INTRO TO PANDAS & NUMPY

INTRO TO PANDAS & NUMPY

In this section we'll introduce **Pandas** & **NumPy**, two critical Python libraries that help structure data in arrays & DataFrames and contain built-in functions for data analysis

TOPICS WE'LL COVER:

- Intro to Pandas & NumPy
- NumPy Array Basics
- Array Creation
- Array Indexing & Slicing
- Array Operations
- Vectorization & Broadcasting

GOALS FOR THIS SECTION:

- Convert Python lists to NumPy arrays, and create new arrays from scratch using functions
- Apply array indexing, slicing, methods, and functions to perform operations on NumPy arrays
- Understand the concepts of vectorization and broadcasting, which are critical in making NumPy and Pandas more efficient than base Python

MEET PANDAS

- Intro to Pandas & NumPy
- NumPy Array Basics
- Array Creation
- Array Indexing & Slicing
- Array Operations
- Vectorization & Broadcasting

Pandas is Python's most widely used library for data analysis, and contains functions for accessing, aggregating, joining, and analyzing data

Its data structure, the DataFrame, is analogous to SQL tables or Excel worksheets

Custom indices & column titles make working with datasets more intuitive!

	id	date	store_nbr	family	sales	onpromotion
0	0	2013-01-01	1	AUTOMOTIVE	0.0	0
1	1	2013-01-01	1	BABY CARE	0.0	0
2	2	2013-01-01	1	BEAUTY	0.0	0
3	3	2013-01-01	1	BEVERAGES	0.0	0
4	4	2013-01-01	1	BOOKS	0.0	0

MEET NUMPY

- Intro to Pandas & NumPy
- NumPy Array Basics
- Array Creation
- Array Indexing & Slicing
- Array Operations
- Vectorization & Broadcasting

NumPy is an open-source library that is the universal standard for working with numerical data in Python, and forms the foundation of other libraries like Pandas

Pandas DataFrames are built on NumPy arrays and can leverage NumPy functions

The indices, column names, and data columns are all stored as NumPy arrays

Pandas just adds convenient wrappers and functions!

	id	date	store_nbr	family	sales	onpromotion
0	0	2013-01-01	1	AUTOMOTIVE	0.0	0
1	1	2013-01-01	1	BABY CARE	0.0	0
2	2	2013-01-01	1	BEAUTY	0.0	0
3	3	2013-01-01	1	BEVERAGES	0.0	0
4	4	2013-01-01	1	BOOKS	0.0	0

NUMPY ARRAYS

NumPy arrays are fixed-size containers of items that are more efficient than Python lists or tuples for data processing

- They only store a single data type *(mixed data types are stored as a string)*
- They can be one dimensional or multi-dimensional
- Array elements can be modified, but the array size cannot change

'np' is the standard alias for the NumPy library

```
import numpy as np
```

```
sales = [0, 5, 155, 0, 518, 0, 1827, 616, 317, 325]

sales_array = np.array(sales)
sales_array
```

```
array([   0,    5,  155,    0,  518,    0, 1827,  616,  317,  325])
```

*NumPy's **array** function converts Python lists and tuples into NumPy arrays*

ARRAY PROPERTIES

NumPy arrays have these key properties:

- **ndim** – the number of dimensions (axes) in the array
- **shape** – the size of the array for each dimension
- **size** – the total number of elements in the array
- **dtype** – the data type of the elements in the array

```
sales = [0, 5, 155, 0, 518, 0, 1827, 616, 317, 325]

sales_array = np.array(sales)

type(sales_array)
```

```
numpy.ndarray
```

*NumPy arrays are a **ndarray** Python data type, which stands for n-dimensional array*

```
print(f"ndim: {sales_array.ndim}")
print(f"shape: {sales_array.shape}")
print(f"size: {sales_array.size}")
print(f"dtype: {sales_array.dtype}")
```

```
ndim: 1
shape: (10,)
size: 10
dtype: int64
```

The sales_array has 1 dimension
The dimension has a size of 10
The array has 10 elements total
The elements are stored as 64-bit integers

ARRAY PROPERTIES

NumPy arrays have these key properties:

- **ndim** – the number of dimensions (axes) in the array
- **shape** – the size of the array for each dimension
- **size** – the total number of elements in the array
- **dtype** – the data type of the elements in the array

```
sales = [[0, 5, 155, 0, 518], [0, 1827, 616, 317, 325]]

sales_array = np.array(sales)
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

Converting a nested list creates a multi-dimensional array, where each nested list is a dimension

NOTE: The nested lists must be of equal length

```
print(f"ndim: {sales_array.ndim}")
print(f"shape: {sales_array.shape}")
print(f"size: {sales_array.size}")
print(f"dtype: {sales_array.dtype}")
```

```
ndim: 2
```
→ *The sales_array has 2 dimensions*

```
shape: (2, 5)
```
→ *The first dimension has a size of 2 (rows) and the second a size of 5 (columns)*

```
size: 10
```
→ *It has 10 elements total*

```
dtype: int64
```
→ *The elements are stored as 64-bit integers*

ASSIGNMENT: ARRAY BASICS

NEW MESSAGE

June 16, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **NumPy?**

Hi there, welcome to the Maven MegaMart!

Your resume mentions you have basic Python experience. Our finance team has been asking us to cut software costs – can you help us dig into Python as an analysis tool?

I know NumPy is foundational, but not much beyond that.

Can you convert a Python list into a NumPy array and help me get familiar with their properties?

Thanks!

numpy_assignments.ipynb

Reply Forward

Results Preview

