(MSc) Data Mining

Topic 01 : Module Overview

Part 13 : Top X pandas commands

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Spring Semester, 2026

Outline

- Reading data formats
- Computing descriptive statistics
- Processing data by filtering and grouping

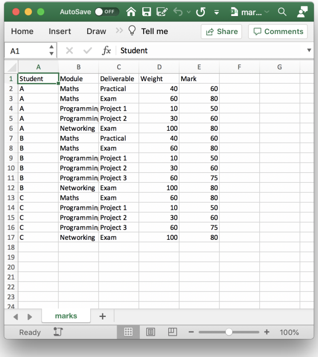
Part I

Introduction

Minimal Dataset

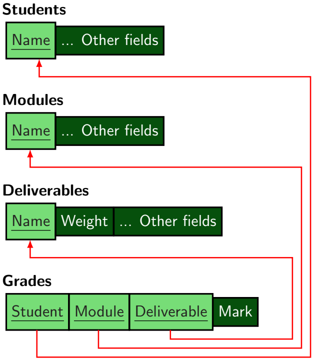
To better understand the various pandas operations we are going use a tiny* dataset based on (fictional) student results. (marks.csv)

In Excel . . .



	A	B	C	D	E	F	G
1	Student	Module	Deliverable	Weight	Mark		
2	A	Maths	Practical	40	60		
3	A	Maths	Exam	60	80		
4	A	Programmin	Project 1	10	50		
5	A	Programmin	Project 2	30	60		
6	A	Networking	Exam	100	80		
7	B	Maths	Practical	40	60		
8	B	Maths	Exam	60	80		
9	B	Programmin	Project 1	10	50		
10	B	Programmin	Project 2	30	60		
11	B	Programmin	Project 3	60	75		
12	B	Networking	Exam	100	80		
13	C	Maths	Exam	60	80		
14	C	Programmin	Project 1	10	50		
15	C	Programmin	Project 2	30	60		
16	C	Programmin	Project 3	60	75		
17	C	Networking	Exam	100	80		
18							
19							
20							
21							
22							
23							
24							

. . . or database schema . . .



Students

Name	... Other fields

Modules

Name	... Other fields

Deliverables

Name	Weight	... Other fields

Grades

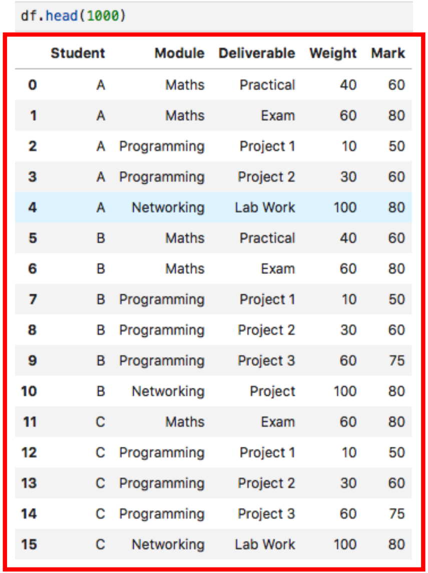
Student	Module	Deliverable	Mark

. . . like to know . . .

- Student performance — weighted mark on each module, missing deliverables etc.
- Module performance — number of attempts and average mark.
- Deliverable performance — number of attempts and average mark, predictor of overall module grade, etc.

*Dataset is small enough that you can verify operation results by hand.

Terminology



```
df.head(1000)
```

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3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
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10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
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13	C	Programming	Project 2	30	60
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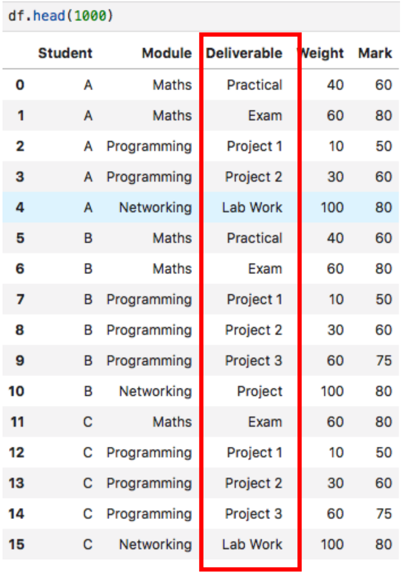
15	C	Networking	Lab Work	100	80

- A DataFrame is a table of data values.
  - `df = pd.read_csv("Marks.csv")`
- A Series is a list of data values — typically columns in a dataframe. We can access an individual column using
  - `df.Deliverable` (dot notation)
  - `df["Deliverable"]` (dict notation)
  - `df.iloc[:,2]` (numpy, index notation)
- The index is a special column whose values can be used to access rows — rather using row number.
  - The default index is equal to the row number.

