NumPy

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- Creating arrays
- Indexing and slicing
- Iterators
- Manipulation of array
- Statistical operations
- Algorithms
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NumPy – Numerical Python

Using NumPy, a developer can perform the following operations:

- Mathematical and logical operations on arrays.
- Fourier transforms and routines for shape manipulation.
- Operations related to linear algebra. NumPy has in-built functions for linear algebra and random number generation.

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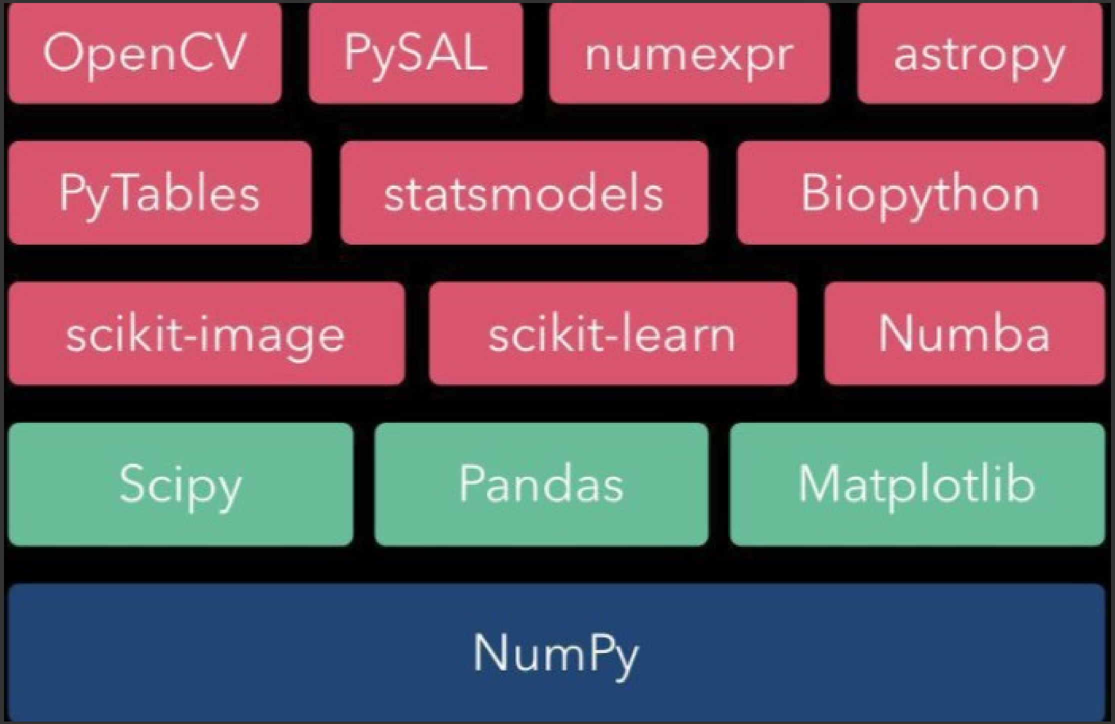
NumPy - Echo system



OpenCV PySAL numexpr astropy

PyTables statsmodels Biopython

scikit-image scikit-learn Numba

Scipy Pandas Matplotlib

NumPy

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NumPy Objects:

The most important object defined in NumPy is an N-dimensional array type called “ndarray”.

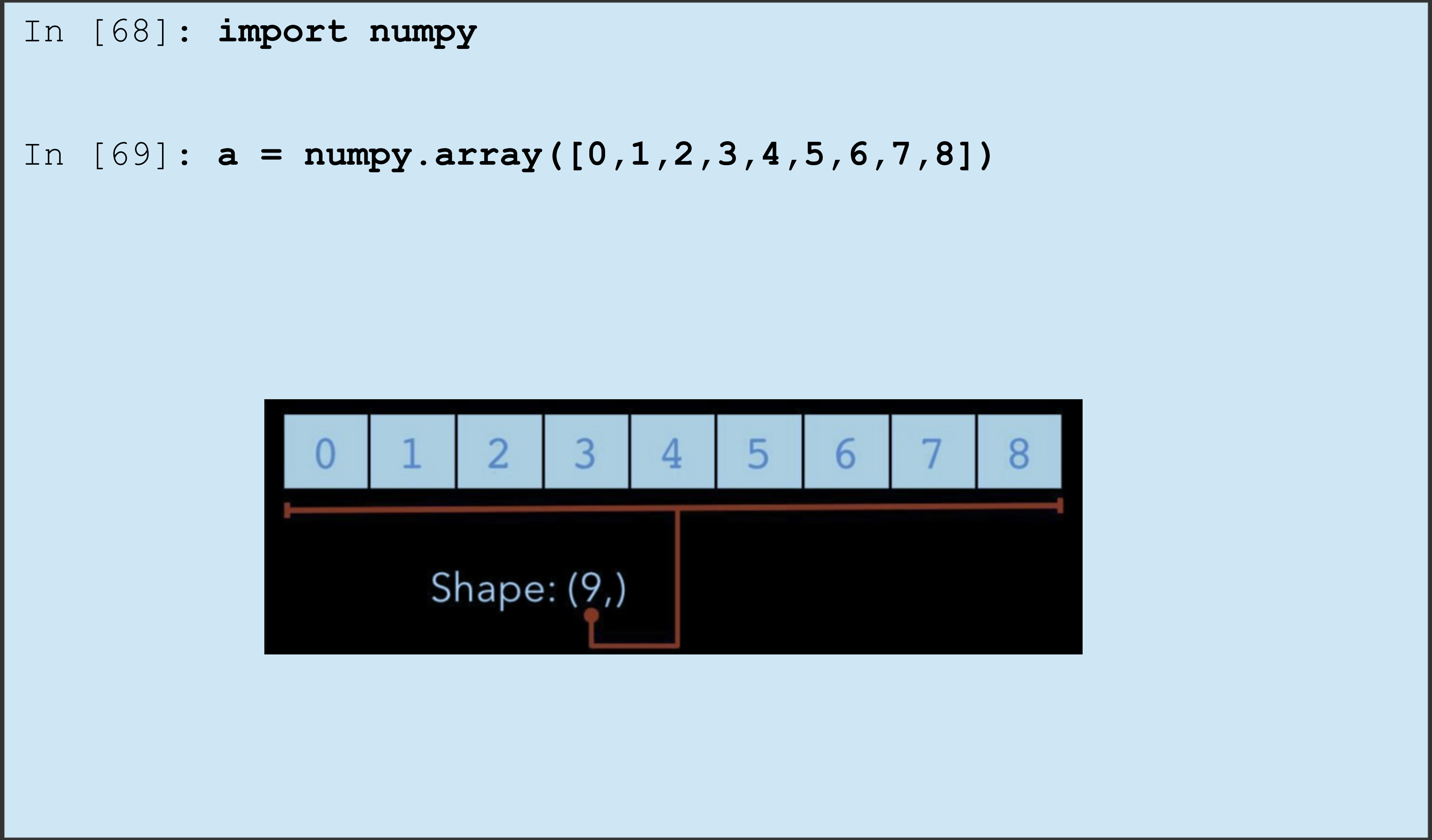
It describes the collection of items of the same type.

Items in the collection can be accessed using a zero-based index.

Every item in an ndarray takes the same size of block in the memory.

Each element in ndarray is an object of data-type object (called dtype).

Let us start a simple program:



```
In [68]: import numpy


In [69]: a = numpy.array([0,1,2,3,4,5,6,7,8])
```

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```
A= numpy.array(object, dtype=None, copy=True, order='K',
subok=False, ndmin=0)

Parameters
----------
object : array_like
    An array, any object exposing the array interface, an
object whose

dtype : data-type, optional
    The desired data-type for the array.

