SI 506 Lecture 03

Topics

1. Comments (single line, block)
2. Values (objects) and types
3. Variables (labels) and variable assignment
4. Built-in functions `print()`, `type()`, `len()`
5. Basic arithmetic operations (add, subtract, multiply, divide)

Vocabulary

- **Boolean**. A type (`bool`) or an expression that evaluates to either `True` or `False`.
- **Built-in Function**. A function defined by the Standard Library that is always available for use.
- **Dictionary**. An associative array or a map, wherein each specified value is associated with or mapped to a defined key that is used to access the value.
- **Immutable**. Object state cannot be modified following creation. Strings and tuples are immutable.
- **Mutable**. Object state can be modified following creation. Lists are mutable.
- **Operator**. A symbol for performing operations on values and variables. The assignment operator (`=`) and arithmetic operators (`+`, `-`, `*`, `/`, `**`, `%`, `//`).
- **Sequence**. An ordered set such as `str`, `list`, or `tuple`, the members of which (e.g., characters, elements, items) can be accessed.
- **Tuple**. An ordered sequence that cannot be modified once it is created.

1.0 Comments

Explanatory text known as "comments" can be embedded in code with no impact on the runtime characteristics of the program or script. In Python single line comments are delinated by prefacing the line with a hash (`#`) character.

```
# A single line comment
```

Successive lines of comments are considered a "block" comment.

```
# A single line comment
# Yet another single line comment
# And yet another single line comment
```

You can also comment code rendering it inert and incapable of being interpreted (i.e., executed) at runtime.

```
# x = 5
# y = 2
# sum = x + y
```

You can also place a comment "inline" at the end of a line of code:

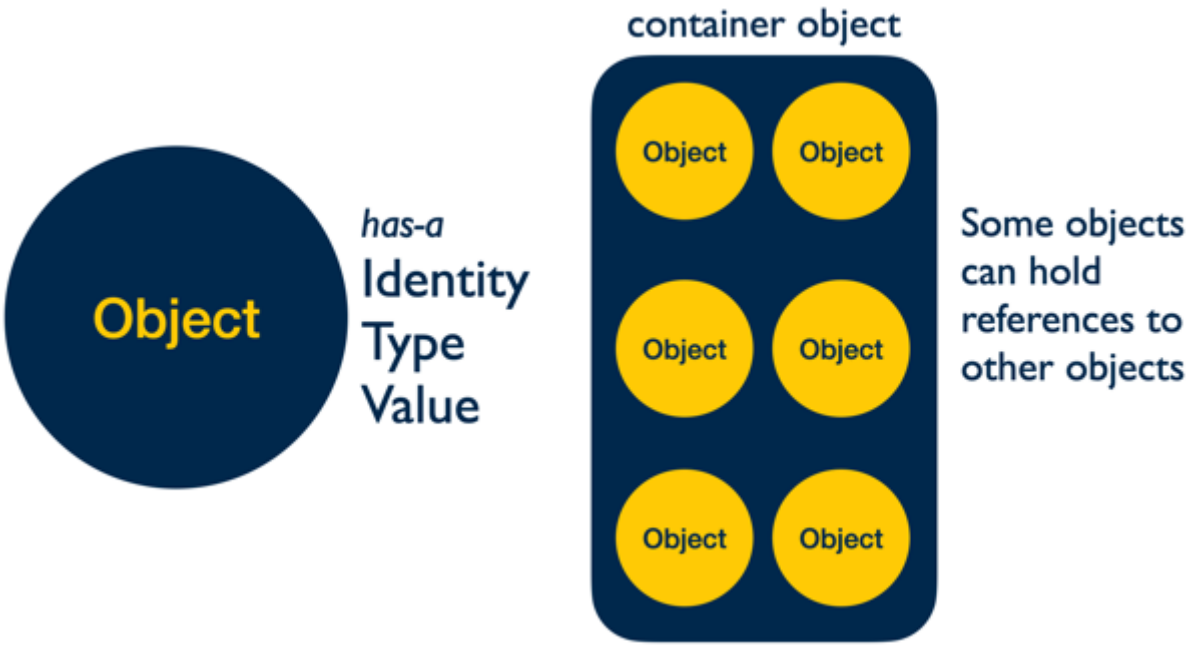
```
welcome = 'Welcome to SI 506' # string
```

💡 Later in the course you will be introduced to documentation strings or "docstrings" which are used to document classes, functions, and methods.

