Practical Notebook 2

Pandas

In this course, we will use pandas to import the data into DataFrame objects. Pandas is a commonly used library working with and manipulating data in various formats, such as txt, csv, excel format, and more.

You can read more about pandas here, or by searching online.

In [ ]:
```
# The first thing we need to do is to import pandas
import pandas as pd

# We will also change how the floating point numbers are displayed
pd.set_option("display.float_format", lambda x: f"{x:.5f}")
```

Creating our own dataset to file

We will start by creating our own data set, but later on we will import the data from a file.

In [ ]:
```
names = ['Alice', 'Bob', 'Charlie']
animals = ['Dog', 'Cat', None]
age = [27, 12, 43]
sex = ['Female', 'Male', 'Male']
```

We will then merge the lists together using the *zip* function.

In [ ]:
```
people = list(zip(names, animals, age, sex))
print(people)
```

```
[('Alice', 'Dog', 27, 'Female'), ('Bob', 'Cat', 12, 'Male'), ('Charlie', Non
e, 43, 'Male')]
```

Now we can make our merged list into a DataFrame object by using pandas.

In [ ]:
```
df = pd.DataFrame(data=people, columns=['Names','Animals','Age','Sex'])
print(df)
```

```
     Names Animals  Age     Sex
0    Alice     Dog   27  Female
1      Bob     Cat   12    Male
2  Charlie    None   43    Male
```

You can also export the dataframe to a csv file, where we use the function *to_csv* to export the file. You will find the file you created in the folder you are in. (In colab you will find the folder to the left.) The index parameter is set to *False*, i.e. we won't write

the row names to the new file (in this case the row names are *0, 1, 2*). The header parameter is set to *True*, i.e. we will write the column names to the file (in this case the column names are *Names*, *Animals*, *Age*, *Sex*). You can change these parameters yourself to see the difference.

In [ ]:
```
df.to_csv('test_people.csv', index=False, header=True)
```

Read a dataset from file

To read the data from a csv file we will use the function *read_csv*.

In [ ]:
```
df = pd.read_csv('test_people.csv')
print(df)
```

```
     Names Animals  Age     Sex
0    Alice     Dog   27  Female
1      Bob     Cat   12    Male
2  Charlie     NaN   43    Male
```

We can inspect the numerical values in the data using the function describe.

In [ ]:
```
print(df.describe())
```

```
             Age
count   3.00000
mean   27.33333
std    15.50269
min    12.00000
25%    19.50000
50%    27.00000
75%    35.00000
max    43.00000
```

And look at one specific column by using the names of the header.

In [ ]:
```
print(f"Here you will see the names: \n{df['Names']}")
print(f"\nHere you will see the animals: \n{df['Animals']}")
print(f"\nHere you will see the ages: \n{df['Age']}")
print(f"\nHere you will see the sex: \n{df['Sex']}")
```

```
Here you will see the names:
0      Alice
1        Bob
2    Charlie
Name: Names, dtype: object

Here you will see the animals:
0    Dog
1    Cat
2    NaN
Name: Animals, dtype: object

Here you will see the ages:
0    27
1    12
2    43
Name: Age, dtype: int64

Here you will see the sex:
0    Female
1      Male
2      Male
Name: Sex, dtype: object
```

You can also divide the groups into females and males.

In [ ]:
```
male, female = df['Sex'].value_counts()
print(f"Here we have {male} male(s) and {female} female(s).")
```

```
Here we have 2 male(s) and 1 female(s).
```

By looking only at one column, as we did before, we can find some interesting data about it as well.

In [ ]:
```
# finding the mean value of the ages (with 2 decimals)
print(f"mean: {df['Age'].mean():.2f}")
# and the standard deviation (with 2 decimals)
print(f"std: {df['Age'].std():.2f}")
```

```
mean: 27.33
std: 15.50
```

Titanic

Now we will download and use a larger dataset, to get a better understanding about the pandas library. The dataset contains passenger data from Titanic, and later on we will predict "what sort of people were most likely to survive?". The passenger data has 7 features: Name, Sex, Socio-economic class, Siblings/Spouses Aboard, Parents/Children Aboard and Fare and a binary responce variable "survived".

In [ ]:
```
# Downloading the titanic dataset
#!wget https://web.stanford.edu/class/archive/cs/cs109/cs109.1166/stuff/tita
```

Assignment a)

In [ ]:
```
# ASSIGNMENT:
# Load the data and get familiar with it
# Use the .describe() method to inspect numerical values

df = pd.read_csv('titanic.csv')
print(df)
df.describe()
```

```
     Survived  Pclass                                               Name  \
0           0       3                            Mr. Owen Harris Braund
1           1       1  Mrs. John Bradley (Florence Briggs Thayer) Cum...
2           1       3                        Miss. Laina Heikkinen
3           1       1       Mrs. Jacques Heath (Lily May Peel) Futrelle
4           0       3                           Mr. William Henry Allen
..        ...     ...                                               ...
882         0       2                          Rev. Juozas Montvila
883         1       1                   Miss. Margaret Edith Graham
884         0       3                  Miss. Catherine Helen Johnston
885         1       1                          Mr. Karl Howell Behr
886         0       3                            Mr. Patrick Dooley

        Sex      Age  Siblings/Spouses Aboard  Parents/Children Aboard  \
0      male 22.00000                        1                        0
1    female 38.00000                        1                        0
2    female 26.00000                        0                        0
3    female 35.00000                        1                        0
4      male 35.00000                        0                        0
..      ...      ...                      ...                      ...
882    male 27.00000                        0                        0
883  female 19.00000                        0                        0
884  female  7.00000                        1                        2
885    male 26.00000                        0                        0
886    male 32.00000                        0                        0

        Fare
0    7.25000
1   71.28330
2    7.92500
3   53.10000
4    8.05000
..       ...
882 13.00000
883 30.00000
884 23.45000
885 30.00000
886  7.75000

[887 rows x 8 columns]
```

Out[ ]:

	Survived	Pclass	Age	Siblings/Spouses Aboard	Parents/Children Aboard	Fare
count	887.00000	887.00000	887.00000	887.00000	887.00000	887.00000
mean	0.38557	2.30552	29.47144	0.52537	0.38331	32.30542
std	0.48700	0.83666	14.12191	1.10467	0.80747	49.78204
min	0.00000	1.00000	0.42000	0.00000	0.00000	0.00000
25%	0.00000	2.00000	20.25000	0.00000	0.00000	7.92500
50%	0.00000	3.00000	28.00000	0.00000	0.00000	14.45420
75%	1.00000	3.00000	38.00000	1.00000	0.00000	31.13750
max	1.00000	3.00000	80.00000	8.00000	6.00000	512.32920

Assignment b)

In [ ]:
```
# ASSIGNMENT:
# Count the number of males and females
male, female = df['Sex'].value_counts()
print(f"Males: {male}\nFemales: {female}")
```

```
male      573
female    314
Name: Sex, dtype: int64
Males: 573
Females: 314
```

Assignment c)

In [ ]:
```
# ASSIGNMENT:
# Find the mean fare and display with 2 floating point numbers

mean_fare = df['Fare'].mean()
print(f"Fare mean: {mean_fare:.2f}")

# Find the standard deviation of the fare and display with 2 floating point

std_fare = df['Fare'].std()
print(f"Fare std dev: {std_fare:.2f}")
```

```
Fare mean: 32.31
Fare std dev: 49.78
```

Assignment d)

