# Tutorial 2

## Outline

- Simulated Annealing (for HW#2)
- Pandas
- Numba

## Simulated Annealing

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

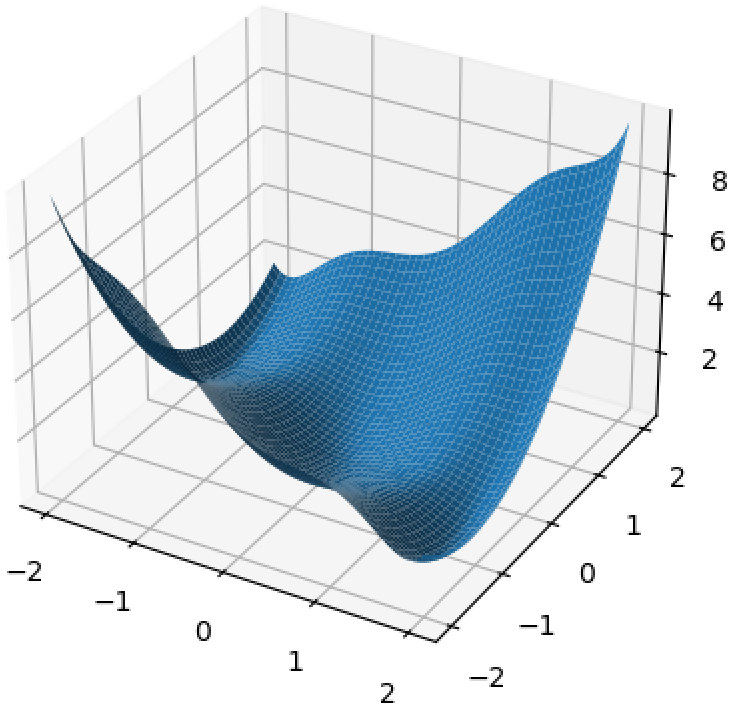

def Camel(X):
    x, y = X
    return 2 * x**2 - 1.05 * x**4 + x**6 / 6 + x * y + y**2

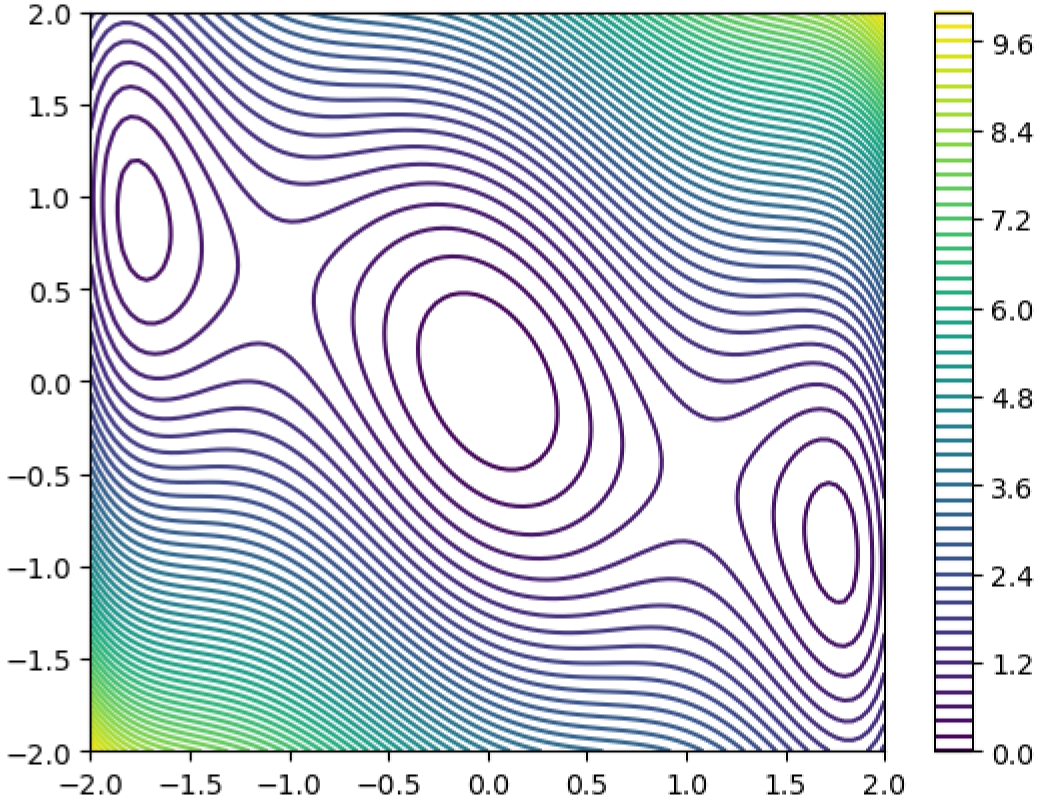
def plot_surface(func, x_min=-2, x_max=2, y_min=-2, y_max=2):
    a = np.linspace(x_min, x_max, 100)
    b = np.linspace(y_min, y_max, 100)
    x,y = np.meshgrid(a, b)
    z = func((x, y))
    fig = plt.figure()
    ax = fig.add_subplot(projection='3d')
    ax.plot_surface(x, y, z)

