

Introduction to Programming with Scientific Applications



Course evaluation

*"Den første forelæsning var meget
skræmmende og overvældende"*

Course description – kursuskatalog.au.dk/en/course/97754/

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**,
- use the documentation for a programming language and available software packages.

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 3 x 1 hour/week

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	
2018-	BSc course on Introduction to Programming with Scientific Applications
2004-	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) Data Science
- d) Chemistry
- e) Physics
- f) Other Science-Technology
- g) 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	Studiecafé				Lecture
9:15-10:00		Hold TV		Hold MA1	Studiecafé
10:15-11:00					
11:15-12:00			Hold DV1		Hold Mø3
12:15-13:00					
13:15-14:00	Hold KE	Hold Mø1			
14:15-15:00			Lecture	Hold MA2	
15:15-16:00			Studiecafé		
16:15-17:00					
17:15-18:00					



Week	Monday	Tuesday	Wednesday	Thursday	Friday
5	(no TA classes)		/ F1		F2 /
6	TØ1	TØ1	TØ1 / F3	TØ1	F4 / TØ1
7	TØ2	TØ2	TØ2 / F5	TØ2	F6 / TØ2
8	TØ3	TØ3	TØ3 / F7	TØ3	F8 / TØ3
9	TØ4	TØ4	TØ4 / F9	TØ4	F10 / TØ4
10	TØ5	TØ5	TØ5 / F11	TØ5	F12 / TØ5
11	TØ6	TØ6	TØ6 / F13	TØ6	F14 / TØ6
12	TØ7	TØ7	TØ7 / F15	TØ7	F16 / TØ7
13	TØ8	TØ8	TØ8 / F17	TØ8	F18 / TØ8
14	TØ9	TØ9	TØ9 / F19	TØ9	F20 / TØ9
15	Easter				
16		-	- / F21	-	F22 / TØ10
17	TØ10	TØ10	TØ10 / F23	TØ10	F24 / TØ11
18	TØ11	TØ11	TØ11 / F25	TØ11	F26 / TØ12
19	TØ12	TØ12	TØ12 / F27	TØ12	Prayer Day
20	TØ13	TØ13	TØ13 / F28	TØ13	- / TØ13

Course page on Blackboard

 blackboard.au.dk

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Welcome to AU Blackboard

F20 - Introduktion til programmering med videnskabelige anvendelser [220171U028]  Introduction to Programming with Scientific Applications (Spring 2020)



F20 - Introduktion til programmering med videnskabelige anvendelser [220171U028]

Introduction to Programming with Scientific Applications (Spring 2020)

Course plan

Exercises

Final project

Handins

Groups & participants

Exam

PeerWise

Installing Python

Python resources

Introduction to Programming with Scientific Applications (Spring 2020)

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.

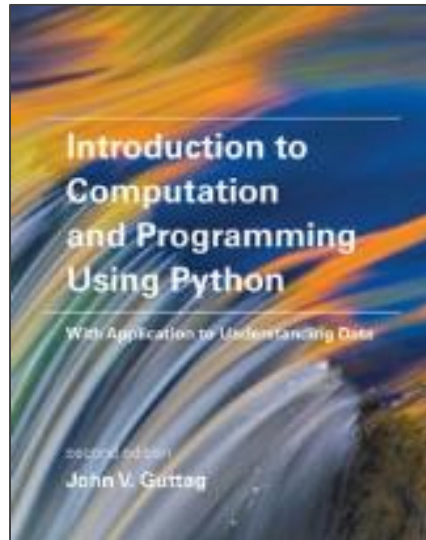
The course will be run with 2 x 2 hours of weekly lectures, 3 hours of TA classes ("øvelser"), and 3 hours of staffed study café.

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.*

Course content

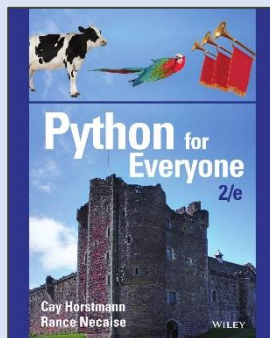
The course gives an introduction to programming with scientific applications. Programming concepts and techniques are introduced using the Python programming language. The programming concepts are illustrated in other programming languages. The following content is included.

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

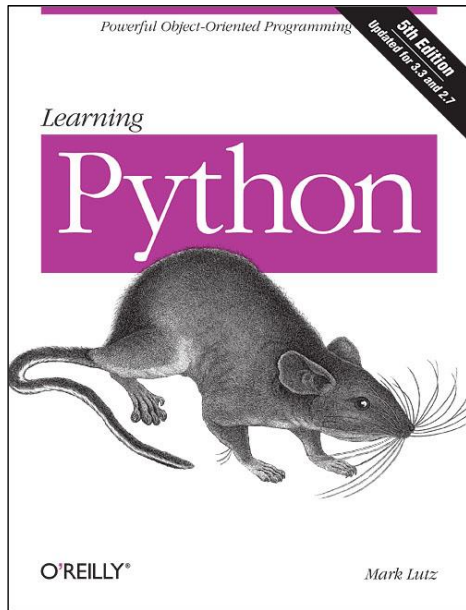
- *[Guttag, page 8] The reader should be forewarned that this book is by no means a comprehensive introduction to Python*
- *Covers all basic features of Python enabling you to deal with data in Chapters 1-8 (134 pages) - remaining chapters are applications*
- *Other resources: Google, **stackoverflow**,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



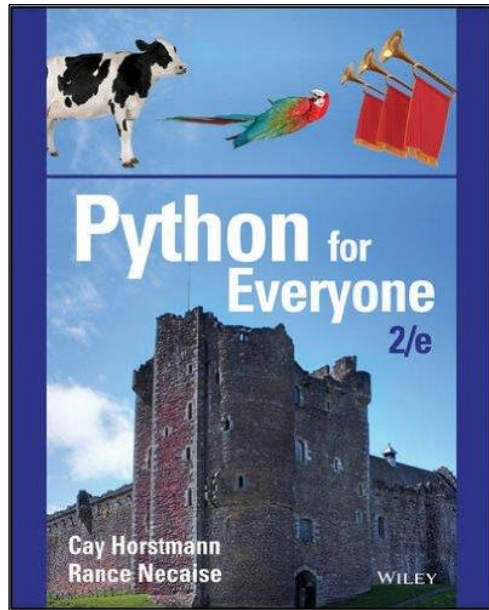
Comparison to a standard text book on the *programming language* Python by Cay Horstmann and Rance Necaise:

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

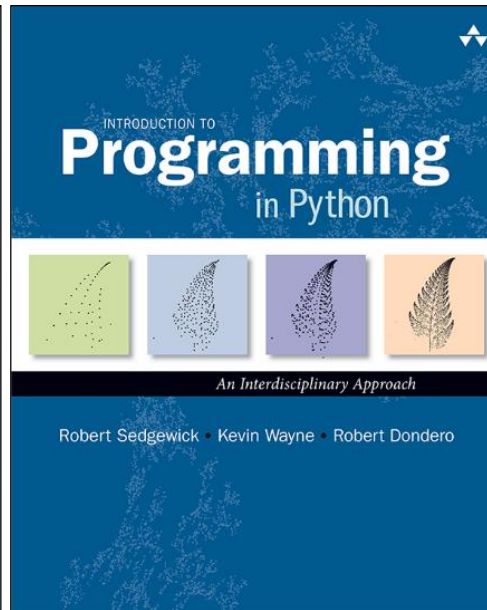
Some other books on Python



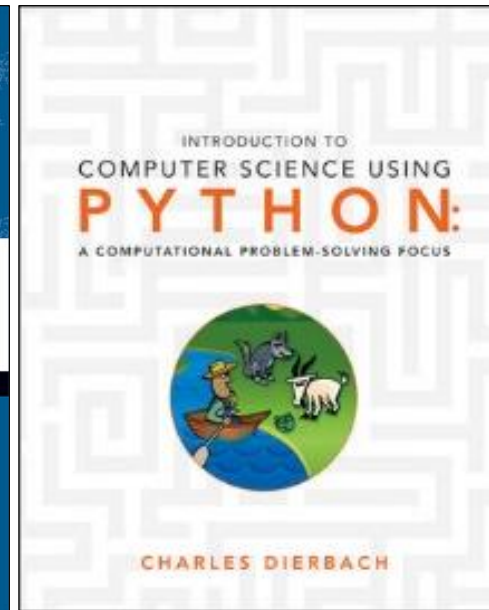
O'Reilly, 2013
1684 pages



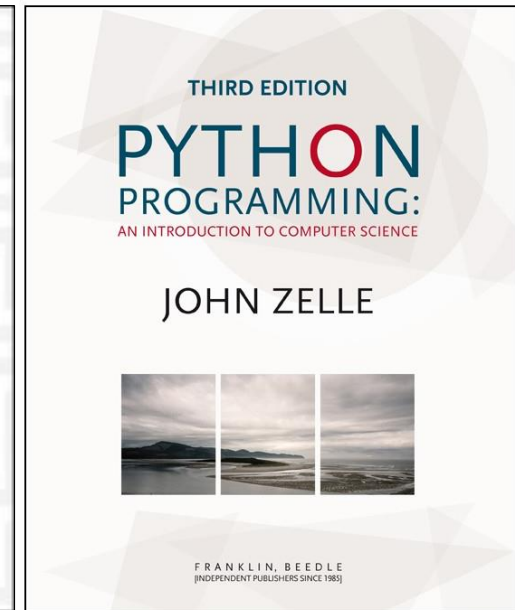
Wiley, 2016
752 pages



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

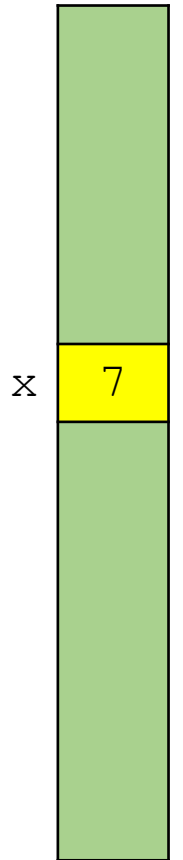
A Python program

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?

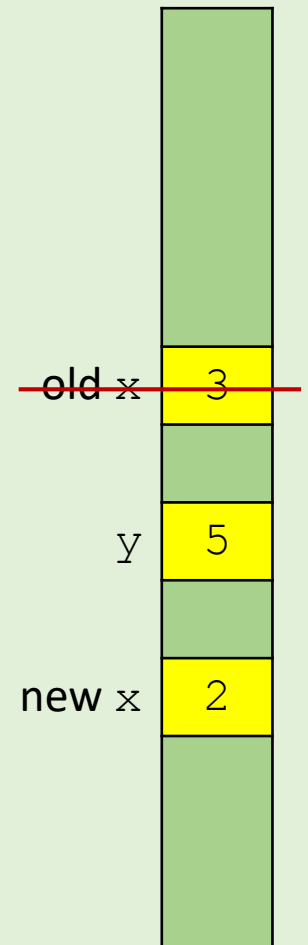
Python shell

```
> 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

Memory

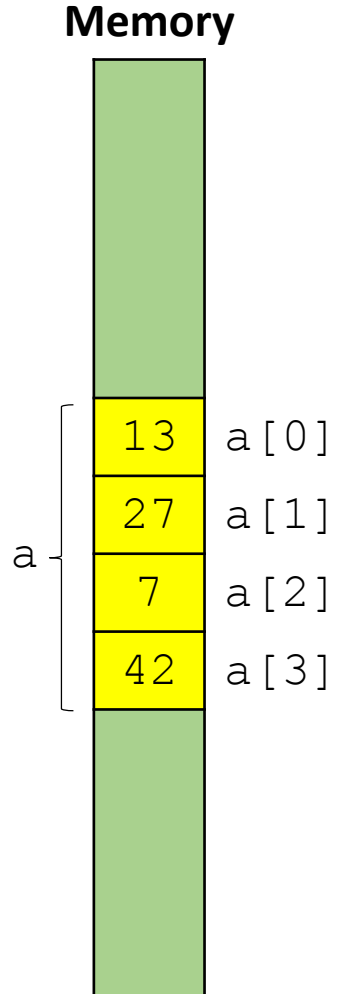


Another Python program using lists

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

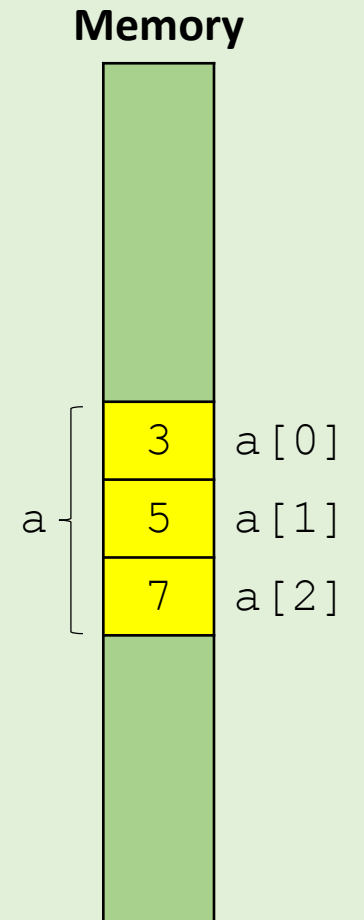


Question – What is the result of this program?

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 2020

Jan 2020	Jan 2019	Change	Programming Language	Ratings	Change
1	1		Java	16.896%	-0.01%
2	2		C	15.773%	+2.44%
3	3		Python	9.704%	+1.41%
4	4		C++	5.574%	-2.58%
5	7	⬆	C#	5.349%	+2.07%
6	5	⬇	Visual Basic .NET	5.287%	-1.17%
7	6	⬇	JavaScript	2.451%	-0.85%
8	8		PHP	2.405%	-0.28%
9	15	⬆	Swift	1.795%	+0.61%
10	9	⬇	SQL	1.504%	-0.77%

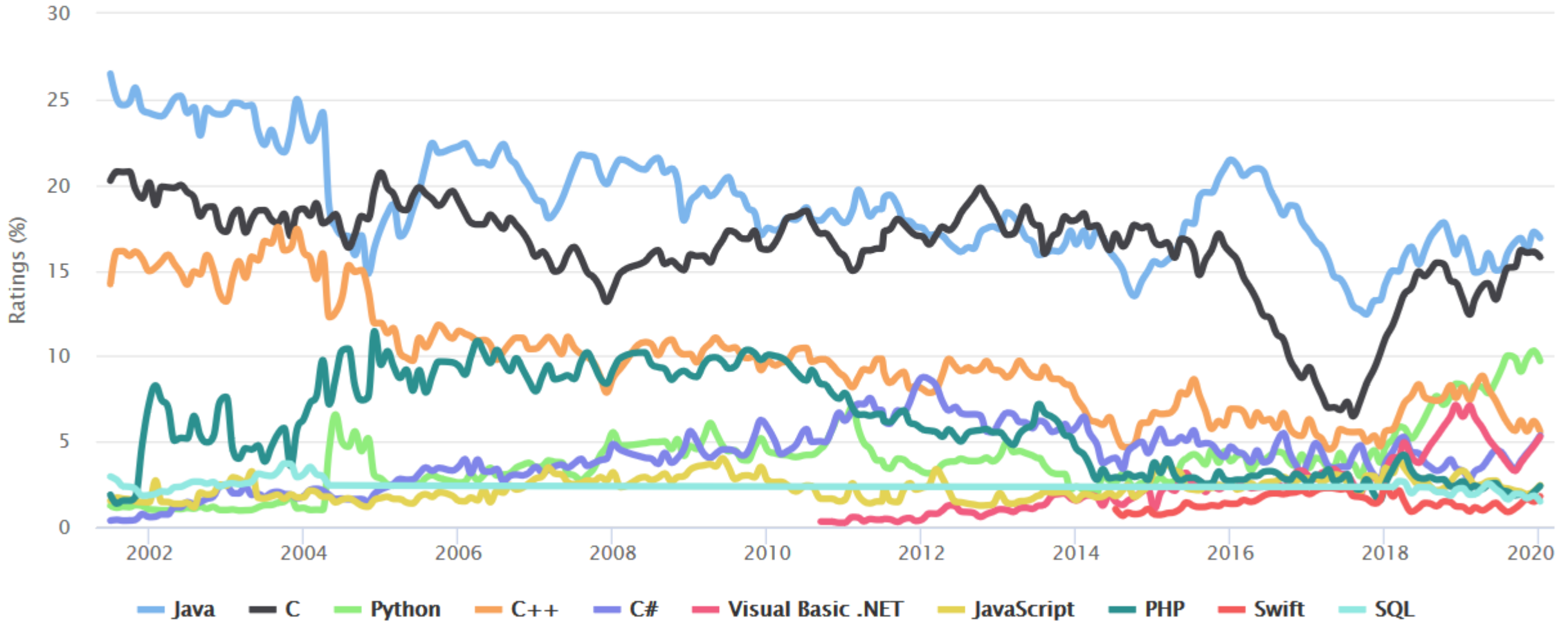
The TIOBE Programming Community index is an indicator of the *popularity of programming languages*. The index is updated once a month. The ratings are based on the number of skilled engineers world-wide, courses and third party vendors. Popular search engines such as Google, Bing, Yahoo!, Wikipedia, 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.

www.tiobe.com

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")
```

