PYTHON BASICS

CSC 109 - Introduction to programming in Python - Fall 2023

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Contents

1 Python Basics

To write handy little programs that automate 'boring' tasks, you only need some basics:

1. expressions `2 + 2`
2. data types like `integer`
3. variables like `spam`
4. statements like `spam = 1`
5. debugging dealing with errors like `NameError`

The code is available as GitHub gist and in the `ipynb` in GitHub.

2 Expressions: values and operators (gist)

Enter the classic formula `2 + 2` at the prompt and press `RET` (Enter) to (hopefully) get the classic answer `4`.

```
print(2+2)
```

```
4
```

`2 + 2` is called an *expression*, a basic programming instruction.

An expression consist of *values* (such as `2`) in computer memory, and *operators* (such as the binary operator `+`), which are *functions*.

Expressions can always *evaluate* i.e. reduce to a single value - so you can e.g. use `2+2` anywhere instead of `4` because you know it's going to be reduced to `4`.

Examples:

1. use `2+2` as the *argument* of a `print` function.
2. use `2+2` as the argument of a `str` function.
3. look at the help for `print`
4. look at the help for `str`

```
print(2+2)
print(str(2+2))
```

```
>>> 4
4
```

A single value like `2` is also an expression (it doesn't express anything else but itself) and evaluates to itself.

3 Error messages

When Python cannot evaluate an expression, it "throws" an error. Here is list of common error messages in Python with a plain English explanation (Sweigart, 2019).

Let's create a couple of error messages using wrong expressions:

1. Enter `2 +`
2. Enter `2 + '2'`
3. Enter `2` and then on the next line enter `2` again
4. Enter `2` then `\` and then on the next line `2` again
5. Enter `2 + ++ 2` then change the first `+` to a `-`

4 Operators

The table shows a list of all math operators in Python. They are listed from highest to lowest precedence:

![img]("file")

The precedence is the order of operations: when Python gets an expression with more than one operator, it evaluates from left to right (you can force execution with parentheses).

For example, the expression `-2+24/8` is evaluated as `1` and not as `2.75` because `(24/8)=3` and `3-2=1`:

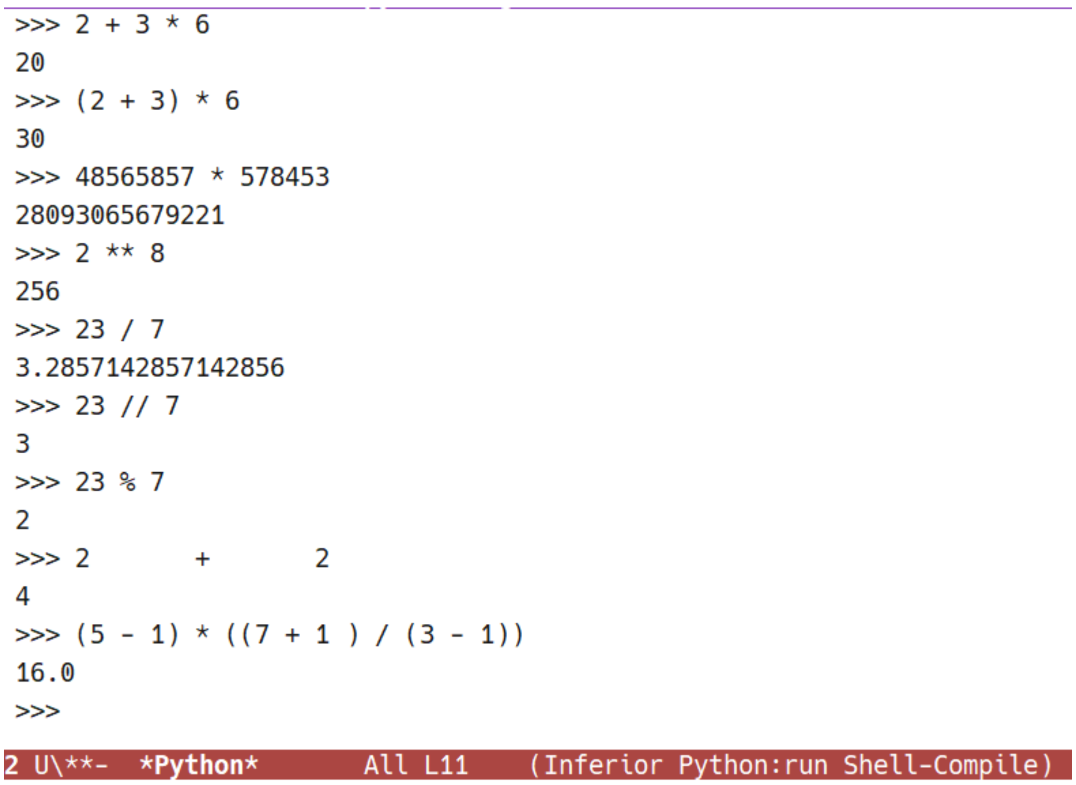
1. Enter `-2 + 24 / 8`
2. Enter `(-2 + 24) / 8`

