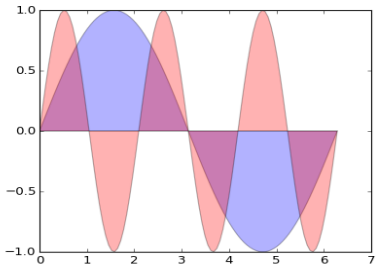
Data Visualization

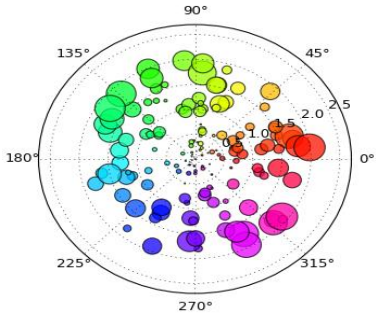
using

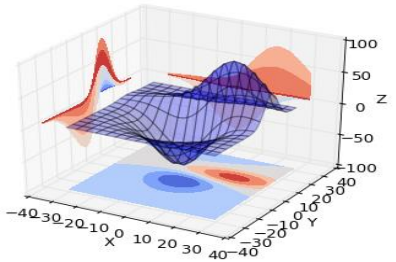
matplotlib and pyplot

What is data visualization?

- Data visualization is the graphical representation of information and data.
  - Can be achieved using visual elements like figures, charts, graphs, maps, and more.
- Data visualization tools provide a way to present these figures and graphs.
- Often, it is essential to analyze massive amounts of information and make data-driven decisions.
  - converting complex data into an easy to understand representation.







Matplotlib

- **Matplotlib** is one of the most powerful tools for data visualization in Python.
- **Matplotlib** is an incredibly powerful (and beautiful!) 2-D plotting library.
  - It is easy to use and provides a huge number of examples for tackling unique problems
- In order to get **`matplotlib`** into your script,
  - first you need to import it, for example:

```
import matplotlib.pyplot as plt
```

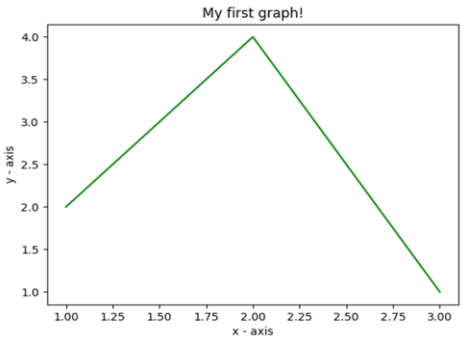
- However, if it is not installed, you may need to install it:
  - Easiest way to install **matplotlib** is using **`pip`**.
  - Type the following command in the command prompt (cmd) or your Linux shell;
    - **`pip install matplotlib`**
    - *Note that you may need to run the above cmd as an administrator*

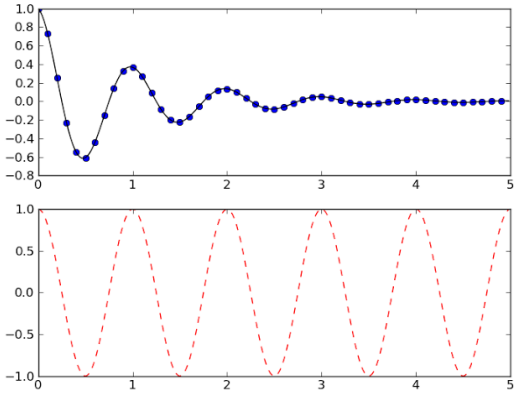
matplotlib

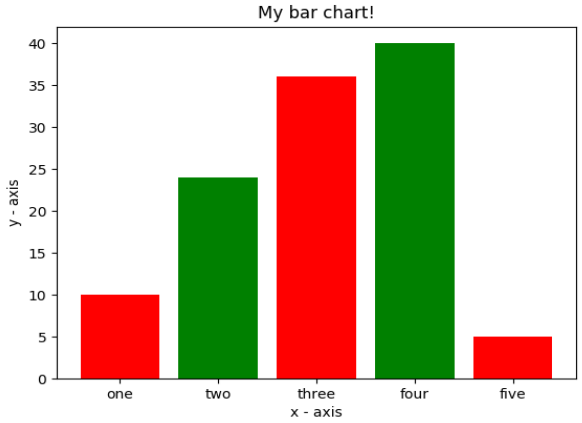
- Strives to emulate MATLAB
  - **`matplotlib.pyplot`** is a collection of command style functions that make **`matplotlib`** work like **MATLAB**.
- Each **`pyplot`** function makes some change to the figure:
  - e.g.,
    - creates a figure,
    - creates a plotting area in the figure,
    - plots some lines in the plotting area,
    - decorates the plot with labels, etc.
- **Note** that **<u>various states</u>** are preserved **<u>across function calls</u>**
- Whenever you plot with **`matplotlib`**, the two main code lines should be considered:
  - Type of graph
    - this is where you define a bar chart, line chart, etc.
  - Show the graph
    - this is to display the graph

