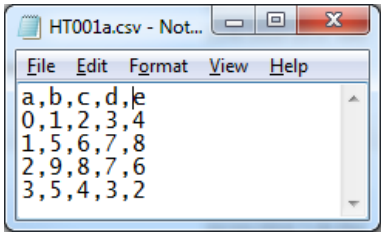
QF627 Programming and Computational Finance

S0304: Data Manipulation and Visualization

(part 2)

Learning Outcomes:

99. ☑ True / ☐ False Both **Python** and **MATLAB** can **use one command** to import data from a CSV file, say **`HT001a.csv`** (see the screenshot), using the first row as column labels, and the first column as row labels and store the data in a variable with the name **`data`**.

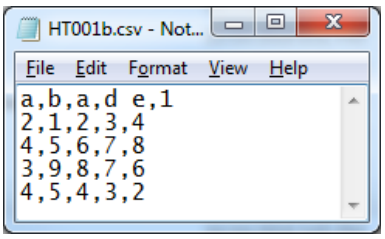


Python
`data=pd.read_csv('HT001a.csv', index_col=0, header=0)`
MATLAB
`data=readtable('HT001a.csv', ReadrowNames, true, 'ReadVariableNames', true)`

100. If the `filename` is **`newfolder\newfile.csv`**, we need to use the string as follows:

Python		
Windows:	Method 1:	`data=pd.read_csv('newfolder\\newfile.csv')`
	Method 2:	`data=pd.read_csv(r'newfolder\newfile.csv')`
Mac:	`data=pd.read_csv('newfolder/newfile.csv')`	
MATLAB		
Windows:	`data=readtable('newfolder\newfile.csv')`	
Mac:	`data=readtable('newfolder/newfile.csv')`	

101. ☑ True / ☐ False **Python DataFrame** is a dict-like containers of Series. Duplicate **column labels** are not allowed. With the parameter **`mangle_dupe_cols=True`** (default value), duplicate columns will be specified as **`X`**, **`X.1`**, … **`X.N`**, rather than **`X`**, …, **`X`**. Numbers can be used as column names, e.g. **`1`**. However, duplicate row names are allowed. For example, for the CSV file **`HT001b.csv`**, the DataFrame **`data`** obtained from **`pandas.read_csv`** has the following column labels and row labels.



`data.columns`	`Index(['b', 'a.1', 'd e', '1'], dtype='object')`
`data.index`	`Int64Index([2, 4, 3, 4], dtype='int64', name='a')`

102. ☑ True / ☐ False **MATLAB tables** do not allow duplicate column names (a.k.a. variable names) or row names. Column/Variable names must be a valid identifier. For example, **`'1'`** and **`'d e'`** cannot be used as a column/variable name. Function **`readtable`** will automatically convert them to **`'x1'`** and **`'dE'`**. However, **`'1'`** can be used as a row name. After loading **`data`** from **`HT001b.csv`** using **`readtable`**, column labels and row labels are as following:

`data.Properties.VariableNames`	`{'b' 'a' 'dE' 'x'}`
`data.Properties.RowNames`	`{'2', '4', '3', '4_1'}`

103. ☑ True / ☐ False Both Python and MATLAB can use **position-based indexing/slicing** method to select data in **`data`**.

<table>
<tr><th>Python</th><th>MATLAB</th></tr>
<tr><td colspan="2"><code>data</code>

a	b	a.1	de	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td colspan="2"><code>data</code>

```
data =
              b     a     dE     x1
            ___   ___   ___    ___
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

</td></tr>
<tr><td>

a	b	a.1	de	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td><code>data.iloc[0,0]</code>

```
Out[7]: 1
```

</td><td>

```
data =
              b     a     dE     x1
            ___   ___   ___    ___
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

</td><td><code>data{1,1}</code>

```
ans =
     1
```

</td></tr>
<tr><td>

a	b	a.1	de	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td><code>data.iloc[0:2,0:2]</code>

a	b	a.1
2	1	2
4	5	6

</td><td>

```
data =
              b     a     dE     x1
            ___   ___   ___    ___
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

</td><td><code>data{1:2,1:2}</code>

```
ans =
     1     2
     5     6
```

</td></tr>
<tr><td>

a	b	a.1	de	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td><code>data.iloc[0,:]</code>

```
b       1
a.1     2
d e     3
1       4
Name: 2, dtype: int64
```

</td><td>

```
data =
              b     a     dE     x1
            ___   ___   ___    ___
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

