NIAPythonDay1_July2017

July 17, 2017

NIA Intro to Python Class - July 17, 2017

1 Day 1 - Introduction to Python

1.1 About the instructor

- Chris Coletta, Computer Scientist
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1.2 Course format

- Bootcamp style - no prior programming knowledge assumed
- 6 total hours of instruction
- No homework
- Goal of this course: Spreadsheet Manipulation
  - Read in and Excel file
  - Do some transformations on the data
  - Visualize the data
- Roadmap
  - Day 1: Background; the IDE; basic syntax; data types; basic operators
  - Day 2: Complex data types; reading in data; slicing and sorting
  - Day 3: Statistics
  - Day 4: Visualization

1.3 Python fast facts!

- General-purpose programming language
- Open-source software
- Free
- Started in 1989 by Guido van Rossum
- Emphasizes code readability => Lower barrier to entry than other programming languages
- Case-sensitive

1.4 Help Learning Python

- Python for Scientists and Engineers - Free Book by Shantnu Tiwari
- Google the error message
  - Questions and answers on StackOverflow.com
- Use Jupyter built-in operator ?
- Use Python help() command to see documentation

1.5 Ecosystem of Python Data Analysis Software

Anaconda is one of many Python "distributions" that bundles the following three types of software:

1.5.1 "Core" Python

- The Python interpreter - understands the syntax of the Python language
- Python Standard Library
  - Built-in tools, mathmatical functions, algorithms
  - Organized into sub-units called "packages" that you import

1.5.2 Third-party packages

- There are hundreds of them. My favorites:
  - NumPy - Linear algebra/matrices
  - SciPy - Statistics + math
  - statsmodels - Linear models/regression
  - matplotlib - Makes plots/figures
  - Seaborn - Really nice plots/figures
  - Pandas - Spreadsheet replacement/data manipulation
  - Scikit-learn - Machine Learning
  - Scikit-image - Image processing
  - Biopython - Bioinformatics
  - WND-CHARM - NIA in-house image analysis/machine learning

1.5.3 IDEs

- Jupyter Notebook - Creates sharable documents containing live code, equations, visualizations and explanatory text.
- Spyder - "Scientific PYthon Development EnviRonment"

1.6 IDE Concepts

- Integrated Development Environment - The software app you use to build and test your code
- Example notebooks here and here
- Compare and contrast how the user interfaces with Python and Excel
  - Excel: Little cubby holes that you can shove data into

  - Python: Give it a command to enter data
  - Excel: You're the customer in the restaurant: All possible operations listed in the MENU
  - Python: You're the chef in the restaurant: Write your own program by following recipes/cookbooks
  - Excel: Don't really talk to other files
  - Python: Input/output to other files is fundamental
  - Excel: Sandbox: input and output to the same place
  - Python & Jupyter Notebook: Clear workflow, like a cooking recipe or driving directions. Good for reproducible science.

- Jupyter components
  - Do coding inside web browser
  - Browser communicates with a "kernel" (on local machine or in the cloud)
  - Can optionally "Download as..." notebook into a .py, HTML, PDF, LaTeX, etc

1.7 Exploring the Jupyter IDE

- Do the user interface tour

1.7.1 Cell types

Markdown cells

- Markdown Document-formatting style that is easly convertable to HTML
- Headings preceeded by #
- unordered lists preceeded by a *
- ordered lists preceeded by a number
- Math equations go in between two $, example: $t = \frac{\hat{\beta} - \beta_{H_0}}{s.e.(\hat{\beta})}$
- Create links like this

Code Cells

- commands go in here
- tab-completion

1.7.2 Interacting with cells

Command mode

- Press Esc - box turns blue
- Useful shortcuts:
  - b = Insert cell below
  - a = inser cell above
  - dd = Delete cell
  - Shift + up or down = select/highlight two or more cells
  - M = merge highlightes cells into one

Edit mode

- Double click to edit - box turns green
- Useful shortcuts
  - Ctrl + Shift + - = split cell at cursor location
  - Enter = gives you a new line inside the same cell
  - Shift + Enter = Runs the code in this cell and go to the next one
  - Ctrl + Enter = Runs the code in this cell and stay on this one

1.8 Linux-style file system commands

Here are some useful Linux file commands that Jupyter notebook understands:

1.8.1 pwd

pwd stands for "Present working directory." Tell me whare I am on the filesystem right now.

```
In [1]: pwd
```

```
Out[1]: '/Users/colettace/courses/July2017_NIA_Python_Course'
```

