COMS BC1016
Introduction to Computational Thinking and Data Science

Lecture 3: Arrays and Tables

January 28, 2025

Lab Reminders

- **Reminder: You must be enrolled in a 1017 section!**
  - As of Tuesday, there are still more people enrolled in 1016 than 1017
- Labs begin this week (today and tomorrow)
  - **Email your TA if you'll be late or missing!**
    - **Wednesday**: Nami Jain nbj2115@columbia.edu
    - **Thursday**: Sathya Raman sr4213@columbia.edu
  - 50% of your lab grade is attendance!
  - One unexcused absence + lowest lab dropped

Course Website

Slides, emails, and helpful links are on the course website:

https://www.eysalee.com/courses/s26/bc1016.html

Course Links

Jupyter Hub: Link (login required)

Class Discussion Forum: EdStem (login required)

Courseworks: Link

Syllabus: Link

Resources

Python Resources:
Data8 Python Reference: https://www.data8.org/fa24/reference/
DataScience Python Library Developer Documentation: https://www.data8.org/datascience/

Data8 Textbook: https://inferentialthinking.com/chapters/intro.html

Lecture Schedule

The schedule below will be updated as the course progresses.

Week	Date	Topic	Lab	Assignment
1	1/21	1 - Introduction [Slides]	*No Lab*	
2	1/26	2 - Introduction to Python [Slides] (Remote - Snow Day)		

Last time: Data Types

Types

Type	Example
Int	3
Float	3.78
String	‘Gertrude’
Boolean	True
Lists/Arrays	[“Hamby", “Fig”, “Ruby”]
Functions	abs(-5)

What’s the type?

Suppose we download information about the class.

What data type would each of the following fields be?

- Course title:
- Enrollment count:
- Names of students enrolled in the class:
- Average GPA of students in the class:

What's the type?

Suppose we download information about the class.

What data type would each of the following fields be?

- Course title: String
- Enrollment count: Integer
- Names of students enrolled in the class: Array (or list) of strings
- Average GPA of students in the class: Float

Variables and Assignments

- **Assignments** change the meaning of the name to the left the = symbol

- **Variables** are values you can assign values to

  - “Variable” because they can change

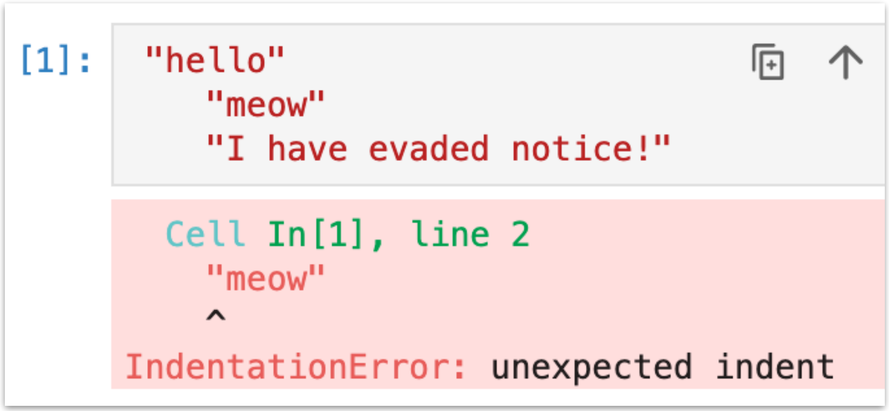
- You can assign outputs of functions and operations to variables

```
max_of_list = max(4,200,7)
max_of_list + 5
```

```
205
```

Python quirks

- Python is case sensitive
  - `Apple` is not the same as `apple`
- Indentation and new lines matter
  - Be careful not to add extra spaces or indentations at the beginning of the line!
- Python runs line-by-line
  - It'll stop as soon as it runs into an issue and tell you what's wrong
- Lines starting with `#` are comments and are ignored



Type Exercise

Open a new notebook and define these three variables:

```
x = 3
y = '4'
z = '5.6'
```

What would the source of the error in these examples?

How could you fix it?

```
1. x + y
2. x + int(y + z)
3. str(x) + int(y)
4. y + float(z)
```

Type Exercise

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What would the source of the error in this example:

```
y + float(z)
```

How could you fix it?