Terminology



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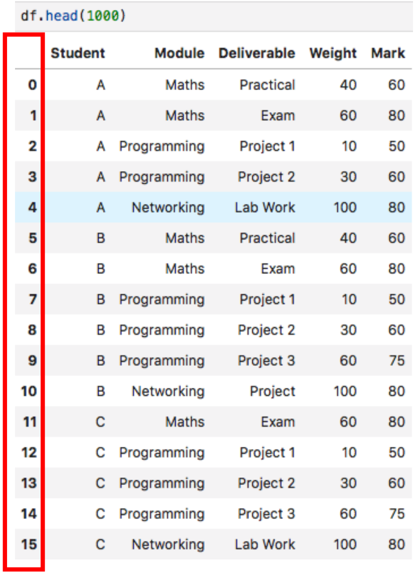

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Part II

Input and Output

Setup

Minimal

We begin every data mining project with importing the three core data science packages:

1

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
plt.style.use('seaborn-darkgrid')
```

numpy — fast array operations
pandas — data manipulation
matplotlib — visualisation

- We give modules nicknames (`np`, `pd`, . . .) to simplify their later use, and we access properties/functions of a package using the dot notation (`np.max`, `pd.DataFrame`, . . .).

Extra

2

```python
import seaborn as sns
import statsmodels.api as sm

pd.set_option('display.max_columns', 500)
pd.set_option('display.width', 1000)
```

seaborn — statistical visualisation
statsmodels — statistical data exploration
pandas options to show all columns for wider datasets

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Reading data from a CSV file

Pandas supports a huge variety of input/output formats so best approach is to focus on what is needed to process the given data and verify input. Our marks dataset is in CSV format so we start with

5

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and input using

6

```
df = pd.read_csv('Marks.csv', sep=',')
print(df.shape)
df.head()
```

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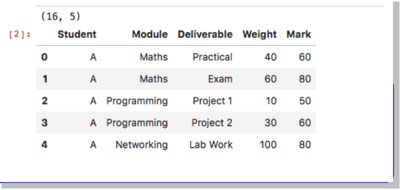
```
(16, 5)
```



```
(16, 5)
```

[2]:

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Always verify input by checking dataset dimensions and looking at some rows!!! ;

Datatypes

Pandas data types:

- object — used for text or mixed numeric and non-numeric values.
- int64 — integer values,
  - Does not support missing values, so an int column containing at least one missing value will automatically be converted to float.
- float64 — floating point numbers.
- bool — True/False values
- datetime64 — date and time values
- category — Finite (typically small) list of text values

```
df.dtypes
```

```
Student        object
Module         object
Deliverable    object
Weight          int64
Mark            int64
dtype: object
```

Regularly verifying datatypes is vital[†] :

- Operations differ based on datatype, eg, '+' concatenate strings but adds numerical values.
- Datatype can change based on results, eg, int converts to float due to missing values.

[†] Google "Detecting Excel's gene auto-conversions."

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Datatypes — Converting

We will deal with modifying and creating new columns later, but while we are on datatypes, we will look at changing datatype . . .

Using the Series function astype

14

```
df["Weight"] = df["Weight"].astype('float')
df["Weight"].dtype
```

```
dtype('float64')
```

- New datatype is required argument — 'int', 'float', 'str', 'object', 'category', etc.
- Simple, but fragile if data conversion is possible.

or using pandas function to_numeric

15

```
df["Weight"] = pd.to_numeric(df["Weight"])
df["Weight"].dtype
```

```
dtype('float64')
```

- More powerful, can specify what to do in cases where the conversion fails etc
- Have functions to_numeric, to_datetime, and to_timedelta.

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```

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- Have functions `to_numeric`, `to_datetime`, and `to_timedelta`.

Missing Values

Identifying and dealing with missing values is critical step in data preparation. What should you do? delete rows containing missing values? or impute then?

Here we will just look at identifying missing values.

20

```
df.isna()
```

```
   Student Module Deliverable Weight  Mark
0    False  False       False  False False
1    False  False       False  False False
2    False  False       False  False False
3    False  False       False  False False
4    False  False       False  False False
5    False  False       False  False False
6    False  False       False  False False
7    False  False       False  False False
8    False  False       False  False False
9    False  False       False  False False
10   False  False       False  False False
11   False  False       False  False False
12   False  False       False  False False
13   False  False       False  False False
14   False  False       False  False False
15   False  False       False  False False
```

21

```
df.isna().sum()
```

```
Student        0
Module         0
Deliverable    0
Weight         0
Mark           0
dtype: int64
```

22

```
df.isna().sum().sum()
```

```
0
```

- Use dataframe function `fillna` to replace missing values.
- Recall `False` and `True` map to 0 and 1 respectively.
- Use `df.isna().sum(axis=1)` to sum along rows.

Output

Saving dataframe to CSV is straightforward (I rarely include the (default) index when saving datasets).

