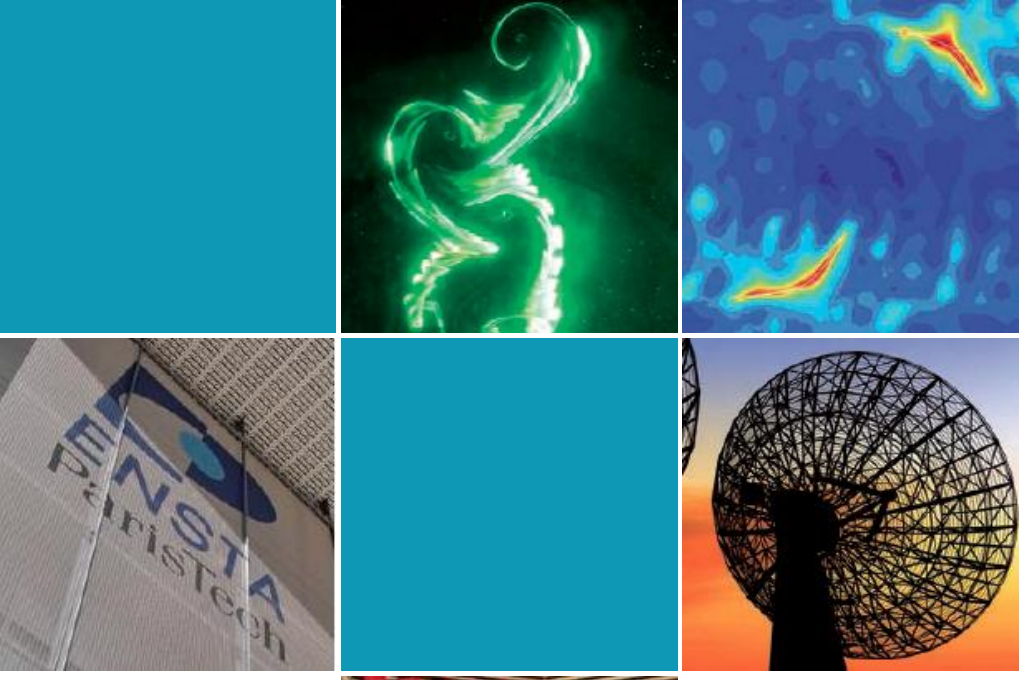


Une école
en mouvement

# IN101: Algorithmique et Programmation

F. Brandner, A. Gepperth, T. Hecht, F. Stulp, V. Paun
ENSTA ParisTech

École Nationale Supérie
de **Techniques Avanc**



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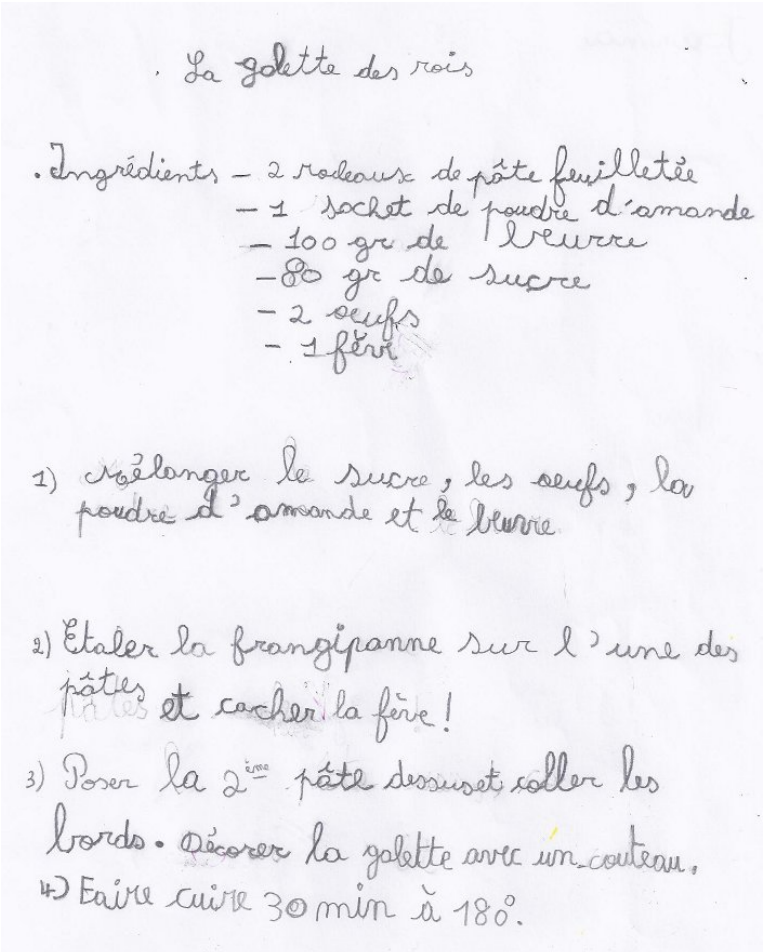
univer
PARIS-SAC

# What is an algorithm?



La galette des rois

. Ingrédients – 2 rouleaux de pâte feuilletée
– 1 sachet de poudre d'amande
– 100 gr de beurre
– 80 gr de sucre
– 2 oeufs
– 1 fève

1) mélanger le sucre, les oeufs, la poudre d'amande et le beurre

2) Etaler la frangipanne sur l'une des pâtes et cacher la fève!

3) Poser la 2ème pâte dessus et coller les bords. décorer la galette avec un couteau.

4) Faire cuire 30 min à 180°.

- An algorithm is like a cooking recipe

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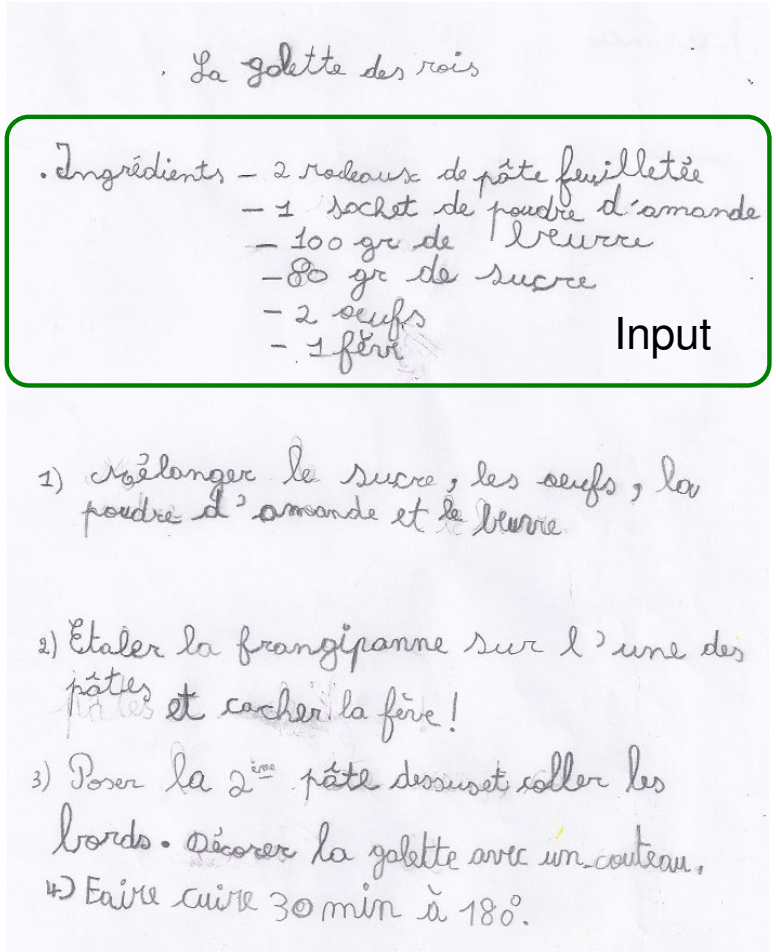