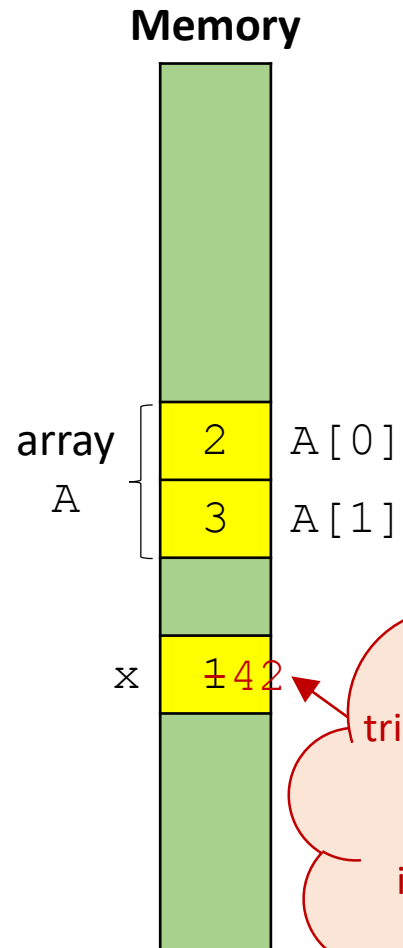
Why Python ?

- **Short concise code**

C index out of bounds

Debugging is the process of finding and resolving defects or problems within a computer program that prevent correct operation of computer software or a system.

en.wikipedia.org/wiki/Debugging



"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

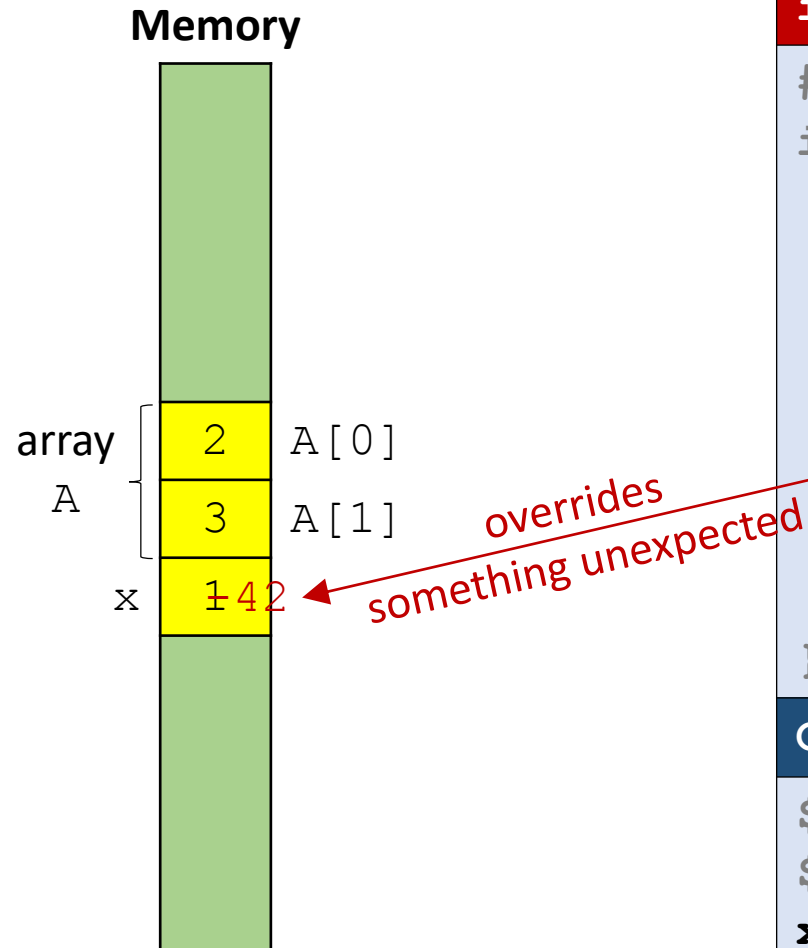
```
#include <stdio.h>
int main() {
    int x = 1;
    int A[2] = {2, 3}; // A[0] = 2, A[1] = 3
    printf("x = %d, A = {%d, %d}\n", x, A[0], A[1]);
    A[3] = 42; // index A[3] out of bounds
    printf("x = %d, A = {%d, %d}\n", x, A[0], A[1]);
    return 0;
}
```

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



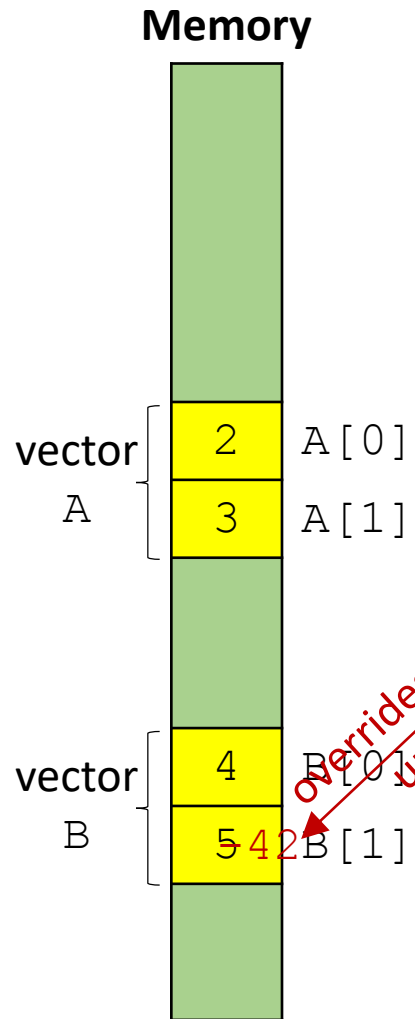
indexing.cpp

```
#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



overrides something
unexpected

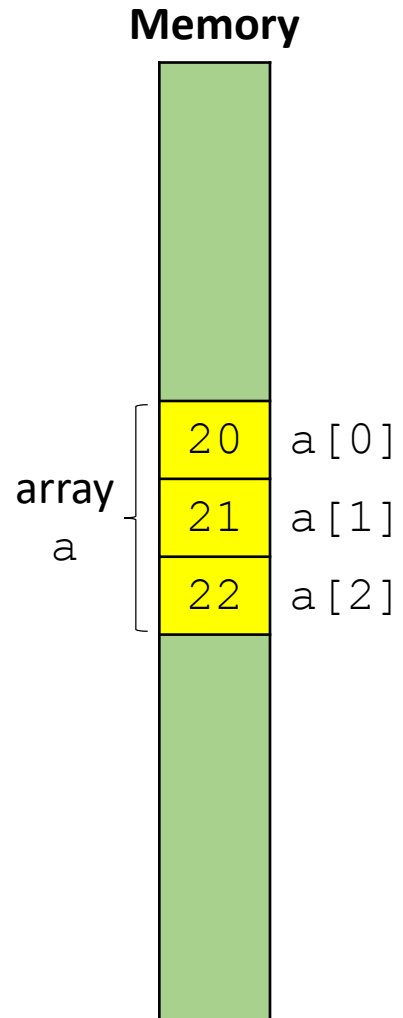
indexing.cpp