```
df.to_csv('marks_2.csv', index=False)
```

- CSV has become the default file format in Data Mining application especially for ’informal’ datasets.
  - ✓ human readable, easy to generate / parse (if correct).
  - ✗ Can be highly redundant, slow to input/output.
  - ✗ No meta information.
- Other formats are better for speed and resulting file size and for saving meta data not supported by CSV (such as columns datatypes, category information, etc).

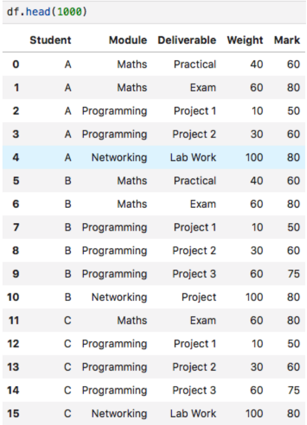
towards data science : The Best Format to Save Pandas Data

Part III

Filtering

Selecting individual rows/columns results in a series

Columns can accessed using dot, dict and numpy index notation.



```
df.head(1000)
```

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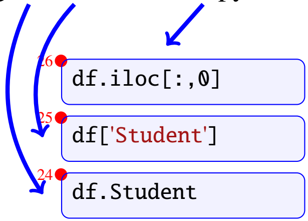

26
```
df.iloc[:,0]
```

25
```
df['Student']
```

24
```
df.Student
```

⇒

```
0       A
1       A
2       A
3       A
4       A
5       B
6       B
7       B
8       B
9       B
10      B
11      C
12      C
13      C
14      C
15      C
Name: Student, dtype: object
```

```
Student              A
Module           Maths
Deliverable  Practical
Weight              40
Mark                60
Name: 0, dtype: object
```

27
```
df.iloc[0]
```

⇐ Access row using numpy index

Selecting individual rows/columns results in a series

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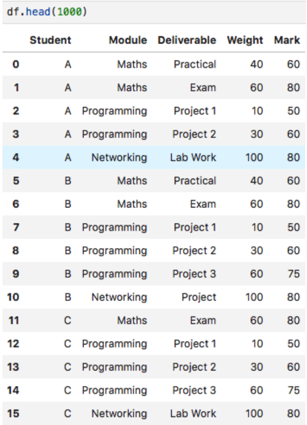

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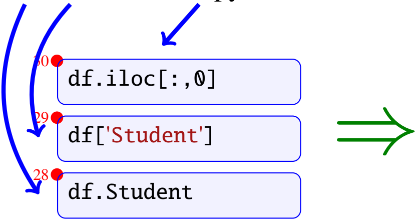

```
df.iloc[:,0]
```

```
df['Student']
```

```
df.Student
```

```
0       A
1       A
2       A
3       A
4       A
5       B
6       B
7       B
8       B
9       B
10      B
11      C
12      C
13      C
14      C
15      C
Name: Student, dtype: object
```

```
Student              A
Module           Maths
Deliverable  Practical
Weight              40
Mark                60
Name: 0, dtype: object
```

```
df.iloc[0]
```

⇐ Access row using numpy index

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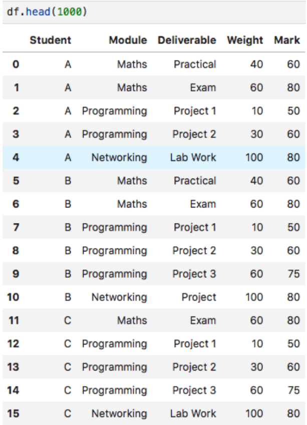

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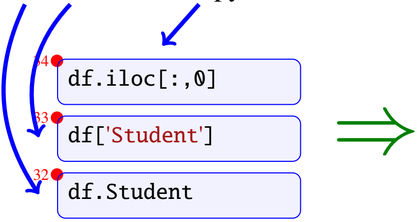

```
df.iloc[:,0]
```

```
df['Student']
```

```
df.Student
```

```
0     A
1     A
2     A
3     A
4     A
5     B
6     B
7     B
8     B
9     B
10    B
11    C
12    C
13    C
14    C
15    C
Name: Student, dtype: object
```

```
Student                 A
Module              Maths
Deliverable     Practical
Weight                 40
Mark                   60
Name: 0, dtype: object
```

35

```
df.iloc[0]
```

⟸ Access row using numpy index

Head and Tail

Commands `head` and `tail` return the first and last n rows (default $n = 5$) of a dataframe/series.

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36
```
df.head()
```

37
```
df.head(1)
```

38
```
df.tail()
```

39
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df.tail()
```

Head and Tail

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0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

40
```
df.head()
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80

41
```
df.head(1)
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60

42
```
df.tail()
```

43
```
df.tail()
```

Head and Tail

Commands `head` and `tail` return the first and last n rows (default $n = 5$) of a dataframe/series.