1.8.2 ls

ls will list files in present working directory.

```
In [2]: ls
```

```
NIAPythonDay1_July2017.ipynb  NIAPythonDay4_July2017.ipynb*
NIAPythonDay1_July2017.pdf    images/
NIAPythonDay2_July2017.ipynb* samplefile.xlsx
NIAPythonDay3_July2017.ipynb*
```

1.8.3 mkdir

mkdir- "make a new folder"

```
In [3]: mkdir NewFolder
```

```
In [4]: ls
```

```
NIAPythonDay1_July2017.ipynb  NIAPythonDay4_July2017.ipynb*
NIAPythonDay1_July2017.pdf    NewFolder/
NIAPythonDay2_July2017.ipynb* images/
NIAPythonDay3_July2017.ipynb* samplefile.xlsx
```

1.8.4 cd

cd foldername - Change Directory of present working directory to foldername

```
In [5]: cd NewFolder
```

```
/Users/colettace/courses/July2017_NIA_Python_Course/NewFolder
```

1.8.5 cd ..

cd .. means make the current working directory one folder up.

```
In [6]: cd ..
```

```
/Users/colettace/courses/July2017_NIA_Python_Course
```

1.8.6 cd ~

cd ~ (tilde character) means make the current working directory your home folder.

```
In [7]: cd ~
```

```
/Users/colettace
```

1.8.7 rmdir

rmdir foldername means delete the folder in the current working directory named foldername.

```
In [8]: cd /Users/colettace/courses/July2017_NIA_Python_Course
```

```
/Users/colettace/courses/July2017_NIA_Python_Course
```

```
In [9]: rmdir NewFolder
```

1.8.8 Some other commands

- cp which copies a file from one place to another
- mv which moves a file from one place to another, or changes the name of a file.
- more...

1.9 The Python Statement

- Your Python code is broken up into statements
- One statement per line, except:
  - You can put two statements on one line if they are separated by a semi-colon ;
  - You can break up one statement over multiple lines using a backslash, which is called the "continuation" character.
- Can have multiple statements inside a code cell

```
In [ ]:
```

1.10 Comments

Lines preceededed by a hash symbol "#" are ignored by the Python interpreter

```
In [10]: # Run me! nothing happens!!!
```

1.11 Assignment, i.e., give a value a name

- An assignment is the name on the left side of an equal sign.
- It gives a name to a value.
- Names can have upper and lowercase letters, numbers (as long as it's not the first character), as well as underscores (Shift + -).
- Don't use a name that is also a Python Syntax keyword

```
In [11]: my_fav_number = 42

In [12]: f00 = "asdfasdf"
```

See the value attached to the name by typing the name

```
In [13]: my_fav_number

Out[13]: 42
```

1.12 print() function

Use the print function to output one or more values at once.

```
In [14]: print( my_fav_number, f00)

42 asdfasdf
```

1.13 Code-completion using TAB key

Hit the TAB key to use code completion to help you type faster. Most IDEs have this option. Usually a pop-up menu will appear

```
In [15]: my_fav_number

Out[15]: 42
```

1.14 Python Data Types: what are they, and why do we care?

- Different types of data, different data types
- Each type has their own various "superpowers," i.e., functionality.
- Advanced programmers often define their own types with their own functionality
- Here, "simple" means that these are types that are built into core Python, and you can use them right away.
- "Fancy" means simply that you need to use the import command before you use them.

1.14.1 What the difference between "scalar" and "iterable"?

- You can't loop over a scalar.

1.14.2 Scalar Data Types (simple)

- integer int: counting numbers
- float float: decimal numbers
- boolean bool: true/false

1.14.3 Iterable Data Types (simple)

- string str: words
- list list: collection of things (ordered)
- dictionary dict: map one value to another (unordered)
- set set: unique collection of things (unordered)

1.14.4 Iterable Data Types (fancy)

- NumPy multi-dimensional array: data, images
- Pandas DataFrame: spreadsheet analog

And many more...