</td><td><code>data{1,:}</code>

```
ans =
     1     2     3     4
```

</td></tr>
<tr><td>

a	b	a.1	de	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td><code>data.iloc[:,0]</code>

```
a
2    1
4    5
3    9
4    5
Name: b, dtype: int64
```

</td><td>

```
data =
              b     a     dE     x1
            ___   ___   ___    ___
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

</td><td><code>data{:,1}</code>

```
ans =
     1
     5
     9
     5
```

</td></tr>
<tr><td>

a	b	a.1	de	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td><code>data.iloc[[2,0],[0:1]]</code>

a	b	a.1
3	9	8
2	1	2

</td><td>

```
data =
              b     a     dE     x1
            ___   ___   ___    ___
    2         1     2     3      4
    4         5     6     7      8
    3         9     8     7      6
    4_1       5     4     3      2
```

</td><td><code>data{[3,1],[1:2]}</code>

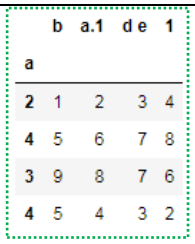
```
ans =
     9     8
     1     2
```

</td></tr>
</table>

104. ☐ True / ☑ False In Python, **`data.values`** returns the whole DataFrame as a 2D Numpy ndarray. In MATLAB, **`data{:,:}`** returns the whole table as a 2D array/matrix.
105. ☑ True / ☐ False Both Python and MATLAB can use **label-based indexing/slicing** method to select data in **`data`**.

<table>
<tr><th>Python</th><th>MATLAB</th></tr>
<tr><td colspan="2">

`data`



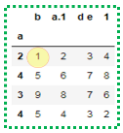
a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

</td><td colspan="2">

`data`

```
data =
     b    a    dE    x1
     _    _    __    __
2    1    2    3     4
4    5    6    7     8
3    9    8    7     6
4_1  5    4    3     2
```

</td></tr>
<tr><td>

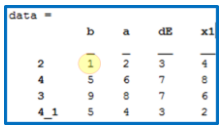


</td><td>

`data.loc[2, 'b']` or **`data.loc['b'][2]`**

```
Out[7]: 1
```

</td><td>

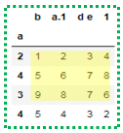


</td><td>

`data{'2', 'b'}`

```
ans =
     1
```

</td></tr>
<tr><td>

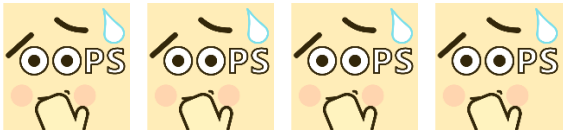


</td><td>

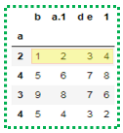
`data.loc[2:3,'b':'1']`

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6

</td><td colspan="2">



</td></tr>
<tr><td>

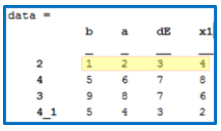


</td><td>

`data.loc[2,:]`

```
b       1
a.1     2
d e     3
1       4
Name: 2, dtype: int64
```

</td><td>

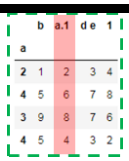


</td><td>

`data{'2', :}`

```
ans =
     1     2     3     4
```

</td></tr>
<tr><td>

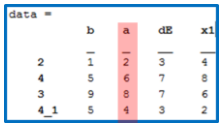


</td><td>

`data.loc[:,'a.1']`

```
a
2    2
4    6
3    8
4    4
Name: a.1, dtype: int64
```

</td><td>



</td><td>

`data{:, 'a'}`

```
ans =
     2
     6
     8
     4
```

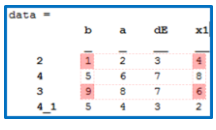
</td></tr>
<tr><td>

</td><td>

`data.loc[[2,3],['b','1']]`

a	b	1
2	1	4
3	9	6

</td><td>



</td><td>

`data{{'2','3'}, {'b','x1'}`

```
ans =
     1     4
     9     6
```

</td></tr>
</table>

106. (Python) Add a column of **1**s to **data** with column name **f1**.