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

44

```
df.head()
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80

45

```
df.head(1)
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60

46

```
df.tail()
```

	Student	Module	Deliverable	Weight	Mark
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

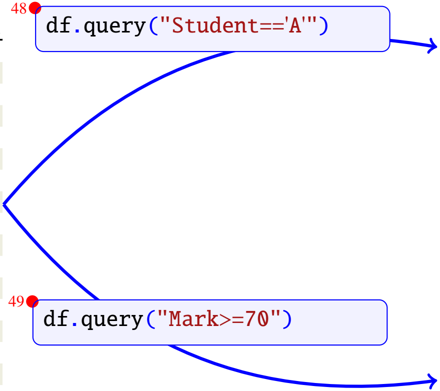
47

```
df.tail()
```

	Student	Module	Deliverable	Weight	Mark
15	C	Networking	Lab Work	100	80

Query — on a single-column criteria

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80



48

```
df.query("Student=='A'")
```

49

```
df.query("Mark>=70")
```

Query — on a single-column criteria

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

50

```
df.query("Student=='A'")
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

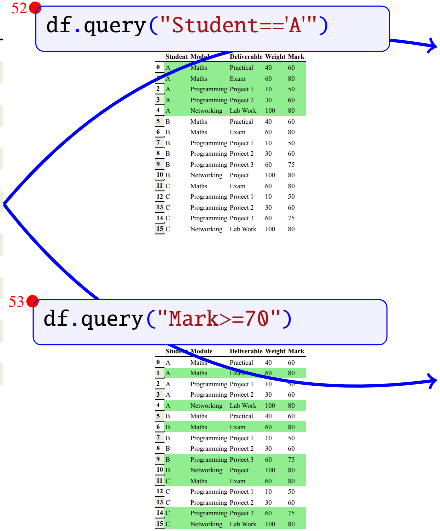
51

```
df.query("Mark>=70")
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

Query — on a single-column criteria

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80



52

```
df.query("Student=='A'")
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80

53

```
df.query("Mark>=70")
```

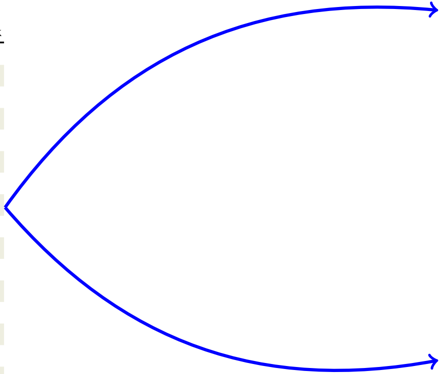
	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

	Student	Module	Deliverable	Weight	Mark
1	A	Maths	Exam	60	80
4	A	Networking	Lab Work	100	80
6	B	Maths	Exam	60	80
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

Query — on multiple columns (using python logical operators)

54
```
df.query("Mark<70 and Module=='Maths'")
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

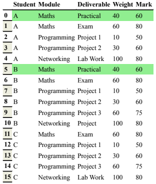


55
```
df.query("Mark<70 or Module=='Maths'")
```

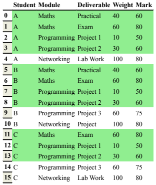
Query — on multiple columns (using python logical operators)

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

56
```
df.query("Mark<70 and Module=='Maths'")
```



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

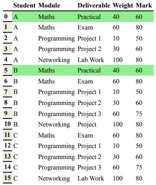
57
```
df.query("Mark<70 or Module=='Maths'")
```

Query — on multiple columns (using python logical operators)

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

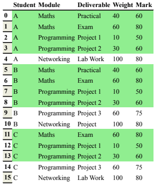
58

```
df.query("Mark<70 and Module=='Maths'")
```



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
5	B	Maths	Practical	40	60



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

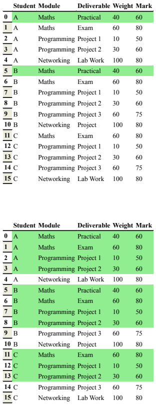
	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60

59

```
df.query("Mark<70 or Module=='Maths'")
```

Query — on multiple columns (using pandas logical operators)

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

60

```
df.query("(Mark<70) & (Module=='Maths')")
```

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
5	B	Maths	Practical	40	60

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60

61

```
df.query("(Mark<70) | (Module=='Maths')")
```

Filtering using `loc`

Note the square (not round) brackets — think of `loc` as array indexing not a function call.