1.15 Scalar Data Types: Integer (int)

- A counting number 1, 2, 3, -89 ..., 0

```
In [16]: -23
```

```
Out[16]: -23
```

1.16 Scalar Data Types: Float (float)

- Decimal numbers
- An accurate approximation to many many decimal places, but technically not an EXACT representation
- If you want to know more about why decimal numbers are called "floats", click here.

```
In [17]: 3.14159
```

```
Out[17]: 3.14159
```

```
In [18]: 1/3
```

```
Out[18]: 0.3333333333333333
```

1.17 PEMDAS operators

1. Parentheses - ()
2. Exponent - **
3. Multiplication - *
4. Division - /
5. Addition - +
6. Subtraction - -

Example: What is $9 - 3 \div \frac{1}{3} + 1 =$?

```
In [19]: 9 - 3 / 1/3 + 1
```

```
Out[19]: 9.0
```

```
In [20]: 9 - 3 / (1/3) + 1
```

```
Out[20]: 1.0
```

1.18 Using the type() function

Use this to have Python tell you the data type of any expression or named value.

```
In [21]: type( my_fav_number )
```

```
Out[21]: int
```

```
In [22]: type( 3.14159 )
```

```
Out[22]: float
```

1.19 Scalar Data Types: Boolean (bool)

Bools can only have a value of True or False.

```
In [23]: True
```

```
Out[23]: True
```

1.20 Boolean operators and, or, and not

and and or are "binary operators", meaning you slap them in between two truth values to make one value.

```
In [24]: True and False
```

```
Out[24]: False
```

```
In [25]: True or False
```

```
Out[25]: True
```

```
In [26]: my_bool_value = True and False
         print( my_bool_value )
```

```
False
```

not is a unary operator that negates the value after it.

```
In [27]: not True
```

```
Out[27]: False
```

1.21 Some math operators

- < less than
- <= less than or equal to
- > greater than
- >= greater than or equal to
- == is equal to
- != is not equal to

Note the double equal signs is an operator, not an assignment!!

```
In [28]: 5 < 6
```

```
Out[28]: True
```

```
In [29]: 6 <= 6
```

```
Out[29]: True
```

```
In [30]: -6 <= 6
```

```
Out[30]: True
```

```
In [31]: 6 != 6
```

```
Out[31]: False
```

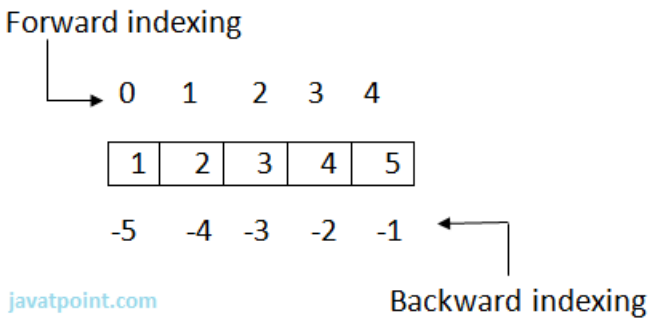
```
In [32]: not( 6 == 6 )
```

```
Out[32]: False
```

1.22 Using whos command to keep track of named values

```
In [33]: whos
```

```
Variable        Type    Data/Info
---------------------------------
f00             str     asdfasdf
my_bool_value   bool    False
my_fav_number   int     42
```



https://www.javatpoint.com/python/images/elementsinalists.png

1.23 Iterable Data Types: Strings (str)

- A data type that contains one or more characters
- Strings are surrounded, a.k.a. "delimited" by matching single or double quotes
- You choose whether to use single or double quotes based on what's in the string.

```
In [34]: "Hello, world!"

Out[34]: 'Hello, world!'

In [35]: 'Hello, world!'

Out[35]: 'Hello, world!'
```

I repeat: ***No difference between single and double quotes strings!!!!*** I promise!

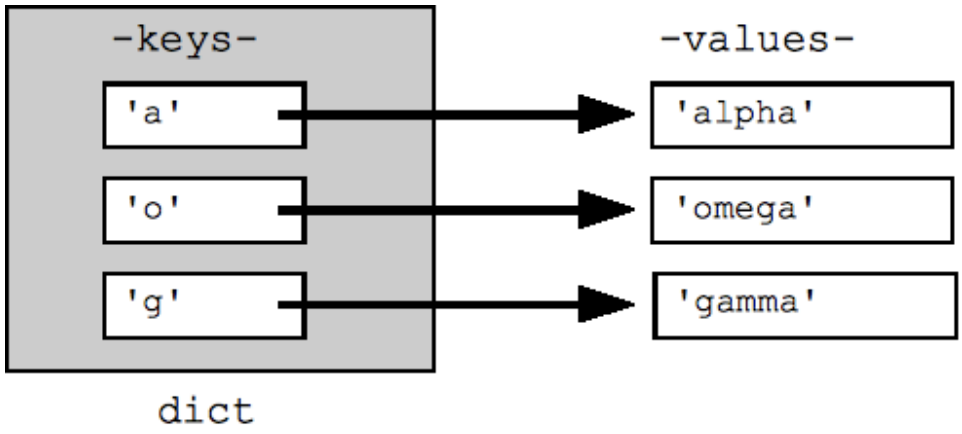
```
In [36]: "Can't"

Out[36]: "Can't"

In [37]: '"Really," she said?'

Out[37]: '"Really," she said?'
```