2.0 Values (Objects) and Types

> "Everything is an Object"
>
> Jake VanderPlas, *A Whirlwind Tour of Python* (O'Reilly Media, Inc., 2016)

> "Objects are Python's abstraction for data. All data in a Python program is represented by objects or by relations between objects."
>
> Python Software Foundation, "The Python Language Reference"



Python is an object-oriented programming language. This means that the Python data model represents strings, integers, floating point numbers, containers (e.g., `list`, `tuple`, `set`), mappings (`dict`), functions, class instances, modules and other types as **objects**.

The basic characteristics of a Python object can be summarized as follows:

1. Every object possesses an *identity* (memory address), *type*, and *value*.
2. An object's *type* determines its behavior as well as defines the possible values it may contain.
3. The value of some objects can be modified. An object's *mutability* (e.g., *mutable* = capable of modification; *immutable* = incapable of modification) is determined by its *type*.
4. Objects are never explicitly destroyed; memory management and "garbage-collection" is typically ceded to the Python interpreter without the need for manual intervention.

2.1 Numbers: integer, float (decimal)

```
506 # integer

.25 # float
```

2.2 Sequences

- string (ordered, immutable)
- list (ordered, mutable)
- tuple (ordered, immutable)
- set (unordered, mutable, but each element *must* be immutable as well as unique)

```
'I am a sequence of characters' # string

['arwhyte', 'brooksch', 'collemc', 'csev', 'cteplovs'] # list with five
elements

(504, 506, 507) # tuple with three items

{27, 24, False, 7.5, True, 'text'} # each set element is immutable
```

A "multiline" string (actually a string constant) can also be defined using triple quotation marks at the start and end of the string as in the following example which highlights the first few lines of Amanda Gordon's poem "The Hill We Climb" (2021).

 You can denote a multiline string by using either three double quotes (`"""`) or three single quotes (`'''`).

```
"""When day comes we ask ourselves,
‘where can we find light in this never-ending shade,’
the loss we carry,
a sea we must wade?
We’ve braved the belly of the beast.
We’ve learned that quiet isn’t always peace,
and the norms and notions
of what just is
isn’t always just-ice.
"""
```

2.3 Dictionary (associative array)

A dictionary is composed of key-value pairs. Insertion order is maintained.

```
{'course': 'SI 506', 'instructor_count': 1, 'gsi_count': 6, 'ia_count': 2}
# four key-value pairs
```

2.4 Boolean

```
True
False
```

2.5 None

`None` is an object of type `<class 'NoneType'>` and represents `null` or the absence of a concrete value.

❗ Note that `None` does not equal 0.

```
None
```

3.0 Variable (name, label, pointer)

A Python *variable* is a name or label that refers to an object in memory. Jake VanderPlus describes the concept in *A Whirlwind Tour of Python*:

> ". . . variables are simply pointers [to objects], and the variable names themselves have no attached type information."

Or as Naomi Cedar writes in *The Quick Python Book*, Third Edition (Manning Publications, 2018):

> "The name variable is somewhat misleading . . .; name or label would be more accurate."

3.1 Variable assignment

You use the assignment (=) operator to *assign* a value to a variable or *bind* the name (i.e., pointer, label) to the object (e.g., `variable_name = < object >`).

```
num = 506

welcome_message = 'Welcome to SI 506'

uniqnames = ['arwhyte', 'brooksch', 'collemc', 'csev', 'cteplovs'] # list
literal

chorus = """Hail! to the victors valiant
Hail! to the conquering heroes
Hail! Hail! to Michigan
the leaders and best!
"""
```

4.0 Variable Naming Rules and Conventions

Default convention: lowercase word(s) or recognizable abbreviation (e.g., num, val, var); separate words with an underscore.

❗ Readability and comprehensibility matters. See the Python Community's Style Guide for Python Code (PEP 8 (reformatted by Kenneth Reitz).