```
my_list = [x * 10 for x in range(1, 11)]
```

```
array([ 10,  20,  30,  40,  50,  60,  70,  80,  90, 100])
```

```
ndim: 1
shape: (10,)
size: 10
dtype: int64
```

SOLUTION: ARRAY BASICS

NEW MESSAGE

June 16, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **NumPy?**

Hi there, welcome to the Maven MegaMart!

Your resume mentions you have basic Python experience. Our finance team has been asking us to cut software costs – can you help us dig into Python as an analysis tool?

I know NumPy is foundational, but not much beyond that.

Can you convert a Python list into a NumPy array and help me get familiar with their properties?

Thanks!

numpy_assignments.ipynb

Reply Forward

Solution Code

```
my_list = [x * 10 for x in range(1, 11)]

my_array = np.array(my_list)

my_array
```

```
array([ 10,  20,  30,  40,  50,  60,  70,  80,  90, 100])
```

```
print(f"ndim: {my_array.ndim}")
print(f"shape: {my_array.shape}")
print(f"size: {my_array.size}")
print(f"dtype: {my_array.dtype}")
```

```
ndim: 1
shape: (10,)
size: 10
dtype: int64
```

ARRAY CREATION

As an alternative to converting lists, you can **create arrays** using functions

ones	*Creates an array of ones of a given size, as float by default*	**np.ones((*rows*, *cols*), *dtype*)**
zeros	*Creates an array of zeros of a given size, as float by default*	**np.zeros((*rows*, *cols*), *dtype*)**
arange	*Creates an array of integers with given start & stop values, and a step size (only stop is required, and is not inclusive)*	**np.arange(*start*, *stop*, *step*)**
linspace	*Creates an array of floats with given start & stop values with n elements, separated by a consistent step size (stop is inclusive)*	**np.linspace(*start*, *stop*, *n*)**
reshape	*Changes an array into the specified dimensions, if compatible*	**np.array.reshape(*rows*, *cols*)**

ARRAY CREATION

As an alternative to converting lists, you can **create arrays** using functions

np.ones((*rows*, *cols*), *dtype*)

```
np.ones(4,)
```

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

np.zeros((*rows*, *cols*), *dtype*)

```
np.zeros((2, 5), dtype=int)
```

```
array([[0, 0, 0, 0, 0],
       [0, 0, 0, 0, 0]])
```

np.arange(*start*, *stop*, *step*) *start is 0 and step is 1 by default*

```
np.arange(10)
```

```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
```

stop is not inclusive

np.linspace(*start*, *stop*, *n*)

```
np.linspace(0, 100, 5)
```

```
array([  0.,  25.,  50.,  75., 100.])
```

stop is inclusive

np.array.reshape(*rows*, *cols*)

```
np.arange(1, 9, 2).reshape(2, 2)
```

```
array([[1, 3],
       [5, 7]])
```

RANDOM NUMBER ARRAYS

- Intro to Pandas & NumPy
- NumPy Array Basics
- Array Creation
- Array Indexing & Slicing
- Array Operations
- Vectorization & Broadcasting

You can create **random number arrays** from a variety of distributions using NumPy functions and methods *(great for sampling and simulation!)*

default_rng	*Creates a random number generator (the seed is for reproducibility)*	**np.default_rng(*seed*)**
random	*Returns n random numbers from a uniform distribution between 0 and 1*	**rng.random(*n*)**
normal	*Returns n random numbers from a normal distribution with a given mean and standard deviation*	**rng.normal(*mean*, *stdev*, *n*)**

'rng' is the standard variable name for the default_rng number generator

RANDOM NUMBER ARRAYS

You can create **random number arrays** from a variety of distributions using NumPy functions and methods *(great for sampling and simulation!)*

```
from numpy.random import default_rng

rng = default_rng(12345)

random_array = rng.random(10)
random_array
```

```
array([0.22733602, 0.31675834, 0.79736546, 0.67625467, 0.39110955,
       0.33281393, 0.59830875, 0.18673419, 0.67275604, 0.94180287])
```

*First, we're creating a random number generator with a seed of 12345 and assigning it to 'rng' using **default_rng***

*Then we're using the **random** method on 'rng' to return an array with 10 random numbers*

```
rng = default_rng(12345)
mean, stddev = 5, 1
random_normal = rng.normal(mean, stddev, size=10)
random_normal
```

```
array([3.57617496, 6.26372846, 4.12933826, 4.74082677, 4.92465669,
       4.25911535, 3.6322073 , 5.6488928 , 5.36105811, 3.04713694])
```

*Here we're using the **normal** method on 'rng' to return an array with 10 random numbers from a normal distribution with a mean of 5 and a st. deviation of 1*

PRO TIP: Even though it's optional, make sure to **set a seed** when generating random numbers to ensure you and others can recreate the work you've done (the value for the seed is less important)

ASSIGNMENT: ARRAY CREATION

NEW MESSAGE

June 17, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Array Creation**

Thanks for your help last time – I'm starting to understand NumPy Arrays!

Are there any NumPy functions that can create arrays so we don't have to convert from a Python list? Recreate the array from the first assignment but make it 5 rows by 2 columns.

Once you've done that, create an array of random numbers between 0 and 1 in a 3x3 shape. One of our data scientists has been asking about this so I want to make sure it's possible.

Thanks!

numpy_assignments.ipynb

Reply Forward

Results Preview

