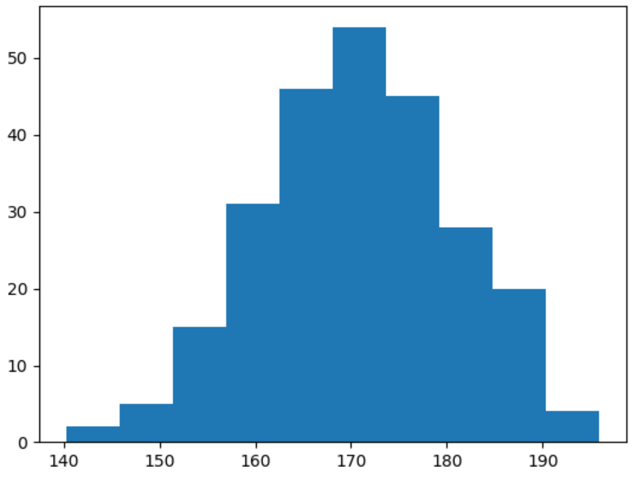
The bar() function takes arguments that describes the layout of the bars.

The categories and their values represented by the *first* and *second* argument as arrays.

import matplotlib.pyplot as plt
 	
x = ["APPLES", "BANANAS"]
y = [400, 350]
plt.bar(x, y)
	

1.5 Histogram

A histogram is a graph showing *frequency* distributions. It is a graph showing the number of observations within each given interval. Example: Say you ask for the height of 250 people; you might end up with a histogram like this:

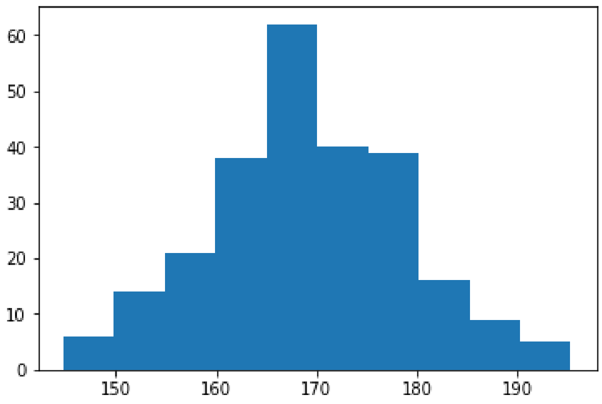
You can read from the histogram that there are approximately: 2 people from 140 to 145cm 5 people from 145 to 150cm 15 people from 151 to 156cm 31 people from 157 to 162cm 46 people from 163 to 168cm 53 people from 168 to 173cm 45 people from 173 to 178cm 28 people from 179 to 184cm 21 people from 185 to 190cm 4 people from 190 to 195cm	

1.5.1 Create Histogram

In Matplotlib, we use the hist() function to create histograms.

The hist() function will use an array of numbers to create a histogram, the array is sent into the function as an argument. For simplicity we use NumPy to randomly generate an array with 250 values, where the values will concentrate around 170, and the standard deviation is 10.

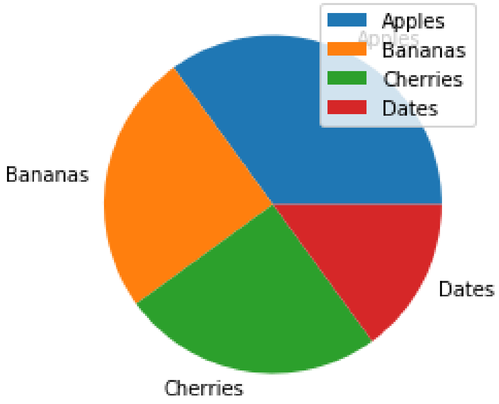
Code	**Output**

import matplotlib.pyplot as plt
import numpy as np
 	
x = np.random.normal(170, 10, 250)
 	
plt.hist(x)
plt.show()
	

1.6 Creating Pie Charts

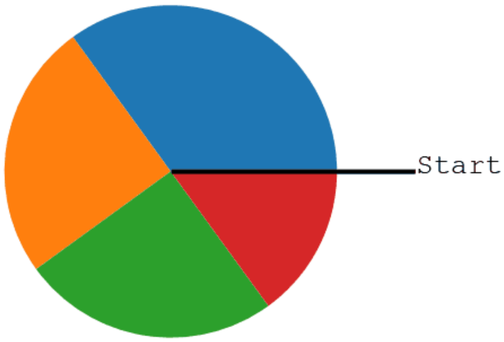
With Pyplot, you can use the pie() function to draw pie charts:

Code	**Output**

import matplotlib.pyplot as plt
import numpy as np
 	
y = np.array([35, 25, 25, 15])
mylabels =
["Apples","Bananas","Cherries","Dates"
]
 	
plt.pie(y, labels = mylabels)
 	
plt.legend()
plt.show()
	

As you can see the pie chart draws one piece (called a wedge) for each value in the array (in this case [35, 25, 25, 15]).

By default, the plotting of the first wedge starts from the x-axis and move *counterclockwise*:

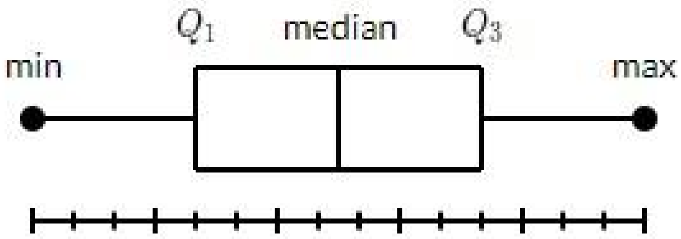


Note: The size of each wedge is determined by comparing the value with all the other values, by using this formula:

The value divided by the sum of all values: x/sum(x)

1.7 Box Plot

A box plot which is also known as a whisker plot displays a summary of a set of data containing the minimum, first quartile, median, third quartile, and maximum. In a box plot, we draw a box from the first quartile to the third quartile. A vertical line goes through the box at the median. The whiskers go from each quartile to the minimum or maximum.



The image is taken from: https://www.tutorialspoint.com/matplotlib/matplotlib_box_plot.htm

Example 1: Draw a box-and-whisker plot for the data set {3, 7, 8, 5, 12, 14, 21, 13, 18}.

Minimum: 3, Q_1: 6, Median: 12, Q_3: 16, and Maximum: 21.

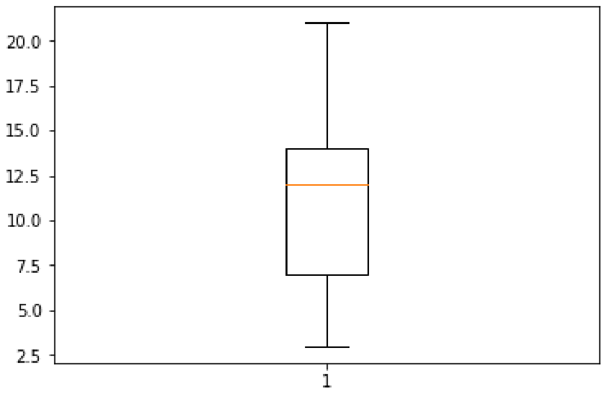
Code	**Output**

```
import matplotlib.pyplot as plt

data = [3, 7, 8, 5, 12, 14, 21, 13, 18]

plt.boxplot(data)

plt.show()
```


20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
1