So-called "whitespace" (empty space) between symbols does not matter, so `24/8` is evaluated identically to `24 / 8`.

Enter the following expressions into the interactive shell:

```
2 + 3 * 6
(2 + 3) * 6
48565857 * 578453
2 ** 8
23 / 7
23 // 7
2      +     2
(5 - 1) * ((7 + 1 ) / (3 - 1))
```

You can see the result in `py_ops_example.png`.



```
>>> 2 + 3 * 6
20
>>> (2 + 3) * 6
30
>>> 48565857 * 578453
28093065679221
>>> 2 ** 8
256
>>> 23 / 7
3.2857142857142856
>>> 23 // 7
3
>>> 23 % 7
2
>>> 2       +       2
4
>>> (5 - 1) * ((7 + 1 ) / (3 - 1))
16.0
>>>
2 U\**-  *Python*       All L11    (Inferior Python:run Shell-Compile)
```

Figure 1: Expressions in the interactive Python shell (in Emacs)

This diagram shows how Python ruthlessly evaluates parts of the expression until it has reached a single value: `py_ops_example1.png`.

5 Variables

A data type is a category for values: every value belongs to exactly one data type.

Variables in Python do not need to be declared but they are dynamically typed, i.e. at runtime.

Common data types are listed in this table: `1_data_types.png` - insert it here:

Python's names for these data types are:

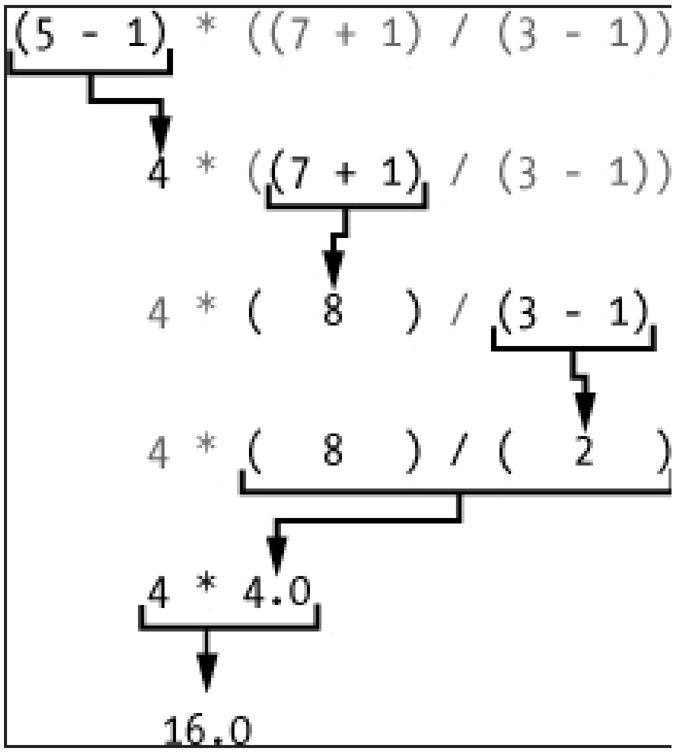
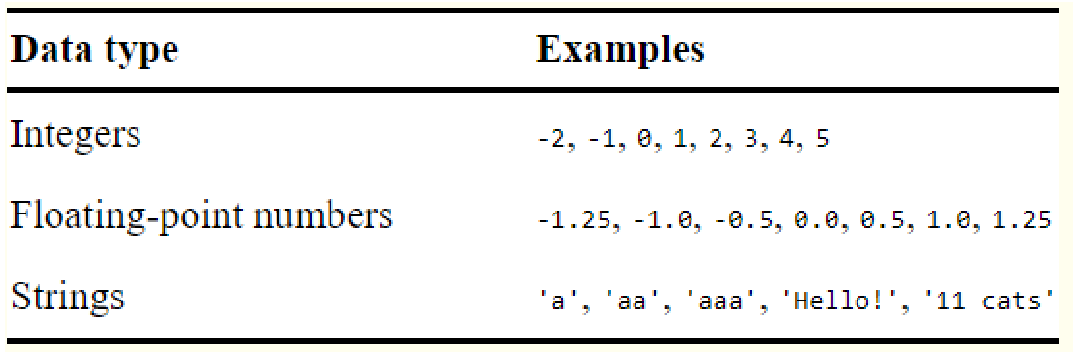


