

Real Python

The pandas DataFrame: Make Working With Data Delightful

by Mirko Stojiljković  10 Comments  data-science  intermediate

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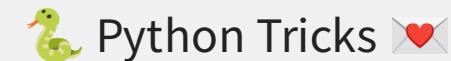


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```

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The **pandas DataFrame** is a [structure](#) that contains **two-dimensional data** and its corresponding **labels**. DataFrames are widely used in [data science](#), [machine learning](#), [scientific computing](#), and many other data-intensive fields.

DataFrames are similar to [SQL tables](#) or the spreadsheets that you work with in Excel or Calc. In many cases, DataFrames are faster, easier to use, and more powerful than tables or spreadsheets because they're an integral part of the [Python](#) and [NumPy](#) ecosystems.

In this tutorial, you'll learn:

- What a **pandas DataFrame** is and how to create one
- How to **access, modify, add, sort, filter, and delete** data
- How to handle **missing values**
- How to work with **time-series data**
- How to quickly **visualize** data

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Introducing the pandas DataFrame

pandas DataFrames are data structures that contain:

- **Data** organized in **two dimensions**, rows and columns
- **Labels** that correspond to the **rows** and **columns**

You can start working with DataFrames by [importing pandas](#):

Python

>>>

```
>>> import pandas as pd
```

Now that you have pandas imported, you can work with DataFrames.

Imagine you're using pandas to analyze data about job candidates for a position developing [web applications with Python](#). Say you're interested in the candidates' names, cities, ages, and scores on a Python programming test, or py-score:

	name	city	age	py-score
101	Xavier	Mexico City	41	88.0
102	Ann	Toronto	28	79.0
103	Jana	Prague	33	81.0
104	Yi	Shanghai	34	80.0
105	Robin	Manchester	38	68.0

106	Amal	Cairo	31	61.0
107	Nori	Osaka	37	84.0

In this table, the first row contains the **column labels** (name, city, age, and py-score). The first column holds the **row labels** (101, 102, and so on). All other cells are filled with the **data values**.

Now you have everything you need to create a pandas DataFrame.

There are several ways to create a pandas DataFrame. In most cases, you'll use the [DataFrame constructor](#) and provide the data, labels, and other information. You can pass the data as a two-dimensional [list](#), [tuple](#), or [NumPy array](#). You can also pass it as a [dictionary](#) or [pandas Series](#) instance, or as one of several other data types not covered in this tutorial.

For this example, assume you're using a [dictionary](#) to pass the data:

```
Python >>>
>>> data = {
...     'name': ['Xavier', 'Ann', 'Jana', 'Yi', 'Robin', 'Amal', 'Nori'],
...     'city': ['Mexico City', 'Toronto', 'Prague', 'Shanghai',
...              'Manchester', 'Cairo', 'Osaka'],
...     'age': [41, 28, 33, 34, 38, 31, 37],
...     'py-score': [88.0, 79.0, 81.0, 80.0, 68.0, 61.0, 84.0]
... }

>>> row_labels = [101, 102, 103, 104, 105, 106, 107]
```

data is a [Python variable](#) that refers to the dictionary that holds your candidate data. It also contains the labels of the columns:

- 'name'
- 'city'

- 'age'
- 'py-score'

Finally, `row_labels` refers to a list that contains the labels of the rows, which are numbers ranging from 101 to 107.

Now you're ready to create a pandas DataFrame:

Python

>>>

```
>>> df = pd.DataFrame(data=data, index=row_labels)
>>> df
   name      city  age  py-score
101 Xavier  Mexico City    41     88.0
102 Ann      Toronto     28     79.0
103 Jana     Prague      33     81.0
104 Yi       Shanghai    34     80.0
105 Robin   Manchester   38     68.0
106 Amal     Cairo       31     61.0
107 Nori     Osaka       37     84.0
```

That's it! `df` is a variable that holds the reference to your pandas DataFrame. This pandas DataFrame looks just like the candidate table above and has the following features:

- **Row labels** from 101 to 107
- **Column labels** such as 'name', 'city', 'age', and 'py-score'
- **Data** such as candidate names, cities, ages, and Python test scores

This figure shows the labels and data from `df`:



The row labels are outlined in blue, whereas the column labels are outlined in red, and the data values are outlined in purple.

pandas DataFrames can sometimes be very large, making it impractical to look at all the rows at once. You can use `.head()` to show the first few items and `.tail()` to show the last few items:

Python

>>>

```
>>> df.head(n=2)
      name          city  age  py-score
101  Xavier  Mexico City   41      88.0
102      Ann      Toronto   28      79.0

>>> df.tail(n=2)
      name    city  age  py-score
106  Amal    Cairo   31      61.0
107  Nori    Osaka   37      84.0
```

That's how you can show just the beginning or end of a pandas DataFrame. The parameter `n`

specifies the number of rows to show.

Note: It may be helpful to think of the pandas DataFrame as a dictionary of columns, or pandas Series, with many additional features.

You can access a column in a pandas DataFrame the same way you would get a value from a dictionary:

Python

>>>

```
>>> cities = df['city']
>>> cities
101    Mexico City
102      Toronto
103      Prague
104      Shanghai
105      Manchester
106      Cairo
107      Osaka
Name: city, dtype: object
```

This is the most convenient way to get a column from a pandas DataFrame.

If the name of the column is a string that is a valid [Python identifier](#), then you can use **dot notation** to access it. That is, you can access the column the same way you would get the [attribute of a class instance](#):

Python

>>>

```
>>> df.city  
101    Mexico City  
102      Toronto  
103      Prague  
104     Shanghai  
105   Manchester  
106      Cairo  
107      Osaka  
Name: city, dtype: object
```

That's how you get a particular column. You've extracted the column that corresponds with the label 'city', which contains the locations of all your job candidates.

It's important to notice that you've extracted both the data and the corresponding row labels:



Each column of a pandas DataFrame is an instance of `pandas.Series`, a structure that holds one-dimensional data and their labels. You can get a single item of a Series object the same way you would with a dictionary, by using its label as a key:

Python

>>>

```
>>> cities[102]  
'Toronto'
```

In this case, 'Toronto' is the data value and 102 is the corresponding label. As you'll see in [a later section](#), there are other ways to get a particular item in a pandas DataFrame.

You can also access a whole row with the `accessor .loc[]`:

Python

>>>

```
>>> df.loc[103]
name      Jana
city     Prague
age       33
py-score    81
Name: 103, dtype: object
```

This time, you've extracted the row that corresponds to the label 103, which contains the data for the candidate named Jana. In addition to the data values from this row, you've extracted the labels of the corresponding columns:



The returned row is also an instance of `pandas.Series`.

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Creating a pandas DataFrame

As already mentioned, there are several way to create a pandas DataFrame. In this section, you'll learn to do this using the `DataFrame` constructor along with:

- Python dictionaries
- Python lists
- Two-dimensional NumPy arrays
- Files

There are other methods as well, which you can learn about in the [official documentation](#).

You can start by importing pandas along with [NumPy](#), which you'll use throughout the following examples:

Python

>>>

```
>>> import numpy as np  
>>> import pandas as pd
```

That's it. Now you're ready to create some DataFrames.

Creating a pandas DataFrame With Dictionaries

As you've already seen, you can create a pandas DataFrame with a Python dictionary:

Python

>>>

```
>>> d = {'x': [1, 2, 3], 'y': np.array([2, 4, 8]), 'z': 100}

>>> pd.DataFrame(d)
   x   y    z
0  1   2  100
1  2   4  100
2  3   8  100
```

The keys of the dictionary are the DataFrame's column labels, and the dictionary values are the data values in the corresponding DataFrame columns. The values can be contained in a [tuple](#), [list](#), one-dimensional [NumPy array](#), [pandas Series object](#), or one of several other data types. You can also provide a single value that will be copied along the entire column.