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  1. Input (*80gr de sucre, etc.*)

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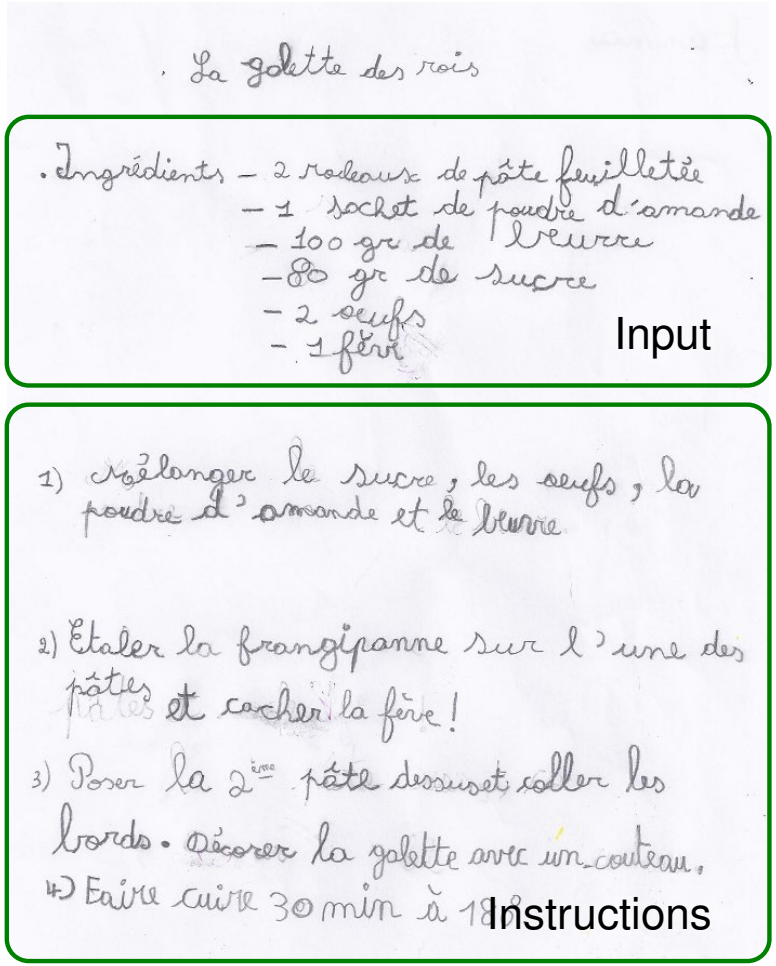


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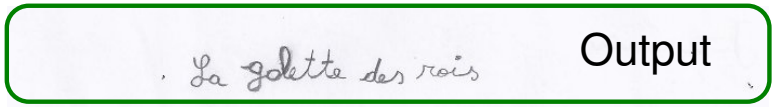


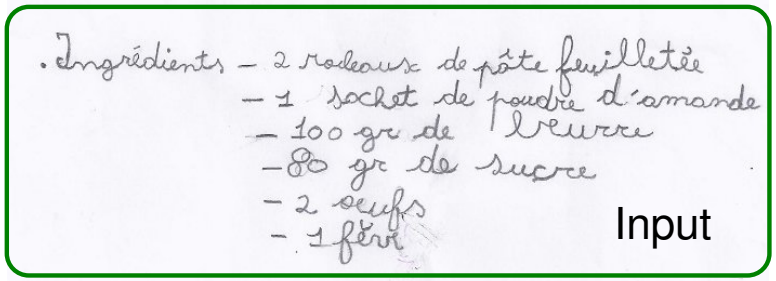


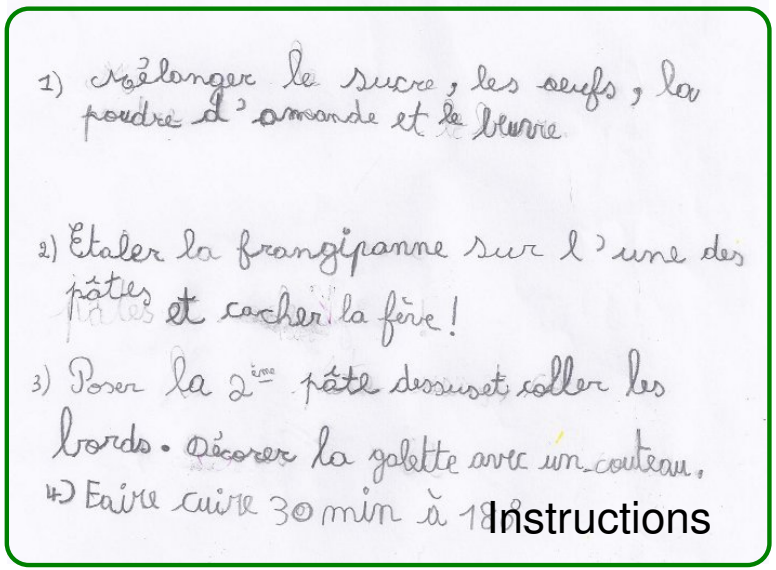


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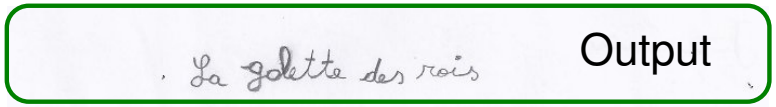


