Workshop Details

Intermediate Workshop to Python Programming

Building the Foundation for Coding Success

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January 23, 2024

Presentation Overview

Data Types: Deeper Dive

— Previously in Python Programming —

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- `int`: Whole numbers without decimal points
- `float`: Numbers with decimal points
- `bool`: Represents the truth values `True` or `False`
- `NoneType` (`None`): Represents absence of a value (or null)
- `string`: Ordered sequence of characters

Collections

- `list`: Ordered and mutable sequence of elements
- `tuple`: Ordered and immutable sequence of elements
- `dict`: Unordered collection of key-value pairs

NoneType

NoneType

- `None` is a Singleton — there is only ever a single instance of it inside a running Python program
- Multiple variables may refer to that same instance

Comparisons using Keyword `"is"`

Keyword `is` checks whether two names refer to the same object

```python
a = [1, 2]
b = a
x = [1, 2]

a == b # True
a is b # True
a == x # True
a is x # False
```

As `None` is a singleton, we can check for it via `is None`

```python
if a is None:
    print("a is None")
```

BoolType

BoolType

- The `bool` type is a built-in data type representing truth values
- It has two possible values: `True` and `False`

```python
a = True
if a:
    print('hello')
```

```python
x, y = 10, 20
is_greater = x > y    # False
if is_greater:
    print("x greater than y")
else:
    print("x not greater than
    ↪   y")
```

Booleans are a subset of integers (subclass of int) where `True` behaves as 1 and `False` as 0 in numerical contexts

```
False + True # 1
```

Numbers

Operations with Numbers

- Integer Division: 10 // 3 = 3
- Remainder: 10 % 3 = 1
- Exponentiation: 2 ** 3 = 8

Numbers

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Underscores in Numeric Literals for Enhanced Readibility

- Revenue: 1000000000
- Revenue: 1_000_000_000

Integer Type Representations

Integers

1. Python supports integers of arbitrary size, allowing representation of very large numbers
2. It also supports different numeral systems
   - Decimal — `a = 42`
   - Binary — `b = 0b101010`
   - Octal — `c = 0o52`
   - Hexadecimal — `d = 0x2a`
   - Conversion from a string in binary to an integer — `e = int('101010', 2)`

Tip — Maximum Size of Integers on the Current System

```python
import sys
print(sys.maxsize)  # Maximum size
```

Float Type Representations

Integers

1. Floating-point numbers in Python use 64 bits
   - **Numbering** — `a = .12` or `b = 2.55`
   - **Scientific Notation** — `c = 6e23`
   - **Special Values** — `d = float('nan')` or `e = float('inf')`

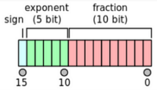
type	range	signi-ficant digits*	 exponent (5 bit) fraction (10 bit) sign 15 10 0	type	composed of
float16	$\pm(6.0*10^{-8} \;..\; 65504)$	3	1bit 5bit 10bit	–	–
float32	$\pm(1.4*10^{-45} \;..\; 3.4*10^{38})$	6	1bit 8bit 23bit	complex64	two float32's
float64	$\pm(4.9*10^{-324} \;..\; 1.8*10^{308})$	15	1bit 11bit 52bit	complex128	two float64's
float128**	$\pm(3.7*10^{-4951} \;..\; 1.1*10^{4932})$	18	1bit 15bit 64bit	complex256	two float128's

Figure: Based on IEEE 754 — Standardized Floating-point Arithmetic

Float Type Representations

Warning!

Floating-point numbers, while versatile, can't perfectly represent all real numbers. This limitation leads to rounding errors, causing some numbers to be approximations rather than precise representations

Float Type Representations

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In the decimal system:

1. Fractions like 1/3 and 1/7 can't be represented exactly
2. Constant like π isn't fully representable without approximation

In binary floats:

1. Decimals like 1/2 and 1/10 can't be precisely represented
2. Fractions like 1/3 and even suffer from approximation

Float Rounding Errors

Warning!