By the way, I'm ***not*** talking about the backtick ‘, which shares a key with the tilde ~ character. Backtick is ***different*** than a single quote ’, which shares a key with the double quote ".

1.24 Iterable Data Types: Lists (list)

- Container for a collection of values
- Can all be the same type or different, doesn't matter.
- Items delimited by commas, all surrounded by brackets [], not parentheses ()
- The order of the values in the list is remembered

```
In [38]: a_list = [ 1, 2, 3, 1, "a dog" ]
```



https://developers.google.com/edu/python/images/dict.png

1.24.1 Get the ith element from a list using bracket notation

```
In [39]: a_list[0]

Out[39]: 1

In [40]: a_list[4]

Out[40]: 'a dog'
```

1.24.2 Negative index counts from the back of the list

```
In [41]: a_list[-1]

Out[41]: 'a dog'
```

1.24.3 Use the "unpacking" syntax to get values out of small lists

```
In [42]: a_few_things = [ "hello", "goodbye", 42 ]

In [43]: first, second, third = a_few_things

In [44]: first

Out[44]: 'hello'
```

1.25 Iterable Data Types: Dictionaries (dict)

- A dict is one-way associative array, where "keys" are mapped to "values."
- Note: A dict does not keep track of the order in which you inputted the key-value pairs
  - for that you need collections.OrderedDict

1.25.1 Create a dict with stuff in it

The keys are separated by the values by a colon (:), and the key-value pairs are separated by commas.

```
In [45]: simple = { 1 : 'a', 2 : 'b', 3: 'c'}

In [46]: simple

Out[46]: {1: 'a', 2: 'b', 3: 'c'}
```

1.25.2 Access an element in a dict using its key and bracket notation []

```
In [47]: simple[1]

Out[47]: 'a'
```

1.25.3 Create an empty dict

Declare empty dict with {}, or dict().

```
In [48]: {}

Out[48]: {}
```

1.25.4 Add a new key-value pair to an existing dict using bracket notation []

```
In [49]: simple['new_key'] = 'new_value'

In [50]: simple

Out[50]: {1: 'a', 2: 'b', 3: 'c', 'new_key': 'new_value'}
```

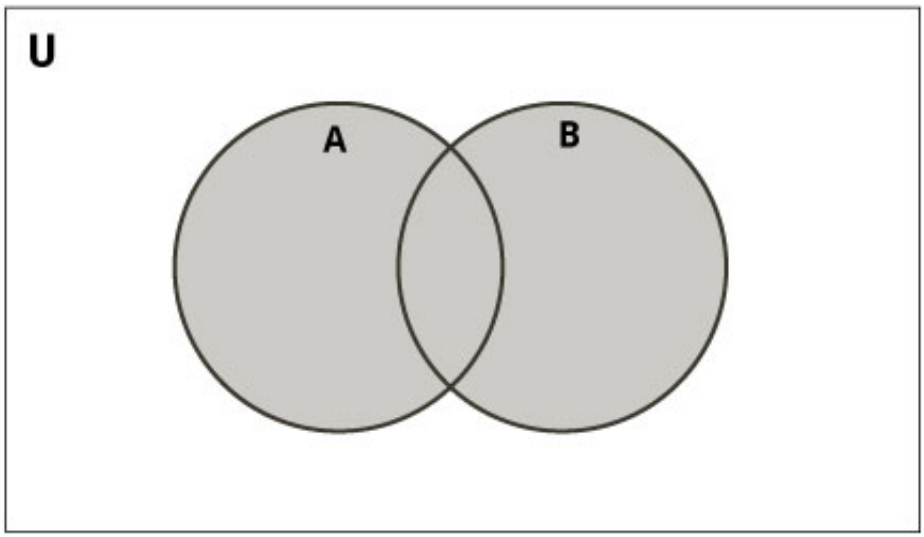
1.26 Iterable Data Types: Sets (set)

- Similar to math concept of sets; has operations like union, intersection, etc.
- Sets are unindexed, unordered, and contains no duplicates.
- My personal favorite of the Python standard types!

