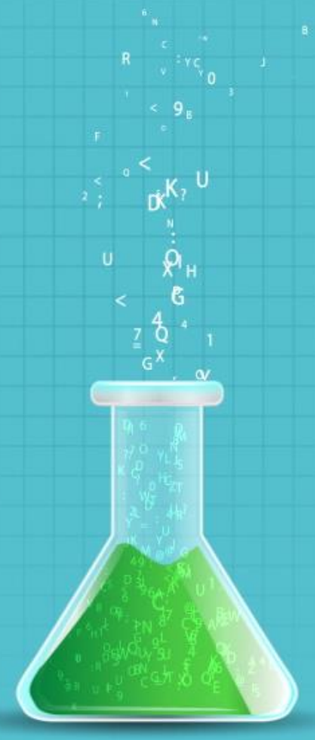
Data Science with Python

Lesson 10—Data Visualization in Python using matplotlib

DATA SCIENCE

What’s In It For Me

- Explain what data visualization is and its importance in our world today
- Understand why Python is considered one of the best data visualization tools
- Describe matplotlib and its data visualization features in Python
- List the types of plots and the steps involved in creating these plots



Data Visualization

Data visualization is a technique to present the data in a pictorial or graphical format.

Well, you might wonder why data visualization is important?

Data Visualization (contd.)

You are a Sales Manager in a leading global organization. The organization plans to study the sales details of each product across all regions and countries. This is to identify the product which has the highest sales in a particular region and up the production. This research will enable the organization to increase the manufacturing of that product in that particular region.

Data Visualization (contd.)

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Data Visualization (contd.)

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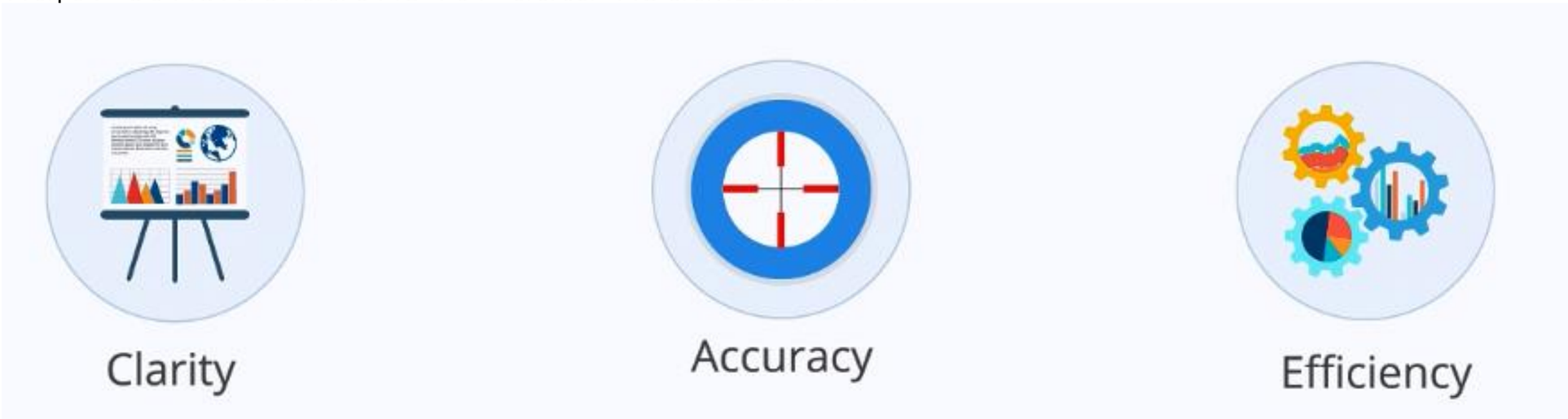
Data Visualization

The main benefits of data visualization are as follows:

Data Visualization Considerations

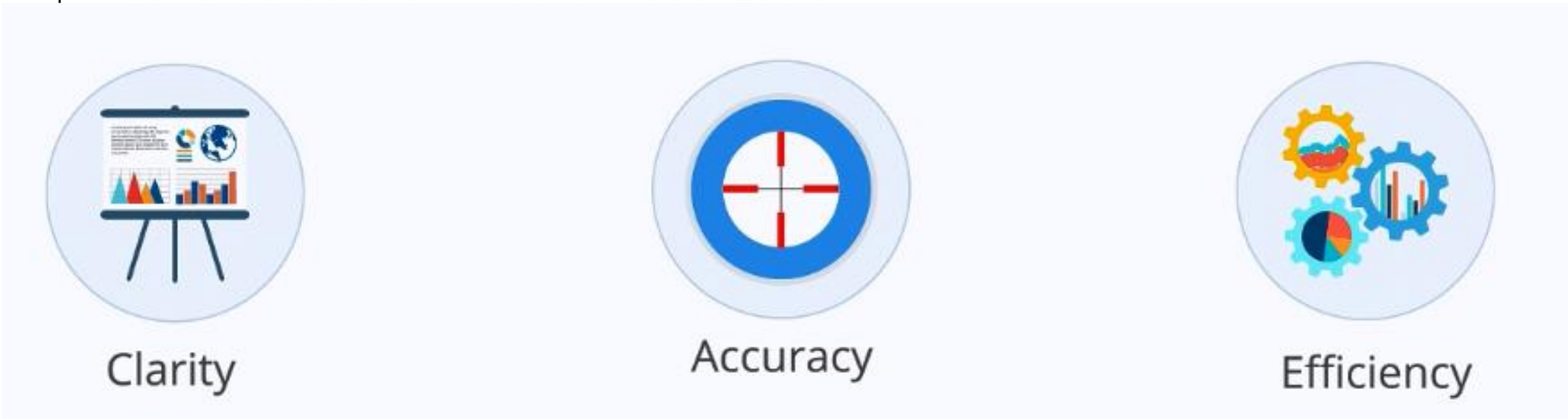
Three major considerations for data visualization:



Ensure the dataset is complete and relevant. This enables the Data Scientist to use the new patterns obtained from the data in the relevant places.

Data Visualization Considerations (contd.)

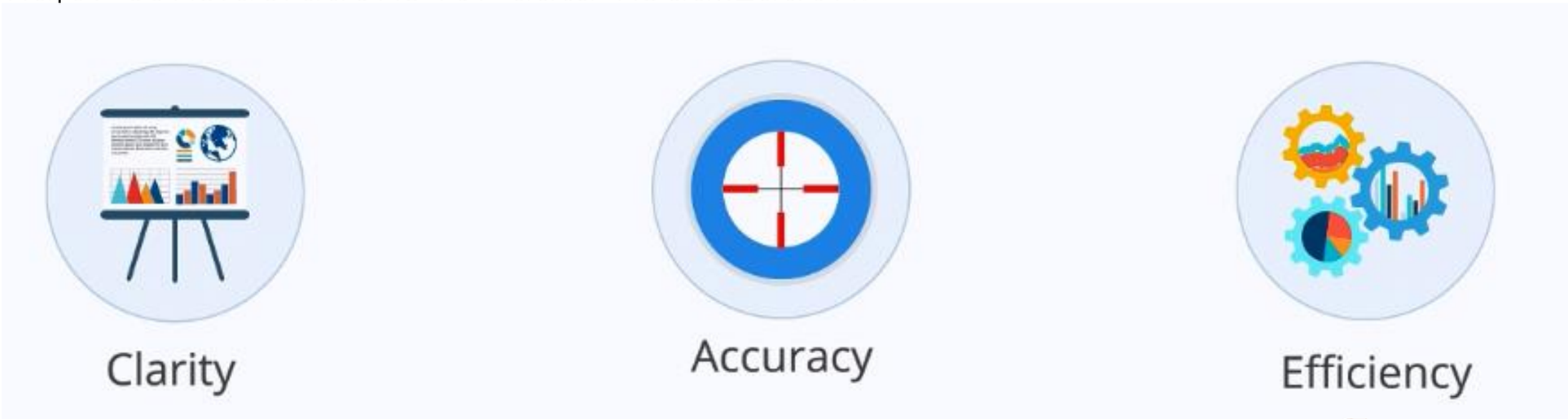
Three major considerations for data visualization:



Ensure you use appropriate graphical representation to convey the intended message.

Data Visualization Considerations (contd.)

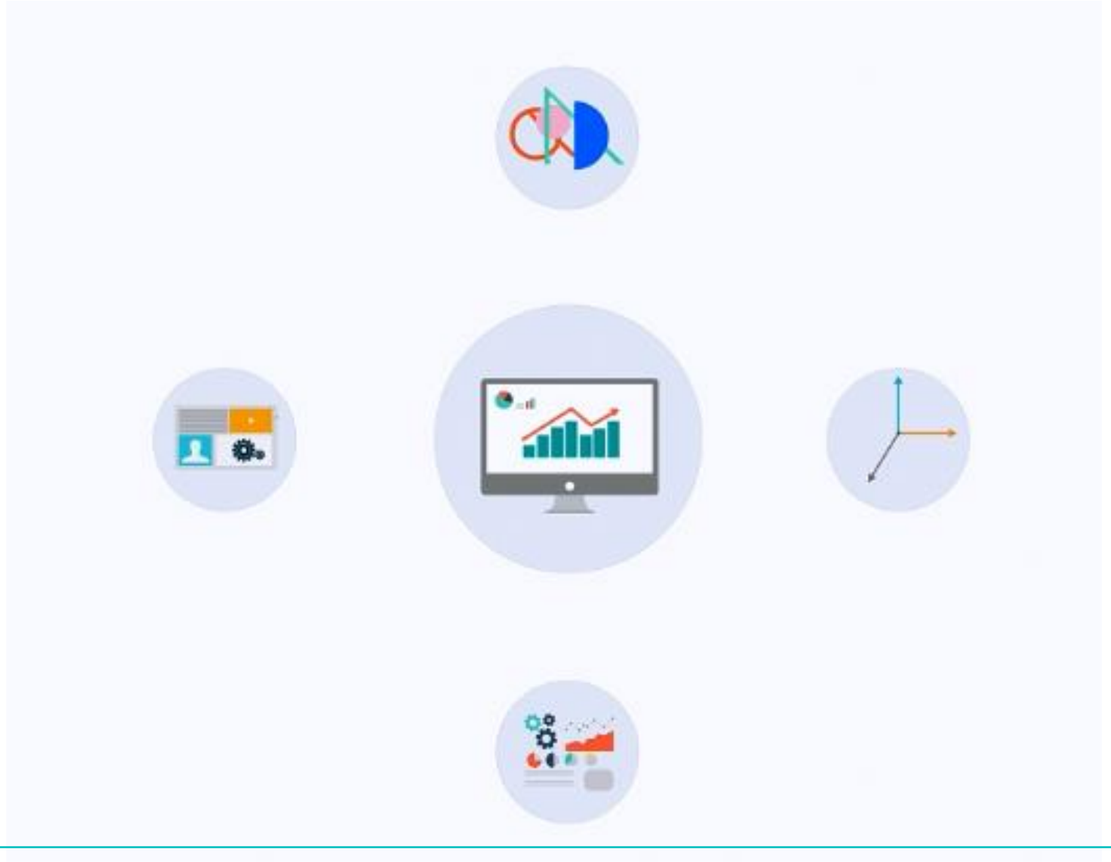
Three major considerations for data visualization:



Use efficient visualization techniques that highlight all the data points.

