

MA 506 Probability and Statistical Inference

Lecture 3: Plotting in python through matplotlib

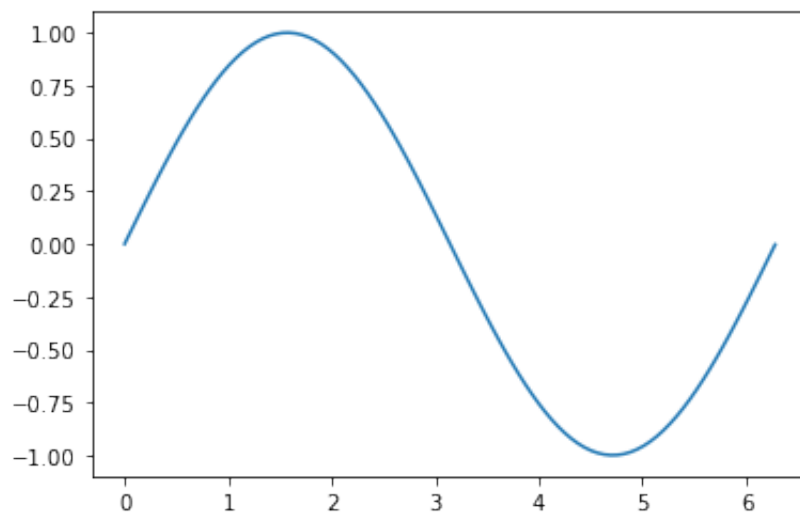
```
In [1]: import numpy as np  
from matplotlib.pyplot import *
```

1 Basics

1.1 Generating data for Sin(x) and Cos(x) and begin plotting ¶

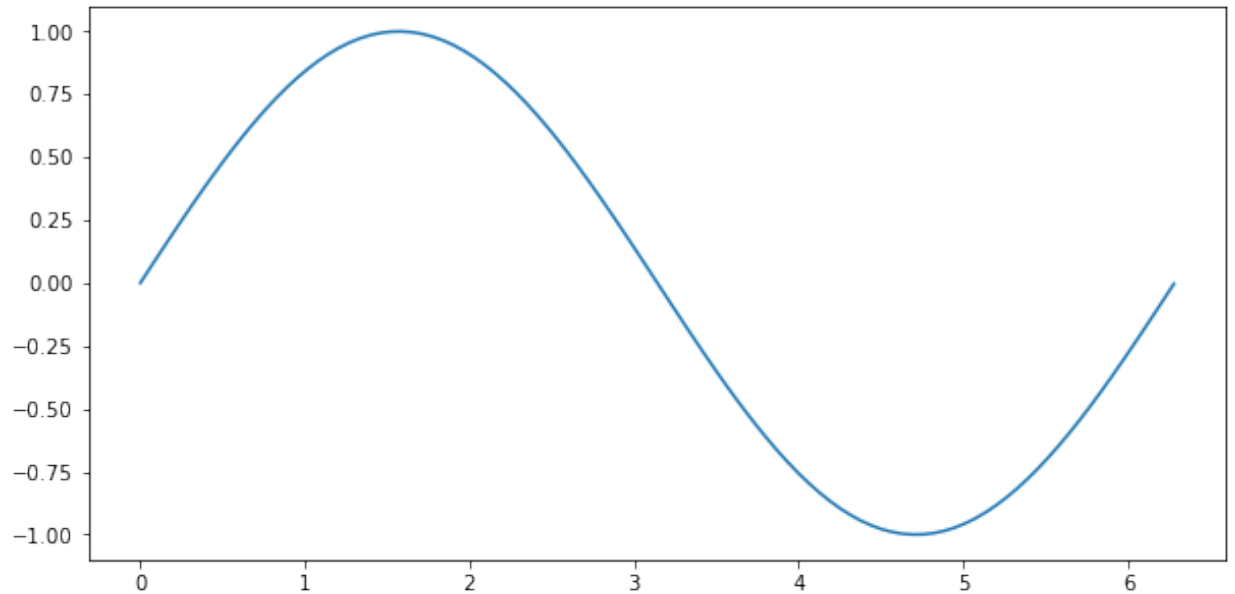
```
In [2]: x = np.linspace(0,6.28,100)  
y1 = np.sin(x)  
y2 = np.cos(x)
```

```
In [3]: plot(x,y1) ## connects the data points (x_i,y_i) with straight lines:  
show()
```



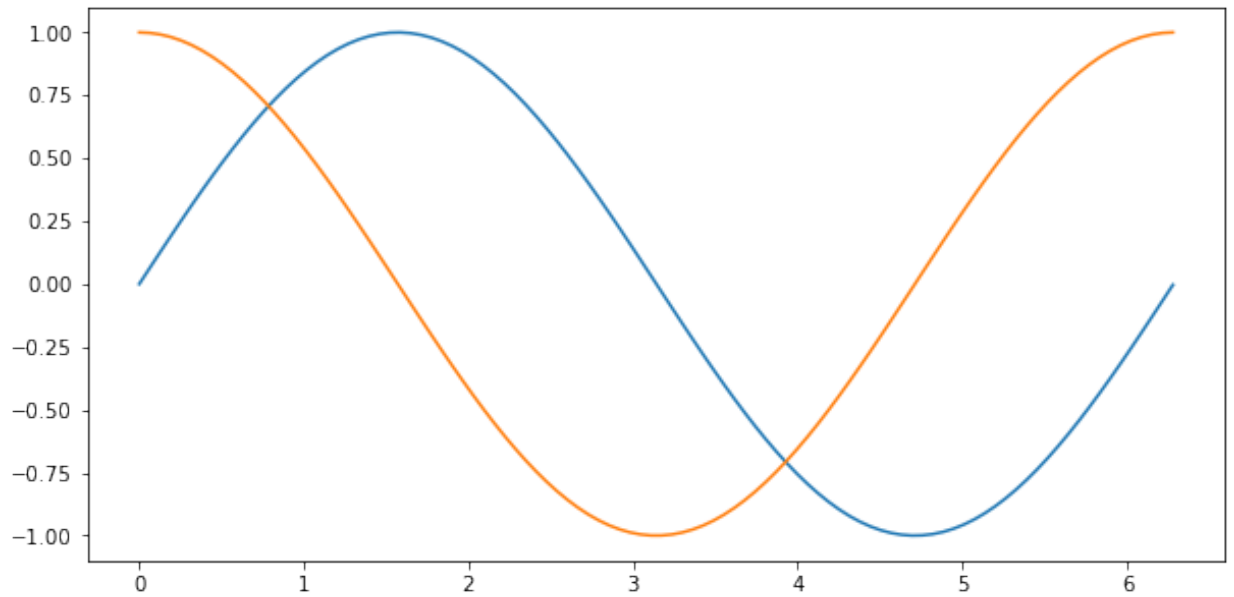
1.2 Changing figure size

```
In [4]: fig = figure(figsize=(10,5))  ## width, height in inches  
ax = fig.add_subplot(1,1,1)  
ax.plot(x,y1)  
show()
```



