Programming Languages

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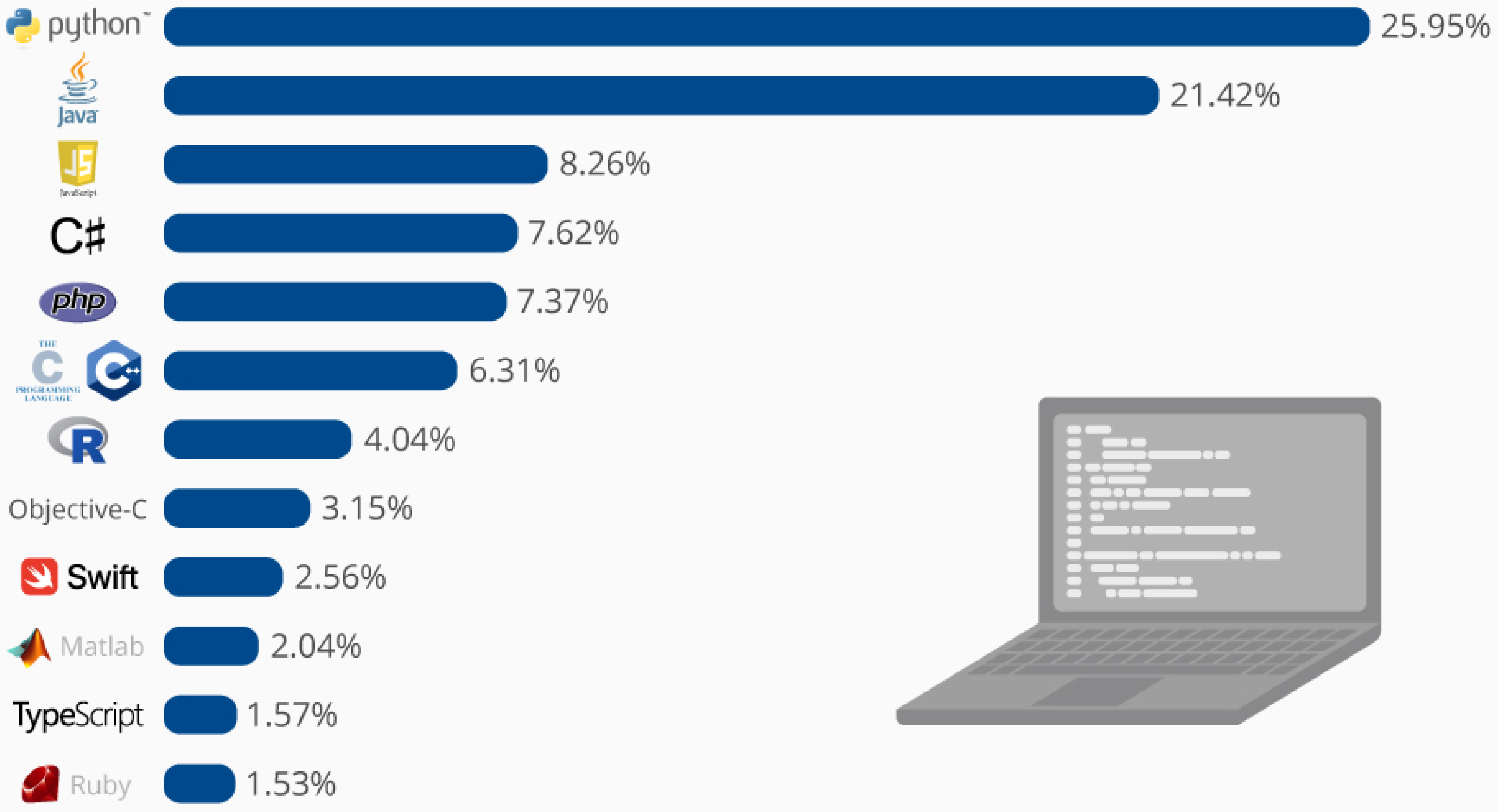
Languages

- **Symbolic** and **numeric** computing environments.
- Multi-paradigm programming languages.

The Most Popular Programming Languages

Share of the most popular programming languages in the world*



* Based on the PYPL-Index, an analysis of Google search trends for programming language tutorials.

Source: PYPL

Types of Languages

Compiled

- The code you write must be compiled, i.e., turned into machine code.
- Syntax errors will prevent the code from being compiled.
- Slower to develop with (must compile, link, run).
- Programs are (relatively) faster.
- Syntax is (tipically) not very clean.
- Good for low-level programming when you need fine control of memory or direct access to hardware.