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

```
df.loc[ROW_SELECTION, COL_SELECTION]
```

where row and columns selection can be

- Single values: row number or column name
- An integer list for rows or list of column names
- A boolean list for logical indexing of rows
- A colon to indicate every row/column

```python
df.loc[df.Module=="Maths", ["Student", "Mark"]]
```

Filtering using `loc`

Note the square (not round) brackets — think of `loc` as array indexing not a function call.

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

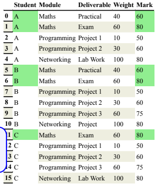
```
df.loc[ROW_SELECTION, COL_SELECTION]
```

where row and columns selection can be

- Single values: row number or column name
- An integer list for rows or list of column names
- A boolean list for logical indexing of rows
- A colon to indicate every row/column

63

```
df.loc[df.Module=="Maths", ["Student", "Mark"]]
```



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

Filtering using `loc`

Note the square (not round) brackets — think of `loc` as array indexing not a function call.

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

```
df.loc[ROW_SELECTION, COL_SELECTION]
```

where row and columns selection can be

- Single values: row number or column name
- An integer list for rows or list of column names
- A boolean list for logical indexing of rows
- A colon to indicate every row/column

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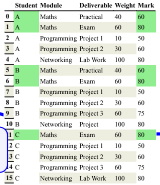
```
df.loc[df.Module=="Maths", ["Student", "Mark"]]
```

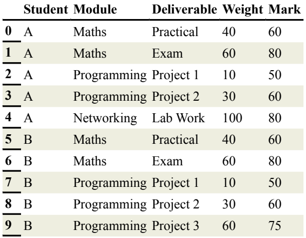


	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

	Student	Mark
0	A	60
1	A	80
5	B	60
6	B	80
11	C	80

More complicated example

I prefer to define define row selection criteria, and the column list and order, separately to the `loc` statement.



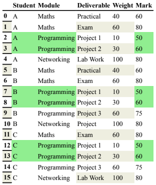
	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75

```
criteria = ((df.Mark<50) & (df.Module=='Maths')) | ((df.Mark<70) & (df.Module!='Maths'))
columns = ['Module', 'Student', 'Mark']

df.loc[criteria, columns]
```

More complicated example

I prefer to define define row selection criteria, and the column list and order, separately to the `loc` statement.

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75

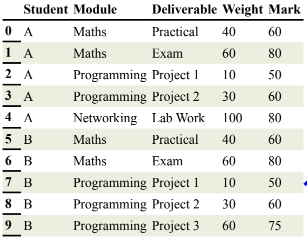


	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80

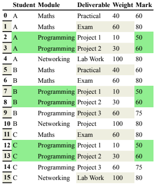
```
criteria = ((df.Mark<50) & (df.Module=='Maths')) | ((df.Mark<70) & (df.Module!='Maths'))
columns = ['Module', 'Student', 'Mark']

df.loc[criteria, columns]
```

More complicated example

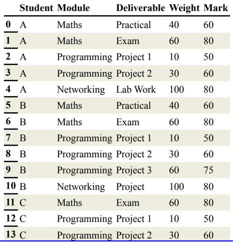
I prefer to define define row selection criteria, and the column list and order, separately to the `loc` statement.



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80



	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60

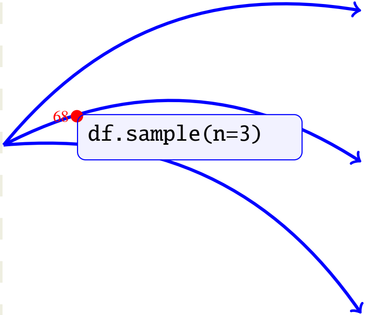
```
criteria = ((df.Mark<50) & (df.Module=='Maths')) | ((df.Mark<70) & (df.Module!='Maths'))
columns = ['Module', 'Student', 'Mark']

df.loc[criteria, columns]
```

Sampling

The `sample` function selects a random subset of the dataframe rows.

- Either specify the number of rows (as an integer) or fraction of the data (as a float).
- Can set the seed using `random_state` parameter for reproducible samples.