Figure 2: Evaluation of composite expression to a single value



Data type	Examples
Integers	-2, -1, 0, 1, 2, 3, 4, 5
Floating-point numbers	-1.25, -1.0, -0.5, 0.0, 0.5, 1.0, 1.25
Strings	'a', 'aa', 'aaa', 'Hello!', '11 cats'

Figure 3: Common data types (Source: Sweigart, 2019)

- `int` for integer numbers,
- `float` for floating point numbers,
- `str` for strings.

The `type` function reveals a value's or a variable's data type: check the type of `-2`, `2`, `1.25`, `'a'`, `'name'`, `a`.

```
type(-2)
type(2)
type(1.25)
type('a')
type('name')
type(a)
```

Why does `type(a)` give a "Name Error"? Answer: Because Python expects a variable named `a`, which is not defined.

6 String concatenation and replication

The meaning of an operator may change based on the data types of its operands.

Enter the following examples in separate code cells (otherwise you only get the last result - or you have to add `print`). Create a new code cell after the current cell by typing `b`.

Examples:

1. 'Alice' + 'Bob'
2. 'Alice' + 42

```
print('Alice' + 'Bob')
print('Alice' + 42)  # generates a TypeError (+ needs string or number
```

```
> AliceBob
```

Python can only concatenate numbers or strings. You have to explicitly convert the 2nd argument to a string:

1. 'Alice' + str(42)
2. 'Alice' + str(Bob)

```
print('Alice' + str(42))
print('Alice' + str(Bob))  # Bob is not defined: NameError
```

```
~~
TypeError: can only concatenate str (not "int") to str
>>> Alice42
Alice5
```

Unless `Bob` is initialized as an integer, this will not work:

1. Bob = 42
2. 'Alice' + str(Bob)

```
Bob = 42
print('Alice' + str(Bob))
```

```
Alice42
```

The `*` operator can be used with one string and one integer value for replication:

1. 'Alice' * 'Bob'
2. 'Alice' * 5.0
3. 'Alice' * 5
4. 'Alice' * int(5.0)