Interpreted

- The code you write is run by an interpreter, line by line.
- Syntax errors are found when the interpreter hits that line.
- The text file is the program.
- Much faster to write and experiment in.
- Slower than compiled languages, but modern techniques and computers have vastly narrowed this gap.

Which one should you use?

- Computers are fast today.
  - There is no need to worry about memory allocation.
- Code readability and reuse tends to be more important than running time for almost all contexts.
- If things go out of control, you should
  - Use profiling for time-critical or CPU intensive code.
  - You can find the bottleneck using the current tools, avoid guessing.

You need

- A computer.
    - Best if is Unix-like.
- Anaconda/pip.
- C/C++ compilers.
- A good text editor.
    - Pick one that is easy to use and can help you.
    - Probably we'll use VSC for profiling, but you are free to use another.
    - If you like terminal editors like **emacs/(neo)vim**, there are plenty of extensions in the IDE-based ones that emulate their behavior.
    - should have
        - Syntax highlighting.
        - Line numbers.
        - Can execute code directly from the editor.
        - Aware of functions.

C++ Reminder

Basic C++ Program

```
// hello_world.cpp
// This program prints "Hello World"
#include <stdio.h> //including files
#include <string>
int main(int argc, char *argv[]) //main function
{
        // braces delimit a code block
        std::string message = "Hello World!";
        printf("%s",message.c_str()); // casting
        return 0;
        // return value to shell
}
```

We compile it

```
$g++ -std=c++11 -o hello_world hello_world.cpp
```

and execute it

```
$./hello_world
```

- We can include other C++ files using the **#include** directive.
- Each executable statement or declaration ends with a **semicolon**.
- **Curly braces** denote a code block.
- When declaring a variable of certain **type**, the type is specified before the variable or function name.
- The value to be given back by a function is specified by the **return** statement, which exits the function.
- Comments can be added using the double slashes //.

Variables

```cpp
int a = 3;
int b = -4;
int c = a + b;

double d = 4.5;
float e;
e += c;

char* str = "String Pointer.";
bool val = true;

int lista[3] = {1, 2, 3};
bool vals[4];
vals = {true, true, false, false};
```

type name [=value]

- Floating point type.
  - float, double, long double std::complex <float, complex>
- Integer type.
  - [unsigned] short, int, long, long long
- Character or string of characters:
  - char, char*, std::string
- Boolean
  - bool
- Array, pointer, class, structure, enumerated type, union, etc.

Functions

```
// functions.cpp
// Including Math Functions
#include <math.h>
#include <stdio.h>
// declaration
double exponentiation(double a, double b);

// main function, called when the program starts
int main(void){
        double x = 4;
        double y = 0.5;
        double result = exponentiation(x, y);
        printf("%f", result);
        return 0;
}

// function definition
double exponentiation(double a, double b){
        return pow(a,b);
}
```

Loops

for

```c
#include <stdio.h>
int main(){
        // initialization ; condition; increment
        for (int ii = 0; ii <= 10; ii++){
                // statements
                printf("%i", ii * ii);
        }
}
```

while

```c
#include <stdio.h>
int main(){
          int ii = 0;
          // condition
          while (ii <= 10);
                    // statement
                    printf("%i", ii * ii);
                    ii ++;
}
```

- Both loops can be stopped using **break**.

Conditionals

```
#include <iostream>
int main(){
        int ii;
        std::cin >> ii;
        if (ii > 0)
                std::cout << ii << " is greater than zero.";
        else if (ii < 0)
                std::cout << ii << " is smaller than zero.";
        else
                std::cout << ii << " is zero.";
}
```

Hands on!

Consider the Fibonacci sequence $a_0 = a_1 = 1$, $a_{n+2} = a_{n+1} + a_n$. Assume that $\lim_{n \to \infty} a_{n+1}/a_n = \phi$.

- Estimate ϕ with a relative error of at most 10^{-6}, where

$$relative\ error(n) = \left| \frac{a_{n+1}}{a_n} - \frac{a_n}{a_{n-1}} \right|$$

- For which value of n do we get this estimation?

Mathematical (driven) questions.

- What is the exact value of ϕ?
- What happens to the limit if we take arbitrary $a_0, a_1 \in \mathbb{N}$?

Let's go to Python