



# NumPy

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# Numpy

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NumPy is a Python package for general-purpose array-processing. It provides a high-performance multidimensional array object, and tools for working with these arrays.

It is the fundamental package for scientific computing with Python. It contains various features but the most important feature is **vectorization**.

The vectorization results in more “Pythonic” code. Without vectorization, our code would be littered with inefficient and difficult to read for loops.

# Numpy

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Vectorization describes the absence of any explicit looping, indexing, etc., in the code - these things are taking place, of course, just “behind the scenes” in optimized, pre-compiled C code. Vectorized code has many advantages, among which are:

vectorized code is more concise and easier to read

fewer lines of code generally means fewer bugs

the code more closely resembles standard mathematical notation (making it easier, typically, to correctly code mathematical constructs)

# np.array()

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The screenshot shows the PyCharm IDE interface. The main editor window displays a Python script named `np1.py` with the following code:

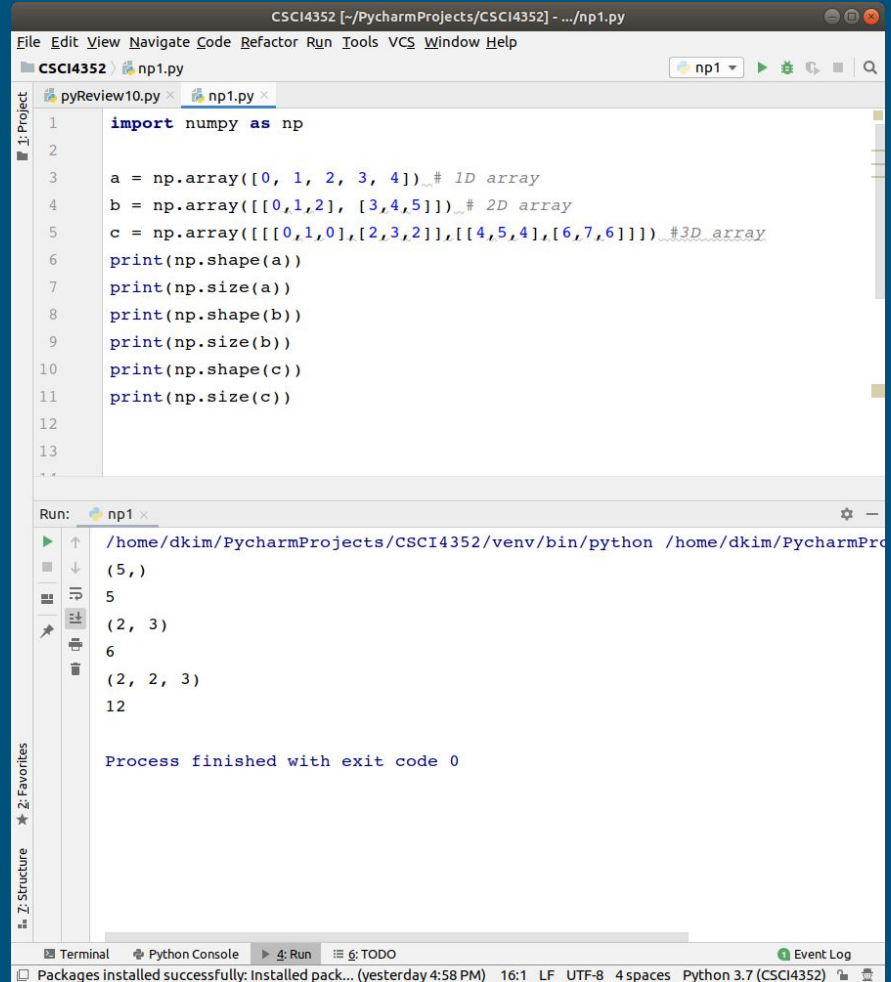
```
1 import numpy as np
2
3 a = np.array([0, 1, 2, 3, 4]) # 1D array
4 print(a)
5 b = np.array([[0,1,2], [3,4,5]]) # 2D array
6 print(b)
7 c = np.array([[[0,1],[2,3]],[[4,5],[6,7]]]) # 3D array
8 print(c)
9
10
11
12
13
```

Below the editor, the Run console shows the output of the script:

```
Run: np1
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/PycharmPro
[0 1 2 3 4]
[[0 1 2]
 [3 4 5]]
[[[0 1]
 [2 3]]
 [[4 5]
 [6 7]]]
Process finished with exit code 0
```