4.1 Good

```
# Choose lowercase
uniqname = 'arwhyte'
```

```
# Separate words with underscore (_)
course_code = 'SI 506'

# Use plural form to indicate a set or sequence
course_codes = ['SI 506', 'SI 507', 'SI 618']

# Ok to use recognizable abbreviations like num[ber], val[ue] or
var[iable].
num = 24

# "is_", "has_" prefix: Boolean True/False
is_enrolled = False
has_mask = True

# All caps designates a module level constant (special case)
BASE_URL = 'https://si506.org/'

# Function definition specifying two parameters x and y (a foreshadowing
of the weeks ahead)
def multiply(x, y):
    return x * y # arithmetic

# Call the function and pass two numeric arguments
product = multiply(14, 24)

print(f"product = {product}") # formatted string literal (f-string)

# For loop incorporating a counter < i > value
course_codes = ['SI 564', 'SI 574', 'SI 579', 'SI 582']
i = 1 # counter
for code in course_codes:
    print(f"{i}. {code}")
    i += 1 # addition assignment (increment)

# Alternative: call built-in function enumerate()
for i, code in enumerate(course_codes, start=1):
    print(f"{i}. {code}")
```

4.2 Bad (But Legal)

```
# Opaque
c = 'SI 506'
si = 'SI 506'

# Reserve CamelCase for class names.
CourseCode = 'SI 506' # correct name = course_code

# Not a fan of trailing data type suffixes (_list)
course_code_list = ['SI 506', 'SI 507'] # prefer course_codes (plural)
```

❗ Avoid prefixing or suffixing variable names with single (_) or double underscores (__) — known in the Python community as a "dunder" — until you gain experience as a Python programmer.

Variable names prefixed with a single underscore like `_course_code` are, by convention, considered private member variables in a class. Variable names prefixed with a double underscore like `__course_code__`, gets renamed at runtime by the Python interpreter in a process known as "name mangling".

💡 These and other naming conventions that employ leading and/or trailing underscores are *out of scope* for SI 506. That said, if you want to learn more on the subject see D. Bader, "The Meaning of Underscores in Python" (dbader.org, nd).

4.3 Ugly (Illegal)

The Python Interpreter will raise a `SyntaxError` at runtime whenever it encounters the following illegal names:

❗ Python keywords are reserved and cannot be used as variable names.

```
# Illegal: keyword used as a variable name (language-specific identifiers
reserved by Python)

class = 'SI 506'

# Illegal: variable name commences with a numeric value.

506_umsi = 'SI 506'

# Illegal: variable name commences with a special character (e.g., `@`,
`%`, `$`, `&`, `!`)

$number = 506

# Illegal: variable name includes a dash (`-`).

course-list = ['SI 506', 'SI 507', 'SI 618']

# Illegal: variable name includes whitespace.

course name = 'SI 506' # illegal; uncomment to test
```

❗ Also avoid use of built-in function names as variable names. Name clashes may occur in your code. If you do opt to use or "shadow" such names add a trailing underscore character to the name (_) per the PEP 08 recommendation or opt for a different name (`len_` or `length` for `len`).

```
# Shadowing; risk name clash with built-in functions
id = 506
str = 'Go Blue'
min = 0
max = 27
len = 6

# Alternative names
id_ = 506

str_ = 'Go Blue'
val = 'Go Blue'

min_ = 0
min_val = 0

max_ = 27
max_val = 27

len_ = 6
length = 6
```

5.0 Built-in Functions (`print()`, `type()`, `len()`)

The Python Interpreter includes a number of built-in functions that are always available for you to call.

💡 A function is a defined block of code that performs (ideally) a single task. Functions only run when they are explicitly called. A function can be defined with one or more *parameters* that allow it to accept *arguments* from the caller in order to perform a computation. A function can also be designed to return a computed value. Functions are considered "first-class" objects in the Python eco-system. You will soon write your own functions; for now we introduce a select number of built-in functions for you to use.