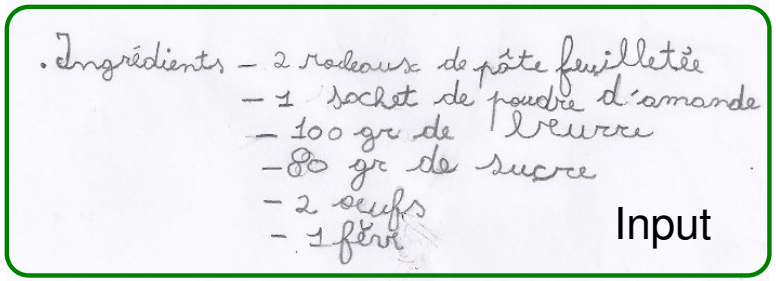


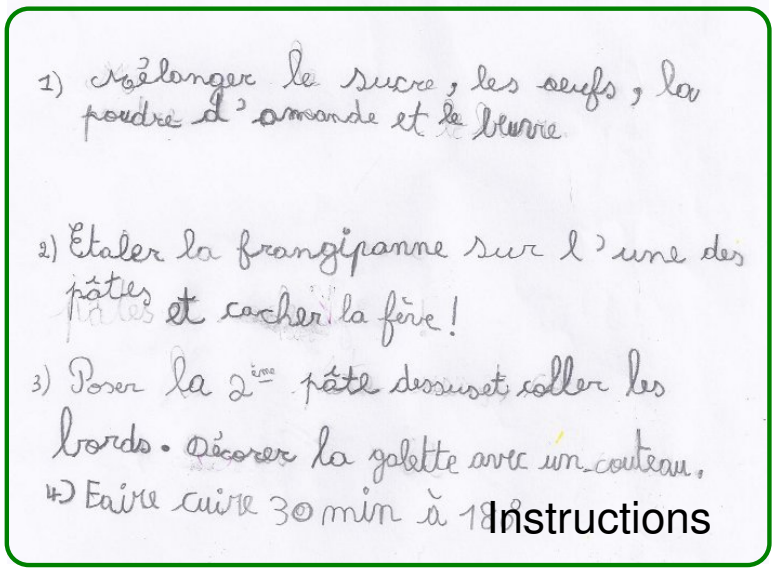


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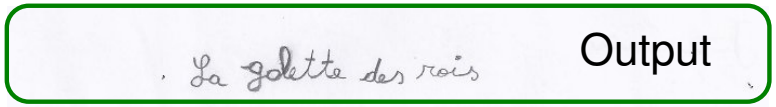


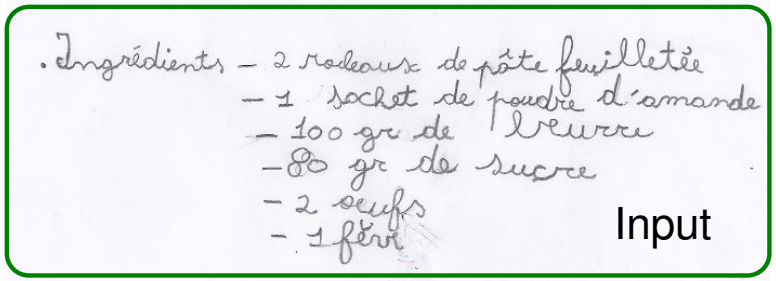


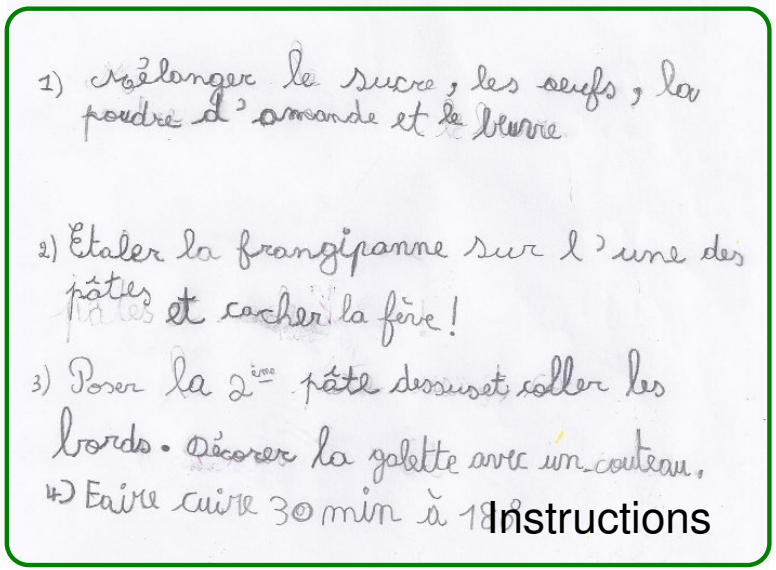


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Input:

| 5 | 1 | 4 | 2 | 3 |
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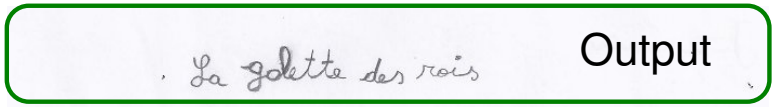


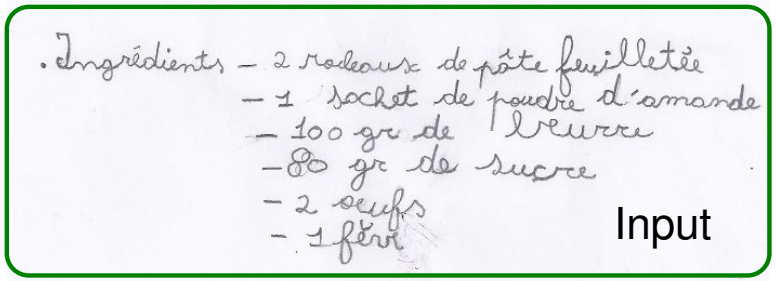


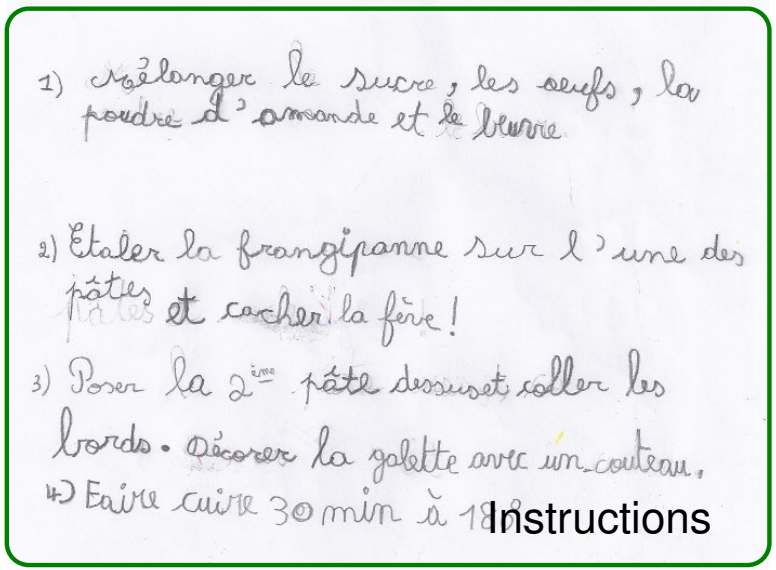


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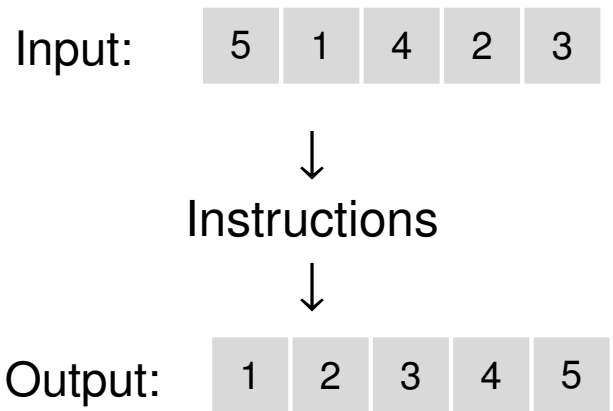