```
data['f1']=1
data.loc[:,'f1']=1
```

107. (Python) Add a column of integers **0, 1, 2, 3** to **data** with column name **f2** through a Python basic iterable, such as **range**, **list**, etc.

`data['f2']` or `data.loc[:,'f2']`	=	Using `range`	`range(4)`
		Using `list`	`[0,1,2,3]`
			`[[0], [1], [2], [3]]`

108. (Python) Add a column of integers **0, 1, 2, 3** to **data** with column name **f3** through a Numpy ndarray generated by **numpy.arange**.

`data['f3']` or `data.loc[:,'f3']`	=	`np.arange(4)`
		`np.arange(4).reshape(4,1)`

109. (Python) To add a column to **data** through a Series, we have the following results:

```
data=pd.read_csv('HT001b.csv', index_col=0, header=0)
data
```

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

`data['f4']=` or `data.loc[:,'f4']=`

`pd.Series(range(3))`

	b	a.1	d e	1	f4
a					
2	1	2	3	4	2.0
4	5	6	7	8	NaN
3	9	8	7	6	NaN
4	5	4	3	2	NaN

`pd.Series(range(4))`

	b	a.1	d e	1	f4
a					
2	1	2	3	4	2.0
4	5	6	7	8	NaN
3	9	8	7	6	3.0
4	5	4	3	2	NaN

`pd.Series(range(5))`

	b	a.1	d e	1	f4
a					
2	1	2	3	4	2.0
4	5	6	7	8	4.0
3	9	8	7	6	3.0
4	5	4	3	2	4.0

110. (Python) To add a column to **data** through a 1-row or 1-column DataFrame, we have the following results:

```
data=pd.read_csv('HT001b.csv', index_col=0, header=0)
data
```

a	b	a.1	d e	1
2	1	2	3	4
4	5	6	7	8
3	9	8	7	6
4	5	4	3	2

```
data['f5']=pd.DataFrame([[i] for i in range(3)]) or
data.loc[:,'f5']=pd.DataFrame([[i] for i in range(3)])
```

data

	b	a.1	d e	1	f5
a					
2	1	2	3	4	2.0
4	5	6	7	8	NaN
3	9	8	7	6	NaN
4	5	4	3	2	NaN

```
data['f5']=pd.DataFrame([[i] for i in range(4)]) or
data.loc[:,'f5']=pd.DataFrame([[i] for i in range(4)])
```

data

	b	a.1	d e	1	f5
a					
2	1	2	3	4	2.0
4	5	6	7	8	NaN
3	9	8	7	6	3.0
4	5	4	3	2	NaN

```
data['f5']=pd.DataFrame([[i] for i in range(5)]) or
data.loc[:,'f5']=pd.DataFrame([[i] for i in range(5)])
```

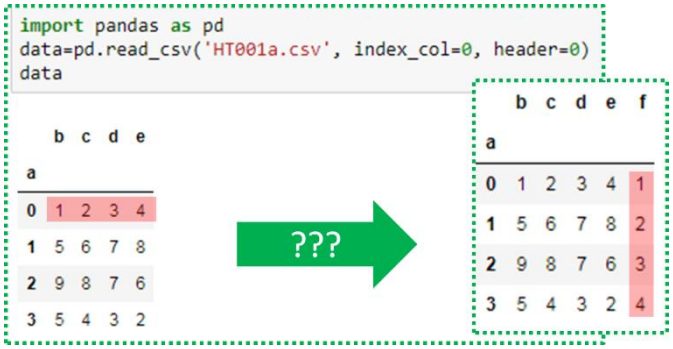
data

	b	a.1	d e	1	f5
a					
2	1	2	3	4	2.0
4	5	6	7	8	4.0
3	9	8	7	6	3.0
4	5	4	3	2	4.0

```
data['f5']=pd.DataFrame([[i for i in range(4)]]) or
data.loc[:,'f5']=pd.DataFrame([[i for i in range(4)]])
```

Error

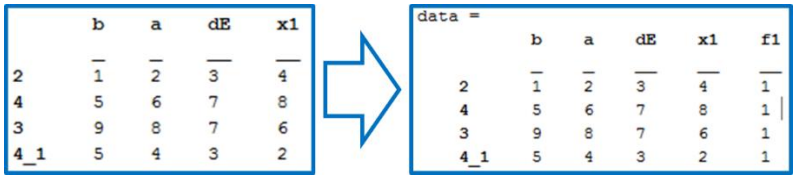
111. ☑ True / ☐ False Homework question: (Python) Use one command to add a column to **`data`**, using the first row of **`data`**, and name this column **`f`**.



112. Complete the following diagram:

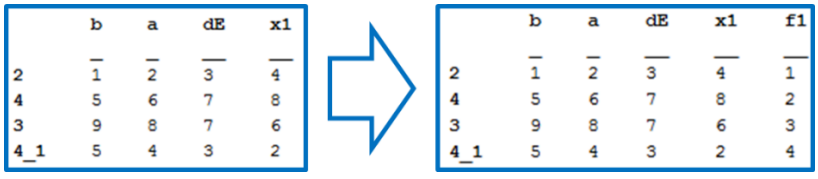
DataFrame	–	**`.values`**	→	**ndarray (2D)**
✓ Selection by `[]` ✓ Selection by **`.loc`** ✓ Selection by **`.iloc`**		**Hint**		✓ Indexing
↓				↓
Series	–	**`.values`**	→	**ndarray (1D)**

113. (MATLAB) Add a column of **1**s to **`data`** with column name **`f1`**.



`data.f1(:,1)=1`	**`data{:, 'f1'}=1`**	**`data(:, 'f1')={1}`**

114. (MATLAB) Add a column of integers **`0, 1, 2, 3`** to **`data`** with column name **`f2`** through a Python basic iterable, such as **`range`**, **`list`**, etc.



`data.f1=[1;2;3;4]`	**`data.f1((:, 1))=[1;2;3;4]`**
`data.f1(:,1)=1:4`	**`data{:,'f1'}=[1;2;3;4]`**

115. ☑ True / ☐ False Homework question: (MATLAB) Use one command to add a column to **`data`**, using the first row of **`data`**, and name this column **`f`**.