plot_surface(Camel)

def draw_path(func, path=None, x_min=-2, x_max=2, y_min=-2, y_max=2):
    a = np.linspace(x_min, x_max, 100)
    b = np.linspace(y_min, y_max, 100)
    x, y = np.meshgrid(a, b)
    z = func((x, y))
    fig, ax = plt.subplots()
    contour = ax.contour(x, y, z, 50)
    plt.colorbar(contour)
    if path:
        ax.plot(path[:, 0], path[:, 1], color='red')
        print(len(path))

draw_path(Camel)
```





No description has been provided for this image

- Random Displacement:

$$X_{i+1} = X_i + \Delta * (2 * \mathrm{URN} - 1)$$

- Metropolis Rule:

$$P(\text{accept}) = \exp\left(-\frac{\Delta E}{T}\right)$$

In [2]:
```
def SA(solution, func, schedule, delta, boundary, n_iter, report_interval=None):
    """
    Simulated Annealing for minimization

    Parameters
    ----------
    solution: np.ndarray
        Initial guess
    func: Callable
        Function to minimize
    schedule: np.ndarray
        An array of temperatures for simulated annealing
    delta: float
        Magnitude of random displacement
    boundary: tuple
        Boundary of the variables to minimize. (lowerbound,upperbound)
    n_iter: int
        Number of random displacement move in each temperature
    report_interavl: int
        Number of temperature steps to report result

    Returns
    -------
    res: dict
        Minimized point and its evaulation value
    """

    best_solution = solution.copy()
    lowest_eval = func(best_solution)

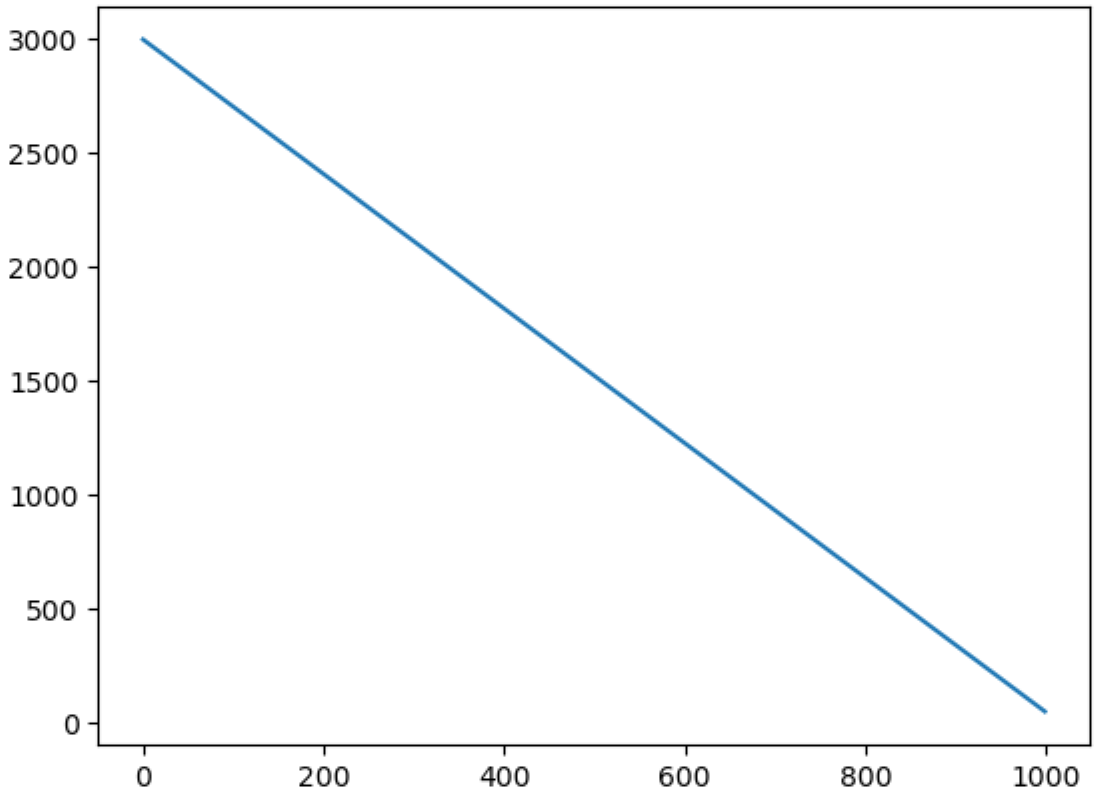
    for idx, temp in enumerate(schedule):
        if report_interval is not None and ((idx + 1) % report_interval == 0 or idx
            msg = (
                f"{idx + 1}/{len(schedule)}, Temp: {temp:.2f}, "
                f"Best solution: {best_solution}, Value: {lowest_eval:.7f}"
            )
            print(msg)