It's possible to control the order of the columns with the `columns` parameter and the row labels with `index`:

Python

>>>

```
>>> pd.DataFrame(d, index=[100, 200, 300], columns=['z', 'y', 'x'])

      z   y   x
100  100   2   1
200  100   4   2
300  100   8   3
```

As you can see, you've specified the row labels 100, 200, and 300. You've also forced the order of columns: z, y, x.

Creating a pandas DataFrame With Lists

Another way to create a pandas DataFrame is to use a list of dictionaries:

Python

>>>

```
>>> l = [{x: 1, y: 2, z: 100},  
...       {x: 2, y: 4, z: 100},  
...       {x: 3, y: 8, z: 100}]  
  
>>> pd.DataFrame(l)  
   x  y    z  
0  1  2  100  
1  2  4  100  
2  3  8  100
```

Again, the dictionary keys are the column labels, and the dictionary values are the data values in the DataFrame.

You can also use a **nested** list, or a list of lists, as the data values. If you do, then it's wise to explicitly specify the labels of columns, rows, or both when you create the DataFrame:

Python

>>>

```
>>> l = [[1, 2, 100],  
...       [2, 4, 100],  
...       [3, 8, 100]]  
  
>>> pd.DataFrame(l, columns=[x, y, z])  
   x  y    z  
0  1  2  100  
1  2  4  100  
2  3  8  100
```

That's how you can use a nested list to create a pandas DataFrame. You can also use a list of tuples in the same way. To do so, just replace the nested lists in the example above with tuples.

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Creating a pandas DataFrame With NumPy Arrays

You can pass a two-dimensional NumPy array to the `DataFrame` constructor the same way you do with a list:

Python

>>>

```
>>> arr = np.array([[1, 2, 100],  
...                 [2, 4, 100],  
...                 [3, 8, 100]])  
  
>>> df_ = pd.DataFrame(arr, columns=['x', 'y', 'z'])  
>>> df_  
     x   y   z  
0   1   2  100  
1   2   4  100  
2   3   8  100
```

Although this example looks almost the same as the nested list implementation above, it has one advantage: You can specify the optional parameter `copy`.

When `copy` is set to `False` (its default setting), the data from the NumPy array isn't copied. This means that the original data from the array is assigned to the pandas DataFrame. If you modify the array, then your DataFrame will change too:

Python

>>>

```
>>> arr[0, 0] = 1000
```

```
>>> df_
```

	x	y	z
0	1000	2	100
1	2	4	100
2	3	8	100

As you can see, when you change the first item of `arr`, you also modify `df_`.

Note: Not copying data values can save you a significant amount of time and processing power when working with large datasets.

If this behavior isn't what you want, then you should specify `copy=True` in the `DataFrame` constructor. That way, `df_` will be created with a copy of the values from `arr` instead of the actual values.

Creating a pandas DataFrame From Files

You can [save and load the data and labels](#) from a pandas DataFrame to and from a number of file types, including CSV, Excel, SQL, JSON, and more. This is a very powerful feature.

You can save your job candidate DataFrame to a [CSV file](#) with `.to_csv()`:

Python

>>>

```
>>> df.to_csv('data.csv')
```

The statement above will produce a [CSV file](#) called `data.csv` in your working directory:

CSV

```
,name,city,age,py-score
101,Xavier,Mexico City,41,88.0
102,Ann,Toronto,28,79.0
103,Jana,Prague,33,81.0
104,Yi,Shanghai,34,80.0
105,Robin,Manchester,38,68.0
106,Amal,Cairo,31,61.0
107,Nori,Osaka,37,84.0
```

Now that you have a CSV file with data, you can load it with `read_csv()`:

Python

>>>

```
>>> pd.read_csv('data.csv', index_col=0)
      name          city  age  py-score
101  Xavier  Mexico City   41     88.0
102    Ann      Toronto   28     79.0
103   Jana      Prague   33     81.0
104     Yi      Shanghai   34     80.0
105   Robin  Manchester   38     68.0
106   Amal       Cairo   31     61.0
107    Nori      Osaka   37     84.0
```

That's how you get a pandas DataFrame from a file. In this case, `index_col=0` specifies that the row labels are located in the first column of the CSV file.

Retrieving Labels and Data

Now that you've created your DataFrame, you can start retrieving information from it. With pandas, you can perform the following actions:

- Retrieve and modify row and column labels as sequences
- Represent data as NumPy arrays
- Check and adjust the [data types](#)
- Analyze the size of DataFrame objects



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pandas DataFrame Labels as Sequences

You can get the DataFrame's row labels with `.index` and its column labels with `.columns`:

Python

>>>

```
>>> df.index  
Int64Index([1, 2, 3, 4, 5, 6, 7], dtype='int64')  
  
>>> df.columns  
Index(['name', 'city', 'age', 'py-score'], dtype='object')
```

Now you have the row and column labels as special kinds of sequences. As you can with any other Python sequence, you can get a single item:

Python

>>>

```
>>> df.columns[1]  
'city'
```

In addition to extracting a particular item, you can apply other sequence operations, including iterating through the labels of rows or columns. However, this is rarely necessary since pandas offers other ways to [iterate over DataFrames](#), which you'll see in [a later](#)

section.

You can also use this approach to modify the labels:

Python

>>>

```
>>> df.index = np.arange(10, 17)

>>> df.index
Int64Index([10, 11, 12, 13, 14, 15, 16], dtype='int64')

>>> df
   name      city  age  py-score
10  Xavier  Mexico City    41     88.0
11      Ann      Toronto    28     79.0
12     Jana      Prague    33     81.0
13       Yi     Shanghai    34     80.0
14    Robin  Manchester    38     68.0
15     Amal       Cairo    31     61.0
16      Nori      Osaka    37     84.0
```

In this example, you use `numpy.arange()` to generate a new sequence of row labels that holds the integers from 10 to 16. To learn more about `arange()`, check out [NumPy arange\(\): How to Use np.arange\(\)](#).

Keep in mind that if you try to modify a particular item of `.index` or `.columns`, then you'll get a [TypeError](#).

Data as NumPy Arrays

Sometimes you might want to extract data from a pandas DataFrame without its labels. To get a NumPy array with the unlabeled data, you can use either `.to_numpy()` or `.values`:

Python

>>>

```
>>> df.to_numpy()
array([['Xavier', 'Mexico City', 41, 88.0],
       ['Ann', 'Toronto', 28, 79.0],
       ['Jana', 'Prague', 33, 81.0],
       ['Yi', 'Shanghai', 34, 80.0],
       ['Robin', 'Manchester', 38, 68.0],
       ['Amal', 'Cairo', 31, 61.0],
       ['Nori', 'Osaka', 37, 84.0]], dtype=object)
```

Both `.to_numpy()` and `.values` work similarly, and they both return a NumPy array with the data from the pandas DataFrame:



The pandas documentation suggests using `.to_numpy()` because of the flexibility offered by two optional parameters:

1. **dtype**: Use this parameter to specify the data type of the resulting array. It's set to `None` by default.
2. **copy**: Set this parameter to `False` if you want to use the original data from the `DataFrame`. Set it to `True` if you want to make a copy of the data.

However, `.values` has been around for much longer than `.to_numpy()`, which was introduced in pandas version 0.24.0. That means you'll probably see `.values` more often, especially in older code.

Data Types

The **types of the data values**, also called **data types** or **dtypes**, are important because they determine the amount of memory your `DataFrame` uses, as well as its calculation speed and level of precision.

pandas relies heavily on [NumPy data types](#). However, pandas 1.0 introduced some additional types:

- `BooleanDtype` and `BooleanArray` support missing Boolean values and [Kleene three-value logic](#).
- `StringDtype` and `StringArray` represent a dedicated string type.