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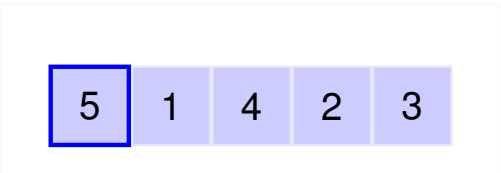

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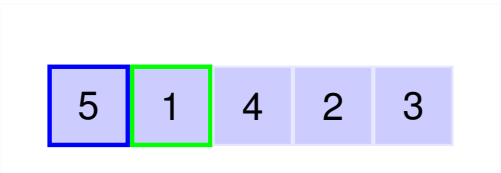

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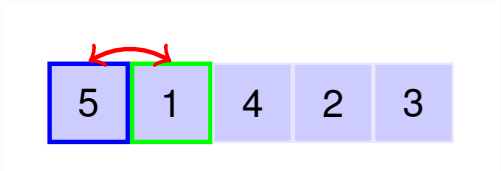

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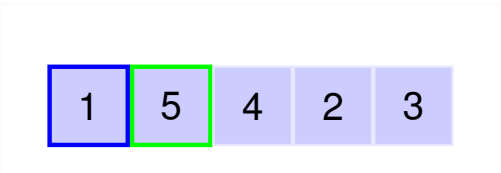

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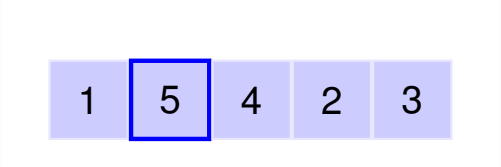

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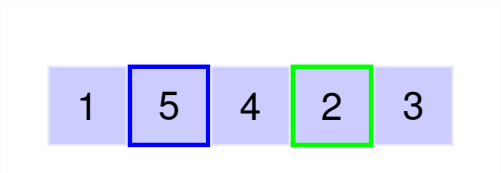

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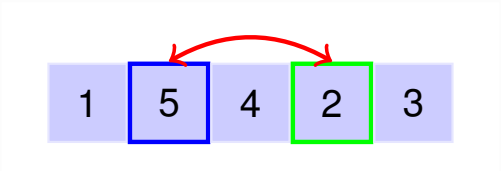

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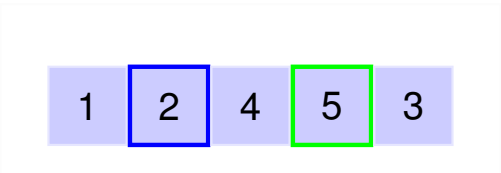

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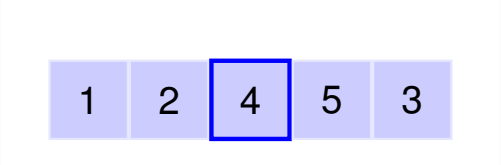

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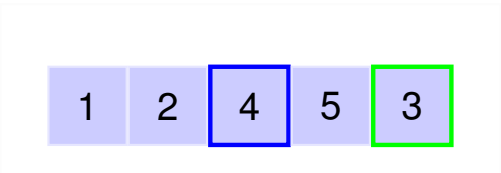

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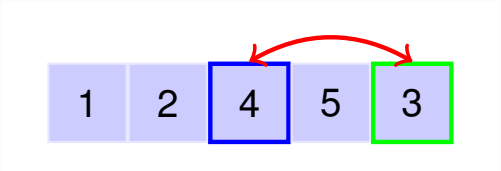

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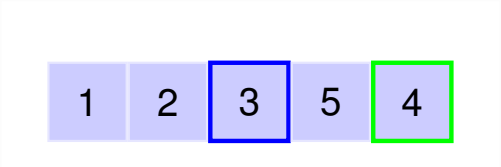

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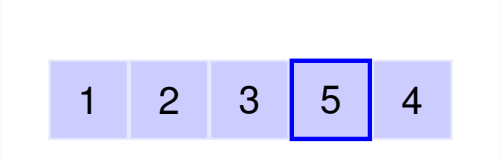

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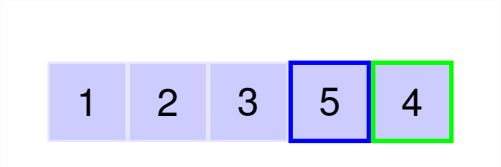

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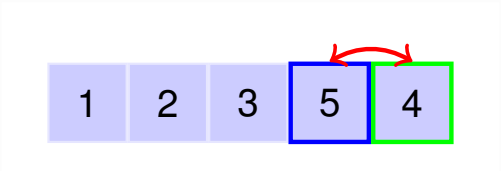

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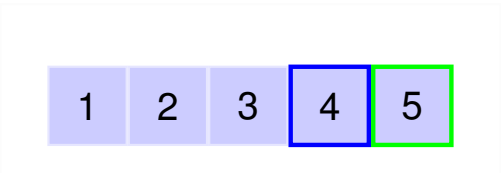

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| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

# Example Algorithm: Selection Sort

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- You call a sorting algorithm dozens of times a day!

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## Sort search results by relevance

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  - It is not magic… somewhere, a sorting algorithm is doing the work
  - Algorithms automate repetitive work, if we program them

## Sort hotels by price or stars

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- Represent algorithms in a formal language that
  - Humans can (learn to) understand and write
  - Computers can read and execute
- Example languages: C, C++, Java, Matlab, Python

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```
# Finding the smallest number
# in a list of numbers in Python