Data Visualization Factors

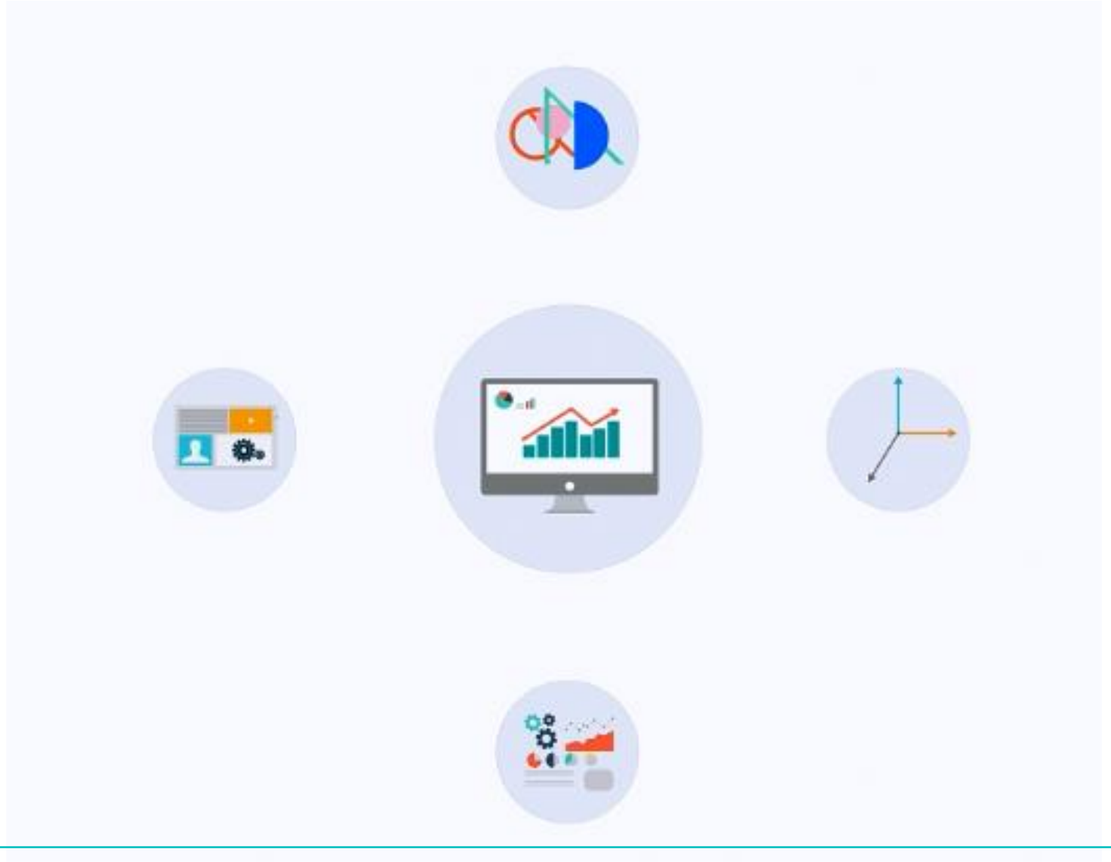
There are some basic factors that one needs to be aware of before visualizing the data:



The visual effect includes the usage of appropriate shapes, colors, and sizes to represent the analyzed data.

Data Visualization Factors (contd.)

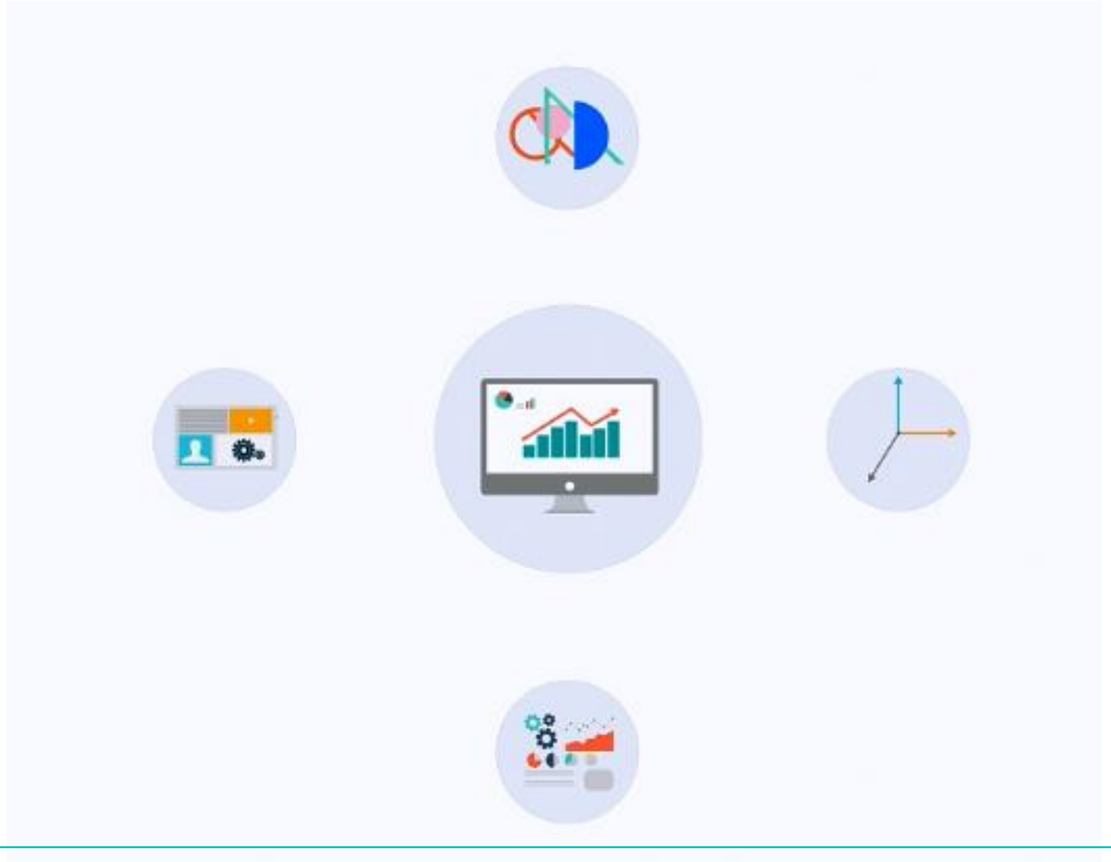
There are some basic factors that one needs to be aware of before visualizing the data:



The coordinate system helps organize the data points within the provided coordinates.

Data Visualization Factors (contd.)

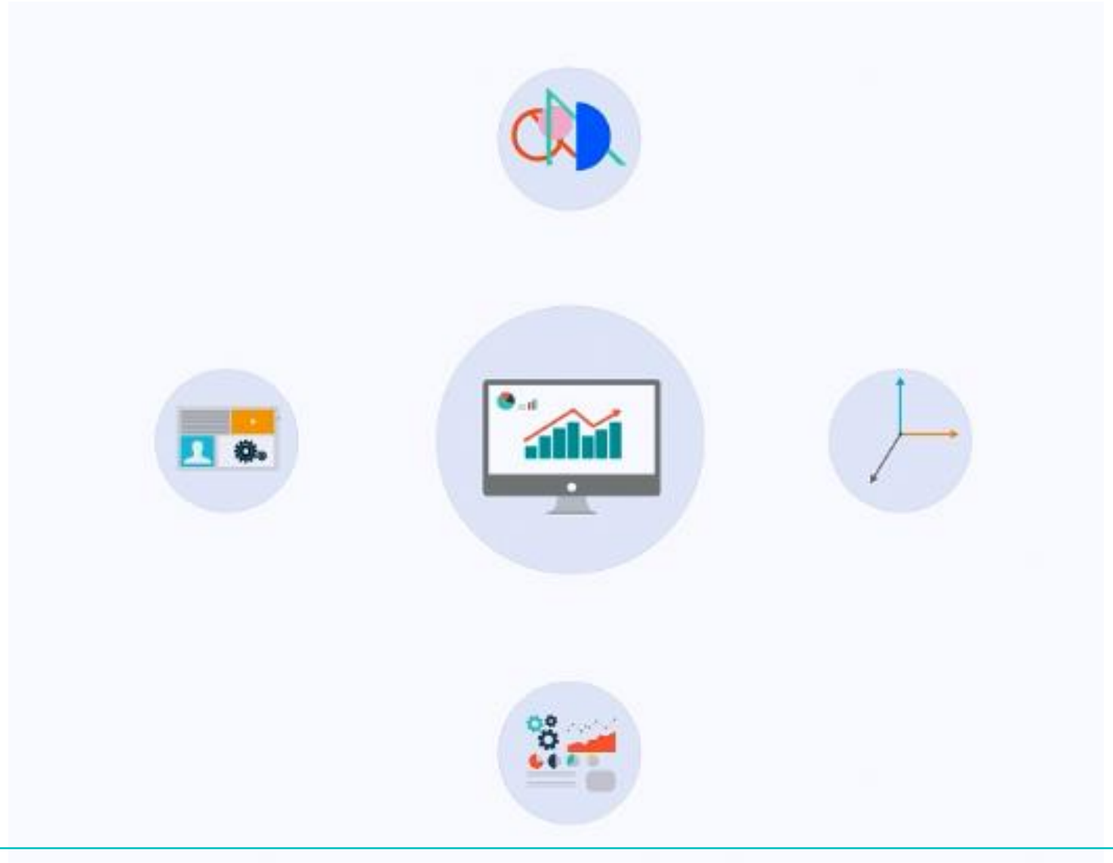
There are some basic factors that one needs to be aware of before visualizing the data:



The data types and scale choose the type of data, for example, numeric or categorical.

Data Visualization Factors

There are some basic factors that one needs to be aware of before visualizing the data:



The informative interpretation helps create visuals in an effective and easily interpretable manner using labels, title, legends, and pointers.

