CS303E: Elements of Computers and Programming

Python

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Some Thoughts about Programming

"A computer lets you make mistakes faster than any invention in human history—with the possible exception of handguns and Tequila." –Mitch Ratcliffe, digital thinker

"The only way to learn a new programming language is by writing programs in it." –B. Kernighan and D. Ritchie

"Computers are good at following instructions, but not at reading your mind." –D. Knuth

Program:

> *n. A magic spell cast over a computer allowing it to turn one's input into error messages.*
>
> *tr. v. To engage in a pastime similar to banging one's head against a wall, but with fewer opportunities for reward.*

What is Python?

Python is a high-level programming language developed by Guido van Rossum in the Netherlands in the late 1980s. It was released in 1991.

Python has twice received recognition as the language with the largest growth in popularity for the year (2007, 2010).

It's named after the British comedy troupe Monty Python.

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- Easy and intuitive mode of interacting with the system.
- Clean syntax that is concise. You can say/do a lot with few words.
- Design is compact. You can carry the most important language constructs in your head.
- There is a very powerful library of useful functions available.

You can be productive quite quickly. You will be spending more time solving problems and writing code, and less time grappling with the idiosyncrasies of the language.

What is Python?

Python is a **general purpose** programming language. That means you can use Python to write code for any programming tasks.

Python was used to write code for:

- the Google search engine
- mission critical projects at NASA
- programs for exchanging financial transactions at the NY Stock Exchange
- the grading scripts for this class

What is Python?

Python is an **object-oriented** programming language. Object-oriented programming is a powerful approach to developing reusable software. More on that later!

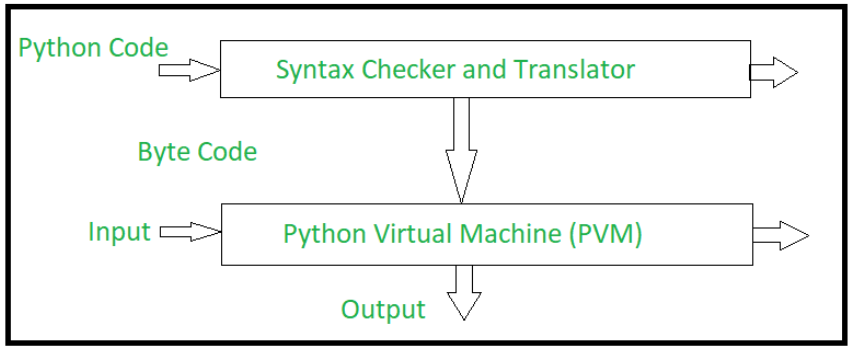
Python is **interpreted**, which means that Python code is translated and executed one statement at a time.

This is different from other languages such as C which are **compiled**.

The Interpreter

Actually, Python is always translated into **byte code**, a lower level representation.

The byte code is then interpreted by the Python Virtual Machine.



Getting Python

To install Python on your personal computer / laptop, you can download it for free at: `www.python.org/downloads`

- There are two major versions: Python 2 and Python 3. Python 3 is newer and *is not backward compatible with Python 2.* Make sure you're running Python 3.
- It's available for Windows, Mac OS, Linux.
- If you have a Mac, it *may* already be pre-installed.
- It should already be available on most computers on campus.
- It comes with an editor and user interface called IDLE.

A Simple Python Program: Interactive Mode

This illustrates using Python in **interactive mode** from the command line. *Your command to start Python may be different.*

```
> python
Python 3.6.9 (default, Nov  7 2019, 10:44:02)
[GCC 8.3.0] on linux
Type "help", "copyright", "credits" or "license" for more
    information.
>>> print("Hello, World!")
Hello, World!
>>> print("Go Horns Go")
Go Horns Go
>>> print((10.5 + 2 * 3) / 45 - 3.5)
-3.1333333333333333
```

Here you see the prompt for the OS/command loop, and for the Python interpreter command loop.

A Simple Python Program: Script Mode

Here's the "same" program as I'd be more likely to write it. Enter the following text using a text editor into a file called, say, `MyFirstProgram.py`. This is called *script mode*.

In file `MyFirstProgram.py`:

```
# Display two messages:
print("Hello, World!")
print("Go Horns Go")

# Evaluate an arithmetic expression:
print((10.5 + 2 * 3) / 45 - 3.5)
```

A Simple Python Program

```
> python MyFirstProgram.py
Hello, World!
Go Horns Go
-3.1333333333333333
>
```

This submits the program in file `MyFirstProgram.py` to the Python interpreter to execute.

This is better, because you have a file containing your program and you can fix errors and resubmit without retyping a bunch of stuff.

A Simple Python Program: Another Way

Here's the "same" program as you might see it written, again in *script mode*, but using a function.

```
def main():
    # Display two messages:
    print("Hello, World!")
    print("Go Horns Go")

    # Evaluate an arithmetic expression:
    print((10.5 + 2 * 3) / 45 - 3.5)

# Call the function main()
main()
```

You'll see this style in many examples here.

A Simple Python Program: One Last Way

Finally, if you have your Python code in a file, you can access it in interactive mode as follows:

```
>>> import MyFirstProgram
Welcome to Python!
Go Horns Go
-3.1333333333333333
```

The `import` command submits the contents of file `MyFirstProgram.py` to the interpreter and executes any commands found there.

Notice: `MyFirstProgram.py` is a file. From Python's perspective this defines a *module* called `MyFirstProgram` (no .py extension). It's the module you import, not the file.