```
#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

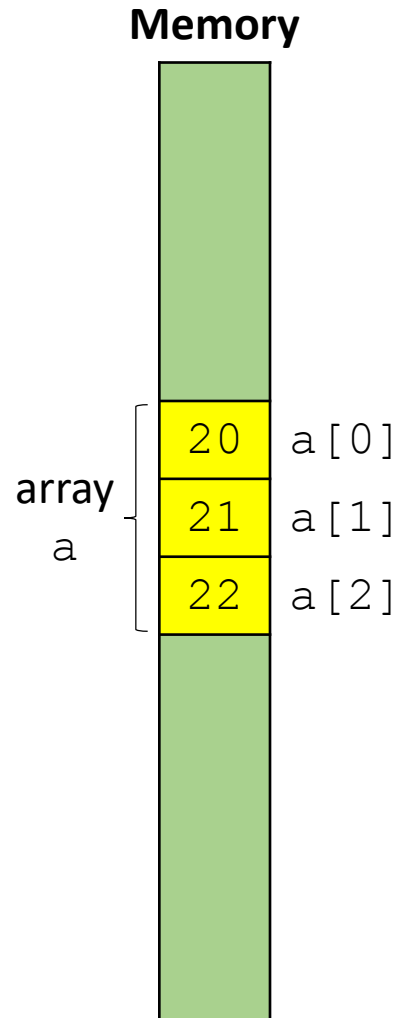
```
class IndexingTest{  
    public static void main(String args[]){  
        int a[] = {20, 21, 22};  
        a[5] = 42; // index a[5] out of bounds  
    }  
}
```

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>

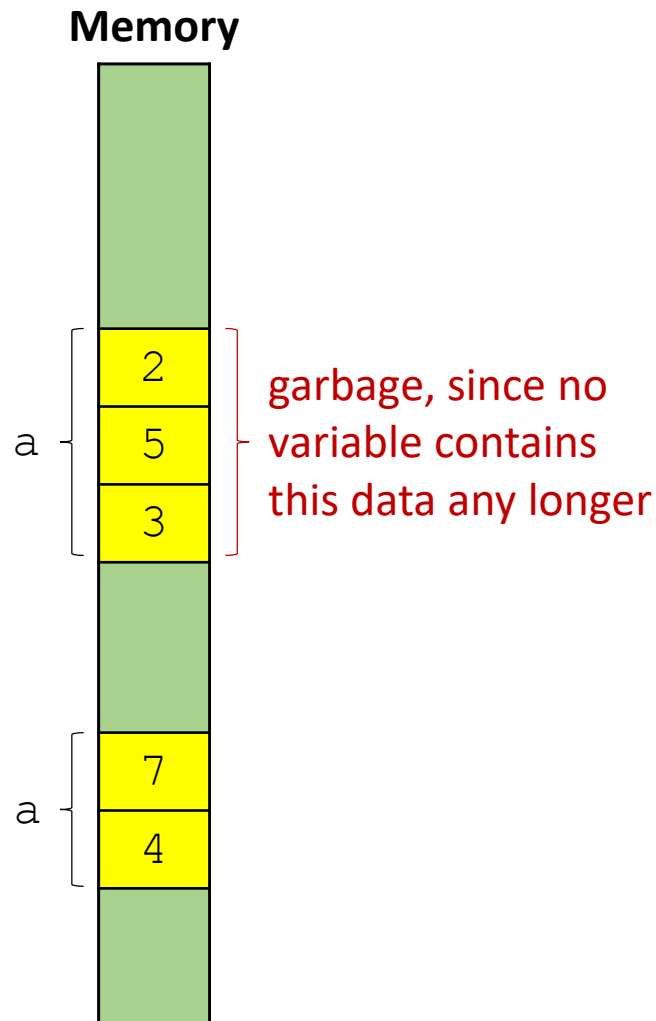
int main() {
    std::vector<int> A = {2, 3};
    std::cout << A << std::endl;
    return 0;
}
```

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

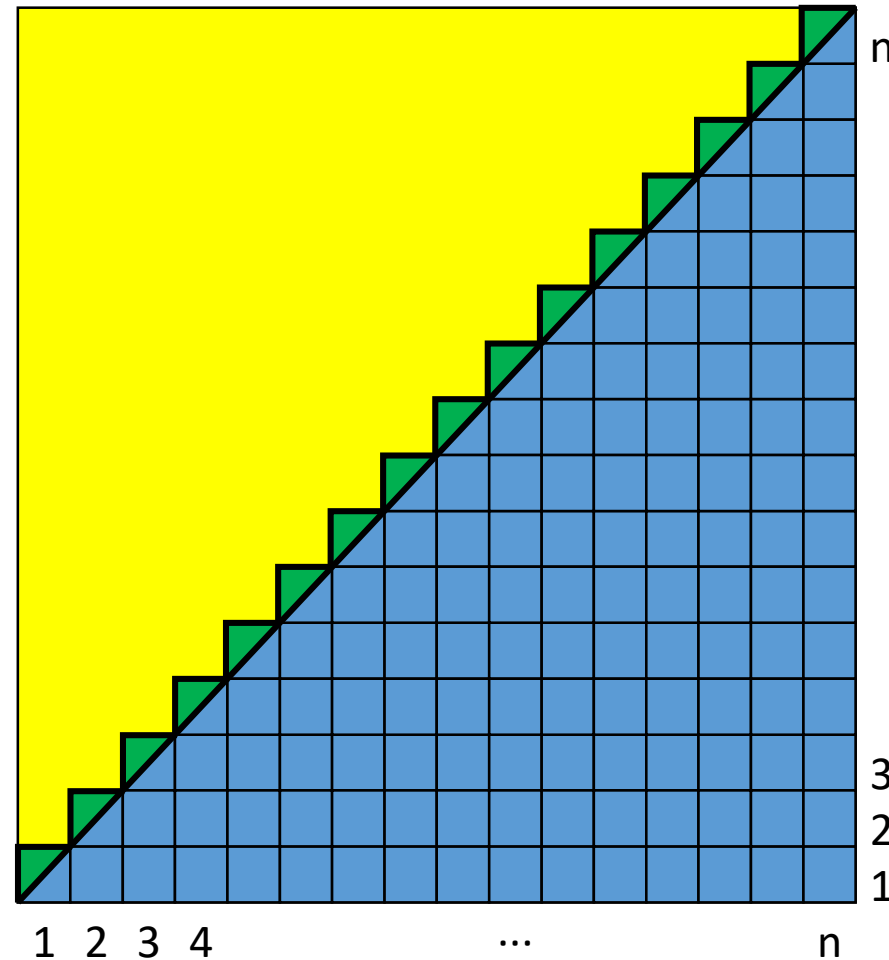
- Python and e.g. Java, C# and JavaScript have a **garbage collector** to automatically recycle garbage
- C and C++ garbage collection must be done explicitly by the program; forgetting to **free** memory again results in **memory leaks** – which can be really hard to find. **Have fun debugging!**

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 $1 + 2 + 3 + \dots + n = n^2/2 + n/2$



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

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

Python							
n	C (gcc 9.2)	C++, int (g++ 9.2)	C++, long (g++ 9.2)	Java (12.0)	Python (3.8.1)	PyPy (7.3.0)	Numba, int64
10 ⁷	0.001 sec*	0.001 sec*	0.003 sec	0.006 sec*	1.5 sec	0.27 sec	0.002 sec
10 ⁹	0.10 sec**	0.10 sec**	0.30 sec	0.40 sec**	145 sec	27 sec	0.2 sec

Wrong output (overflow)

* -2004260032 instead of 50000005000000

** -243309312 instead of 500000000500000000

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

Have fun
debugging!