        for n in range(n_iter):
            trial = solution.copy()
            trial += delta * (2 * np.random.random(trial.shape) - 1)
            if np.all(trial >= boundary[0]) and np.all(trial <= boundary[1]):
                # fill in acceptance criterion
                if np.exp(-(func(trial) - func(solution)) / temp) > np.random.rando
                    solution = trial
                    if func(solution) < lowest_eval:
                        # update solution here
                        best_solution = solution.copy()
                        lowest_eval = func(best_solution)
    return {"solution":best_solution, "evaluation":lowest_eval}
```

Try linear cooling

In [3]:
```
linear_cooling = np.linspace(3000, 50, 1000)
plt.plot(linear_cooling)
```

Out[3]:
```
[<matplotlib.lines.Line2D at 0x1a54d604710>]
```



In [4]:
```
# Start from a point which is close to local minimum
starting_point = np.array([-1.7, 0.7])
SA(starting_point, Camel, linear_cooling, 0.1, (-2, 2), 5, 100)
```

```
1/1000, Temp: 3000.00, Best solution: [-1.7  0.7], Value: 0.3332232
100/1000, Temp: 2707.66, Best solution: [ 0.02742354 -0.38066902], Value: 0.1359731
200/1000, Temp: 2412.36, Best solution: [0.08827732 0.04828203], Value: 0.0221154
300/1000, Temp: 2117.07, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
400/1000, Temp: 1821.77, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
500/1000, Temp: 1526.48, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
600/1000, Temp: 1231.18, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
700/1000, Temp: 935.89, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
800/1000, Temp: 640.59, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
900/1000, Temp: 345.30, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
1000/1000, Temp: 50.00, Best solution: [ 0.01358763 -0.03255679], Value: 0.0009868
```

Out[4]:
```
{'solution': array([ 0.01358763, -0.03255679]),
 'evaluation': 0.000986786501804797}
```

In [5]:
```
# Local minimization methods fail to find the global minimum
from scipy.optimize import minimize
```

```
minimize(Camel, starting_point, method="BFGS")
```

Out[5]:
```
  message: Optimization terminated successfully.
  success: True
   status: 0
      fun: 0.298638442236861
        x: [-1.748e+00  8.738e-01]
      nit: 5
      jac: [ 3.129e-07 -7.451e-09]
 hess_inv: [[ 8.564e-02 -4.261e-02]
            [-4.261e-02  5.250e-01]]
     nfev: 21
     njev: 7
```

## Pandas

- Documentation

In [6]:
```
import pandas as pd
```

```
C:\Users\artui\AppData\Local\Temp\ipykernel_12292\4080736814.py:1: DeprecationWarnin
g:
Pyarrow will become a required dependency of pandas in the next major release of pan
das (pandas 3.0),
(to allow more performant data types, such as the Arrow string type, and better inte
roperability with other libraries)
but was not found to be installed on your system.
If this would cause problems for you,
please provide us feedback at https://github.com/pandas-dev/pandas/issues/54466

  import pandas as pd
```

### Read CSV file

In [7]:
```
df = pd.read_csv("Datasets/titanic.csv")
print(type(df))
df
```