copy : bool, optional

order : {'C', 'F'}, optional

subok : bool, optional

ndmin : int, optional
```

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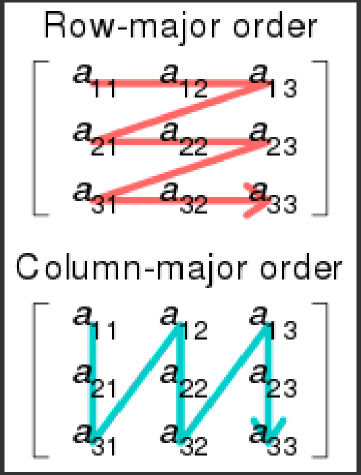
order:

In computing, **row-major order** and **column-major order** are methods for storing multidimensional arrays in linear storage such as random access memory.


Row-major order
a_{11} a_{12} a_{13}
a_{21} a_{22} a_{23}
a_{31} a_{32} a_{33}
Column-major order
a_{11} a_{12} a_{13}
a_{21} a_{22} a_{23}
a_{31} a_{32} a_{33}

dtype:

- NumPy arrays comprise elements of a single data type
- The type object is accessible through the .dtype attribute Here are a few of the most important attributes of dtype objects.
- Array dtypes are usually inferred automatically, but can also be specified explicitly

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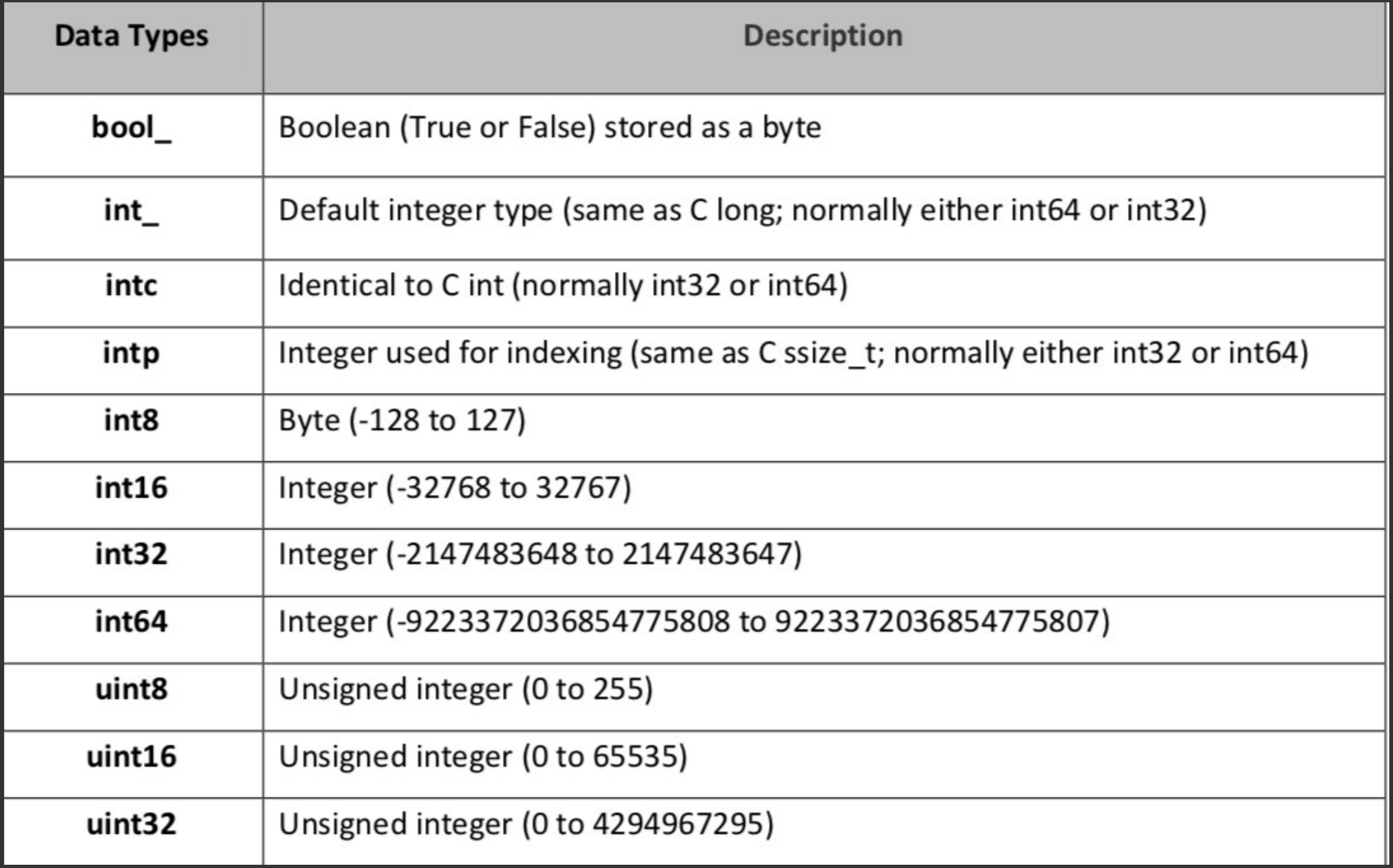
Mentioning data types is very important:



Data Types	Description
bool_	Boolean (True or False) stored as a byte
int_	Default integer type (same as C long; normally either int64 or int32)
intc	Identical to C int (normally int32 or int64)
intp	Integer used for indexing (same as C ssize_t; normally either int32 or int64)
int8	Byte (-128 to 127)
int16	Integer (-32768 to 32767)
int32	Integer (-2147483648 to 2147483647)
int64	Integer (-9223372036854775808 to 9223372036854775807)
uint8	Unsigned integer (0 to 255)
uint16	Unsigned integer (0 to 65535)
uint32	Unsigned integer (0 to 4294967295)

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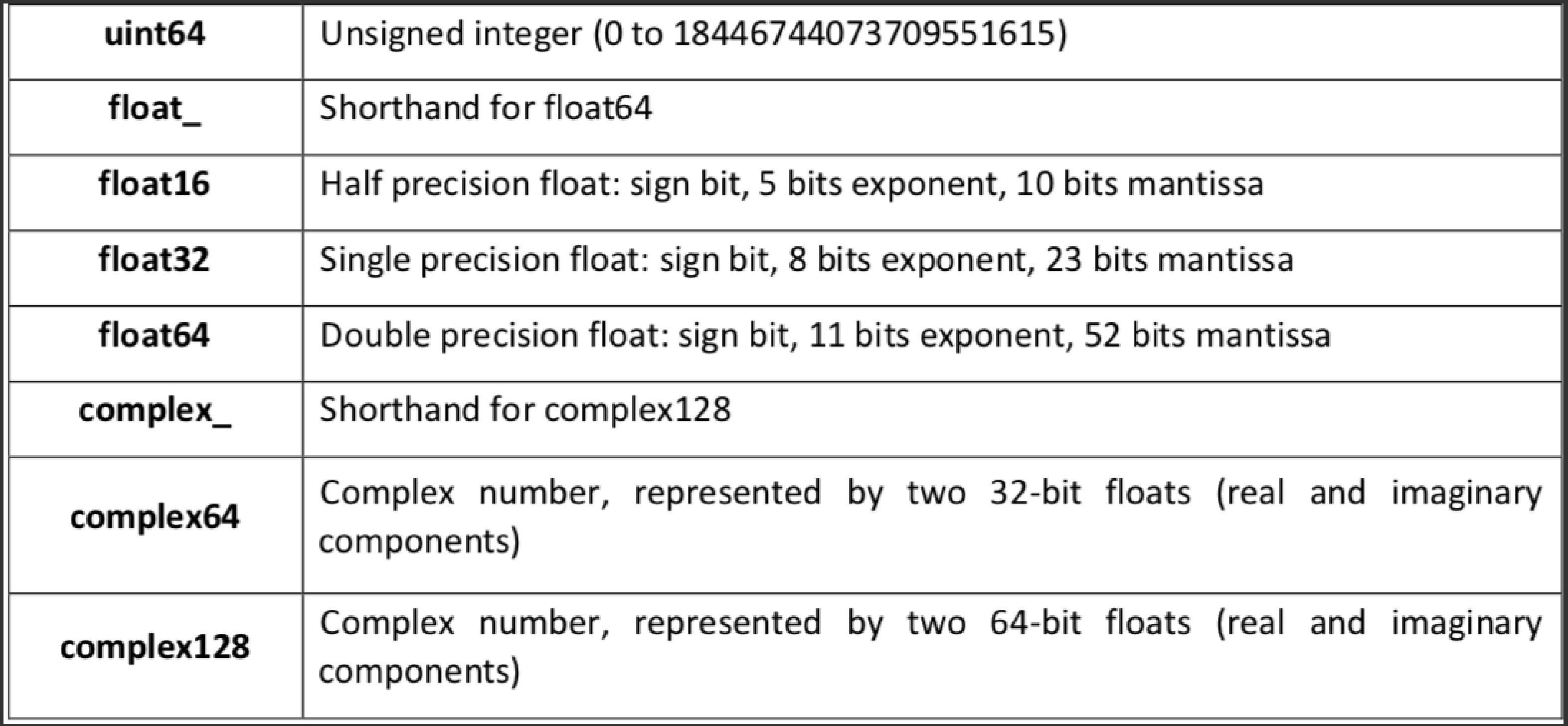
Mentioning data types is very important: Cont…



uint64	Unsigned integer (0 to 18446744073709551615)
float_	Shorthand for float64
float16	Half precision float: sign bit, 5 bits exponent, 10 bits mantissa
float32	Single precision float: sign bit, 8 bits exponent, 23 bits mantissa
float64	Double precision float: sign bit, 11 bits exponent, 52 bits mantissa
complex_	Shorthand for complex128
complex64	Complex number, represented by two 32-bit floats (real and imaginary components)
complex128	Complex number, represented by two 64-bit floats (real and imaginary components)

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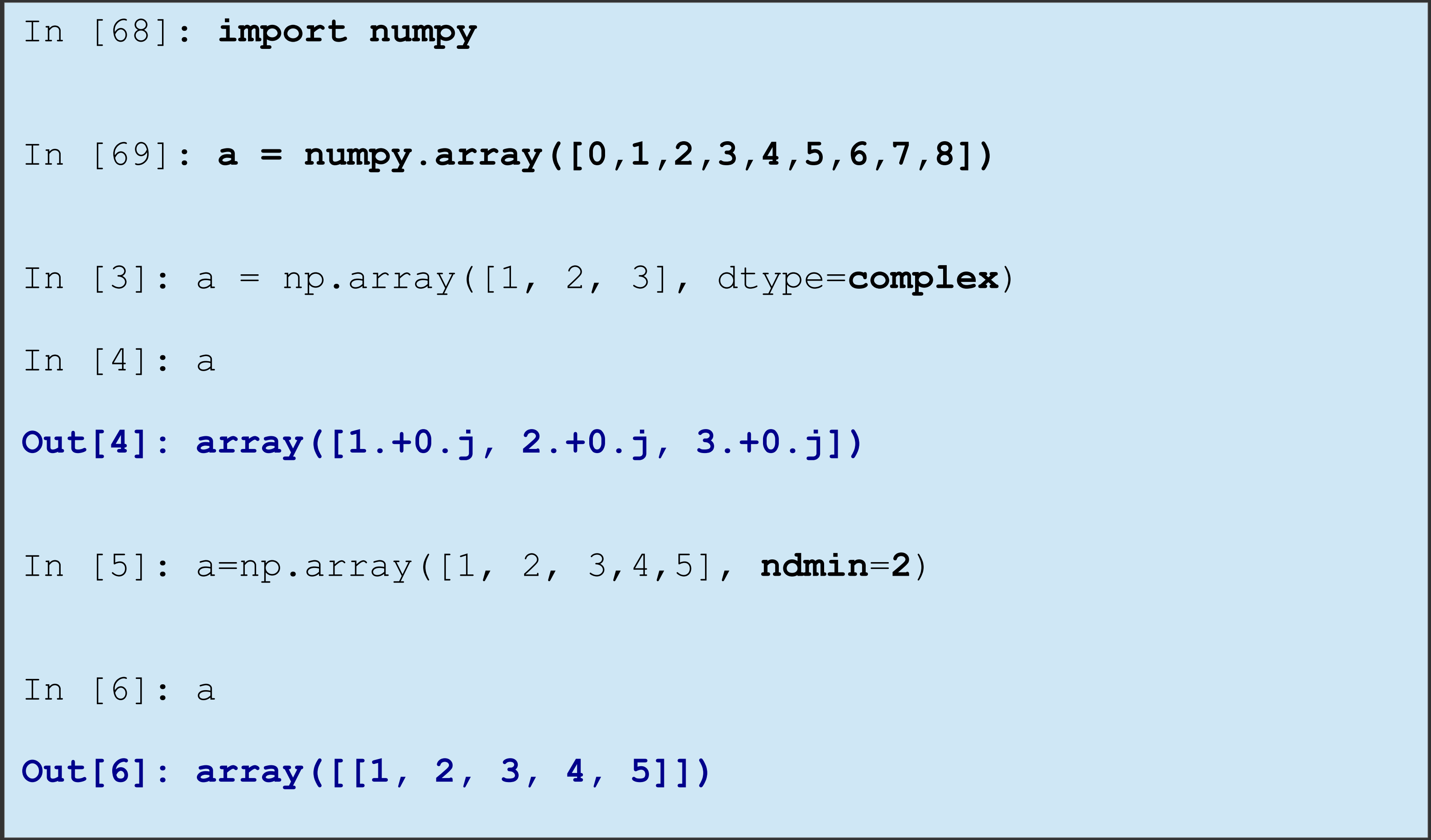
Let us start a simple program:



```
In [68]: import numpy

In [69]: a = numpy.array([0,1,2,3,4,5,6,7,8])

In [3]: a = np.array([1, 2, 3], dtype=complex)

In [4]: a

Out[4]: array([1.+0.j, 2.+0.j, 3.+0.j])

In [5]: a=np.array([1, 2, 3,4,5], ndmin=2)

In [6]: a

Out[6]: array([[1, 2, 3, 4, 5]])
```

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Numpy operations are faster than lists:

```
import time
import numpy as np
num = 10000000
count = num
l1=list(range(count))
l2=list(range(count))

start=time.time()
list3 = [l1[i]+l2[i] for i in range(num)]
end=time.time()
elapsed = 1000*(end-start)
print("List time:",elapsed)

a1 = np.arange(count)
a2 = np.arange(count)
start=time.time()
a3=a1+a2
end=time.time()
elapsed = 1000*(end-start)
print("Numpy time:",elapsed)
```

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Numpy arrays are memory efficient:

```
import sys
import numpy as np
list1 = [1,3,7,100,4,6,10,45,3,6,8,99,87]
print("Size taken by list = ", sys.getsizeof(list1))

a = np.array([1,3,7,100,4,6,10,45,3,6,8,99,87],dtype=np.int8)
print("Size taken by numpy array = ", sys.getsizeof(a))
```

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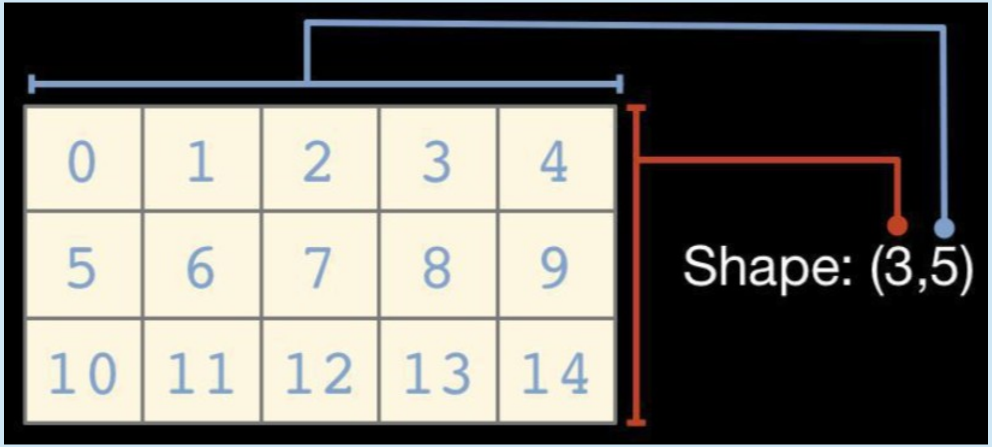
Creating Two dimensional array:

```
In [91]: m1 = numpy.array([[0,1,2,3,4],[5,6,7,8,9],
[10,11,12,13,14]], dtype="int64")

In [92]: m1.ndim

Out[92]: 2

In [93]: m1.size

Out[93]: 15

In [94]: m1.nbytes

Out[94]: 120

In [95]: m1.shape

Out[95]: (3, 5)
```



0	1	2	3	4
5	6	7	8	9
10	11	12	13	14

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Creating using arange(init, final, increment)

```
array1 = np.arange(21,32)
print("array1 = ",array1)



array1 =  [21 22 23 24 25 26 27 28 29 30 31]
```

Creating using linspace(init, final, number of elements)

```
array2 = np.linspace(12,22,11)


array2 =  [12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22.]
```

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Creating using “random()”:

```
ar = np.random.rand(10)
print(ar)


[0.76165674 0.290724   0.0366434  0.56961439 0.55207746 0.14025679
 0.01142086 0.28403208 0.13511246 0.49535445]
```

Creating using linspace(init, final, number of elements)

```
a = numpy.linspace(0,1, 100)
import matplotlib.pyplot as plt
plt.plot(a,numpy.sin(a*np.pi*2))
```

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Creating using “zero()”:

```
In  [4]: np.zeros((2,2))

Out[4]:
array([[ 0., 0.],
[ 0., 0.]])
```

Creating using “ones()”:

```
In  [13]: np.ones((1,5))


Out[13]: array([[1., 1., 1., 1., 1.]])
```

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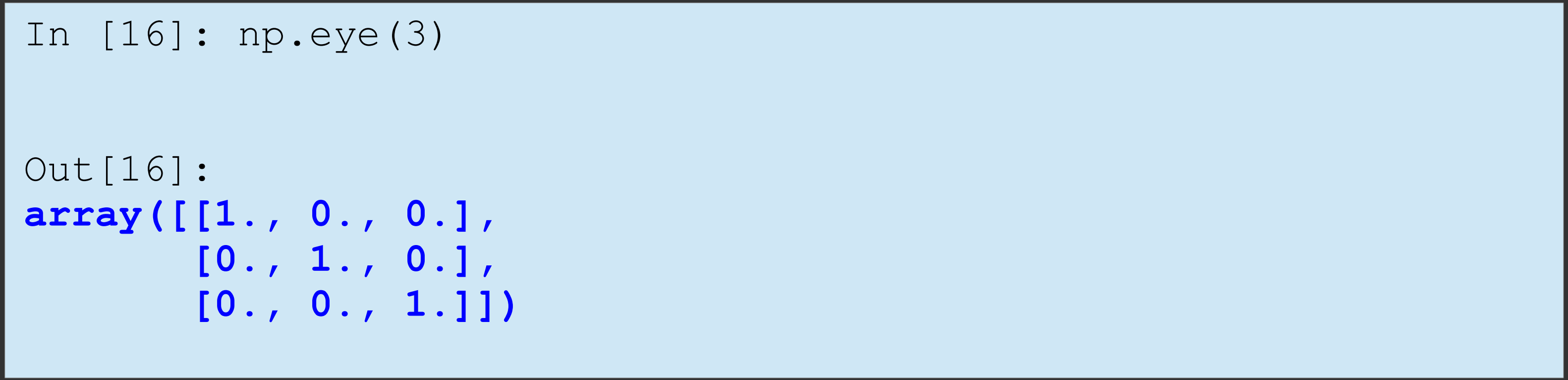
Creating using “empty()”:

```
In [14]: np.empty((1,5))


Out[14]: array([[1., 1., 1., 1., 1.]])
```

Creating using “ones()”:

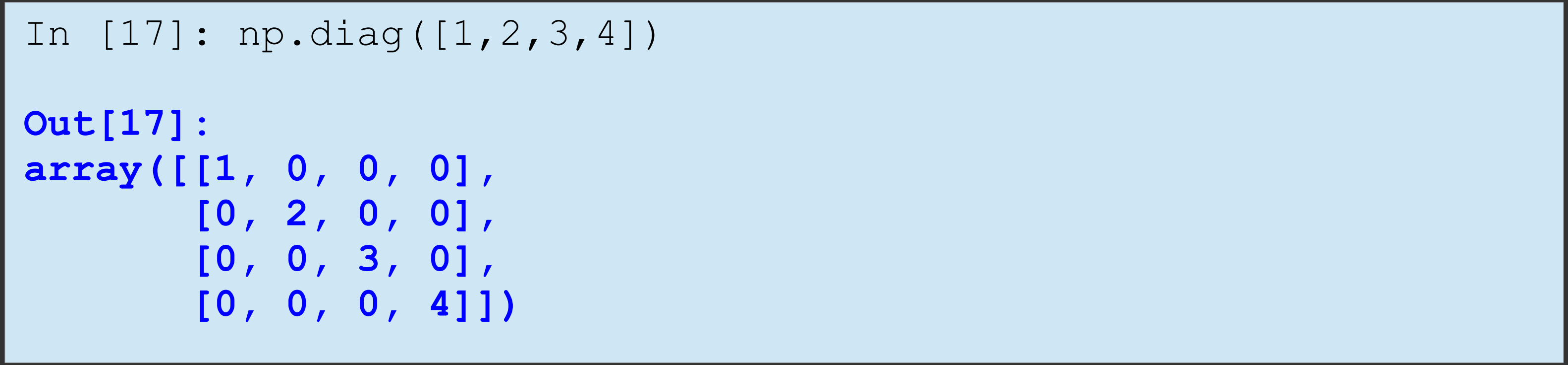
```
In [14]: np.empty((1,5))


Out[14]: array([[1., 1., 1., 1., 1.]])
```

Creating using “eye()”:



```
In [16]: np.eye(3)


Out[16]:
array([[1., 0., 0.],
       [0., 1., 0.],
       [0., 0., 1.]])
```

Creating using “diag()”:



```
In [17]: np.diag([1,2,3,4])