The bottom status bar indicates the package manager output: "Packages installed successfully: Installed packages... (today 4:58 PM) 12:1 LF UTF-8 4 spaces Python 3.7 (CSCI4352)".

```
np.shape()
np.size()
```



The screenshot shows a PyCharm IDE window titled "CSCI4352 [-/PycharmProjects/CSCI4352] - .../np1.py". The editor displays a Python script with the following code:

```
1 import numpy as np
2
3 a = np.array([0, 1, 2, 3, 4]) # 1D array
4 b = np.array([[0,1,2], [3,4,5]]) # 2D array
5 c = np.array([[[0,1,0],[2,3,2]],[[4,5,4],[6,7,6]]) #3D array
6 print(np.shape(a))
7 print(np.size(a))
8 print(np.shape(b))
9 print(np.size(b))
10 print(np.shape(c))
11 print(np.size(c))
12
13
```

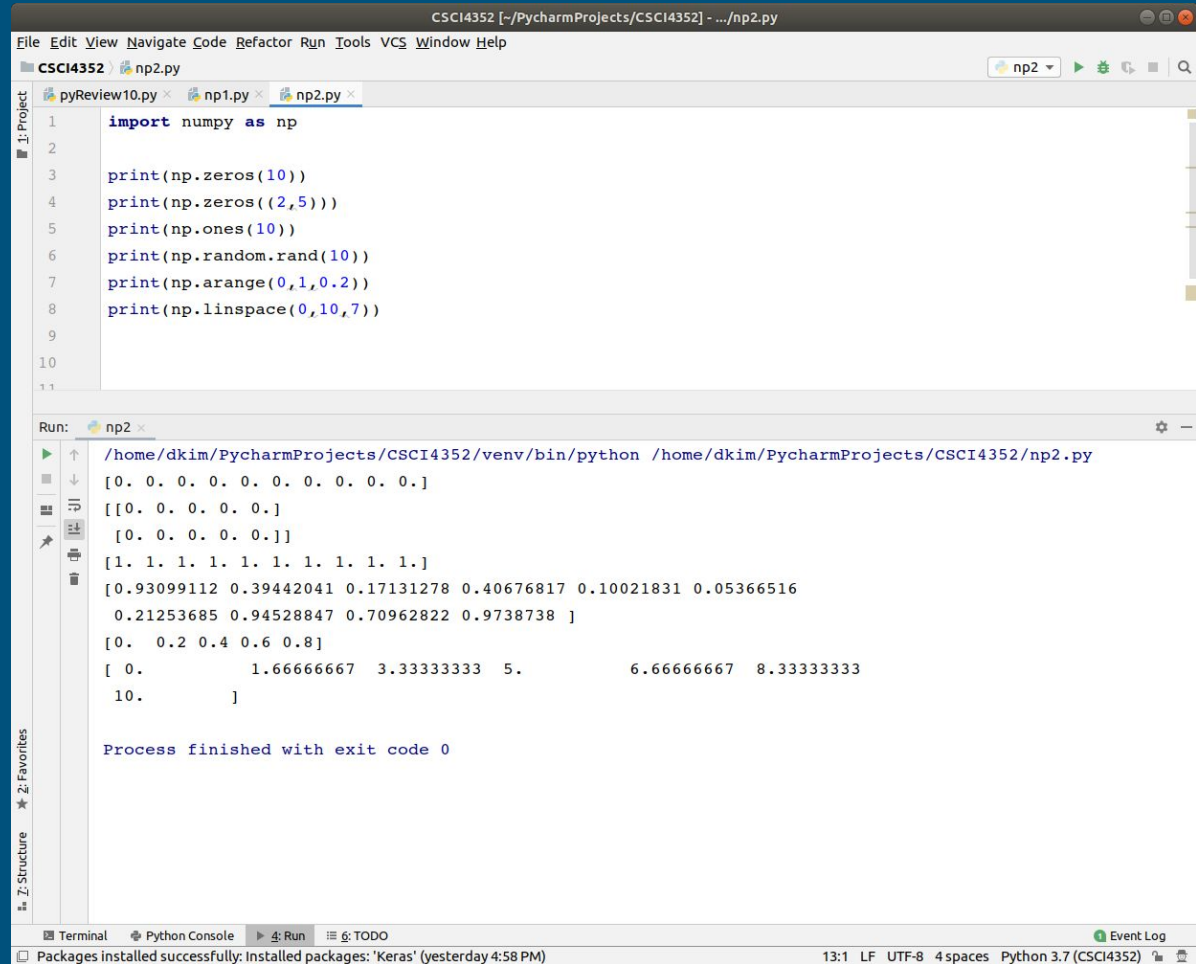
The Run window below the editor shows the execution output for "np1":

```
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/PycharmPro
(5,)
5
(2, 3)
6
(2, 2, 3)
12

Process finished with exit code 0
```