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
4	A	Networking	Lab Work	100	80
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60
14	C	Programming	Project 3	60	75
15	C	Networking	Lab Work	100	80



```
df.sample(n=3)
```

	Student	Module	Deliverable	Weight	Mark
11	C	Maths	Exam	60	80
3	A	Programming	Project 2	30	60
8	B	Programming	Project 2	30	60

	Student	Module	Deliverable	Weight	Mark
13	C	Programming	Project 2	30	60
8	B	Programming	Project 2	30	60
1	A	Maths	Exam	60	80

	Student	Module	Deliverable	Weight	Mark
12	C	Programming	Project 1	10	50
5	B	Maths	Practical	40	60
2	A	Programming	Project 1	10	50

Part IV

Sorting

Sorting

A pandas dataframe has two sorting operations:

- `sort_index()` orders rows based on current index.
- `sort_values(COLUMNS)` orders rows based on single column or list of columns.

Two important modifications:

- By default, the sort order is in ascending. Set parameter `ascending=False` to reverse this.
- By default, a new dataframe is returned with desired sort order, set parameter `inplace=True` to update current dataframe instead (then no output is generated).

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2		
4	A	Networking	Lab Work		
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60

```
df.sort_values(['Module','Deliverable'])
```

Sorting

A pandas dataframe has two sorting operations:

- `sort_index()` orders rows based on current index.
- `sort_values(COLUMNS)` orders rows based on single column or list of columns.

Two important modifications:

- By default, the sort order is in ascending. Set parameter `ascending=False` to reverse this.
- By default, a new dataframe is returned with desired sort order, set parameter `inplace=True` to update current dataframe instead (then no output is generated).

	Student	Module	Deliverable	Weight	Mark
0	A	Maths	Practical	40	60
1	A	Maths	Exam	60	80
2	A	Programming	Project 1	10	50
3	A	Programming	Project 2	[illegible]	[illegible]
4	A	Networking	Lab Work	[illegible]	[illegible]
5	B	Maths	Practical	40	60
6	B	Maths	Exam	60	80
7	B	Programming	Project 1	10	50
8	B	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
10	B	Networking	Project	100	80
11	C	Maths	Exam	60	80
12	C	Programming	Project 1	10	50
13	C	Programming	Project 2	30	60

```
df.sort_values(['Module','Deliverable'])
```

	Student	Module	Deliverable	Weight	Mark
1	A	Maths	Exam	60	80
6	B	Maths	Exam	60	80
11	C	Maths	Exam	60	80
[illegible]	A	Maths	Practical	40	60
[illegible]	B	Maths	Practical	40	60
4	A	Networking	Lab Work	100	80
15	C	Networking	Lab Work	100	80
10	B	Networking	Project	100	80
2	A	Programming	Project 1	10	50
7	B	Programming	Project 1	10	50
12	C	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
8	B	Programming	Project 2	30	60
13	C	Programming	Project 2	30	60

Part V

Defining New Columns

Defining new columns — row-wise operation

We want to compute the weighted mark for each module for each student. Two steps:

- Create column, `W_Mark`, to store the weighted mark for each deliverable. This is a row by row calculation — only need data in current row to compute the result.
- Create column, `M_Mark`, to store the module mark for each student. This is a group calculation — need all rows for that student and module to compute the result.

	Student	Module	Deliverable	Weight	Mark
1	A	Maths	Exam	60	80
6	B	Maths	Exam	60	80
11	C	Maths	Exam	60	80
0	A	Maths	Practical	40	60
5	B	Maths	Practical	40	60
4	A	Networking	Lab Work	100	[illegible]
15	C	Networking	Lab Work	100	80
10	B	Networking	Project	100	80
2	A	Programming	Project 1	10	50
7	B	Programming	Project 1	10	50
12	C	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
8	B	Programming	Project 2	30	60
13	C	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
14	C	Programming	Project 3	60	75

```
df['W_Mark'] = df.Weight * df.Mark // 100
```

Need to use dict notation (not dot notation) when defining a new column.

Defining new columns — row-wise operation

We want to compute the weighted mark for each module for each student. Two steps:

- Create column, `W_Mark`, to store the weighted mark for each deliverable. This is a row by row calculation — only need data in current row to compute the result.
- Create column, `M_Mark`, to store the module mark for each student. This is a group calculation — need all rows for that student and module to compute the result.