```
array([[ 10.,  20.],
       [ 30.,  40.],
       [ 50.,  60.],
       [ 70.,  80.],
       [ 90., 100.]])
```

```
random_array
```

```
array([[0.24742606, 0.09299006, 0.61176337],
       [0.06066207, 0.66103343, 0.75515778],
       [0.1108689 , 0.04305584, 0.41441747]])
```

SOLUTION: ARRAY CREATION

NEW MESSAGE

June 17, 2022

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Subject: **Array Creation**

Thanks for your help last time – I'm starting to understand NumPy Arrays!

Are there any NumPy functions that can create arrays so we don't have to convert from a Python list? Recreate the array from the first assignment but make it 5 rows by 2 columns.

Once you've done that, create an array of random numbers between 0 and 1 in a 3x3 shape. One of our data scientists has been asking about this so I want to make sure it's possible.

Thanks!

numpy_assignments.ipynb

Reply Forward

Solution Code

```
my_array = np.linspace(10, 100, 10).reshape(5, 2)

my_array
```

```
array([[ 10.,  20.],
       [ 30.,  40.],
       [ 50.,  60.],
       [ 70.,  80.],
       [ 90., 100.]])
```

```
from numpy.random import default_rng

rng = default_rng(2022)

random_array = rng.random(9).reshape(3, 3)

random_array
```

```
array([[0.24742606, 0.09299006, 0.61176337],
       [0.06066207, 0.66103343, 0.75515778],
       [0.1108689 , 0.04305584, 0.41441747]])
```

INDEXING & SLICING ARRAYS

Indexing & **slicing** one-dimensional arrays is the same as base Python

- **array[index]** – indexing to access a single element *(0-indexed)*
- **array[start:stop:step size]** – slicing to access a series of elements *(stop is not inclusive)*

```
product_array
```

```
array(['fruits', 'vegetables', 'cereal', 'dairy', 'eggs', 'snacks',
       'beverages', 'coffee', 'tea', 'spices'], dtype='<U10')
```

```
print(product_array[1])
print(product_array[-1])
```

```
vegetables
spices
```

*This grabs the **second** and **last** elements of product_array*

```
product_array[:5]
```

```
array(['fruits', 'vegetables', 'cereal', 'dairy', 'eggs'], dtype='<U10')
```

*This grabs the **first five** elements of product_array*

```
product_array[5::2]
```

```
array(['snacks', 'coffee', 'spices'], dtype='<U10')
```

*This starts at the **sixth** element and grabs **every other** element **until the end** of product_array*

INDEXING & SLICING ARRAYS

Indexing & **slicing** two-dimensional arrays requires an extra index or slice

- **array[row index, column index]** – indexing to access a single element *(0-indexed)*
- **array[start:stop:step size, start:stop:step size]** – slicing to access a series of elements

```
product_array2D = product_array.reshape(2, 5)
product_array2D
```

```
array([['fruits', 'vegetables', 'cereal', 'dairy', 'eggs'],
       ['snacks', 'beverages', 'coffee', 'tea', 'spices']], dtype='<U10')
```

```
product_array2D[1, 2]
```

```
'coffee'
```

*This goes to the **second** row and grabs the **third** element*

```
product_array2D[:, 2:]
```

```
array([['cereal', 'dairy', 'eggs'],
       ['coffee', 'tea', 'spices']], dtype='<U10')
```

*This goes to **all** rows and grabs all the elements starting from the **third** in each row*

```
product_array2D[1:, :]
```

```
array([['snacks', 'beverages', 'coffee', 'tea', 'spices']], dtype='<U10')
```

*This goes to the **second** row and grabs **all** its elements*

ASSIGNMENT: ARRAY ACCESS

NEW MESSAGE

May 17, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Indexing & Slicing Arrays**

Ok, last 'theoretical' exercise before we start working with real data.

I am familiar with indexing and slicing in base Python but have no idea how it works in multiple dimensions.

I've provided a few different 'cuts' of the data in the notebook – can you slice and dice the random array we created in the last exercise?

Thanks!

numpy_assignments.ipynb

Reply Forward

Results Preview

```
array([[0.24742606, 0.09299006, 0.61176337],
       [0.06066207, 0.66103343, 0.75515778],
       [0.1108689 , 0.04305584, 0.41441747]])
```

First two 'rows'

```
array([[0.24742606, 0.09299006, 0.61176337],
       [0.06066207, 0.66103343, 0.75515778]])
```

First 'column'

```
array([0.09299006, 0.66103343, 0.04305584])
```

Second number in third 'row':

```
0.04305584439252108
```

SOLUTION: ARRAY ACCESS

NEW MESSAGE

May 17, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Indexing and Slicing Arrays**

Ok, last 'theoretical' exercise before we start working with real data.

I am familiar with indexing and slicing in base Python but have no idea how it works in multiple dimensions.

I've provided a few different 'cuts' of the data in the notebook – can you slice and dice the random array we created in the last exercise?

Thanks!

numpy_assignments.ipynb

Reply Forward

Solution Code