Data Visualization Tool—Python

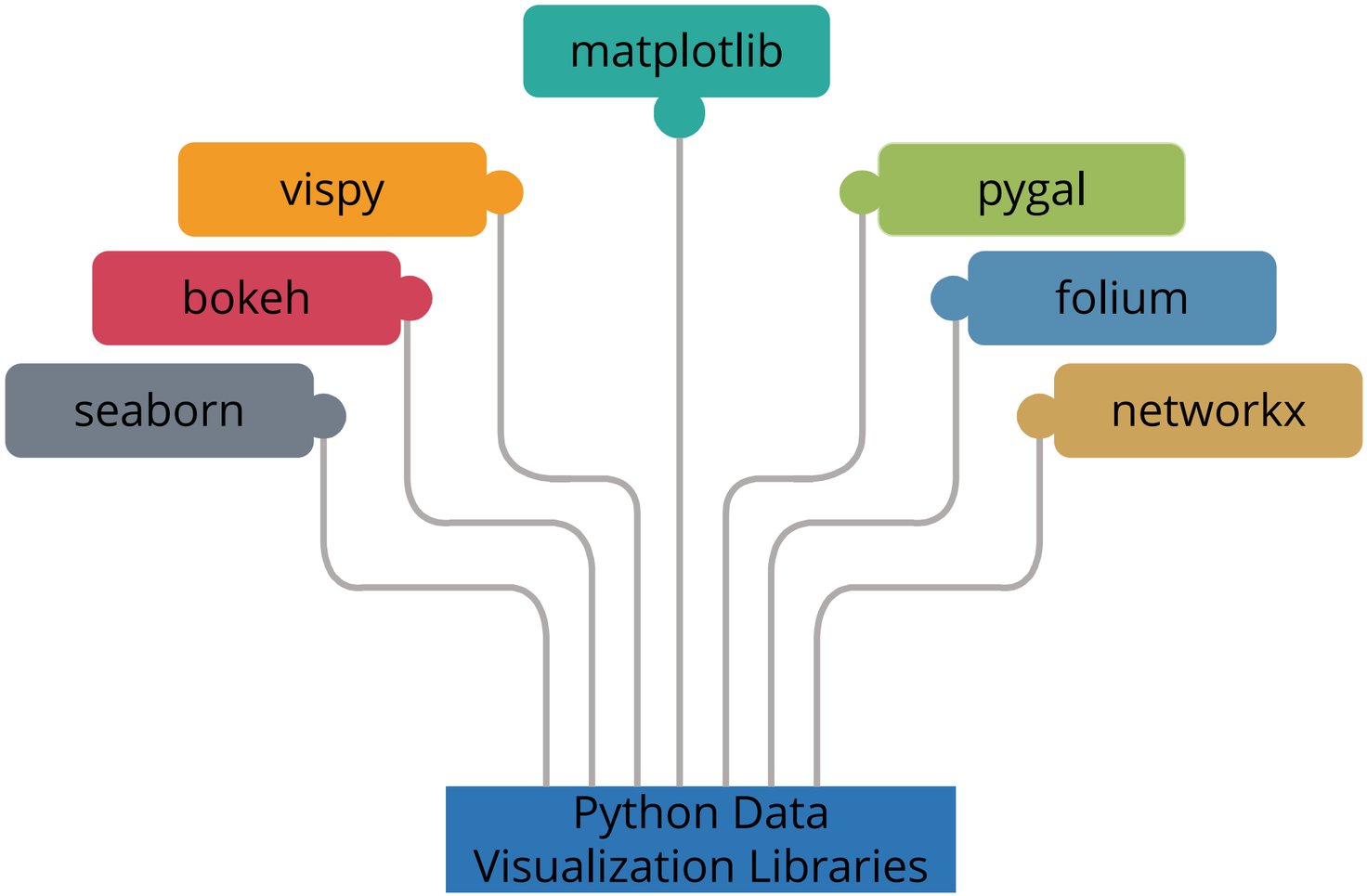
How is data visualization performed for large and complex data?

What data visualization is?

How data visualization helps interpret results with large data

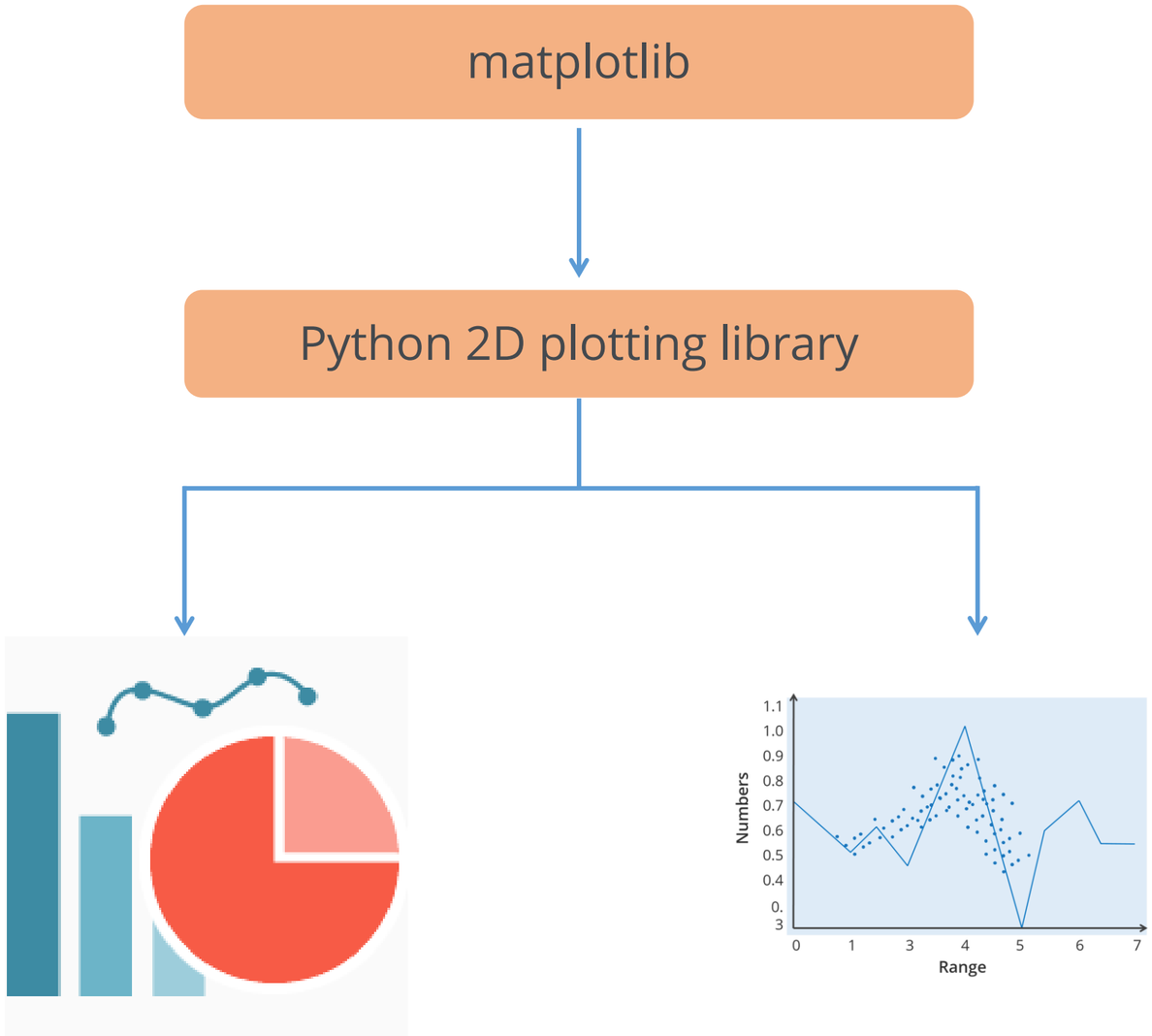
Python Libraries

Many new Python data visualization libraries are introduced recently such as:



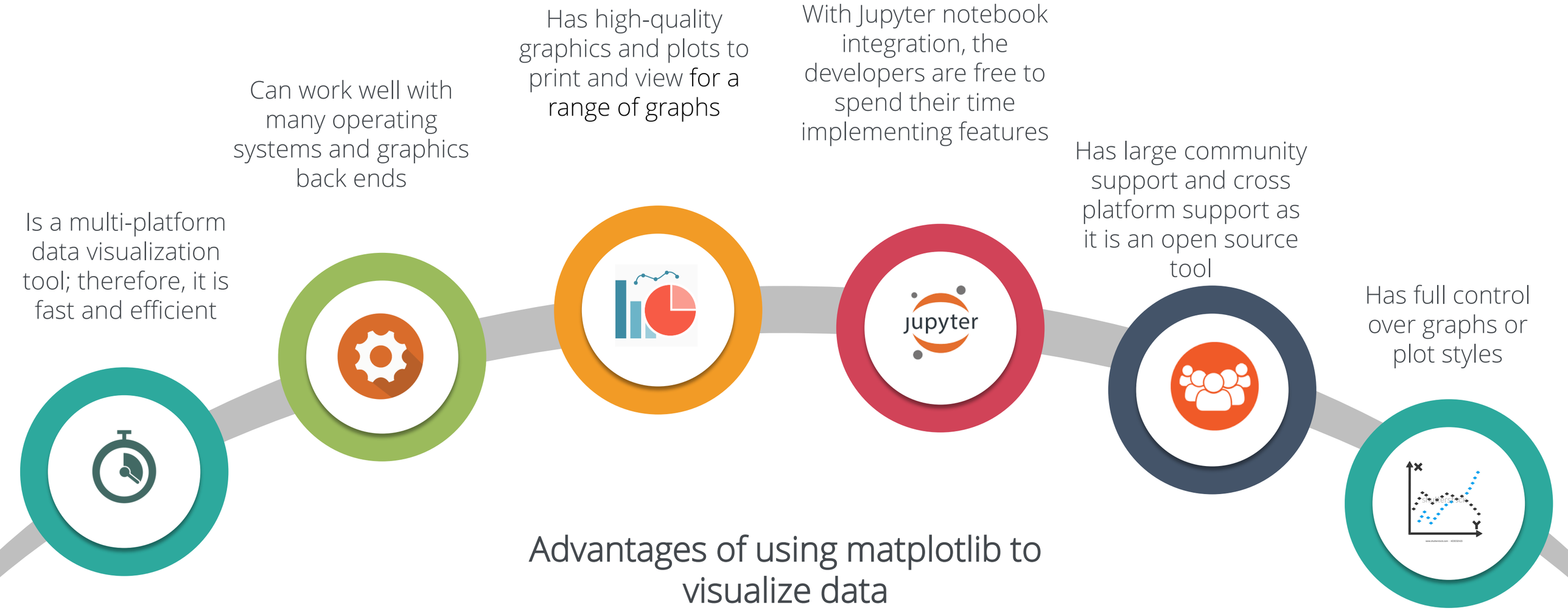
Python Libraries—matplotlib

Using Python's matplotlib, the data visualization of large and complex data becomes easy.



Python Libraries—matplotlib (contd.)

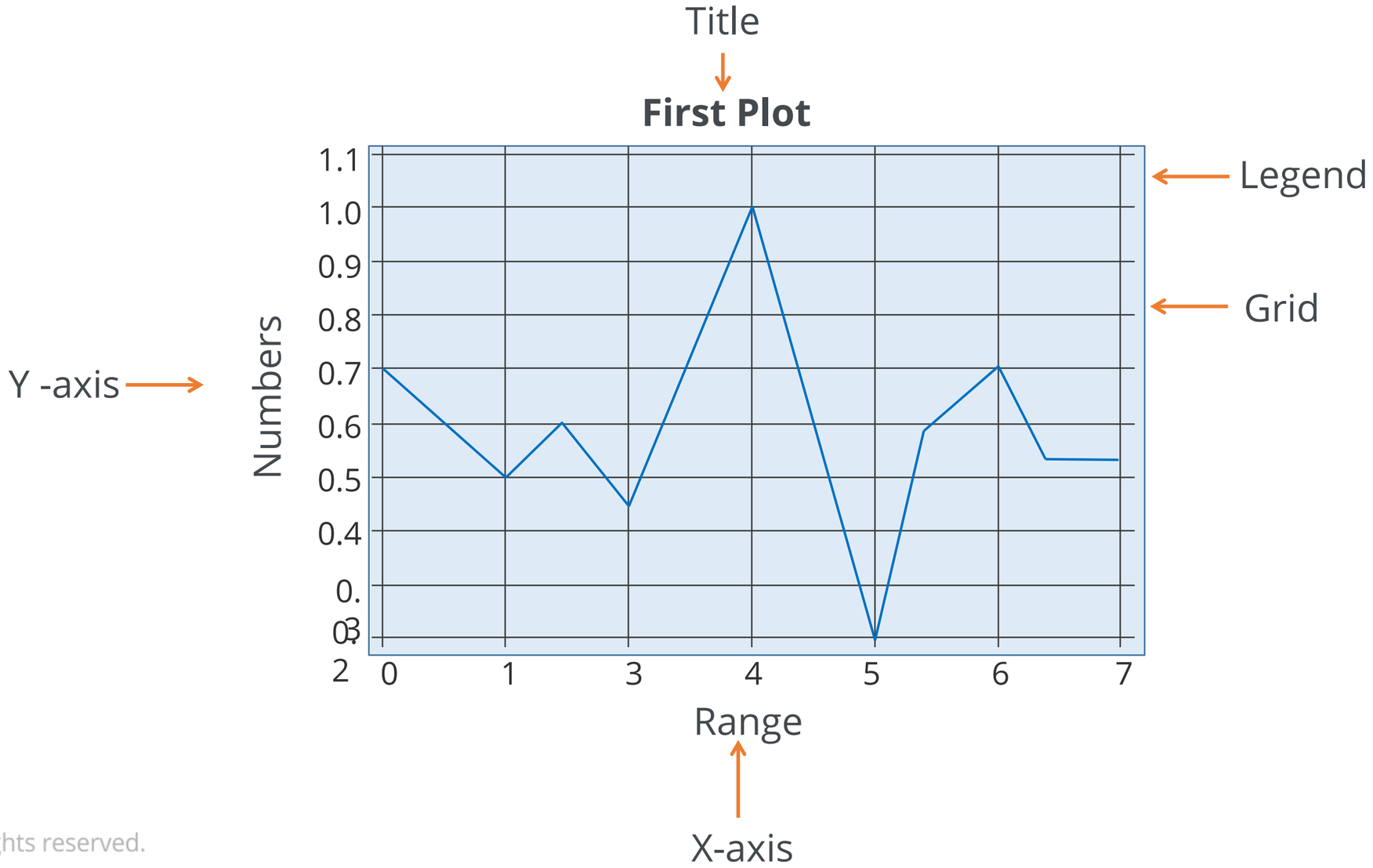
There are several advantages of using matplotlib to visualize data. They are as follows:



Advantages of using matplotlib to visualize data

The Plot

A plot is a graphical representation of data, which shows the relationship between two variables or the distribution of data.



Steps to Create a Plot

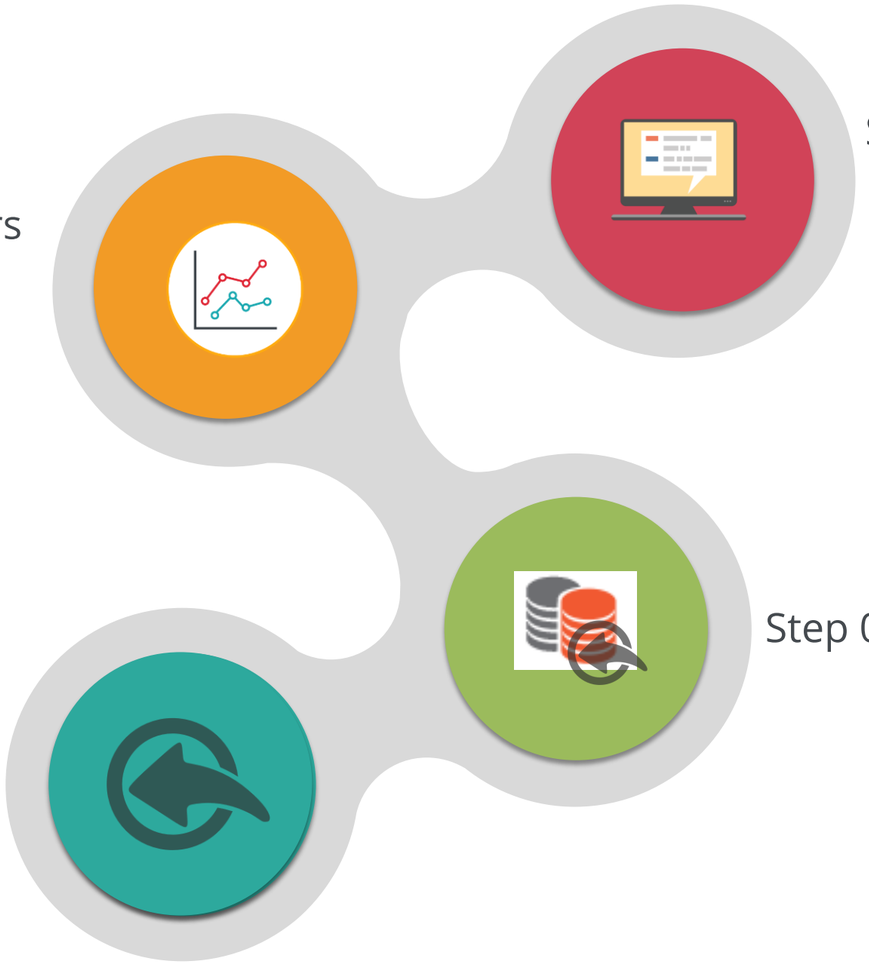
You can create a plot using four simple steps.

Step 01: Import the required libraries

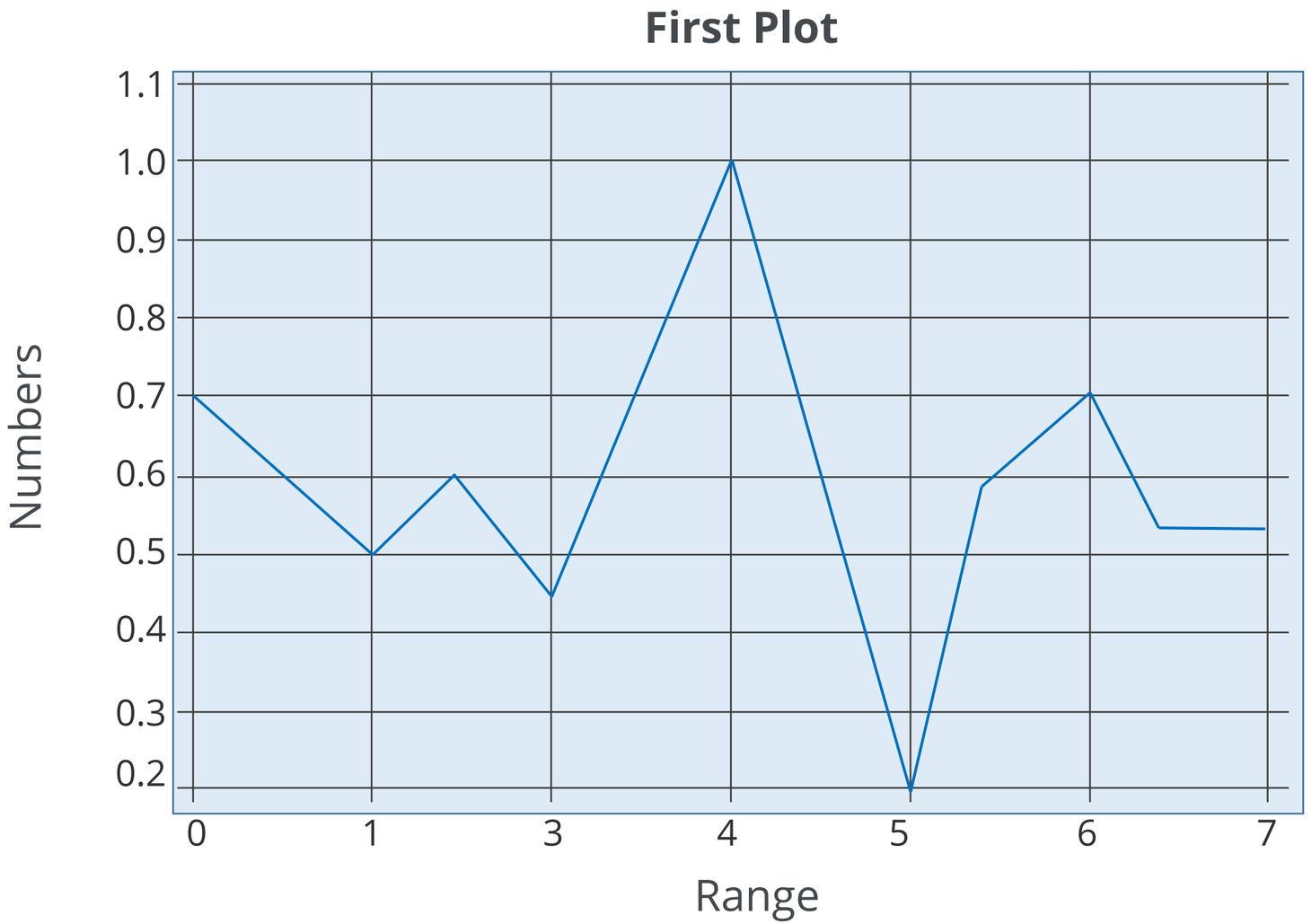
Step 02: Define or import the required dataset

Step 03: Set the plot parameters

Step 04: Display the created plot



Steps to Create Plot – Example



Steps to Create Plot – Example (contd.)

```
In [1]: #import numpy for generating random numbers
        import numpy as np
        #import matplotib library
        import matplotlib.pyplot as plt
        from matplotlib import style
        %matplotlib inline
```

Generate random numbers — numpy

Plot the numbers — pyplot

set the grid style — style

```
In [21]: #generate random numbers (total 10)
         randomNumber = np.random.rand(10)
```

used numpy random method — Defined the dataset

```
In [22]: #view them
         print randomNumber
```

view the created random numbers — Print method

```
[ 0.71892609  0.49065612  0.61092193  0.43397501  0.94771363  0.31505178
  0.58568599  0.6929941   0.4288734   0.43774794]
```

```
In [23]: #select the style of the plot
         style.use('ggplot')
         #plot the random number
         plt.plot(randomNumber,'g',label='line one',linewidth=2)
         #x axis is number of random numbers (index)
         plt.xlabel('Range')
         #y axis is actual random number
         plt.ylabel('Numbers')
         #Title of the plot
         plt.title('First Plot')
```

ggplot — Set the style

Set the legend

Set line width

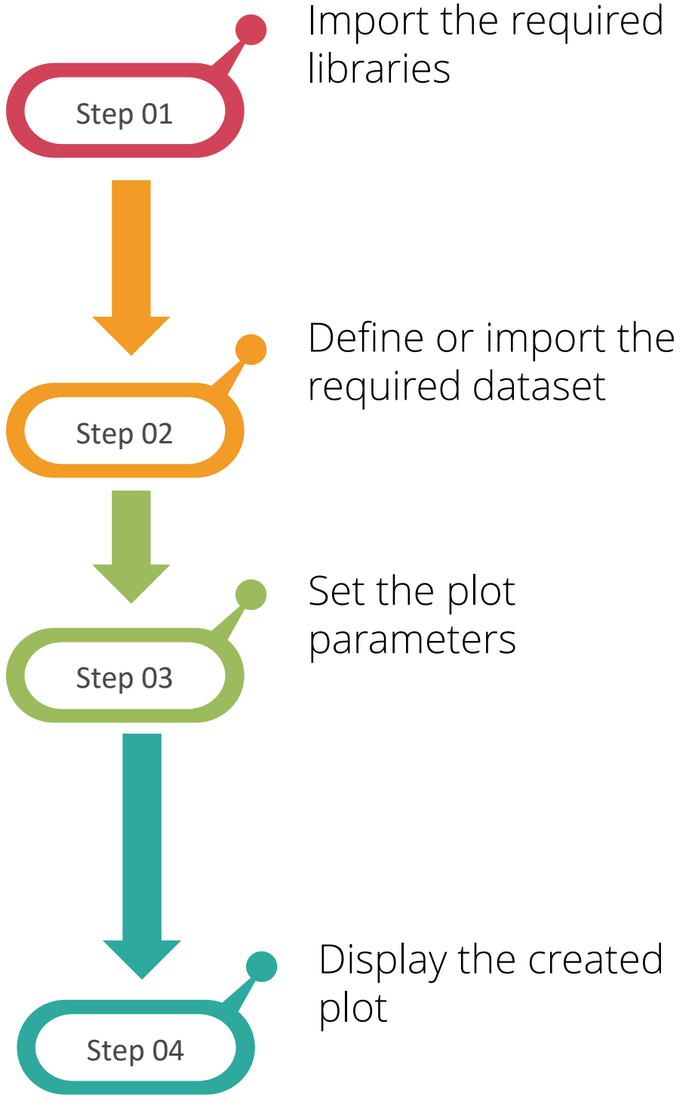
Set coordinates labels

Set the title

```
plt.legend()
plt.show()
```

Plot the graph

Display the created plot



Knowledge Check

KNOWLEDGE CHECK

Which of the following methods is used to set the title?

a. Plot()

b. Plt.title()

c. Plot.title()

d. Title()

KNOWLEDGE CHECK

Which of the following methods is used to set the title?

a. Plot()

b. Plt.title()

c. Plot.title()

d. Title()

The correct answer is b.