	Student	Module	Deliverable	Weight	Mark
1	A	Maths	Exam	60	80
6	B	Maths	Exam	60	80
11	C	Maths	Exam	60	80
0	A	Maths	Practical	40	60
5	B	Maths	Practical	40	60
4	A	Networking	Lab Work	100	[illegible]
15	C	Networking	Lab Work	100	80
10	B	Networking	Project	100	80
2	A	Programming	Project 1	10	50
7	B	Programming	Project 1	10	50
12	C	Programming	Project 1	10	50
3	A	Programming	Project 2	30	60
8	B	Programming	Project 2	30	60
13	C	Programming	Project 2	30	60
9	B	Programming	Project 3	60	75
14	C	Programming	Project 3	60	75

```
df['W_Mark'] = df.Weight * df.Mark // 100
```

	Student	Module	Deliverable	Weight	Mark	W_Mark
1	A	Maths	Exam	60	80	48
6	B	Maths	Exam	60	80	48
11	C	Maths	Exam	60	80	48
0	A	Maths	Practical	40	60	24
5	B	Maths	Practical	40	60	24
[illegible]	[illegible]	Networking	Lab Work	100	80	80
15	C	Networking	Lab Work	100	80	80
10	B	Networking	Project	100	80	80
2	A	Programming	Project 1	10	50	5
7	B	Programming	Project 1	10	50	5
12	C	Programming	Project 1	10	50	5
3	A	Programming	Project 2	30	60	18
8	B	Programming	Project 2	30	60	18
13	C	Programming	Project 2	30	60	18
9	B	Programming	Project 3	60	75	45
14	C	Programming	Project 3	60	75	45

Need to use dict notation (not dot notation) when defining a new column.

Defining new columns — group aggregate result I

- Create column, `W_Mark`, to store the weighted mark for each deliverable. This is a row by row calculation — only need data in current row to compute the result.
- Create column, `M_Mark`, to store the module mark for each student. This is a group calculation — need all rows for that student and module to compute the result.

columns to group on | output cols | aggregate

```
df.groupby(['Student','Module'])['W_Mark'].sum()
```

	Student	Module	Deliverable	Weight	Mark	W_Mark
1	A	Maths	Exam	60	80	48
6	B	Maths	Exam	60	80	48
11	C	Maths	Exam	60	80	48
0	A	Maths	Practical	40	60	24
5	B	Maths	Practical	40	60	24
4	A	Networking	Lab Work	100	80	80
15	C	Networking	Lab Work	100	80	80
10	B	Networking	Project	100	80	80
2	A	Programming	Project 1	10	50	5
7	B	Programming	Project 1	10	50	5
12	C	Programming	Project 1	10	50	5
3	A	Programming	Project 2	30	60	18
8	B	Programming	Project 2	30	60	18
13	C	Programming	Project 2	30	60	18
9	B	Programming	Project 3	60	75	45
14	C	Programming	Project 3	60	75	45

Result has multi-level index, need to use `reset_index` to revert to default index

Defining new columns — group aggregate result

- Create column, `W_Mark`, to store the weighted mark for each deliverable. This is a row by row calculation — only need data in current row to compute the result.
- Create column, `M_Mark`, to store the module mark for each student. This is a group calculation — need all rows for that student and module to compute the result.

columns to group on | output cols | aggregate

```
df.groupby(['Student','Module'])['W_Mark'].sum()
```

	Student	Module	Deliverable	Weight	Mark	W_Mark
1	A	Maths	Exam	60	80	48
6	B	Maths	Exam	60	80	48
11	C	Maths	Exam	60	80	48
0	A	Maths	Practical	40	60	24
5	B	Maths	Practical	40	60	24
4	A	Networking	Lab Work	100	80	80
15	C	Networking	Lab Work	100	80	80
10	B	Networking	Project	100	80	80
2	A	Programming	Project 1	10	50	5
7	B	Programming	Project 1	10	50	5
12	C	Programming	Project 1	10	50	5
3	A	Programming	Project 2	30	60	18
8	B	Programming	Project 2	30	60	18
13	C	Programming	Project 2	30	60	18
9	B	Programming	Project 3	60	75	45
14	C	Programming	Project 3	60	75	45

Result has multi-level index, need to use `reset_index` to revert to default index

		W_Mark
Student	Module	
A	Maths	72
	Networking	80
	Programming	23
B	Maths	72
	Networking	80
	Programming	68
C	Maths	48
	Networking	80
	Programming	68

Defining new columns — group aggregate result II

columns to group on | output cols | aggregate

```
df.groupby(['Student','Module'])[ ['W_Mark'] ].sum().reset_index()
```