Out[17]:
array([[1, 0, 0, 0],
       [0, 2, 0, 0],
       [0, 0, 3, 0],
       [0, 0, 0, 4]])
```

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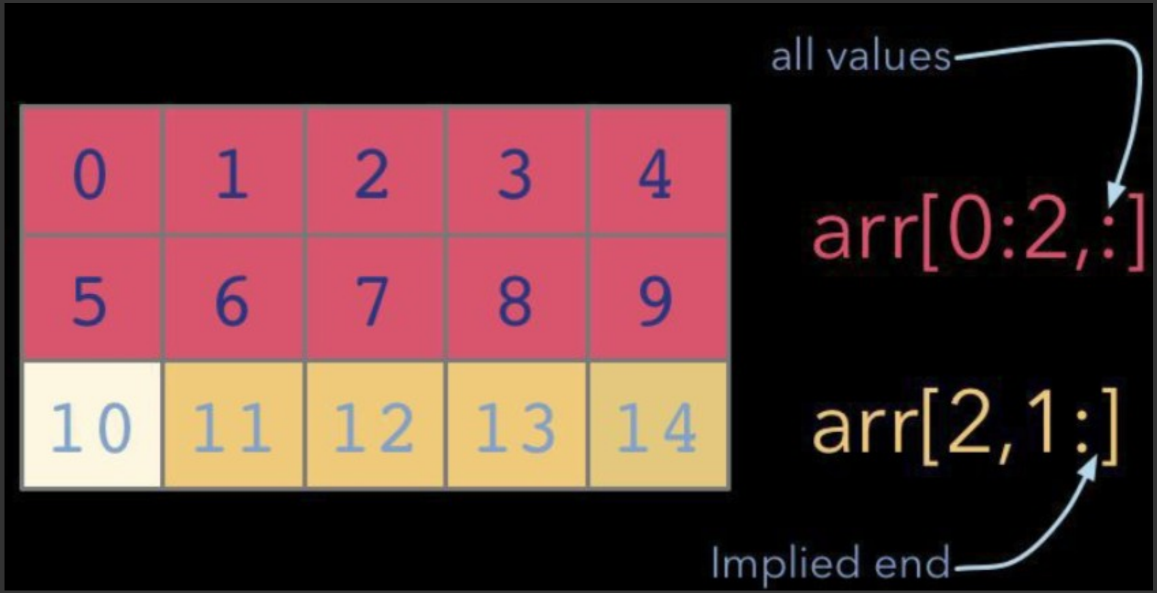
Indexing:

- Same as lists/tuples/string:



0	1	2	3	4
5	6	7	8	9
10	11	12	13	14

```
arr[0:2,:]
arr[2,1:]
```

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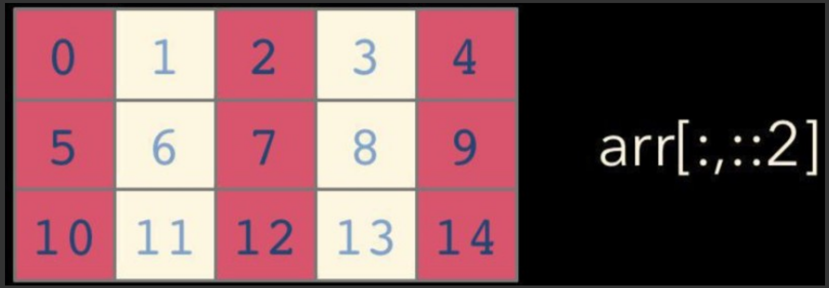
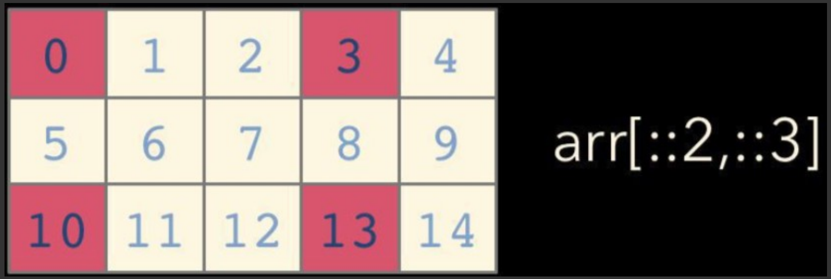


0	1	2	3	4
5	6	7	8	9
10	11	12	13	14

arr[:,::2]



0	1	2	3	4
5	6	7	8	9
10	11	12	13	14

arr[::2,::3]

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Operations using vectors:

```
#Vector addition, subtraction, multiplication, division,
modulus,
x = np.array([2,4,6])
y = np.array([1,3,5])
add = x+y
sub = x-y
div = x/y
mul = x*y
mod = x%y
matmul = np.matmul(x,y) or x@y or np.dot(x,y)
a**2+b**2+2*a*b (Where a and b are two arrays)
print("matmul", matmul)
```

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Comparison : <, <=, ==, !=, >=, > arithmetic: +, -, *, /, reciprocal, square

Exponential : exp, expm1, exp2, log, log10, log1p, log2, power, sqrt

Trigonometric : sin, cos, tan, acsin, arccos, atctan hyperbolic: sinh, cosh, tanh, acsinh, arccosh, atctanh

Bitwise operations : &, |, ~, ^, left_shift, right_shift logical

Operations : and, logical_xor, not, or

Predicates : isfinite, isinf, isnan, signbit

Other : abs, ceil, floor, mod, modf, round, sinc, sign, trunc

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Broadcasting:

```
array = np.ones(30)

Array[:] = 100

[100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
100. 100.
 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
100. 100.
 100. 100.]
```

reshape():

```
a = np.arange(30)
array_matrix = a.reshape(5,6)

[[ 0  1  2  3  4  5]
 [ 6  7  8  9 10 11]
 [12 13 14 15 16 17]
 [18 19 20 21 22 23]
 [24 25 26 27 28 29]]
```

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:

```
array = np.ones(30)

Array[:] = 100

[100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
100. 100.
 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
100. 100.
 100. 100.]
```

reshape():

```
a = np.arange(30)
array_matrix = a.reshape(5,6)

[[ 0  1  2  3  4  5]
 [ 6  7  8  9 10 11]
 [12 13 14 15 16 17]
 [18 19 20 21 22 23]
 [24 25 26 27 28 29]]
```

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Relations operators:

```
arr = np.eye(3)

arr[arr == 0] = 21

array([[ 1., 21., 21.],
       [21.,  1., 21.],
       [21., 21.,  1.]])
```

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Getting statistics about an array:

```
In [51]: reviews = numpy.array([[3.3,5,4,2.8,5,4],[1,2,3,4,5,6]])


In [52]: reviews.sum()

Out[52]: 45.1

In [53]: reviews.sum(axis=0)

Out[53]: array([ 4.3,  7. ,  7. ,  6.8, 10. , 10. ])

In [54]: reviews.sum(axis=1)

Out[54]: array([24.1, 21. ])

In [55]: reviews.mean()

Out[55]: 3.7583333333333333
```

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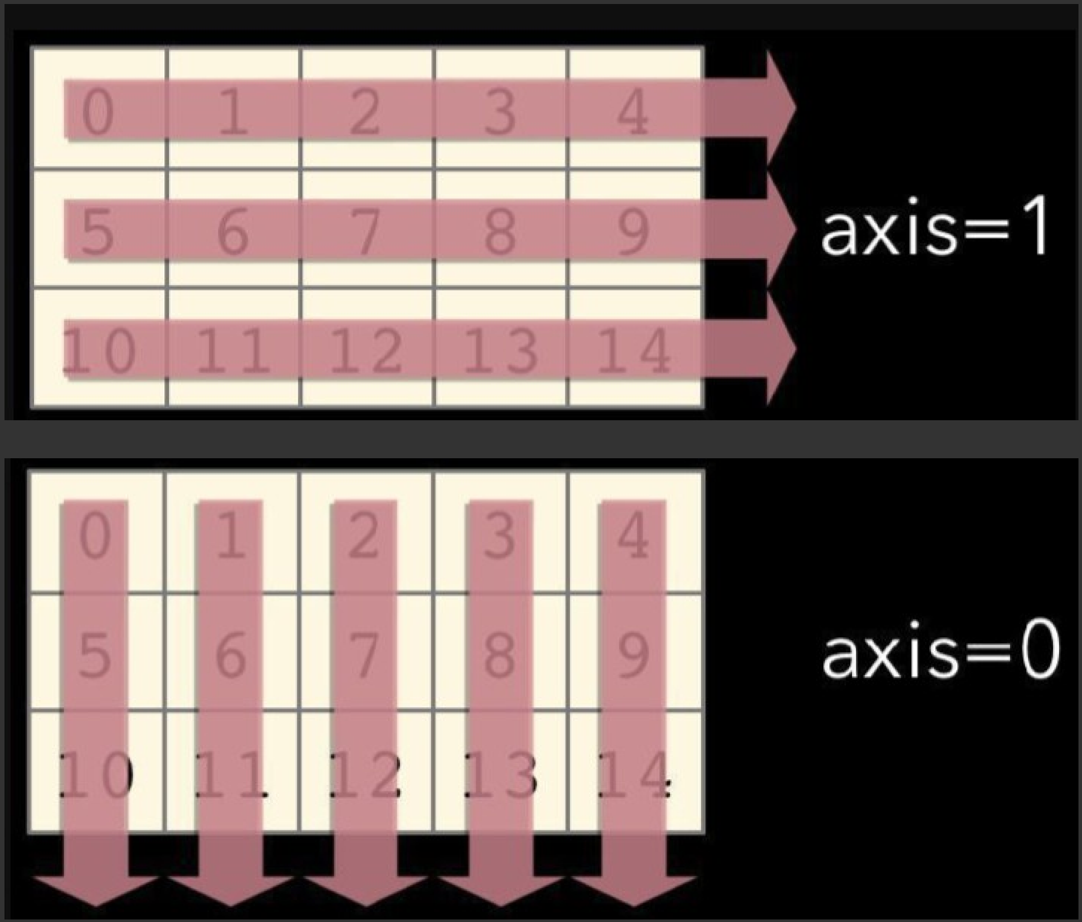
axis =0, axis = 1



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Getting statistics about an array:

```
In [56]: reviews.max()

Out[56]: 6.0

In [57]: reviews.std()

Out[57]: 1.361040247588423

In [58]: reviews.var()

Out[58]: 1.852430555555556

In [59]: reviews.var(axis=0)

Out[59]: array([1.3225, 2.25  , 0.25  , 0.36  , 0.    , 1.    ])