```
Bit          6666666666555555555544444444443333333333222222222211111111110000000000
position     987654321098765432109876543210987654321098765432109876543210
bin(10**9)                                     111011100110101100101000000000
bin(50000005000000)                          1011010111100110001000100010010110101101000000
bin(-2004260032+2**32)                       10001000100010010110101101000000
bin(500000000500000000) 110111100000101101101011001111000101111110110010100000000
bin(-243309312+2**32)    11110001011111110110010100000000
```

Timing results

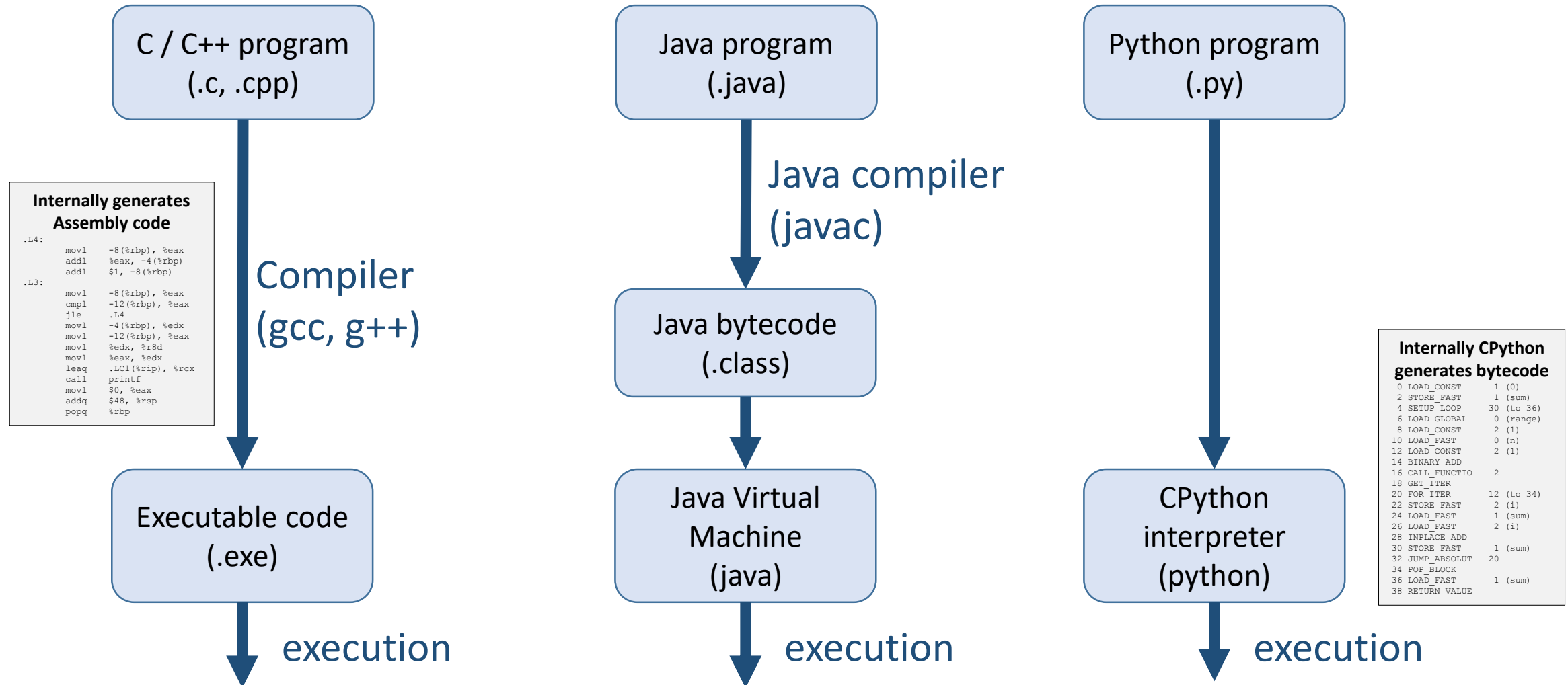
n	C (gcc 9.2)	C++, int (g++ 9.2)	C++, long (g++ 9.2)	Java (12.0)	Python		
					Python (3.8.1)	PyPy (7.3.0)	Numba, int64
10 ⁷	0.001 sec*	0.001 sec*	0.003 sec	0.006 sec*	1.5 sec	0.27 sec	0.002 sec
10 ⁹	0.10 sec**	0.10 sec**	0.30 sec	0.40 sec**	145 sec	27 sec	0.2 sec

- Relative speed

C ≈ C++ > Java >> Python

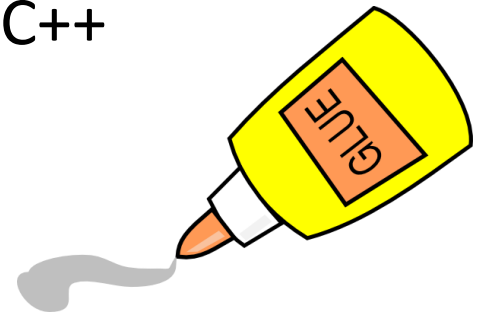
- C, C++, Java need to care about integer overflows – select integer representation carefully with sufficient number of bits (8, 16, 32, 64, 128)
- Python natively works with arbitrary long integers (as memory on your machine allows). Also possible in Java using the class `java.math.BigInteger`
- Python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

Interpreter vs Compiler



Why Python ?

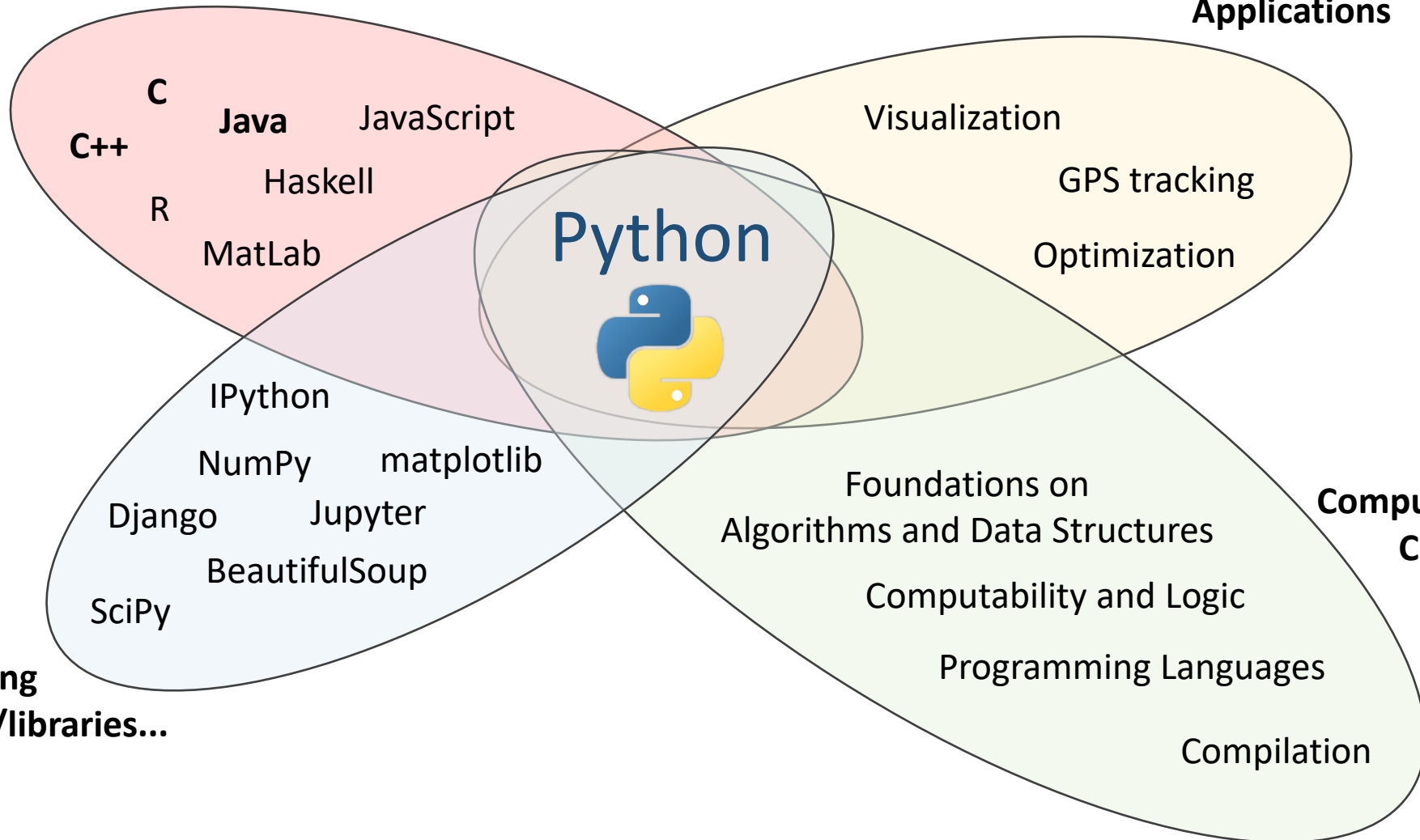
- Short concise code
- Index out of range exceptions
- Elegant for-each loop
- Python hopefully better error messages than C++
- Garbage collection is done automatically
- **Exact integer arithmetic (no overflows)**
- **Can delegate number crunching to C, C++, ...**



This course

Programming Languages

**(Scientific)
Applications**



Course overview

Basic programming
Advanced / specific python
Libraries & applications

1. Introduction to Python	10. Functions as objects	19. Linear programming
2. Python basics / if	11. Object oriented programming	20. Generators, iterators, with
3. Basic operations	12. Class hierarchies	21. Modules and packages
4. Lists / while / for	13. Exceptions and files	22. Working with text
5. Tuples / comprehensions	14. Doc, testing, debugging	23. Relational data
6. Dictionaries and sets	15. Decorators	24. Clustering
7. Functions	16. Dynamic programming	25. Graphical user interfaces (GUI)
8. Recursion	17. Visualization and optimization	26. Java vs Python
9. Recursion and Iteration	18. Multi-dimensional data	27. Final lecture

10 handins
1 final project (last 1 month)

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 3.8.1
- Python 3 is *not* backward compatible, libraries incompatible

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

Python.org

The screenshot shows the Python.org homepage. At the top, a navigation bar includes links for Python, PSF, Docs, PyPI, Jobs, and Community. Below this is the Python logo and a search bar. A secondary navigation bar contains links for About, Downloads, Documentation, Community, Success Stories, and News. The main content area features a code snippet for a Fibonacci sequence, a section titled 'Functions Defined' with a description of Python's extensibility, and a 'Learn More' link. At the bottom, four columns provide quick links: 'Get Started' (with a power icon), 'Download' (with a download icon), 'Docs' (with a document icon), and 'Jobs' (with a briefcase icon). Three red arrows are overlaid on the image: one pointing to the 'Docs' link in the top navigation bar with the text 'Documentation', one pointing to the 'Downloads' link in the secondary navigation bar with the text 'Download Python and IDLE', and one pointing to the 'PyPI' link in the top navigation bar with the text '+200.000 Python packages'.

Welcome to Python.org

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

Python PSF Docs PyPI Jobs Community

python™

Search GO Socialize

About Downloads Documentation Community Success Stories News Events