```
<class 'pandas.core.frame.DataFrame'>
```

Out[7]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | F |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1 | 0 | 3 | Braund, Mr. Owen Harris | male | 22.0 | 1 | 0 | A/5 21171 | 7.2 |
| **1** | 2 | 1 | 1 | Cumings, Mrs. John Bradley (Florence Briggs Th... | female | 38.0 | 1 | 0 | PC 17599 | 71.2 |
| **2** | 3 | 1 | 3 | Heikkinen, Miss. Laina | female | 26.0 | 0 | 0 | STON/O2. 3101282 | 7.9 |
| **3** | 4 | 1 | 1 | Futrelle, Mrs. Jacques Heath (Lily May Peel) | female | 35.0 | 1 | 0 | 113803 | 53.1 |
| **4** | 5 | 0 | 3 | Allen, Mr. William Henry | male | 35.0 | 0 | 0 | 373450 | 8.0 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| **886** | 887 | 0 | 2 | Montvila, Rev. Juozas | male | 27.0 | 0 | 0 | 211536 | 13.0 |
| **887** | 888 | 1 | 1 | Graham, Miss. Margaret Edith | female | 19.0 | 0 | 0 | 112053 | 30.0 |
| **888** | 889 | 0 | 3 | Johnston, Miss. Catherine Helen "Carrie" | female | NaN | 1 | 2 | W./C. 6607 | 23.4 |
| **889** | 890 | 1 | 1 | Behr, Mr. Karl Howell | male | 26.0 | 0 | 0 | 111369 | 30.0 |
| **890** | 891 | 0 | 3 | Dooley, Mr. Patrick | male | 32.0 | 0 | 0 | 370376 | 7.7 |

891 rows × 12 columns

In [8]:
```
df.head(40)
```

Out[8]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1 | 0 | 3 | Braund, Mr. Owen Harris | male | 22.0 | 1 | 0 | A/5 21171 | 7 |
| **1** | 2 | 1 | 1 | Cumings, Mrs. John Bradley (Florence Briggs Th... | female | 38.0 | 1 | 0 | PC 17599 | 71 |
| **2** | 3 | 1 | 3 | Heikkinen, Miss. Laina | female | 26.0 | 0 | 0 | STON/O2. 3101282 | 7 |
| **3** | 4 | 1 | 1 | Futrelle, Mrs. Jacques Heath (Lily May Peel) | female | 35.0 | 1 | 0 | 113803 | 53 |
| **4** | 5 | 0 | 3 | Allen, Mr. William Henry | male | 35.0 | 0 | 0 | 373450 | 8 |
| **5** | 6 | 0 | 3 | Moran, Mr. James | male | NaN | 0 | 0 | 330877 | 8 |
| **6** | 7 | 0 | 1 | McCarthy, Mr. Timothy J | male | 54.0 | 0 | 0 | 17463 | 51 |
| **7** | 8 | 0 | 3 | Palsson, Master. Gosta Leonard | male | 2.0 | 3 | 1 | 349909 | 21 |
| **8** | 9 | 1 | 3 | Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg) | female | 27.0 | 0 | 2 | 347742 | 11 |
| **9** | 10 | 1 | 2 | Nasser, Mrs. Nicholas (Adele Achem) | female | 14.0 | 1 | 0 | 237736 | 30 |
| **10** | 11 | 1 | 3 | Sandstrom, Miss. Marguerite Rut | female | 4.0 | 1 | 1 | PP 9549 | 16 |
| **11** | 12 | 1 | 1 | Bonnell, Miss. Elizabeth | female | 58.0 | 0 | 0 | 113783 | 26 |
| **12** | 13 | 0 | 3 | Saundercock, Mr. William Henry | male | 20.0 | 0 | 0 | A/5. 2151 | 8 |

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | |
|---|---|---|---|---|---|---|---|---|---|---|
| **13** | 14 | 0 | 3 | Andersson, Mr. Anders Johan | male | 39.0 | 1 | 5 | 347082 | 31 |
| **14** | 15 | 0 | 3 | Vestrom, Miss. Hulda Amanda Adolfina | female | 14.0 | 0 | 0 | 350406 | 7 |
| **15** | 16 | 1 | 2 | Hewlett, Mrs. (Mary D Kingcome) | female | 55.0 | 0 | 0 | 248706 | 16 |
| **16** | 17 | 0 | 3 | Rice, Master. Eugene | male | 2.0 | 4 | 1 | 382652 | 29 |
| **17** | 18 | 1 | 2 | Williams, Mr. Charles Eugene | male | NaN | 0 | 0 | 244373 | 13 |
| **18** | 19 | 0 | 3 | Vander Planke, Mrs. Julius (Emelia Maria Vande... | female | 31.0 | 1 | 0 | 345763 | 18 |
| **19** | 20 | 1 | 3 | Masselmani, Mrs. Fatima | female | NaN | 0 | 0 | 2649 | 7 |
| **20** | 21 | 0 | 2 | Fynney, Mr. Joseph J | male | 35.0 | 0 | 0 | 239865 | 26 |
| **21** | 22 | 1 | 2 | Beesley, Mr. Lawrence | male | 34.0 | 0 | 0 | 248698 | 13 |
| **22** | 23 | 1 | 3 | McGowan, Miss. Anna "Annie" | female | 15.0 | 0 | 0 | 330923 | 8 |
| **23** | 24 | 1 | 1 | Sloper, Mr. William Thompson | male | 28.0 | 0 | 0 | 113788 | 35 |
| **24** | 25 | 0 | 3 | Palsson, Miss. Torborg Danira | female | 8.0 | 3 | 1 | 349909 | 21 |
| **25** | 26 | 1 | 3 | Asplund, Mrs. Carl Oscar (Selma Augusta Emilia... | female | 38.0 | 1 | 5 | 347077 | 31 |
| **26** | 27 | 0 | 3 | Emir, Mr. Farred | male | NaN | 0 | 0 | 2631 | 7 |

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Chehab | | | | | | |
| **27** | 28 | 0 | 1 | Fortune, Mr. Charles Alexander | male | 19.0 | 3 | 2 | 19950 | 263 |
| **28** | 29 | 1 | 3 | O'Dwyer, Miss. Ellen "Nellie" | female | NaN | 0 | 0 | 330959 | 7 |
| **29** | 30 | 0 | 3 | Todoroff, Mr. Lalio | male | NaN | 0 | 0 | 349216 | 7 |
| **30** | 31 | 0 | 1 | Uruchurtu, Don. Manuel E | male | 40.0 | 0 | 0 | PC 17601 | 27 |
| **31** | 32 | 1 | 1 | Spencer, Mrs. William Augustus (Marie Eugenie) | female | NaN | 1 | 0 | PC 17569 | 146 |
| **32** | 33 | 1 | 3 | Glynn, Miss. Mary Agatha | female | NaN | 0 | 0 | 335677 | 7 |
| **33** | 34 | 0 | 2 | Wheadon, Mr. Edward H | male | 66.0 | 0 | 0 | C.A. 24579 | 10 |
| **34** | 35 | 0 | 1 | Meyer, Mr. Edgar Joseph | male | 28.0 | 1 | 0 | PC 17604 | 82 |
| **35** | 36 | 0 | 1 | Holverson, Mr. Alexander Oskar | male | 42.0 | 1 | 0 | 113789 | 52 |
| **36** | 37 | 1 | 3 | Mamee, Mr. Hanna | male | NaN | 0 | 0 | 2677 | 7 |
| **37** | 38 | 0 | 3 | Cann, Mr. Ernest Charles | male | 21.0 | 0 | 0 | A./5. 2152 | 8 |
| **38** | 39 | 0 | 3 | Vander Planke, Miss. Augusta Maria | female | 18.0 | 2 | 0 | 345764 | 18 |
| **39** | 40 | 1 | 3 | Nicola-Yarred, Miss. Jamila | female | 14.0 | 1 | 0 | 2651 | 11 |

In [9]:
```
df.tail(10)
```

Out[9]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | |
|---|---|---|---|---|---|---|---|---|---|---|
| **881** | 882 | 0 | 3 | Markun, Mr. Johann | male | 33.0 | 0 | 0 | 349257 | 7. |
| **882** | 883 | 0 | 3 | Dahlberg, Miss. Gerda Ulrika | female | 22.0 | 0 | 0 | 7552 | 10. |
| **883** | 884 | 0 | 2 | Banfield, Mr. Frederick James | male | 28.0 | 0 | 0 | C.A./SOTON 34068 | 10. |
| **884** | 885 | 0 | 3 | Sutehall, Mr. Henry Jr | male | 25.0 | 0 | 0 | SOTON/OQ 392076 | 7. |
| **885** | 886 | 0 | 3 | Rice, Mrs. William (Margaret Norton) | female | 39.0 | 0 | 5 | 382652 | 29. |
| **886** | 887 | 0 | 2 | Montvila, Rev. Juozas | male | 27.0 | 0 | 0 | 211536 | 13. |
| **887** | 888 | 1 | 1 | Graham, Miss. Margaret Edith | female | 19.0 | 0 | 0 | 112053 | 30. |
| **888** | 889 | 0 | 3 | Johnston, Miss. Catherine Helen "Carrie" | female | NaN | 1 | 2 | W./C. 6607 | 23. |
| **889** | 890 | 1 | 1 | Behr, Mr. Karl Howell | male | 26.0 | 0 | 0 | 111369 | 30. |
| **890** | 891 | 0 | 3 | Dooley, Mr. Patrick | male | 32.0 | 0 | 0 | 370376 | 7. |

## Drop columns

In [10]:
```
df2 = df.drop(['Cabin'], axis=1, inplace=True)
```

## Drop NaN values

Drop the rows where at least one element is missing