You can get the data types for each column of a pandas `DataFrame` with `.dtypes`:

```
Python >>>
>>> df.dtypes
name      object
city      object
age       int64
py-score   float64
```

```
dtype: object
```

As you can see, `.dtypes` returns a `Series` object with the column names as labels and the corresponding data types as values.

If you want to modify the data type of one or more columns, then you can use `.astype()`:

Python

>>>

```
>>> df_ = df.astype(dtype={'age': np.int32, 'py-score': np.float32})
>>> df_.dtypes
name      object
city      object
age      int32
py-score  float32
dtype: object
```

The most important and only mandatory parameter of `.astype()` is `dtype`. It expects a data type or dictionary. If you pass a dictionary, then the keys are the column names and the values are your desired corresponding data types.

As you can see, the data types for the columns `age` and `py-score` in the DataFrame `df` are both `int64`, which represents 64-bit (or 8-byte) integers. However, `df_` also offers a smaller, 32-bit (4-byte) integer data type called `int32`.

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pandas DataFrame Size

The attributes `.ndim`, `.size`, and `.shape` return the number of dimensions, number of data

values across each dimension, and total number of data values, respectively:

Python

```
>>> df_.ndim
```

```
2
```

```
>>> df_.shape
```

```
(7, 4)
```

```
>>> df_.size
```

```
28
```

>>>

DataFrame instances have two dimensions (rows and columns), so `.ndim` returns 2. A Series object, on the other hand, has only a single dimension, so in that case, `.ndim` would return 1.

The `.shape` attribute returns a tuple with the number of rows (in this case 7) and the number of columns (4). Finally, `.size` returns an integer equal to the number of values in the DataFrame (28).

You can even check the amount of memory used by each column with `.memory_usage()`:

Python

```
>>> df_.memory_usage()
```

```
Index      56
name       56
city       56
age        28
py-score   28
dtype: int64
```

>>>

As you can see, `.memory_usage()` returns a Series with the column names as labels and the memory usage in bytes as data values. If you want to exclude the memory usage of the column that holds the row labels, then pass the optional argument `index=False`.

In the example above, the last two columns, age and py-score, use 28 bytes of memory each. That's because these columns have seven values, each of which is an integer that takes 32 bits, or 4 bytes. Seven integers times 4 bytes each equals a total of 28 bytes of memory usage.

Accessing and Modifying Data

You've already learned how to get a particular row or column of a pandas DataFrame as a Series object:

Python

```
>>> df['name']
10    Xavier
11    Ann
12    Jana
13    Yi
14    Robin
15    Amal
16    Nori
Name: name, dtype: object

>>> df.loc[10]
name            Xavier
city      Mexico City
age             41
py-score        88
Name: 10, dtype: object
```

In the first example, you access the column name as you would access an element from a dictionary, by using its label as a key. If the column label is a valid Python identifier, then you can also use dot notation to access the column. In the second example, you use `.loc[]` to get the row by its label, 10.

Getting Data With Accessors

In addition to the accessor `.loc[]`, which you can use to get rows or columns by their labels, pandas offers the accessor `.iloc[]`, which retrieves a row or column by its integer index. In most cases, you can use either of the two:

Python

>>>

```
>>> df.loc[10]
name           Xavier
city      Mexico City
age              41
py-score        88
Name: 10, dtype: object
```

```
>>> df.iloc[0]
name           Xavier
city      Mexico City
age              41
py-score        88
Name: 0, dtype: object
```

`df.loc[10]` returns the row with the label 10. Similarly, `df.iloc[0]` returns the row with the zero-based index 0, which is the first row. As you can see, both statements return the same row as a Series object.

pandas has four accessors in total:

1. `.loc[]` accepts the labels of rows and columns and returns Series or DataFrames. You can use it to get entire rows or columns, as well as their parts.
2. `.iloc[]` accepts the zero-based indices of rows and columns and returns Series or DataFrames. You can use it to get entire rows or columns, or their parts.
3. `.at[]` accepts the labels of rows and columns and returns a single data value.

4. `.iat[]` accepts the zero-based indices of rows and columns and returns a single data value.

Of these, `.loc[]` and `.iloc[]` are particularly powerful. They support [slicing](#) and [NumPy-style indexing](#). You can use them to access a column:

Python

>>>

```
>>> df.loc[:, 'city']
10    Mexico City
11    Toronto
12    Prague
13    Shanghai
14    Manchester
15    Cairo
16    Osaka
Name: city, dtype: object
```

```
>>> df.iloc[:, 1]
10    Mexico City
11    Toronto
12    Prague
13    Shanghai
14    Manchester
15    Cairo
16    Osaka
Name: city, dtype: object
```

`df.loc[:, 'city']` returns the column `city`. The [slice](#) construct `(:)` in the row label place means that all the rows should be included. `df.iloc[:, 1]` returns the same column because the zero-based index `1` refers to the second column, `city`.

Just as you can with NumPy, you can provide slices along with lists or arrays instead of indices to get multiple rows or columns:

Python

>>>

```
>>> df.loc[11:15, ['name', 'city']]  
      name      city  
11    Ann    Toronto  
12   Jana    Prague  
13     Yi  Shanghai  
14  Robin  Manchester  
15   Amal     Cairo  
  
>>> df.iloc[1:6, [0, 1]]  
      name      city  
11    Ann    Toronto  
12   Jana    Prague  
13     Yi  Shanghai  
14  Robin  Manchester  
15   Amal     Cairo
```

Note: Don't use tuples instead of lists or integer arrays to get ordinary rows or columns. Tuples are reserved for [representing multiple dimensions in NumPy](#) and [pandas](#), as well as [hierarchical, or multi-level, indexing in pandas](#).

In this example, you use:

- **Slices** to get the rows with the labels 11 through 15, which are equivalent to the indices 1 through 5
- **Lists** to get the columns name and city, which are equivalent to the indices 0 and 1

Both statements return a pandas DataFrame with the **intersection** of the desired five rows and two columns.

This brings up a very important difference between .loc[] and .iloc[]. As you can see

from the previous example, when you pass the row labels 11:15 to `.loc[]`, you get the rows

11 through 15. However, when you pass the row indices 1:6 to `.iloc[]`, you only get the rows with the indices 1 through 5.

The reason you only get indices 1 through 5 is that, with `.iloc[]`, the **stop index** of a slice is **exclusive**, meaning it is excluded from the returned values. This is consistent with [Python sequences](#) and NumPy arrays. With `.loc[]`, however, both start and stop indices are **inclusive**, meaning they are included with the returned values.

You can skip rows and columns with `.iloc[]` the same way you can with slicing tuples, lists, and NumPy arrays:

Python

>>>

```
>>> df.iloc[1:6:2, 0]
11      Ann
13      Yi
15     Amal
Name: name, dtype: object
```

In this example, you specify the desired row indices with the slice `1:6:2`. This means that you start with the row that has the index 1 (the second row), stop before the row with the index 6 (the seventh row), and skip every second row.

Instead of using the slicing construct, you could also use the built-in Python class `slice()`, as well as `numpy.s_[]` or `pd.IndexSlice[]`:

Python

>>>

```
>>> df.iloc[slice(1, 6, 2), 0]
11      Ann
13      Yi
15     Amal
Name: name, dtype: object

>>> df.iloc[np.s_[1:6:2], 0]
11      Ann
13      Yi
15     Amal
Name: name, dtype: object

>>> df.iloc[pd.IndexSlice[1:6:2], 0]
11      Ann
13      Yi
15     Amal
Name: name, dtype: object
```

You might find one of these approaches more convenient than others depending on your situation.