```
data=readtable('HT001a.csv','ReadRowNames',true,'ReadVariableNames',true)
   ??????????????????????????
```

```
data =
          b    c    d    e
          _    _    _    _
    0     1    2    3    4
    1     5    6    7    8
    2     9    8    7    6
    3     5    4    3    2
data =
          b    c    d    e    f
          _    _    _    _    _
    0     1    2    3    4    1
    1     5    6    7    8    2
    2     9    8    7    6    3
    3     5    4    3    2    4
```

116. (Python) To **use one command** to add a row of **1**s to **`data`** with the row name **`100`**, we can use

```
data.loc[100, :]=1 or
data=data.append(pd.DataFrame(1,
                              columns=data.columns,
                              index=[100])
```

117. (Python) To **use one command** to add a row of numbers, say **1**, **2**, **3** and **4**, to **`data`** with the row name **`100`**, we can use

```
data.loc[100, :]=range(1, 5) or
data=data.append(pd.DataFrame(np.arange(1, 5).reshape(1,4),
                              columns=data.columns,
                              index=[100])
```

118. ☑ True / ☐ False (Python) **`pandas.DataFrame.append(other,…)`** appends rows of ***`other`*** to the end of the dataframe and returns a new object. Columns not in this frame are added as new columns. Some examples are given as follows.

```
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

```
data=data.append({k:v for (v,k) in enumerate(data.columns,1)}, ignore_index=True)
```

data

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
4	**1**	**2**	**3**	**4**

```
data=data.append([{k:v for (v,k) in enumerate(data.columns,1)}], ignore_index=False)
```

data

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
0	**1**	**2**	**3**	**4**

```
data=data.append([{k:v for (v,k) in enumerate(data.columns,1)}], ignore_index=True)
```

data

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
4	**1**	**2**	**3**	**4**

```
data=data.append(pd.Series(range(1,5),index=data.columns),ignore_index=True)
```

data

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
4	**1**	**2**	**3**	**4**

```
data=data.append([pd.Series(range(1,5),index=data.columns)],ignore_index=False)
```

data

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
0	**1**	**2**	**3**	**4**

```
data=data.append([pd.Series(range(1,5),index=data.columns)],ignore_index=True)
```

data

	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2
4	**1**	**2**	**3**	**4**

119. (MATLAB) To **use one command** to add a row of **1**s to **`data`** with the row name **`100`**, we can use **`data{'100', :}=1 or data('100',:)={1}`**.
120. (MATLAB) To **use one command** to add a row of numbers, say **1**, **2**, **3** and **4**, to **`data`** with the row name **`100`**, we can use **`data{'100', :}=[1,2,3,4]`** or **`data{'100',:}=1:4`**.
121. (Python) To **use one command** to delete column **`b`** in **`data`** we can use **`del data['b']`** or **`data.drop('b', axis=1, inplace=True)`**.
122. (Python) To **use one command** to delete the **`n`**th column in **`data`** we can use **`del data[data.columns[n-1]]`** or **`data.drop(data.columns[n-1], axis=1, inplace=True)`**.
123. (Python) To **use one command** to delete row **`b`** in **`data`** we can use **`data.drop('b', axis=0, inplace=True)`**.
124. (Python) To **use one command** to delete the **`n`**th row in **`data`** we can use **`data.drop(index[n-1],inplace=True)`**.
125. (MATLAB) To **use one command** to delete a column **`b`** in **`data`** we can use **`data.b=[]`** or **`data(:,'b')=[]`**.
126. (Python) To **use one command** to delete the **`n`**th column in **`data`** we can use **`data(:,n)=[]`**.
127. (Python) To **use one command** to delete a row **`b`** in **`data`** we can use **`data('b',:)=[]`**.
128. (Python) To **use one command** to delete the **`n`**th row in **`data`** we can use **`data(n,:)=[]`**.
129. (Python) We can use the following code to swap the objects bounded by **`a`** and **`b`** respectively.

```
a=1
b=2
```

```
#Solution 1
tembp=a
a=b
b=temp
```

```
#Solution 2
a,b=b,a
```