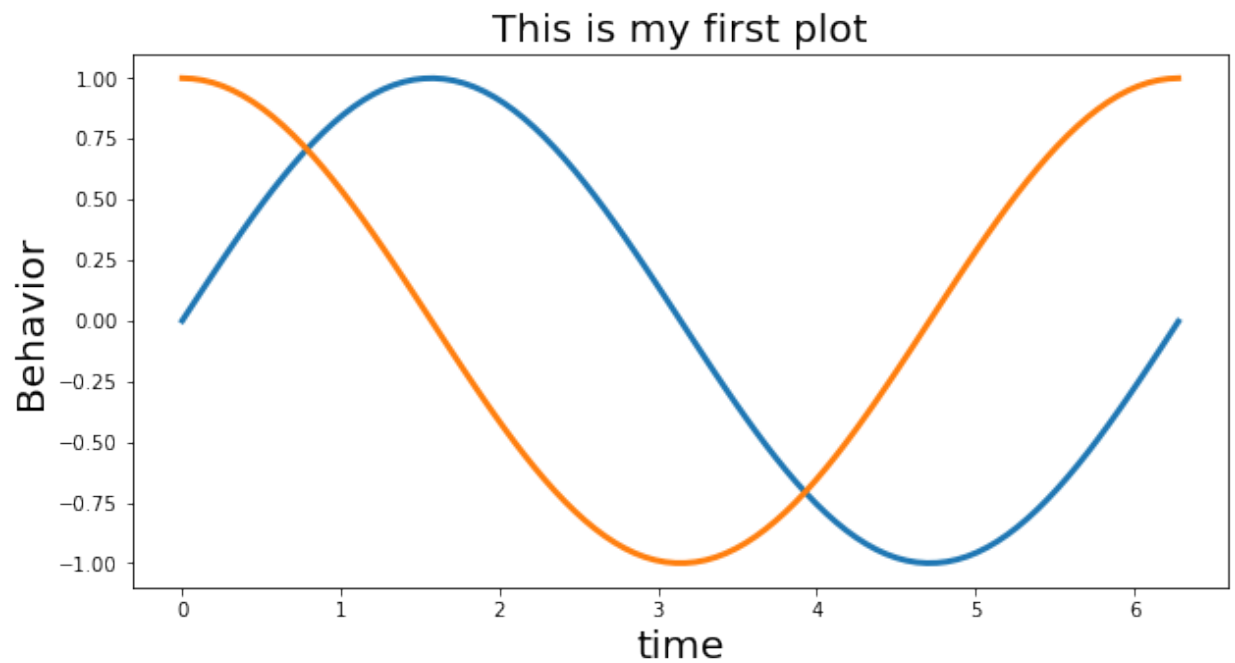
1.3 multiple plots on the same axis

```
In [5]: fig = figure(figsize=(10,5))  
ax = fig.add_subplot(1,1,1)  
ax.plot(x,y1)  
ax.plot(x,y2)  
show()
```



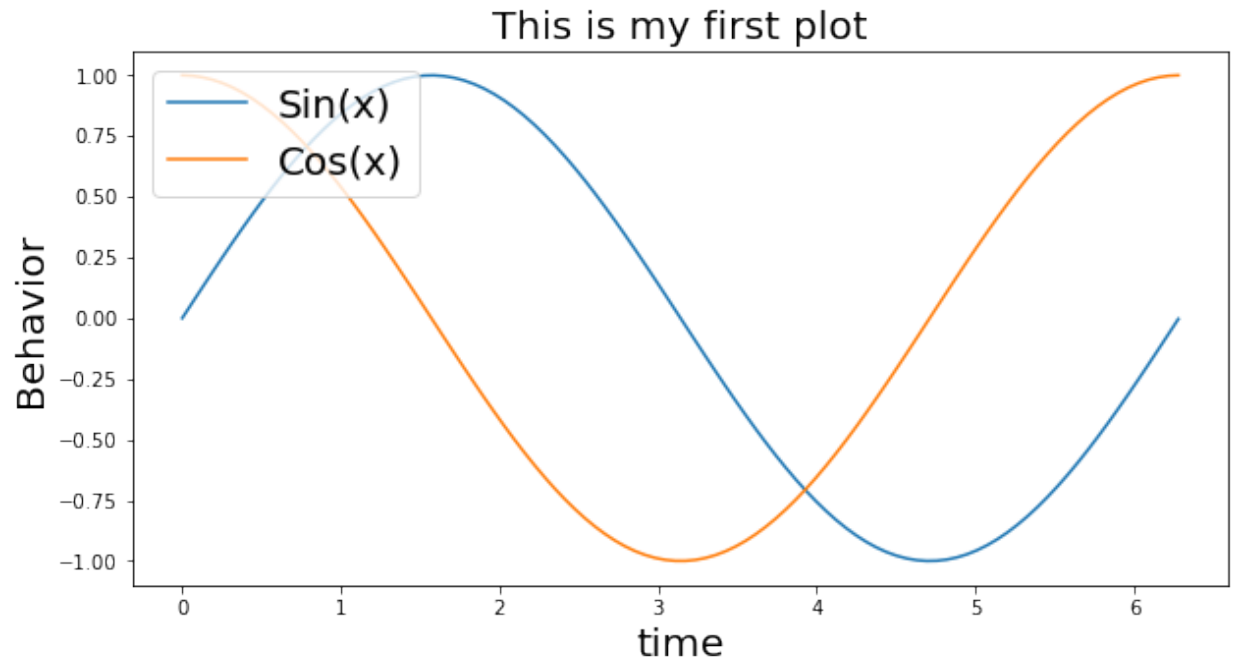
1.4 Adding labels and titles

```
In [6]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
ax.plot(x,y1,lw = 3)
ax.plot(x,y2,lw = 3)
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
ax.set_title('This is my first plot',size = 20)
show()
```