5.1 `print()`: print passed in argument to the screen

```
# Passing a hard-coded string.
print('SI 506 rocks!')

# Passing a variable name which points to a string.
print(welcome_message)

# Passing a variable name which points to a multiline string.
print(chorus)
```

5.2 `type()`: determine object's data type

```
data_type = type(num)
print(data_type) # returns <class 'int'>

data_type = type(welcome_message)
print(data_type) # returns <class 'str'>

data_type = type(uniqnames)
print(data_type) # returns <class 'list'>
```

5.3 `len()`: check length of a sequence (i.e., number of elements)

```
# Count characters in string (including whitespace).
chars_count = len(welcome_message)
print(chars_count)

# Count number of elements in list.
uniqname_count = len(uniqnames)
print(uniqname_count)
```

5.4 Challenge 01

Task: Create a list of strings that represent three popular U-M attractions. Explore use of the built-in functions `len()`, `type()`, and `print()`.

1. Create a list containing the following three strings:
    - 'Detroit Observatory'
    - 'Museum of Art'
    - 'Museum of Natural History'

     Employ a *list literal* to create the list. Assign the list to a variable named `attractions`.
2. Call the built-in function `print()`, pass `attractions` as an argument, and print the list and its elements to the terminal screen.
3. Call the built-in function `type()` passing `attractions` as the argument. Assign the return value to a variable named `attractions_type`.
4. Print `attractions_type` to the terminal screen.

5. Return the length of the `attractions` list and print the value to the terminal screen. Perform the task by writing only a *single line of code*.

6.0 Basic Arithmetic (addition, subtraction, multiplication, division operators)

Python supports math operations. The order of operations is expressed conveniently by the acronym **PEMDAS**: Parentheses, Exponentation, Multiplication | Division (same precedence), Addition | Subtraction.

1. Parentheses have the highest precedence and can be used to force an expression to evaluate in the order you want. Since expressions in parentheses are evaluated first, `2 * (3-1)` is 4, and `(1+1)**(5-2)` is 8. You can also use parentheses to make an expression easier to read, as in `(minute * 100) / 60`, even though it doesn't change the result.

2. Exponentiation has the next highest precedence, so `2 ** 1 + 1` is 3 and not 4, and `3 * 1 ** 3` is 3 and not 27.

3. Multiplication and both division operators have the same precedence, which is higher than addition and subtraction, which also have the same precedence. So `2*3-1` yields 5 rather than 4, and `5-2*2` is 1, not 6.

4. Operators with the same precedence (except for **) are evaluated from left-to-right. In algebra we say they are left-associative. So in the expression `6-3+2`, the subtraction happens first, yielding 3. We then add 2 to get the result 5. If the operations had been evaluated from right to left, the result would have been `6-(3+2)`, which is 1.

6.1 Arithmetic operators

Operator	Name	Description
+	Addition	
-	Subtraction	
*	Multiplication	
/	(Floating Point) Division	Returns a floating-point value (a `float`) that contains a fractional component (`5 / 2` returns `2.5`).
//	Floor Division	Returns an integer (i.e., a whole number) ignoring any fractional component (`5 // 2` returns `2`).
%	Modulus	Returns the remainder of a division operation (e.g., `5 % 2` returns `1`).
**	Exponentiation	Returns the product of a number (the base) multiplied `n` times specified exponent (`2.5 ** 2` returns `6.25`).

6.2 Challenge 02

Task. Perform various SI 506-inspired arithmetic operations starting off with the values assigned to the following variables:

```
# SI 506
lecturer_count = 1
gsi_count = 6
ia_count = 2
lab_count = 12
student_count = 301
```

1. Return a count of all members of the teaching team. Assign the value to a variable named `team_count`. Then print the value to the terminal screen.
2. Return a count of teaching team members who are approved instructors. Note that instructional assistants (IAs) are not considered instructors. Assign the return value to a variable named `instructor_count`. Then print the value to the terminal screen.
3. Return the maximum enrollment for the course. You can approximate the max enrollment by multiplying the `lab_count` by twenty-five (`25`). Assign the return value to a variable named `max_enrollment`. Then print the value to the terminal screen.
4. Calculate the average number of students served by each GSI using *floor* division. Assign the return value to a variable named `students_per_gsi`. Then print the value to the terminal screen.
5. Calculate SI 506's current enrollment expressed as *a percentage* of the max enrollment using *floating-point* division. Assign the return value to a variable named `max_enrolled_pct`. Then print the value to the terminal screen.