It's possible to use `.loc[]` and `.iloc[]` to get particular data values. However, when you need only a single value, pandas recommends using the specialized accessors `.at[]` and `.iat[]`:

Python

>>>

```
>>> df.at[12, 'name']
'Jana'

>>> df.iat[2, 0]
'Jana'
```

Here, you used `.at[]` to get the name of a single candidate using its corresponding column and row labels. You also used `.iat[]` to retrieve the same name using its column and row indices.

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Setting Data With Accessors

You can use accessors to modify parts of a pandas DataFrame by passing a Python sequence, NumPy array, or single value:

Python

>>>

```
>>> df.loc[:, 'py-score']
10    88.0
11    79.0
12    81.0
13    80.0
14    68.0
15    61.0
16    84.0
Name: py-score, dtype: float64

>>> df.loc[:13, 'py-score'] = [40, 50, 60, 70]
>>> df.loc[14:, 'py-score'] = 0

>>> df['py-score']
10    40.0
11    50.0
12    60.0
13    70.0
14     0.0
15     0.0
16     0.0
Name: py-score, dtype: float64
```

The statement `df.loc[:13, 'py-score'] = [40, 50, 60, 70]` modifies the first four items (rows 10 through 13) in the column `py-score` using the values from your supplied list. Using `df.loc[14:, 'py-score'] = 0` sets the remaining values in this column to 0.

The following example shows that you can use negative indices with `.iloc[]` to access or modify data:

Python

>>>

```
>>> df.iloc[:, -1] = np.array([88.0, 79.0, 81.0, 80.0, 68.0, 61.0, 84.0])

>>> df['py-score']
10    88.0
11    79.0
12    81.0
13    80.0
14    68.0
15    61.0
16    84.0
Name: py-score, dtype: float64
```

In this example, you've accessed and modified the last column ('py-score'), which corresponds to the integer column index -1. This behavior is consistent with Python sequences and NumPy arrays.

Inserting and Deleting Data

pandas provides several convenient techniques for inserting and deleting rows or columns. You can choose among them based on your situation and needs.

Inserting and Deleting Rows

Imagine you want to add a new person to your list of job candidates. You can start by [creating a new Series object](#) that represents this new candidate:

Python

>>>

```
>>> john = pd.Series(data=['John', 'Boston', 34, 79],  
...                     index=df.columns, name=17)  
>>> john  
name      John  
city     Boston  
age       34  
py-score    79  
Name: 17, dtype: object  
  
>>> john.name  
17
```

The new object has labels that correspond to the column labels from df. That's why you need `index=df.columns`.

You can add john as a new row to the end of df with `.append()`:

Python

>>>

```
>>> df = df.append(john)  
>>> df  
   name      city  age  py-score  
10 Xavier  Mexico City   41     88.0  
11 Ann     Toronto    28     79.0  
12 Jana    Prague     33     81.0  
13 Yi      Shanghai   34     80.0  
14 Robin   Manchester  38     68.0  
15 Amal    Cairo      31     61.0  
16 Nori    Osaka      37     84.0  
17 John    Boston     34     79.0
```

Here, `.append()` returns the pandas DataFrame with the new row appended. Notice how

pandas uses the attribute `john.name`, which is the value 17, to specify the label for the new row.

You've appended a new row with a single call to `.append()`, and you can delete it with a single call to `.drop()`:

Python

>>>

```
>>> df = df.drop(labels=[17])
>>> df
   name      city  age  py-score
10 Xavier  Mexico City   41     88.0
11 Ann    Toronto    28     79.0
12 Jana    Prague    33     81.0
13 Yi     Shanghai   34     80.0
14 Robin  Manchester  38     68.0
15 Amal    Cairo     31     61.0
16 Nori    Osaka     37     84.0
```

Here, `.drop()` removes the rows specified with the parameter `labels`. By default, it returns the pandas DataFrame with the specified rows removed. If you pass `inplace=True`, then the original DataFrame will be modified and you'll get `None` as the return value.

Inserting and Deleting Columns

The most straightforward way to insert a column in a pandas DataFrame is to follow the same procedure that you use when you [add an item to a dictionary](#). Here's how you can append a column containing your candidates' scores on a [JavaScript](#) test:

Python

>>>

```
>>> df['js-score'] = np.array([71.0, 95.0, 88.0, 79.0, 91.0, 91.0, 80.0])
>>> df
   name      city  age  py-score  js-score
10 Xavier  Mexico City   41     88.0    71.0
11 Ann    Toronto    28     79.0    95.0
12 Jana    Prague    33     81.0    88.0
13 Yi     Shanghai   34     80.0    79.0
14 Robin  Manchester  38     68.0    91.0
15 Amal    Cairo     31     61.0    91.0
16 Nori    Osaka     37     84.0    80.0
```

Now the original DataFrame has one more column, js-score, at its end.

You don't have to provide a full sequence of values. You can add a new column with a single value:

Python

>>>

```
>>> df['total-score'] = 0.0
>>> df
   name      city  age  py-score  js-score  total-score
10 Xavier  Mexico City   41     88.0    71.0        0.0
11 Ann    Toronto    28     79.0    95.0        0.0
12 Jana    Prague    33     81.0    88.0        0.0
13 Yi     Shanghai   34     80.0    79.0        0.0
14 Robin  Manchester  38     68.0    91.0        0.0
15 Amal    Cairo     31     61.0    91.0        0.0
16 Nori    Osaka     37     84.0    80.0        0.0
```

The DataFrame df now has an additional column filled with zeros.

If you've used dictionaries in the past, then this way of inserting columns might be familiar

to you. However, it doesn't allow you to specify the location of the new column. If the location of the new column is important, then you can use `.insert()` instead:

Python

>>>

```
>>> df.insert(loc=4, column='django-score',
...             value=np.array([86.0, 81.0, 78.0, 88.0, 74.0, 70.0, 81.0]))
>>> df
   name      city  age  py-score  django-score  js-score  total-score
10 Xavier  Mexico City   41      88.0        86.0     71.0        0.0
11 Ann      Toronto    28      79.0        81.0     95.0        0.0
12 Jana     Prague     33      81.0        78.0     88.0        0.0
13 Yi       Shanghai   34      80.0        88.0     79.0        0.0
14 Robin    Manchester  38      68.0        74.0     91.0        0.0
15 Amal     Cairo      31      61.0        70.0     91.0        0.0
16 Nori     Osaka      37      84.0        81.0     80.0        0.0
```

You've just inserted another column with the score of the [Django](#) test. The parameter `loc` determines the location, or the zero-based index, of the new column in the pandas DataFrame. `column` sets the label of the new column, and `value` specifies the data values to insert.

You can delete one or more columns from a pandas DataFrame just as you would with a regular Python dictionary, by using the [del statement](#):

Python

>>>

```
>>> del df['total-score']
>>> df
   name      city  age  py-score  django-score  js-score
10 Xavier  Mexico City   41      88.0        86.0     71.0
11 Ann      Toronto    28      79.0        81.0     95.0
12 Jana     Prague     33      81.0        78.0     88.0
13 Yi       Shanghai   34      80.0        88.0     79.0
14 Robin    Manchester  38      68.0        74.0     91.0
15 Amal     Cairo      31      61.0        70.0     91.0
16 Nori     Osaka      37      84.0        81.0     80.0
```

Now you have df without the column total-score. Another similarity to dictionaries is the ability to use `.pop()`, which removes the specified column and returns it. That means you could do something like `df.pop('total-score')` instead of using `del`.