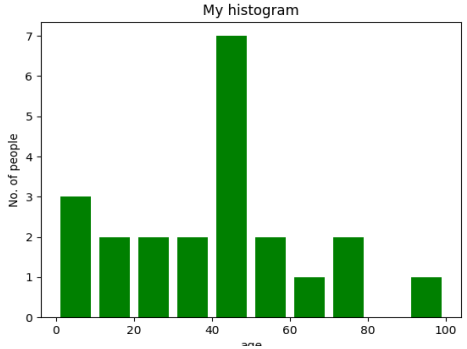
E.g. Matplotlib

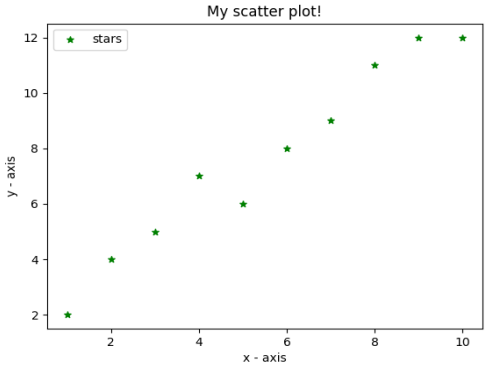
- `Matplotlib` allows you to make easy things
- You can generate **plots**, **histograms**, **power spectra**, **bar charts**, **errorcharts**, **scatterplots**, etc., with just a few lines of code.