# Input
an_input = [8, 9, 6, 5]
print(an_input)

# Instructions
smallest = an_input[0]
for number in an_input:
    if (number < smallest):
        smallest = number

# Output
output = smallest
print(output)
```

# Example Algorithm: Inceptionism

- “Inceptionism: Going Deeper into Neural Networks”

  http://googleresearch.blogspot.co.uk/2015/06/inceptionism-going-deeper-into-neural.html

- Neural networks that dream!
- So what do they dream? Example...

# Outline

# IN101 Algorithmique et Programmation: Why?

Automation is everywhere!

⇒ Algorithms are everywhere!

⇒ Programming is everywhere!

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  - do an Internet search
  - use your smartphone
  - drive your car


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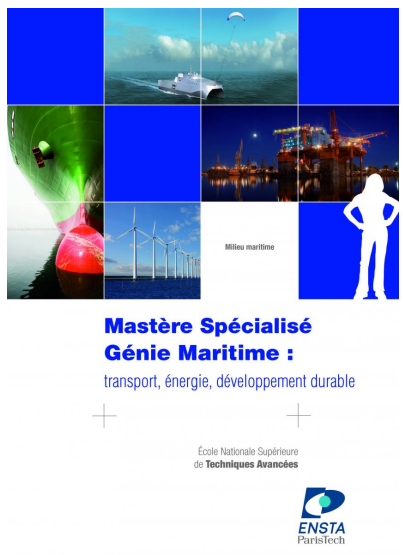


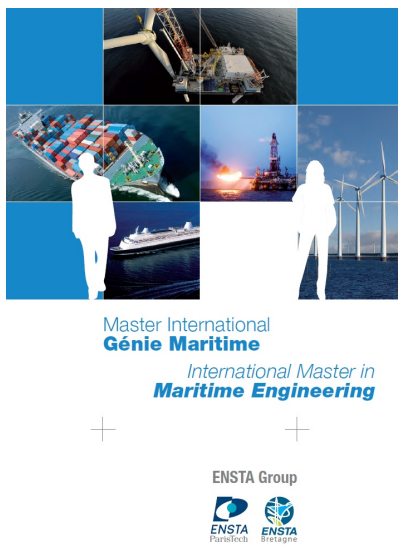

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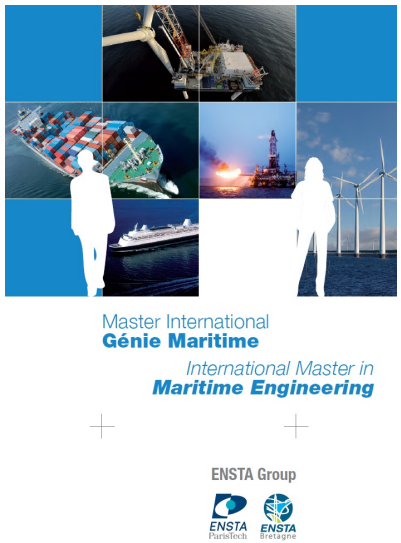


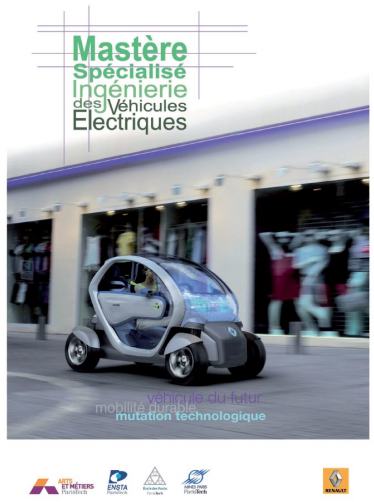

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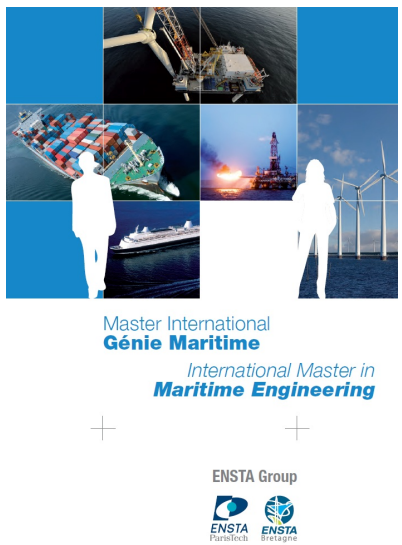


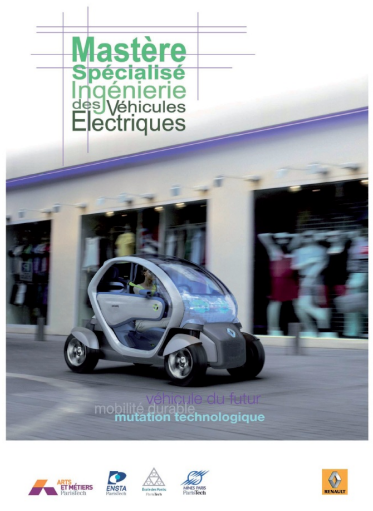


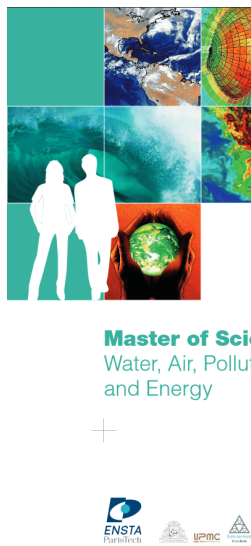

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Automation is everywhere!

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⇒ Programming is everywhere!

Two robots cooking pancakes, with algorithms written in Python and C++.

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- Objectives are to learn to
  - formulate algorithms from problem descriptions
  - implement algorithms in a programming language
    - the programming language being Python
  - apply several common algorithms in computer science
  - formulate and implement algorithms **autonomously**

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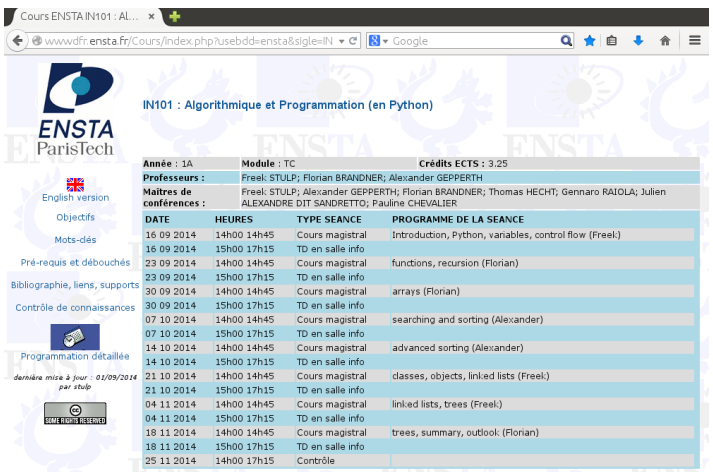
  - formulate and implement algorithms **autonomously**
- Objectives are **not** to learn
  - how algorithms/programs are executed on a computer (→ IN102)
  - all features of Python (→ `https://docs.python.org/`)
  - all programming concepts (→ IN102, IN103, IN104, IN204)

# IN101 Modalites

- Main source of information is DFR website:
  - `http://wwwdfr.ensta.fr/Cours/index.php?usebdd=ensta&sigle=IN101`
  - Schedule, links to books, links to PDFs of CM and TDs.



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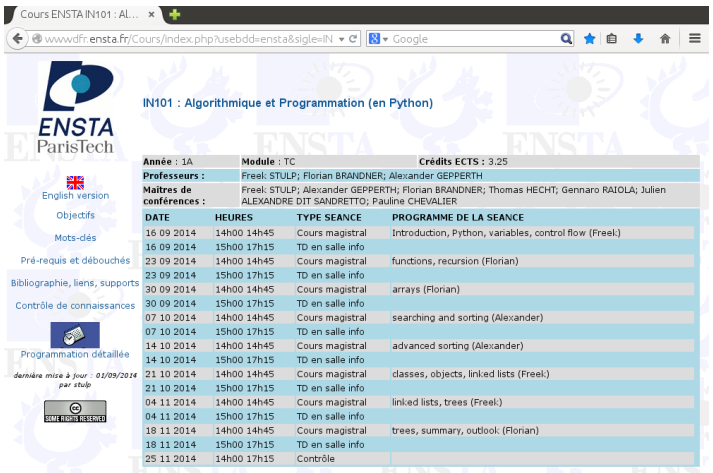
  - 15:15 – ≈16:15 “cours magistral”
  - 15 minute break
  - ≈16:30 – 18:30 “travaux dirigés”
    - programming autonomously, exercises



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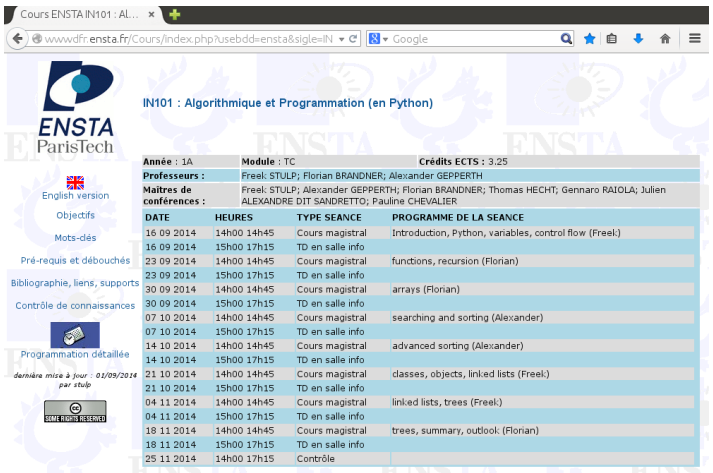
- Contrôle de connaissances, marks