You can also remove one or more columns with `.drop()` as you did previously with the rows. Again, you need to specify the labels of the desired columns with `labels`. In addition, when you want to remove columns, you need to provide the argument `axis=1`:

Python

>>>

```
>>> df = df.drop(labels='age', axis=1)
>>> df
   name      city  py-score  django-score  js-score
10 Xavier  Mexico City      88.0        86.0      71.0
11 Ann     Toronto       79.0        81.0      95.0
12 Jana     Prague       81.0        78.0      88.0
13 Yi      Shanghai      80.0        88.0      79.0
14 Robin   Manchester     68.0        74.0      91.0
15 Amal    Cairo         61.0        70.0      91.0
16 Nori    Osaka         84.0        81.0      80.0
```

You've removed the column age from your DataFrame.

By default, `.drop()` returns the DataFrame without the specified columns unless you pass `inplace=True`.

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Applying Arithmetic Operations

You can apply basic arithmetic operations such as addition, subtraction, multiplication, and

division to pandas Series and DataFrame objects [the same way you would with NumPy arrays](#):

Python

>>>

```
>>> df['py-score'] + df['js-score']
10    159.0
11    174.0
12    169.0
13    159.0
14    159.0
15    152.0
16    164.0
dtype: float64

>>> df['py-score'] / 100
10    0.88
11    0.79
12    0.81
13    0.80
14    0.68
15    0.61
16    0.84
Name: py-score, dtype: float64
```

You can use this technique to insert a new column to a pandas DataFrame. For example, try calculating a total score as a [linear combination](#) of your candidates' Python, Django, and JavaScript scores:

Python

>>>

```
>>> df['total'] =\n...     0.4 * df['py-score'] + 0.3 * df['django-score'] + 0.3 * df['js-score']\n>>> df\n      name      city  py-score  django-score  js-score  total\n10  Xavier  Mexico City      88.0        86.0      71.0    82.3\n11      Ann      Toronto      79.0        81.0      95.0    84.4\n12     Jana      Prague      81.0        78.0      88.0    82.2\n13      Yi      Shanghai      80.0        88.0      79.0    82.1\n14     Robin   Manchester      68.0        74.0      91.0    76.7\n15     Amal       Cairo      61.0        70.0      91.0    72.7\n16     Nori       Osaka      84.0        81.0      80.0    81.9
```

Now your DataFrame has a column with a total score calculated from your candidates' individual test scores. Even better, you achieved that with just a single statement!

Applying NumPy and SciPy Functions

Most NumPy and [SciPy](#) routines can be applied to pandas Series or DataFrame objects as arguments instead of as NumPy arrays. To illustrate this, you can calculate candidates' total test scores using the NumPy routine `numpy.average()`.

Instead of passing a NumPy array to `numpy.average()`, you'll pass a part of your pandas DataFrame:

Python

>>>

```
>>> import numpy as np

>>> score = df.iloc[:, 2:5]
>>> score
   py-score  django-score  js-score
10      88.0          86.0      71.0
11      79.0          81.0      95.0
12      81.0          78.0      88.0
13      80.0          88.0      79.0
14      68.0          74.0      91.0
15      61.0          70.0      91.0
16      84.0          81.0      80.0

>>> np.average(score, axis=1,
...               weights=[0.4, 0.3, 0.3])
array([82.3, 84.4, 82.2, 82.1, 76.7, 72.7, 81.9])
```

The variable `score` now refers to the DataFrame with the Python, Django, and JavaScript scores. You can use `score` as an argument of `numpy.average()` and get the linear combination of columns with the specified weights.

But that's not all! You can use the NumPy array returned by `average()` as a new column of `df`. First, delete the existing column `total` from `df`, and then append the new one using `average()`:

Python

>>>

```
>>> del df['total']
>>> df
   name      city  py-score  django-score  js-score
10 Xavier  Mexico City      88.0        86.0      71.0
11 Ann     Toronto       79.0        81.0      95.0
12 Jana    Prague        81.0        78.0      88.0
13 Yi      Shanghai      80.0        88.0      79.0
14 Robin   Manchester     68.0        74.0      91.0
15 Amal    Cairo          61.0        70.0      91.0
16 Nori    Osaka          84.0        81.0      80.0

>>> df['total'] = np.average(df.iloc[:, 2:5], axis=1,
...                           weights=[0.4, 0.3, 0.3])
>>> df
   name      city  py-score  django-score  js-score  total
10 Xavier  Mexico City      88.0        86.0      71.0    82.3
11 Ann     Toronto       79.0        81.0      95.0    84.4
12 Jana    Prague        81.0        78.0      88.0    82.2
13 Yi      Shanghai      80.0        88.0      79.0    82.1
14 Robin   Manchester     68.0        74.0      91.0    76.7
15 Amal    Cairo          61.0        70.0      91.0    72.7
16 Nori    Osaka          84.0        81.0      80.0    81.9
```

The result is the same as in the previous example, but here you used the existing NumPy function instead of writing your own code.

Sorting a pandas DataFrame

You can sort a pandas DataFrame with `.sort_values()`:

Python

>>>

```
>>> df.sort_values(by='js-score', ascending=False)
      name      city  py-score  django-score  js-score  total
11    Ann     Toronto      79.0        81.0      95.0    84.4
14   Robin   Manchester      68.0        74.0      91.0    76.7
15   Amal      Cairo       61.0        70.0      91.0    72.7
12   Jana     Prague       81.0        78.0      88.0    82.2
16   Nori     Osaka       84.0        81.0      80.0    81.9
13     Yi    Shanghai      80.0        88.0      79.0    82.1
10 Xavier Mexico City      88.0        86.0      71.0    82.3
```

This example sorts your DataFrame by the values in the column js-score. The parameter by sets the label of the row or column to sort by. ascending specifies whether you want to sort in ascending (True) or descending (False) order, the latter being the default setting. You can pass axis to choose if you want to sort rows (axis=0) or columns (axis=1).

If you want to sort by multiple columns, then just pass lists as arguments for by and ascending:

Python

>>>

```
>>> df.sort_values(by=['total', 'py-score'], ascending=[False, False])
      name      city  py-score  django-score  js-score  total
11    Ann     Toronto      79.0        81.0      95.0    84.4
10 Xavier Mexico City      88.0        86.0      71.0    82.3
12   Jana     Prague       81.0        78.0      88.0    82.2
13     Yi    Shanghai      80.0        88.0      79.0    82.1
16   Nori     Osaka       84.0        81.0      80.0    81.9
14   Robin   Manchester      68.0        74.0      91.0    76.7
15   Amal      Cairo       61.0        70.0      91.0    72.7
```

In this case, the DataFrame is sorted by the column total, but if two values are the same, their order is determined by the values from the column py-score.

then their order is determined by the values from the column py-score.

The optional parameter `inplace` can also be used with `.sort_values()`. It's set to `False` by default, ensuring `.sort_values()` returns a new pandas DataFrame. When you set `inplace=True`, the existing DataFrame will be modified and `.sort_values()` will return `None`.

If you've ever tried to [sort values in Excel](#), then you might find the pandas approach much more efficient and convenient. When you have large amounts of data, pandas can significantly outperform Excel.

For more information on sorting in pandas, check out [pandas Sort: Your Guide to Sorting Data in Python](#).

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Filtering Data

Data filtering is another powerful feature of pandas. It works similarly to [indexing with Boolean arrays in NumPy](#).

If you apply some logical operation on a Series object, then you'll get another Series with the Boolean values `True` and `False`:

Python

>>>

```
>>> filter_ = df['django-score'] >= 80
>>> filter_
10    True
11    True
12   False
13    True
14   False
15   False
16    True
Name: django-score, dtype: bool
```

In this case, `df['django-score'] >= 80` returns `True` for those rows in which the Django score is greater than or equal to 80. It returns `False` for the rows with a Django score less than 80.