```
array([[0.24742606, 0.09299006, 0.61176337],
       [0.06066207, 0.66103343, 0.75515778],
       [0.1108689 , 0.04305584, 0.41441747]])
```

First two 'rows'

```
random_array[:2]
```

```
array([[0.24742606, 0.09299006, 0.61176337],
       [0.06066207, 0.66103343, 0.75515778]])
```

First 'column'

```
random_array[:, 1]
```

```
array([0.09299006, 0.66103343, 0.04305584])
```

Second number in third 'row':

```
random_array[2, 1]
```

```
0.04305584439252108
```

ARRAY OPERATIONS

Arithmetic operators can be used to perform **array operations**

```
sales = [[0, 5, 155, 0, 518], [0, 1827, 616, 317, 325]]

sales_array = np.array(sales)
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

Array operations are applied via **vectorization** and **broadcasting**, which eliminates the need to loop through the array's elements

```
sales_array + 2
```

```
array([[   2,    7,  157,    2,  520],
       [   2, 1829,  618,  319,  327]])
```

*This **adds 2** to every element in the array*

```
quantity = sales_array[0, :]
price = sales_array[1, :]

quantity * price
```

```
array([     0,   9135,  95480,      0, 168350])
```

*This assigns **all** the elements in the **first row** to 'quantity'*

*Then assigns **all** the elements in the **second row** to 'price'*

*Finally, it multiplies the corresponding elements in each array: (0*0, 5*1827, 155*616, 0*317, and 518*325)*

ASSIGNMENT: ARRAY OPERATIONS

NEW MESSAGE

May 18, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Applying Discounts to Arrays**

Ok, so now that we've gotten the basics down, we can start using NumPy for our first tasks. As part of a promotion, we want to apply a random discount to surprise our customers and generate social media buzz.

First, add a flat shipping cost of 5 to our prices to get the 'total' amount owed.

The numbers in the random array represent 'discount percent'. To get the 'percent owed', subtract the first 6 numbers in the random array from 1, then multiply 'percent owed' by 'total' to get the final amount owed.

numpy_assignments.ipynb

Reply Forward

Results Preview

```
prices = np.array([5.99, 6.99, 22.49, 99.99, 4.99, 49.99])

total
```

```
array([ 10.99,  11.99,  27.49, 104.99,   9.99,  54.99])
```

```
print(discount_pct)
print(pct_owed)
print(final_owed.round(2))
```

```
[0.24742606 0.09299006 0.61176337 0.06066207 0.66103343 0.75515778]
[0.75257394 0.90700994 0.38823663 0.93933793 0.33896657 0.24484222]
[ 8.27 10.88 10.67 98.62  3.39 13.46]
```

The .round() array method rounds the elements of the array to the specified decimals

SOLUTION: ARRAY OPERATIONS

NEW MESSAGE

May 18, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Random Discounts Using Arrays**

Ok, so now that we've gotten the basics down, we can start using NumPy for our first tasks. As part of a promotion, we want to apply a random discount to surprise our customers and generate social media buzz.

First, add a flat shipping cost of 5 to our prices to get the 'total' amount owed.

The numbers in the random array represent 'discount percent'. To get the 'percent owed', subtract the first 6 numbers in the random array from 1, then multiply 'percent owed' by 'total' to get the final amount owed.

numpy_assignments.ipynb

Reply Forward

Solution Code

```
prices = np.array([5.99, 6.99, 22.49, 99.99, 4.99, 49.99])

total = prices +  5

total
```

```
array([ 10.99,  11.99,  27.49, 104.99,   9.99,  54.99])
```

```
discount_pct = random_array[:2].reshape(6)

pct_owed = 1 - discount_pct

final_owed = total * pct_owed

final_owed.round(2)
```

```
array([ 8.27, 10.88, 10.67, 98.62,  3.39, 13.46])
```

The .round() array method rounds the elements of the array to the specified decimals

FILTERING ARRAYS

You can **filter arrays** by indexing them with a logical test

- Only the array elements in positions where the logical test returns True are returned

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

```
sales_array != 0
```

```
array([[False,  True,  True, False,  True],
       [False,  True,  True,  True,  True]])
```

*Performing a logical test on a NumPy array returns a **Boolean array** with the results of the logical test on each array element*

```
sales_array[sales_array != 0]
```

```
array([   5,  155,  518, 1827,  616,  317,  325])
```

*Indexing an array with a Boolean array returns an array with the elements where the Boolean value is **True***

FILTERING ARRAYS

You can filter arrays with **multiple logical tests**

- Use **|** for **or** conditions and **&** for **and** conditions

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

```
sales_array[(sales_array == 616) | (sales_array < 100)]
```

```
array([  0,   5,   0,   0, 616])
```

*This returns an array with elements equal to 616 **or** less than 100*

```
sales_array[(sales_array > 100) & (sales_array < 500)]
```

```
array([155, 317, 325])
```

*This returns an array with elements greater than 100 **and** less than 500*

```
mask = (sales_array > 100) & (sales_array < 500)

sales_array[mask]
```