  50% 1 graded TD

  50% TD8, 15.11.2016

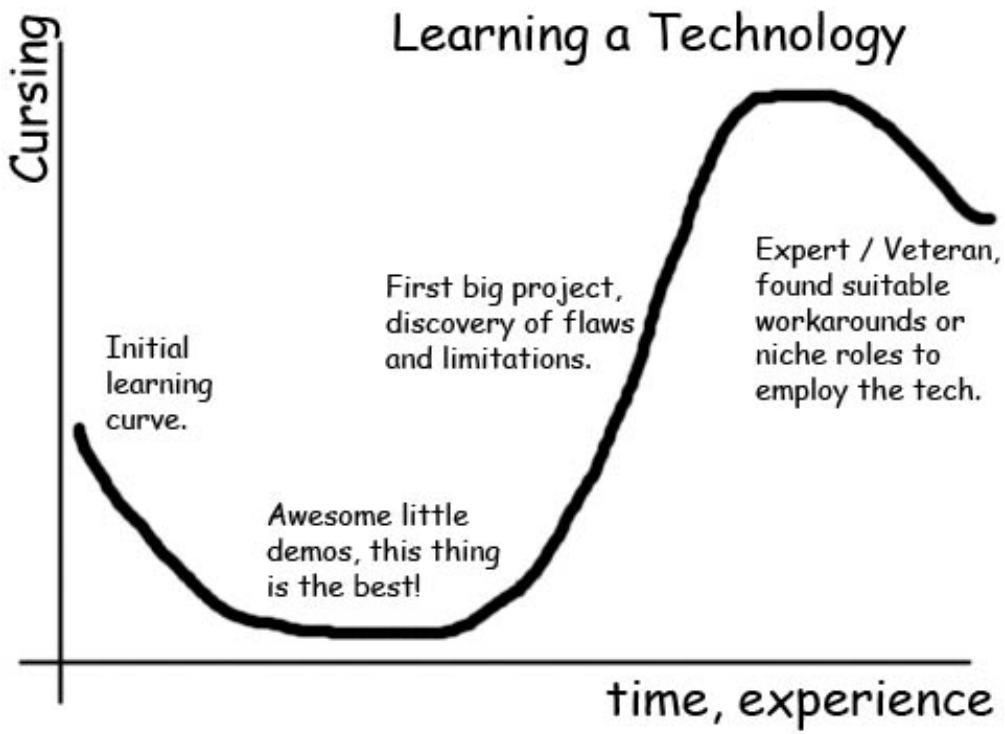


# Who are we?

- Cours magistraux (+ travaux dirigés)
  - Vladimir Paun
    - Research topics: formal methods, hard real-time system verification, WCET
    - Nationality: Romanian
    - Email: paun@ensta-paristech.fr
    - Office: R.3.28 UIIS, ENSTA ParisTech

# Who are you?

- Up until 2 years ago, 90% of the students that arrived at ENSTA had never programmed before
- But **you** have all (?) had Python in your “prépa”
  - but we don’t know at all how well you learned it...



# Who are you?

- Up until 2 years ago, 90% of the students that arrived at ENSTA had never programmed before
- But **you** have all (?) had Python in your “prépa”
  - but we don’t know at all how well you learned it...
- Our strategy
  - If you don’t know Python at all: we want you to be able to learn
    - “Basic” part of the TD
  - If you are already a hacker: we don’t want to bore you
    - “Advanced” part of the TD (you can skip “Basic”, if you want)
  - “Everyone” part of the TD: for everyone
- Please give us your (constructive) feedback!

# Outline

# Programming

- Programming: represent algorithms in a formal language that
  - Humans can (learn to) understand and write
  - Computers can read and execute
- Example languages: C, C++, Java, Matlab, Python

# Programming

- Programming: represent algorithms in a formal language that
  - Humans can (learn to) understand and write
  - Computers can read and execute
- Example languages: C, C++, Java, Matlab, Python
- Why Python in IN101?
  - easy to learn
  - emphasizes readability
  - multiple programming paradigms
  - fun!
  - you already know it from the prépa

# Origins of Python

Guido van Rossum – *“in December 1989, I was looking for a "hobby" programming project that would keep me occupied during the week around Christmas.”*

Name from *“Monty Python’s Flying Circus”*

Core philosophy: “The Zen of Python”

- Beautiful is better than ugly
- Explicit is better than implicit
- Simple is better than complex
- Complex is better than complicated

# Origins of Python

Guido van Rossum – *“in December 1989, I was looking for a "hobby" programming project that would keep me occupied during the week around Christmas.”*

Name from *“Monty Python’s Flying Circus”*

Core philosophy: “The Zen of Python”

- Préfèrer le beau au laid,
- l’explicite à l’implicite,
- le simple au complexe,
- le complexe au compliqué,

# And now for something completely different...

let's write some programs in Python!

# “Hello World” in the Python language

- Put the following in a file `helloworld.py`
  - Called a “Python script”