In [60]: reviews.var(axis=1)

Out[60]: array([0.65472222, 2.91666667])
```

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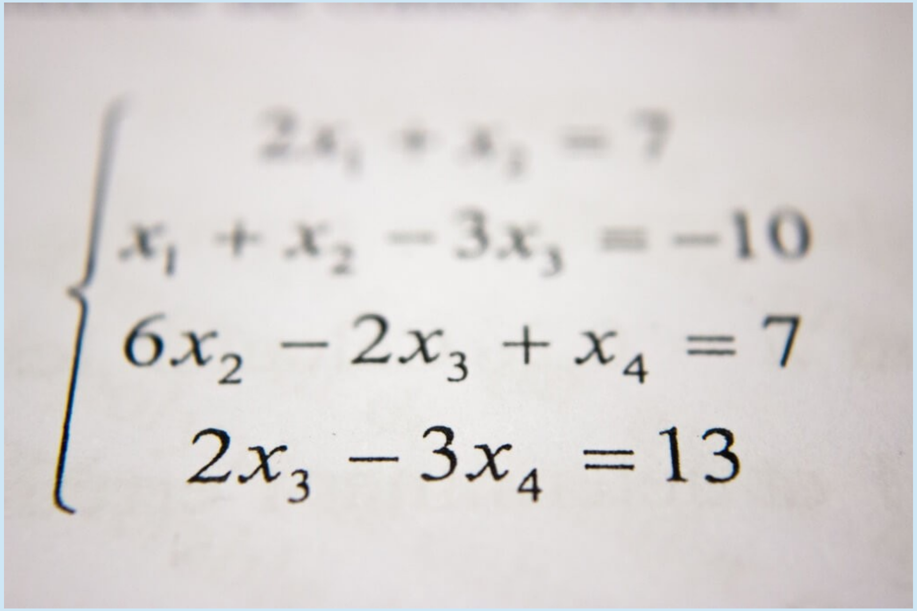
Linear Algebra: Solving equation

```
In [130]: a = numpy.array([[1,2],[3,4]],ndmin=2)


In [131]: b = numpy.array([1,2])


In [132]: numpy.linalg.solve(a,b)

Out[132]: array([0. , 0.5])
```



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Linear Algebra: Finding euclidean distance

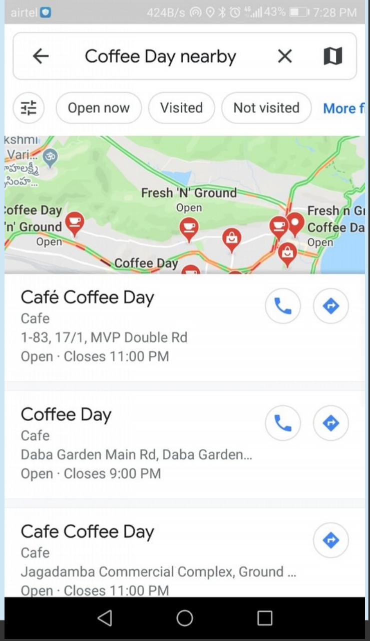
```
In [133]: point = numpy.array([1,3])


In [134]: points = numpy.array([[1,2],[3,4],[6,7]])


In [135]: index = numpy.argmin(numpy.linalg.norm(points-
point,axis=1))

In [136]: print(index)

0
```



Café Coffee Day
Cafe
1-83, 17/1, MVP Double Rd
Open · Closes 11:00 PM

Coffee Day
Cafe
Daba Garden Main Rd, Daba Garden...
Open · Closes 9:00 PM

Cafe Coffee Day
Cafe
Jagadamba Commercial Complex, Ground ...
Open · Closes 11:00 PM

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Difference between “matrix” and “array”

```
In [65]: a = np.array([1,2,3])


In [66]: print("Ndim = ", a.ndim)

Ndim =  1

In [67]: print("Shape = ", a.shape)

Shape =  (3,)

In [68]: a = np.matrix([1,2,3])


In [69]: print("Ndim = ", a.ndim)

Ndim =  2

In [70]: print("Shape = ", a.shape)

Shape =  (1, 3)
```

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Operations using matrices:

```
#Matrix operations
x = np.matrix( ((2,3), (3, 5)) )
y = np.matrix( ((1,2), (5, -1)) )
print(x+y)
print(x*y)
print(x**2)
print(x**-1)
Indexing: x[1,1]
```

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Linear Algebra: Finding euclidean distance

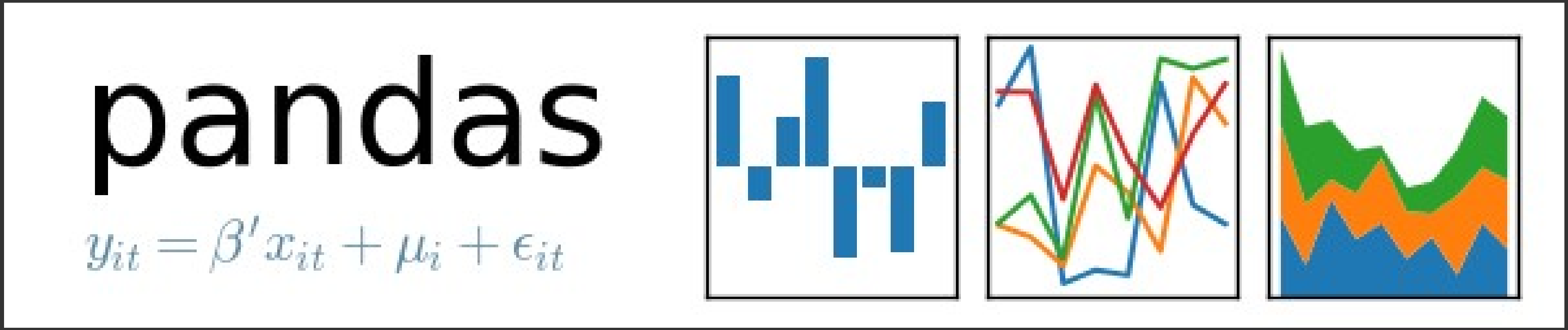
```
a = np.matrix([1,2,3,4]).reshape((2,2))
b = np.matrix([1,2,3,4]).reshape([2,2])

print(numpy.concatenate([a,b], axis=0))
```

```
[[1, 2],
       [3, 4],
       [1, 2],
       [3, 4]]
```

```
print(numpy.concatenate([a,b], axis=1))
```

```
[[1 2 1 2]
 [3 4 3 4]]
```

Thank You......


pandas
$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$

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Pandas Data Frames

DF: Accessing data

DF: Adding data

DF: Dropping/Deleting data

DF: Sorting

DF: Selecting data and copy

DF: Grouping

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Pandas Series

Pandas Data Frames

DF: Accessing data

DF: Adding data

DF: Dropping/Deleting

DF: Sorting

DF: Selecting data and copy

DF: Grouping

PanDaS - Panel Data Sets

- **Pandas provides** set of functions to process various types of data.
- Panda is fast, easy and more expressive than other tools

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Pandas Data Frames

DF: Accessing data

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Series:

- Series is a one-dimensional array.
- The row labels in a Series are called the index.
- Any list, tuple and dictionary can be converted in to Series using ‘series’ method.

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Pandas Data Frames

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DF: Grouping

Creating Series using dictionary:

```
In [6]: dict1 = {"One":1, "Two":2}


In [7]: s1 = pd.Series(dict1)


In [8]: s1

Out[8]:
One     1
Two     2
dtype: int64

In [9]: s1.index

Out[9]: Index(['One', 'Two'], dtype='object')

In [10]: s1.values

Out[10]: array([1, 2])
```

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Creating Series using Tuple:

```
In [21]: b = (8,1,25,1,0,0,3.13)


In [22]: s = pd.Series(b)
```

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DF: Grouping

Adding “Index” using list:

```
In [35]: s =
pd.Series(b,index=["overs","M","runs",'wickets',"nb","wd","avg"])


In [36]: s

Out[36]:
overs        8.00
M            1.00
runs        25.00
wickets      1.00
nb           0.00
wd           0.00
avg          3.13
dtype: float64
```

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Accessing data in Series:

```
In [44]: s['M']

Out[44]: 1.0

In [45]: s['overs']

Out[45]: 8.0

In [46]: s['wickets']

Out[46]: 1.0
```

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Pandas Series

Pandas Data Frames

DF: Accessing data

DF: Adding data

DF: Dropping/Deleting

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DF: Selecting data and copy

DF: Grouping

Using “Describe()”:

```
In [52]: Bumrah = (3,4,2,1,6,3,0)


In [53]: s = pd.Series(Bumrah)


In [54]: s.describe()

Out[54]:
count    7.000000
mean     2.714286
std      1.976047
min      0.000000
25%      1.500000
50%      3.000000
75%      3.500000
max      6.000000
dtype: float64
```

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Using “Describe()”:

```
In [59]: s = pd.Series(Bumrah)


In [60]: s[0] = 3#Modifying the data


In [61]: s[7] = 7#Adding new data

In [62]: s

Out[62]:
0     3
1     4
2     2
3     1
4     6
5     3
6     0
7     7
dtype: int64
```

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Dropping duplicates:

```
In [71]: s1

Out[71]:
0     3
1     3
2     2
3     1
4     6

dtype: int64

In [72]: s1.drop_duplicates()

Out[72]:
0     3
2     2
3     1
4     6
```

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Other operations”:

```
In [64]: s+10    #Adding 10 to all the values


In [63]: s-1     #Subtracting 1 from all the values

In [68]: s1+s2   #Adding two series
```

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Data Frame:

DataFrame is the widely used data structure of pandas.
DataFrame has two different index i.e. column-index and row-index.

The most common way to create a DataFrame is by using the dictionary of equal-length list
ll the spreadsheets and text files are read as DataFrame

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Creating data frames:

```
In [86]: bowlers = {'Bhuvneshwar Kumar':
[8.1,1,30,1,0,0,3.67],'Jasprit Bumrah':
[8,1,25,1,0,0,3.13],'Hardik Pandya':[10,0,55,1,0,5,
    ...: 5.50]}


In [87]: df1 = pd.DataFrame(data=bowlers)