Explanation Plt.title() is used to set the title.

Line Properties

Line Properties

1. alpha
   set the transparency of the line
2. animated
   set the transparency of the line

Plot Graphics

1. linestyle
2. linewidth
3. marker style

View Line Properties

matplotlib also offers various line colors.

Click **View Line Properties** *to know more.*

Line Properties (contd.)

Property	Value Type
alpha	float
animated	[True | False]
antialiased or aa	[True | False]
clip_box	a matplotlib.transform.Bbox instance
clip_on	[True | False]
clip_path	a Path instance and a Transform instance, a Patch
color or c	any matplotlib color
contains	the hit testing function
dash_capstyle	['butt' | 'round' | 'projecting']
linestyle or ls	['-' | '--' | '-.' | ':' | 'steps' | ...]
linewidth or lw	float value in points
marker	['+' | ',' | '.' | '1' | '2' | '3' | '4']

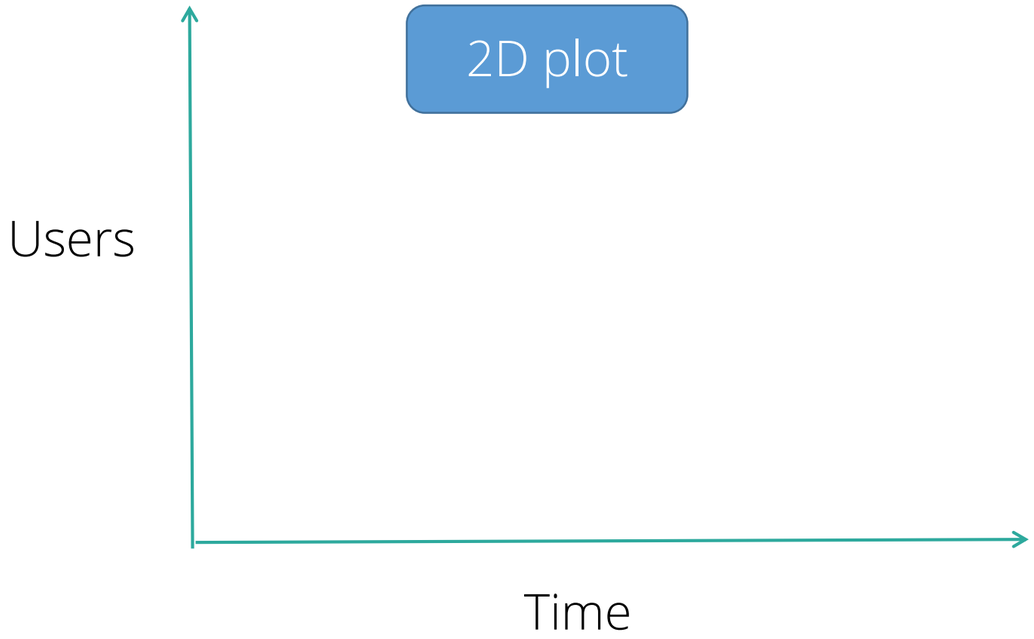
Alias	Color
b	Blue
r	Red
c	Cyan
m	Magenta
g	Green
y	Yellow
k	Black
w	White

View Line Properties

Click **View Line Properties** *to know more.*

Plot With (X,Y)

A leading global organization wants to know how many people visit its website in a particular time. This analysis helps it control and monitor the website traffic.



Plot With (X,Y)

In [1]:
```
#import matplotib library
import matplotlib.pyplot as plt
from matplotlib import style
%matplotlib inline
```

In [2]:
```
#website traffic data
#number of users/ visitors on the web site
web_customers = [123,645,950,1290,1630,1450,1034,1295,465,205,80 ]
#Time distribution (hourly)
time_hrs = [7,8,9,10,11,12,13,14,15,16,17]
```

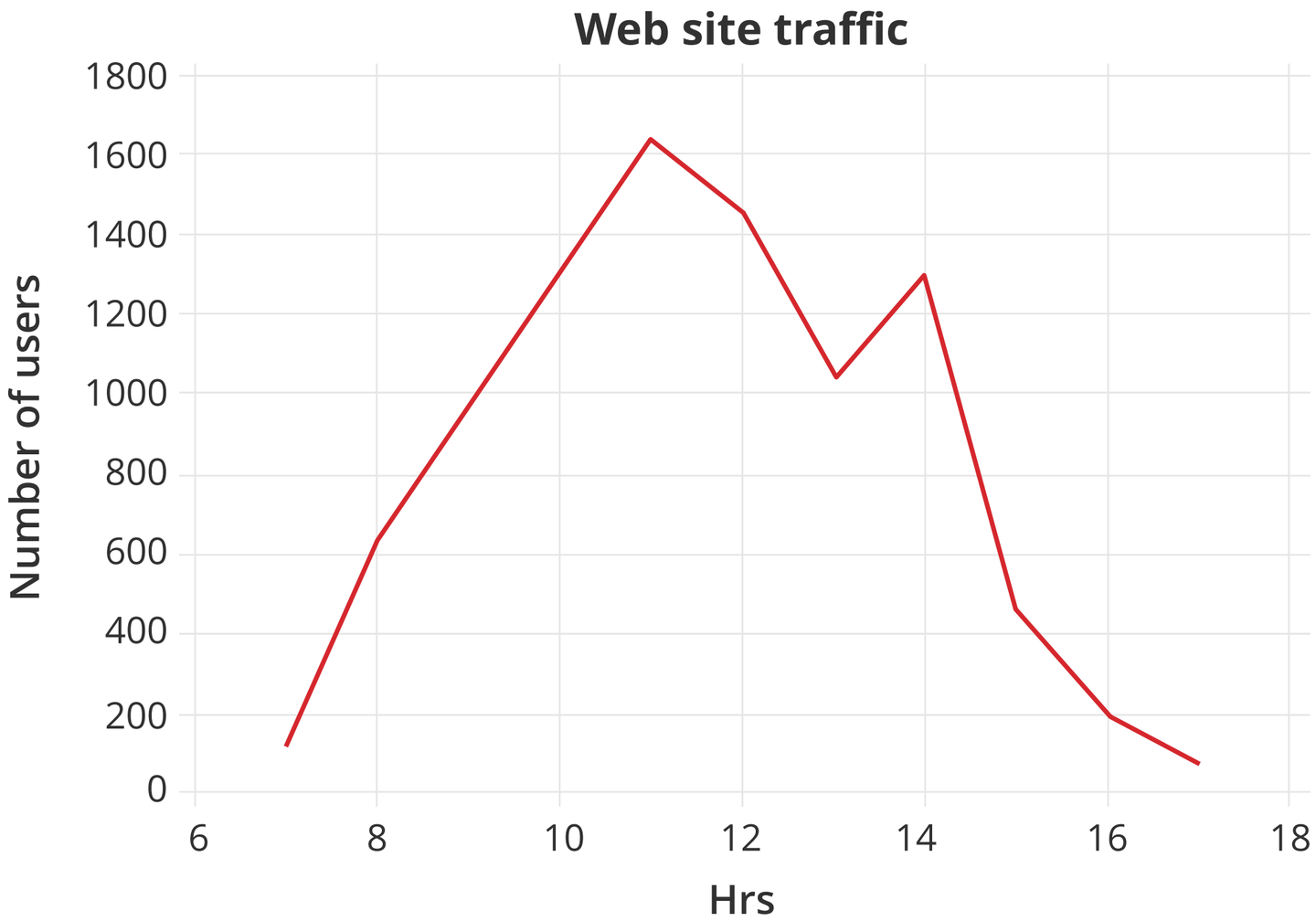
List of users

Time

In [3]:
```
#select the style of the plot
style.use('ggplot')
#plot the web site traffif data (X-axis hrs and Y axis as number of users)
plt.plot(time_hrs,web_customers)
#set the title of the plot
plt.title('Web site traffic')
#set label for x axis
plt.xlabel('Hrs')
#set label for y axis
plt.ylabel('Number of users')
plt.show()
```

Use %matplotlib inline to display or view the plot on Jupyter notebook.

Plot with (x,y)

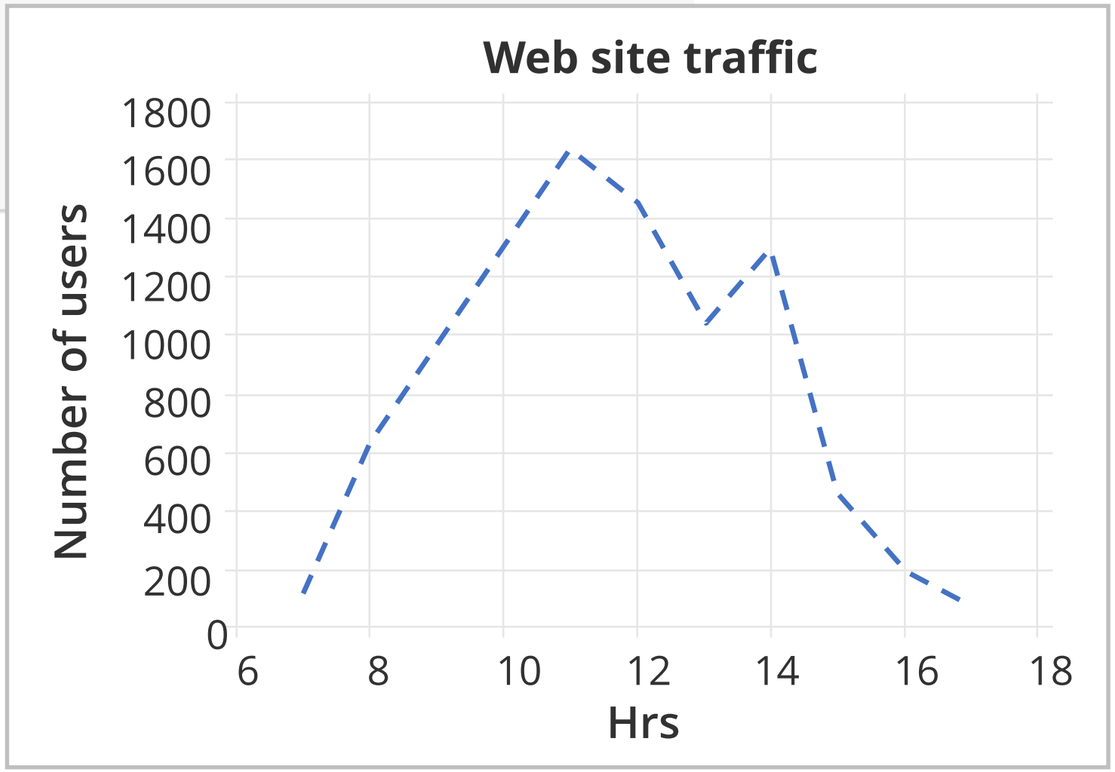


Controlling Line Patterns and Colors

```
#select the style of the plot
style.use('ggplot')
#plot the web stite traffic data (x axis hrs and y asis as number of users)
plt.plot(time_hrs,web_customers,color = 'b',linestyle = '--',linewidth=2.5)
#set the title of the plot
plt.title('Web site traffic')
#set the label for x axis
plt.xlabel('hrs')
#set the label for y axis
plt.ylabel('number of users')
plt.show()
```