```
# 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
```

Functions Defined

The core of extensible programming is defining functions. Python allows mandatory and optional arguments, keyword arguments, and even arbitrary argument lists. [More about defining functions in](#)

1 2 3 4 5

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

Get Started
Whether you're new to programming or an experienced developer, it's easy to learn and use Python.
[Start with our Beginner's Guide](#)

Download
Python source code and installers are available for download for all versions! Not sure which version to use? [Check here](#).
Latest: Python 3.6.4 - Python 2.7.14

Docs
Documentation for Python's standard library, along with tutorials and guides, are available online.
[docs.python.org](#)

Jobs
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.
[jobs.python.org](#)

Installing Python

1. Python.org homepage: The 'Downloads' link in the navigation bar is circled.

2. Download Python | Python.org: The 'Windows' link under 'Looking for Python with a different OS?' is circled.

3. Python Releases for Windows: The 'Download Windows x86 web-based installer' link under 'Python 3.6.4 - 2017-12-19' is circled.

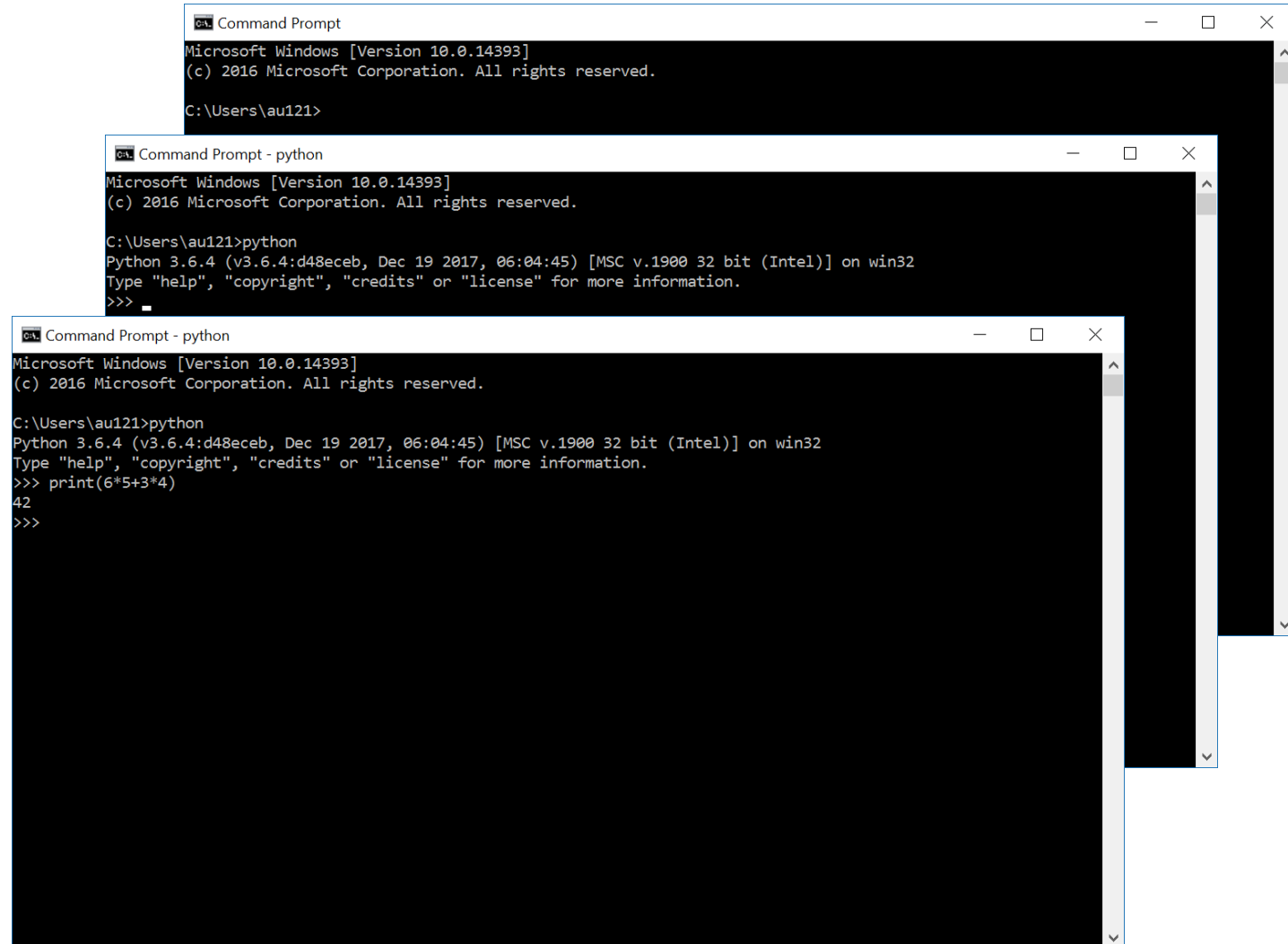
4. Python 3.6.4 (32-bit) Setup: The 'Install Now' button is circled.

5. Python 3.6.4 (32-bit) Setup: The 'Add Python 3.6 to PATH' checkbox is checked and circled.

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



The image displays three overlapping screenshots of a Windows Command Prompt window, illustrating the process of running the Python interpreter. The top window shows the standard Windows boot-up text and the user's prompt at C:\Users\au121>. The middle window shows the user typing 'python' and the system outputting the Python version (3.6.4) and architecture (MSC v.1900 32 bit (Intel)) on win32. The bottom window shows the user typing 'print(6*5+3*4)' and the system outputting the result '42'.