PRO TIP: Store complex filtering criteria in a variable (known as a Boolean mask)

FILTERING ARRAYS

You can filter arrays based on **values in other arrays**

- Use the Boolean array returned from the other array to index the array you want to filter

```
sales_array
```

```
array([  0,   5, 155,   0, 518])
```

```
product_array
```

```
array(['fruits', 'vegetables', 'cereal', 'dairy', 'eggs'], dtype='<U10')
```

```
product_array[sales_array > 0]
```

```
array(['vegetables', 'cereal', 'eggs'], dtype='<U10')
```

This returns the elements from product_array where values in sales_array are greater than 0

MODIFYING ARRAY VALUES

- Intro to Pandas & NumPy
- NumPy Array Basics
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- Array Indexing & Slicing
- Array Operations
- Vectorization & Broadcasting

You can **modify array values** by assigning new ones

```
sales_array
```

```
array([  0,   5, 155,   0, 518])
```

```
sales_array[1] = 25

sales_array
```

```
array([  0,  25, 155,   0, 518])
```

*This assigns a single value via **indexing***

```
sales_array[sales_array == 0] = 5

sales_array
```

```
array([  5,  25, 155,   5, 518])
```

*This **filters** the zero values in sales_array and assigns them a new value of 5*

THE WHERE FUNCTION

The **where()** NumPy function performs a logical test and returns a given value if the test is True, or another if the test is False

```
np.where(logical test,
         value if True,
         value if False)
```

A logical expression that evaluates to True or False

Value to return when the expression is True

Calls the NumPy function library

Value to return when the expression is False

THE WHERE FUNCTION

The **where()** NumPy function performs a logical test and returns a given value if the test is True, or another if the test is False

```
inventory_array
```

```
array([ 12, 102,  18,   0,   0])
```

```
product_array
```

```
array(['fruits', 'vegetables', 'cereal', 'dairy', 'eggs'], dtype='<U10')
```

```
np.where(inventory_array <= 0, "Out of Stock", "In Stock")
```

```
array(['In Stock', 'In Stock', 'In Stock', 'Out of Stock', 'Out of Stock'],
      dtype='<U12')
```

If inventory is zero or negative, assign 'Out of Stock', otherwise assign 'In Stock'

```
np.where(inventory_array <= 0, "Out of Stock", product_array)
```

```
array(['fruits', 'vegetables', 'cereal', 'Out of Stock', 'Out of Stock'],
      dtype='<U12')
```

If inventory is zero or negative, assign 'Out of Stock', otherwise assign the product_array value

ASSIGNMENT: FILTERING ARRAYS

NEW MESSAGE

May 1, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Subsetting and Slicing Arrays**

Hey there,

We're working on some more promotions. Can you filter our product list to only include prices greater than 25?

Once you've done that, modify your logic to force cola into the list. Call this array 'fancy_feast_special'.

Finally, we need to modify our shipping logic. Create a new shipping cost array, but this time if price is greater than 20, shipping cost is 0, otherwise shipping cost is 5.

Thanks!

numpy_assignments.ipynb

Reply Forward

Results Preview

```
products[ ]
```

```
array(['rare tomato', 'gourmet ice cream'], dtype='<U17')
```

```
fancy_feast_special
```

```
array(['rare tomato', 'cola', 'gourmet ice cream'], dtype='<U17')
```

```
shipping_cost
```

```
array([5, 5, 0, 0, 5, 0])
```

SOLUTION: FILTERING ARRAYS

NEW MESSAGE

May 1, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Indexing and Slicing Arrays**

Hey there,

We're working on some more promotions. Can you filter our product list to only include prices greater than 25?

Once you've done that, modify your logic to force cola into the list. Call this array 'fancy_feast_special'.

Finally, we need to modify our shipping logic. Create a new shipping cost array, but this time if price is greater than 20, shipping cost is 0, otherwise shipping cost is 5.

Thanks!

numpy_assignments.ipynb

Reply Forward

Solution Code

```
products[prices > 25]
```

```
array(['rare tomato', 'gourmet ice cream'], dtype='<U17')
```

```
mask = (prices > 25) | (products == "cola")

fancy_feast_special = products[mask]

fancy_feast_special
```

```
array(['rare tomato', 'cola', 'gourmet ice cream'], dtype='<U17')
```

```
shipping_cost = np.where(prices > 20, 0, 5)

shipping_cost
```

```
array([5, 5, 0, 0, 5, 0])
```

ARRAY AGGREGATION METHODS

Array aggregation methods let you calculate metrics like sum, mean, and max

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

array.sum() *Returns the sum of all values in an array*

```
sales_array.sum()
```

```
3763
```

array.max() *Returns the largest value in an array*

```
sales_array.max()
```

```
1827
```

array.mean() *Returns the average of the values in an array*

```
sales_array.mean()
```

```
376.3
```

array.min() *Returns the smallest value in an array*

```
sales_array.min()
```

```
0
```

ARRAY AGGREGATION METHODS

You can also aggregate across **rows** or **columns**

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

array.sum() *Returns the sum of all values in an array*

```
sales_array.sum()
```

```
3763
```

array.sum(axis=0) *Aggregates across rows*

```
sales_array.sum(axis=0)
```

```
array([   0, 1832,  771,  317,  84
```

array.sum(axis=1) *Aggregates across columns*

```
sales_array.sum(axis=1)
```

```
array([ 678, 3085])
```