```
In [11]: df.dropna()
```

Out[11]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | Fa |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1 | 0 | 3 | Braund, Mr. Owen Harris | male | 22.0 | 1 | 0 | A/5 21171 | 7.25 |
| **1** | 2 | 1 | 1 | Cumings, Mrs. John Bradley (Florence Briggs Th... | female | 38.0 | 1 | 0 | PC 17599 | 71.28 |
| **2** | 3 | 1 | 3 | Heikkinen, Miss. Laina | female | 26.0 | 0 | 0 | STON/O2. 3101282 | 7.92 |
| **3** | 4 | 1 | 1 | Futrelle, Mrs. Jacques Heath (Lily May Peel) | female | 35.0 | 1 | 0 | 113803 | 53.10 |
| **4** | 5 | 0 | 3 | Allen, Mr. William Henry | male | 35.0 | 0 | 0 | 373450 | 8.05 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| **885** | 886 | 0 | 3 | Rice, Mrs. William (Margaret Norton) | female | 39.0 | 0 | 5 | 382652 | 29.12 |
| **886** | 887 | 0 | 2 | Montvila, Rev. Juozas | male | 27.0 | 0 | 0 | 211536 | 13.00 |
| **887** | 888 | 1 | 1 | Graham, Miss. Margaret Edith | female | 19.0 | 0 | 0 | 112053 | 30.00 |
| **889** | 890 | 1 | 1 | Behr, Mr. Karl Howell | male | 26.0 | 0 | 0 | 111369 | 30.00 |
| **890** | 891 | 0 | 3 | Dooley, Mr. Patrick | male | 32.0 | 0 | 0 | 370376 | 7.75 |

712 rows × 11 columns

Drop the columns where at least one element is missing.