In [88]: df1

Out[88]:
   Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya
0               8.10            8.00           10.0
1               1.00            1.00            0.0
2              30.00           25.00           55.0
3               1.00            1.00            1.0
4               0.00            0.00            0.0
5               0.00            0.00            5.0
6               3.67            3.13            5.5
```

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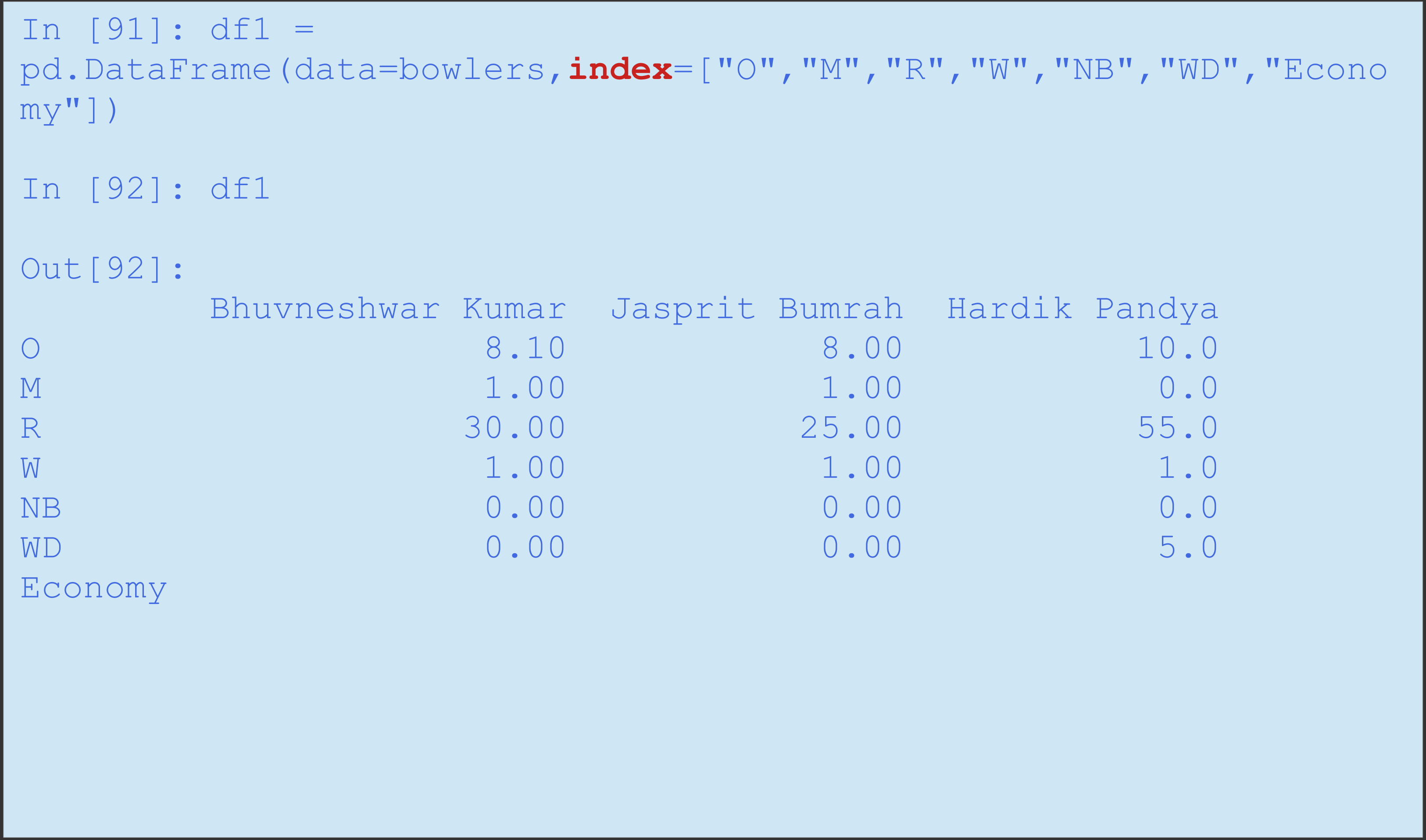
Creating data frames: Adding “index”:



```
In [91]: df1 =
pd.DataFrame(data=bowlers,index=["O","M","R","W","NB","WD","Econo
my"])

In [92]: df1

Out[92]:
         Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya
O                     8.10            8.00           10.0
M                     1.00            1.00            0.0
R                    30.00           25.00           55.0
W                     1.00            1.00            1.0
NB                    0.00            0.00            0.0
WD                    0.00            0.00            5.0
Economy
```

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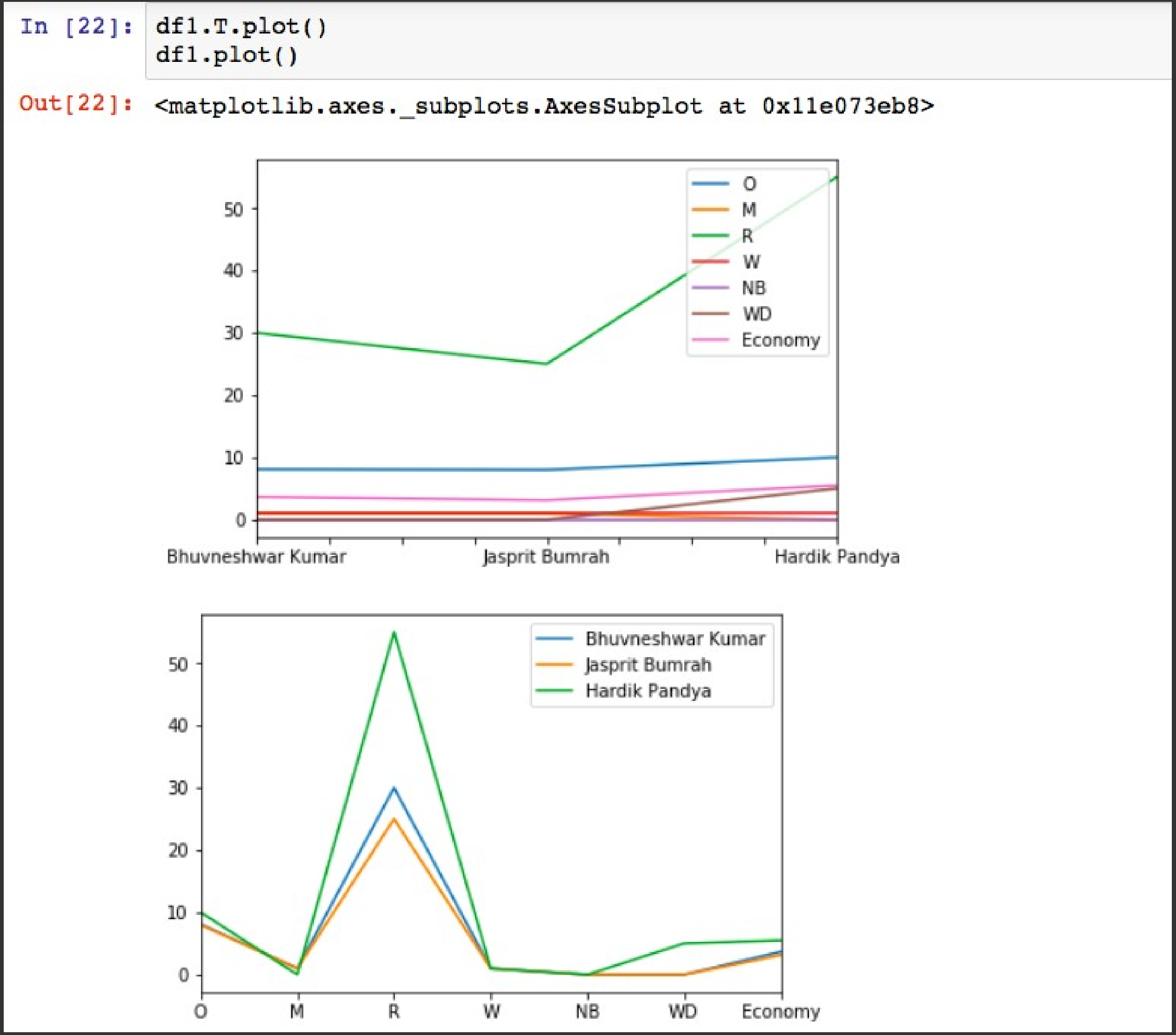