The status bar at the bottom indicates "Packages installed successfully: Installed pack... (yesterday 4:58 PM) 16:1 LF UTF-8 4 spaces Python 3.7 (CSCI4352)".

```
np.zeros()
np.ones()
np.random.rand()
np.arange()
np.linspace()
```



The screenshot shows the PyCharm IDE interface. The main editor window displays a Python script named `np2.py` with the following code:

```
1 import numpy as np
2
3 print(np.zeros(10))
4 print(np.zeros((2,5)))
5 print(np.ones(10))
6 print(np.random.rand(10))
7 print(np.arange(0,1,0.2))
8 print(np.linspace(0,10,7))
9
10
11
```

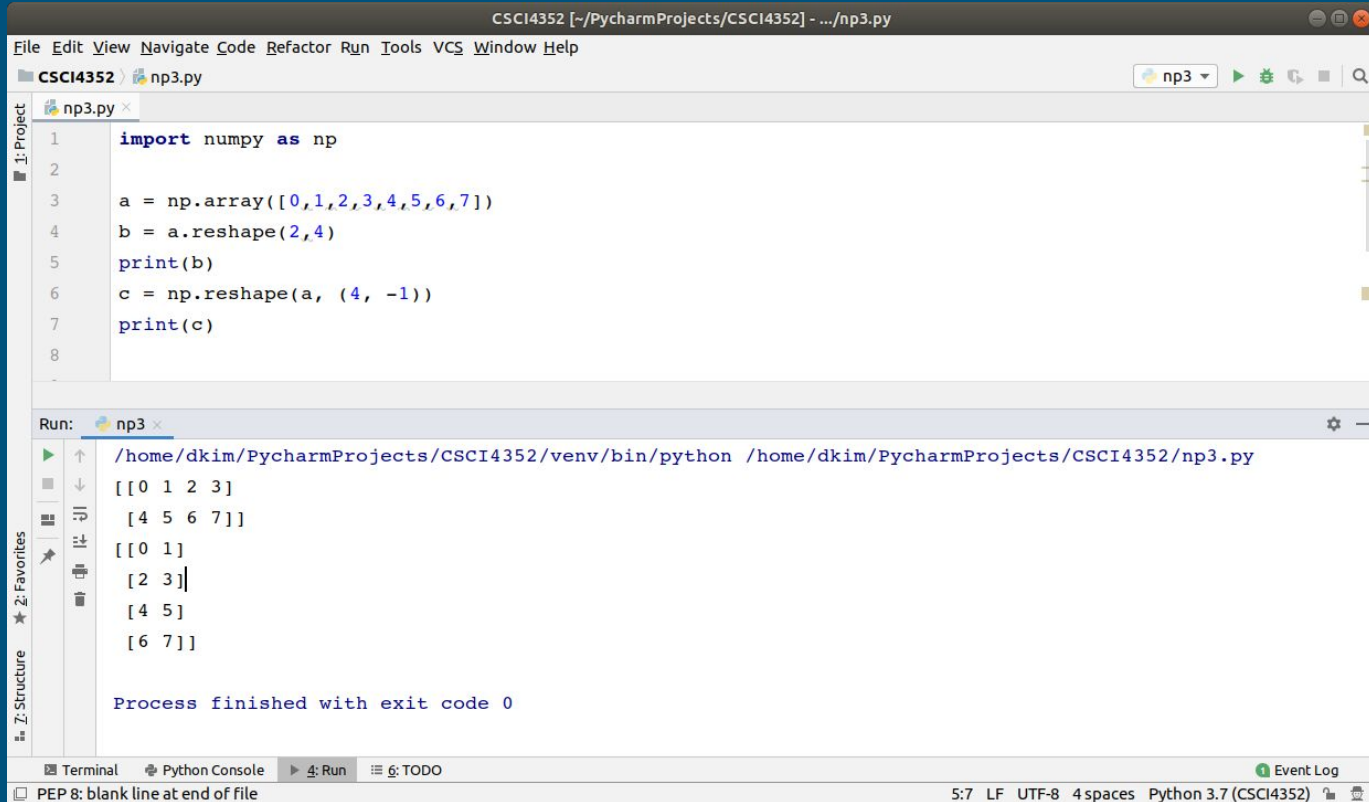
Below the editor, the Run console shows the output of the script:

```
Run: np2
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/PycharmProjects/CSCI4352/np2.py
[0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
[[0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0.]]
[1. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
[0.93099112 0.39442041 0.17131278 0.40676817 0.10021831 0.05366516
 0.21253685 0.94528847 0.70962822 0.9738738 ]
[0. 0.2 0.4 0.6 0.8]
[ 0.          1.66666667  3.33333333  5.          6.66666667  8.33333333
 10.         ]

Process finished with exit code 0
```