In [ ]:
```
# ASSIGNMENT:
# Count how many survived (1) and how many died (0)

# YOUR CODE HERE
```

```
died, survived = df['Survived'].value_counts()
print(f"Died: {died}\nSurvived: {survived}")
```

```
0    545
1    342
Name: Survived, dtype: int64
Died: 545
Survived: 342
```

Assignment e)

In [ ]:
```
# ASSIGNMENT:
# count and display the number of women who survived
# and the number of men who survived

# YOUR CODE HERE
female_survived, male_survived = df[df["Survived"].isin([1])]["Sex"].value_c
print(f"Female survivors: {female_survived}\nMale survivors: {male_survived}
```

```
Female survivors: 233
Male survivors: 109
```

Assignment f)

In [ ]:
```
# ASSIGNMENT:
# Separate the dataset from Titanic into X and y,
# where y is the column Survived, and X is the rest.
# Inspect the data. Look at for instance the function "describe" in pandas

# YOUR CODE HERE
X = df.loc[:,'Pclass':'Fare'] # as Survived is the 1st column, we can just i
y = df['Survived']

x_describe = X.describe()
y_describe = y.describe()

print(x_describe,"\n", y_describe)
```

```
          Pclass       Age  Siblings/Spouses Aboard  Parents/Children Aboard
\
count 887.00000 887.00000                887.00000                887.00000
mean    2.30552  29.47144                  0.52537                  0.38331
std     0.83666  14.12191                  1.10467                  0.80747
min     1.00000   0.42000                  0.00000                  0.00000
25%     2.00000  20.25000                  0.00000                  0.00000
50%     3.00000  28.00000                  0.00000                  0.00000
75%     3.00000  38.00000                  1.00000                  0.00000
max     3.00000  80.00000                  8.00000                  6.00000

           Fare
count 887.00000
mean   32.30542
std    49.78204
min     0.00000
25%     7.92500
50%    14.45420
75%    31.13750
max   512.32920
 count   887.00000
mean      0.38557
std       0.48700
min       0.00000
25%       0.00000
50%       0.00000
75%       1.00000
max       1.00000
Name: Survived, dtype: float64
```

Assignment g)

In [ ]:
```
# ASSIGNMENT:
# Standardize the data by subtracting the mean and dividing by the standard
# Inspect the data again to see that the mean is (close to) zero and the sta

# YOUR CODE HERE
X = X.select_dtypes(include='number') # There was an error telling me to onl

X_new = (X - X.mean())/X.std()
y_new = (y - y.mean())/y.std()

# Inspecting the data again:
X_new_describe = X_new.describe()
y_new_describe = y_new.describe()

print(X_new_describe,"\n", y_new_describe)
```

```
         Pclass       Age  Siblings/Spouses Aboard  Parents/Children Aboard
\
count 887.00000 887.00000                887.00000                887.00000
mean   -0.00000   0.00000                  0.00000                 -0.00000
std     1.00000   1.00000                  1.00000                  1.00000
min    -1.56040  -2.05719                 -0.47559                 -0.47471
25%    -0.36517  -0.65299                 -0.47559                 -0.47471
50%     0.83006  -0.10420                 -0.47559                 -0.47471
75%     0.83006   0.60392                  0.42966                 -0.47471
max     0.83006   3.57803                  6.76640                  6.95594

           Fare
count 887.00000
mean    0.00000
std     1.00000
min    -0.64894
25%    -0.48974
50%    -0.35859
75%    -0.02346
max     9.64251
 count   887.00000
mean     -0.00000
std       1.00000
min      -0.79172
25%      -0.79172
50%      -0.79172
75%       1.26165
max       1.26165
Name: Survived, dtype: float64
```

Matplotlib

Matplotlib is a commonly used library for visualizing data in Python. Other visualization libraries exist for Python, such as seaborn, plotly, and more. Beyond the first practical notebook, we do not enforce any particular plotting library, but strongly encourage the use of Matplotlib. Below we will use the plotting functions inside of *matplotlib.pyplot*. You can read more about matplotlib here and pyplot here.

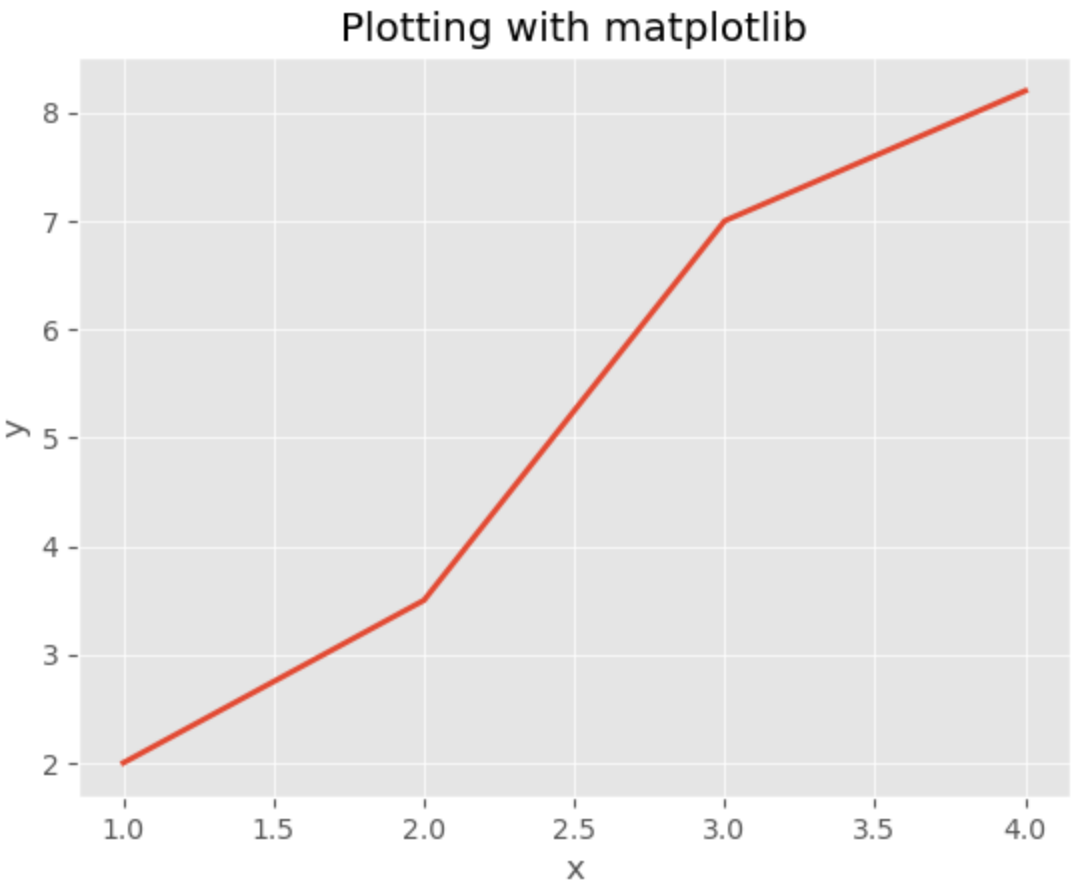
Examples

In [ ]:
```
# import the relevant libraries
import matplotlib.pyplot as plt
import numpy as np
```

We will start by looking at some small lists.