Line Color (blue)

Dashed (--)



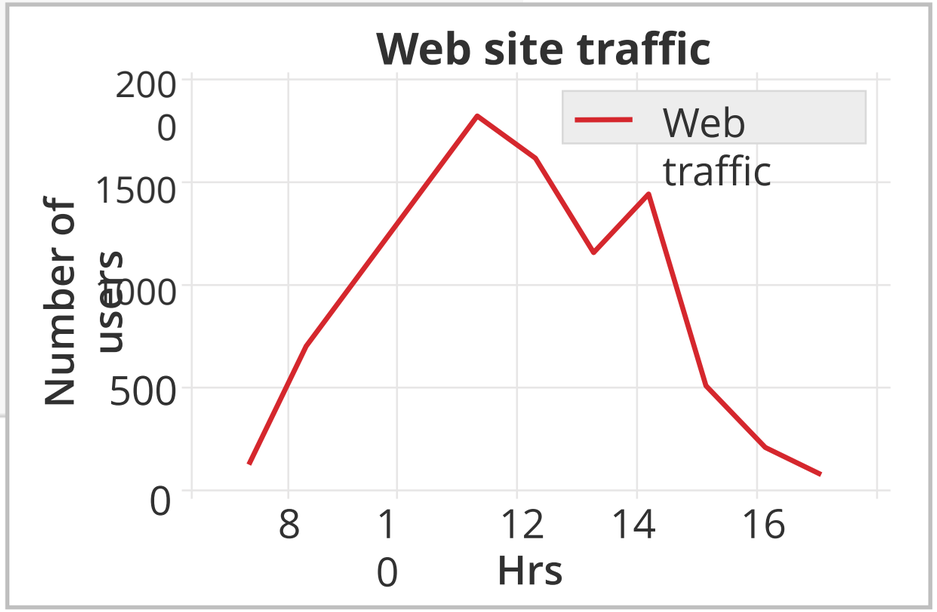
Set Axis, Labels, and Legend Property

Using matplotlib, it is also possible to set the desired axis to interpret the result.

Axis is used to define the range on the x axis and y axis.

```
:  #select the style of the plot
   style.use('ggplot')
   #plot the web site traffif data (X-axis hrs and Y axis as number of users)
   plt.plot(time_hrs,web_customers,'r',label='web traffic',linewidth=1.5)
   plt.axis([6.5,17.5,50,2000])
   #set the title of the plot
   plt.title('Web site traffic')
   #set label for x axis
   plt.xlabel('Hrs')
   #set label for y axis
   plt.ylabel('Number of users')
   plt.legend()
   plt.show()
```

Set the axis



Alpha and Annotation

Alpha is an attribute that controls the transparency of the line.
The lower the alpha value, the more transparent the line is.

```
#select the style of the plot
style.use('ggplot')
#plot the web stite traffic data (x axis hrs and y asis as number of users)
#also setting the alpha value for transparency
plt.plot(time_hrs,web_customers,alpha=.4)
#set the title of the plot
plt.title('Website Traffic')
#Annotate
plt.annotate('Max',ha='center',va='bottom',xytext=(8,1500),xy=(11,1630),arrowprops =
             { 'facecolor' : 'green'})
#set the label for x axis
plt.xlabel('hrs')
#set the label for y axis
plt.ylabel('number of users')

plt.show()
```

Alpha and Annotation

Annotate() method is used to annotate the graph. It has several attributes which help annotate the plot.

```
#select the style of the plot
style.use('ggplot')
#plot the web stite traffic data (x axis hrs and y asis as number of users)
#also setting the alpha value for transparency
plt.plot(time_hrs,web_customers,alpha=.4)
#set the title of the plot
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#Annotate
plt.annotate('Max',ha='center',va='bottom',xytext=(8,1500),xy=(11,1630),arrowprops =
             { 'facecolor' : 'green'})
#set the label for x axis
plt.xlabel('hrs')
#set the label for y axis
plt.ylabel('number of users')

plt.show()
```

"Max" denotes the annotation text,
"ha" indicates the horizontal alignment,
"va" indicates the vertical alignment,
"xytext" indicates the text position,
"xy" indicates the arrow position, and
"arrowprops" indicates the properties of the arrow.

Alpha and Annotation

Annotate() method is used to annotate the graph. It has several attributes which help annotate the plot.