The bottom status bar indicates the package manager status: "Packages installed successfully: Installed packages: 'Keras' (yesterday 4:58 PM)". The system tray shows "13:1 LF UTF-8 4 spaces Python 3.7 (CSCI4352)".

# reshape ()



```
CSCI4352 [~/PycharmProjects/CSCI4352] - .../np3.py
File Edit View Navigate Code Refactor Run Tools VCS Window Help
CSCI4352 np3.py
np3
1 import numpy as np
2
3 a = np.array([0,1,2,3,4,5,6,7])
4 b = a.reshape(2,4)
5 print(b)
6 c = np.reshape(a, (4, -1))
7 print(c)
8

Run: np3
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/PycharmProjects/CSCI4352/np3.py
[[0 1 2 3]
 [4 5 6 7]]
[[0 1]
 [2 3]
 [4 5]
 [6 7]]

Process finished with exit code 0
```

Terminal Python Console Run TODO Event Log

PEP 8: blank line at end of file 5:7 LF UTF-8 4 spaces Python 3.7 (CSCI4352)

## Addition of two vectors (1D array)

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$$A+B = [a_1, a_2]^T + [b_1, b_2]^T = [a_1+b_1, a_2+b_2]^T$$

## Scalar product

$$A \cdot c = [a_1, a_2]^T \cdot c = [a_1 \cdot c, a_2 \cdot c]^T$$



CSCI4352 [~/PycharmProjects/CSCI4352] - .../np3.py

File Edit View Navigate Code Refactor Run Tools VCS Window Help

CSCI4352 > np3.py

```
1 import numpy as np
2
3 a = np.array([0,1,2,3])
4 b = np.array([2,3,1,3])
5 print(a+b)
6
```

Run: np3

```
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python3
[2 4 3 6]

Process finished with exit code 0
```

Terminal Python Console Run TODO Event Log

Packages ... (yesterday 4:58 PM) 5:1 LF UTF-8 4 spaces Python 3.7 (CSCI4352)

CSCI4352 [~/PycharmProjects/CSCI4352] - .../np3.py

File Edit View Navigate Code Refactor Run Tools VCS Window Help

CSCI4352 > np3.py

```
1 import numpy as np
2
3 a = np.array([0,1,2,3])
4 b = 3
5 print(a*b)
6
```

Run: np3

```
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python3
[0 3 6 9]

Process finished with exit code 0
```

Terminal Python Console Run TODO Event Log

Packages ... (yesterday 4:58 PM) 9:1 LF UTF-8 4 spaces Python 3.7 (CSCI4352)

# Dot product

$$a \cdot b = \begin{bmatrix} a_1 & a_2 & a_3 & a_4 & a_5 \end{bmatrix}_{(1 \times n)} \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix}_{(n \times 1)} = \left\{ a_1 b_1 + a_2 b_2 + a_3 b_3 + a_4 b_4 + a_5 b_5 \right\}$$

**Dot Product**

CSCI4352 [~/PycharmProjects/CSCI4352] - .../np3.py

File Edit View Navigate Code Refactor Run Tools VCS Window Help

CSCI4352 > np3.py

np3

np3.py x

```
1 import numpy as np
2
3 a = np.array([0,1,2,3])
4 b = np.array([2,3,1,3])
5 print(np.dot(a,b))
6 c = np.array([0,1,2,3,4,5]).reshape(2,3)
7 d = np.array([0,1,2,3,4,5]).reshape(3,2)
8 print(np.dot(c,d))
9
```