In [ ]:
```
# examples of some datapoint
x = [1,2,3,4]
y = [2,3.5,7,8.2]

# plotting the data using matplotlib.pyplot.plot
```

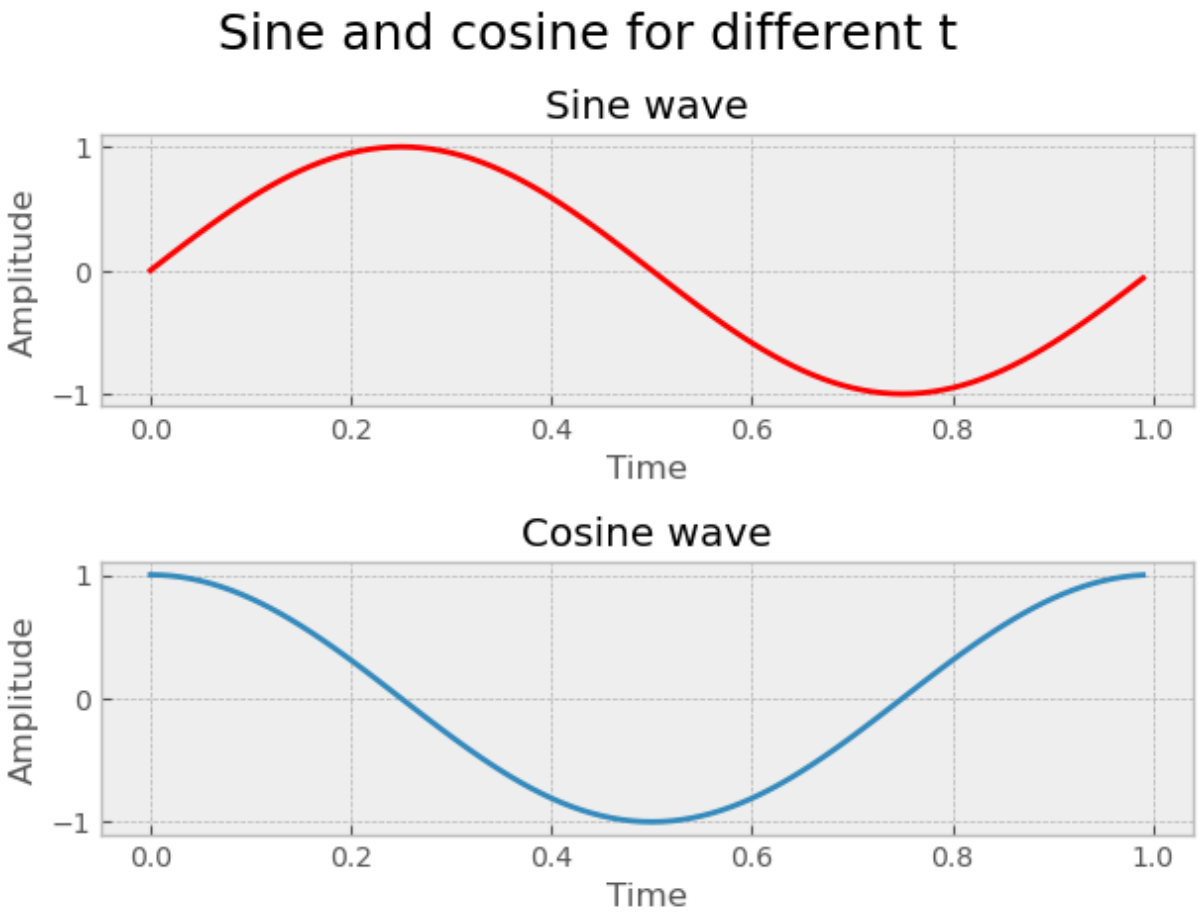
```
plt.plot(x, y)

# It is important to add labels for the axes and a title
plt.xlabel("x")
plt.ylabel("y")
plt.title("Plotting with matplotlib")
# and always end with show(), which will show you the plot.
plt.show()
```



Plots can also be below each other, or side by side by using subplot.

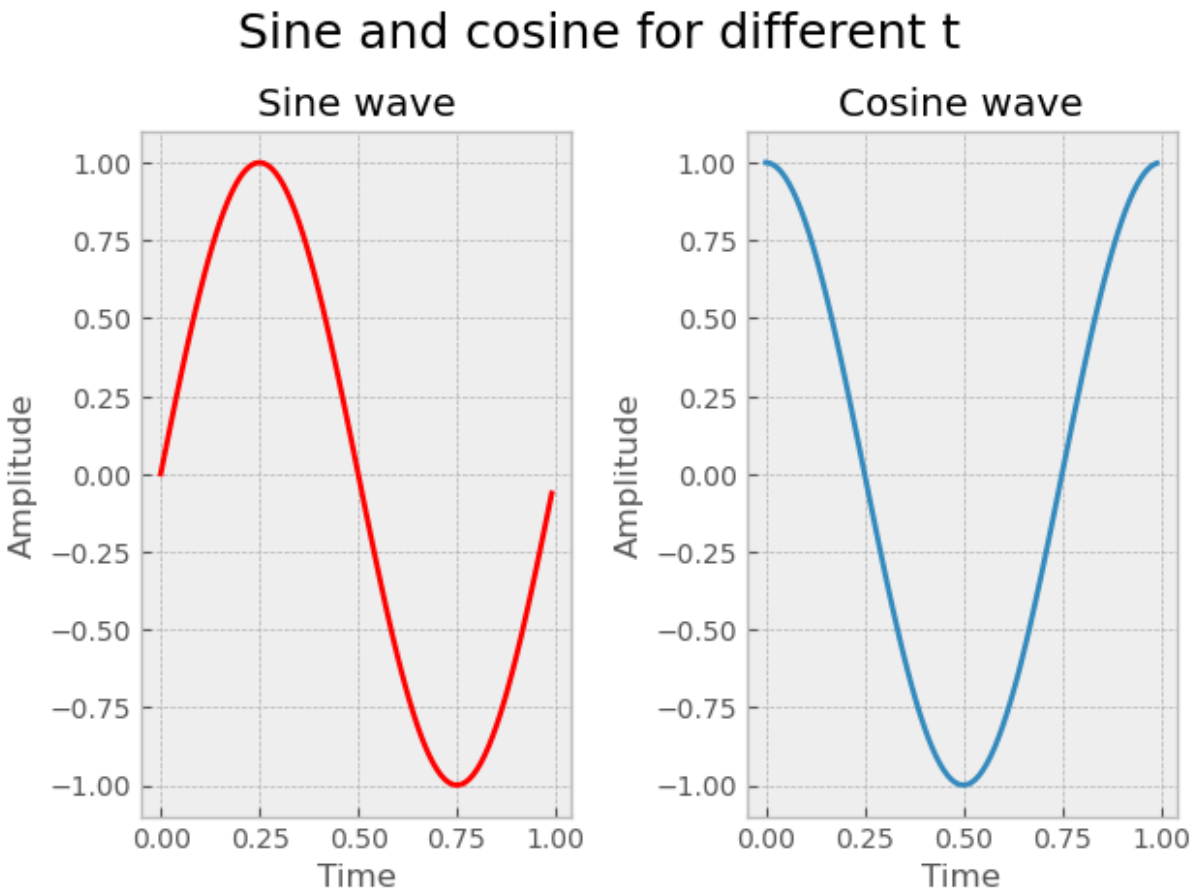
In [ ]:
```
# Vertical subplot

plt.style.use('bmh')

t = np.arange(0.0, 1.0, 0.01)
sin = np.sin(2*np.pi*t)
cos = np.cos(2*np.pi*t)

fig = plt.figure()
fig.suptitle("Sine and cosine for different t", fontsize=18)

ax1 = fig.add_subplot(2,1,1)
ax1.plot(t, sin, color='red', lw=2)
ax1.set_ylabel('Amplitude')
ax1.set_xlabel('Time')
ax1.set_title('Sine wave')
```

```
ax2 = fig.add_subplot(2,1,2)
ax2.plot(t, cos)
ax2.set_ylabel('Amplitude')
ax2.set_xlabel('Time')
ax2.set_title('Cosine wave')

fig.tight_layout() # comment out this line to see the difference
fig.subplots_adjust(top=0.85)
plt.show()
```



