Intermediate Workshop to Python Programming
Building the Foundation for Coding Success

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Presentation Overview

Data Types: Deeper Dive

— Previously in Python Programming —

- `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
1  a = True
2  if a:
3      print('hello')
```

```python
1  x, y = 10, 20
2  is_greater = x > y    # False
3  if is_greater:
4      print("x greater than y")
5  else:
6      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`
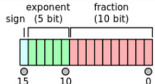   - **Special Values** — `d = float('nan')` or `e = float('inf')`

type	range	signi-ficant digits*	exponent (5 bit) sign fraction (10 bit) 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

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

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 π 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

```
1  0.1 + 0.2 == 0.3 # Returns False if float assigned
2
3  import math      # tolerance = 1e-09
4  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*

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

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: $-=, \quad *=, \quad \ldots$

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', '!', '$', space, and line breaks
2. Latin1 (ISO 8859-1)
   - Extends ASCII to encode the first 256 Unicode characters using 8 bits
   - Adds additional characters like '$\ddot{a}$', '$\acute{a}$', '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 or UTF-8:

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

Examples in Latin1:

Character	Byte Representation
Ä	11000100

Examples in UTF-8:

Character	Byte Representation
Ä	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

```
1 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
1  name = "Ricardo"
2  # Concatenation
3  greeting = "Hello, " + name + "!"
4
5  # f-string (formatted string literals)
6  greeting = f"Hello, {name}!"
```

There are other formatting ways which are currently a bit obsolete

```python
1  city, temperature = 'Graz', 5.7
2  'weather in %s: %f°C' % (city, temperature)
3  'weather in {0}: {1}°C'.format(city, temperature)
4  'weather in {}: {}°C'.format(city, temperature)
5  'weather in {c}: {t}°C'.format(c=city, t=temperature)
6  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

```
1  # Names
2  data = [("Ricardo",  12.51), ("Anand",     8.75),
3          ("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

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

```
1  # Find the length of the longest name
2  longest_name = max(len(name) for name, _ in data)
3
4  # Aligned to longest name and spare money with .1f
5  for name, value in data:
6      print(f"{name:>{longest_name}}{value:.1f}")
```

Lists

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

Thank you!