1.26.1 Create a set with stuff in it

Declare a set by putting values inside braces.

```
In [51]: a_set = {'set', 'of', 'words'}
```



https://cdn.programiz.com/sites/tutorial2program/files/set-union.jpg

1.26.2 Create an empty set

Make an empty using set().

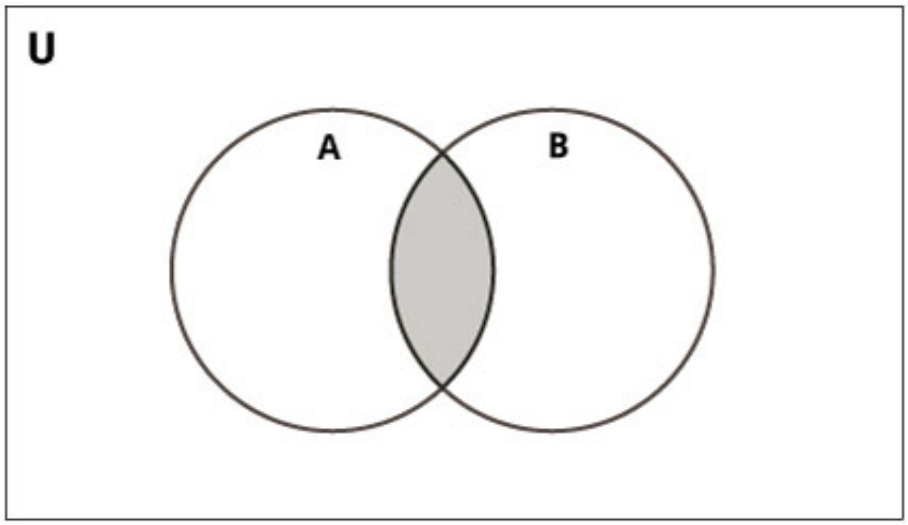
```
In [52]: empty_set = set() # not {}, that would be an empty dict

In [53]: empty_set

Out[53]: set()

In [54]: empty_set.add( 'hi')

In [55]: empty_set

Out[55]: {'hi'}

In [56]: first = {1,2,3,4,5}
         second = {4,5,6,7,8}
```

1.26.3 Set Union Operator (|) - "or"

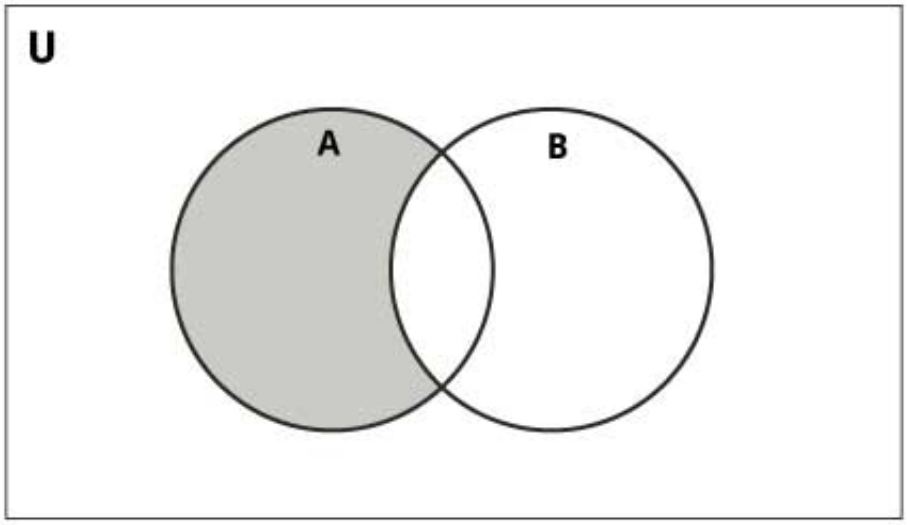
```
In [57]: first | second

Out[57]: {1, 2, 3, 4, 5, 6, 7, 8}
```