Run: np3 x

```
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/Pych
14
[[10 13]
 [28 40]]

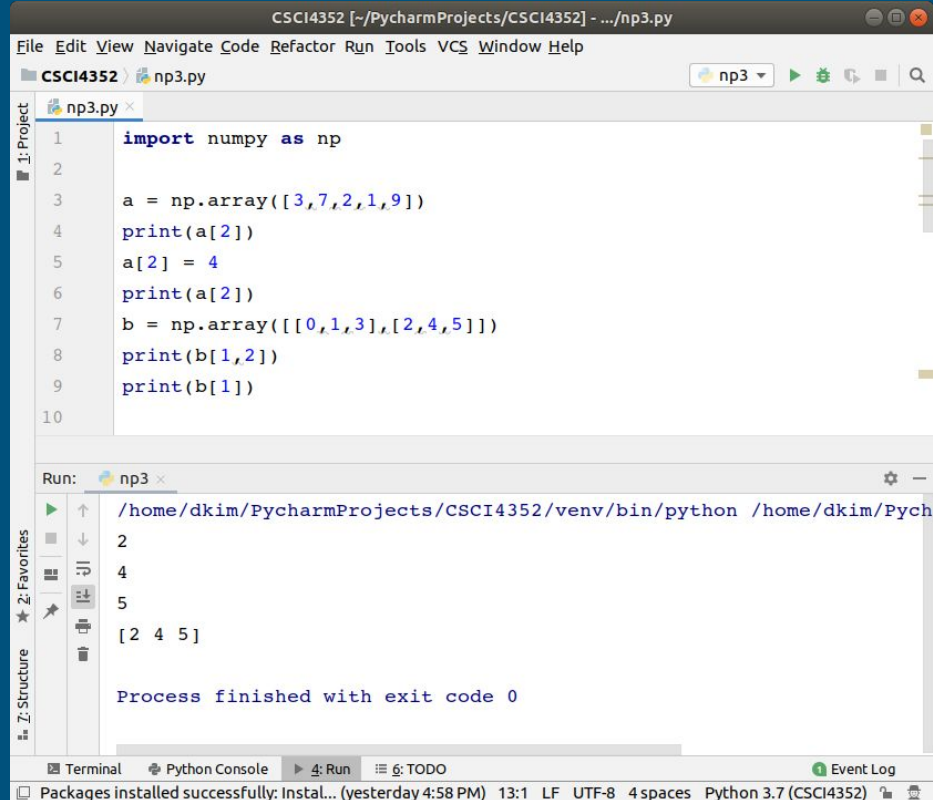
Process finished with exit code 0
```

Z: Structure 2: Favorites

Terminal Python Console 4: Run 6: TODO Event Log

Packages installed successfully: Instal... (yesterday 4:58 PM) 11:1 LF UTF-8 4 spaces Python 3.7 (CSCI4352)

# Access to elements



The screenshot shows the PyCharm IDE interface. The main editor window displays a Python script named `np3.py` with the following code:

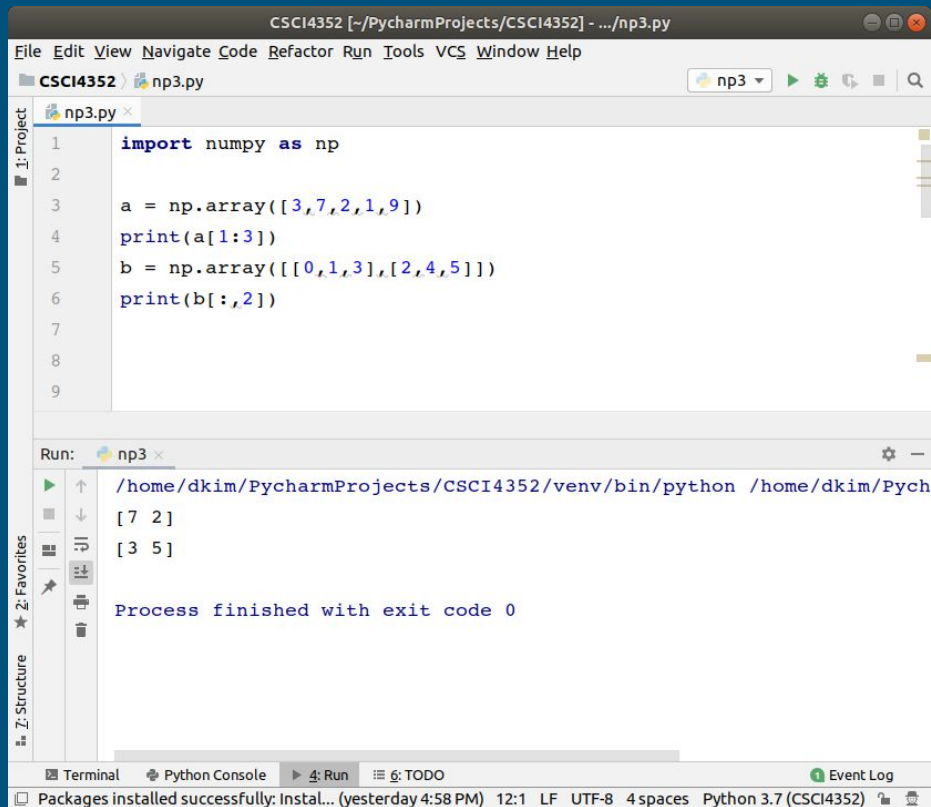
```
1 import numpy as np
2
3 a = np.array([3,7,2,1,9])
4 print(a[2])
5 a[2] = 4
6 print(a[2])
7 b = np.array([[0,1,3],[2,4,5]])
8 print(b[1,2])
9 print(b[1])
10
```

Below the editor, the Run console shows the output of the script:

```
Run: np3 x
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/Pych
2
4
5
[2 4 5]
Process finished with exit code 0
```

The status bar at the bottom indicates that packages were installed successfully and the environment is Python 3.7 (CSCI4352).

# Slicing



The screenshot displays the PyCharm IDE interface. The main editor window shows a Python file named `np3.py` with the following code:

```
1 import numpy as np
2
3 a = np.array([3,7,2,1,9])
4 print(a[1:3])
5 b = np.array([[0,1,3],[2,4,5]])
6 print(b[:,2])
7
8
9
```

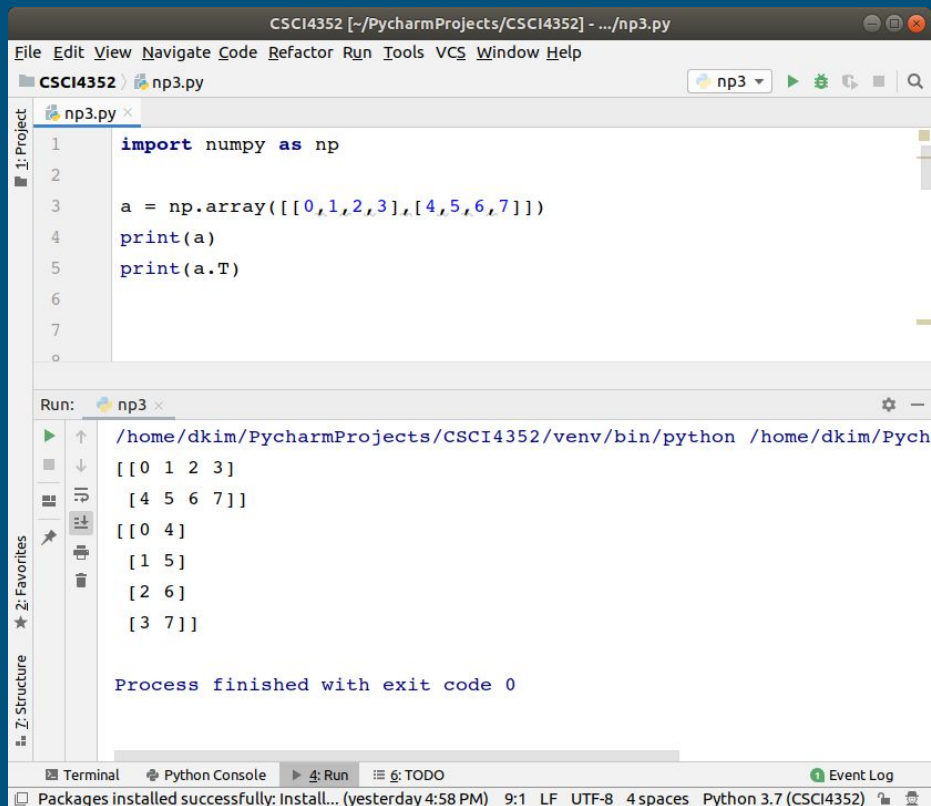
Below the editor, the Run console shows the output of the script:

```
Run: np3 x
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/Pych
[ 7 2]
[ 3 5]

Process finished with exit code 0
```

The status bar at the bottom indicates the file encoding is UTF-8, the font size is 12:1, and the Python version is 3.7 (CSCI4352).