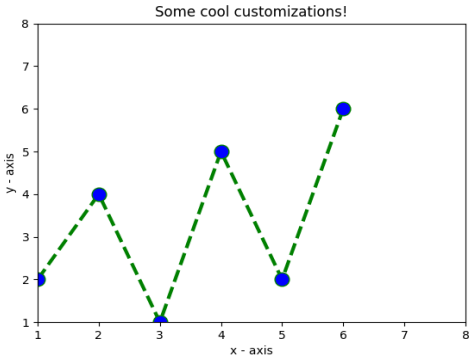


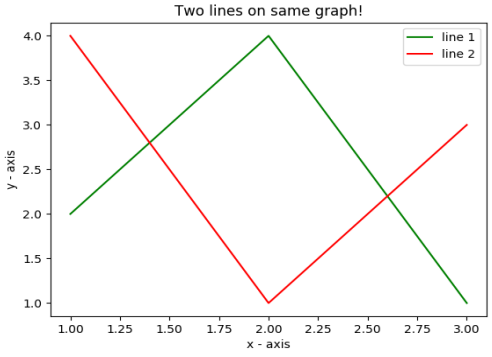






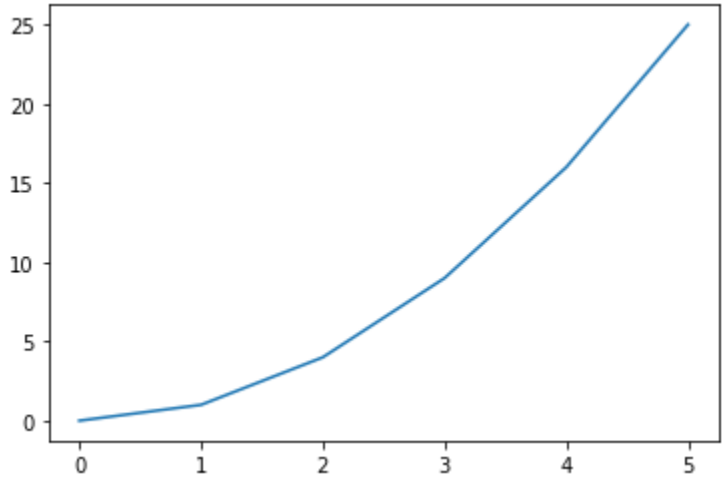






Line Graphs

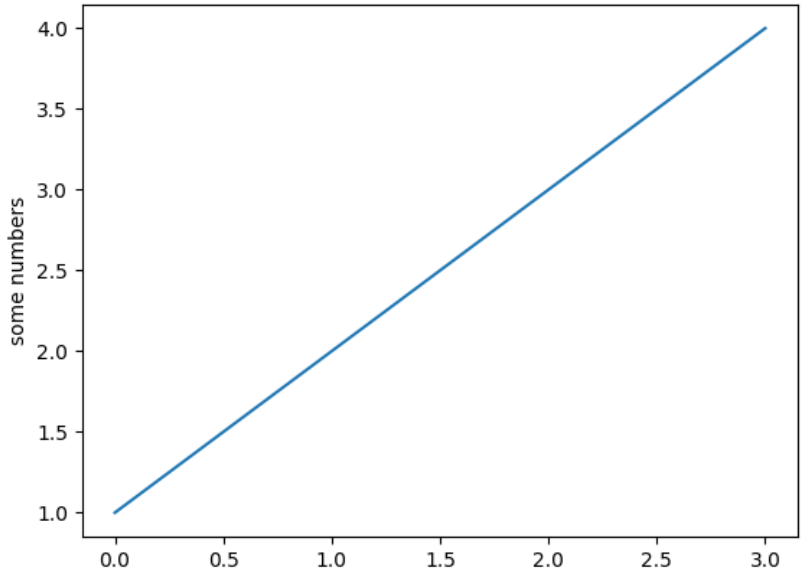
```
import matplotlib.pyplot as plt

#create data for plotting
x_values = [0, 1, 2, 3, 4, 5 ]
y_values = [0, 1, 4, 9, 16,25]

#the default graph style for plot is a line
plt.plot(x_values, y_values)

#display the graph
plt.show()
```



More on Line Graph

- Note: if you provide a single list or array to the `plot()` command,
  - then `matplotlib` assumes it is a sequence of `y values`, and
  - automatically generates the `x values` for you.
- Since python ranges start with `0`, the default `x` vector has the same length as `y` but starts with `0`.
  - Hence the `x` data are `[0, 1, 2, 3]`.

```
import matplotlib.pyplot as plt
plt.plot([1, 2, 3, 4])
plt.ylabel('some numbers')
plt.show()
```

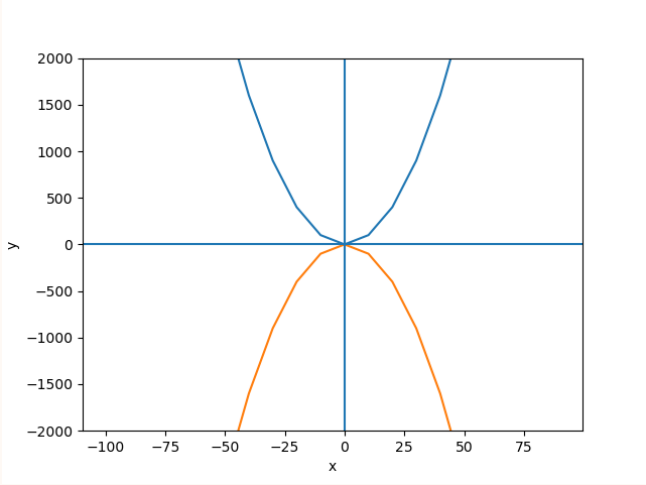


pyplot

- `text()` : adds text in an arbitrary location
- `xlabel()` : adds text to the x-axis
- `ylabel()` : adds text to the y-axis
- `title()` : adds title to the plot
- `clear()` : removes all plots from the axes.
- `savefig()` : saves your figure to a file
- `legend()` : shows a legend on the plot

All methods are available on `pyplot` and on the axes instance generally.

```
import matplotlib.pyplot as plt
y1 =[]
y2 =[]
x = range(-100,100,10)
for i in x: y1.append(i**2)
for i in x: y2.append(-i**2)

plt.plot(x, y1)
plt.plot(x, y2)
plt.xlabel("x")
plt.ylabel("y")
plt.ylim(-2000, 2000)
plt.axhline(0) # horizontal line
plt.axvline(0) # vertical line

plt.savefig("quad.png")
plt.show()
```



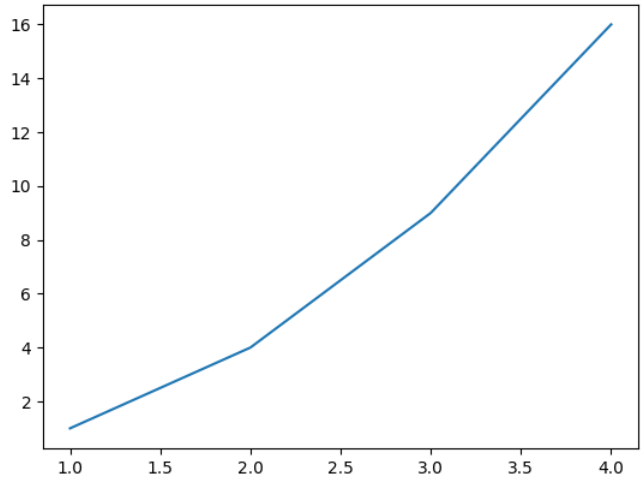
Incrementally modify the figure.