You now have the Series `filter_` filled with Boolean data. The expression `df[filter_]` returns a pandas DataFrame with the rows from `df` that correspond to `True` in `filter_`:

Python

>>>

```
>>> df[filter_]
      name      city  py-score  django-score  js-score  total
10  Xavier  Mexico City      88.0        86.0      71.0    82.3
11     Ann     Toronto      79.0        81.0      95.0    84.4
13      Yi    Shanghai      80.0        88.0      79.0    82.1
16     Nori      Osaka      84.0        81.0      80.0    81.9
```

As you can see, `filter_[10]`, `filter_[11]`, `filter_[13]`, and `filter_[16]` are `True`, so `df[filter_]` contains the rows with these labels. On the other hand, `filter_[12]`, `filter_[14]`, and `filter_[15]` are `False`, so the corresponding rows don't appear in `df[filter_]`.

You can create very powerful and sophisticated expressions by combining logical operations with the following operators:

- **NOT** (`~`)
- **AND** (`&`)
- **OR** (`|`)
- **XOR** (`^`)

For example, you can get a DataFrame with the candidates whose py-score and js-score are greater than or equal to 80:

Python

>>>

```
>>> df[(df['py-score'] >= 80) & (df['js-score'] >= 80)]  
    name     city   py-score  django-score  js-score  total  
12  Jana    Prague      81.0          78.0      88.0    82.2  
16  Nori    Osaka       84.0          81.0      80.0    81.9
```

The expression `(df['py-score'] >= 80) & (df['js-score'] >= 80)` returns a Series with `True` in the rows for which both py-score and js-score are greater than or equal to 80 and `False` in the others. In this case, only the rows with the labels 12 and 16 satisfy both conditions.

You can also apply [NumPy logical routines](#) instead of operators.

For some operations that require data filtering, it's more convenient to use `.where()`. It replaces the values in the positions where the provided condition isn't satisfied:

Python

>>>

```
>>> df['django-score'].where(cond=df['django-score'] >= 80, other=0.0)
10    86.0
11    81.0
12    0.0
13    88.0
14    0.0
15    0.0
16    81.0
Name: django-score, dtype: float64
```

In this example, the condition is `df['django-score'] >= 80`. The values of the DataFrame or Series that calls `.where()` will remain the same where the condition is True and will be replaced with the value of `other` (in this case `0.0`) where the condition is False.

Determining Data Statistics

pandas provides many [statistical methods](#) for DataFrames. You can get basic statistics for the numerical columns of a pandas DataFrame with `.describe()`:

Python

>>>

```
>>> df.describe()
            py-score  django-score    js-score      total
count    7.000000     7.000000    7.000000    7.000000
mean    77.285714    79.714286   85.000000   80.328571
std     9.446592     6.343350   8.544004    4.101510
min     61.000000    70.000000   71.000000   72.700000
25%    73.500000    76.000000   79.500000   79.300000
50%    80.000000    81.000000   88.000000   82.100000
75%    82.500000    83.500000   91.000000   82.250000
max    88.000000    88.000000   95.000000   84.400000
```

Here, `.describe()` returns a new DataFrame with the number of rows indicated by count, as well as the mean, standard deviation, minimum, maximum, and quartiles of the columns.

If you want to get particular statistics for some or all of your columns, then you can call methods such as `.mean()` or `.std()`:

Python

>>>

```
>>> df.mean()
py-score      77.285714
django-score  79.714286
js-score      85.000000
total         80.328571
dtype: float64
```

```
>>> df['py-score'].mean()
77.28571428571429
```

```
>>> df.std()
py-score      9.446592
django-score  6.343350
js-score      8.544004
total         4.101510
dtype: float64
```

```
>>> df['py-score'].std()
9.446591726019244
```

When applied to a pandas DataFrame, these methods return Series with the results for each column. When applied to a Series object, or a single column of a DataFrame, the methods return **scalars**.

To learn more about statistical calculations with pandas, check out [Descriptive Statistics With Python](#) and [NumPy, SciPy, and pandas: Correlation With Python](#).

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Handling Missing Data

Missing data is very common in data science and machine learning. But never fear! pandas has very powerful features for working with missing data. In fact, its documentation has [an entire section dedicated to working with missing data](#).

pandas usually represents missing data with **NaN (not a number) values**. In Python, you can get NaN with `float('nan')`, `math.nan`, or `numpy.nan`. Starting with pandas 1.0, newer types like `BooleanDtype`, `Int8Dtype`, `Int16Dtype`, `Int32Dtype`, and `Int64Dtype` use `pandas.NA` as a missing value.

Here's an example of a pandas DataFrame with a missing value:

Python

>>>

```
>>> df_ = pd.DataFrame({'x': [1, 2, np.nan, 4]})  
>>> df_  
     x  
0   1.0  
1   2.0  
2   NaN  
3   4.0
```

The variable `df_` refers to the DataFrame with one column, `x`, and four values. The third value is `nan` and is considered missing by default.

Calculating With Missing Data

Many pandas methods omit `nan` values when performing calculations unless they are explicitly instructed *not* to:

Python

>>>

```
>>> df_.mean()
x    2.333333
dtype: float64

>>> df_.mean(skipna=False)
x    NaN
dtype: float64
```

In the first example, `df_.mean()` calculates the mean without taking `NaN` (the third value) into account. It just takes `1.0`, `2.0`, and `4.0` and returns their average, which is `2.33`.

However, if you instruct `.mean()` not to skip `nan` values with `skipna=False`, then it will consider them and return `nan` if there's any missing value among the data.

Filling Missing Data

pandas has several options for filling, or replacing, missing values with other values. One of the most convenient methods is `.fillna()`. You can use it to replace missing values with:

- Specified values
- The values above the missing value
- The values below the missing value

Here's how you can apply the options mentioned above:

Python

>>>

```
>>> df_.fillna(value=0)
```

```
    x  
0  1.0  
1  2.0  
2  0.0  
3  4.0
```

```
>>> df_.fillna(method='ffill')
```

```
    x  
0  1.0  
1  2.0  
2  2.0  
3  4.0
```

```
>>> df_.fillna(method='bfill')
```

```
    x  
0  1.0  
1  2.0  
2  4.0  
3  4.0
```

In the first example, `.fillna(value=0)` replaces the missing value with `0.0`, which you specified with `value`. In the second example, `.fillna(method='ffill')` replaces the missing value with the value above it, which is `2.0`. In the third example, `.fillna(method='bfill')` uses the value below the missing value, which is `4.0`.

Another popular option is to apply [interpolation](#) and replace missing values with interpolated values. You can do this with `.interpolate()`:

Python

>>>

```
>>> df_.interpolate()  
      X  
0    1.0  
1    2.0  
2    3.0  
3    4.0
```

As you can see, `.interpolate()` replaces the missing value with an interpolated value.

You can also use the optional parameter `inplace` with `.fillna()`. Doing so will:

- Create and return a new DataFrame when `inplace=False`
- Modify the existing DataFrame and return None when `inplace=True`

The default setting for `inplace` is `False`. However, `inplace=True` can be very useful when you're working with large amounts of data and want to prevent unnecessary and inefficient copying.



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Deleting Rows and Columns With Missing Data

In certain situations, you might want to delete rows or even columns that have missing values. You can do this with `.dropna()`:

Python

>>>

```
>>> df_.dropna()  
      x  
0  1.0  
1  2.0  
3  4.0
```

In this case, `.dropna()` simply deletes the row with nan, including its label. It also has the optional parameter `inplace`, which behaves the same as it does with `.fillna()` and `.interpolate()`.