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#select the style of the plot
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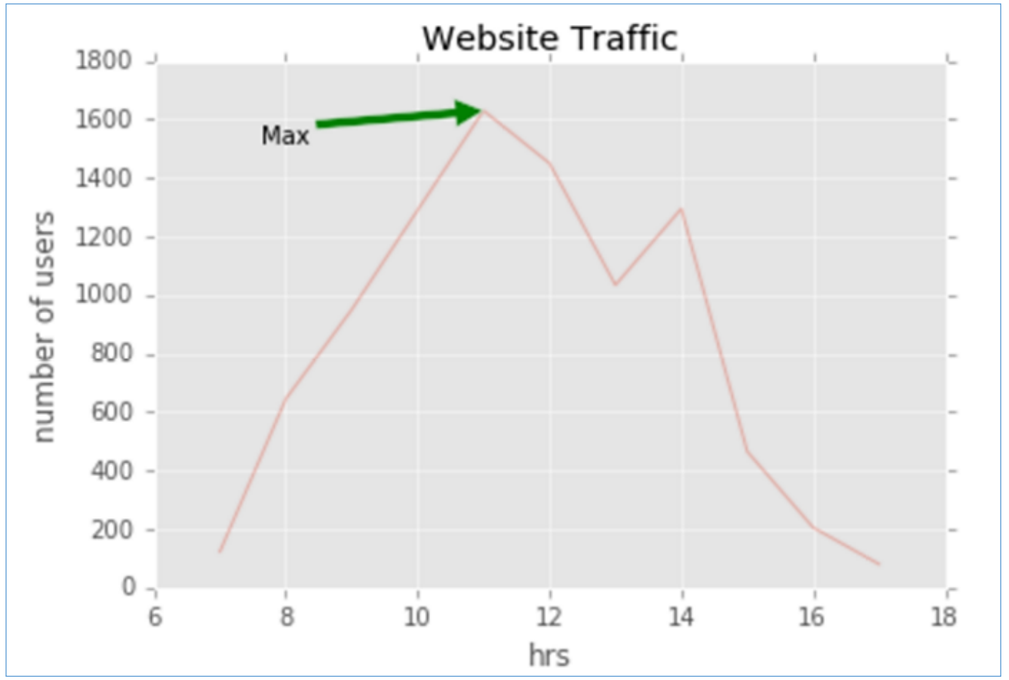
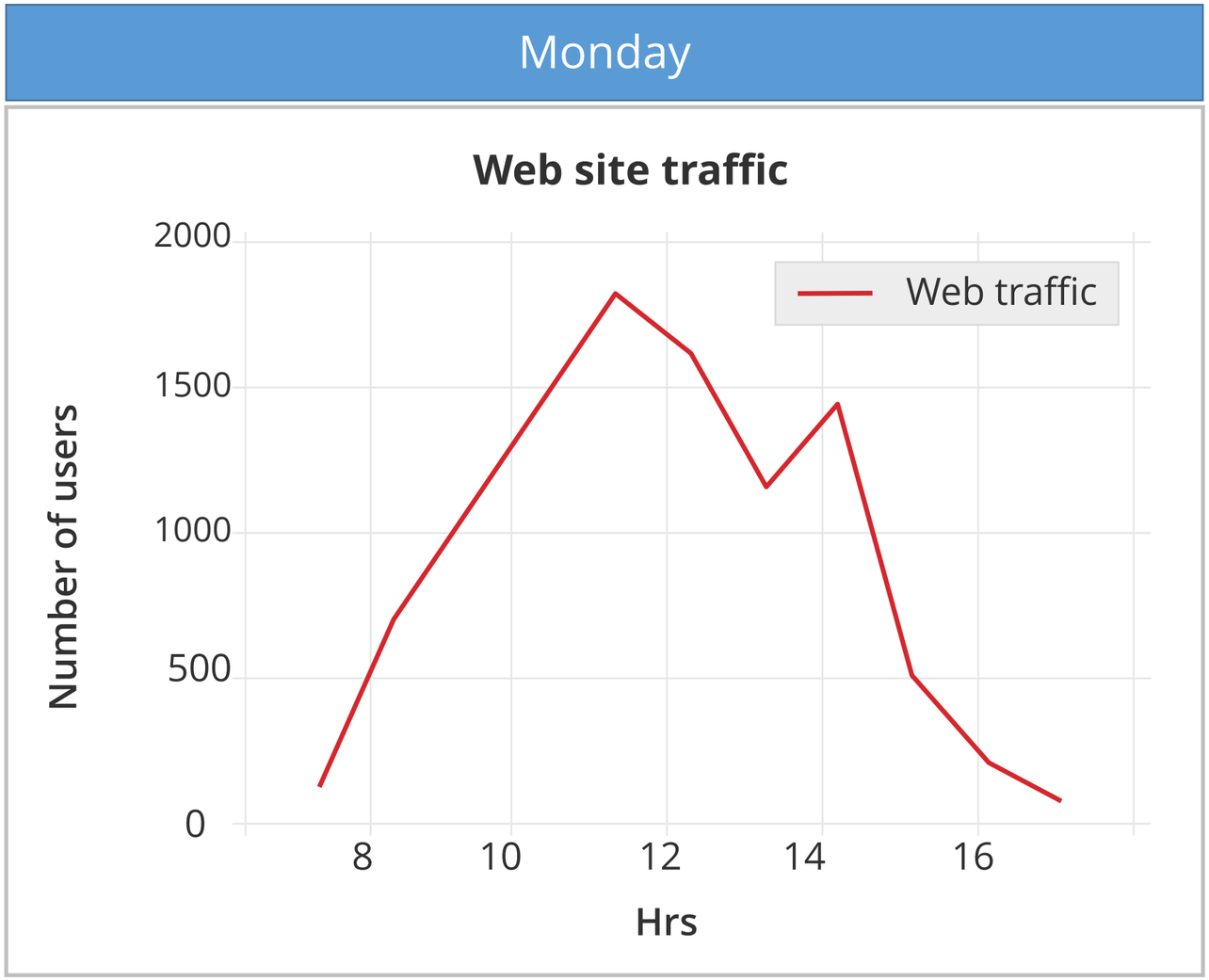
plt.show()
```



Multiple Plots



Multiple Plots

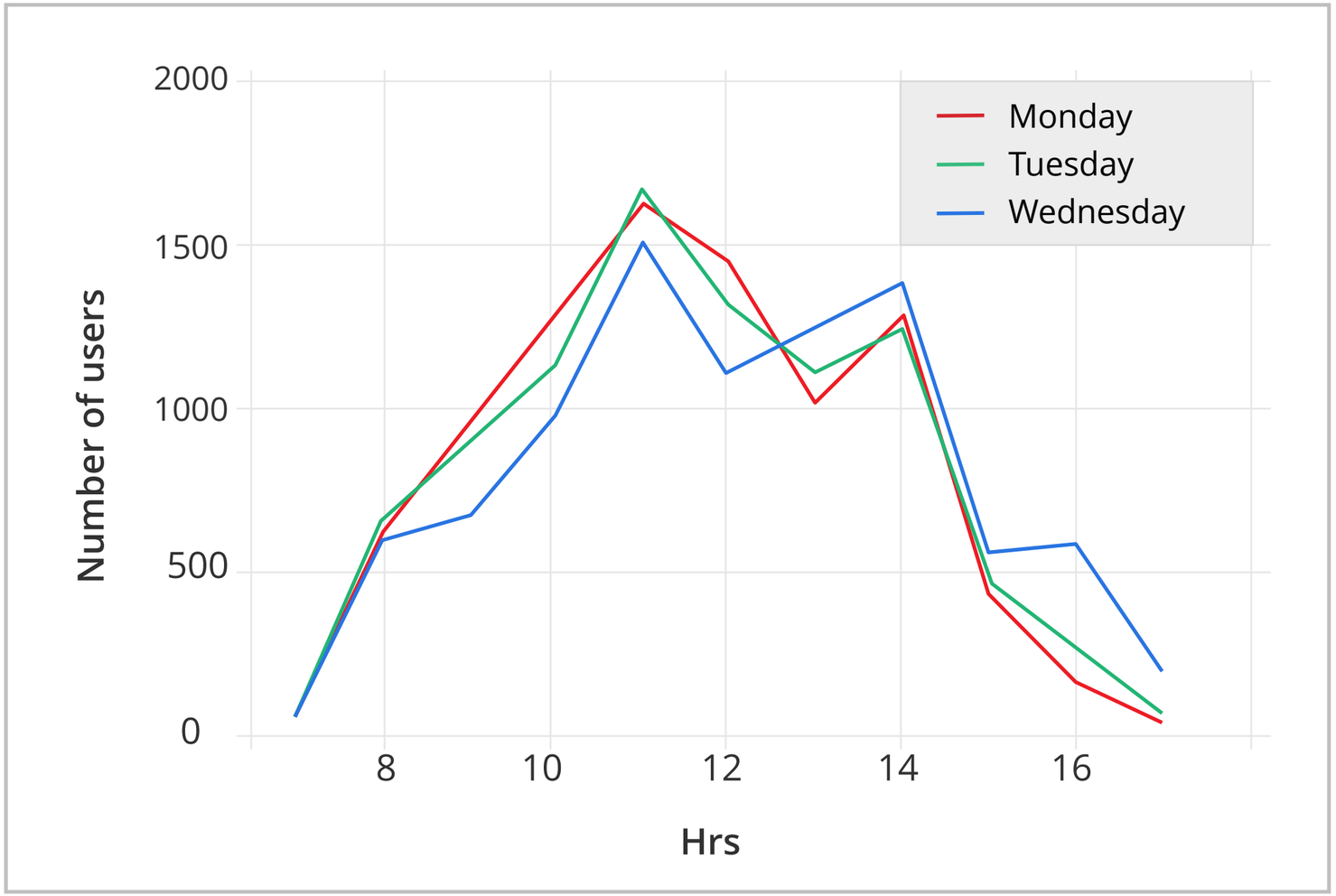
In [4]:
```
#website traffic data
#number of users/ visitors on the web site
#monday web traffic
web_monday = [123,645,950,1290,1630,1450,1034,1295,465,205,80]
#tuesday web traffic
web_tuesday= [95,680,889,1145,1670,1323,1119,1265,510,310,110]
#wednesday web traffic
web_wednesday= [105,630,700,1006,1520,1124,1239,1380,580,610,230]
#Time distribution (hourly)
time_hrs = [7,8,9,10,11,12,13,14,15,16,17]
```

Web traffic data

In [5]:
```
#select the style of the plot
style.use('ggplot')
#plot the web site traffic data (X-axis hrs and Y axis as number of users)
#plot the monday web traffic with red color
plt.plot(time_hrs,web_monday,'r',label='monday',linewidth=1)
#plot the monday web traffic with green color
plt.plot(time_hrs,web_tuesday,'g',label='tuesday',linewidth=1.5)
#plot the monday web traffic with blue color
plt.plot(time_hrs,web_wednesday,'b',label='wednesday',linewidth=2)
plt.axis([6.5,17.5,50,2000])
#set the title of the plot
plt.title('Web site traffic')
#set label for x axis
plt.xlabel('Hrs')
#set label for y axis
plt.ylabel('Number of users')
plt.legend()
plt.show()
```

Set different colors and line widths for different days

Multiple Plots



Subplots

Subplots are used to display multiple plots in the same window.

With subplot, you can arrange plots in a regular grid.

The syntax for subplot is

subplot(m,n,p). → It divides the current window into an m-by-n grid and creates an axis for a subplot in the position specified by p.

For example,

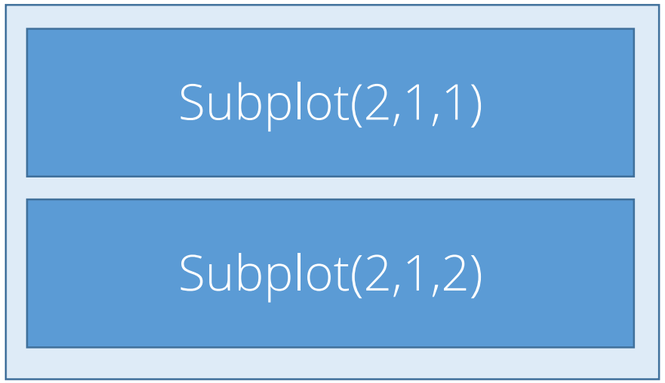
subplot(2,1,2) creates two subplots which are stacked vertically on a grid.
subplot(2,1,4) creates four subplots in one window.

Subplots (contd.)

Subplots are used to display multiple plots in the same window.

With subplots, you can arrange plots in a regular grid.

Grid divided into two vertically stacked plots



Grid divided into four plots

Layout

Layout and Spacing adjustments are two important factors to be considered while creating subplots.

Use the plt.subplots_adjust() method with the parameters hspace and wspace to adjust the distances between the subplots and move them around on the grid.

Knowledge Check

KNOWLEDGE CHECK

Which of the following methods is used to adjust the distances between the subplots?

a. plot.subplots_adjust()

b. plt.subplots_adjust()

c. subplots_adjust()

d. plt.subplots.adjust()

KNOWLEDGE CHECK

Which of the following methods is used to adjust the distances between the subplots?

a. plot.subplots_adjust()

b. plt.subplots_adjust()

c. subplots_adjust()

d. plt.subplots.adjust()

The correct answer is. b.

Explanation plt.subplots_adjust() used to adjust the distances between the subplots.

Types of Plots

You can create different types of plots using matplotlib:

Click each plot to know more.

- Histogram
- Scatter Plot
- Heat Map
- Pie Chart
- Error Bar

Types of Plots (contd.)

You can create different types of plots using matplotlib:

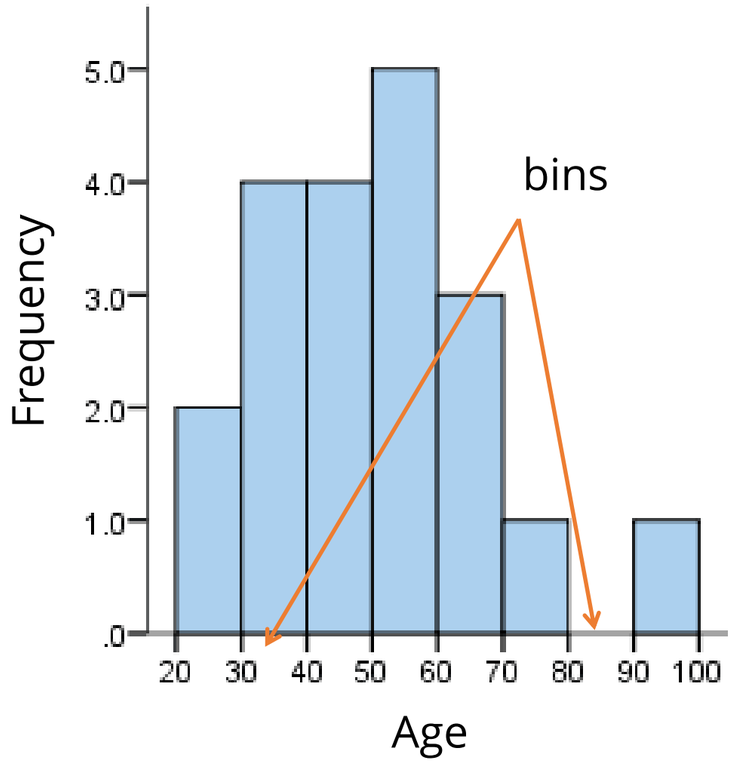
Click each plot to know more.

- Histogram
- Scatter Plot
- Heat Map
- Pie Chart
- Error Bar

Histograms are graphical representations of a probability distribution. A histogram is a kind of a bar chart.
Using matplotlib and its bar chart function, you can create histogram charts.

Advantages of Histogram charts:

- They display the number of values within a specified interval.
- They are suitable for large datasets as they can be grouped within the intervals.



Types of Plots (contd.)

You can create different types of plots using matplotlib:

Click each plot to know more.

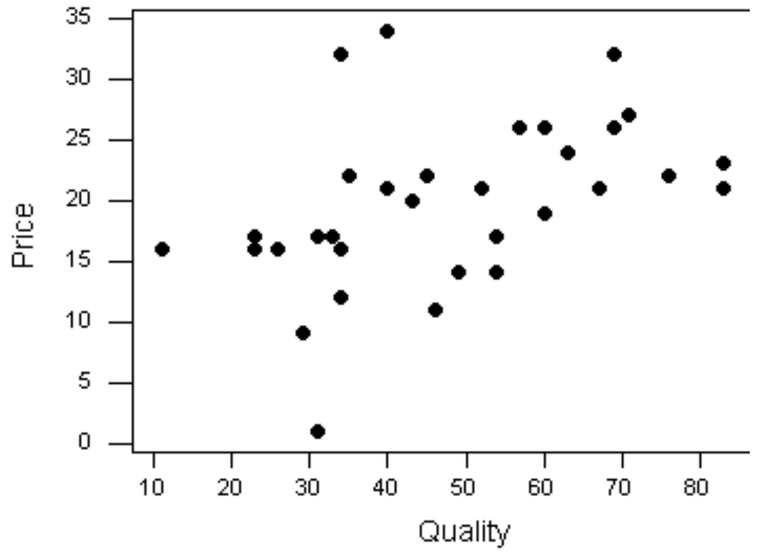
- Histogram
- Scatter Plot
- Heat Map
- Pie Chart
- Error Bar

A scatter plot is used to graphically display the relationships between variables.

However, to control a plot, it is recommended to use scatter() method.

It has several advantages:

- Shows the correlation between variables
- Is suitable for large datasets
- Is easy to find clusters
- Is possible to represent each piece of data as a point on the plot



Types of Plots (contd.)

You can create different types of plots using matplotlib:

Click each plot to know more.

- Histogram
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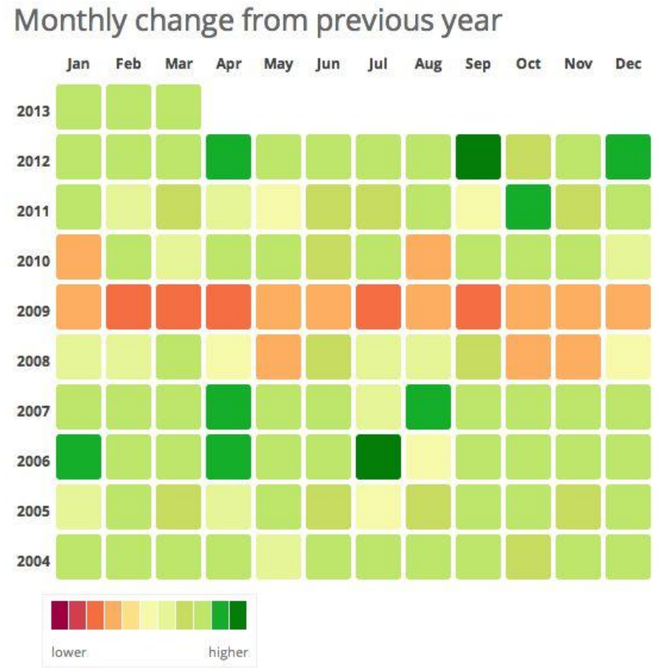
- Heat Map
- Pie Chart
- Error Bar

A heat map is a way to visualize two-dimensional data. Using heat maps, you can gain deeper and faster insights about data than other types of plots.

It has several advantages:

- Draws attention to the risk-prone area
- Uses the entire dataset to draw meaningful insights
- Is used for cluster analysis and can deal with large datasets



Types of Plots (contd.)

You can create different types of plots using matplotlib:

Click each plot to know more.

- Histogram
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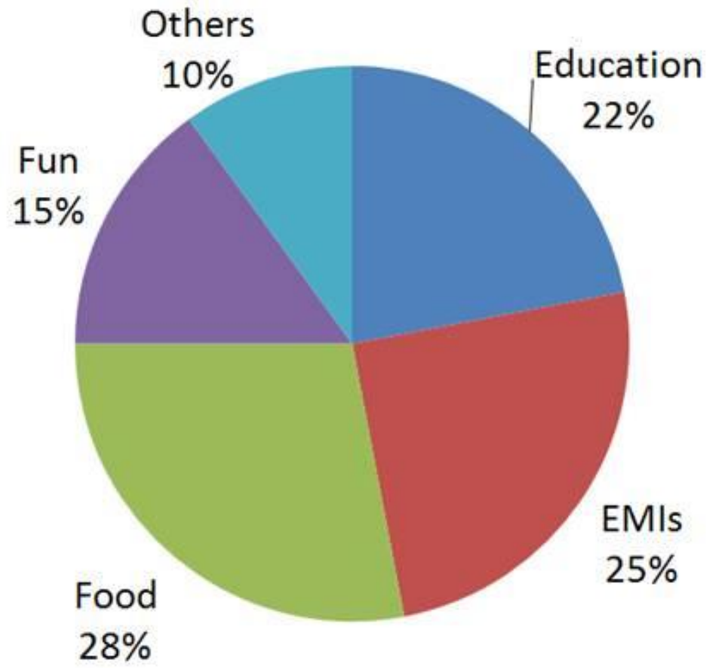
- Heat Map
- Pie Chart
- Error Bar

Pie charts are used to show percentage or proportional data. matplotlib provides the pie() method to create pie charts.

It has several advantages:

- Summarizes a large dataset in visual form