ARRAY FUNCTIONS

Array functions let you perform other aggregations like median and percentiles

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

np.median(array) *Returns the median value in an array*

```
np.median(sales_array)
```

```
236.0
```

np.percentile(array, n) *Returns a value in the nth percentile in an array*

```
np.percentile(sales_array, 90)
```

```
737.0999999999996
```

This uses linear interpolation by default

ARRAY FUNCTIONS

You can also return a **unique** list of values or the **square root** for each number

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

np.unique(array) *Returns the unique values in an array*

```
np.unique(sales_array)
```

```
array([   0,    5,  155,  317,  325,  518,  616, 1827])
```

np.sqrt(array) *Returns the square root of each value in an array*

```
np.sqrt(sales_array)
```

```
array([[ 0.        ,  2.23606798, 12.4498996 ,  0.        , 22.75961335],
       [ 0.        , 42.74342055, 24.81934729, 17.80449381, 18.02775638]])
```

SORTING ARRAYS

The sort() method will **sort arrays** in place

- Use the axis argument to specify the dimension to sort by

```
sales_array
```

```
array([[   0,    5,  155,    0,  518],
       [   0, 1827,  616,  317,  325]])
```

```
sales_array.sort()

sales_array
```

```
array([[   0,    0,    5,  155,  518],
       [   0,  317,  325,  616, 1827]])
```

axis=1 by default, which sorts a two-dimensional array row by row

```
sales_array.sort(axis=0)

sales_array
```

```
array([[   0,    5,  155,    0,  325],
       [   0, 1827,  616,  317,  518]])
```

axis=0 will sort by columns

ASSIGNMENT: SORTING AND AGGREGATING

NEW MESSAGE

May 1, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Indexing and Slicing Arrays**

Hey there,

Thanks for all your hard work. I know we're working with small sample sizes, but we're proving that analysis can be done in Python!

Can you calculate the mean, min, max, and median of our 3 most expensive product prices? Sorting the array first should help!

Then, calculate the number of unique price tiers we have.

Thanks!

numpy_assignments.ipynb

Reply Forward

Results Preview

Top 3 Price Stats

```
Mean: 40.98667062008267
Min: 10.875049160510919
Max: 98.62108889965567
Median: 13.46387380008141
```

Unique Price Tiers

```
3
```

SOLUTION: SORTING AND AGGREGATING

NEW MESSAGE

May 1, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Indexing and Slicing Arrays**

Hey there,

Thanks for all your hard work. I know we're working with small sample sizes, but we're proving that analysis can be done in Python!

Can you calculate the mean, min, max, and median of our 3 most expensive product prices? Sorting the array first should help!

Then, calculate the number of unique price tiers we have.

Thanks!

numpy_assignments.ipynb

Reply Forward

Solution Code

Top 3 Price Stats

```
Mean: 40.98667062008267
Min: 10.875049160510919
Max: 98.62108889965567
Median: 13.46387380008141
```

Unique Price Tiers

```
np.unique(products).size
```

```
3
```

VECTORIZATION

Vectorization is the process of pushing array operations into optimized C code, which is easier and more efficient than writing for loops

```
def for_loop_multiply_lists(list1, list2):
    product_list = []
    for element1, element2 in zip(tuple1, tuple2):
        product_list.append(element1 * element2)
    return product_list
```

*Function that multiplies two Python **lists***

```
def multiply_arrays(array1, array2):
    return array1 * array2
```

*Function that multiplies two NumPy **arrays***

```
list1 = list(range(1000))
list2 = list(range(1000))
```

```
%%timeit -r 5 -n 10000
for_loop_multiply_lists(list1, list2)
```

```
75.8 µs ± 2 µs per loop (mean ± std. dev. of 5 runs, 10000 loops each)
```

Generating and multiplying two lists

```
array1 = np.array(list1)
array2 = np.array(list2)
```

```
%%timeit -r 5 -n 10000
multiply_arrays(array1, array2)
```

```
876 ns ± 44.7 ns per loop (mean ± std. dev. of 5 runs, 10000 loops each)
```

Converting and multiplying two arrays

~86 times faster!

VECTORIZATION

Vectorization is the process of pushing array operations into optimized C code, which is easier and more efficient than writing for loops

```
def for_loop_multiply_lists(list1, list2):
    product_list = []
    for element1, element2 in zip(tuple1, tuple2):
        product_list.append(element1 * element2)
    return product_list


def multiply_arrays(array1, array2):
    return array1 * array2
```

```
list1 = list(range(1000))
list2 = list(range(1000))
```

```
%%timeit -r 5 -n 10000
for_loop_multiply_lists(list1, list2)
```

```
75.8 µs ± 2 µs per loop (mean ± std. dev. of 5 runs, 10000 loops each)
```

```
array1 = np.array(list1)
array2 = np.array(list2)
```

```
%%timeit -r 5 -n 10000
multiply_arrays(array1, array2)
```

```
876 ns ± 44.7 ns per loop (mean ± std. dev. of 5 runs, 10000 loops each)
```

Converting and multiplying two arrays

~86 times faster!

PRO TIP: Use vectorized operations whenever possible when manipulating data, and avoid writing loops

BROADCASTING

Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension

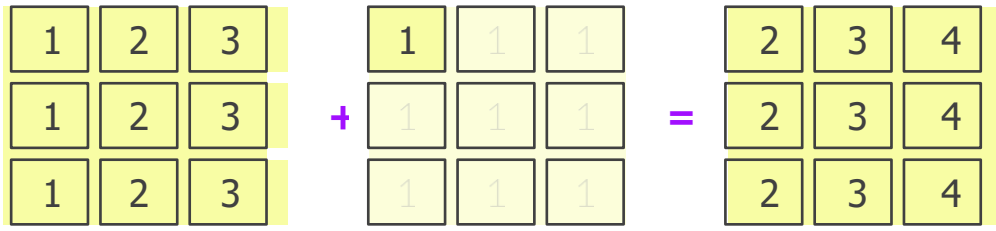
```
test_array = np.array([[1, 2, 3], [1, 2, 3], [1, 2, 3]])

test_array
```

```
array([[1, 2, 3],
       [1, 2, 3],
       [1, 2, 3]])
```

```
test_array + 1
```

```
array([[2, 3, 4],
       [2, 3, 4],
       [2, 3, 4]])
```

How does this code work?



BROADCASTING

Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension
- Dimensions with a length greater than one must be the same size

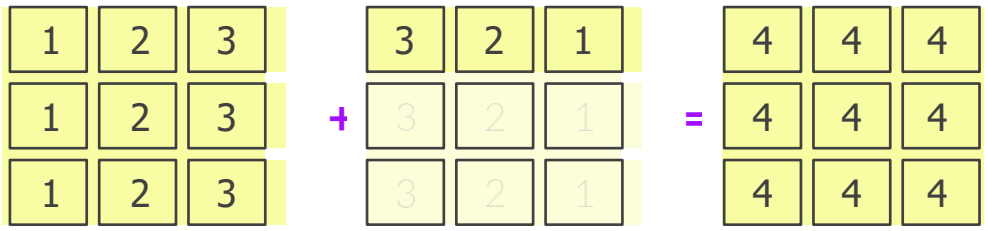
```
test_array = np.array([[1, 2, 3], [1, 2, 3], [1, 2, 3]])

test_array
```

```
array([[1, 2, 3],
       [1, 2, 3],
       [1, 2, 3]])
```

```
test_array + np.array([3, 2, 1])
```

```
array([[4, 4, 4],
       [4, 4, 4],
       [4, 4, 4]])
```

How does this code work?



BROADCASTING

Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension
- Dimensions with a length greater than one must be the same size

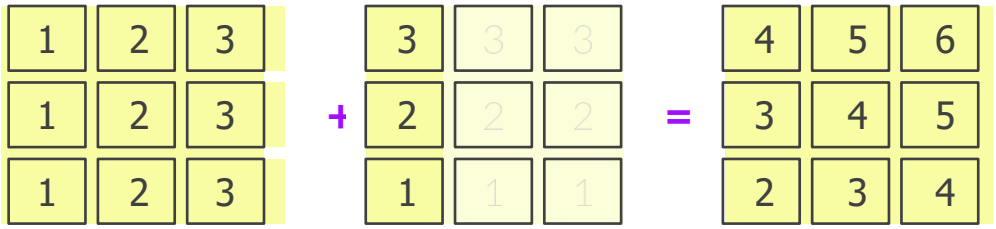
```
test_array = np.array([[1, 2, 3], [1, 2, 3], [1, 2, 3]])

test_array
```

```
array([[1, 2, 3],
       [1, 2, 3],
       [1, 2, 3]])
```

```
test_array + np.array([3, 2, 1]).reshape(3, 1)
```

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

How does this code work?



BROADCASTING

Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension
- Dimensions with a length greater than one must be the same size

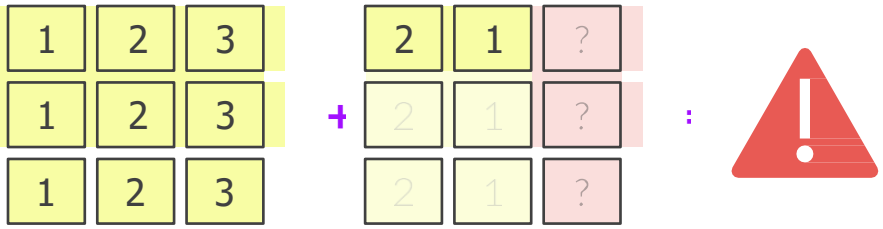
```
test_array = np.array([[1, 2, 3], [1, 2, 3], [1, 2, 3]])

test_array
```

```
array([[1, 2, 3],
       [1, 2, 3],
       [1, 2, 3]])
```

```
test_array + np.array([2, 1])
```

```
ValueError: operands could not be broadcast
            together with shapes (3,3) (2,)
```

How does this code work?



BROADCASTING

Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension
- Dimensions with a length greater than one must be the same size

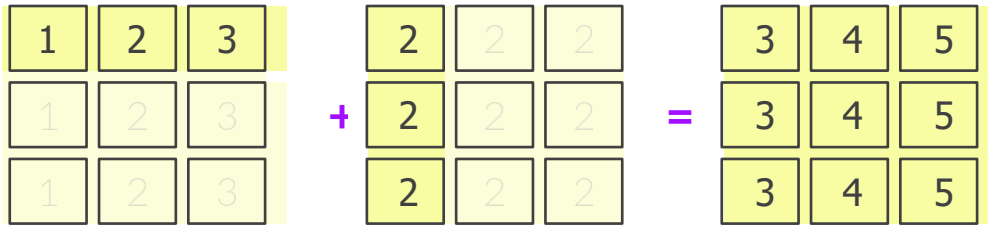
```
test_array = np.array([[1, 2, 3], [1, 2, 3], [1, 2, 3]])

test_array
```

```
array([[1, 2, 3],
       [1, 2, 3],
       [1, 2, 3]])
```

```
test_array[0, :] + test_array[:, 1].reshape(3, 1)
```

```
array([[3, 4, 5],
       [3, 4, 5],
       [3, 4, 5]])
```

How does this code work?



BROADCASTING

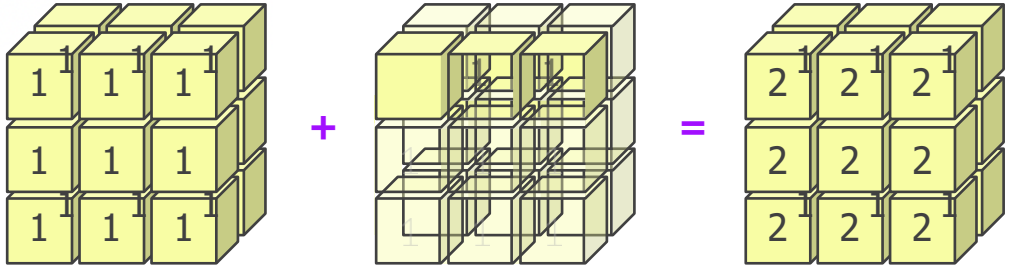
Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension
- Dimensions with a length greater than one must be the same size

```
np.ones((2, 3, 3), dtype=int) + np.ones(3, dtype=int)
```

```
array([[[2, 2, 2],
        [2, 2, 2],
        [2, 2, 2]],

       [[2, 2, 2],
        [2, 2, 2],
        [2, 2, 2]]])
```

How does this code work?



BROADCASTING

Broadcasting lets you perform vectorized operations with arrays of different sizes, where NumPy will expand the smaller array to 'fit' the larger one

- Single values (scalars) can be broadcast into arrays of any dimension
- Dimensions with a length greater than one must be the same size

Compatible shapes:

Array 1	Array 2	Output
(3, 3)	(100, 3, 3)	(100, 3, 3)
(3, 1, 5, 1)	(4, 1, 6)	(3, 4, 5, 6)

Incompatible shapes:

Array 1	Array 2
(4, 3)	(100, 3, 3)
(3, 1, 5, 1)	(4, 2, 6)

ASSIGNMENT: BRINGING IT ALL TOGETHER

NEW MESSAGE

May 1, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: Finishing Up Challenge Arrays

Alright, our new data scientist set up a little test case for us. She provided code to read in data from a csv and convert two columns to arrays.

Filter 'sales_array' to only include sales that had the product family 'PRODUCE' in the 'family_array'. Call this produce_sales.

Then randomly sample half of the remaining sales and calculate the mean of those sales.

Thanks!

numpy_assignments.ipynb

Reply Forward

Results Preview

```
import pandas as pd

retail_df = pd.read_csv("../retail/retail.csv").sample(1000, random_state=100)

family_array = np.array(retail_df["family"])
sales_array = np.array(retail_df["sales"])
```

```
1556.4381428571428
```

SOLUTION: BRINGING IT ALL TOGETHER

NEW MESSAGE

May 12, 2022

From: **Ross Retail** *(Head of Analytics)*

Subject: **Finding Sales Arrays**

Alright, our new data scientist set up a little test case for us. She provided code to read in data from a csv and convert two columns to arrays.

Filter 'sales_array' to only include sales that had the product family 'PRODUCE' in the 'family_array'. Call this produce_sales.

Then randomly sample half of the remaining sales and calculate the mean of those sales.

Thanks!

numpy_assignments.ipynb

Reply Forward

Solution Code

```
import pandas as pd

retail_df = pd.read_csv("../retail/retail.csv").sample(1000, random_state=100)

family_array = np.array(retail_df["family"])
sales_array = np.array(retail_df["sales"])
```

```
produce_sales = sales_array[family_array == "PRODUCE"]
```

```
produce_sales[rng.random(30) < 0.5].mean()
```

```
1556.4381428571428
```

KEY TAKEAWAYS

NumPy forms the **foundation for Pandas**

- *As an analyst, it's important to be comfortable working with NumPy arrays & functions in order to use Pandas data structures & functions properly*

NumPy arrays are **more efficient** than base Python lists and tuples

- *They are semi-mutable data structures capable of storing many data types*
- *Their values can be modified, but their size cannot*

Array operations let you **aggregate**, **filter**, and **sort** data

- *Broadcasting and vectorization make these operations convenient and efficient without the use of loops*
- *The syntax for NumPy array operations is very similar to Pandas*