130. (MATLAB) We can use the following code to swap the values stored in **`a`** and **`b`** respectively.

```
a=1
b=2
```

```
%Solution 1
temp=a;
a=b;
b=temp;
```

```
%Solution 2
[a,b]=deal(b,a)
```

131. (Python) To **use one command** to swap two columns (**b** and **c**) in **data**, we can use

```
temp=data['b'].copy()
data['b']=data['c']
data['c']=temp
```

```
#Solution 1
data['b'], data['c'] = data['c'].copy(), data['b'].copy()
```

```
#Solution 2
data['b'], data['c'] = data['c'], data['b'].copy()
```

```
#Solution 3
data[['b','c']]=data[['c','b']]
```

```
#Solution 4
data[['b','c']]=data.loc[:, ['c','b']]
```

```
#Solution 5
data.loc[:, ['b', 'c']]=data.loc[:, ['c', 'b']].values
```

```
#Solution 6
data.loc[:, ['b', 'c']]=data[['c', 'b']].values
```

132. (Python) To **use one command** to swap two rows (**b** and **c**) in **data**, we can use
data.loc[[b,c],:]=data.loc[[c,b],:].values
133. (Python) To **use one command** to swap two rows (**m**th and **n**th) in **data**, we can use
data.iloc[[m-1,n-1],:]=data.loc[[n-1,m-1],:].values
134. (MATLAB) To **use one command** (without using function **deal**) to swap two columns (**b** and **c**) in **data**, we can use
data(:,{'b','c'})=data(:,{'c','b'}) or
data{:,{'b','c'}}=data{:,{'c','b'}}
135. (MATLAB) To **use one command** (without using function **deal**) to swap two rows (**b** and **c**) in **data**, we can use
data({'b','c'}, :)=data({'c','b'}, :) or
data{{'b','c'}, :}=data{{'c','b'}, :}
136. (MATLAB) To **use one command** (without using function **deal**) to swap two columns (**n**th and **m**th) in **data**, we can use
data(:,[m,n])=data(:,[n,m]) or
data{:,[m,n]}=data{:,[n,m]}
137. (MATLAB) To **use one command** (without using function **deal**) to swap two rows (**n**th and **m**th) in **data**, we can use
data([m,n],:)=data([n,m],:) or
data{[m,n],:}=data{[n,m],:}

138. (MATLAB) To **use temp** (without using function **`deal`**) to swap two rows (**n**th and **m**th) in **`data`**, we can use

```
temp=data(m, :);
data(m, :)=data(n,:);
data(n,:)=temp;
```

139. (MATLAB) To **use** function **`deal`** to swap two rows (**n**th and **m**th) in **`data`**, we can use

```
[data(n,:), data(m, :)]=deal(data(m,:), data(n, :))
```

140. (Python) **Use one command** to compute and return the square root of every cell in **`data`** as a new dataframe, we can use
`data.apply(np.sqrt)` or **`data.apply(math.sqrt)`**
141. (Python) **Use one command** to compute the sum of every column in **`data`**, we can use **`data.apply(np.sum, axis=0)`**. The return value is a ☐ DataFrame / ☑ Series.
142. (Python) **Use one command** to compute the sum of every row in **`data`**, we can use **`data.apply(np.sum, axis=1)`**. The return value is a ☐ DataFrame / ☑ Series.
143. (Python) **Use one command with the library function `pandas.DataFrame.apply`** to use the following formula to compute and return a number on every column in **`data`**:

$$(\text{value in row } 1)^2 + (\text{sum of all elements in the column})$$

`data.apply(lambda x:x[0]**2+np.sum(x), axis=0)`. The command returns a ☐ DataFrame / ☑ Series.
144. (Python) **Use one command with the library function `pandas.DataFrame.apply`** to use the following formula to compute and return a list on every row in **`data`**:

$$[(\text{value in column } \mathbf{d})^{\mathbf{2}}, (\text{value in column } \mathbf{c})^2 + (\text{sum of all elements in the row})]$$