Arrays

Arrays

- Arrays are a sequence of values
  - e.g., `["Mystery", "Abby", "Jinu", "Baby", "Romance"]` or `[1,2,3,5]`
    - Elements of an array should have the same type
- Can make arrays using `datascience.make_array` or `numpy.array`
- Can perform component-wise arithmetic
  - Note this only works for numpy arrays but not built-in Python lists!

```
from datascience import *
onetwothree = make_array(1,2,3)
onetwothree * 2
```

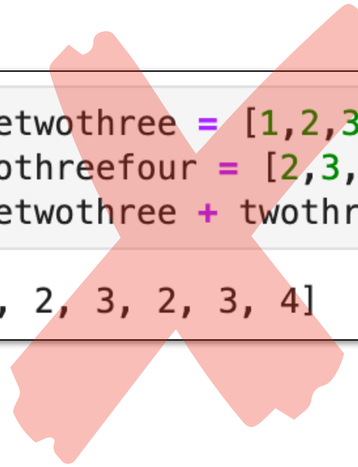
```
array([2, 4, 6])
```

```
from datascience import *
onetwothree = make_array(1,2,3)
twothreefour = make_array(2,3,4)
onetwothree + twothreefour
```

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

```
onetwothree = [1,2,3]
twothreefour = [2,3,4]
onetwothree + twothreefour
```

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



Arrays

- Can access the `i`th element either using `.item(i)` or `[i]`
  - Example (for an array `x`): `x.item(i)` or `x[i]`
- `len(x)` and `x.size` give the number of elements in the array `x`
- Counting starts at 0 (sometimes referred to as being 0-indexed)
  - `x[0]` gives the first element
  - `x[len(x)-1]` gives the last element

Arrays

- Many useful functions for operating on arrays
  - Helpful to be aware of, but you do not need to memorize them!

Function	Description
`np.prod`	Multiply all elements together
`np.sum`	Add all elements together
`np.all`	Test whether all elements are true values (non-zero numbers are true)
`np.any`	Test whether any elements are true values (non-zero numbers are true)
`np.count_nonzero`	Count the number of non-zero elements

Function	Description
`np.char.lower`	Lowercase each element
`np.char.upper`	Uppercase each element
`np.char.strip`	Remove spaces at the beginning or end of each element
`np.char.isalpha`	Whether each element is only letters (no numbers or symbols)
`np.char.isnumeric`	Whether each element is only numeric (no letters)

Function	Description
`np.diff`	Difference between adjacent elements
`np.round`	Round each number to the nearest integer (whole number)
`np.cumprod`	A cumulative product: for each element, multiply all elements so far
`np.cumsum`	A cumulative sum: for each element, add all elements so far
`np.exp`	Exponentiate each element
`np.log`	Take the natural logarithm of each element
`np.sqrt`	Take the square root of each element
`np.sort`	Sort the elements

Function	Description
`np.char.count`	Count the number of times a search string appears among the elements of an array
`np.char.find`	The position within each element that a search string is found first
`np.char.rfind`	The position within each element that a search string is found last
`np.char.startswith`	Whether each element starts with the search string

Ranges

A **range** is an array of consecutive numbers:

- `np.arange(end)`

  Create an array of increasing integers from `0` up to `end`

- `np.arange(start, end)`

  Create an array of increasing integers from `start` up to `end`

- `np.arange(start, end, step)`

  A range where `step` is added between consecutive values

The range always includes `start` but *excludes* `end`

Tables

Tables

A **table** is a way of representing data sets

- Each **row** is an **individual**

- Each **column** is an **attribute** of the individual

Name	Age	Coloring	Favorite Food
Gertrude	15 yrs	Tuxedo	Milk
Ruby	14 yrs	Tuxedo	Potato chips
Corina	6 yrs	Dilute Tortoiseshell	Kibble
Frito	1 yr	Tabby	Cheese

Creating `datascience` Tables

Create an empty table using `Table()`

Each column of a table is an array and `with_columns` creates a table with the array of values as a new column

Name	Description	Input	Output
`Table()`	Create an empty table, usually to extend with data (Ch 6)	None	An empty **Table**
`Table().read_table(filename)`	Create a table from a data file (Ch 6)	**string**: the name of the file	**Table** with the contents of the data file
`tbl.with_columns(name, values)` `tbl.with_columns(n1, v1, n2, v2,...)`	A table with an additional or replaced column or columns. `name` is a string for the name of a column, `values` is an array (Ch 6)	1. **string**: the name of the new column; 2. **array**: the values in that column	**Table**: a copy of the original Table with the new columns added