As a consequence to not being able to perfectly represent all real numbers, float numbers will lead to rounding error mismatches

Example 1 — Precision Limitations

1. Computing $\pi + \pi$ might yield 6.2 when using decimal numbers with a precision of 2, whereas a more precise result would be 6.3

Example 1 — Arithmetic Precision

1. Simple addition like 0.1 + 0.2 might oddly evaluate to $\approx$ 0.30000000000000004 due to limitations in 64-bit floats

```python
0.1 + 0.2 == 0.3 # Returns False if float assigned

import math       # tolerance = 1e-09
math.isclose(0.1 + 0.2, 0.3) # Returns True
```

Complex Type and Augmented Assignment

A complex number is a numerical type used to represent numbers that have both a real part and an imaginary part: `a = 1 + 2j`

Let us increment the real part `(1)` of the variable *a*

$$a = a + 1 \quad \texttt{or} \quad a+ = 1$$

Augmented Assignment

This operation means ”add 1 to the current value of *a* and assign the result back to *a*

Calculation:

$$a = 1 + 2j + 1$$

Result:

$$a = 2 + 2j$$

Other operations include: `-=, *=, ...`

Character Encodings

Character encodings are used to represent characters in a form that computers can understand and manipulate — mapping characters to bit sequences

Types of Character Encodings

1. ASCII (American Standard Code for Information Interchange)
    - Encodes the first 128 Unicode characters using 7 bits, covering basic English characters, digits, and symbols
    - Represents characters like 'A', '!', '$', space, and line breaks
2. Latin1 (ISO 8859-1)
    - Extends ASCII to encode the first 256 Unicode characters using 8 bits
    - Adds additional characters like '*ä*', '*á*', 'β', '§', etc
3. UTF-8, UTF-16, UTF-32
    - Encode the entire Unicode character set
    - UTF-8, a popular encoding, uses variable-width encoding

Character Encodings

Examples in ASCII / Latin1 / UTF-8:

Character	Byte Representation
!	00100001
A	01000001
Line Feed — Line Break — ”\n”	00001010

Examples in Latin1:

Character	Byte Representation
$\ddot{A}$	11000100

Examples in UTF-8:

Character	Byte Representation
$\ddot{A}$	11000011 10100100
🙂	11110000 10011111 10011001 10000010

Strings

Strings represent sequences of Unicode characters, allowing the manipulation and representation of text data

↓

1. **String Literals** — Representations of strings in Python
   - Single quotes: `a = 'test'`
   - Double quotes: `b = "test"`

2. **Multi-line String Literals** — Multi-line representation

```
a = """this
is a multi-line
string literal """
```

3. **Escape Sequences** — `a = "He said:\n\"Hi!\""`
   \n for line feed or line break!

Strings

If there is no need to use any escape sequences in a string

```python
path = r"C:\documents\course\news.txt"
```

Handy when writing directory paths and regular expressions

Useful String Methods

- `.lower()` and `.upper()`
- `.startswith(...)` and `.endswith(".xlsx")`
- `.center(10)` — centered in 10 chars
- `.ljust(10)` — left justified or `.rjust(10)` — right justified
- `.strip()` — removes leading and trailing spaces
- `.split(' ')` — splits a string into a list of substrings
- `' '.join(list)` — join a list of strings into a single string

String Exercises

Exercises

1. Later

String Formatting

String formatting allows for the inclusion of values within strings

```python
name = "Ricardo"
# Concatenation
greeting = "Hello, " + name + "!"

# f-string (formatted string literals)
greeting = f"Hello, {name}!"
```

There are other formatting ways which are currently a bit obsolete

```python
city, temperature = 'Graz', 5.7
'weather in %s: %f°C' % (city, temperature)
'weather in {0}: {1}°C'.format(city, temperature)
'weather in {}: {}°C'.format(city, temperature)
'weather in {c}: {t}°C'.format(c=city, t=temperature)
f'weather in {city}: {temperature}°C' # fstring pref
```

Format Specifications

If we want to specify the format value itself — ie, `.4g` or `.4f`

```python
# Four decimal places after the decimal point
print(f"Pi is {math.pi:.4f}") # Output: Pi is 3.1416

# Four significant digits
print(f"Pi is {math.pi:.4g}") # Output: Pi is 3.142
```

If we want to specify the sentence alignment

```python
first_name, last_name = "Ricardo", "Chin"

# Right-aligned (total width 8 characters)
print(f"{first_name:>8}")   # Output: " Ricardo"
print(f"{last_name:>8}")    # Output: "    Chin"
```

- String Formatting Reference — Hyperlink

Format Specifications

Exercise

- Create a program that formats a set of names and associated floating-point numbers representing current spare money, finds longest name, returns the names aligned to the right (longest name) and the spare money with 1 floating point

```python
# Names
data = [("Ricardo",   12.51), ("Anand",      8.75),
        ("Simon",     15.32), ("Khaled",    10.27)]
```