`data.apply(lambda x:[x['d']**2,x['c']**2+np.sum(x)], axis=1)`. The return value is a ☐ DataFrame / ☑ Series.
145. (Python) Continued from 144, with the parameter **`result_type='expand'`**, the return value is a ☑ DataFrame / ☐ Series. List-like results will be expanded to columns of DataFrame.
146. (Python) Continued from 144, if the function returns a Series, the return value is a ☐ DataFrame / ☑ Series. Similar to 145, the resulting column names will be the Series index.
147. ☑ True / ☐ False (MATLAB) **`B=rowfun(func,A)`** applies the function **`func`** to rows in table **`A`**. The number of parameters in the function **`func`** should be the same as the number of columns in **`A`**. Each parameter denotes a column in **`A`**. The return value **`B`** is a table. To return a numeric vector instead of a table, use **`B=rowfun(func,A,Name,Value)`**.
148. ☑ True / ☐ False (MATLAB) **`B=varfun(func,A)`** applies the function **`func`** to columns/variables in table **`A`**. The function **`func`** is a one-variable function. The variable denotes the whole column. The return value **`B`** is a table. To return a numeric vector instead of a table, use **`B=varfun(func,A,Name,Value)`**.

149. ☑ True / ☐ False (Python) Complete the following table for basic operations on two rows/columns of **`data`**.

	DataFrame	Series	Numpy 2D array	Numpy 1D array
DataFrame	element-wise, aligned by labels	broadcasting, align DataFrame's column labels and Series' labels	element-wise, size must agree	use array as a row, broadcasting, element-wise, **size** must agree
Series		element-wise, aligned by labels	N.A.	element-wise, size must agree
Numpy 2D array			broadcasting, element-wise, size must agree	broadcasting
Numpy 1D array				element-wise, size must agree

150. (Python) **Use one command** to add the a row (e.g. the 1st row) to every row in **`data`** with **`data` *`op`* `row-Series`**

```
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

`data+data.iloc[0,:]`

	b	C	d	e
a				
0	2	4	6	8
1	6	8	10	12
2	10	10	10	10
3	6	6	6	6

```
import pandas as pd
data=pd.read_csv('HT001b.csv', index_col=0, header=0)
print(data)
```

```
   b  a.1  d e  1
a
2  1    2    3  4
4  5    6    7  8
3  9    8    7  6
4  5    4    3  2
```

`data+data.iloc[0,:]`

	b	a.1	d e	1
a				
2	2	4	6	8
4	6	8	10	12
3	10	10	10	10
4	6	6	6	6

151. (Python) **Use one command** to add a vector to every row in **`data`** with **`data` *`op`* `1D-array`** (or **`list`**)

```
import pandas as pd
data=pd.read_csv('HT001a.csv', index_col=0, header=0)
print(data)
```