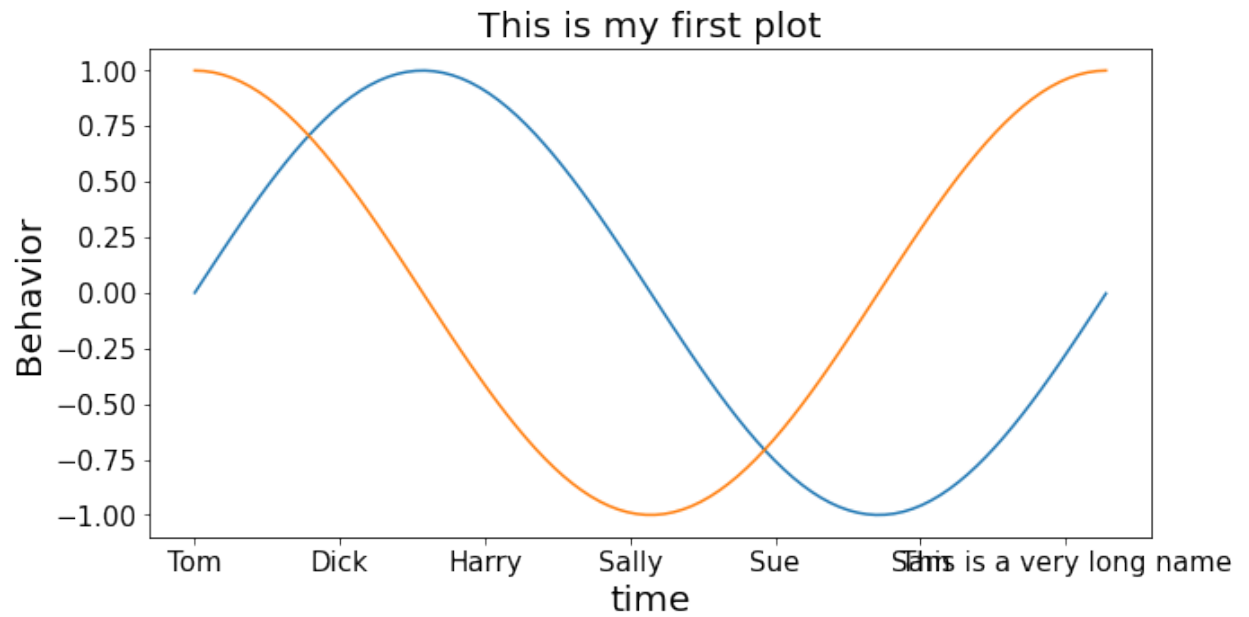
1.5 Adding Legends

```
In [7]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
ax.plot(x,y1,label = 'Sin(x)')
ax.plot(x,y2,label= 'Cos(x)')
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
ax.set_title('This is my first plot',size = 20)
ax.legend(loc=2, prop={'size': 20})
#ax.legend(bbox_to_anchor=(0.5, 0.5), prop={'size': 10})
show()
```



1.6 Editing ticks

```
In [8]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
ax.plot(x,y1)
ax.plot(x,y2)
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
ax.set_title('This is my first plot',size = 20)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue', 'Sam', 'This is a very long name'))
show()
```



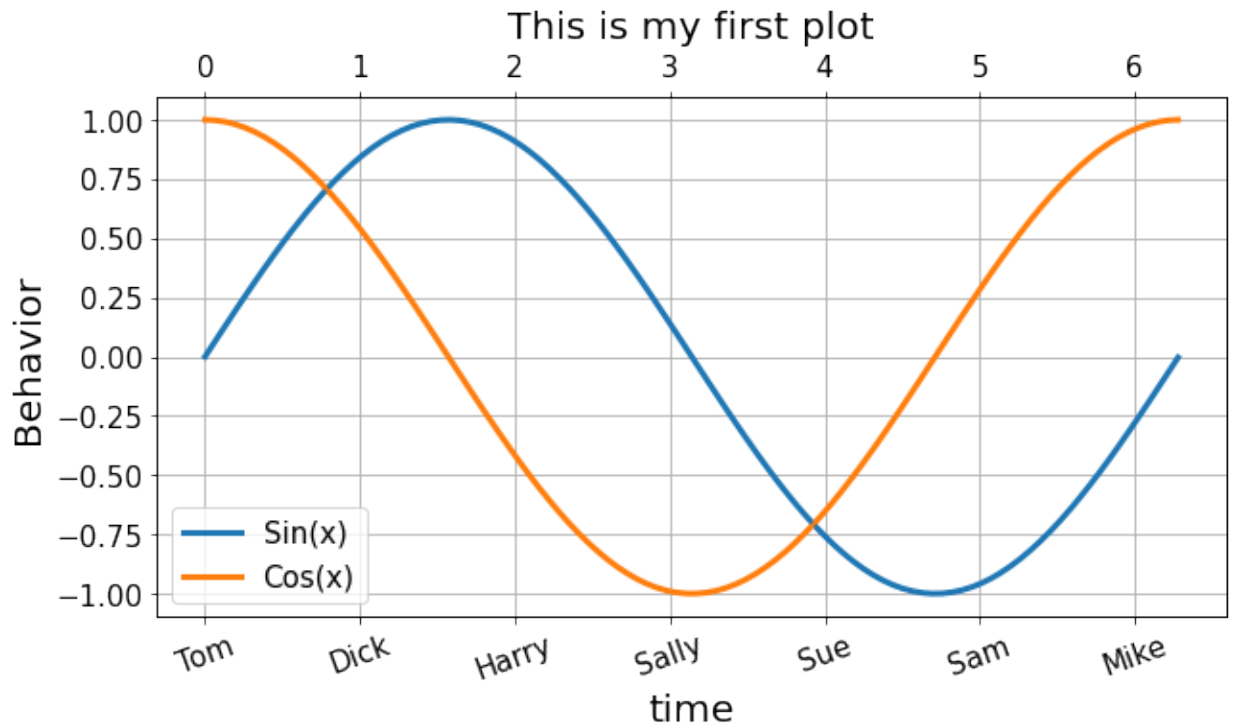
```
In [9]: fig = figure(figsize=(10,5))
ax = subplot2grid((1,1),(0,0))
ax.plot(x,y1)
ax.plot(x,y2)
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
ax.set_title('This is my first plot',size = 20)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue', 'Sam', 'This is a very long name'))
show()
```



1.7 Multiple axis and grid

```
In [10]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
ax.plot(x,y1,label = 'Sin(x)',lw = 3)
ax.plot(x,y2,label = 'Cos(x)',lw = 3)
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
grid(True)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue', 'Sam', 'Mike'),
ax.legend(loc=3, prop={'size': 15})

ax2 = ax.twinx()
ax2.plot(x,y1)
ax2.plot(x,y2)
xticks(size = 15)
ax.set_title('This is my first plot',size = 20,pad=30)
show()
```