Save your figure to a file

Show it on the screen

Plot

```
import matplotlib.pyplot as plt

x = [1, 2, 3, 4]
y = [1, 4, 9, 16]

plt.plot(x, y)
```

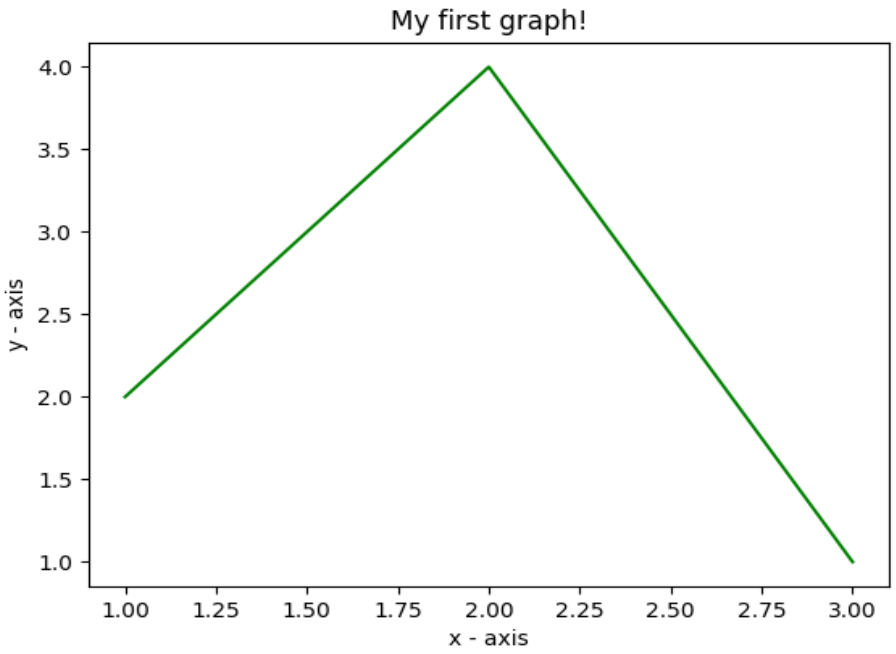


no return value?

- We are operating on a “hidden” variable representing the figure.
- This is a terrible, terrible trick.
- Its only purpose is to pander to MATLAB users.
- I’ll show you how this works in the next lecture

Simple line

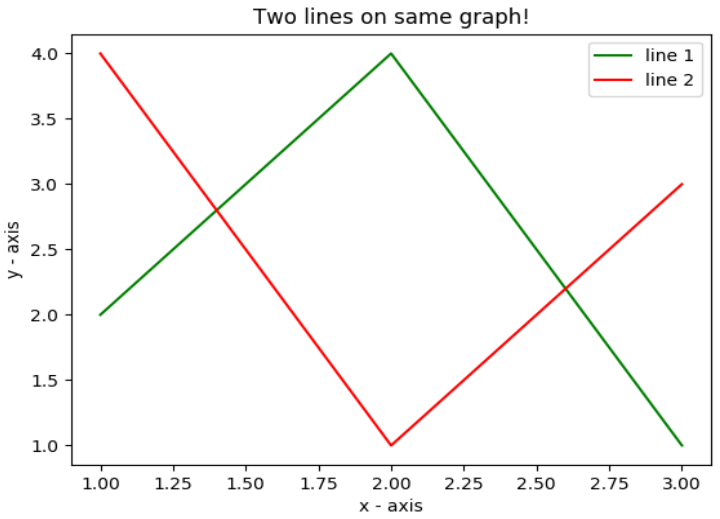
```
# importing the required module
import matplotlib.pyplot as plt

# x axis values
x = [1,2,3]
# corresponding y axis values
y = [2,4,1]

# plotting the points
plt.plot(x, y)

# naming the x axis
plt.xlabel('x - axis')
# naming the y axis
plt.ylabel('y - axis')

# giving a title to my graph
plt.title('My first graph!')

# function to show the plot
plt.show()
```



- Define the **`x-axis`** and corresponding **`y-axis`** values as lists.
- Plot them on canvas using **`.plot()`** function.
- Give a name to x-axis and y-axis using **`.xlabel()`** and **`.ylabel()`** functions.
- Give a title to your plot using **`.title()`** function.
- Finally, to view your plot, we use **`.show()`** function.