```
   b  c  d  e
a
0  1  2  3  4
1  5  6  7  8
2  9  8  7  6
3  5  4  3  2
```

`data+range(4)`

or

`data+np.arange(4)`

	b	C	d	e
a				
0	1	3	5	7
1	5	7	9	10
2	9	9	9	9
3	5	5	5	5

152. (Python) **Use one command** to add a column (e.g. the 1st column) to every row in **`data`** without changing the **`id`** of **`data`**.

`data+np.tile(data.iloc[:,0].values.reshape(4, 1), 4)`
`data+np.tile(data.iloc[:, [0]].values, 4)`
`data.apply(lambda x:x+data.iloc[:, 0].values, axis=0)`

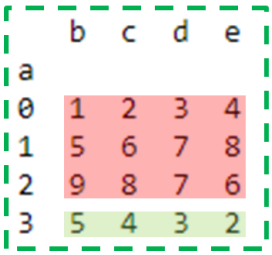
153. (Python) Numpy array arithmetic operations: **`array1` *`op`* `array2`**

`array1`	**`array2`**	**`array1 + array2`**
`(3,)` 1D array	`(3,)` 1D array	☐ Error / ☑ `(3,)` 1D array
`(3,)` 1D array	`(4,)` 1D array	☑ Error / ☐ `(  ,)` 1D array
`(3,4)` 2D array	`(3,4)` 2D array	☐ Error / ☑ `(3, 4)` 2D array
`(3,3)` 2D array	`(3,4)` 2D array	☑ Error / ☐ `(  ,  )` 2D array
`(3,3)` 2D array	`(4,3)` 2D array	☑ Error / ☐ `(  ,  )` 2D array
`(3,4)` 2D array	`(3,1)` 2D array	☐ Error / ☑ `(3, 4)` 2D array
`(3,4)` 2D array	`(1,4)` 2D array	☐ Error / ☑ `(3, 4)` 2D array
`(3,4)` 2D array	`(4,)` 1D array	☐ Error / ☑ `(3, 4)` 2D array
`(3,4)` 2D array	`(3,)` 1D array	☑ Error / ☐ `(  ,  )` 2D array

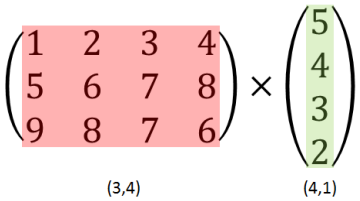
154. (Python) Matrix multiplication using Numpy 1D/2D arrays.

Shape of **A**	Shape of **B**	Shape of **A@B**
(M, N)	**(N, P)**	**(M,P)**
(M, N)	**(N, 1)**	**(M,1)**
(M, N)	**(N,)**	**(M,)**
(1, N)	**(N, P)**	**(1,P)**
(N,)	**(N, P)**	**(P,)**
(1, N)	**(N, 1)**	**(1, 1)**
(N,)	**(N,)**	**( )**

155. **Use one command** to compute the matrix multiplication, using the first 3 rows in **data** as the first matrix, and using the last row (without finding the number of rows) in **data** as the second 1-column matrix.



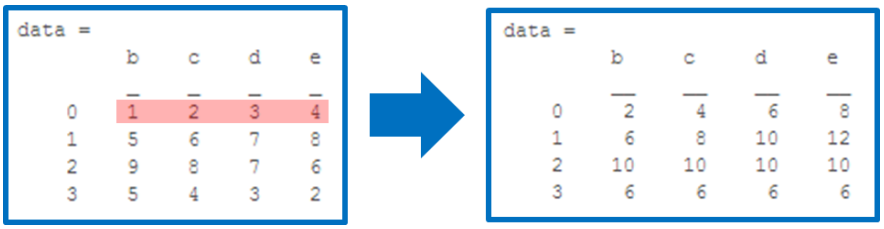
a	b	c	d	e
0	1	2	3	4
1	5	6	7	8
2	9	8	7	6
3	5	4	3	2




```
data.values[:3] @ data.value[-1]
data.values[:3] @ data.values[-1:].T
data.values[:3] @ data.values[[-1]].T
```

156. ☑ True / ☐ False (MATLAB) MATLAB tables do not support arithmetic operations. We can use the dot syntax or **{}**-indexing/slicing to obtain arrays. A 1D array is a 1-row 2D array. Matrix dimensions must agree or one is a scalar when applying arithmetic operation. There is no auto "broadcasting" except for the scalar.

157. (MATLAB) **Use one command** to add the first row of **data** to every row in **data**.

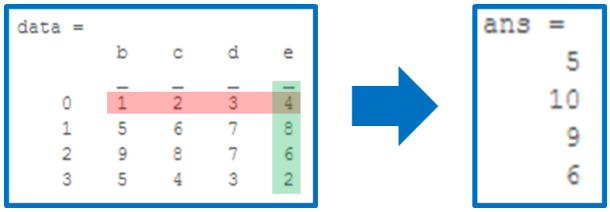


```
data =
      b    c    d    e
      _    _    _    _
0     1    2    3    4
1     5    6    7    8
2     9    8    7    6
3     5    4    3    2
```

```
data =
      b    c    d    e
     __   __   __   __
0     2    4    6    8
1     6    8   10   12
2    10   10   10   10
3     6    6    6    6
```

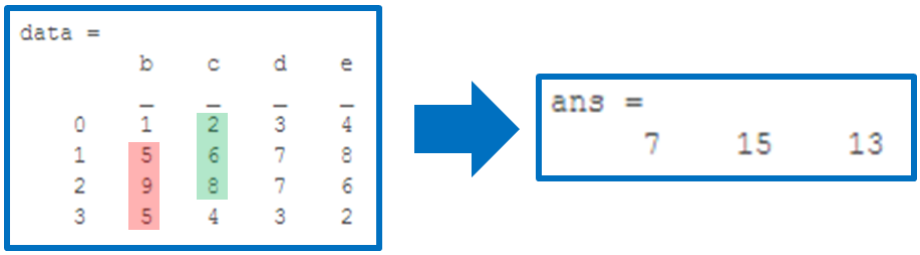
```
data{:, :}=data{:,:}+repmat(data{1,:}, size(data,1),1)
```

158. (MATLAB) **Use one command** to add the first row and the last column (without using the size of **data**) of **data** elementwise to every row in **data**.