Iterating Over a pandas DataFrame

As you learned earlier, a DataFrame's row and column labels can be retrieved as sequences with `.index` and `.columns`. You can use this feature to iterate over labels and get or set data values. However, pandas provides several more convenient methods for iteration:

- `.items()` to iterate over columns
- `.iteritems()` to iterate over columns
- `.iterrows()` to iterate over rows
- `.itertuples()` to iterate over rows and get named tuples

With `.items()` and `.iteritems()`, you iterate over the columns of a pandas DataFrame. Each iteration yields a tuple with the name of the column and the column data as a Series object:

Python

>>>

```
>>> for col_label, col in df.iteritems():  
...     print(col_label, col, sep='\n', end='\n\n')
```

name

10 Xavier
11 Ann
12 Jana
13 Yi
14 Robin
15 Amal
16 Nori

Name: name, dtype: object

city

10 Mexico City
11 Toronto
12 Prague
13 Shanghai
14 Manchester
15 Cairo
16 Osaka

Name: city, dtype: object

py-score

10 88.0
11 79.0
12 81.0
13 80.0
14 68.0
15 61.0
16 84.0

Name: py-score, dtype: float64

django-score

10 86.0
11 81.0
12 78.0
13 88.0
14 74.0
15 70.0
16 81.0

Name: django-score, dtype: float64

```
js-score
10    71.0
11    95.0
12    88.0
13    79.0
14    91.0
15    91.0
16    80.0
Name: js-score, dtype: float64
```

```
total
10    82.3
11    84.4
12    82.2
13    82.1
14    76.7
15    72.7
16    81.9
Name: total, dtype: float64
```

That's how you use `.items()` and `.iteritems()`.

With `.iterrows()`, you iterate over the rows of a pandas DataFrame. Each iteration yields a tuple with the name of the row and the row data as a Series object:

Python

>>>

```
>>> for row_label, row in df.iterrows():
...     print(row_label, row, sep='\\n', end='\\n\\n')
...
10
name           Xavier
city        Mexico City
py-score          88
django-score       86
js-score           71
total            82.3
Name: 10, dtype: object
```

```
11
name          Ann
city          Toronto
py-score      79
django-score  81
js-score      95
total         84.4
Name: 11, dtype: object
```

```
12
name          Jana
city          Prague
py-score      81
django-score  78
js-score      88
total         82.2
Name: 12, dtype: object
```

```
13
name          Yi
city          Shanghai
py-score      80
django-score  88
js-score      79
total         82.1
Name: 13, dtype: object
```

```
14
name          Robin
city          Manchester
py-score      68
django-score  74
js-score      91
total         76.7
Name: 14, dtype: object
```

```
15
name          Amal
city          Cairo
```

```
py-score      61
django-score 70
js-score     91
total        72.7
Name: 15, dtype: object
```

```
16
name          Nori
city          Osaka
py-score      84
django-score 81
js-score     80
total        81.9
Name: 16, dtype: object
```

That's how you use `.iterrows()`.

Similarly, `.itertuples()` iterates over the rows and in each iteration yields a named tuple with (optionally) the index and data:

```
Python >>>
>>> for row in df.loc[:, ['name', 'city', 'total']].itertuples():
...     print(row)
...
pandas(Index=10, name='Xavier', city='Mexico City', total=82.3)
pandas(Index=11, name='Ann', city='Toronto', total=84.4)
pandas(Index=12, name='Jana', city='Prague', total=82.19999999999999)
pandas(Index=13, name='Yi', city='Shanghai', total=82.1)
pandas(Index=14, name='Robin', city='Manchester', total=76.7)
pandas(Index=15, name='Amal', city='Cairo', total=72.7)
pandas(Index=16, name='Nori', city='Osaka', total=81.9)
```

You can specify the name of the named tuple with the parameter `name`, which is set to 'pandas' by default. You can also specify whether to include row labels with `index`, which is set to `True` by default.

Working With Time Series

pandas excels at [handling time series](#). Although this functionality is partly based on [NumPy datetimes](#) and [timedeltas](#), pandas provides much more flexibility.

Creating DataFrames With Time-Series Labels

In this section, you'll create a pandas DataFrame using the hourly temperature data from a single day.

You can start by creating a list (or tuple, NumPy array, or other data type) with the data values, which will be hourly temperatures given in [degrees Celsius](#):

Python

>>>

```
>>> temp_c = [ 8.0,  7.1,  6.8,  6.4,  6.0,  5.4,  4.8,  5.0,
...             9.1, 12.8, 15.3, 19.1, 21.2, 22.1, 22.4, 23.1,
...             21.0, 17.9, 15.5, 14.4, 11.9, 11.0, 10.2,  9.1]
```

Now you have the variable `temp_c`, which refers to the list of temperature values.

The next step is to create a sequence of dates and times. pandas provides a very convenient function, [date_range\(\)](#), for this purpose:

Python

>>>

```
>>> dt = pd.date_range(start='2019-10-27 00:00:00.0', periods=24,
...                      freq='H')
>>> dt
DatetimeIndex(['2019-10-27 00:00:00', '2019-10-27 01:00:00',
                '2019-10-27 02:00:00', '2019-10-27 03:00:00',
                '2019-10-27 04:00:00', '2019-10-27 05:00:00',
                '2019-10-27 06:00:00', '2019-10-27 07:00:00',
                '2019-10-27 08:00:00', '2019-10-27 09:00:00',
                '2019-10-27 10:00:00', '2019-10-27 11:00:00',
                '2019-10-27 12:00:00', '2019-10-27 13:00:00',
                '2019-10-27 14:00:00', '2019-10-27 15:00:00',
                '2019-10-27 16:00:00', '2019-10-27 17:00:00',
                '2019-10-27 18:00:00', '2019-10-27 19:00:00',
                '2019-10-27 20:00:00', '2019-10-27 21:00:00',
                '2019-10-27 22:00:00', '2019-10-27 23:00:00'],
               dtype='datetime64[ns]', freq='H')
```

`date_range()` accepts the arguments that you use to specify the start or end of the range, number of periods, frequency, [time zone](#), and more.

Note: Although other options are available, pandas mostly uses the [ISO 8601 date and time format](#) by default.

Now that you have the temperature values and the corresponding dates and times, you can create the DataFrame. In many cases, it's convenient to use date-time values as the row labels:

Python

>>>

```
>>> temp = pd.DataFrame(data={'temp_c': temp_c}, index=dt)
>>> temp
      temp_c
2019-10-27 00:00:00    8.0
2019-10-27 01:00:00    7.1
2019-10-27 02:00:00    6.8
2019-10-27 03:00:00    6.4
2019-10-27 04:00:00    6.0
2019-10-27 05:00:00    5.4
2019-10-27 06:00:00    4.8
2019-10-27 07:00:00    5.0
2019-10-27 08:00:00    9.1
2019-10-27 09:00:00   12.8
2019-10-27 10:00:00   15.3
2019-10-27 11:00:00   19.1
2019-10-27 12:00:00   21.2
2019-10-27 13:00:00   22.1
2019-10-27 14:00:00   22.4
2019-10-27 15:00:00   23.1
2019-10-27 16:00:00   21.0
2019-10-27 17:00:00   17.9
2019-10-27 18:00:00   15.5
2019-10-27 19:00:00   14.4
2019-10-27 20:00:00   11.9
2019-10-27 21:00:00   11.0
2019-10-27 22:00:00   10.2
2019-10-27 23:00:00   9.1
```

That's it! You've created a DataFrame with time-series data and date-time row indices.



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Indexing and Slicing

Once you have a pandas DataFrame with time-series data, you can conveniently apply slicing to get just a part of the information:

Python

>>>

```
>>> temp['2019-10-27 05':'2019-10-27 14']
           temp_c
2019-10-27 05:00:00    5.4
2019-10-27 06:00:00    4.8
2019-10-27 07:00:00    5.0
2019-10-27 08:00:00    9.1
2019-10-27 09:00:00   12.8
2019-10-27 10:00:00   15.3
2019-10-27 11:00:00   19.1
2019-10-27 12:00:00   21.2
2019-10-27 13:00:00   22.1
2019-10-27 14:00:00   22.4
```

This example shows how to extract the temperatures between 05:00 and 14:00 (5 a.m. and 2 p.m.). Although you've provided strings, pandas knows that your row labels are date-time values and interprets the strings as dates and times.