```
In [22]: df1.T.plot()
         df1.plot()
```

```
Out[22]: <matplotlib.axes._subplots.AxesSubplot at 0x11e073eb8>
```

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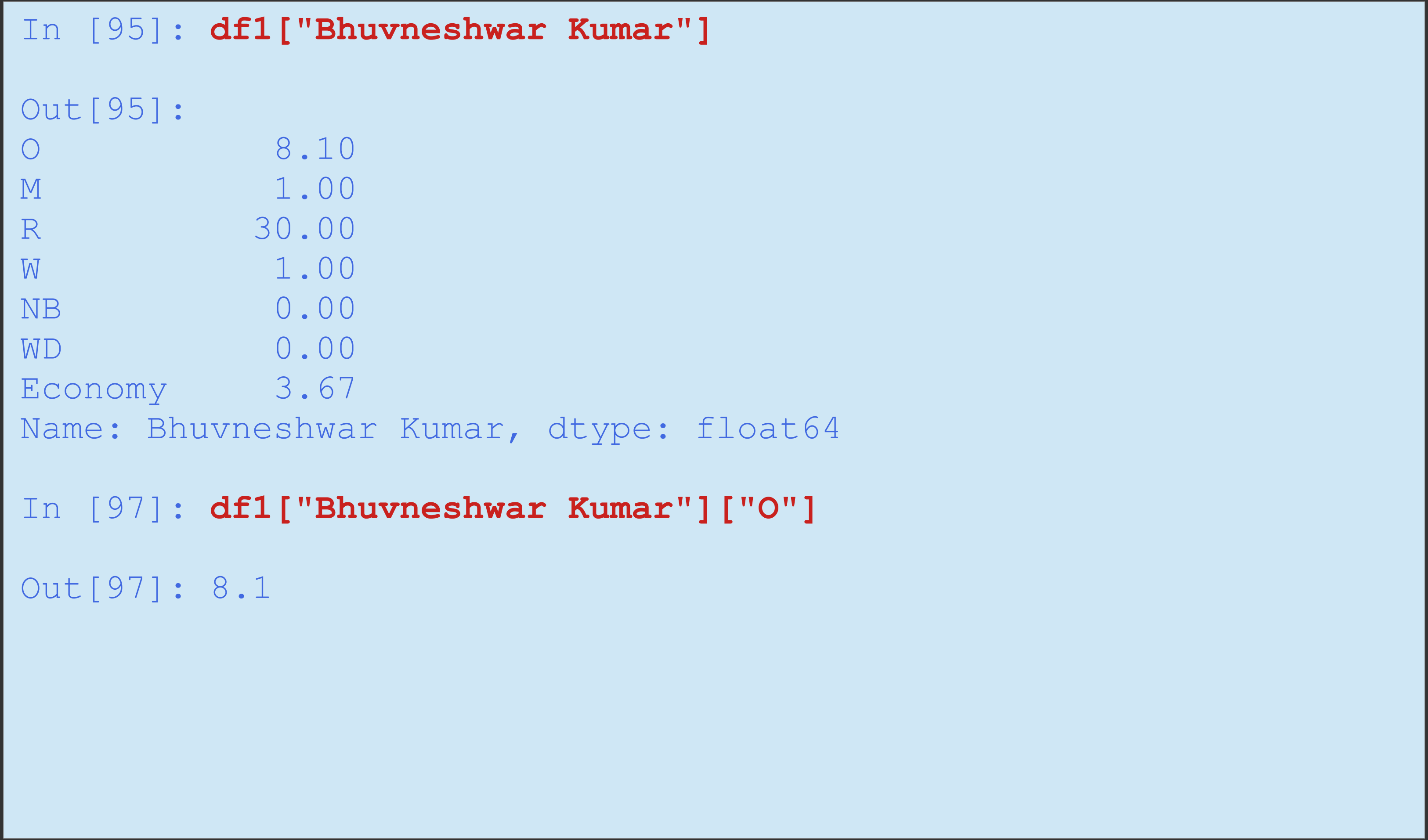
Accessing the data:



```
In [95]: df1["Bhuvneshwar Kumar"]

Out[95]:
O              8.10
M              1.00
R             30.00
W              1.00
NB             0.00
WD             0.00
Economy        3.67
Name: Bhuvneshwar Kumar, dtype: float64

In [97]: df1["Bhuvneshwar Kumar"]["O"]

Out[97]: 8.1
```

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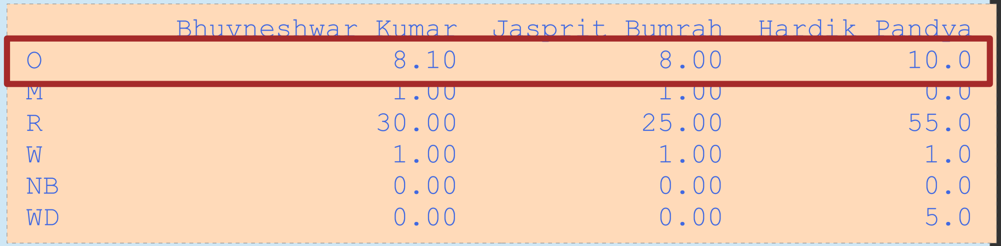
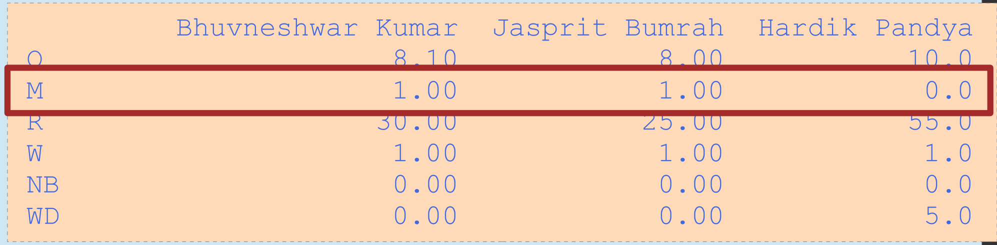
Accessing the data using “loc” and “iloc”:

```
In [98]: df1.loc["O"]

Out[98]:
Bhuvneshwar Kumar     8.1
Jasprit Bumrah        8.0
Hardik Pandya        10.0
Name: O, dtype: float64
```



```
      Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya
O                  8.10            8.00           10.0
M                  1.00            1.00            0.0
R                 30.00           25.00           55.0
W                  1.00            1.00            1.0
NB                 0.00            0.00            0.0
WD                 0.00            0.00            5.0
```

```
In [101]: df1.iloc[1]      #Index location

Out[101]:
Bhuvneshwar Kumar    1.0
Jasprit Bumrah       1.0
Hardik Pandya        0.0
Name: M, dtype: float64
```



```
      Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya
O                  8.10            8.00           10.0
M                  1.00            1.00            0.0
R                 30.00           25.00           55.0
W                  1.00            1.00            1.0
NB                 0.00            0.00            0.0
WD                 0.00            0.00            5.0
```

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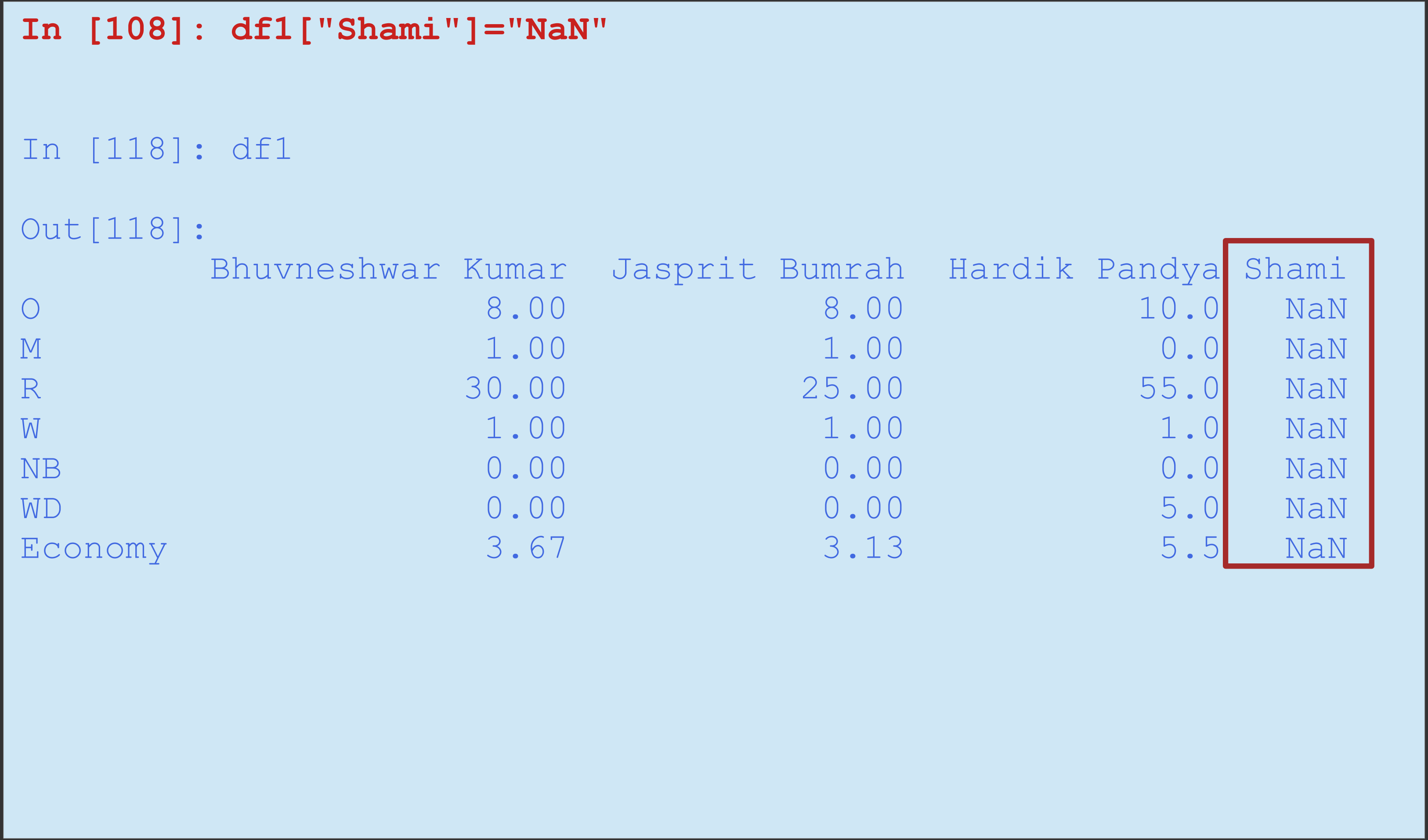
Adding the data:



```
In [108]: df1["Shami"]="NaN"