```
transpose(data{1, :})+data{:, end}
```

159. (MATLAB) **Use one command** to add elements in the first column from the second row to the last row (without using the size of **data**) and elements in the second column from the first row to the second to the last row (without finding the size of **data**) element wise and return the result in a row array.

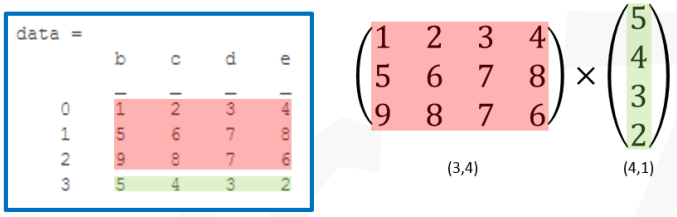



```
transpose(data{2:end, 1}+data{1:end-1, 2})
```

160. (MATLAB) MATLAB basic matrix operations.

matrix multiplication	`X*Y`	elementwise multiplication	`X.*Y`
matrix power	`X^Y`	elementwise power	`X.^Y`
matrix right division	`X/Y`	elementwise divide	`X./Y`

161. (MATLAB) **Use one command** to compute the matrix multiplication, using the first 3 rows in **data** as the first matrix, and using the last row (without using the size of **data**) as the second 1-column matrix.




```
data{1:3, :}*transpose(data{end, :})
```

162. (Python) **Use one command** to sort rows in **`data`** in-place by the 3rd column in **`data`** in ascending order.

```
data.sort_values(by=data.columns[2], axis=0, inplace=True)
```
or
```
data.values[np.argsort(data.values,axis=0)[:,2],:]
```

163. (Python) **Use one command** to sort columns in **`data`** in-place by the 3rd row in **`data`** in ascending order.

```
data.sort_values(by=data.index[2], axis=1, inplace=True)
```
or
```
data.values[np.argsort(data.values,axis=1)[:,2]]
```

164. (MATLAB) **`sortrows(X,COL)`** sorts the matrix **`X`** based on the columns specified in vector **`COL`**. To use the matrix **`X`** based on rows specified in vector **`ROW`**, we can use **`transpose(sortrows(transpose(X),ROW))`**

165. (MATLAB) **`sort`** works on matrices but not on tables. **`sortrows`** works on both matrices and tables. Therefore,
(1) to sort rows in **`data`** by the 3rd column, we can **use one command**:

```
data=sortrows(data,3)
```

(2) to sort columns in **`data`** by the 3rd row, we need to use two commands:

```
[y,I]=sortrows(transpose(data{:,:}),3);
data=data(:,I)
```

166. (MATLAB) When assigning values from one matrix to another matrix, e.g. `A(J,K,…)=B(M,N,…)`, the following must be true:
    - The number of subscripts specified for `B`, not including trailing subscripts equal to `1`, does not exceed `ndims(B)`. For example, if `B` is a `2x3x4` 3D array, `ndims(B)=3`, `B(2,2:end,1:2,1,1)` is a valid indexing.
    - The number of nonscalar subscripts specified for `A` equals the number of nonscalar subscripts specified for `B`. For example, `A(5,1:4,1,2)=B(5:8)` is valid because both sides of the equation use one nonscalar subscript.
    - The order and length of all nonscalar subscripts specified for `A` matches the order and length of nonscalar subscripts specified in `B`. For example, `A(1:4,3,3:9)=B(5:8,1:7)` is valid because both sides of the equation (ignoring the one scalar subscript 3) use a 4-element subscript followed by a 7-element subscript.

    In view of the above, in a 3x3 matrix **`x`**, we can use the following command to copy the 3rd column of **`x`** and paste it to the 2nd row of **`x`**.

```
x(2,:)=x(:,3)
```

167. ☑ True / ☐ False (Python) Slicing of Numpy arrays are views. In the assignment **`slicing_1=slicing_2`**, it is a good practice to use **`.copy()`** on **`slicing_2`**. For example, in a 3x3 2D array **`x`**, to copy the 3rd column of **`x`** and paste it to the 2nd row of **`x`**, it will be nice to use **`x[1,:]=x[:,2].copy()`**.