Resampling and Rolling

You've just seen how to combine date-time row labels and use slicing to get the information you need from the time-series data. This is just the beginning. It gets better!

If you want to split a day into four six-hour intervals and get the mean temperature for each interval, then you're just one statement away from doing so. pandas provides the method `.resample()`, which you can combine with other methods such as `.mean()`:

Python

>>>

```
>>> temp.resample(rule='6h').mean()
           temp_c
2019-10-27 00:00:00    6.616667
2019-10-27 06:00:00   11.016667
2019-10-27 12:00:00  21.283333
2019-10-27 18:00:00  12.016667
```

You now have a new pandas DataFrame with four rows. Each row corresponds to a single six-hour interval. For example, the value 6.616667 is the mean of the first six temperatures from the DataFrame `temp`, whereas 12.016667 is the mean of the last six temperatures.

Instead of `.mean()`, you can apply `.min()` or `.max()` to get the minimum and maximum temperatures for each interval. You can also use `.sum()` to get the sums of data values, although this information probably isn't useful when you're working with temperatures.

You might also need to do some **rolling-window analysis**. This involves calculating a statistic for a specified number of adjacent rows, which make up your window of data. You can "roll" the window by selecting a different set of adjacent rows to perform your calculations on.

Your first window starts with the first row in your DataFrame and includes as many adjacent rows as you specify. You then move your window down one row, dropping the first row and adding the row that comes immediately after the last row, and calculate the same statistic again. You repeat this process until you reach the last row of the DataFrame.

pandas provides the method `.rolling()` for this purpose:

Python

>>>

```
>>> temp.rolling(window=3).mean()
           temp_c
2019-10-27 00:00:00      NaN
2019-10-27 01:00:00      NaN
2019-10-27 02:00:00    7.300000
2019-10-27 03:00:00    6.766667
2019-10-27 04:00:00    6.400000
2019-10-27 05:00:00    5.933333
2019-10-27 06:00:00    5.400000
2019-10-27 07:00:00    5.066667
2019-10-27 08:00:00    6.300000
2019-10-27 09:00:00    8.966667
2019-10-27 10:00:00   12.400000
2019-10-27 11:00:00   15.733333
2019-10-27 12:00:00   18.533333
2019-10-27 13:00:00   20.800000
2019-10-27 14:00:00   21.900000
2019-10-27 15:00:00   22.533333
2019-10-27 16:00:00   22.166667
2019-10-27 17:00:00   20.666667
2019-10-27 18:00:00   18.133333
2019-10-27 19:00:00   15.933333
2019-10-27 20:00:00   13.933333
2019-10-27 21:00:00   12.433333
2019-10-27 22:00:00   11.033333
2019-10-27 23:00:00   10.100000
```

Now you have a DataFrame with mean temperatures calculated for several three-hour windows. The parameter `window` specifies the size of the moving time window.

In the example above, the third value (7.3) is the mean temperature for the first three hours (00:00:00, 01:00:00, and 02:00:00). The fourth value is the mean temperature for the hours 02:00:00, 03:00:00, and 04:00:00. The last value is the mean temperature for the

hours 02:00:00, 03:00:00, and 04:00:00. The last value is the mean temperature for the last three hours, 21:00:00, 22:00:00, and 23:00:00. The first two values are missing because there isn't enough data to calculate them.

Plotting With pandas DataFrames

pandas allows you to [visualize data](#) or [create plots based on DataFrames](#). It uses [Matplotlib](#) in the background, so exploiting pandas' plotting capabilities is very similar to [working with Matplotlib](#).

If you want to display the plots, then you first need to import `matplotlib.pyplot`:

Python

>>>

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

Now you can use `pandas.DataFrame.plot()` to create the plot and `plt.show()` to display it:

Python

>>>

```
>>> temp.plot()  
<matplotlib.axes._subplots.AxesSubplot object at 0x7f070cd9d950>  
>>> plt.show()
```

Now `.plot()` returns a plot object that looks like this:



You can also apply `.plot.line()` and get the same result. Both `.plot()` and `.plot.line()` have many optional parameters that you can use to specify the look of your plot. Some of them are passed directly to the underlying Matplotlib methods.

You can save your figure by chaining the methods `.get_figure()` and `.savefig()`:

Python

>>>

```
>>> temp.plot().get_figure().savefig('temperatures.png')
```

This statement creates the plot and saves it as a file called 'temperatures.png' in your working directory.

You can get [other types of plots](#) with a pandas DataFrame. For example, you can visualize your job candidate data from before as a [histogram](#) with `.plot.hist()`:

Python

>>>

```
>>> df.loc[:, ['py-score', 'total']].plot.hist(bins=5, alpha=0.4)
<matplotlib.axes._subplots.AxesSubplot object at 0x7f070c69edd0>
>>> plt.show()
```

In this example, you extract the Python test score and total score data and visualize it with a histogram. The resulting plot looks like this:



This is just the basic look. You can adjust details with optional parameters including `.plot.hist()`, [Matplotlib's plt.rcParams](#), and many others. You can find detailed explanations in the [Anatomy of Matplotlib](#).

Further Reading

`pandas` DataFrames are very comprehensive objects that support many operations not

mentioned in this tutorial. Some of these include:

- Hierarchical (multi-level) indexing
- Grouping
- Merging, joining, and concatenating
- Working with categorical data

The [official pandas tutorial](#) summarizes some of the available options nicely. If you want to learn more about pandas and `DataFrames`, then you can check out these tutorials:

- [Pythonic Data Cleaning With pandas and NumPy](#)
- [pandas DataFrames 101](#)
- [Introduction to pandas and Vincent](#)
- [Python pandas: Tricks & Features You May Not Know](#)
- [Idiomatic pandas: Tricks & Features You May Not Know](#)
- [Reading CSVs With pandas](#)
- [Writing CSVs With pandas](#)
- [Reading and Writing CSV Files in Python](#)
- [Reading and Writing CSV Files](#)
- [Using pandas to Read Large Excel Files in Python](#)
- [Fast, Flexible, Easy and Intuitive: How to Speed Up Your pandas Projects](#)

You've learned that pandas `DataFrames` handle two-dimensional data. If you need to work with labeled data in more than two dimensions, you can check out [xarray](#), another powerful Python library for data science with very similar features to pandas.

If you work with big data and want a `DataFrame`-like experience, then you might give [Dask](#) a chance and use its [DataFrame API](#). A **Dask DataFrame** contains many pandas `DataFrames` and performs computations in a **lazy** manner.

Conclusion

You now know what a **pandas DataFrame** is, what some of its features are, and how you can use it to work with data efficiently. pandas DataFrames are powerful, user-friendly data structures that you can use to gain deeper insight into your datasets!

In this tutorial, you've learned:

- What a **pandas DataFrame** is and how to create one
- How to **access, modify, add, sort, filter, and delete** data
- How to use **NumPy routines** with DataFrames
- How to handle **missing values**
- How to work with **time-series data**
- How to **visualize** data contained in DataFrames

You've learned enough to cover the fundamentals of DataFrames. If you want to dig deeper into [working with data in Python](#), then check out [the entire range of pandas tutorials](#).

If you have questions or comments, then please put them in the comment section below.

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Watch Now This tutorial has a related video course created by the Real Python team. Watch it together with the written tutorial to deepen your understanding: [The Pandas DataFrame: Working With Data Efficiently](#)



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2 # in Python 3.5+
3
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5 >>> y = {'b': 3, 'c': 4}
6
7 >>> z = {**x, **y}
8
9 >>> z
10 {'c': 4, 'a': 1, 'b': 3}
```

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