```
print("Hello World!")
```

# “Hello World” in the Python language

- Put the following in a file `helloworld.py`
  - Called a “Python script”

```
print("Hello World!")
```

- Execute the instructions in the script in a terminal
  - Calls the “Python interpreter”
  - Interprets the instructions and executes them one by one
  - “Reads” from top to bottom

```
commline> python3 helloworld.py
Hello World!
```

# Comments in Python

- Comments
  - Everything on a line following `#` (le dièze)
  - Ignored by the Python interpreter
  - Intended only for humans reading the script
- Why comments?
  - Documentation: explaining the code

```
# This is a Python script that will print
# "Hello World"
print("Hello World!")
```

```
commline> python3 helloworldcomments.py
Hello World!
```

# Summary

- Python is a programming language
- The Python interpreter...
  - is called from the command line (in a terminal)
  - interprets a Python script from top to bottom
  - executes the instructions in the script
  - ignore comments (everything after a #)

# Summary

- Python is a programming language
- The Python interpreter...
  - is called from the command line (in a terminal)
  - interprets a Python script from top to bottom
  - executes the instructions in the script
  - ignore comments (everything after a #)
- Writing a Python script

# Outline

# Variables

- Variables in mathematics
  - Character which is not fully specified, or unknown
  - Example: $f(x) = x^2$ (what is the value of the variable $x$?)
- Variables in computer science and programming are different...

# Variables: names and values

- Variables (in computer science/programming)
  - A name/indentifier (“a”) associated with a value (“1”)
  - Assignment: associating a variable with a value (“a = 1”)
  - The value of a variable can change


```
a = 1     # Assign value '1' to variable with name 'a'
print(a)
```

```
commline> python3 variables1.py
1
```

# Variables: names and values

- Variables (in computer science/programming)
  - A name/indentifier (“a”) associated with a value (“1”)
  - Assignment: associating a variable with a value (“a = 1”)
  - The value of a variable can change


```
a = 1     # Assign value '1' to variable with name 'a'
print(a)
a = 7     # Assign a new value to variable 'a'
print(a)
```

```
commline> python3 variables1.py
1
7
```

# Variables: names and values

- Variables (in computer science/programming)
  - A name/indentifier (“a”) associated with a value (“1”)
  - Assignment: associating a variable with a value (“a = 1”)
  - The value of a variable can change


```
a = 1     # Assign value '1' to variable with name 'a'
print(a)
a = 7     # Assign a new value to variable 'a'
print(a)
b = 3     # Assign value '3' to variable with name 'b'
print(b)
```

```
commline> python3 variables1.py
1
7
3
```

# Variables: names and values

- Variables (in computer science/programming)
  - A name/indentifier (“a”) associated with a value (“1”)
  - Assignment: associating a variable with a value (“a = 1”)
  - The value of a variable can change


```
a = 1     # Assign value '1' to variable with name 'a'
print(a)
a = 7     # Assign a new value to variable 'a'
print(a)
b = 3     # Assign value '3' to variable with name 'b'
print(b)
b = a * b  # Assign value 'a*b' (=7*3) to variable with name 'b'
print(b)
```

```
commline> python3 variables1.py
1
7
3
21
```

# Different types of variables

- What types of variables are there? Some examples
  - Numbers – whole numbers or real numbers
  - Boolean – either `True` or `False`
  - Strings – sequence of characters

```
whole_number = 1
real_number  = 1.540
boolean      = True
string       = "Hello world"
print(whole_number)
print(real_number)
print(boolean)
print(string)
```

```
commline> python3 variables2.py
1
1.54
True
Hello world
```

# Different types of variables

- What types of variables are there? Some examples
  - Numbers – whole numbers or real numbers
  - Boolean – either `True` or `False`
  - Strings – sequence of characters
- Determine variable type with `type()`

```
whole_number = 1
real_number  = 1.540
boolean      = True
string       = "Hello world"
print(type(whole_number))  # integer
print(type(real_number))   # float
print(type(boolean))       # bool
print(type(string))        # str
```

```
commline> python3 variables3.py
<class 'int'>
<class 'float'>
<class 'bool'>
<class 'str'>
```

# Different types of variables

- What types of variables are there? Some examples
  - Numbers – whole numbers or real numbers
  - Boolean – either `True` or `False`
  - Strings – sequence of characters
- Determine variable type with **`type()`**
- 'Typing' discussed in detail in IN102

```
whole_number = 1
real_number  = 1.540
boolean      = True
string       = "Hello world"
print(type(whole_number))  # integer
print(type(real_number))   # float
print(type(boolean))       # bool
print(type(string))        # str
```

```
commline> python3 variables3.py
<class 'int'>
<class 'float'>
<class 'bool'>
<class 'str'>
```

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$

```
a = 1  # Assignment operator
print(a)
a = 3  # Assignment operator
print(a)
```

```
commline> python3 operators1.py
1
3
```

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$
  - Arithmetic Operators: $+$ $-$ $*$ $/$ $**$ $\%$

```
a = 4 + 3          # Addition
print(a)
print( 4 - 3 )     # Subtraction
print( 4 * 3 )     # Multiplication
print( 4 / 3 )     # Division
print( 4 ** 3 )    # To the power of
```

```
commline> python3 operators2.py
7
1
12
1.3333333333333333
64
```

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$
  - Arithmetic Operators: $+$ $-$ $*$ $/$ $**$ $\%$

```
# Division
print( 9  / 2 )  #  => 4.5 (float)
print( 9 // 2 )  #  => 4   (int)

# Remainder (modulo operator)
print( 9 % 9 )
print( 9 % 7 )
```

```
commline> python3 operators4.py
4.5
4
0
2
```

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$
  - Arithmetic Operators: $+$ $-$ $*$ $/$ $**$ $\%$
  - Comparison Operators: $==$ $!=$ $<$ $>$ $<=$ $>=$

```
print( 4 == 3 ) # Equal?
print( 4 != 3 ) # Not equal?
print( 4 < 3 )  # Smaller than?
print( 4 > 3 )  # Larger than?

a = (4==3) # Assign result of operator
           # to variable with name 'a'
print(a)
```

```
commline> python3 operators3.py
False
True
False
True
False
```

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$
  - Arithmetic Operators: $+$ $-$ $*$ $/$ $**$ $\%$
  - Comparison Operators: $==$ $!=$ $<$ $>$ $<=$ $>=$
  - Logical Operators: and or not

```
print( 1>0  and 1>2 )          # Both true: No...
print( 1>0  or 1>2 )           # One of them true: Yes!
print( not (1>0  and 1>2) )    # Not true that both are true? Yes!
print( not not 1>0 )           # Double negation
```

```
commline> python3 operators5.py
False
True
True
True
```

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$
  - Arithmetic Operators: $+$ $-$ $*$ $/$ $**$ $\%$
  - Comparison Operators: $==$ $!=$ $<$ $>$ $<=$ $>=$
  - Logical Operators: and or not

- Expression: valid combination of value, variables and operators
  - Examples: `23` `23+4` `23+a` `2*(23+a)`
  - Examples: `True` `True and (1>0)`

# Operators

- Returns a value when evaluated (e.g. $4 + 3$ evaluates to 7)
  - Assignment Operators: $=$
  - Arithmetic Operators: $+$ $-$ $*$ $/$ $**$ $\%$
  - Comparison Operators: $==$ $!=$ $<$ $>$ $<=$ $>=$
  - Logical Operators: and or not

- Later in IN101
  - Formal definition
  - Membership and Identity Operators
  - $+=$ $-=$ $*=$ $/=$ $**=$
  - Operators are actually functions (CM02)

# Summary

- Variables are names associated with values
- Variables and values may be combined with operators
  - this yields expressions, which themselves yield values

# Outline

# Outline: Control Flow

1. for loop (“boucle for”)
2. conditional execution (“alternatives”)
3. while loop (“boucle tant que”)

# Control Flow: for loop (“boucle for”)

- What if you want to execute the same instruction several times?