```
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

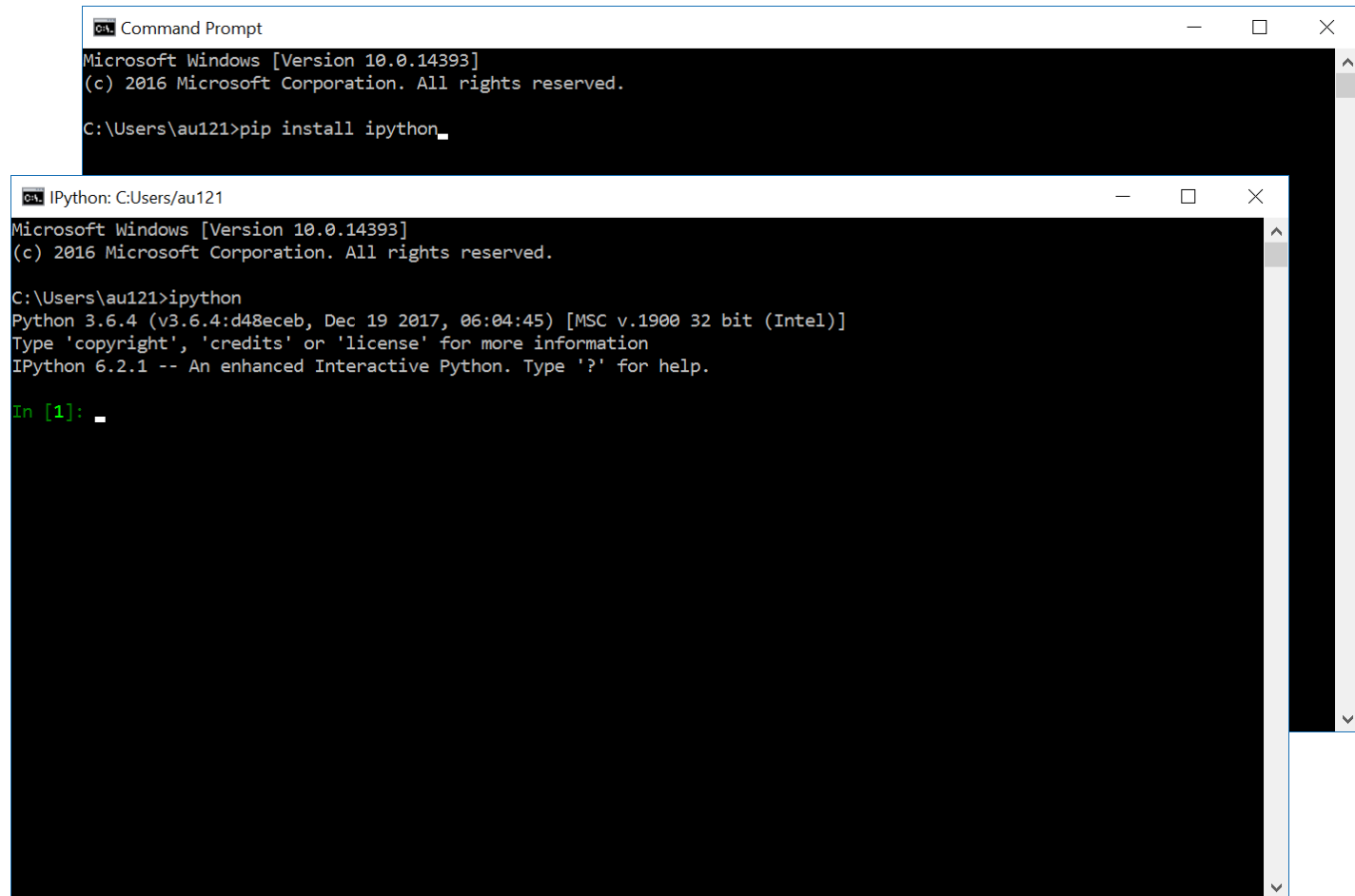
- Execute:

```
pip install ipython
```

- Start ipython

```
ipython
```

pip = the Python package manager



The image shows two overlapping Windows Command Prompt windows. The top window, titled 'Command Prompt', shows the command `pip install ipython` being entered at the prompt `C:\Users\au121>`. The bottom window, titled 'IPython: C:\Users\au121', shows the output of the command. It displays the IPython version (6.2.1) and the Python version (3.6.4) being used. The prompt is `In [1]:`.

```
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 usefull packages

- Try installing some more Python packages:

```
pip install numpy
```

linear algebra support (N-dimensional arrays)

```
pip install scipy
```

numerical integration and optimization

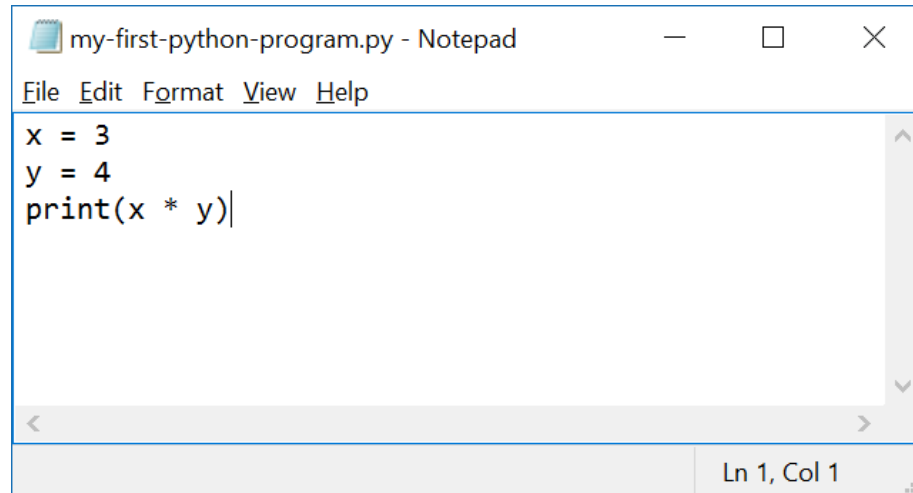
```
pip install matplotlib
```

2D plotting library