	Student	Module	Deliverable	Weight	Mark	W_Mark
1	A	Maths	Exam	60	80	48
6	B	Maths	Exam	60	80	48
11	C	Maths	Exam	60	80	48
0	A	Maths	Practical	40	60	24
5	B	Maths	Practical	40	60	24
4	A	Networking	Lab Work	100	80	80
15	C	Networking	Lab Work	100	80	80
10	B	Networking	Project	100	80	80
2	A	Programming	Project 1	10	50	5
7	B	Programming	Project 1	10	50	5
12	C	Programming	Project 1	10	50	5
3	A	Programming	Project 2	30	60	18
8	B	Programming	Project 2	30	60	18
13	C	Programming	Project 2	30	60	18
9	B	Programming	Project 3	60	75	45
14	C	Programming	Project 3	60	75	45

Defining new columns — group aggregate result II

columns to group on output cols aggregate

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```
df.groupby(['Student','Module'])[ ['W_Mark'] ].sum().reset_index()
```

	Student	Module	Deliverable	Weight	Mark	W_Mark
1	A	Maths	Exam	60	80	48
6	B	Maths	Exam	60	80	48
11	C	Maths	Exam	60	80	48
0	A	Maths	Practical	40	60	24
5	B	Maths	Practical	40	60	24
4	A	Networking	Lab Work	100	80	80
15	C	Networking	Lab Work	100	80	80
10	B	Networking	Project	100	80	80
2	A	Programming	Project 1	10	50	5
7	B	Programming	Project 1	10	50	5
12	C	Programming	Project 1	10	50	5
3	A	Programming	Project 2	30	60	18
8	B	Programming	Project 2	30	60	18
13	C	Programming	Project 2	30	60	18
9	B	Programming	Project 3	60	75	45
14	C	Programming	Project 3	60	75	45

This is the required result and we can save this to a new dataframe. However, we often want to put this into to out original dataframe as an extra column. Only problem we have different rows so can't just assign to a new column — need to use `transform` function.

	Student	Module	W_Mark
0	A	Maths	72
1	A	Networking	80
2	A	Programming	23
3	B	Maths	72
4	B	Networking	80
5	B	Programming	68
6	C	Maths	48
7	C	Networking	80
8	C	Programming	68

Defining new columns — group aggregate result III

columns to group on   output cols   aggregate

```
df['M_Mark'] = df.groupby(['Student','Module'])[ ['W_Mark'] ].transform(sum)
```

	Student	Module	Deliverable	Weight	Mark	W_Mark
1	A	Maths	Exam	60	80	48
6	B	Maths	Exam	60	80	48
11	C	Maths	Exam	60	80	48
0	A	Maths	Practical	40	60	24
5	B	Maths	Practical	40	60	24
4	A	Networking	Lab Work	100	80	80
15	C	Networking	Lab Work	100	80	80
10	B	Networking	Project	100	80	80
2	A	Programming	Project 1	10	50	5
7	B	Programming	Project 1	10	50	5
12	C	Programming	Project 1	10	50	5
3	A	Programming	Project 2	30	60	18
8	B	Programming	Project 2	30	60	18
13	C	Programming	Project 2	30	60	18
9	B	Programming	Project 3	60	75	45
14	C	Programming	Project 3	60	75	45

	Student	Module	W_Mark
0	A	Maths	72
1	A	Networking	80
2	A	Programming	23
3	B	Maths	72
4	B	Networking	80
5	B	Programming	68
6	C	Maths	48
7	C	Networking	80
8	C	Programming	68

	Student	Module	Deliverable	Weight	Mark	W_Mark	M_Mark
1	A	Maths	Exam	60	80	48	72
6	B	Maths	Exam	60	80	48	72
11	C	Maths	Exam	60	80	48	48
0	A	Maths	Practical	40	60	24	72
5	B	Maths	Practical	40	60	24	72
4	A	Networking	Lab Work	100	80	80	80
15	C	Networking	Lab Work	100	80	80	80
10	B	Networking	Project	100	80	80	80
2	A	Programming	Project 1	10	50	5	23
7	B	Programming	Project 1	10	50	5	68
12	C	Programming	Project 1	10	50	5	68
3	A	Programming	Project 2	30	60	18	23
8	B	Programming	Project 2	30	60	18	68
13	C	Programming	Project 2	30	60	18	68
9	B	Programming	Project 3	60	75	45	68
14	C	Programming	Project 3	60	75	45	68

The `transform` broadcasts the result for each group over every row in that group.

Part VI

Review Exercises

Review Exercises

Generate the following reports:

1. Number of deliverables by each student. (`value_counts`, or `groupby` and `count`)
2. List and rank deliverables by grade. (`sort_values`, `rank`)
3. Top 2 deliverables (by grade).
4. Top 2 module (by average grade).
5. Top 2 modules (by minimum grade).
6. Modules (by minimum grade).

Harder exercises (new functions)

1. List which students missed which deliverables. (`pivot`, `melt`)