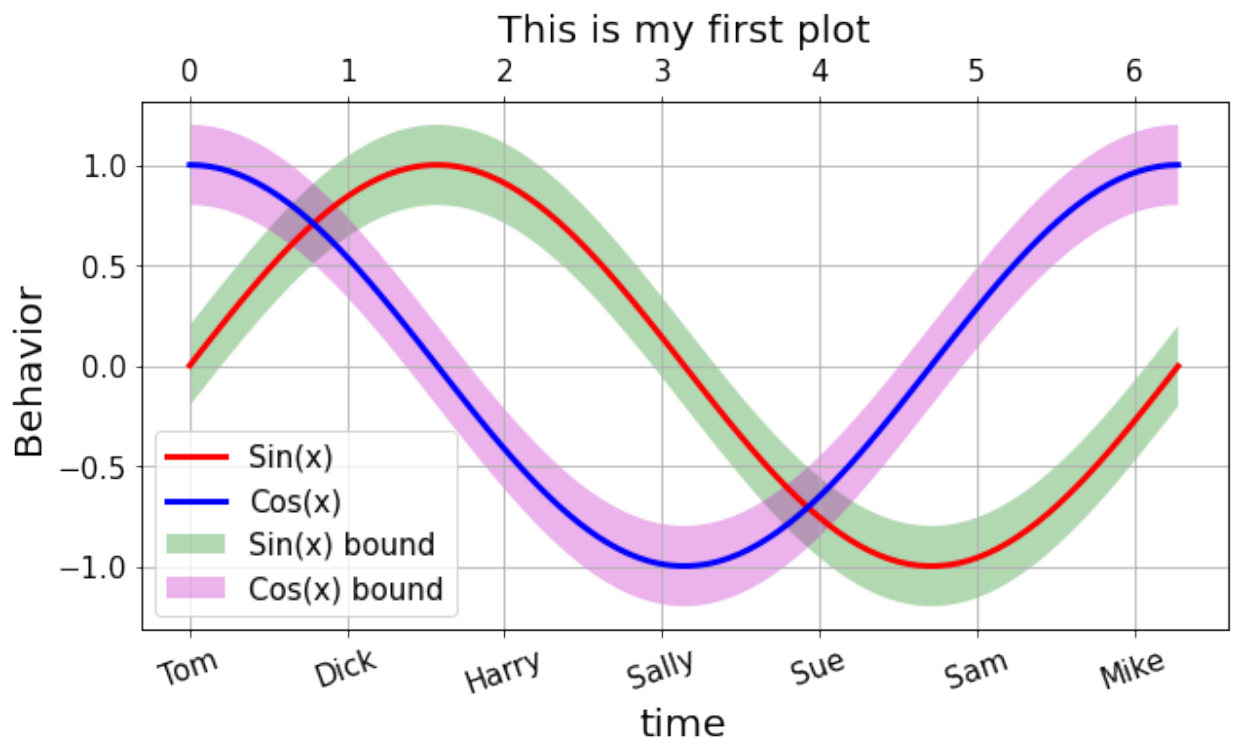


1.8 Plotting bounds on the curve as a shaded region


```
In [11]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
ax.plot(x,y1,label = 'Sin(x)',lw = 3,color = 'r')
ax.plot(x,y2,label = 'Cos(x)',lw = 3, color = 'b')
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
grid(True)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue','Sam','Mike'))

ax.fill_between(x,y1-0.2,y1+0.2, facecolor = 'g', alpha = 0.3, label = 'Sin(x) bound')
ax.fill_between(x,y2-0.2,y2+0.2, facecolor = 'm', alpha = 0.3, label = 'Cos(x) bound')
ax.legend(loc=3, prop={'size': 15})

ax2 = ax.twinx()
ax2.plot(x,y1,alpha = 0)
ax2.plot(x,y2,alpha = 0)
xticks(size = 15)
ax.set_title('This is my first plot',size = 20,pad=30)
show()
```



2 Using different style sheets

For other style options look at

https://matplotlib.org/stable/gallery/style_sheets/style_sheets_reference.html

(https://matplotlib.org/stable/gallery/style_sheets/style_sheets_reference.html). Here I have shown the dark_background

```
In [12]: style.use('dark_background')
fig = figure(figsize=(10,5))
ax = subplot2grid((1,1),(0,0))
ax.plot(x,y1,label = 'Sin(x)',lw = 3,color = 'r')
ax.plot(x,y2,label = 'Cos(x)',lw = 3, color = 'b')
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
grid(True)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue','Sam','Mike'))

ax.fill_between(x,y1-0.2,y1+0.2, facecolor = 'g', alpha = 0.3, label = 'Sin(x) bound')
ax.fill_between(x,y2-0.2,y2+0.2, facecolor = 'm', alpha = 0.3, label = 'Cos(x) bound')
ax.legend(loc=3, prop={'size': 15})

ax2 = ax.twinx()
ax2.plot(x,y1,alpha = 0)
ax2.plot(x,y2,alpha = 0)
xticks(size = 15)
ax.set_title('This is my first plot',size = 20,pad=30)
show()
```



```
In [13]: style.use('default')
```

3 Surface plots

```
In [14]: from mpl_toolkits.mplot3d import Axes3D
         from matplotlib import cm
```

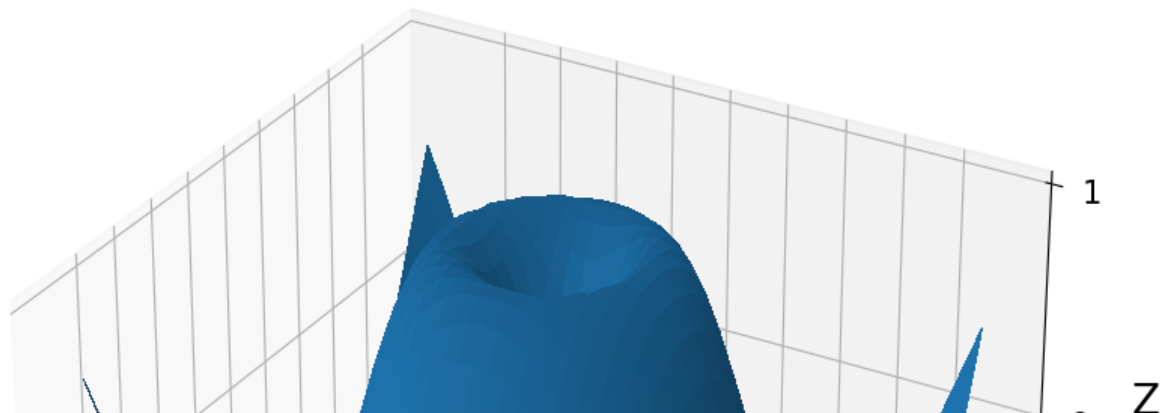
```
In [15]: fig = figure(figsize=(15,10))
         ax = fig.add_subplot(1,1,1,projection = '3d')

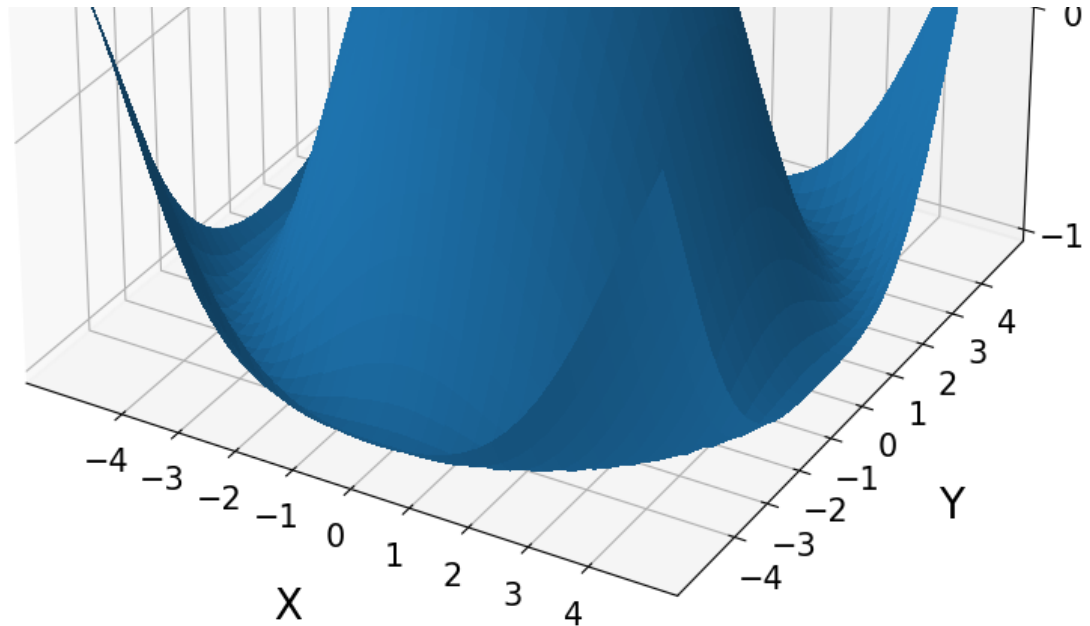
         # Make data.
         X = np.arange(-5, 5, 0.25)
         Y = np.arange(-5, 5, 0.25)
         X, Y = np.meshgrid(X, Y)
         R = np.sqrt(X**2 + Y**2)
         Z = np.sin(R)

         # Plot the surface.
         surf = ax.plot_surface(X, Y, Z,linewidth=0,rstride=1, cstride=1, antialiased=True)

         ax.set_zlim(-1.01, 1.01)
         ax.set_xlabel('X',size = 20,labelpad=20)
         ax.set_ylabel('Y',size = 20,labelpad=20)
         ax.set_zlabel('Z',size = 20,labelpad=10)
         tick_params(labelsize=15)
         ax.set_xticks([-4,-3,-2,-1,0,1,2,3,4])  ## custom ticks
         ax.set_yticks([-4,-3,-2,-1,0,1,2,3,4])
         ax.set_zticks([-1,0,1])

         show()
```