In [ ]:
```
# Horizontal subplot

plt.style.use('bmh')

t = np.arange(0.0, 1.0, 0.01)
sin = np.sin(2*np.pi*t)
cos = np.cos(2*np.pi*t)

fig = plt.figure()
fig.suptitle("Sine and cosine for different t", fontsize=18)

ax1 = fig.add_subplot(1,2,1)  # we have changed (2,1,1) to (1,2,1)
ax1.plot(t, sin, color='red', lw=2)
ax1.set_ylabel('Amplitude')
ax1.set_xlabel('Time')
ax1.set_title('Sine wave')
```

```
ax2 = fig.add_subplot(1,2,2)  # we have changed (2,1,2) to (1,2,2)
ax2.plot(t, cos)
ax2.set_ylabel('Amplitude')
ax2.set_xlabel('Time')
ax2.set_title('Cosine wave')

fig.tight_layout() # comment out this line to see the difference
fig.subplots_adjust(top=0.85)
plt.show()
```



And with different stylings

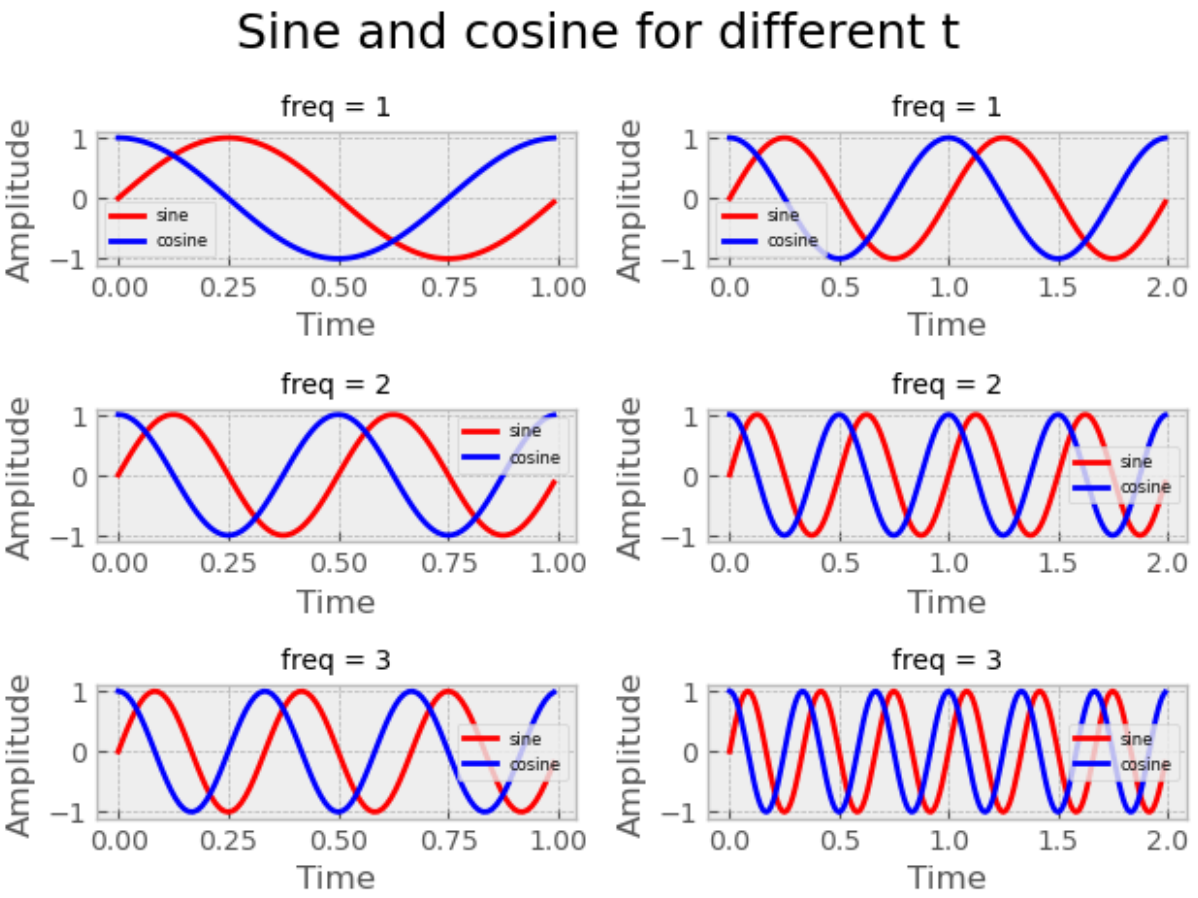
In [ ]:
```
# Here are all the different "pre-configured" styles matplot lib supports
# https://matplotlib.org/tutorials/intermediate/artists.html#sphx-glr-tutori
plt.style.available
```

Out[ ]:
```
['Solarize_Light2',
 '_classic_test_patch',
 '_mpl-gallery',
 '_mpl-gallery-nogrid',
 'bmh',
 'classic',
 'dark_background',
 'fast',
 'fivethirtyeight',
 'ggplot',
 'grayscale',
 'seaborn-v0_8',
 'seaborn-v0_8-bright',
 'seaborn-v0_8-colorblind',
 'seaborn-v0_8-dark',
 'seaborn-v0_8-dark-palette',
 'seaborn-v0_8-darkgrid',
 'seaborn-v0_8-deep',
 'seaborn-v0_8-muted',
 'seaborn-v0_8-notebook',
 'seaborn-v0_8-paper',
 'seaborn-v0_8-pastel',
 'seaborn-v0_8-poster',
 'seaborn-v0_8-talk',
 'seaborn-v0_8-ticks',
 'seaborn-v0_8-white',
 'seaborn-v0_8-whitegrid',
 'tableau-colorblind10']
```

The plotts can also be both below each other and side by side at the same time (as a matrix) as you can see below. Here we have also plotted two graphs together in every figure, and added a color and a label for each one of them.

In [ ]:
```
# Matrix subplot

fig = plt.figure()
fig.suptitle("Sine and cosine for different t", fontsize=18)

i = 1
for freq in [1, 2, 3]:
  for t_max in [1, 2]:
    t = np.arange(0.0, t_max, 0.01)
    sin = np.sin(2*freq*np.pi*t)
    cos = np.cos(2*freq*np.pi*t)

    ax = fig.add_subplot(3,2,i)
    ax.plot(t, sin, color='red', lw=2, label='sine')
    ax.plot(t, cos, color='blue', lw=2, label='cosine')
    ax.set_ylabel('Amplitude')
    ax.set_xlabel('Time')
    ax.legend(fontsize=6)
    ax.set_title(f'freq = {freq}', fontsize=10)
    i += 1

fig.tight_layout() # comment out this line to see the difference
```

```
fig.subplots_adjust(top=0.85)
plt.show()
```



Plotting data from Pandas

Now we will plot some of the datapoints from the titanic dataset to visualize it.