```
pip install pylint
```

Python source code analyzer enforcing a coding standard

Creating a Python program the very basic way

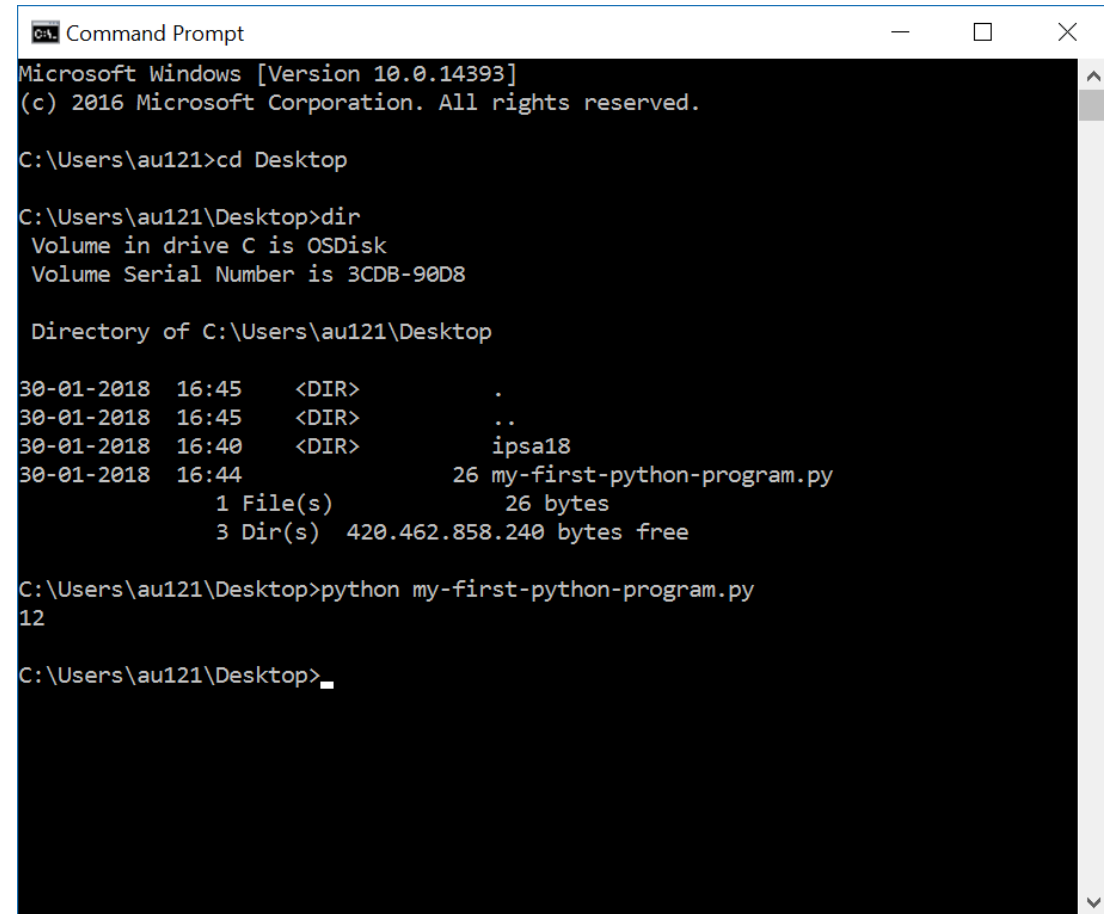


A screenshot of a Notepad window titled "my-first-python-program.py - Notepad". The window contains the following Python code:

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

The status bar at the bottom right indicates "Ln 1, Col 1".

- 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`



A screenshot of a Command Prompt window. The output shows the user navigating to the Desktop directory and listing its contents, which includes the file "my-first-python-program.py". The user then runs the program, and the output "12" is displayed.

```
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

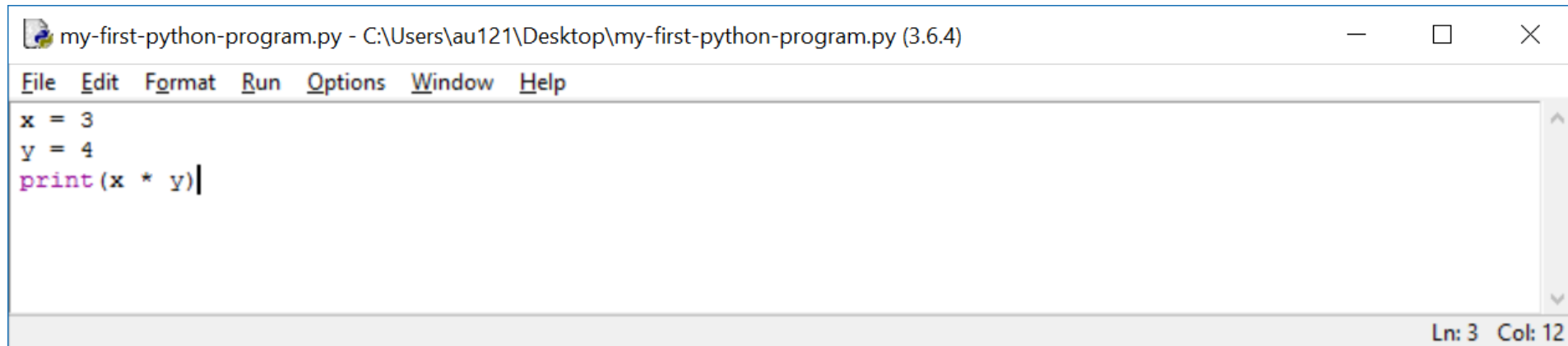
Directory of C:\Users\au121\Desktop

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

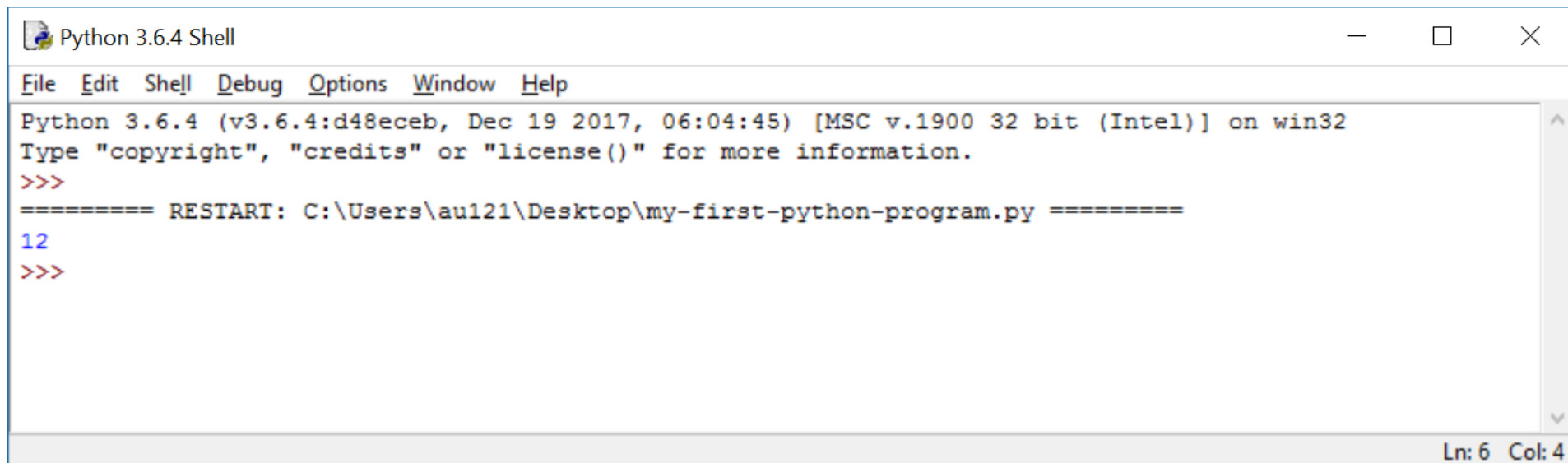
C:\Users\au121\Desktop>
```

... 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 three lines of Python code: `x = 3`, `y = 4`, and `print(x * y)`. The status bar at the bottom right indicates "Ln: 3 Col: 12".

```
my-first-python-program.py - C:\Users\au121\Desktop\my-first-python-program.py (3.6.4)
File Edit Format Run Options Window Help
x = 3
y = 4
print(x * y)
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 text: "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.", and a prompt `>>>`. Below this, it shows the execution of the program: "===== RESTART: C:\Users\au121\Desktop\my-first-python-program.py =====", followed by the output `12` and another prompt `>>>`. The status bar at the bottom right indicates "Ln: 6 Col: 4".

```
Python 3.6.4 Shell
File Edit Shell Debug Options Window Help
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
>>>
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, +200.000 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