```
In [12]: df.dropna(axis=1) # or axis='columns'
```

Out[12]:

| | PassengerId | Survived | Pclass | Name | Sex | SibSp | Parch | Ticket | Fare |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 1 | 0 | 3 | Braund, Mr. Owen Harris | male | 1 | 0 | A/5 21171 | 7.2500 |
| **1** | 2 | 1 | 1 | Cumings, Mrs. John Bradley (Florence Briggs Th... | female | 1 | 0 | PC 17599 | 71.2833 |
| **2** | 3 | 1 | 3 | Heikkinen, Miss. Laina | female | 0 | 0 | STON/O2. 3101282 | 7.9250 |
| **3** | 4 | 1 | 1 | Futrelle, Mrs. Jacques Heath (Lily May Peel) | female | 1 | 0 | 113803 | 53.1000 |
| **4** | 5 | 0 | 3 | Allen, Mr. William Henry | male | 0 | 0 | 373450 | 8.0500 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **886** | 887 | 0 | 2 | Montvila, Rev. Juozas | male | 0 | 0 | 211536 | 13.0000 |
| **887** | 888 | 1 | 1 | Graham, Miss. Margaret Edith | female | 0 | 0 | 112053 | 30.0000 |
| **888** | 889 | 0 | 3 | Johnston, Miss. Catherine Helen "Carrie" | female | 1 | 2 | W./C. 6607 | 23.4500 |
| **889** | 890 | 1 | 1 | Behr, Mr. Karl Howell | male | 0 | 0 | 111369 | 30.0000 |
| **890** | 891 | 0 | 3 | Dooley, Mr. Patrick | male | 0 | 0 | 370376 | 7.7500 |

891 rows × 9 columns

Define in which columns to look for missing values.