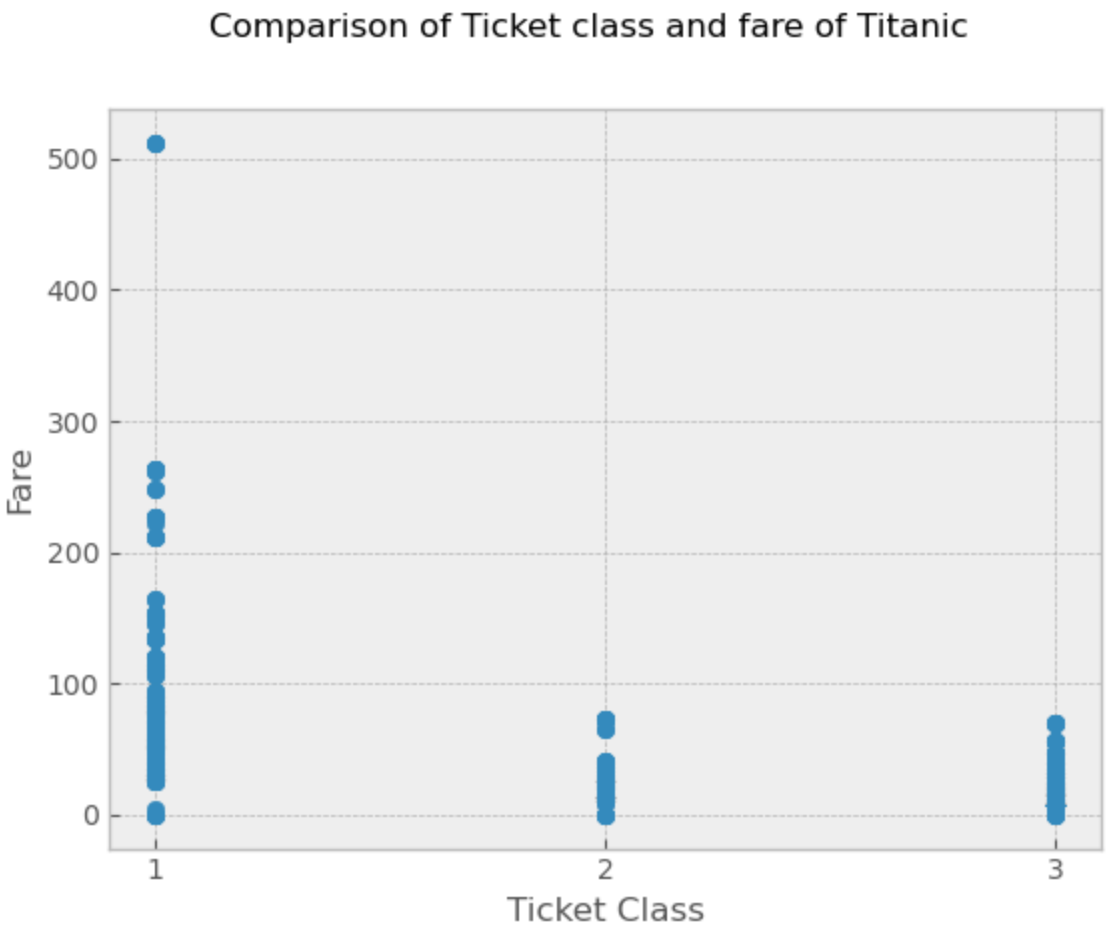
In [ ]:
```
# Downloading the titanic dataset
#!wget https://web.stanford.edu/class/archive/cs/cs109/cs109.1166/stuff/tita
```

In [ ]:
```
# Load the titanic dataset for plotting
import pandas as pd
df = pd.read_csv('titanic.csv')
```

Assignment h)

In [ ]:
```
# ASSIGNMENT:
# make a scatterplot of the class of ticket in the x-axis
# and the fare on the y-axis
# label the plot and the axes appropriately

# YOUR CODE HERE
tic_class = df["Pclass"]
fare = df["Fare"]

plt.scatter(tic_class, fare)
```

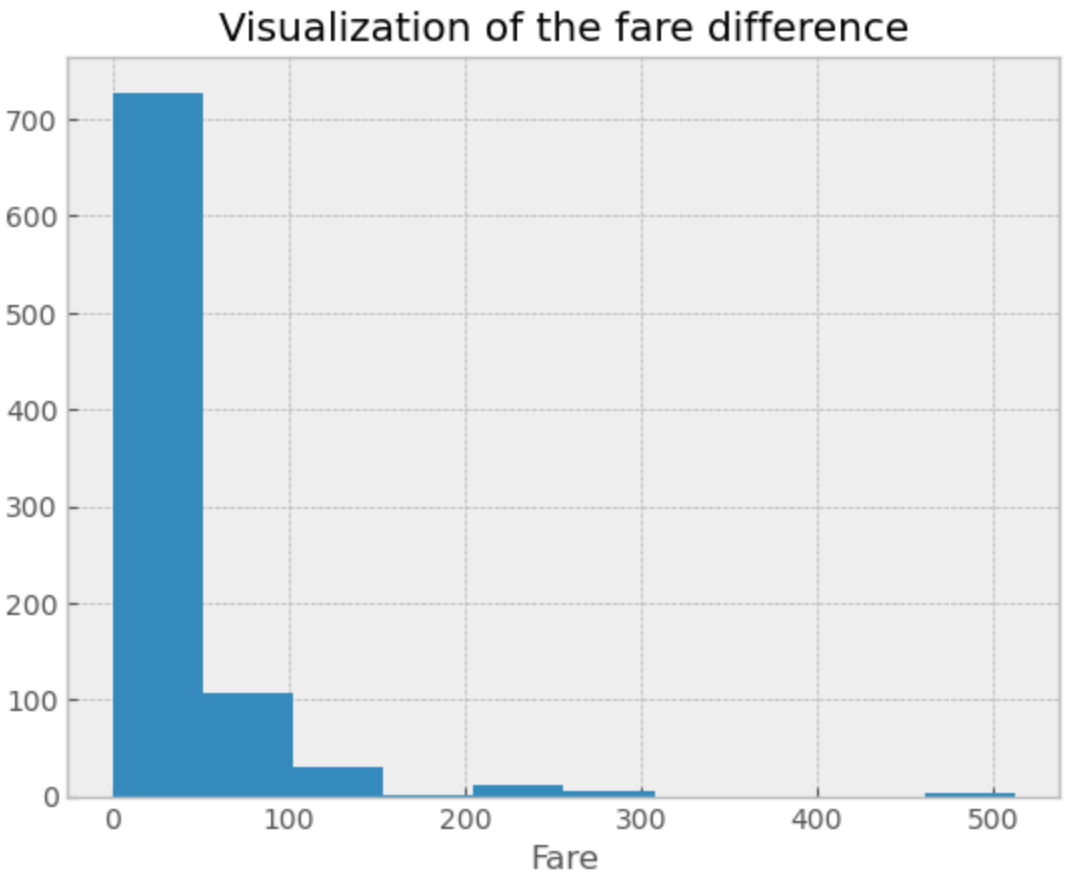
```
plt.xlabel("Ticket Class")
plt.ylabel("Fare")
plt.xticks((1,2,3)) # Since it makes no sense to have continuous values
plt.suptitle("Comparison of Ticket class and fare of Titanic")
plt.show()
```



Assignment i)

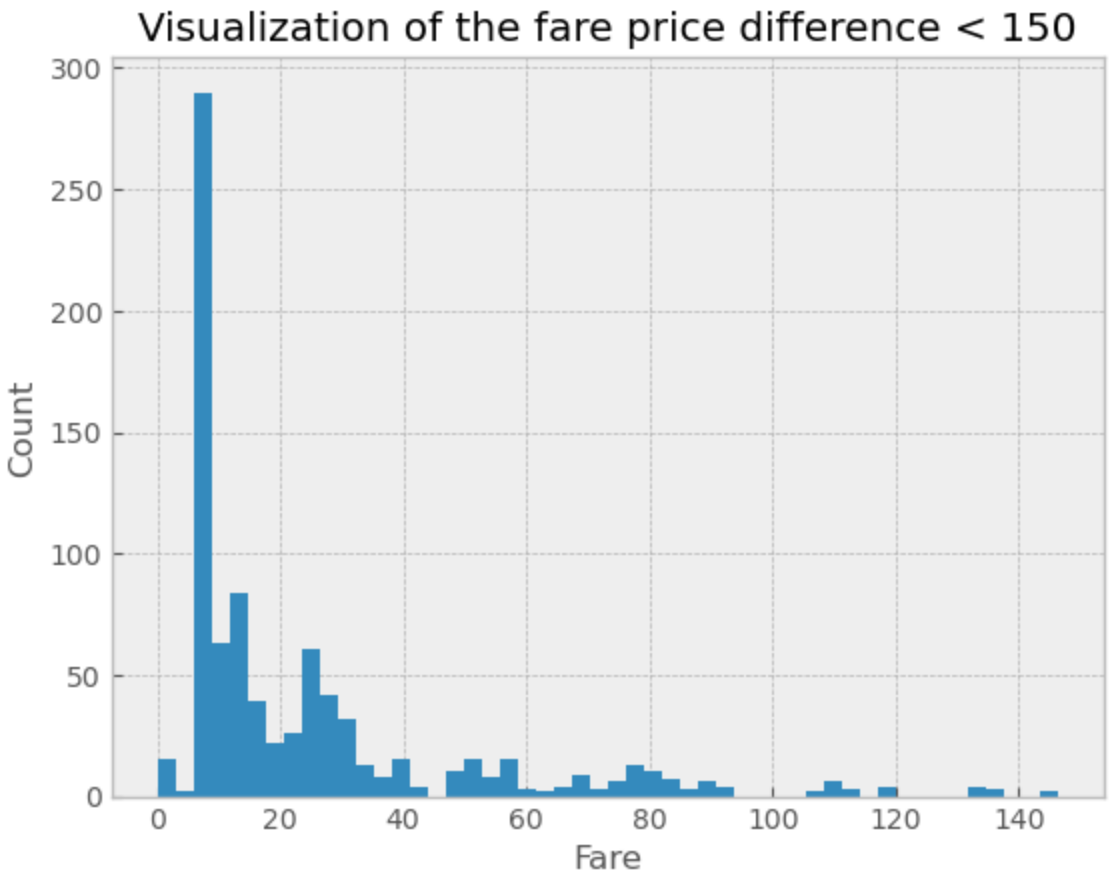
It might also be a good idea to plot a histogram over the data, to get a better understanding of how the data looks. This can be done using the function *hist* from matplotlib.

In [ ]:
```
fare = df["Fare"]
plt.hist(fare)
plt.xlabel("Fare")
plt.title("Visualization of the fare difference")
plt.show()
```



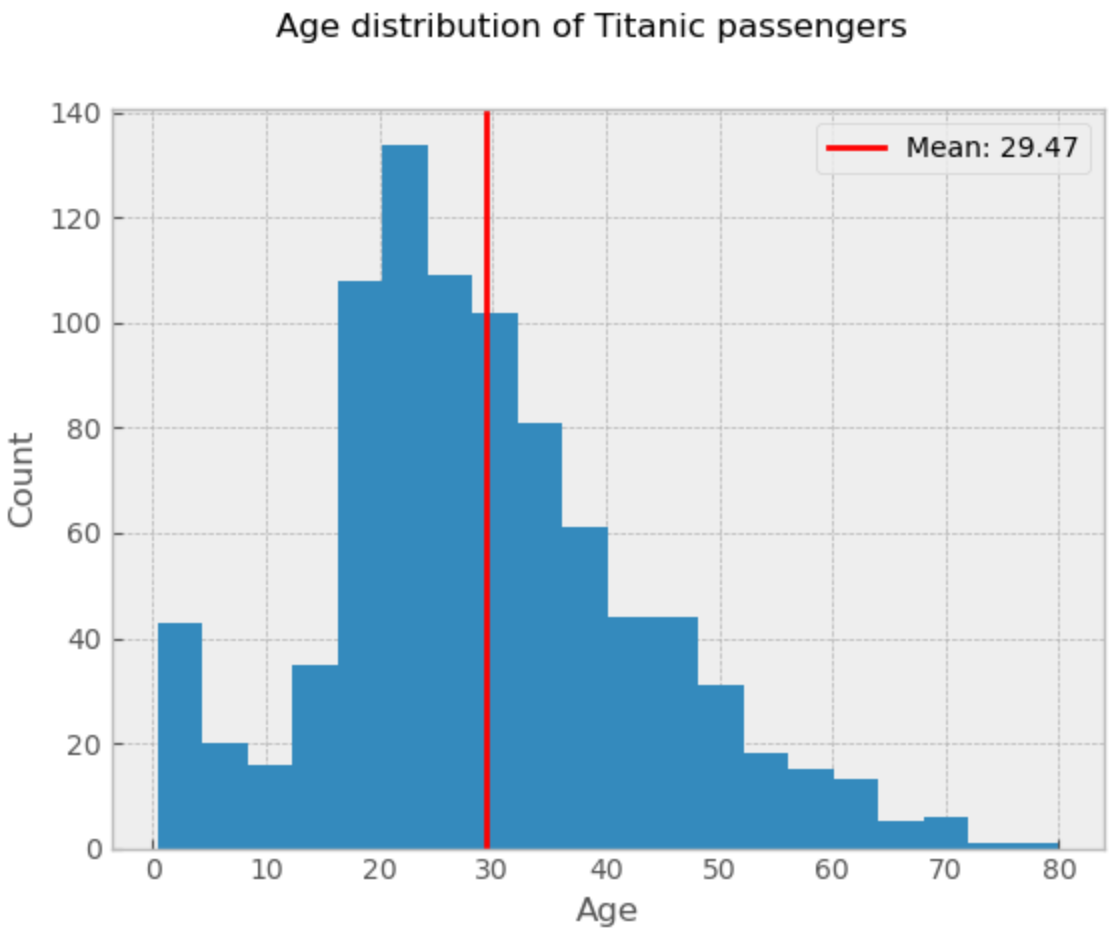
As you can see, most of the people paid less than 150 for the ticket.