Format Specifications

Exercise

- Create a program that formats a set of names and associated floating-point numbers representing current spare money, finds longest name, returns the names aligned to the right (longest name) and the spare money with 1 floating point

```
# Names
data = [("Ricardo",  12.51), ("Anand",     8.75),
        ("Simon",    15.32), ("Khaled",   10.27)]
```

```
# Find the length of the longest name
longest_name = max(len(name) for name, _ in data)

# Aligned to longest name and spare money with .1f
for name, value in data:
    print(f"{name:>{longest_name}}{value:.1f}")
```

Bytes and Hexadecimal Notation

Bytes

- Sequences of integers (8 bits) in the range of 0 to 255
- Represent various data types, including images, text, and more
- Commonly used with storage media or network responses

Hexadecimal

- Bytes are often written in hexadecimal notation
- Values 0 to 15 represented by digits 0-9 and letters A-F

Decimal	Hexadecimal
1	0x1
9	0x9
10	0xa
15	0xf
16	0x10
17	0x11
31	0x1f
32	0x20

- Python uses the ’0x’ prefix to denote hexadecimal literals

Bytes and String Encodings

Creating Bytes from Lists

```python
a = bytes([0, 64, 112, 160, 255])
b = bytes([0, 0x40, 0x70, 0xa0, 0xff])
print(bytes([0x00, 0x40, 0x70, 0xa0, 0xff])) # 'a'
```

- Illustrates creating bytes from a list of numbers
- Hexadecimal values can also be used directly

Creating Bytes from Byte Literal Strings

```python
c = b"\x00\x40\x70\xa0\xff"
```

- 'b' prefix indicates a byte string
- Bytes usually hold encoded text, so we can do: `'ä'.encode('utf-8')` and `b'34'.decode('utf-8')`
- Also possible to represent it with ASCII characters

Lists

Lists

- Dynamic arrays for storing sequences of objects
- Versatile and mutable
- Ideal for homogenous entries of the same type and structure

```python
primes = [2, 3, 5, 7, 11]
users = ["Ricardo", "Anand", "Blazhe"]
```

List Operations

- Indexing

```python
primes[0] # returns 2
primes[-1] # returns last element of the list -> 11
```

- Accessing multiple elements (sublists)

```python
primes[1:4] # returns [3, 5, 7]
```

Lists

- Modifying lists (append, insert, pop)

```python
primes.append(13) # add 13 to the list primes
primes.insert(0, "Khaled") # Khaled to beginning
primes.pop() # pops last element of the list
primes.pop(0) # pops element at index 0
```

- Characteristics of the list

```python
len(primes) # returns the size of the list
max(primes) # returns the max value of the list
min(primes) # returns the min value of the list
```

- Sorting lists

```python
primes.sort() # increasing, alphabet for strings
primes.sort(reverse = True) # sorts decreasingly
primes.sort(key = len) # sorts by length
```

Lists

- Iterating through lists

```python
for prime in primes:
    print(prime)
```

- Conditionals in lists

```python
if "Ricardo" in users:
    print("Ricardo is here.")
```

Example:

```python
users.sort(key = len)

def count_a(s):
    return s.count("a")

users.sort(key=count_a)
```

List Exercises

Exercises

- Create a list of your favorite colors
  Print the length of the list
  Access and print the first and last elements of the list
- Create a list of characters from ’a’ to ’e’
  Print a slice of the list containing elements ’b’ and ’c’
  Modify the original list to replace ’c’ with ’z’ and print it
- More...

Tuples

Tuples

- Lightweight and immutable sequences of objects
- Entries separated by commas, typically surrounded by round brackets
- Commonly used for grouping related data

```python
single_value = ('Ricardo', ) # or
single_value = 'Ricardo', # notice the comma
values = ('Ricardo', 'Chin') # or
values = 'Ricardo', 'Chin'
```

- Elements in a tuple can be accessed using indexing
- `values[0]` returns 'Ricardo'

```python
first_name, last_name = two_values # var to tuple
first_name, last_name = last_name, first_name
```

Interesting References

Books

- Automate the Boring Stuff with Python by Al Sweigart
- Think Python, 2nd Edition by Allen B. Downey
- Python for Everybody by Dr. Charles Severance

Online Courses and Tutorials

- String Formatting
- Codecademy - Beginner Course
- Learn X in Y Minutes - Python
- Python Cheat Sheets by Eric Matthes

The End

Thank you!