```
In [13]: df.dropna(subset=['Age'])
```

Out[13]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | Fa |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1 | 0 | 3 | Braund, Mr. Owen Harris | male | 22.0 | 1 | 0 | A/5 21171 | 7.25 |
| **1** | 2 | 1 | 1 | Cumings, Mrs. John Bradley (Florence Briggs Th... | female | 38.0 | 1 | 0 | PC 17599 | 71.28 |
| **2** | 3 | 1 | 3 | Heikkinen, Miss. Laina | female | 26.0 | 0 | 0 | STON/O2. 3101282 | 7.92 |
| **3** | 4 | 1 | 1 | Futrelle, Mrs. Jacques Heath (Lily May Peel) | female | 35.0 | 1 | 0 | 113803 | 53.10 |
| **4** | 5 | 0 | 3 | Allen, Mr. William Henry | male | 35.0 | 0 | 0 | 373450 | 8.05 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| **885** | 886 | 0 | 3 | Rice, Mrs. William (Margaret Norton) | female | 39.0 | 0 | 5 | 382652 | 29.12 |
| **886** | 887 | 0 | 2 | Montvila, Rev. Juozas | male | 27.0 | 0 | 0 | 211536 | 13.00 |
| **887** | 888 | 1 | 1 | Graham, Miss. Margaret Edith | female | 19.0 | 0 | 0 | 112053 | 30.00 |
| **889** | 890 | 1 | 1 | Behr, Mr. Karl Howell | male | 26.0 | 0 | 0 | 111369 | 30.00 |
| **890** | 891 | 0 | 3 | Dooley, Mr. Patrick | male | 32.0 | 0 | 0 | 370376 | 7.75 |

714 rows × 11 columns

## Indexing

In [14]:
```
df.loc[0, "Pclass"]
```

Out[14]:
```
3
```

In [15]:
```
df.iloc[0, 2]
```

Out[15]:
```
3
```

In [16]:
```
df[['Pclass', 'Survived']]
```

Out[16]:

| | Pclass | Survived |
|---|---|---|
| **0** | 3 | 0 |
| **1** | 1 | 1 |
| **2** | 3 | 1 |
| **3** | 1 | 1 |
| **4** | 3 | 0 |
| **...** | ... | ... |
| **886** | 2 | 0 |
| **887** | 1 | 1 |
| **888** | 3 | 0 |
| **889** | 1 | 1 |
| **890** | 3 | 0 |

891 rows × 2 columns

In [17]:
```
df[df['Survived'] == 1]
```

Out[17]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | Fa |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 2 | 1 | 1 | Cumings, Mrs. John Bradley (Florence Briggs Th... | female | 38.0 | 1 | 0 | PC 17599 | 71.28 |
| **2** | 3 | 1 | 3 | Heikkinen, Miss. Laina | female | 26.0 | 0 | 0 | STON/O2. 3101282 | 7.92 |
| **3** | 4 | 1 | 1 | Futrelle, Mrs. Jacques Heath (Lily May Peel) | female | 35.0 | 1 | 0 | 113803 | 53.1 |
| **8** | 9 | 1 | 3 | Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg) | female | 27.0 | 0 | 2 | 347742 | 11.13 |
| **9** | 10 | 1 | 2 | Nasser, Mrs. Nicholas (Adele Achem) | female | 14.0 | 1 | 0 | 237736 | 30.07 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| **875** | 876 | 1 | 3 | Najib, Miss. Adele Kiamie "Jane" | female | 15.0 | 0 | 0 | 2667 | 7.22 |
| **879** | 880 | 1 | 1 | Potter, Mrs. Thomas Jr (Lily Alexenia Wilson) | female | 56.0 | 0 | 1 | 11767 | 83.15 |
| **880** | 881 | 1 | 2 | Shelley, Mrs. William (Imanita Parrish Hall) | female | 25.0 | 0 | 1 | 230433 | 26.0 |
| **887** | 888 | 1 | 1 | Graham, Miss. | female | 19.0 | 0 | 0 | 112053 | 30.0 |

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | Fa |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Margaret Edith | | | | | | |
| **889** | 890 | 1 | 1 | Behr, Mr. Karl Howell | male | 26.0 | 0 | 0 | 111369 | 30.0( |

342 rows × 11 columns

## Other useful methods

Use `.values` attribute to get values in numpy.ndarray

In [18]:
```
df.values
```

Out[18]:
```
array([[1, 0, 3, ..., 'A/5 21171', 7.25, 'S'],
       [2, 1, 1, ..., 'PC 17599', 71.2833, 'C'],
       [3, 1, 3, ..., 'STON/O2. 3101282', 7.925, 'S'],
       ...,
       [889, 0, 3, ..., 'W./C. 6607', 23.45, 'S'],
       [890, 1, 1, ..., '111369', 30.0, 'C'],
       [891, 0, 3, ..., '370376', 7.75, 'Q']], dtype=object)
```

Use `describe()` method to get statistics

In [19]:
```
df.describe()
```

Out[19]:

| | PassengerId | Survived | Pclass | Age | SibSp | Parch | Fare |
|---|---|---|---|---|---|---|---|
| **count** | 891.000000 | 891.000000 | 891.000000 | 714.000000 | 891.000000 | 891.000000 | 891.00000( |
| **mean** | 446.000000 | 0.383838 | 2.308642 | 29.699118 | 0.523008 | 0.381594 | 32.20420 |
| **std** | 257.353842 | 0.486592 | 0.836071 | 14.526497 | 1.102743 | 0.806057 | 49.69342 |
| **min** | 1.000000 | 0.000000 | 1.000000 | 0.420000 | 0.000000 | 0.000000 | 0.00000( |
| **25%** | 223.500000 | 0.000000 | 2.000000 | 20.125000 | 0.000000 | 0.000000 | 7.91040( |
| **50%** | 446.000000 | 0.000000 | 3.000000 | 28.000000 | 0.000000 | 0.000000 | 14.45420( |
| **75%** | 668.500000 | 1.000000 | 3.000000 | 38.000000 | 1.000000 | 0.000000 | 31.00000( |
| **max** | 891.000000 | 1.000000 | 3.000000 | 80.000000 | 8.000000 | 6.000000 | 512.32920( |

Use `.index` or `.columns` get index/columns

In [20]:
```
for index in df.index:
    print(index)
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In [21]:
```
for col in df.columns:
    print(col)
```

```
PassengerId
Survived
Pclass
Name
Sex
Age
SibSp
Parch
Ticket
Fare
Embarked
```