1.26.4 Set Intersection Operator (&) - "and"

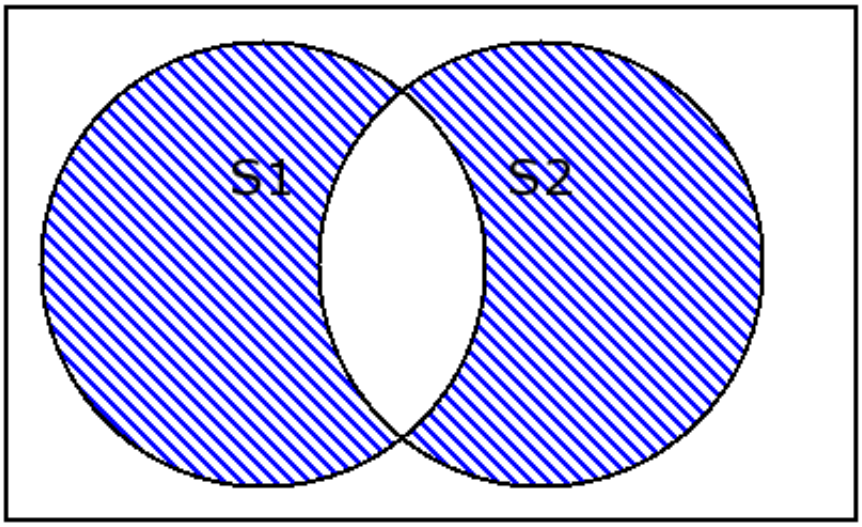
```
In [58]: first & second

Out[58]: {4, 5}
```



https://cdn.programiz.com/sites/tutorial2program/files/set-intersection.jpg



https://cdn.programiz.com/sites/tutorial2program/files/set-difference.jpg



http://www.itmaybeahack.com/book/python-2.6/html/_images/p2c6-symmdiff.png

1.26.5 Set Difference Operator (-)

```
In [59]: first - second
```

```
Out[59]: {1, 2, 3}
```

1.26.6 Set Symmetrical Difference Operator (^)

```
In [60]: first ^ second
```

```
Out[60]: {1, 2, 3, 6, 7, 8}
```

1.27 How many elements in an iterable? Use len()

```
In [61]: len( first ^ second )
```

```
Out[61]: 6
```

```
In [62]: len(a_list)
```

```
Out[62]: 5
```

1.28 Can you change a value's type? Yes!

Use these functions to "coerce" a value from one type to another:

- int()
- float()
- bool()
- list()
- dict()

- set()
- et al.

```
In [63]: a_string = '45'

In [64]: 56 + a_string


         ---------------------------------------------------------------------------

         TypeError                                 Traceback (most recent call last)

         <ipython-input-64-9fc9abcf064a> in <module>()
     ----> 1 56 + a_string


         TypeError: unsupported operand type(s) for +: 'int' and 'str'


In [65]: 56 + int(a_string)

Out[65]: 101

In [66]: str( 56 ) + a_string

Out[66]: '5645'

In [67]: list( "listify me!")

Out[67]: ['l', 'i', 's', 't', 'i', 'f', 'y', ' ', 'm', 'e', '!']

In [68]: set( "listify me!" )

Out[68]: {' ', '!', 'e', 'f', 'i', 'l', 'm', 's', 't', 'y'}

In [69]: float( 3 )

Out[69]: 3.0

In [70]: int( 3.14159 )

Out[70]: 3

In [71]: bool( "a_string")

Out[71]: True

In [72]: bool( "" )

Out[72]: False
```

1.29 Iterating over items in a list using a for loop

- Statements you want to be repeated inside the loop should be *indented* below the first line.
- Use the TAB key to indent.

```
In [73]: months = ['Jan', 'Feb', 'Mar', 'Apr', 'May', 'June']

In [74]: for m in months:
             print( m )
```

```
Jan
Feb
Mar
Apr
May
June
```

1.30 Iterating over items in a dict using a for loop using .items() syntax

```
In [75]: num_days_in_month = { 'Jan' : 31, 'Feb' : 28, 'Mar' : 31, 'Apr' : 30 }

In [76]: for m, d in num_days_in_month.items():
             print( "There are", d, "days in", m )
```

```
There are 31 days in Jan
There are 28 days in Feb
There are 31 days in Mar
There are 30 days in Apr
```

1.31 Day 1 review

1. Python ecosystem of tools
2. Jupyter Notebook is code, output and documentation all in one document
3. Type code into cells, and to run them you press Shift-Enter
4. Tab completion is nice
5. Different data types for different data
6. Operators take one or more input values and turn them into other values *based on the input values type*
7. Converting data from one type to another using the function syntax, e.g., int()
8. Iterating over iterables using a for loop