Simple 2 lines

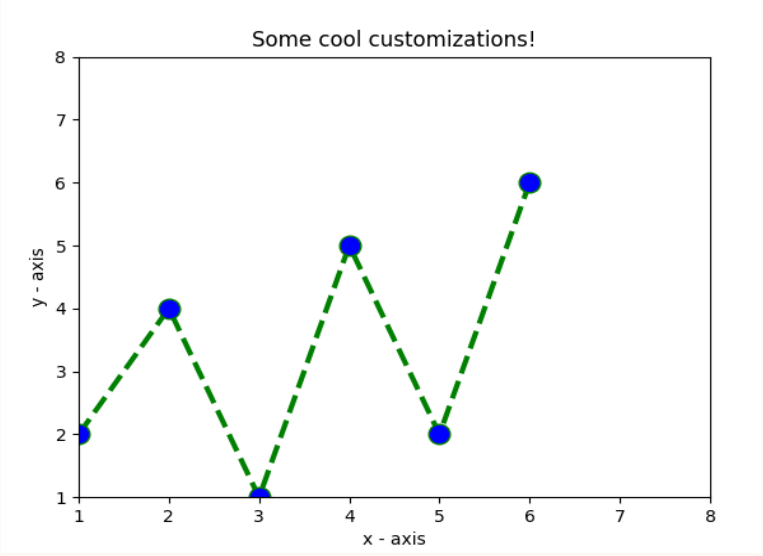
```
import matplotlib.pyplot as plt

# line 1 points
x1 = [1,2,3]
y1 = [2,4,1]
# plotting the line 1 points
plt.plot(x1, y1, label="line 1")

# line 2 points
x2 = [1,2,3]
y2 = [4,1,3]
# plotting the line 2 points
plt.plot(x2, y2, label = "line 2")

# naming the x axis
plt.xlabel('x - axis')
# naming the y axis
plt.ylabel('y - axis')
# giving a title to my graph
plt.title('Two lines on same graph!')

# show a legend on the plot
plt.legend()

# function to show the plot
plt.show()
```



- Here, we plot two lines on same graph. We differentiate between them by giving them a name(label) which is passed as an argument of `.plot()` function.
- The small rectangular box giving information about type of line and its color is called legend. We can add a legend to our plot using `.legend()` function.

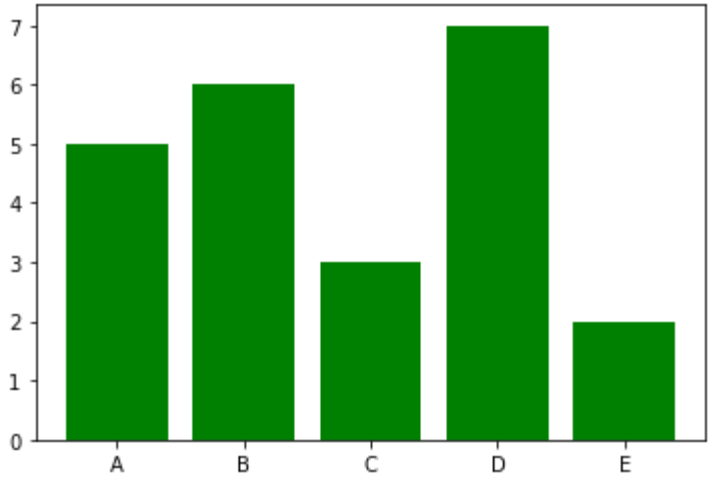
Customization of Plots

```
import matplotlib.pyplot as plt

# x axis values
x = [1,2,3,4,5,6]
# corresponding y axis values
y = [2,4,1,5,2,6]

# plotting the points
plt.plot(x, y, color='green', linestyle='dashed', linewidth = 3,
         marker='o', markerfacecolor='blue', markersize=12)

# setting x and y axis range
plt.ylim(1,8)
plt.xlim(1,8)

# naming the x axis
plt.xlabel('x - axis')
# naming the y axis
plt.ylabel('y - axis')

# giving a title to my graph
plt.title('Some cool customizations!')

# function to show the plot
plt.show()
```



Bar graphs

```
import matplotlib.pyplot as plt

#Create data for plotting
values = [5, 6, 3, 7, 2]
names  = ["A", "B", "C", "D", "E"]

plt.bar(names, values, color="green")
plt.show()
```

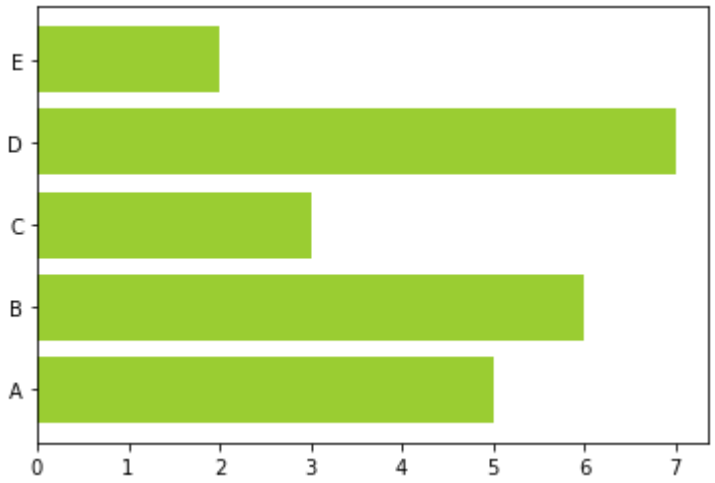


- When using a bar graph, the change in code will be from `plt.plot()` to `plt.bar()` changes it into a bar chart.