3.1 With colormaps and colorbar

Look for different colormaps at: <https://matplotlib.org/stable/tutorials/colors/colormaps.html>
(<https://matplotlib.org/stable/tutorials/colors/colormaps.html>)

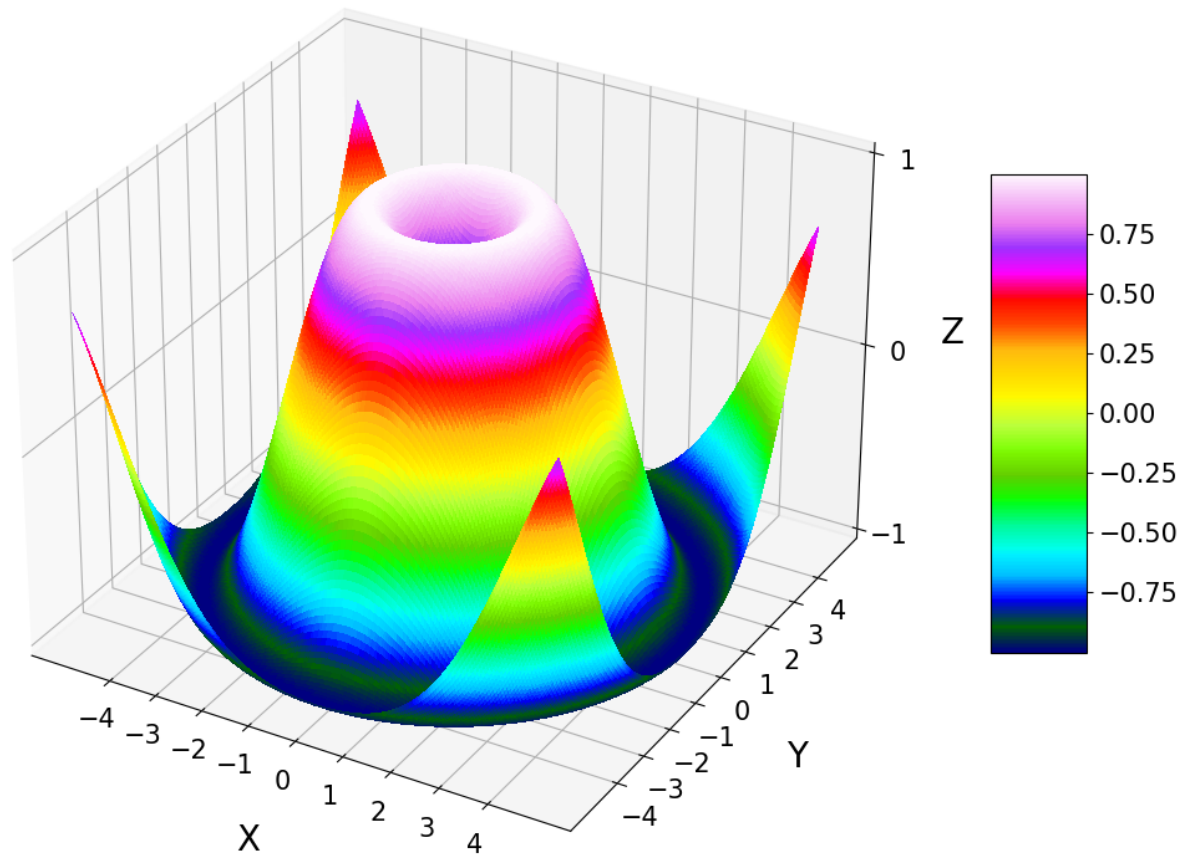
```
In [16]: fig = figure(figsize=(15,10))
ax = fig.add_subplot(1,1,1,projection='3d')

# Make data.
X = np.arange(-5, 5, 0.05)
Y = np.arange(-5, 5, 0.05)
X, Y = np.meshgrid(X, Y)
R = np.sqrt(X**2 + Y**2)
Z = np.sin(R)

# Plot the surface.
surf = ax.plot_surface(X, Y, Z, cmap = 'gist_ncar', linewidth=0, rstride=

ax.set_zlim(-1.01, 1.01)
ax.set_xlabel('X', size = 20, labelpad=20)
ax.set_ylabel('Y', size = 20, labelpad=20)
ax.set_zlabel('Z', size = 20, labelpad=10)
tick_params(labelsize=15)
ax.set_xticks([-4,-3,-2,-1,0,1,2,3,4]) ## custom ticks
ax.set_yticks([-4,-3,-2,-1,0,1,2,3,4])
ax.set_zticks([-1,0,1])
```

```
# Add a color bar which maps values to colors.  
cbar = fig.colorbar(surf, shrink=0.5, aspect=5)  
cbar.ax.tick_params(labelsize=15)  
show()
```