# Transpose



The screenshot shows the PyCharm IDE interface. The main editor window displays a Python script named `np3.py` with the following code:

```
1 import numpy as np
2
3 a = np.array([[0,1,2,3],[4,5,6,7]])
4 print(a)
5 print(a.T)
6
7
8
```

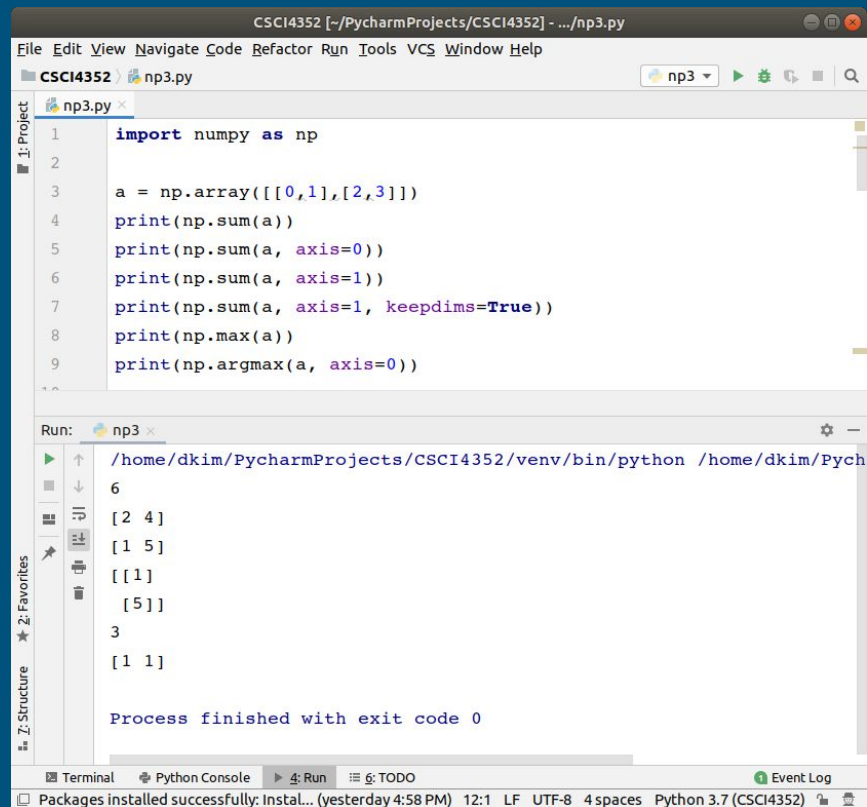
Below the editor, the Run console shows the output of the script:

```
Run: np3 x
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/Pych
[[0 1 2 3]
 [4 5 6 7]]
[[0 4]
 [1 5]
 [2 6]
 [3 7]]

Process finished with exit code 0
```

The status bar at the bottom indicates that packages were installed successfully and shows the Python version as 3.7 (CSCI4352).

# Numpy functions



The screenshot shows a PyCharm IDE window titled "CSCI4352 [~/PycharmProjects/CSCI4352] - .../np3.py". The editor displays the following Python code:

```
1 import numpy as np
2
3 a = np.array([[0,1],[2,3]])
4 print(np.sum(a))
5 print(np.sum(a, axis=0))
6 print(np.sum(a, axis=1))
7 print(np.sum(a, axis=1, keepdims=True))
8 print(np.max(a))
9 print(np.argmax(a, axis=0))
```

The Run window below shows the execution output:

```
Run: np3 x
/home/dkim/PycharmProjects/CSCI4352/venv/bin/python /home/dkim/Pych
6
[2 4]
[1 5]
[[1]
 [5]]
3
[1 1]

Process finished with exit code 0
```

The status bar at the bottom indicates "Python 3.7 (CSCI4352)" and "Packages installed successfully: Instal... (yesterday 4:58 PM)".