Bar graphs

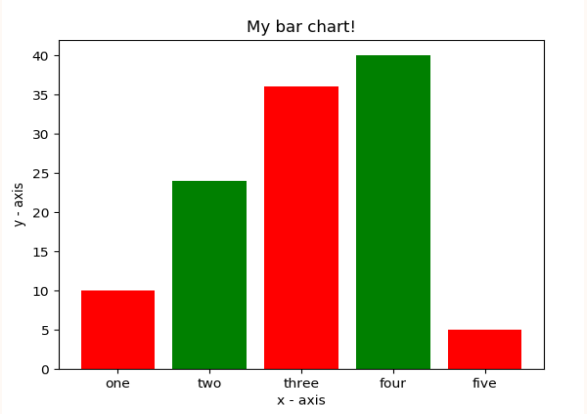
We can also flip the bar graph horizontally with the following

```
import matplotlib.pyplot as plt

#Create data for plotting
values = [5,6,3,7,2]
names  = ["A", "B", "C", "D", "E"]

# Adding an "h" after bar will flip the graph
plt.barh(names, values, color="yellowgreen")
plt.show()
```



Bar Chart

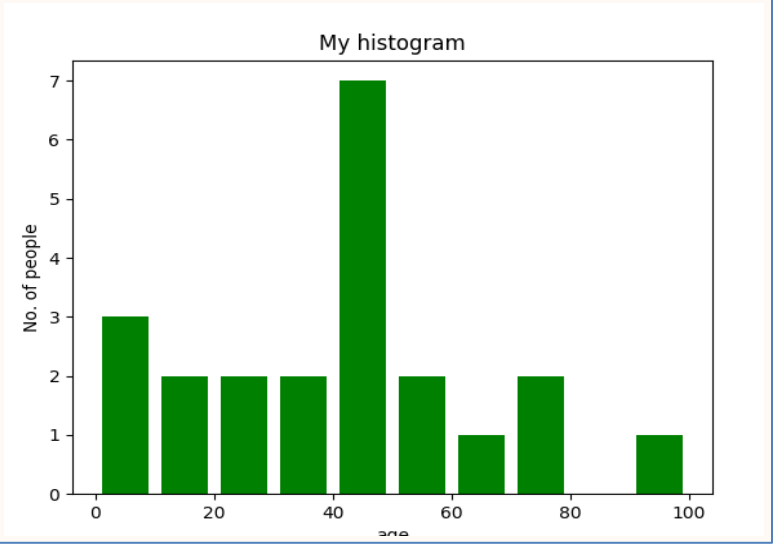
```
import matplotlib.pyplot as plt

# heights of bars
height = [10, 24, 36, 40, 5]

# labels for bars
names = ['one','two','three','four','five']

# plotting a bar chart
c1 =['red', 'green']
c2 =['b', 'g'] # we can use this for color
plt.bar(left, height, width=0.8, color=c1)

# naming the x-axis
plt.xlabel('x - axis')
# naming the y-axis
plt.ylabel('y - axis')
# plot title
plt.title('My bar chart!')

# function to show the plot
plt.show()
```



- Here, we use `plt.bar()` function to plot a bar chart.
- you can also give some name to x-axis coordinates by defining tick_labels

Histogram

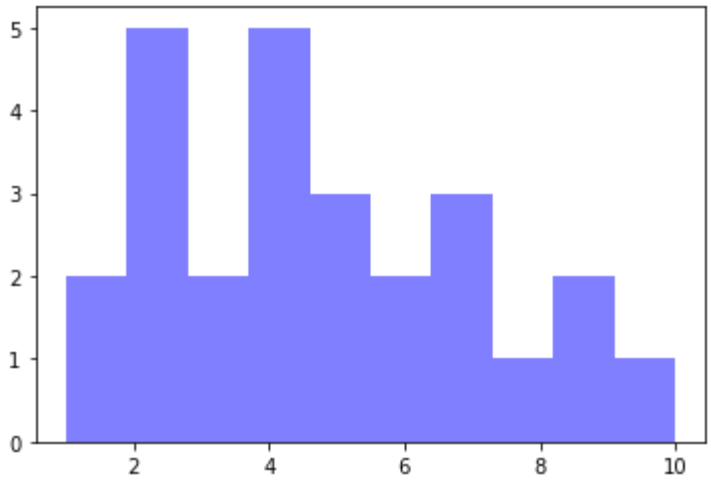
```
import matplotlib.pyplot as plt

# frequencies
ages=[2,5,70,40,30,45,50,45,43,40,44,60,7,13,57,18,90,77,32,21,20,40]

# setting the ranges and no. of intervals
range = (0, 100)
bins = 10

# plotting a histogram
plt.hist(ages, bins, range, color='green',histtype='bar',rwidth=0.8)

# x-axis label
plt.xlabel('age')
# frequency label
plt.ylabel('No. of people')
# plot title
plt.title('My histogram')

# function to show the plot
plt.show()
```



Histograms

```
import matplotlib.pyplot as plt

#generate fake data
x = [2,1,6,4,2,4,8,9,4,2,4,10,6,4,5,7,7,3,2,7,5,3,5,9,2,1]

#plot for a histogram
plt.hist(x, bins = 10, color='blue', alpha=0.5)
plt.show()
```

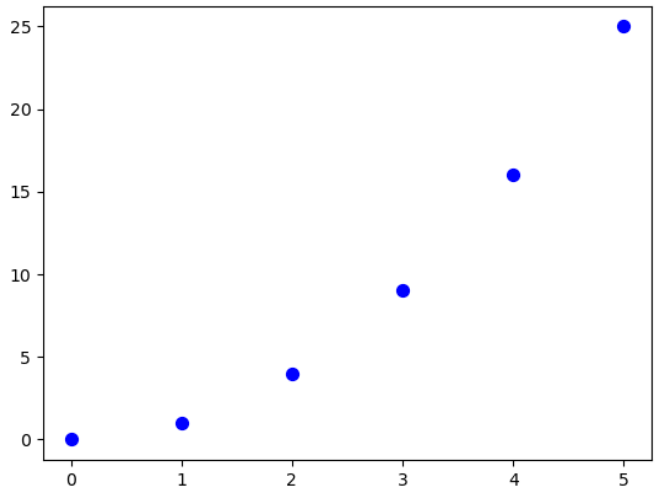
- Looking at the code snippet, I added two new arguments:
  - **Bins** — is an argument specific to a histogram and allows the user to customize how many bins they want.
  - **Alpha** — is an argument that displays the level of transparency of the data points.



Scatter Plots

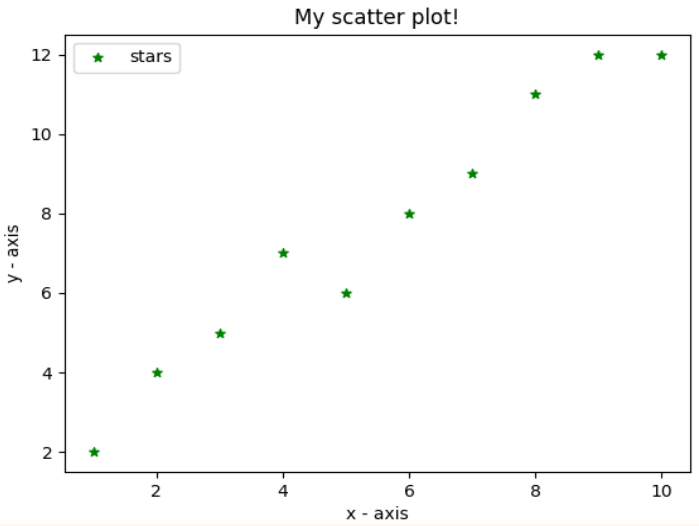
```
import matplotlib.pyplot as plt

#create data for plotting

x_values = [0,1,2,3,4,5]
y_values = [0,1,4,9,16,25]

plt.scatter(x_values, y_values, s=30, color="blue")
plt.show()
```

- Can you see the pattern? Now the code changed from `plt.bar()` to `plt.scatter()`.



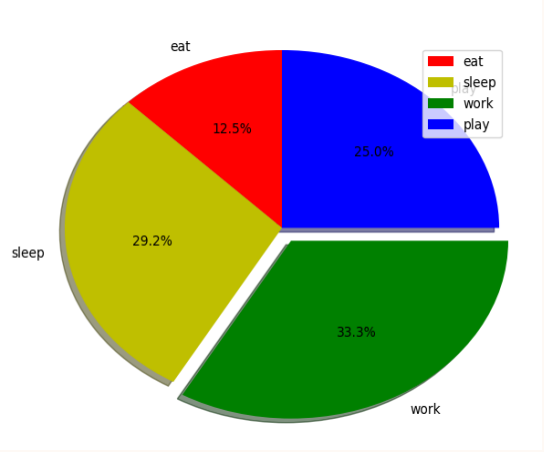
Scatter plot

```
import matplotlib.pyplot as plt

# x-axis values
x = [1,2,3,4,5,6,7,8,9,10]
# y-axis values
y = [2,4,5,7,6,8,9,11,12,12]

# plotting points as a scatter plot
plt.scatter(x, y, label= "stars", color="green", marker="*", s=30)

# x-axis label
plt.xlabel('x - axis')
# frequency label
plt.ylabel('y - axis')
# plot title
plt.title('My scatter plot!')
# showing legend
plt.legend()

# function to show the plot
plt.show()
```