3 Multiple plots on the same figure

```
In [17]: fig = figure(figsize=(15,10))  
  
x = np.linspace(0,6.28,100)  
y1 = np.sin(x)  
y2 = np.cos(x)  
  
## Plotting the first plot  
ax = fig.add_subplot(2, 2, 1)
```

```

ax.plot(x,y1,label = 'Sin(x)',lw = 3,color = 'r')
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
grid(True)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue','Sam','Mik

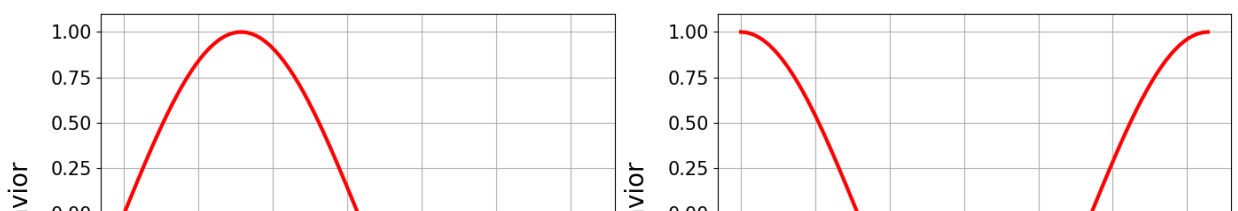
## Plotting the second plot
ax = fig.add_subplot(2, 2, 2)
ax.plot(x,y2,label = 'Cos(x)',lw = 3,color = 'r')
ax.set_xlabel('time',size = 20)
ax.set_ylabel('Behavior',size = 20)
grid(True)
yticks(size=15)
xticks(np.arange(7),('Tom', 'Dick', 'Harry', 'Sally', 'Sue','Sam','Mik

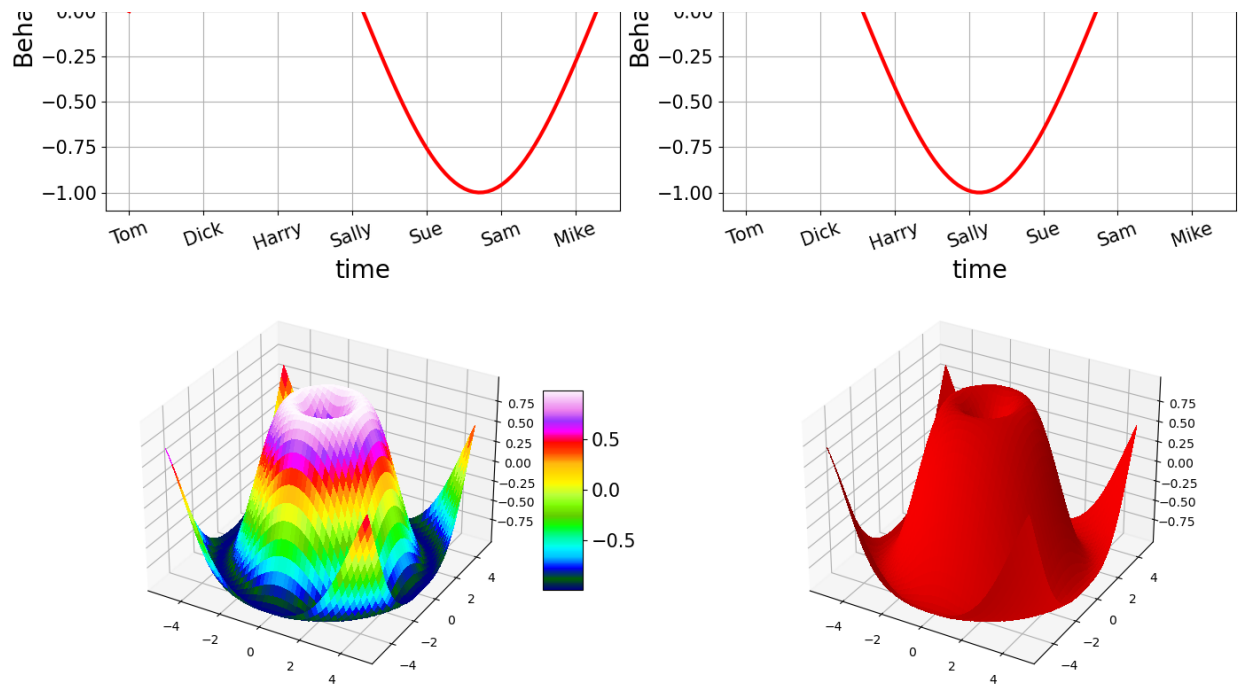
#### Surface plots on the bottom row
# Make data.
X = np.arange(-5, 5, 0.2)
Y = np.arange(-5, 5, 0.2)
X, Y = np.meshgrid(X, Y)
R = np.sqrt(X**2 + Y**2)
Z = np.sin(R)

# Plot the third plot
ax = fig.add_subplot(2, 2, 3, projection='3d')
surf = ax.plot_surface(X, Y, Z,cmap = 'gist_ncar',linewidth=0,rstride=
# Add a color bar which maps values to colors.
cbar = fig.colorbar(surf, shrink=0.5, aspect=5)
cbar.ax.tick_params(labelsize=15)

# Plot the fourth
ax = fig.add_subplot(2, 2, 4, projection='3d')
surf = ax.plot_surface(X, Y, Z,color = 'r',linewidth=0,rstride=1, cstr
subplots_adjust(left=0.09, bottom = 0, right = 0.94, top = 0.99,wspace
show()