In [118]: df1

Out[118]:
         Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya Shami
O                     8.00            8.00           10.0   NaN
M                     1.00            1.00            0.0   NaN
R                    30.00           25.00           55.0   NaN
W                     1.00            1.00            1.0   NaN
NB                    0.00            0.00            0.0   NaN
WD                    0.00            0.00            5.0   NaN
Economy               3.67            3.13            5.5   NaN
```

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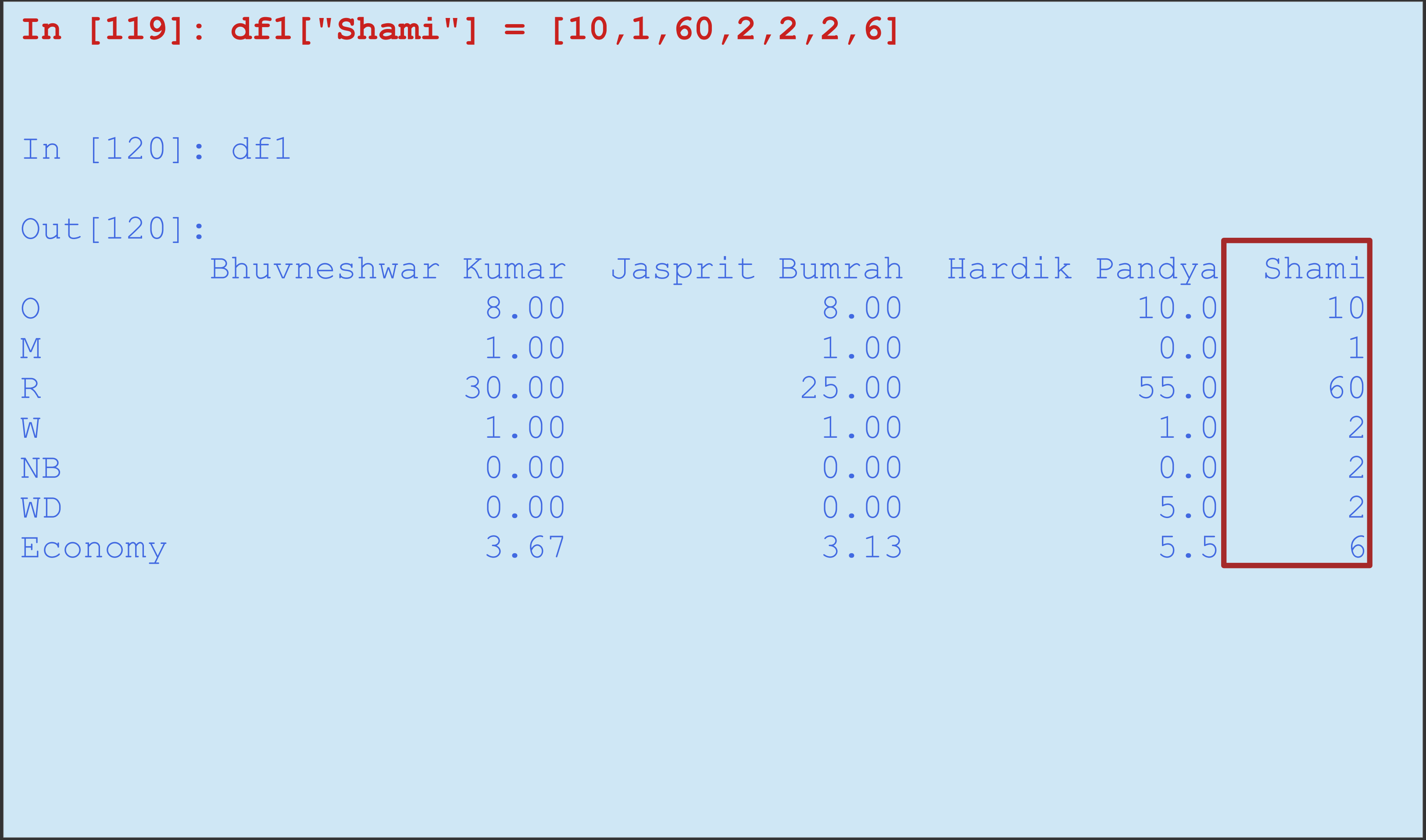
Adding the data:



```
In [119]: df1["Shami"] = [10,1,60,2,2,2,6]


In [120]: df1

Out[120]:
         Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya  Shami
O                     8.00            8.00           10.0     10
M                     1.00            1.00            0.0      1
R                    30.00           25.00           55.0     60
W                     1.00            1.00            1.0      2
NB                    0.00            0.00            0.0      2
WD                    0.00            0.00            5.0      2
Economy               3.67            3.13            5.5      6
```

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In previous data frames, find the rank and assign in column “Rank”

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DF: Grouping

Transposing data frame:

```
In [123]: df2 = df1.T


In [124]: df2

Out[124]:
                      O    M     R    W   NB   WD  Economy
Bhuvneshwar Kumar   8.0  1.0  30.0  1.0  0.0  0.0     3.67
Jasprit Bumrah      8.0  1.0  25.0  1.0  0.0  0.0     3.13
Hardik Pandya      10.0  0.0  55.0  1.0  0.0  5.0     5.50
Shami              10.0  1.0  60.0  2.0  2.0  2.0     6.00
```

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Deleting a column:

```
In [131]: del df3["Bhuvneshwar Kumar"]


In [132]: df3

Out[132]:
         Jasprit Bumrah  Hardik Pandya  Shami
O                  8.00           10.0     10
M                  1.00            0.0      1
R                 25.00           55.0     60
W                  1.00            1.0      2
NB                 0.00            0.0      2
WD                 0.00            5.0      2
Economy            3.13            5.5      6
```

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Dropping a column:

```
In [134]: df1.drop("O")

Out[134]:
         Bhuvneshwar Kumar  Jasprit Bumrah  Hardik Pandya  Shami
M                     1.00            1.00            0.0      1
R                    30.00           25.00           55.0     60
W                     1.00            1.00            1.0      2
NB                    0.00            0.00            0.0      2
WD                    0.00            0.00            5.0      2
Economy               3.67            3.13            5.5      6



df2.drop(columns="Bhuvneshwar Kumar")
df2.drop(columns="Bhuvneshwar Kumar", inplace=True)
```

Other Operations

```
df3 = df2.T
df2.iloc[3,2] # Accessing index locations
df2.iloc[2:5,]
df2.iloc[:,[0,3]]
df2.loc[:,["Shami"]]

df2.reindex(index=["O","W"])
```

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DF: Accessing data

DF: Adding data

DF: Dropping/Deleting

DF: Sorting

DF: Selecting data and copy

DF: Grouping

Merging methods:

- Merge ---- It merges based on column name: To merge, at least one column name must match
- Join ---- Joins based on index
- Concat ---- It appends data frames one after another: No need to match column or index

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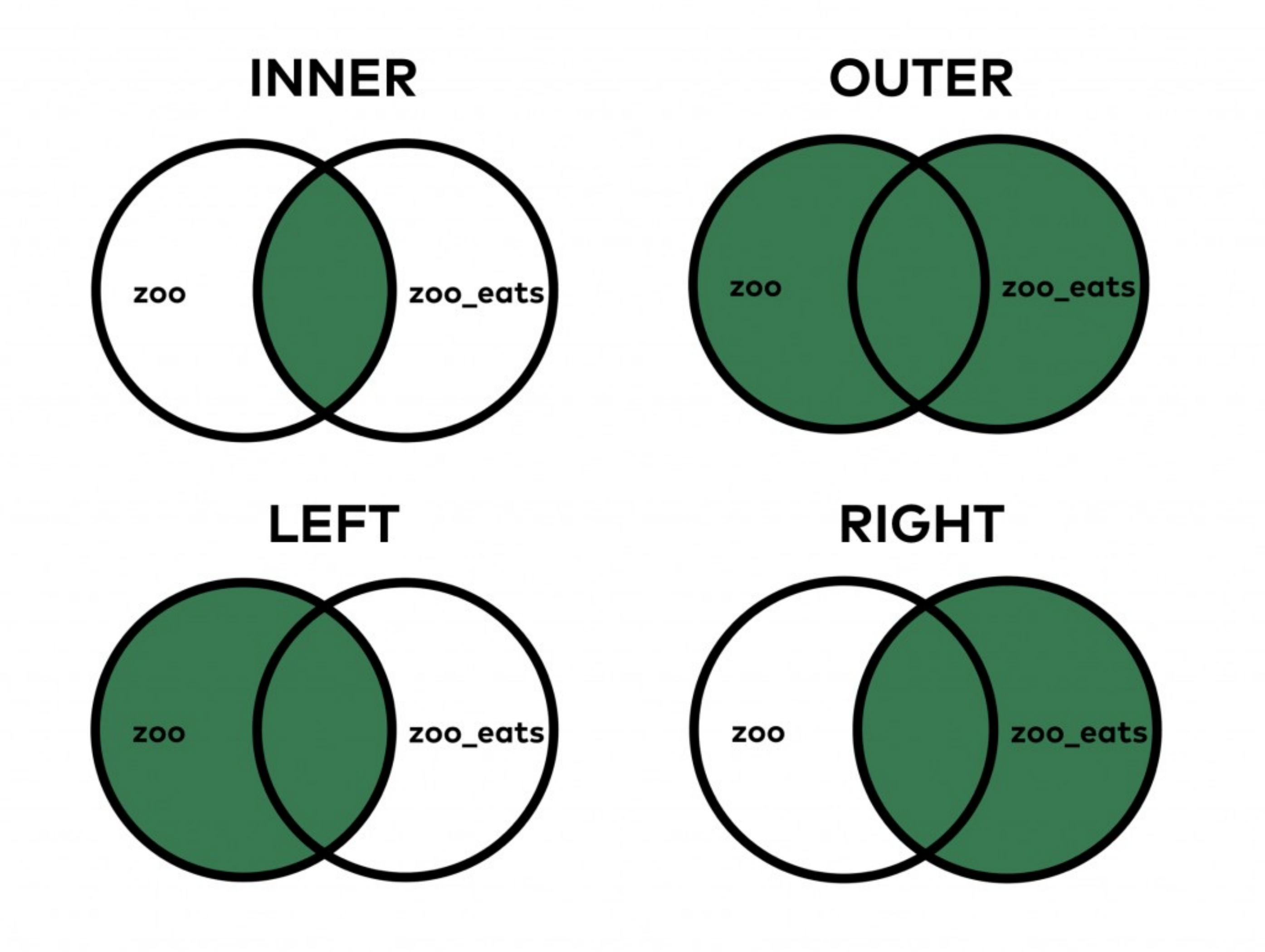

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Merging

- Merged based on column name: At least one common column name should be common in both data frames.
- **pd.merge(left_frame,right_frame, how='right', on=’key’)**
    - **how -> ‘left’, ‘right’, ‘in’, ‘out’**

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Joining

- Joins table based on index value:
  - `Table1.join(Table2)`
  - `Table1.join([Table2,Table3])    #Joining multiple tables`

Concatenating

- Joins table based on index value:
  - `pd.concat([left_frame, right_frame])`
  - `pd.concat([left_frame, right_frame], axis=1)`

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Joining

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  - `Table1.join(Table2)`
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Concatinating

- Joins table based on index value:
  - `pd.concat([left_frame, right_frame])`
  - `pd.concat([left_frame, right_frame], axis=1)`