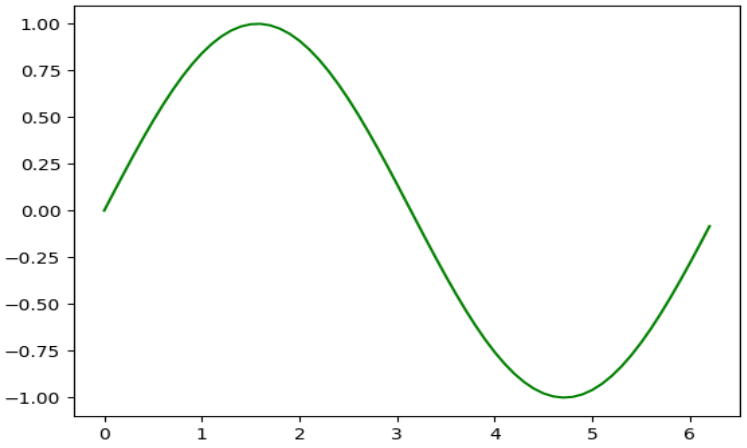
Pie-chart

```
import matplotlib.pyplot as plt

# defining labels
activities = ['eat', 'sleep', 'work', 'play']

# portion covered by each label
slices = [3, 7, 8, 6]

# color for each label
colors = ['r', 'y', 'g', 'b']

# plotting the pie chart
plt.pie(slices, labels = activities, colors=colors,
        startangle=90, shadow = True, explode = (0, 0, 0.1, 0),
        radius = 1.2, autopct = '%1.1f%%')

# plotting legend
plt.legend()

# showing the plot
plt.show()
```



Plotting curves of given equation

```
# importing the required modules
import matplotlib.pyplot as plt
import numpy as np

# setting the x - coordinates
x = np.arange(0, 2*(np.pi), 0.1)
# setting the corresponding y - coordinates
y = np.sin(x)

# potting the points
plt.plot(x, y)

# function to show the plot
plt.show()
```

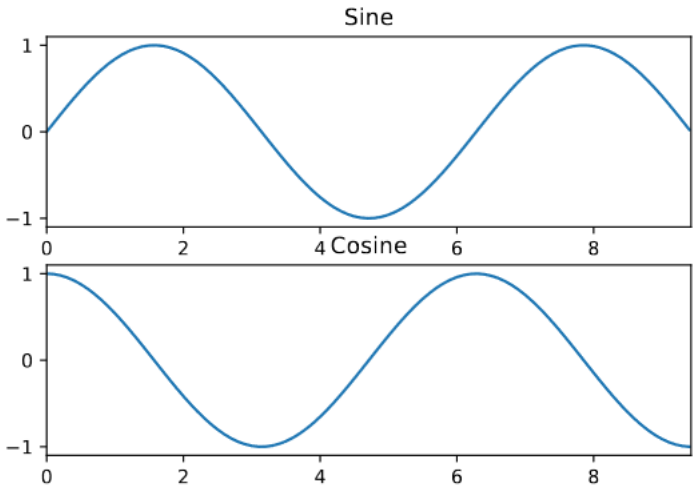


Examples taken from:
Graph Plotting in Python | Set 1

Subplot

- Different plots in the same figure using the `subplots` function

```
x = np.arange(0, 3 * np.pi, 0.1)
y_sin = np.sin(x)

fig, axes = plt.subplots(nbrows=2)
axes[0].plot(x, y_sin)
axes[0].set_xlim(0, 3 * np.pi)
axes[0].set_title('Sine')
fig.show()
```



Images

- Adding an image to the plot

```
import numpy as np
import imageio
import matplotlib.pyplot as plt

img = imageio.imread('assets/cat.jpg')
img_tinted = img * [1, 0.95, 0.9]

# Show the original image
fig, axes = plt.subplots(nbcols=2)
axes[0].imshow(img)

# Show the tinted image

# A slight gotcha with imshow is that it might give strange results
# if presented with data that is not uint8. To work around this, we
# explicitly cast the image to uint8 before displaying it.
axes[1].imshow(np.uint8(img_tinted))

fig.show()
```

Summary

- We just scratched the surface of the power of matplotlib.
- You can read more and find how you can create more colorful, detailed, and vibrant graphs.
- There are a lot more graphs available in the matplotlib library as well as other popular libraries available in python, including:
  - seaborn
    - https://seaborn.pydata.org/
  - pandas plot (pandas.DataFrame.plot)
    - https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.plot.html
  - plotly (Plotly Python Open Source Graphing Library)
    - https://plotly.com/python/