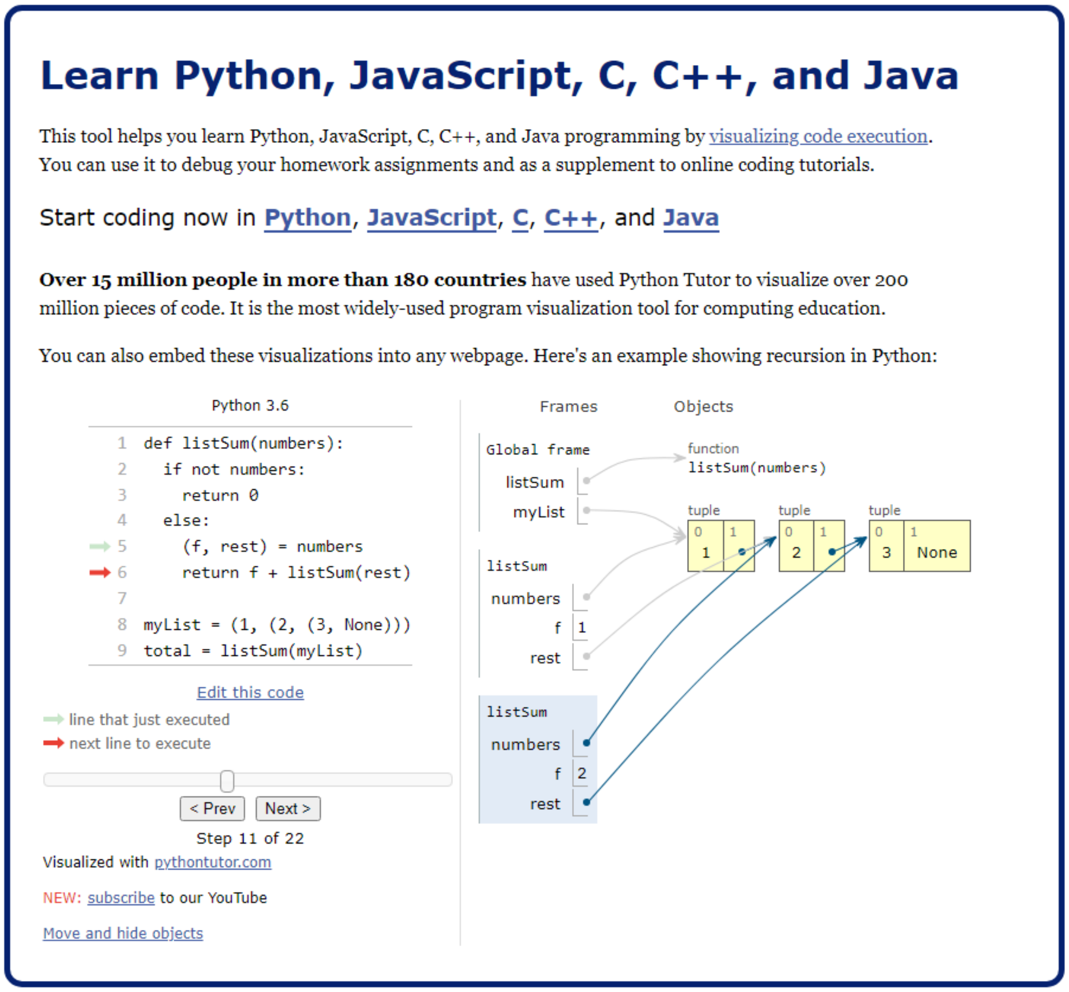
```
Bob = 5
print('Alice' * 'Bob')  # TypeError
print('Alice' * 5.0)    # TypeError
print('Alice' * 5)
print('Alice' * int(5.0))
```

7 Assignments: storing values in variables

A *variable* is like a box in the computer's memory where you can store a single value.

You store values in variables with an `assignment statement`, consisting of: a variable name, the `=` operator, and the value.

A variable is initialized or created the first time a value is stored in it.



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Over 15 million people in more than 180 countries have used Python Tutor to visualize over 200 million pieces of code. It is the most widely-used program visualization tool for computing education.

You can also embed these visualizations into any webpage. Here's an example showing recursion in Python:

Python 3.6

```
def listSum(numbers):
  if not numbers:
    return 0
  else:
    (f, rest) = numbers
    return f + listSum(rest)

myList = (1, (2, (3, None)))
total = listSum(myList)
```

Figure 4: pythontutor.com home page

When a variable is assigned a new value, the old value is forgotten.

For variables and flow control visualization, the site `pythontutor.com` is particularly valuable.

To visualize this, open `pythontutor.com` and enter this code:

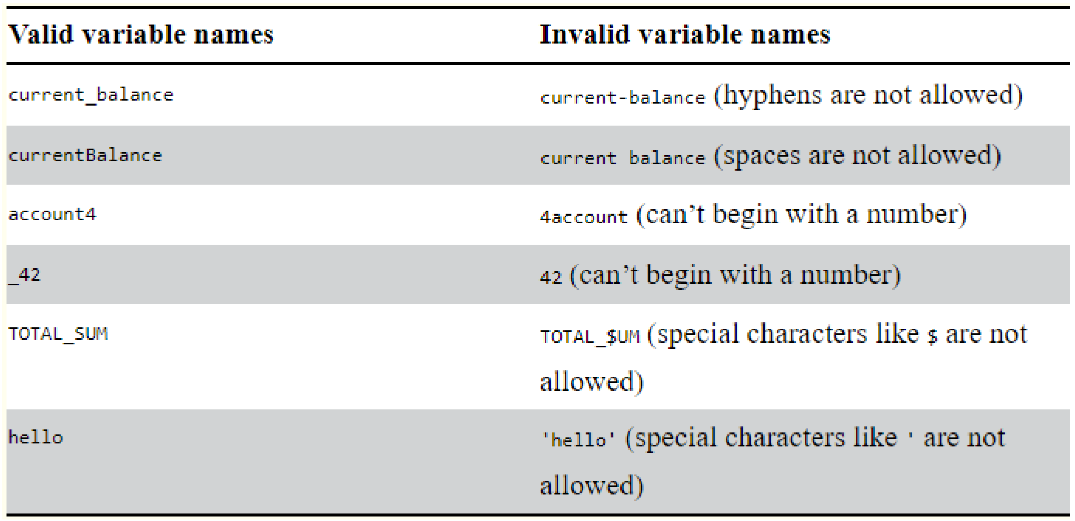
```
spam = 40
eggs = 2
spam + eggs
spam + eggs + spam
spam = spam + eggs
print(spam)
```

Similarly for strings:

```
spam = 'Hello'
print(spam)
spam = 'Goodbye'
print(spam)
```

8 Variable names

Insert the table `py_variable_names.png` for example of valid and invalid variable names.



Valid variable names	**Invalid variable names**
`current_balance`	`current-balance` (hyphens are not allowed)
`currentBalance`	`current balance` (spaces are not allowed)
`account4`	`4account` (can't begin with a number)
`_42`	`42` (can't begin with a number)
`TOTAL_SUM`	`TOTAL_$UM` (special characters like `$` are not allowed)
`hello`	`'hello'` (special characters like `'` are not allowed)

You can name a variable anything as long as it obeys these rules:

1. It can be only one word with no spaces
2. It can only use letters, numbers and the underscore character (`_`)
3. It can't begin with a number

You should not use Python keywords, symbols, function or module names as your variables (though you may be allowed to).

Variables in Python are case-sensitive.

Some people prefer camel-case for variable names instead of underscores: `helloWorld` instead of `hello_world`. Either is OK.

9 Warming up: spooky season

Figure 5: "spooky" by Tony Coates (flickr.com)

Problem: print "spooky" with 2 to 20 vowels (solution).

Let's do it together - open a new notebook `spooky.ipynb` for:

1. solution flow (from input to output)
2. variables (storing values)
3. functions and operators (doing stuff)
4. implementation (coding)
5. testing (debugging)
6. production (submission)

10 Summary

- An instruction that evaluates to a single value is an **expression**. An instruction that doesn't is a **statement**.
- Data types are: integer (`int`), floating-point (`float`), string (`str`)
- Strings hold text and begin and end with quotes: `'Hello world!'`
- Strings can be concatenated (`+`) and replicated (`*`)
- Values can be stored in variables: `spam = 42`
- Variables can be used anywhere where values can be used in expressions: `spam + 1`
- Variable names: one word, letters, numbers (not at beginning), underscore only
- Comments begin with a # character and are ignored by Python; they are notes & reminders for the programmer.
- Functions are like mini-programs in your program.
- The `print` function displays the value passed to it.

11 Glossary

TERM/COMMAND	MEANING
expression	a basic programming instruction, like `2+2`
values	something stored in a computer memory cell
operator	a function that takes values to evaluate them
binary operator	an operator that takes 2 values as arguments
whitespace	empty space between values or operators
indentation	empty spaces at the beginning of a line
precedence	order of operations
Syntax error	you've broken the grammatical Python rules
Type error	you've made a mistake with data types
Concatenation	adding strings with +
Replication	replicating strings with *
Conversion	changing data types
Coercion	implicit conversion of data types
File type	used by the computer to identify a language
Data type	used by the computer to reserve memory
`print`	printing function

12 References

- pythontutor.com (2023). Visualize code execution.
- Sweigart, A. (2016). Invent your own computer games with Python. NoStarch. URL: inventwithpython.com.
- Sweigart, A. (2019). Automate the boring stuff with Python. NoStarch. URL: automatetheboringstuff.com.