```





4 Saving a figure

```
In [18]: fig.savefig('plot_name.png', bbox_inches='tight', dpi = 300)
```

5 Different types of plots

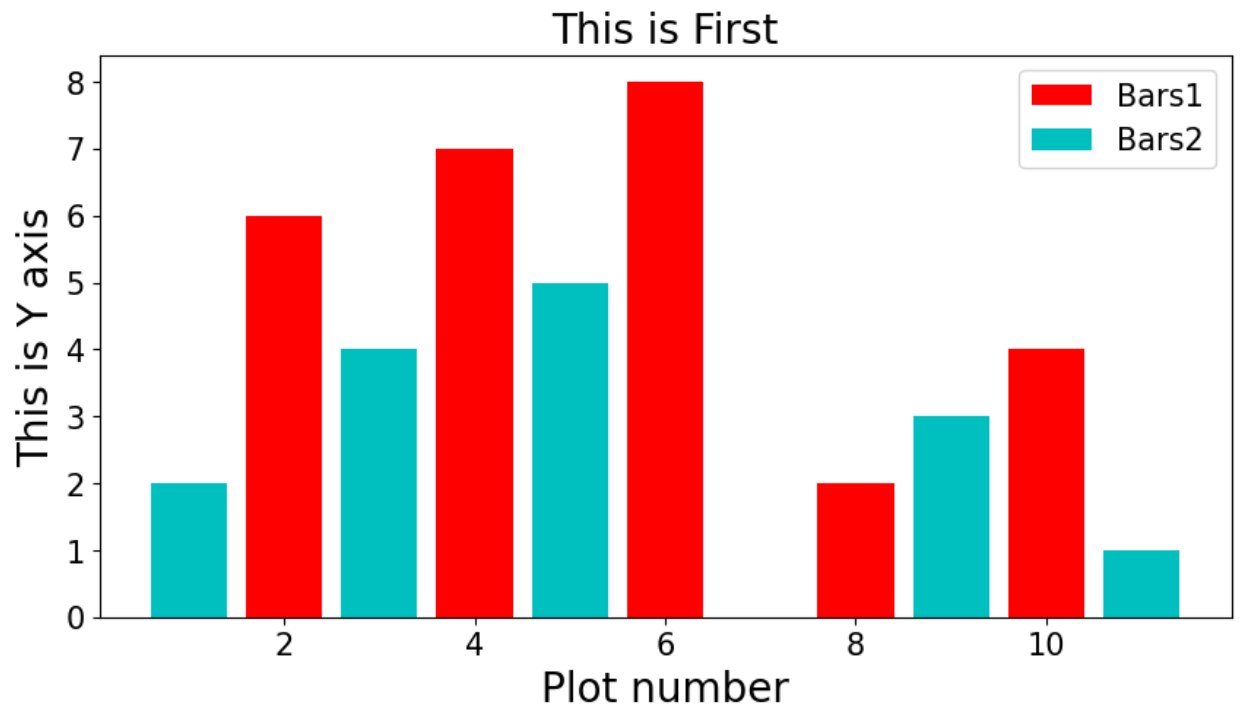
5.1 Bar charts

```
In [19]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
x = [2,4,6,8,10]
y = [6,7,8,2,4]

x2 = [1,3,5,9,11]
y2 = [2,4,5,3,1]

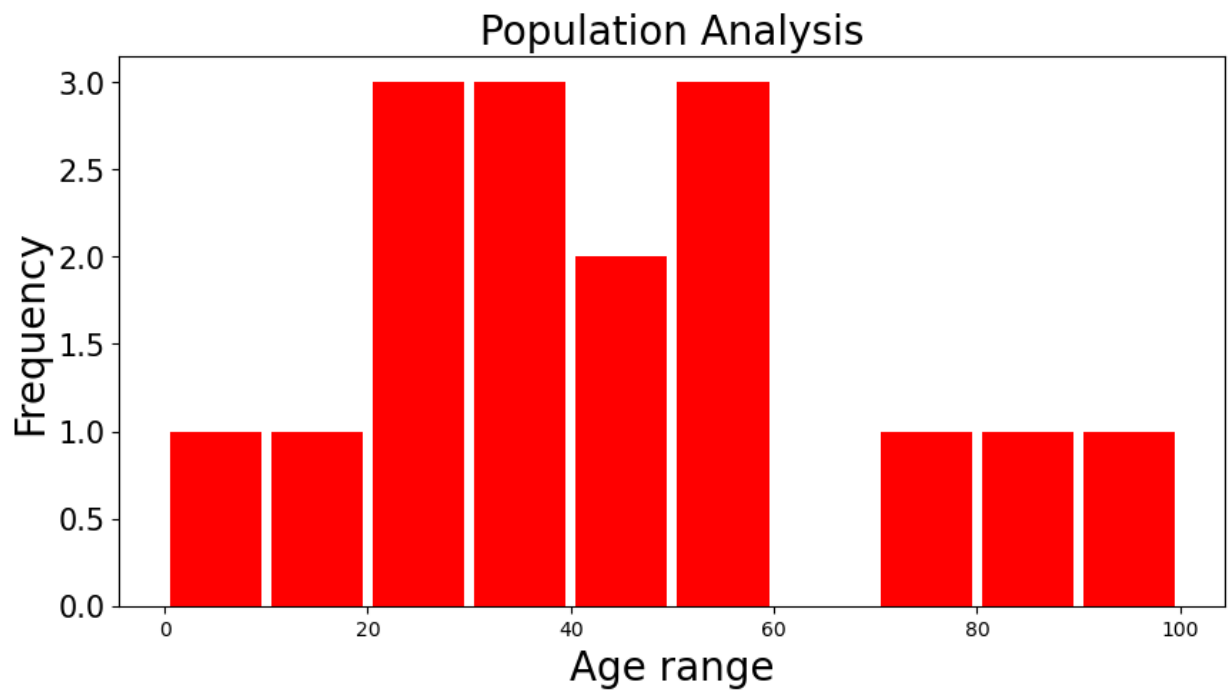
bar(x,y,label = 'Bars1', color = 'r')
bar(x2,y2,label = 'Bars2',color = 'c')

xlabel('Plot number',size = 20)
ylabel('This is Y axis',size = 20)
title('This is First',size = 20)
tick_params(labels=15)
ax.legend(loc=1, prop={'size': 15})
#ax.grid(True)
show()
```