Creating `datascience` Tables

Create an empty table using `Table()`

Each column of a table is an array and `with_columns` creates a table with the array of values as a new column

```
Table().with_columns("Name", make_array("Gertrude",
"Ruby", "Corina", "Frito"))
```

Creating `datascience` Tables

`Table()` **creates an empty table**

`.with_columns()` adds a column

The first argument to `.with_columns` is the column name

… Followed by an array with the column values

…able u…

Each …olumn of a table is an a…ay and `with_columns` cre…y of value… as a new column

```
Table().with_columns("Name", make_array("Gertrude",
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Creating `datascience` Tables

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```
Table().with_columns("Name", make_array("Gertrude",
"Ruby", "Corina", "Frito"))
```

… Followed by an array with the column values

Name
Gertrude
Ruby
Corina
Frito

Creating `datascience` Tables

Create an empty table using `Table()`

Each column of a table is an array and `with_columns` creates a table with the array of values as a new column

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Table().with_columns("Name", make_array("Gertrude",
"Ruby", "Corina", "Frito"))
```

Name
Gertrude
Ruby
Corina
Frito

Creating `datascience` Tables

Create an empty table using `Table()`

Each column of a table is an array and `with_columns` creates a table with the array of values as a new column

```
Table().with_columns("Name", make_array("Gertrude",
"Ruby", "Corina", "Frito"),
"Age", make_array(15,14,6,1))
```

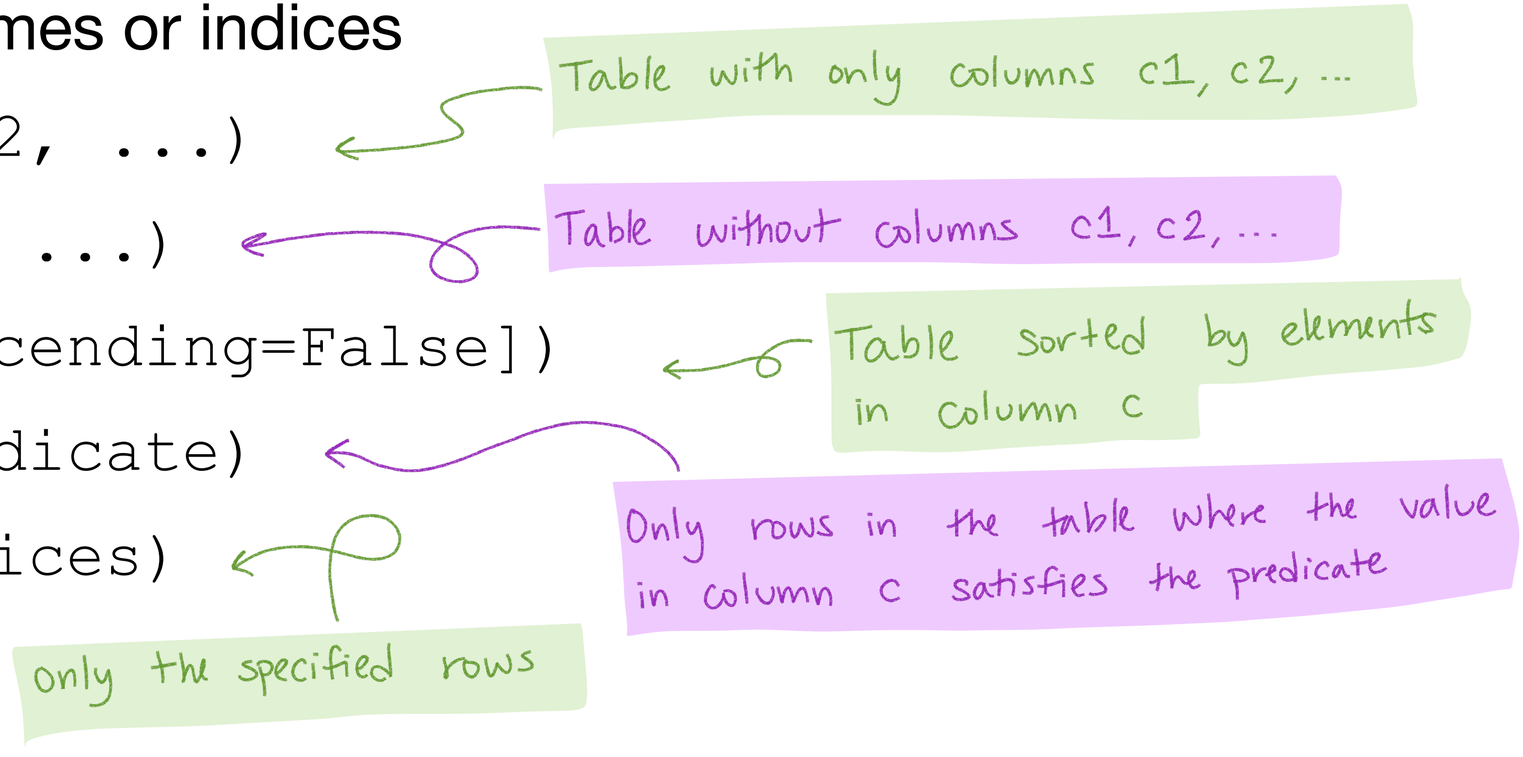
We can add more columns with a comma and following this same pattern

Name	Age
Gertrude	15
Ruby	14
Corina	6
Frito	1

More Ways to Create Tables

- Read from a CSV file
  - `Table.read_table(filename)`

- Create a new table from an existing table. Let `tbl` be a table and `c, c1, c2` be column names or indices
  - `tbl.select(c1 ,c2, ...)`
  - `tbl.drop(c1, c2, ...)`
  - `tbl.sort(c[, descending=False])`
  - `tbl.where(c, predicate)`
  - `tbl.take(row_indices)`



Filtering

https://www.data8.org/sp22/python-reference.html

`Table.where` Predicates

Any of these predicates can be negated by adding `not_` in front of them, e.g. `are.not_equal_to(Z)` or `are.not_containing(S)`.

Predicate	Description
`are.equal_to(Z)`	Equal to `Z`
`are.not_equal_to(Z)`	Not equal to `Z`
`are.above(x)`	Greater than `x`
`are.above_or_equal_to(x)`	Greater than or equal to `x`
`are.below(x)`	Less than `x`
`are.below_or_equal_to(x)`	Less than or equal to `x`
`are.between(x,y)`	Greater than or equal to `x` and less than `y`
`are.between_or_equal_to(x,y)`	Greater than or equal to `x`, and less than or equal to `y`
`are.contained_in(A)`	Is a substring of `A` (if `A` is a string) or an element of `A` (if `A` is a list/array)
`are.containing(S)`	Contains the string `S`
`are.strictly_between(x,y)`	Greater than `x` and less than `y`

Table Methods

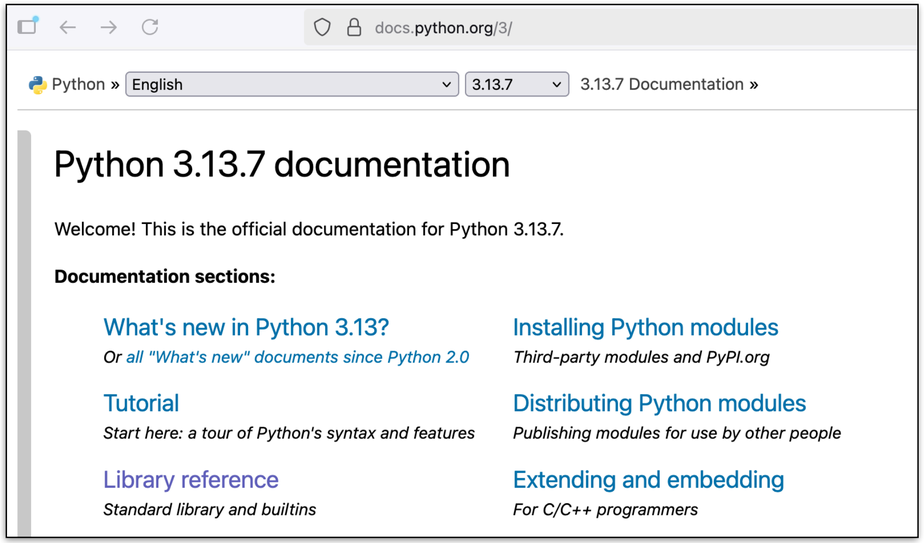
Recall each column in a Table is an array

- `column` takes a label or index and returns an array
- Array methods work on data in the columns
  - e.g., `sum`, `min`, `max`, `average`

Python Reference

https://www.data8.org/sp25/reference/

https://docs.python.org/3/



Next Class

- Today
  - Tables
- Monday (HW 1 is released)
  - Charts & Visualization