- Displays the relative proportions of multiple classes of data
- Size of the circle is made proportional to the total quantity



Types of Plots (contd.)

You can create different types of plots using matplotlib:

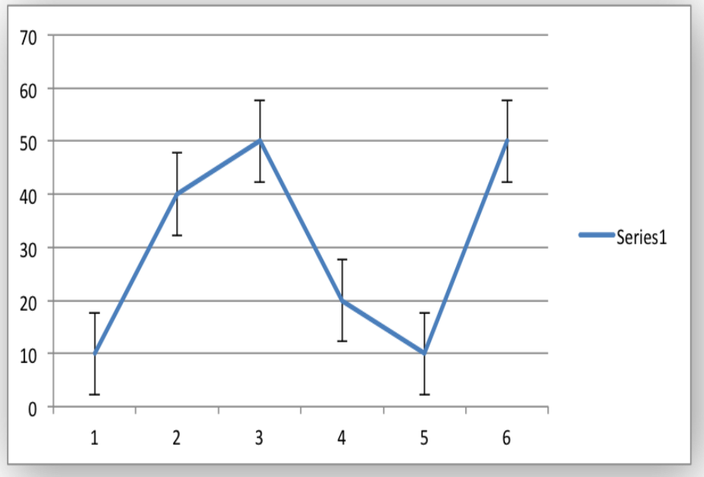
Click each plot to know more.

- Histogram
- Scatter Plot
- Heat Map
- Pie Chart
- Error Bar

An error bar is used to graphically represent the variability of data. It is used mainly to identify errors. It builds confidence about the data analysis by revealing the statistical difference between the two groups of data.

It has several advantages:

- Shows the variability in data and indicates the errors.
- Depicts the precision in the data analysis.
- Demonstrates how well a function and model are used in the data analysis.
- Describes the underlying data.

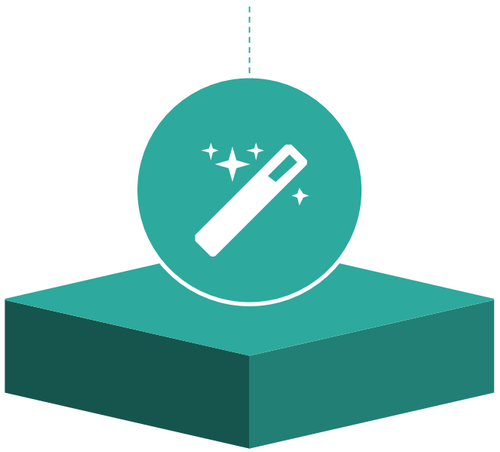


Seaborn

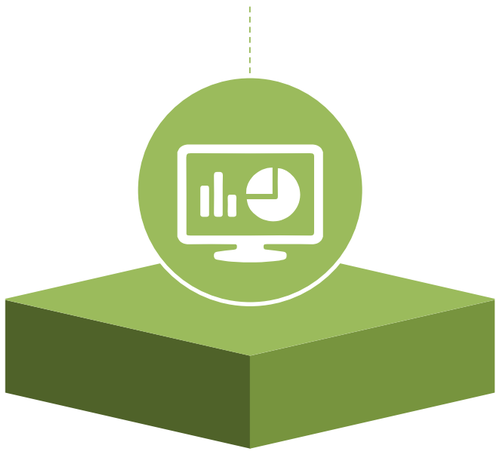
Seaborn is a Python visualization library based on matplotlib. It provides a high-level interface to draw attractive statistical graphics.

There are several advantages:

Possesses built-in themes for better visualizations



Has built-in statistical functions which reveal hidden patterns in the dataset



Has functions to visualize matrices of data

Assignment

Assignment 01

Problem | Instructions

Analyze the “auto mpg data” and draw a pair plot using seaborn library for mpg, weight, and origin.

Sources:

(a) Origin: This dataset was taken from the StatLib library maintained at Carnegie Mellon University.

- Number of Instances: 398
- Number of Attributes: 9 including the class attribute
- Attribute Information:
  - mpg: continuous
  - cylinders: multi-valued discrete
  - displacement: continuous
  - horsepower: continuous

Assignment 01

Problem | Instructions

- weight: continuous
- acceleration: continuous
- model year: multi-valued discrete
- origin: multi-valued discrete
- car name: string (unique for each instance)

Assignment

Assignment 02

Problem | Instructions

You have been provided with a dataset that lists Ohio State's leading causes of death from the year 2012.

Using the two data points:

- Cause of deaths and
- Percentile

Draw a pie chart to visualize the dataset.

Assignment 02

Problem | Instructions

Instructions to perform the assignment:

- Download the dataset “Ohio_State_data”. Use the data provided to create relevant and required variables.

Common instructions:

- If you are new to Python, download the “Anaconda Installation Instructions” document from the “Resources” tab to view the steps for installing Anaconda and the Jupyter notebook.
- Download the “Assignment 02” notebook and upload it on the Jupyter notebook to access it.
- Follow the provided cues to complete the assignment.

Quiz

QUIZ

1

Which of the following libraries needs to be imported to display the plot on Jupyter notebook?

a. %matplotlib

b. %matplotlib inline

c. import matplotlib

d. import style

QUIZ 1

Which of the following libraries needs to be imported to display the plot on Jupyter notebook?

a. %matplotlib

b. %matplotlib inline

c. import matplotlib

d. import style

The correct answer is **b** .

Explanation: To display the plot on Jupyter notebook “import‘%matplotlib inline.”

QUIZ 2

Which of the following keywords is used to decide the transparency of the plot line?

a. Legend

b. Alpha

c. Animated

d. Annotation

QUIZ 2

Which of the following keywords is used to decide the transparency of the plot line?

a. Legend

b. Alpha

c. Animated

d. Annotation

The correct answer is **c**.

Explanation: Alpha decides the line transparency in line properties while plotting line plot/ chart.

QUIZ 3

Which of the following plots is used to represent data in a two-dimensional manner?

a. Histogram

b. Heat Map

c. Pie Chart

d. Scatter Plot

QUIZ 3

Which of the following plots is used to represent data in a two-dimensional manner?

a. Histogram

b. Heat Map

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d. Scatter Plot

The correct answer is **b** .

Explanation: Heat Maps are used to represent data in a two-dimensional manner.

QUIZ

4

Which of the following statements limits both x and y axes to the interval [0, 6]?

a. plt.xlim(0, 6)

b. plt.ylim(0, 6)

c. plt.xylim(0, 6)

d. plt.axis([0, 6, 0, 6])

QUIZ

4

Which of the following statements limits both x and y axes to the interval [0, 6]?

a. plt.xlim(0, 6)

b. plt.ylim(0, 6)

c. plt.xylim(0, 6)

d. plt.axis([0, 6, 0, 6])

The correct answer is **d**.

Explanation: plt.axis([0, 6, 0, 6]) statement limits both x and y axes to the interval [0, 6].

Key Takeaways

- Data visualization is the technique to present the data in a pictorial or graphical format.
- There are three major considerations for data visualization. They are clarity, accuracy, and efficiency.
- The matplotlib is a python 2D plotting library for data visualization and the creation of interactive graphics/ plots.
- A plot is a graphical representation of data which shows the relationship between two variables or the distribution of data.
- Subplots are used to display multiple plots in the same window.
- Seaborn is a Python visualization library based on matplotlib. It provides a high-level interface to draw attractive statistical graphics.

This concludes “Data Visualization in Python using matplotlib”

The next lesson is “Web Scraping with BeautifulSoup.”