In [ ]:
```
# ASSIGNMENT:
# Plot a histogram over the people who paid less than, or equal to, 150.
# label the plot and the axes appropriately

# YOUR CODE HERE

fare = df["Fare"].where(df["Fare"]<= 150)
plt.hist(fare,bins=50) # I experimented a bit with number of bins, and found
plt.xlabel("Fare")
plt.ylabel("Count")
plt.title("Visualization of the fare price difference < 150")
plt.show()
```



Assignment j)

In [ ]:
```
# ASSIGNMENT:
# plot a histogram over all the ages with 20 bins. Draw a vertical line at t
# label the plot and the axes appropriately

# YOUR CODE HERE
ages = df.Age
mean = ages.mean()

plt.hist(ages, bins=20)
plt.axvline(mean,color='r',label=f"Mean: {mean:.2f}")
plt.xlabel("Age")
plt.ylabel("Count")
plt.suptitle("Age distribution of Titanic passengers")
plt.legend()
plt.show()
```

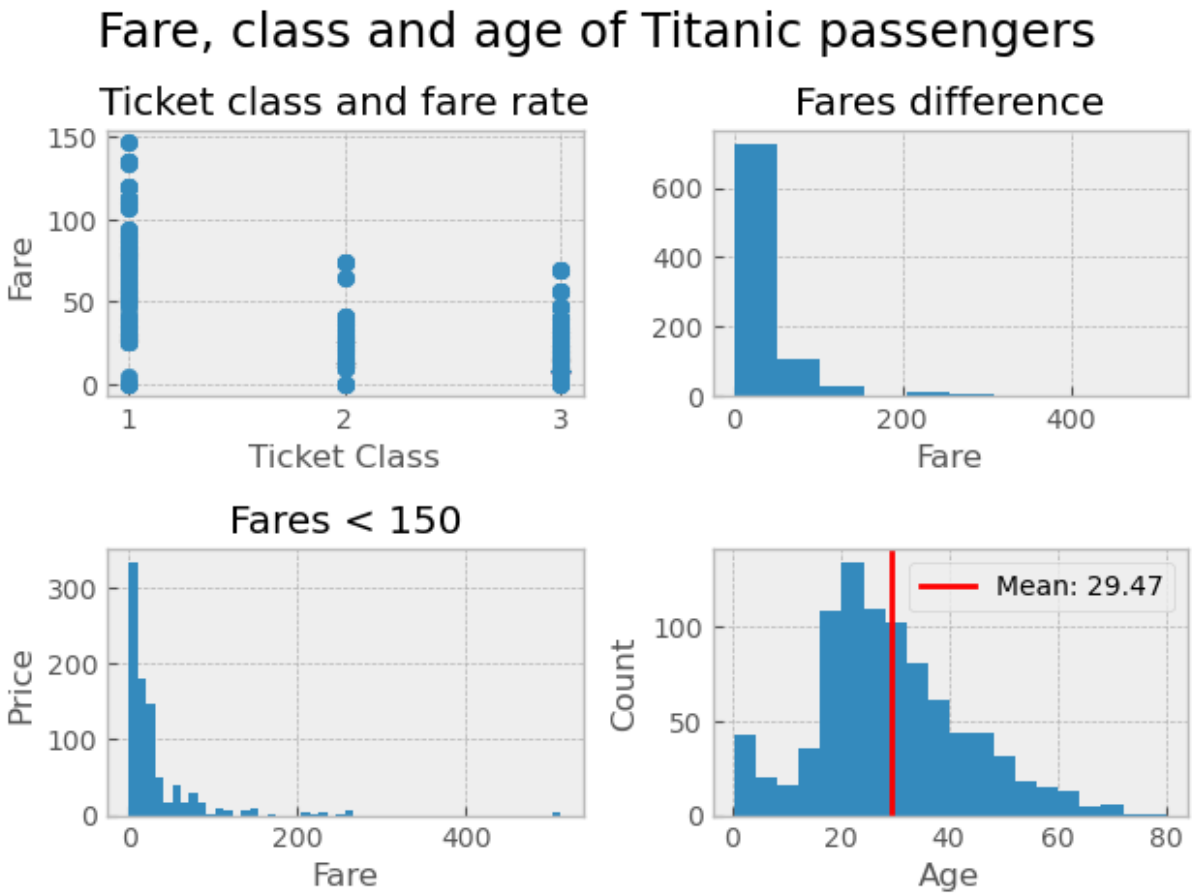


Assignment k)

Sometimes it is better to plot the figures together in one figure instead. This can be done with subplot, as shown in the examples above.

In [ ]:
```
# ASSIGNMENT:
# Make a subplot over the Fare, Class, and Age
# label the plot and the axes appropriately

# YOUR CODE HERE
fig = plt.figure()
fig.suptitle("Fare, class and age of Titanic passengers", fontsize=18)

ax1 = fig.add_subplot(2,2,1)
ax1.scatter(tic_class, fare)
ax1.set_xlabel("Ticket Class")
ax1.set_ylabel("Fare")
ax1.set_xticks((1,2,3)) # Since it makes no sense to have continuous values
ax1.set_title("Ticket class and fare rate")

ax2 = fig.add_subplot(2,2,2)
fare = df["Fare"]
ax2.hist(fare)
ax2.set_xlabel("Fare")
ax2.set_title("Fares difference")
```

```
ax3 = fig.add_subplot(2,2,3)
ax3.hist(fare,bins=50) # I experimented a bit with number of bins, and found
ax3.set_xlabel("Fare")
ax3.set_ylabel("Price")
ax3.set_title("Fares < 150")

ax4 = fig.add_subplot(2,2,4)
ax4.hist(ages, bins=20)
ax4.axvline(mean,color='r',label=f"Mean: {mean:.2f}")
ax4.set_xlabel("Age")
ax4.set_ylabel("Count")

fig.tight_layout() # comment out this line to see the difference
fig.subplots_adjust(top=0.85)
plt.legend()
plt.show()
```

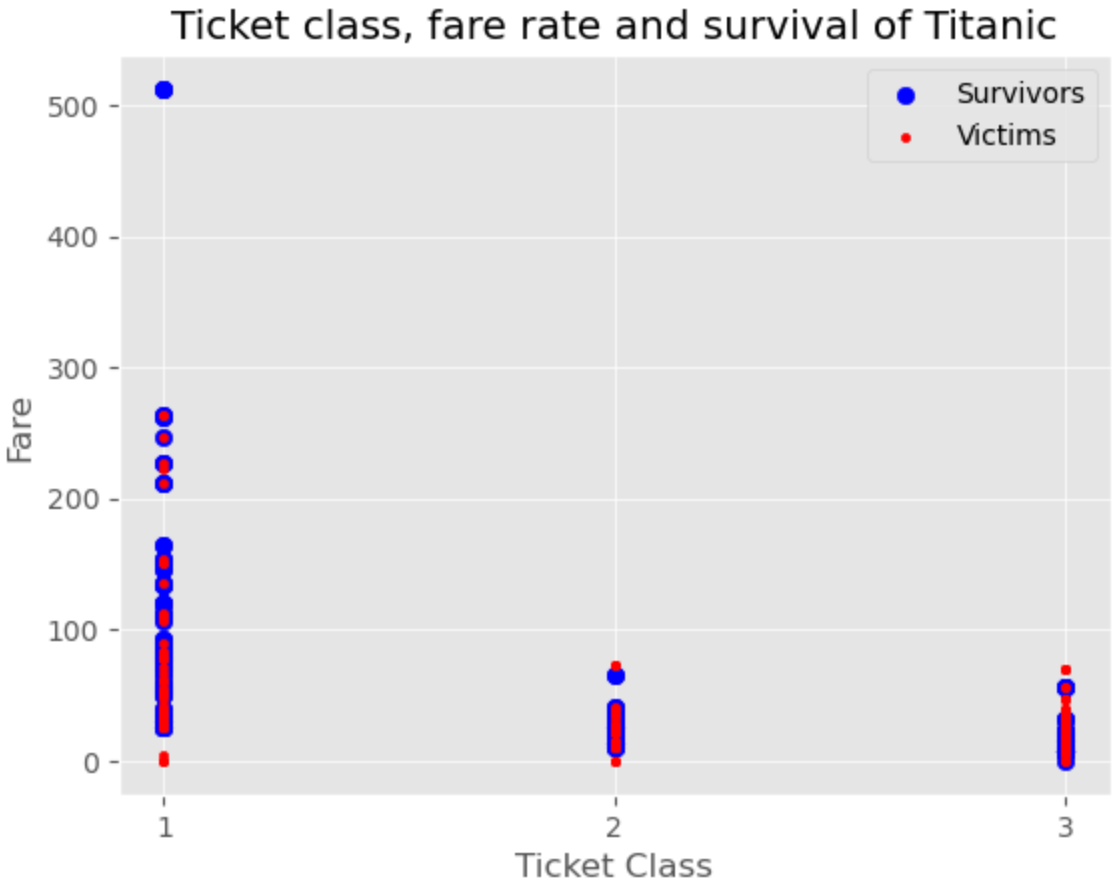


Assignment l)