5.2 Histograms

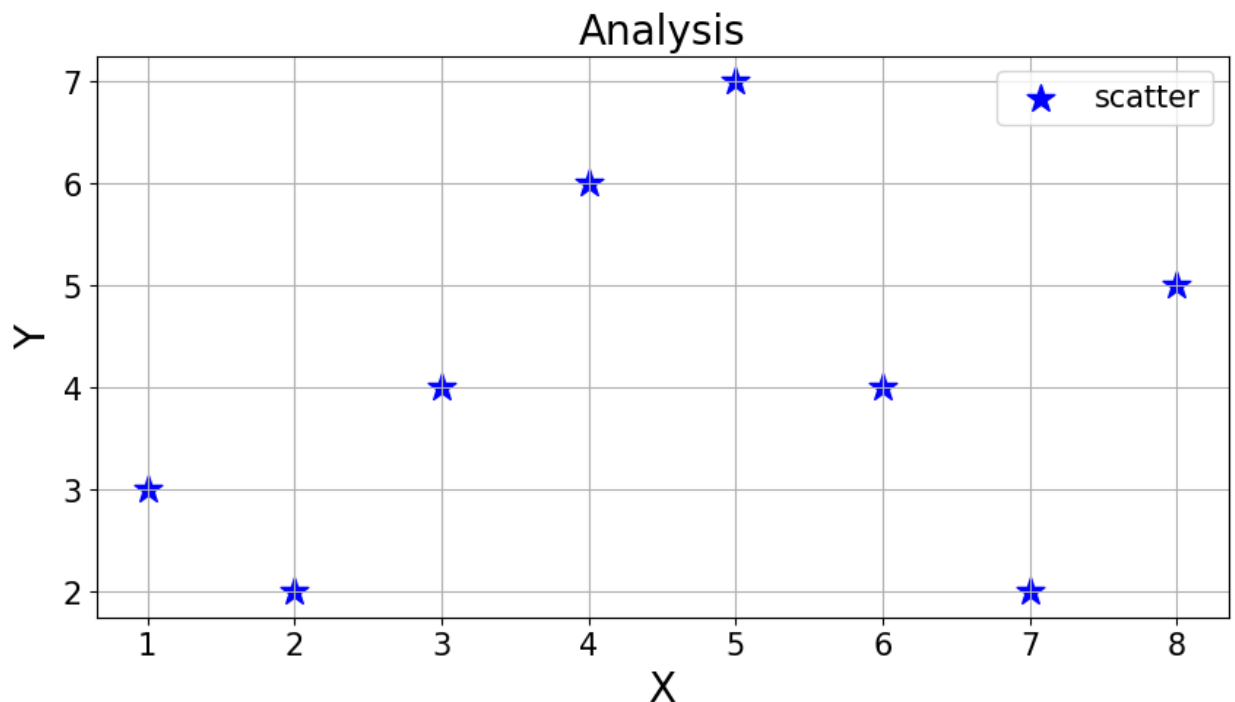

```
In [20]: fig = figure(figsize=(10,5))
ax = fig.add_subplot(1,1,1)
population_ages = [9,22, 44,24,76,32,55,14,87,32,56,43,23,98,54,32]
bins = [0,10,20,30,40,50,60,70,80,90,100]
hist(population_ages,bins, histtype = 'bar',rwidth = 0.9,color = 'r')
xlabel('Age range',size = 20)
ylabel('Frequency',size =20)
title('Population Analysis',size = 20)
#tick_params(labelsize=15)
yticks(size = 15)
show()
```



5.3 Scatter plot

```
In [22]: fig = figure(figsize=(10,5))
ax = subplot2grid((1,1),(0,0))
x = [1,2,3,4,5,6,7,8]
y = [3,2,4,6,7,4,2,5]

scatter(x,y,label = 'scatter',color = 'b',marker = '*',s = 200)
xlabel('X',size = 20)
ylabel('Y',size = 20)
title('Analysis',size = 20)
tick_params(labelsize=15)
ax.legend(loc=1, prop={'size': 15})
ax.grid(True)
show()
```



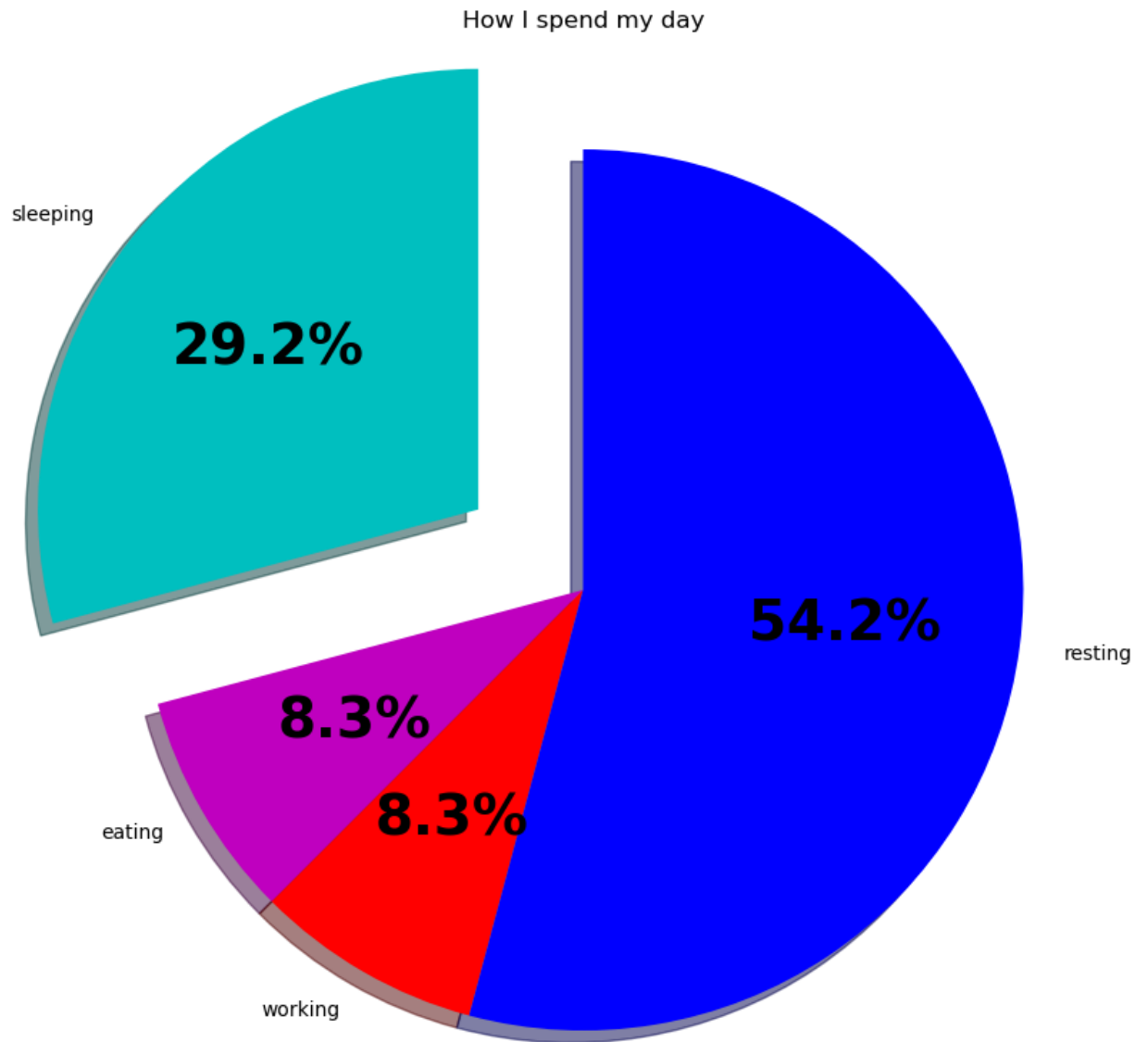
5.4 Pie Chart

```
In [30]: #rcParams['font.size'] = 20.0
fig = figure(figsize=(10,10))
ax = subplot2grid((1,1),(0,0))
slices = [7,2,2,13]
activities = ['sleeping','eating','working','resting']
cols = ['c','m','r','b']

wedges, texts, autotexts = ax.pie(slices,
    labels=activities,
    colors = cols,
    startangle=90.)
```

```
shadow=True,  
explode=(0.3,0,0,0),  
autopct='%1.1f%%')
```

```
title('How I spend my day')  
setp(autotexts, size=28, weight="bold")  
show()
```



In []:

