

Introduction to Programming with Scientific Applications

Course description – kursuskatalog.au.dk/en/course/72773

Introduction to Programming with Scientific Applications

Description of qualifications

After the course the participants will have knowledge of principles and techniques for systematic **construction** of **programs**.

At the end of the course, the participants will be able to:

- apply constructions of a common programming language,
- develop **well-structured** programs and perform **testing** and **debugging** of these,
- explain fundamental programming concepts and basic algorithmic techniques,
- apply standard **tools for scientific applications**.

Contents

The course gives an introduction to programming with scientific applications. Programming concepts and techniques are introduced using the **Python** programming language. The programming concepts are **illustrated in other programming languages**. The following content is included.

Basic programming constructs: Data types, operators, variables, flow of control, conditionals, loops, functions, recursion, scope, exceptions. *Object orientation:* Abstract data types, classes, inheritance, encapsulation. *Basic algorithmic techniques:* Sorting, binary search, dynamic programming. *Systematic development of programs:* Testing and debugging. File-based input/output, numerical analysis, functional programming. Scientific computing using standard packages for Python.

ECTS 10

Hours - weeks - periods

Lectures 2 x 2 hours/week

TA sessions 1 x 3 hours/week

Study café

Language of instruction

Danish

Instructor

Gerth Stølting Brodal

Academic prerequisites

(Some) Linear algebra

Exam

2 hour multiple-choice

Aid: None

7-point grading scale

Prerequisites for examination participation

Submission and approval of 10 mandatory assignments and **1 project**

Notes Grade reflects an overall assessment of implementation project and multiple-choice examination.

Lecturer

Name	Gerth Stølting Brodal
Research	Algorithms and Data Structures (Computer Science)
Teaching	
2004-17	BSc course on Introduction to Algorithms and Data Structures
1999-17	MSc courses on Computational Geometry, Algorithm Engineering, Advanced Data Structures, External Memory Algorithms and Data Structures
Python	Beginner

Question – Primary Education?

- a) Mathematics
- b) Mathematics-Economics
- c) Chemistry
- d) Other Science-Technology
- e) Other

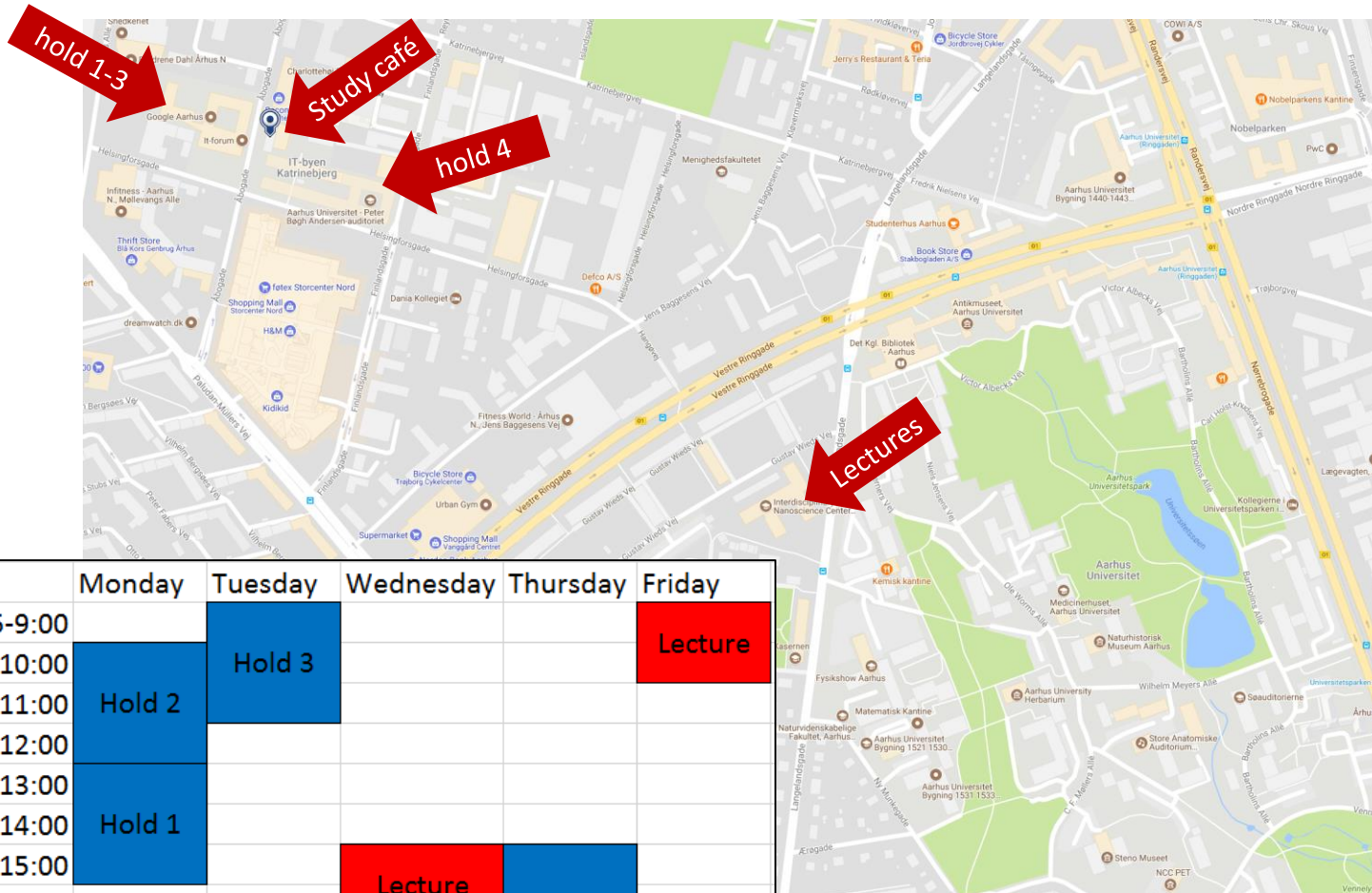
Question – Programming languages you know?

Question – Programming experience?

For the programming language you know best (if any) please state your proficiency level within the language.

- a) None
- b) Fundamental awareness (basic knowledge)
- c) Novice (limited experience)
- d) Intermediate (practical application)
- e) Advanced (applied theory)
- f) Expert (recognized authority)

Some course practicalities



	Monday	Tuesday	Wednesday	Thursday	Friday
8:15-9:00					Lecture
9:15-10:00	Hold 2	Hold 3			
10:15-11:00	Hold 2				
11:15-12:00					
12:15-13:00	Hold 1				
13:15-14:00	Hold 1				
14:15-15:00			Lecture	Hold 4	
15:15-16:00					
16:15-17:00					

Week	Mo	Tu	We	Th	Fr
5			1		2
6	1	1	3	1	4
7	2	2	5	2	6
8	3	3	7	3	8
9	4	4	9	4	10
10	5	5	11	5	12
11	6	6	13	6	14
12	7	7	15	7	16
13	Easter				
14			17	8	18
15	8	8	19	9	20
16	9	9	21	10	22
17	10	10	23	11	
18	11	11	24	12	25
19	12	12	26		27
20	13	13	28	13	-
	Holiday				
	Lecture #				
	Exercise #				

Course page on Blackboard

The screenshot shows a Blackboard course page. At the top, there is a dark green header with a home icon, a notification icon, and the course title "Introduction to Programming with Scientific Applications (Spring 2018)". Below this is a lighter green banner with a house icon and the course title "Introduction to Programming with Scientific Applications (Spring 2018)".

Welcome

Welcome to the course *Introduction to Programming with Scientific Applications*. The course gives an introduction to the Python 3 programming language using the book "Introduction to Computation and Programming Using Python With Application to Understanding Data" by John Guttag. The book covers the basics of Python and contains a long list of scientific applications. For the more subtle features of Python, students are encouraged to seek information online in e.g. the Python language specification.

The course will be run with 2 x 2 hours of weekly lectures, 3 hours of TA classes ("øvelser") supplemented with staffed study café hours.

During the course students are required to hand in 10 weekly handins and one larger implementation project. Handins and the project is done in groups of up to three persons. The final exam will be a multiple-choice exam without aids, and *the final grade will be based on overall evaluation of the project and the multiple choice exam*.

Disclaimer: *This is the first time the course is running. The details of the course are designed while the course is running. Please do not hesitate to contact me with suggestions for improving the course. --- Gerth*

Course content

The course gives an introduction to programming with scientific applications. Programming concepts and techniques are introduced using the Python programming language. The programming concepts are illustrated in other programming languages. The following content is included.

- Basic programming constructs: Data types, operators, variables, flow of control, conditionals, loops, functions, recursion, scope, exceptions.
- Object orientation: Abstract data types, classes, inheritance, encapsulation.
- Basic algorithmic techniques: Sorting, binary search, dynamic programming.
- Systematic development of programs: Testing and debugging.
- File-based input/output, numerical analysis, functional programming.
- Scientific computing using standard packages for Python.

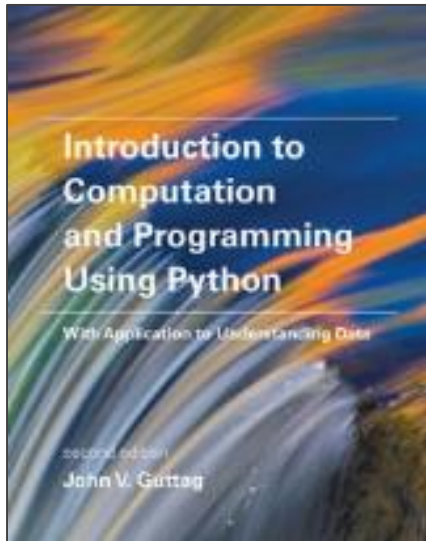
After the course the participants will have knowledge of principles and techniques for systematic construction of programs. At the end of the

Navigation Sidebar:

- ▼ F18 - Introduktion til programmering med videnskabelige anvendelser [220171U028]
- 🏠 Introduction to Programming with Scientific Applications (Spring 2018)
- 📖 Course Description
- 📅 Course Plan
- 📁 Exercises
- 📁 Handins
- 👥 Groups & Participants
- 📢 Announcements
- 💬 Discussion Board
- 🎓 Exam
- 🗣️ AU Course Evaluation

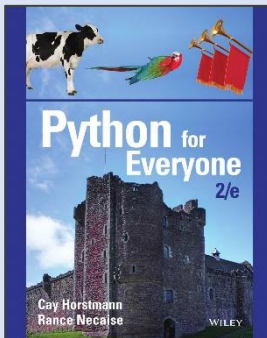
- 📖 Installing Python
- 📖 Python Resources

Course text book



John V. Guttag. **Introduction to Computation and Programming Using Python With Application to Understanding Data.** Second Edition. 472 pages. MIT Press, 2016

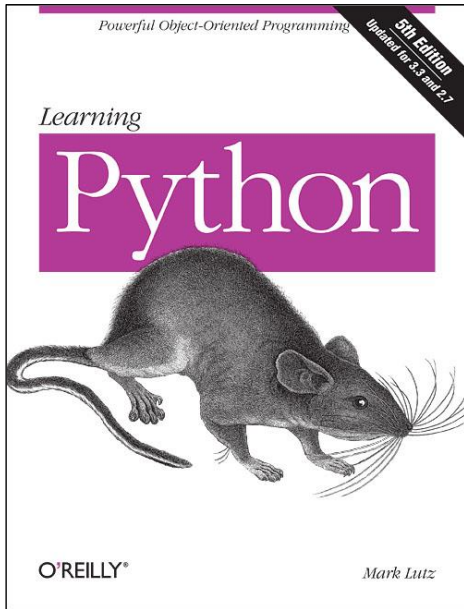
- *[Guttag, page 8] The reader should be forewarned that this book is by no means a comprehensive introduction to Python*
- *Covers all basic features of Python enabling you to deal with data in Chapters 1-8 (134 pages) - remaining chapters are applications*
- *Other resources: Google, **stackoverflow**, Python.org, YouTube, ...*



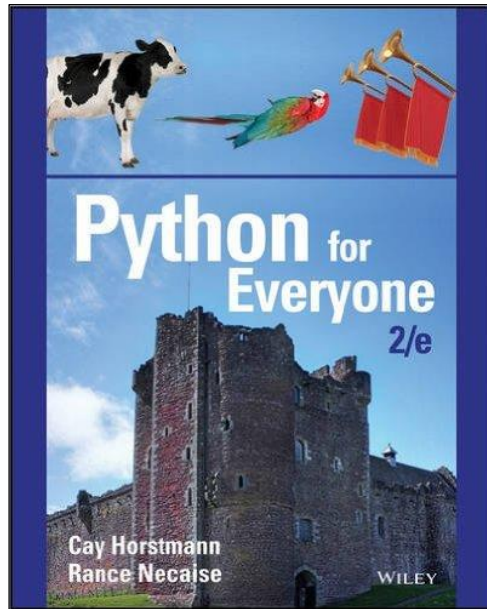
Comparison to a standard text book on the *programming language* Python by Cay Horstmann and Rance Necaise:

Topic **recursion** is covered by Guttag on page 50, Horstmann and Necaise do it on page 611

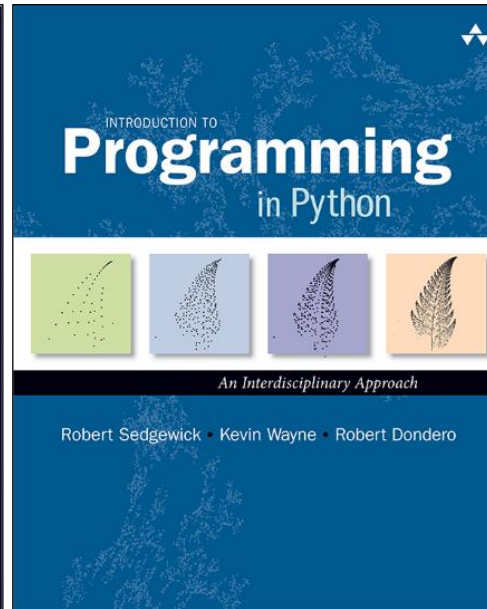
Some other books on Python



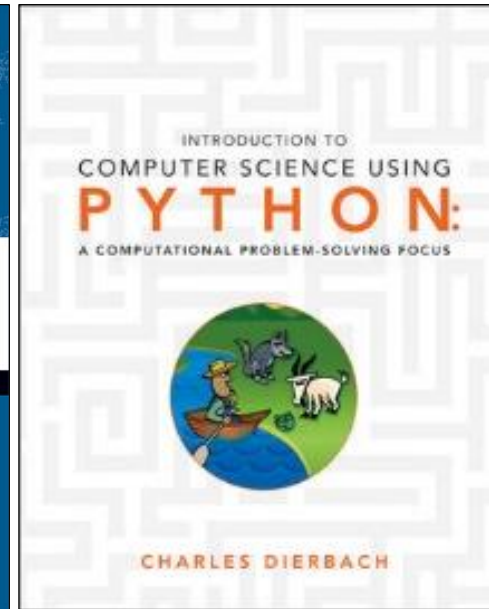
O'Reilly, 2013
1684 pages



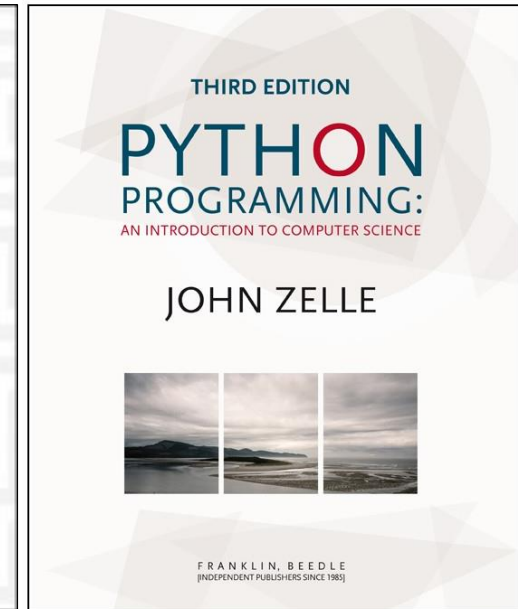
Wiley, 2016
752 pages



Addison-Wesley, 2015
794 pages



Wiley, 2013
580 pages



Franklin & Beedle, 2016
552 pages

... numerous online introduction texts/courses/videos on Python

Two Python programs

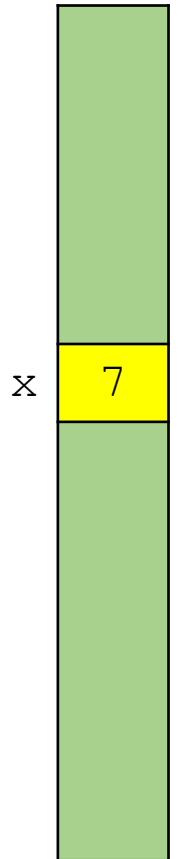
A Python program

```
Python shell
```

```
> x = 7  
> print(x * x)  
| 49
```

- 7 is an *integer literal* – in Python denoted an “int”
- x is the name of a *variable* that can hold some value
- = is assigning a value to a variable
- * denotes multiplication
- print is the name of a built-in *function*, here we call print to print the result of 7*7
- A program consists of a sequence of *statements*, executed sequentially

Memory

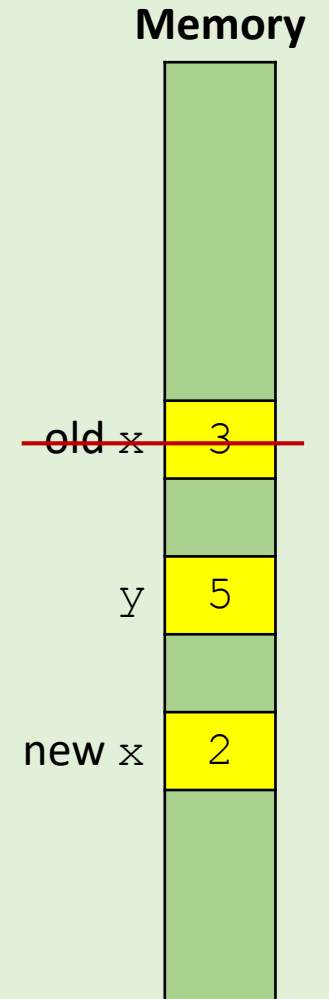


Question – What is the result of this program?

```
Python shell
> x = 3
> y = 5
> x = 2
> print(x * y)
```

x assigned new value

- 😊 a) 10
- b) 15
- c) 25
- d) [15, 10]
- e) Error
- f) Don't know

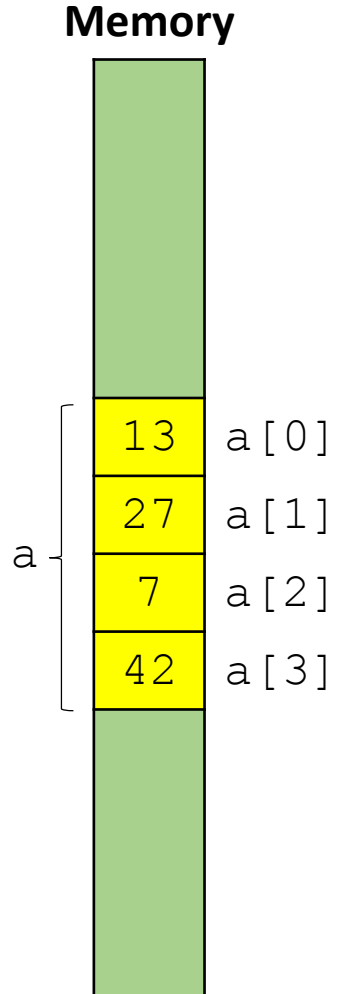


Another Python program using lists

Python shell

```
> a = [13, 27, 7, 42]
> print(a)
| [13, 27, 7, 42]
> print(a[2])
| 7
```

- `[13, 27, 7, 42]` is a *list* containing four integers
- `a[2]` refers to the entry in the list with *index 2* (the first element has index 0, i.e. `a[2]` is the 3rd element of the list)
- Note that `print` also can print a list

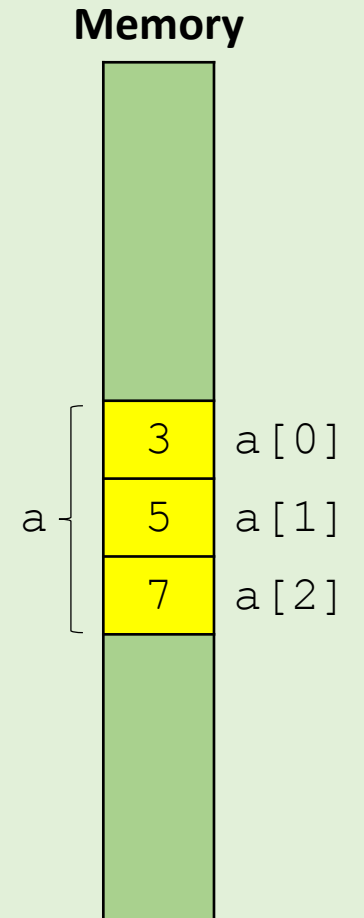


Question – What is the result of this program?

Python shell

```
> a = [3, 5, 7]
> print(a[1] + a[2])
```

- a) 8
- b) 10
- 😊 c) 12
- d) 15
- e) Don't know



Why Python ?



the next slides will be technical

TIOBE Index January 2018

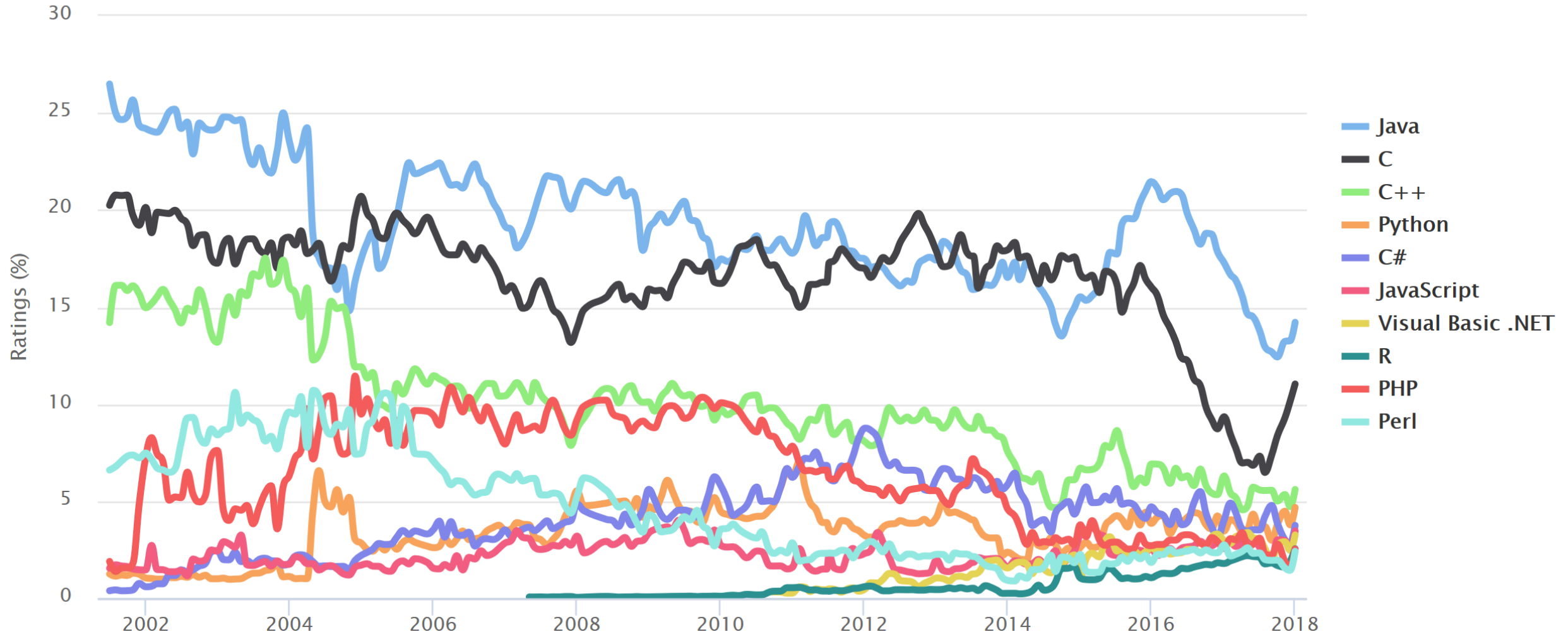
Jan 2018	Jan 2017	Change	Programming Language	Ratings	Change
1	1		Java	14.215%	-3.06%
2	2		C	11.037%	+1.69%
3	3		C++	5.603%	-0.70%
4	5	↑	Python	4.678%	+1.21%
5	4	↓	C#	3.754%	-0.29%
6	7	↑	JavaScript	3.465%	+0.62%
7	6	↓	Visual Basic .NET	3.261%	+0.30%
8	16	↑↑	R	2.549%	+0.76%
9	10	↑	PHP	2.532%	-0.03%
10	8	↓	Perl	2.419%	-0.33%

The TIOBE Programming Community index is an indicator of the *popularity of programming languages*. The index is updated once a month. The ratings are based on the number of skilled engineers world-wide, courses and third party vendors. Popular search engines such as Google, Bing, Yahoo!, Wikipedia, Amazon, YouTube and Baidu are used to calculate the ratings. It is important to note that the TIOBE index is not about the *best* programming language or the language in which *most lines of code* have been written.

Popularity of programming languages

TIOBE Programming Community Index

Source: www.tiobe.com



“Hello World”

- In Java, C, C++ a lot of “{”, “}” and “;” are needed
- Java tends to have a lot of “public...” details that need to be spelled out
- Python is concise

Java

```
public class HelloWorld {  
    public static void main( String[] args ) {  
        System.out.println( "Hello World!" );  
        System.exit( 0 );  
    }  
}
```

C

```
#include <stdio.h>  
  
int main(int argc, char **argv) {  
    printf("Hello World");  
    return 0;  
}
```

C++

```
#include <iostream>  
using namespace std;  
  
int main(int argc, char** argv) {  
    cout << "Hello, World!";  
    return 0;  
}
```

Python 2

```
print "Hello world"
```

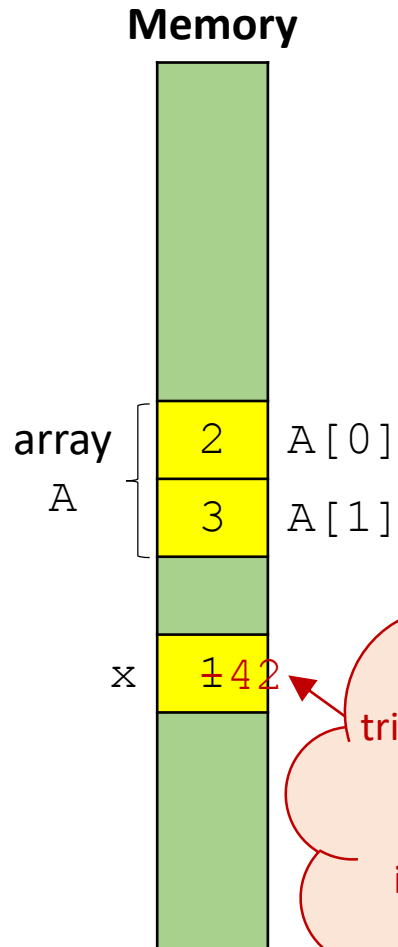
Python 3

```
print("Hello world")
```

Why Python ?

- **Short concise code**

C index out of bounds



“A” only has size 2, but tries to update the 4th entry. No warning is giving. Something unexpected is overridden in memory. **Have fun debugging!**

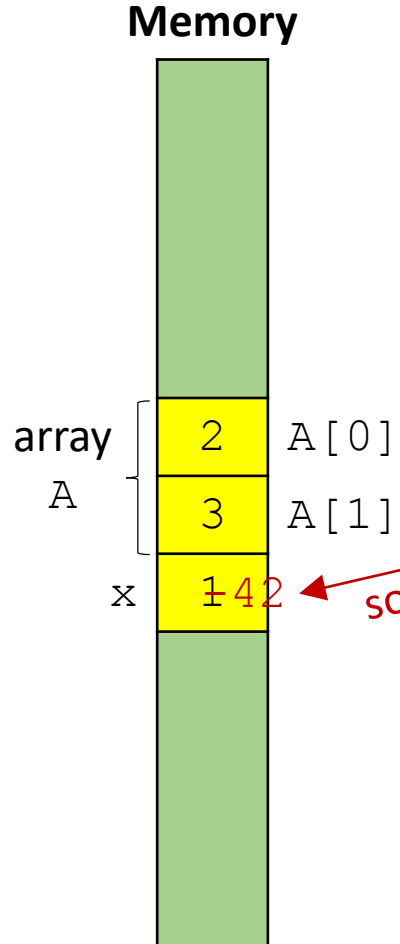
```
indexing.c
#include <stdio.h>
int main() {
    int x = 1;
    int A[2] = {2, 3}; // A[0] = 2, A[1] = 3
    printf("x = %d, A = {%d, %d}\n", x, A[0], A[1]);
    A[3] = 42; // index A[3] out of bounds
    printf("x = %d, A = {%d, %d}\n", x, A[0], A[1]);
    return 0;
}
```

Output

```
$ gcc indexing.c
$ ./a.exe
x = 1, A = {2, 3}
x = 42, A = {2, 3}
```

Skipping checking for invalid indexing makes programs faster, but also requires disciplined programming

... and C++ index out of bounds



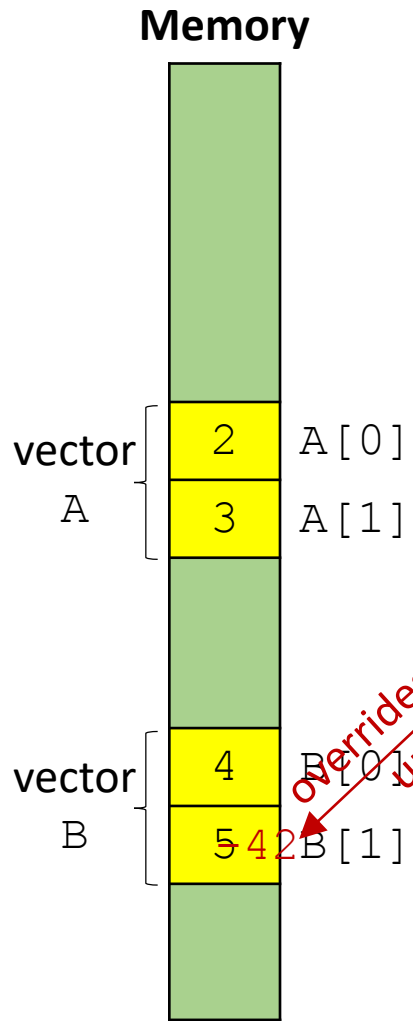
indexing.cpp

```
#include <iostream>
int main() {
    int x = 1;
    int A[2] = {2, 3}; // A[0] = 2, A[1] = 3
    std::cout << "x = " << x << ", A = {"
                << A[0] << ", " << A[1] << "}" << std::endl;
    A[2] = 42; // index A[2] out of bounds
    std::cout << "x = " << x << ", A = {"
                << A[0] << ", " << A[1] << "}" << std::endl;
    return 0;
}
```

Output

```
$ g++ indexing.cpp
$ ./a.exe
x = 1, A = {2, 3}
x = 42, A = {2, 3}
```

... and C++ `vector` index out of bounds



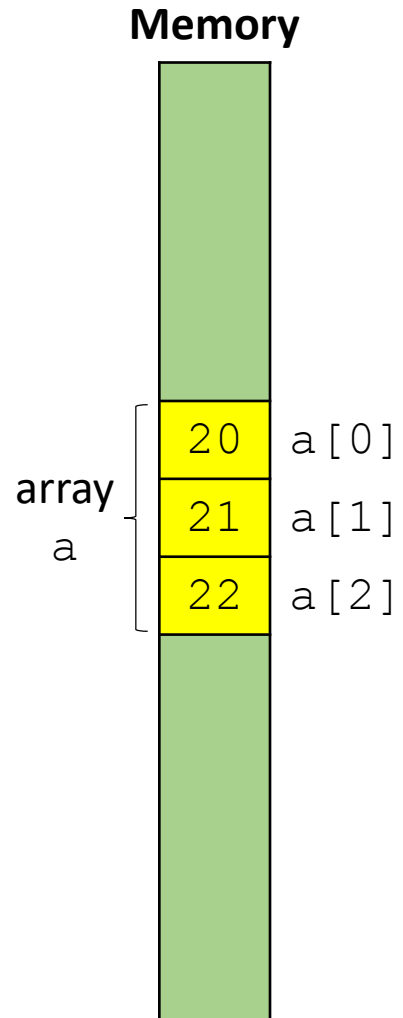
indexing.cpp

```
#include <iostream>
#include <vector>
int main() {
    std::vector<int> A = {2, 3}; // A[0] = 2, A[1] = 3
    std::vector<int> B = {4, 5}; // B[0] = 4, B[1] = 5
    std::cout << "A={" << A[0] << ", " << A[1] << "}, ";
    std::cout << "B={" << B[0] << ", " << B[1] << "}" << std::endl;
    A[9]=42; // index A[9] out of bounds
    std::cout << "A={" << A[0] << ", " << A[1] << "}, ";
    std::cout << "B={" << B[0] << ", " << B[1] << "}" << std::endl;
    return 0;
}
```

Output

```
$ g++ -std=c++11 indexing-vector.cpp
$ ./a.exe
A={2, 3}, B={4, 5}
A={2, 3}, B={4, 42}
```

... and Java index out of bounds exception



indexing.java

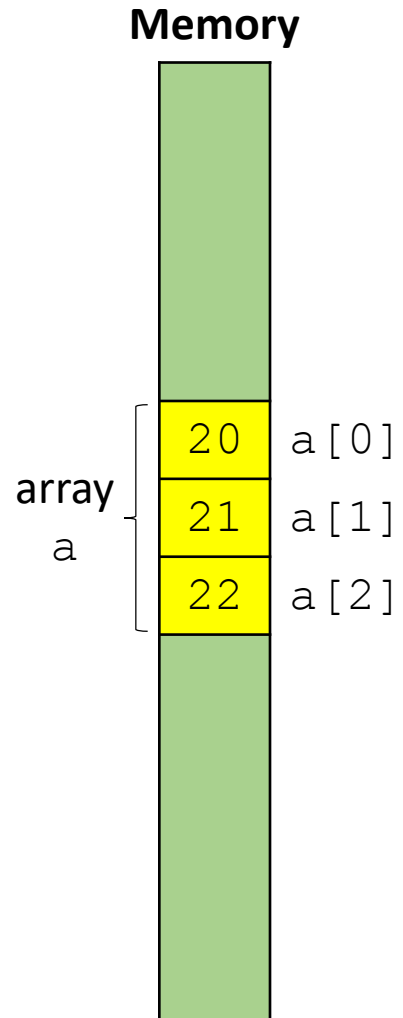
```
class IndexingTest{  
    public static void main(String args[]){  
        int a[] = {20, 21, 22};  
        a[5] = 42; // index a[5] out of bounds  
    }  
}
```

Output

```
$ javac indexing.java  
$ java IndexingTest  
Exception in thread "main"  
java.lang.ArrayIndexOutOfBoundsException: 5  
    at IndexingTest.main(indexing.java:5)
```

Java provides error message when running the program

... and Python index out of bounds exception



indexing.py

```
a = [20, 21, 22]
a[5] = 42 # index a[5] out of bounds
```

Output

```
$ python indexing.py
Traceback (most recent call last):
  File "indexing.py", line 3, in <module>
    a[5] = 42
IndexError: list assignment index out of range
```

Python provides error message when running the program

Why Python ?

- Short concise code
- **Index out-of-range exceptions**

C++ different ways to print a vector

vector-iterator.cpp

```
#include <iostream>
#include <vector>
int main() {
    // Vector is part of STL (Standard Template Library)
    std::vector<int> A = {20, 23, 26};
    // "C" indexing - since C++98
    for (int i=0; i<A.size(); i++)
        std::cout << A[i] << std::endl;
    // iterator - since C++98
    for (std::vector<int>::iterator it = A.begin(); it != A.end(); ++it)
        std::cout << *it << std::endl;
    // "auto" iterator - since C++11
    for (auto it = A.begin(); it != A.end(); ++it)
        std::cout << *it << std::endl;
    // Range-based for-loop - since C++11
    for (auto e : A)
        std::cout << e << std::endl;
}
```

elegant

Java - different ways to print a vector

vector-iterator.java

```
import java.util.Vector;
import java.util.Iterator;

class IteratorTest{
    public static void main(String[] args) {
        Vector<Integer> a = new Vector<Integer>();
        a.add(7);
        a.add(42);
        // "C" for-loop & get method
        for (int i=0; i<a.size(); i++)
            System.out.println(a.get(i));
        // iterator
        for (Iterator it = a.iterator(); it.hasNext(); )
            System.out.println(it.next());
        // for-each loop - since Java 5
        for (Integer e : a)
            System.out.println(e);
    }
}
```

elegant



The Python way to print a list

```
print-list.py
```

```
a = [20, 23, 26]
```

```
for e in a:  
    print(e)
```

```
Output
```

```
$ python print-list.py
```

```
20
```

```
23
```

```
26
```

Why Python ?

- Short concise code
- Index out of range exceptions
- **Elegant for-each loop**

C++ how not to print a vector

print-vector.cpp

```
#include <iostream>
#include <vector>

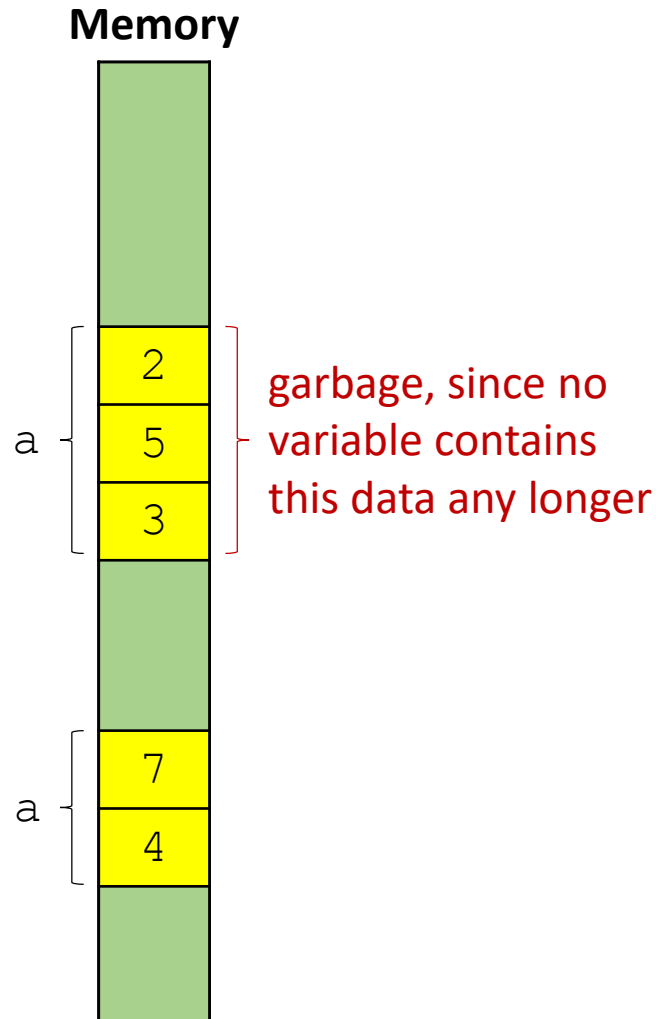
int main() {
    std::vector<int> A = {2, 3};
    std::cout << A << std::endl;
    return 0;
}
```

C++ vectors cannot be printed directly –
mistake results in +200 lines of error messages

Why Python ?

- Short concise code
- Index out of range exceptions
- Elegant for-each loop
- **Python hopefully better error messages than C++**

Python and garbage collection



```
garbage.py
```

```
a = [2, 5, 3]
```

```
a = [7, 4]
```

a gets new value

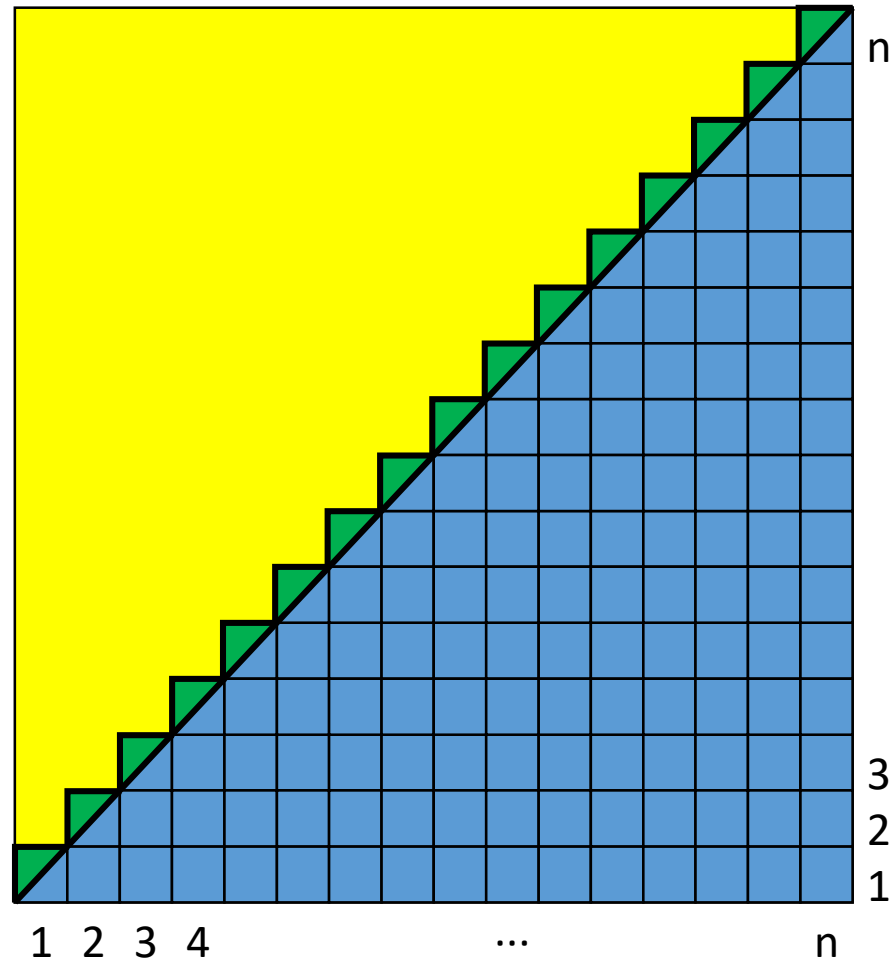
- Python and e.g. Java, C# and JavaScript have a **garbage collector** to automatically recycle garbage
- C and C++ garbage collection must be done explicitly by the program; forgetting to **free** memory again results in **memory leaks** – which can be really hard to find. **Have fun debugging!**

Why Python ?

- Short concise code
- Index out of range exceptions
- Elegant for-each loop
- Python hopefully better error messages than C++
- **Garbage collection is done automatically**

Python performance vs C, C++ and Java

Compute sum $1 + 2 + 3 + \dots + n = \frac{n^2}{2} + \frac{n}{2}$



$$1 + 2 + \dots + n$$

add.py

```
import sys

n = int(sys.argv[1])
sum = 0
for i in range(1, n+1):
    sum += i
print("Sum = %d" % sum)
```

add.c

```
#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[]) {
    int n = atoi(argv[1]);
    int sum = 0;
    for (int i=1; i<=n; i++)
        sum += i;
    printf("Sum = %d\n", sum);
}
```

add.cpp

```
#include <iostream>
#include <cstdlib>
using namespace std;

int main(int argc, char *argv[]) {
    int n = atoi(argv[1]);
    int sum = 0;
    for (int i=1; i<=n; i++)
        sum += i;
    cout << "Sum = " << sum << endl;
}
```

add.java

```
class Add{
    public static void main(String args[]){
        int n = Integer.parseInt(args[0]);
        int sum = 0;
        for (int i=1; i<=n; i++)
            sum += i;
        System.out.println("Sum = " + sum);
    }
}
```

Timing results

n	C (gcc 6.4)	C++, int (g++ 6.4)	C++, long (g++ 6.4)	Java (1.8)	Python (3.6.4)	PyPy (3.5.3)
10^7	0.13 sec*	0.18 sec*	0.15 sec	0.35 sec*	1.3 sec	0.35 sec
10^9	0.25 sec**	0.29 sec**	0.44 sec	0.86 sec**	191 sec	35 sec

Wrong output (overflow)

* -2004260032 instead of 50000005000000

** -243309312 instead of 500000000500000000

- since C, C++, and Java only use 32 bits to represent integers (and 64 bits for "long" integers)



```
Bit          666666666655555555554444444444333333333332222222222111111111110000000000
position     9876543210987654321098765432109876543210987654321098765432109876543210
bin(10**9)                                     111011100110101100101000000000
bin(50000005000000)                           1011010111100110001000100010010110101101000000
bin(-2004260032+2**32)                         10001000100010010110101101000000
bin(500000000500000000)                       1101111000001011011010110011111000101111110110010100000000
bin(-243309312+2**32)                         11110001011111110110010100000000
```

Timing results

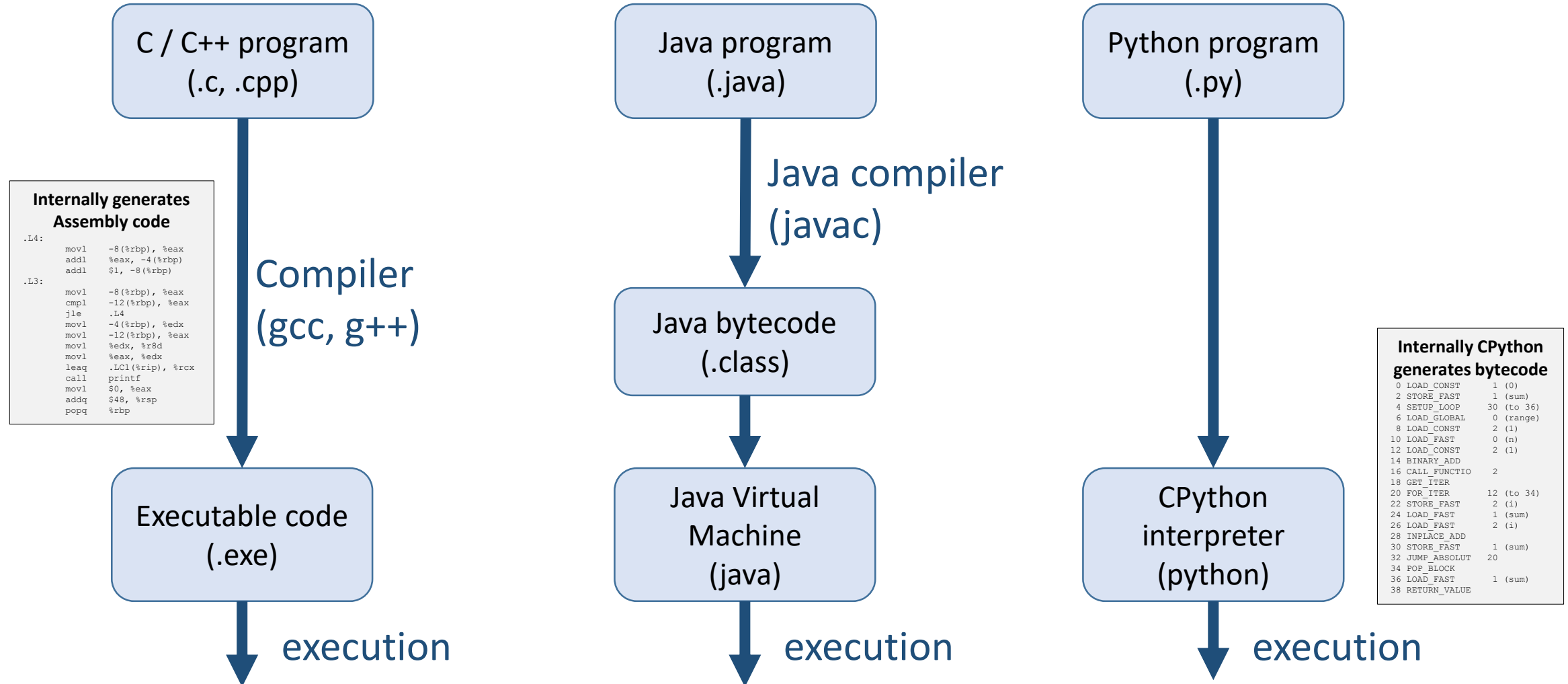
n	C (gcc 6.4)	C++, int (g++ 6.4)	C++, long (g++ 6.4)	Java (1.8)	Python (3.6.4)	PyPy (3.5.3)
10 ⁷	0.13 sec*	0.18 sec*	0.15 sec	0.35 sec*	1.3 sec	0.35 sec
10 ⁹	0.25 sec**	0.29 sec**	0.44 sec	0.86 sec**	191 sec	35 sec

- Relative speed

C ≈ C++ > Java >> Python

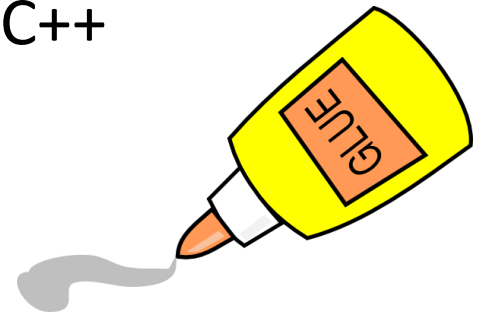
- C, C++, Java need to care about integer overflows – select integer representation carefully with sufficient number of bits (8, 16, 32, 64, 128)
- Python natively works with arbitrary long integers (as memory on your machine allows). Also possible in Java using the class `java.math.BigInteger`
- Python programs can (sometimes) run faster using PyPy
- Number crunching in **Python** should be delegated to **specialized modules (e.g. CPLEX)** – often written in C or C++

Interpreter vs Compiler



Why Python ?

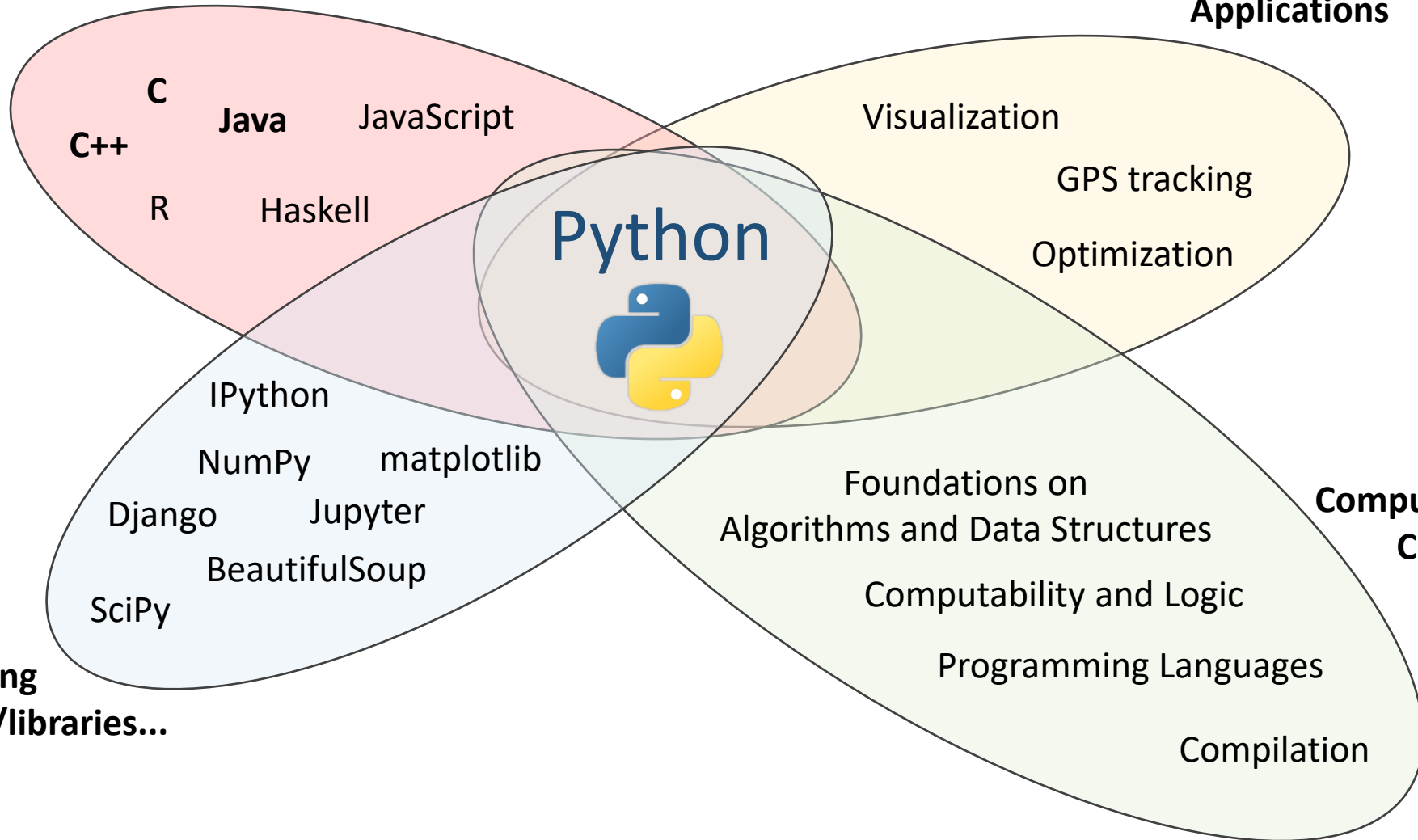
- Short concise code
- Index out of range exceptions
- Elegant for-each loop
- Python hopefully better error messages than C++
- Garbage collection is done automatically
- **Exact integer arithmetic (no overflows)**
- **Can delegate number crunching to C, C++, ...**



This course

Programming Languages

**(Scientific)
Applications**



History of Python development

- Python created by Guido van Rossum in 1989, first release 0.9.0 1991
- Python 2 → Python 3 (clean up of Python 2 language)
 - Python 2 – version 2.0 released 2000, final version 2.7 released mid-2010
 - Python 3 – released 2008, current release 3.6.4
- Python 3 is *not* backward compatible, libraries incompatible

Python 2	Python 3
<code>print 42</code>	<code>print(42)</code>
<code>int = C long (32 bits)</code>	<code>int = arbitrary number of digits (= named “long” in Python 2)</code>
<code>7/3 → 2</code> returns “int”	<code>7/3 → 2.333...</code> returns “float”
<code>range()</code> returns list (memory intensive)	<code>range()</code> returns iterator (memory efficient; <code>xrange</code> in Python 2)

Python.org

The screenshot shows the Python.org homepage. At the top, there is a navigation bar with links for Python, PSF, Docs, PyPI, Jobs, and Community. Below this is the Python logo and a search bar. A secondary navigation bar includes links for About, Downloads, Documentation, Community, Success Stories, and News. The main content area features a code editor with a Fibonacci sequence example and a section titled "Functions Defined" with a brief description of Python's extensibility. At the bottom, there are four columns of links: "Get Started", "Download", "Docs", and "Jobs".

Three red arrows highlight specific features:

- An arrow pointing to the "Docs" link in the top navigation bar, labeled "Documentation".
- An arrow pointing to the "PyPI" link in the top navigation bar, labeled "+100.000 Python packages".
- An arrow pointing to the "Downloads" link in the secondary navigation bar, labeled "Download Python and IDLE".

```
# Python 3: Fibonacci sequence
>>> def fib(n):
>>>     a, b = 0, 1
>>>     while a < n:
>>>         print(a, end=' ')
>>>         a, b = b, a+b
>>>     print()
>>> fib(1000)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610
987
```

Python is a programming language that lets you work quickly and integrate systems more effectively. >>> [Learn More](#)

Get Started	Download	Docs	Jobs
Whether you're new to programming or an experienced developer, it's easy to learn and use Python.	Python source code and installers are available for download for all versions! Not sure which version to use? Check here.	Documentation for Python's standard library, along with tutorials and guides, are available online.	Looking for work or have a Python related position that you're trying to hire for? Our relaunched community-run job board is the place to go.
Start with our Beginner's Guide	Latest: Python 3.6.4 - Python 2.7.14	docs.python.org	jobs.python.org

Installing Python

Welcome to Python.org

Python Software Foundation (US) | <https://www.python.org>

Python | PSF | Docs | PyPI | Jobs | Community

python™

About Downloads Documentation

```
# Python 3: List comprehensions
>>> fruits = ['Banana', 'Apple', 'Lime']
>>> loud_fruits = [fruit.upper() for fruit in fruits]
>>> print(loud_fruits)
['BANANA', 'APPLE', 'LIME']

# List and the enumerate function
>>> list(enumerate(fruits))
[(0, 'Banana'), (1, 'Apple'), (2, 'Lime')]
```

Python is a programming language that can help you work more efficiently and integrate systems more effectively.

Download Python | Python.org

Python Software Foundation (US) | <https://www.python.org/downloads/>

Python | PSF | Docs | PyPI | Jobs | Community

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About Downloads Documentation

Download the latest version for Windows

Download Python 3.6.4 Download Python 2.7.14

Wondering which version to use? [Here's more about the difference between Python 2 and 3.](#)

Looking for Python with a different OS? Python for [Windows](#), [Linux/UNIX, MacOS X](#), [Other](#)

Want to help test development versions of Python? [Pre-releases](#)

Python Releases for Windows

Python Software Foundation (US) | <https://www.python.org/downloads/windows/>

Python 3.6.4 (32-bit) Setup

Install Python 3.6.4 (32-bit)

Select Install Now to install Python with default settings, or choose Customize to enable or disable features.

Install Now
C:\Users\au121\AppData\Local\Programs\Python\Python36-32

Includes IDLE, pip and documentation
Creates shortcuts and file associations

Customize installation
Choose location and features

Install launcher for all users (recommended)

Add Python 3.6 to PATH

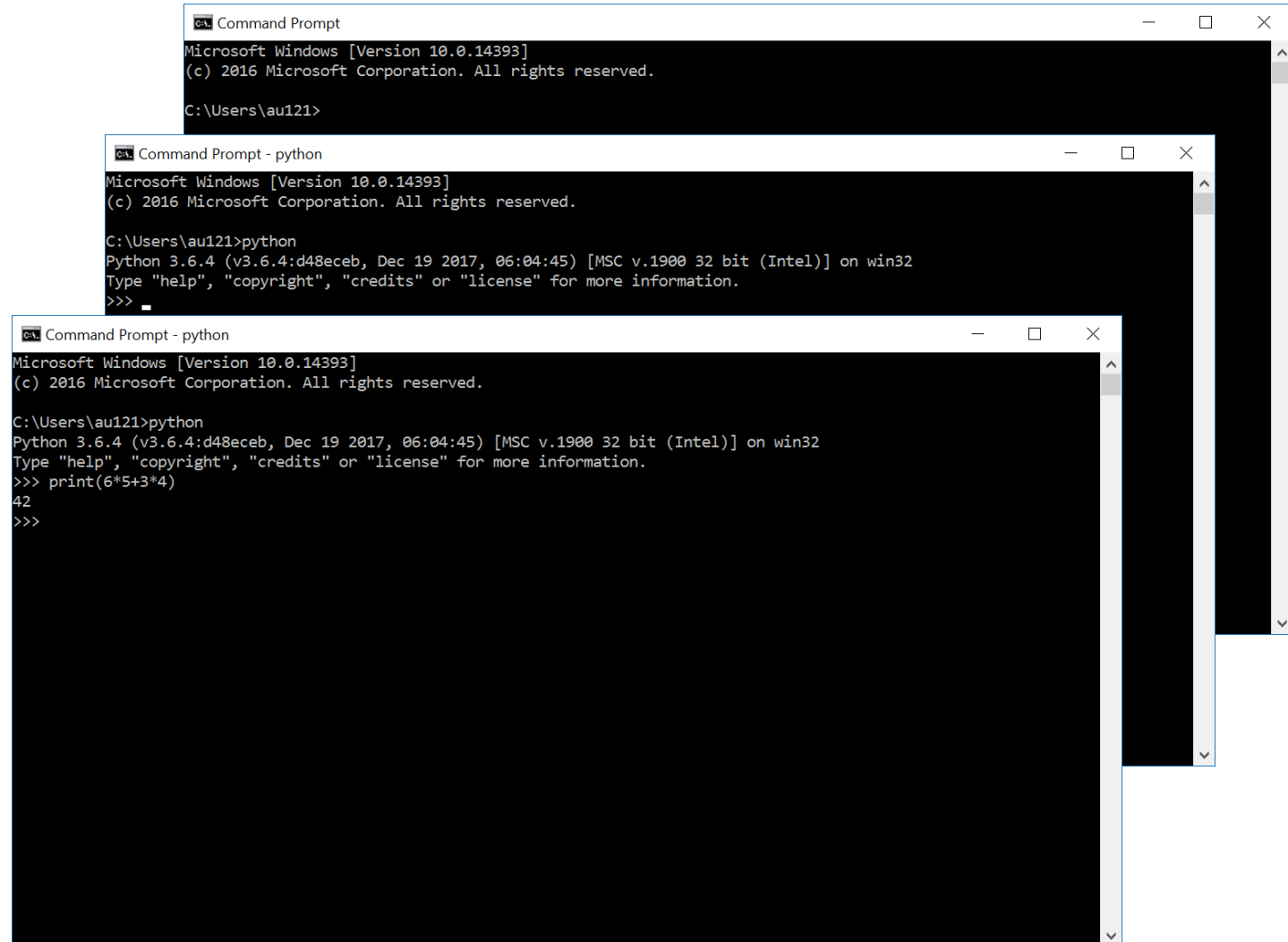
Cancel

IMPORTANT

Running the Python Interpreter

- Open Command Prompt (Windows-key + cmd)
- Type “python” + return
- Start executing Python statements

- To exit shell:
Ctrl-Z + return *or*
exit() + return



```
Command Prompt
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\au121>

Command Prompt - python
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\au121>python
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>

Command Prompt - python
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\au121>python
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>> print(6*5+3*4)
42
>>>
```

Installing IPython –

A more powerful interactive Python shell

- Open Command Prompt

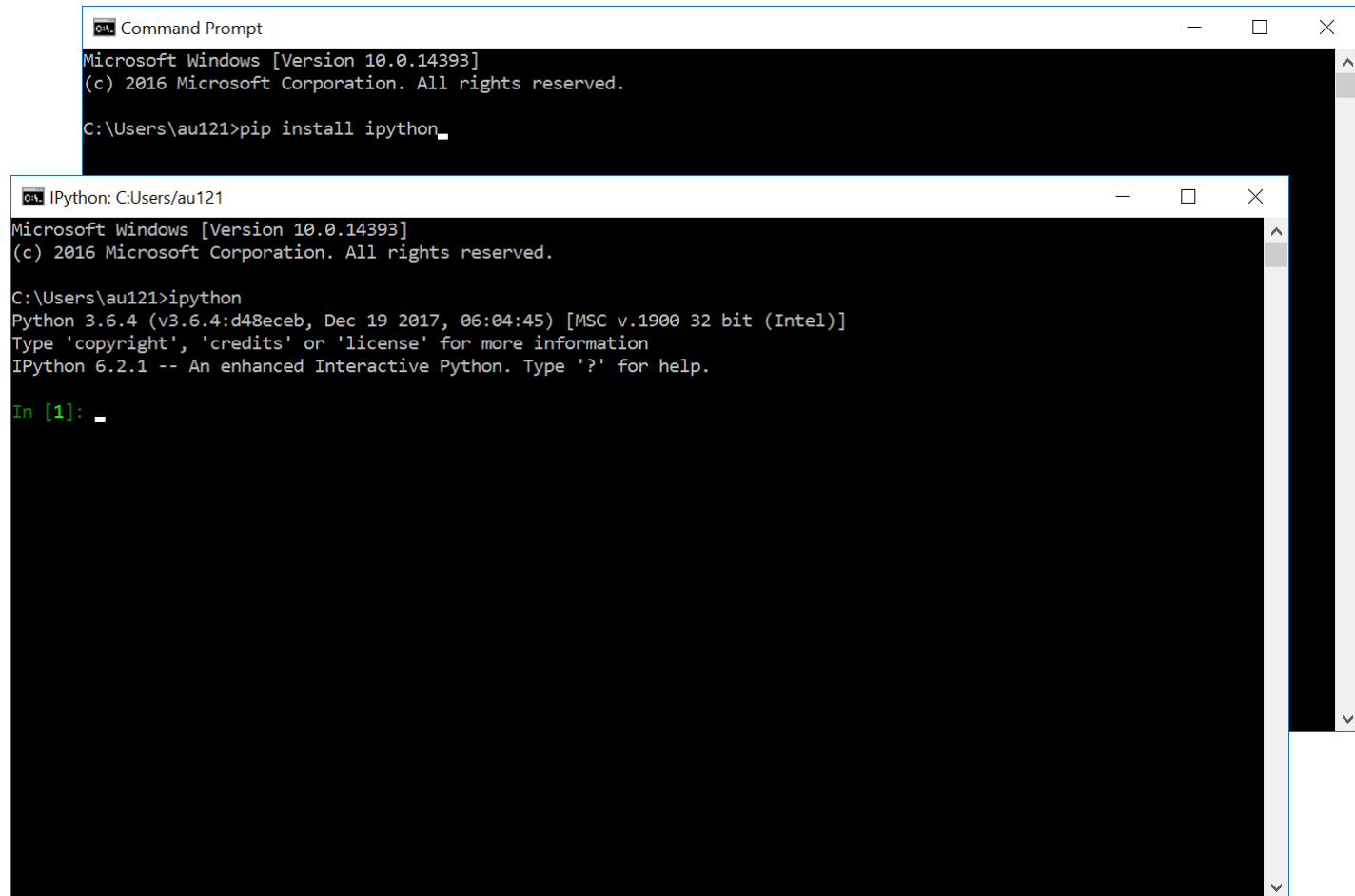
- Execute:

```
pip install ipython
```

- Start ipython

```
ipython
```

pip = the Python package manager



```
Command Prompt
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\au121>pip install ipython_

IPython: C:\Users\au121
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\au121>ipython
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)]
Type 'copyright', 'credits' or 'license' for more information
IPython 6.2.1 -- An enhanced Interactive Python. Type '?' for help.

In [1]: _
```

Some other useful packages

- Try installing some more Python packages:

```
pip install numpy
```

linear algebra support (N-dimensional arrays)

```
pip install scipy
```

numerical integration and optimization

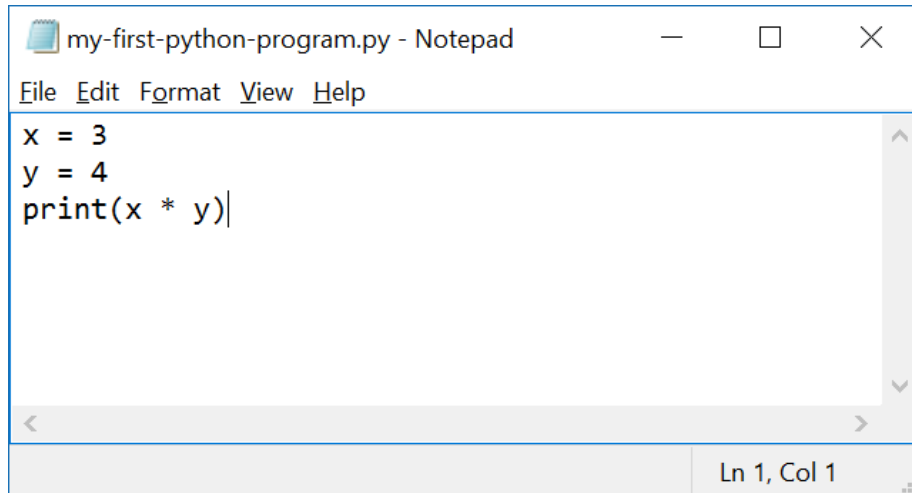
```
pip install matplotlib
```

2D plotting library

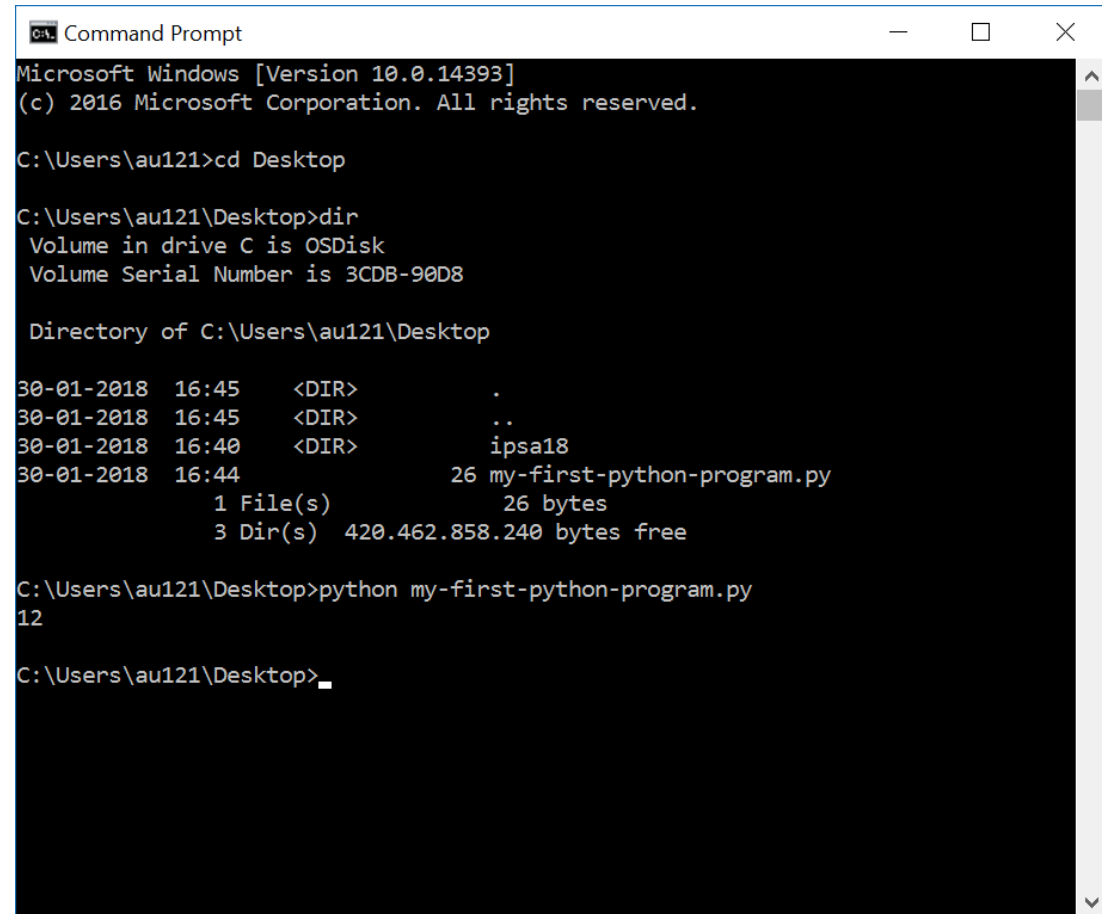
```
pip install pylint
```

Python source code analyzer enforcing a coding standard

Creating a Python program the very basic way



```
my-first-python-program.py - Notepad
File Edit Format View Help
x = 3
y = 4
print(x * y)|
Ln 1, Col 1
```



```
Command Prompt
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\au121>cd Desktop

C:\Users\au121\Desktop>dir
Volume in drive C is OSDisk
Volume Serial Number is 3CDB-90D8

Directory of C:\Users\au121\Desktop

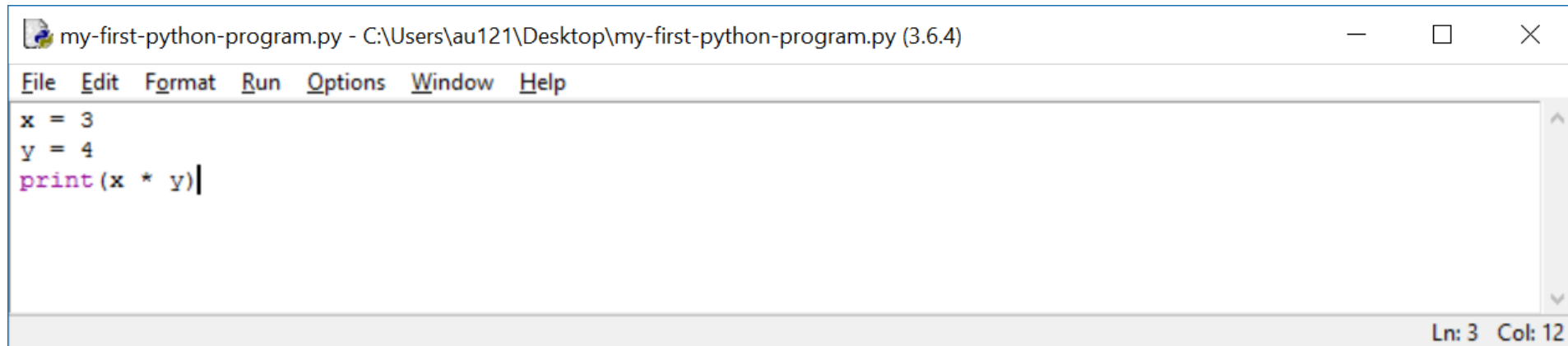
30-01-2018  16:45    <DIR>          .
30-01-2018  16:45    <DIR>          ..
30-01-2018  16:40    <DIR>          ipsa18
30-01-2018  16:44                26 my-first-python-program.py
               1 File(s)                26 bytes
               3 Dir(s)  420.462.858.240 bytes free

C:\Users\au121\Desktop>python my-first-python-program.py
12

C:\Users\au121\Desktop>
```

- Open Notepad
 - write a simple Python program
 - save it
- Open a command prompt
 - go to folder (using cd)
 - run the program using
`python <program name>.py`

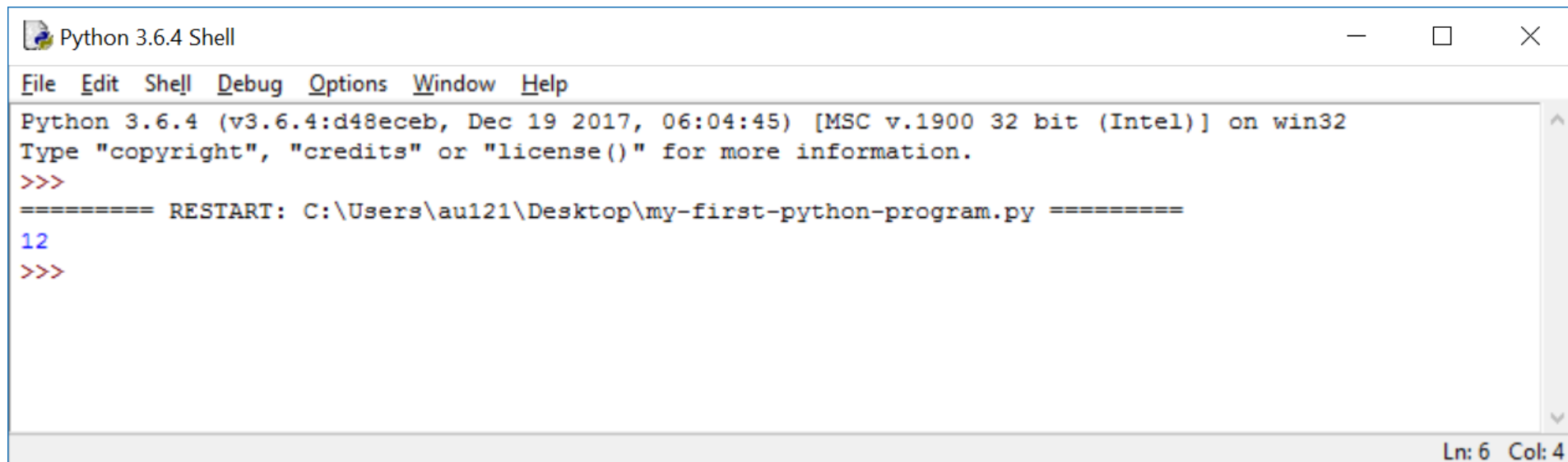
... or open IDLE and run program with F5



The screenshot shows the Python IDLE editor window. The title bar reads "my-first-python-program.py - C:\Users\au121\Desktop\my-first-python-program.py (3.6.4)". The menu bar includes "File", "Edit", "Format", "Run", "Options", "Window", and "Help". The code editor contains the following Python code:

```
x = 3
y = 4
print(x * y)
```

The status bar at the bottom right indicates "Ln: 3 Col: 12".



The screenshot shows the Python 3.6.4 Shell window. The title bar reads "Python 3.6.4 Shell". The menu bar includes "File", "Edit", "Shell", "Debug", "Options", "Window", and "Help". The shell displays the following output:

```
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
===== RESTART: C:\Users\au121\Desktop\my-first-python-program.py =====
12
>>>
```

The status bar at the bottom right indicates "Ln: 6 Col: 4".

The Python Ecosystem

- **Interpreters/compiler**
 - CPython – reference C implementation from python.org
 - PyPy – written in RPython (a subset of Python) – faster than Cpython
 - Jython – written in Java and compiles to Java bytecode, runs on the JVM
 - IronPython – written in C#, compiles to Microsoft's Common Language Runtime (CLR) bytecode
 - Cython – project translating Python-ish code to C
- **Shells (IPython, IDLE)**
- **Libraries/modules/packages**
 - pypi.python.org/pypi (PyPI - the Python Package Index, +100.000 packages)
- **IDEs (Integrated development environment)**
 - IDLE comes with Python (docs.python.org/3/library/idle.html)
 - Anaconda w. Spyder, IPython (www.anaconda.com/download)
 - Canopy (enthought.com/product/canopy)
 - Python tools for Visual Studio (github.com/Microsoft/PTVS)
 - PyCharm (www.jetbrains.com/pycharm/)
 - Emacs (Python mode and ElPy mode)
 - Notepad++
- **Python Style guide (PEP8)**
 - pylint, pep8, flake8