Now we want to compare the fare and class, as we did before, but this time we want to divide them into two colors, depending on if they survived or not.

In [ ]:
```
# ASSIGNMENT:
# Make a scatter plot with fare on the y-axis
# and class on the x-axis
# using red dots for all the people who died
# and blue dots for the people who survived.
```

```
# use different markers for the survived and died points
# label the plot and the axes appropriately

# YOUR CODE HERE
survivors = df[df["Survived"].isin([1])]
victims = df[df["Survived"].isin([0])]

plt.scatter(survivors.Pclass, survivors.Fare, c='blue', marker='o',label="Su
plt.scatter(victims.Pclass, victims.Fare, c='red', marker='.',label="Victims
plt.xticks((1,2,3))

plt.xlabel("Ticket Class")
plt.ylabel("Fare")
plt.xticks((1,2,3)) # Since it makes no sense to have continuous values
plt.title("Ticket class, fare rate and survival of Titanic")

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

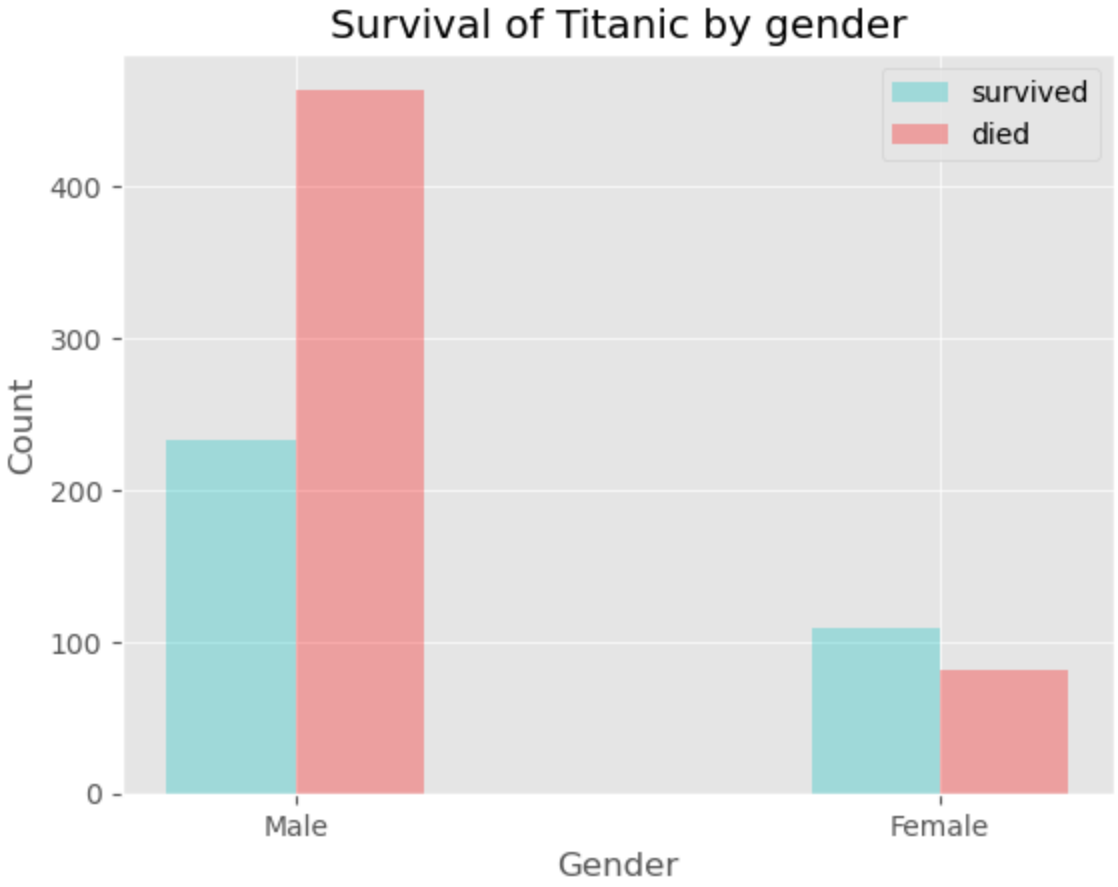


Assignment m)

It might also be interesting to visualize how many of the men and women survived. This can be done with the bar function, which will be given to you.

In [ ]:
```
# ASSIGNMENT:
# Calculate how many women and men died and survived.
# label the plot and the axes appropriately
```

```
# YOUR CODE HERE
female_survived, male_survived = df[df["Survived"].isin([1])]["Sex"].value_c
female_died, male_died = df[df["Survived"].isin([0])]["Sex"].value_counts()

plt.bar([0.9,1.9], [female_survived, male_survived] , color='c', label='surv
plt.bar([1.1, 2.1], [female_died, male_died] , color='r', label='died', widt
plt.xticks([1,2], ['Male','Female']) # Switched the order, as the given code
plt.xlabel("Gender")
plt.ylabel("Count")
plt.title("Survival of Titanic by gender")
plt.legend()
plt.show()
```



OPTIONAL:
Plotting a Histogram of Random values

Your task is to generate 10000 random numbers that follows the normal distribution, with a mean, $\mu = 1$, and variance $\sigma^2 = 0.25$.

Plot the **normalized** histogram with 50 bars and a contour plot.

In [ ]:
```
import numpy as np
import matplotlib.pyplot as plt

plt.style.use('ggplot')
np.random.seed(42)
```

```
# OPTIONAL ASSIGNMENT:
# Draw 10000 random values from a normal distribution with:
#   mu = 1, sigma2 = 0.25
#
# Plot the histogram and cumulative distribution
# label the plot and the axes appropriately

mu = 1
sigma = 0.5 # as sigma² = 0.25
count = 10000
# YOUR CODE HERE
rs = pd.DataFrame(data=np.random.normal(loc=mu, scale=sigma, size=count))
rs_norm = (rs-rs.mean())/rs.std()
fig, (ax1,ax2) = plt.subplots(2,1)
fig.suptitle("Random numbers distribution")
ax1.hist(rs_norm,50)
ax1.set_xlabel("$\sigma$ standard deviations")
ax1.set_ylabel("Count")

ax2.plot(sorted(rs.to_numpy()))
ax2.set_title("Cumulative distribution")
ax2.set_xlabel("Sample number")
ax2.set_ylabel("Value")

plt.tight_layout()
plt.show()
```