Use `to_csv()` to export DataFrame

In [22]:
```
df.to_csv("test_export.csv")
```

Use `sort_values()` method to sort the DataFrame according to values in one column.

In [23]:
```
df.sort_values(by=["Age"], ascending=False)
```

Out[23]:

| | PassengerId | Survived | Pclass | Name | Sex | Age | SibSp | Parch | Ticket | F |
|---|---|---|---|---|---|---|---|---|---|---|
| **630** | 631 | 1 | 1 | Barkworth, Mr. Algernon Henry Wilson | male | 80.0 | 0 | 0 | 27042 | 30.0 |
| **851** | 852 | 0 | 3 | Svensson, Mr. Johan | male | 74.0 | 0 | 0 | 347060 | 7.7 |
| **493** | 494 | 0 | 1 | Artagaveytia, Mr. Ramon | male | 71.0 | 0 | 0 | PC 17609 | 49.5 |
| **96** | 97 | 0 | 1 | Goldschmidt, Mr. George B | male | 71.0 | 0 | 0 | PC 17754 | 34.6 |
| **116** | 117 | 0 | 3 | Connors, Mr. Patrick | male | 70.5 | 0 | 0 | 370369 | 7.7 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| **859** | 860 | 0 | 3 | Razi, Mr. Raihed | male | NaN | 0 | 0 | 2629 | 7.2 |
| **863** | 864 | 0 | 3 | Sage, Miss. Dorothy Edith "Dolly" | female | NaN | 8 | 2 | CA. 2343 | 69.5 |
| **868** | 869 | 0 | 3 | van Melkebeke, Mr. Philemon | male | NaN | 0 | 0 | 345777 | 9.5 |
| **878** | 879 | 0 | 3 | Laleff, Mr. Kristo | male | NaN | 0 | 0 | 349217 | 7.8 |
| **888** | 889 | 0 | 3 | Johnston, Miss. Catherine Helen "Carrie" | female | NaN | 1 | 2 | W./C. 6607 | 23.4 |

891 rows × 11 columns

## Numba

Use `pip install numba` or `conda install numba -c conda-forge` to install numba package.

Numba is a package that help users to accelerate the code.

In [24]:
```python
import numba
```

In [25]:
```python
def test():
    i = 0
    for a in range(100000):
        i += a
    return i

%timeit test()
```

```
4.98 ms ± 219 µs per loop (mean ± std. dev. of 7 runs, 100 loops each)
```

In [26]:
```python
@numba.njit()
def test():
    i = 0
    for a in range(100000):
        i += a
    return i

%timeit test()
```

```
The slowest run took 65.00 times longer than the fastest. This could mean that an in
termediate result is being cached.
1.1 µs ± 2.21 µs per loop (mean ± std. dev. of 7 runs, 1 loop each)
```