Aside: About Print

If you do a computation and want to display the result use the `print` function. You can print multiple values with one print statement:

```
>>> print("The value is: ", 2 * 10 )
The value is:  20
>>> print( 3 + 7, 3 - 10 )
10 -7
>>> 3 + 7
10
>>> 3 - 10
-7
>>> 3 + 7, 3 - 10
(10, -7)
```

Notice that if you're computing an expression in interactive mode, *it will display the value without an explicit* `print`.

Python will figure out the type of the value and print it appropriately.

Break

Let's take a break here and resume in the next video.

The Framework of a Simple Python Program

Define your program in file `Filename.py`:

```
def main ():

    Python statement
    Python statement
    Python statement
        ...
    Python statement
    Python statement
    Python statement

main ()
```

Defining a function called main.

These are the instructions that make up your program. *Indent all of them the same amount (usually 4 spaces).*

This says to execute the function `main`.

To run it:

```
> python Filename.py
```

This submits your program in `YourFilename.py` to the Python interpreter.

Aside: Running Python From a File

Typically, if your program is in file `Hello.py`, you can run your program by typing at the command line:

```
> python Hello.py
```

You can also create a *stand alone script*. On a Unix / Linux machine you can create a *script* called `Hello.py` containing the first line below (assuming that's where your Python implementation lives):

```
#!/lusr/bin/python3
# The line above may vary on your system.
print ("Hello, World!")
```

Aside: Running Python From a File

Let's try running this:

```
> Hello.py
Hello.py: Permission denied.
```

What went wrong?

Before you can run it, you must tell Linux that it's an *executable* file:

```
> chmod +x Hello.py
```

Then run it:

```
> Hello.py
Hello, World!
```

Program Documentation

Documentation refers to comments included within a source code file that explain what the code does.

- Include a **file header**: a summary at the beginning of each file explaining what the file contains, what the code does, and what key feature or techniques appear.
- You should always include your name, date, and a brief description of the program.

```
# Joe Student
# CS303E Assignment 1
# August 24, 2020
#
# This program solves the halting problem,
# cures cancer and ensures world peace.
```

Program Documentation

- Comments should also be interspersed in your code:
  - Before each function or class definition (i.e., program subdivision);
  - Before each major code block that performs a significant task;
  - Before or next to any line of code that may be hard to understand.

```
    sum = 0
    # sum the integers [start ... end]
    for i in range( start, end + 1):
        sum += i
```

Don't Over Comment

Comments are useful so that you and others can understand your code. Useless comments just clutter things up:

```
    x = 1      # assign 1 to x
    y = 2      # assign 2 to y
```

Programming Style

Every language has its own unique *style*. This is a C program.

Good programmers follow certain *conventions* to make programs clear and easy to read, understand, debug, and maintain.

```c
#include <stdio.h>

/* print table of Fahrenheit to Celsius
   [C = 5/9(F-32)] for fahr = 0, 20, ...,
       300 */

main()
{
   int fahr, celsius;
   int lower, upper, step;

   lower = 0;     /* low limit of table */
   upper = 300;   /* high limit of table */
   step = 20;     /* step size */
   fahr = lower;
   while (fahr <= upper) {
     celsius = 5 * (fahr-32) / 9;
     printf("%d\t%d\n", fahr, celsius);
     fahr = fahr + step;
   }
}
```

Programming Style

Some Python programming conventions:

- Follow variable naming conventions.
- Use meaningful variable/function names.
- Document your code.
- Each level indented the same (typically 4 spaces).
- Use blank lines to separate segments of code.

We'll learn more elements of style as we go.

Programming Style

I use Python to compute the grades in each class I teach. Here's a function from one of my grading programs:

```python
def ComputeLabs( l1, l2, l3, l4, l5 ):
    """ Assigned five labs this semester.
        All labs counted 100 points, though there was extra
        credit possible on some (already added in). """
    labSum = l1 + l2 + l3 + l4 + l5
    labAvg = ( labSum / 500.0 ) * 100
    print ("    Lab average (%2d%% of grade): %5.2f" \
        % (LAB_PERCENT, labAvg))
    return labAvg
```

Errors: Syntax

Remember: "Program: *n.* A magic spell cast over a computer allowing it to turn one's input into error messages."

You may encounter three types of *errors* when developing your Python program.

syntax errors: these are ill-formed Python and caught by the interpreter prior to executing your code.

```
>>> 3 = x
  File "<stdin>", line 1
SyntaxError: can't assign to literal
```

These are usually the easiest to find and fix.

Errors: Runtime

runtime errors: you try something illegal while your code is executing

```
>>> x = 0
>>> y = 3
>>> y / x
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ZeroDivisionError: division by zero
```

Errors: Logic

logic errors: your program runs but returns an incorrect result.

```
>>> lst = [1, 2, 3, 4, 5]
>>> prod = 0
>>> for x in lst:
...     prod *= x
>>> print (prod)
0
```

This program is syntactically fine and runs without error. But it probably doesn't do what the programmer intended; it always returns 0 no matter what's in `lst`. How would you fix it?

Logic errors are often the hardest errors to find and fix.

Almost Certainly It's Your Fault!

At some point you'll probably say: "My program is obviously right. The interpreter / operating system must be incorrect / flaky / hate me."

This software has been used for *millions* of programs before yours.

Try It!

"The only way to learn a new programming language is by writing programs in it." –B. Kernighan and D. Ritchie

Python is wonderfully accessible. If you wonder whether something works or is legal, just try it out.

Programming is not a spectator sport! Write programs!