```
1 number = 0
2 print(7 * number)
3 number = 1
4 print(7 * number)
5 number = 2
6 print(7 * number)
7 number = 3
8 print(7 * number)
```

```
commline> python3 forloop0.py
0
7
14
21
```

# Control Flow: for loop (“boucle for”)

- What if you want to execute the same instruction several times?
- for loop: assigns values in a list to a variable, one after the other

```
1 number = 0
2 print(7 * number)
3 number = 1
4 print(7 * number)
5 number = 2
6 print(7 * number)
7 number = 3
8 print(7 * number)
```

```
for number in [0, 1, 2, 3]:
    print(7 * number)
```

```
commline> python3 forloop0.py
0
7
14
21
```

```
commline> python3 forloop1.py
0
7
14
21
```

# Control Flow: for loop (“boucle for”)

- What if you want to execute the same instruction several times?
- for loop: assigns values in a list to a variable, one after the other
- `range()` function (→ CM2) generates sequences of numbers
  - Careful, `range(n1,n2)` stops at `n2-1`
  - `range(n)` starts at `0` and stops at `n-1`

```
1 number = 0
2 print(7 * number)
3 number = 1
4 print(7 * number)
5 number = 2
6 print(7 * number)
7 number = 3
8 print(7 * number)
```

```
for number in [0, 1, 2, 3]:
    print(7 * number)

for number in range(0, 4):
    print(7 * number)

for number in range(4):
    print(7 * number)
```

```
commline> python3 forloop0.py
0
7
14
21
```

```
commline> python3 forloop2.py
0
7
14
21
0
```

# Indentation and code blocks

- Indentation is very important in Python

# Indentation and code blocks

- Indentation is very important in Python

```
1 for number in [0, 1, 2]:
2
3     # Inside the code block
4     print(7 * number)
5
6     # Inside the code block
7     print("abc")
```

```
for number in [0, 1, 2]:

    # Inside the code block
    print(7 * number)

# Outside the code block
print("abc")
```

```
commline> python3 indentation1.py
0
abc
7
abc
14
```

```
commline> python3 indentation2.py
0
7
14
abc
```

# Indentation and code blocks

- Indentation is very important in Python
- Code block (“bloc d’instructions”)
  - A section of code which is grouped together.
  - Python groups code based on indentation

```
1 for number in [0, 1, 2]:
2
3     # Inside the code block
4     print(7 * number)
5
6     # Inside the code block
7     print("abc")
```

```
for number in [0, 1, 2]:

    # Inside the code block
    print(7 * number)

# Outside the code block
print("abc")
```

```
commline> python3 indentation1.py
0
abc
7
abc
14
```

```
commline> python3 indentation2.py
0
7
14
abc
```

# Indentation and code blocks

- Indentation is very important in Python
- Code block (“bloc d’instructions”)
  - A section of code which is grouped together.
  - Python groups code based on indentation
- Indentation: 4 spaces

```
1 for number in [0, 1, 2]:
2
3     # Inside the code block
4     print(7 * number)
5
6     # Inside the code block
7     print("abc")
```

```
for number in [0, 1, 2]:

    # Inside the code block
    print(7 * number)

# Outside the code block
print("abc")
```

```
commline> python3 indentation1.py
0
abc
7
abc
14
```

```
commline> python3 indentation2.py
0
7
14
abc
```

# Nested loop (“boucle imbriquée”)

- Nested loop: a loop inside a loop

```
for number1 in [4000, 1000]:
    for number2 in [20, 30]:
        print(number1 + number2)
```

```
commline> python3 forloopnested.py
4020
4030
1020
1030
```

# Nested loop (“boucle imbriquée”)

- Nested loop: a loop inside a loop

```
for number1 in [4000, 1000]:
    for number2 in [20, 30]:
        for number3 in [6, 7]:
            print(number1 + number2 + number3)
```

```
commline> python3 forloopnested2.py
4026
4027
4036
4037
1026
1027
1036
1037
```

# A first algorithm with `for`: factorial

- Implement factorial: $f(n) = n! = 1 \cdot 2 \cdot \cdots \cdot (n-2) \cdot (n-1) \cdot n$
  1. Basic version (only for $f(4)$, i.e. $f(4) = 1 * 2 * 3 * 4 = 24$)

```
# Algorithm: computes factorial = 4! = 1*2*3*4 = 24
factorial = 1                 #  1
factorial = 2 * factorial     #  2 <- 2*1
factorial = 3 * factorial     #  6 <- 3*2
factorial = 4 * factorial     # 24 <- 4*6

print(factorial) # Output
```

```
commline> python3 factorial0.py
24
```

# A first algorithm with `for`: factorial

- Implement factorial: $f(n) = n! = 1 \cdot 2 \cdot \cdots \cdot (n-2) \cdot (n-1) \cdot n$
  1. Basic version (only for $f(4)$, i.e. $f(4) = 1 * 2 * 3 * 4 = 24$)
  2. With for loop (only for $f(4)$)

```
# Algorithm: computes factorial = 4! = 1*2*3*4 = 24
factorial = 1
for i in [2, 3, 4]:              # 2, 3, 4
    factorial = i * factorial # 2<-2*1, 6<-3*2, 24<-4*6


print(factorial) # Output
```

```
commline> python3 factorial1.py
24
```

# A first algorithm with `for`: factorial

- Implement factorial: $f(n) = n! = 1 \cdot 2 \cdot \cdots \cdot (n-2) \cdot (n-1) \cdot n$
  1. Basic version (only for $f(4)$, i.e. $f(4) = 1 * 2 * 3 * 4 = 24$)
  2. With for loop (only for $f(4)$)
  3. With range (only for $f(4)$)

```
# Algorithm: computes factorial = 4! = 1*2*3*4 = 24
factorial = 1
for i in range(2, 4+1):          # 2, 3, 4
    factorial = i * factorial # 2<-2*1, 6<-3*2, 24<-4*6


print(factorial) # Output
```

```
commline> python3 factorial1a.py
24
```

# A first algorithm with `for`: factorial

- Implement factorial: $f(n) = n! = 1 \cdot 2 \cdot \cdots \cdot (n-2) \cdot (n-1) \cdot n$
  1. Basic version (only for $f(4)$, i.e. $f(4) = 1 * 2 * 3 * 4 = 24$)
  2. With for loop (only for $f(4)$)
  3. With range (only for $f(4)$)
  4. With input (for $f(n)$)

```
n = 4 # Input
# Algorithm: computes factorial = n! = 1*2*...*(n-2)*(n-1)*n
factorial = 1
for i in range(2, n+1):          # 2, 3, 4, ..., n-2, n-1, n
    factorial = i * factorial # 2=2*1, 6=3*2, 24=4*6, etc.


print(factorial) # Output
```

```
commline> python3 factorial2.py
24
```

# A first algorithm with `for`: factorial

- Implement factorial: $f(n) = n! = 1 \cdot 2 \cdot \cdots \cdot (n-2) \cdot (n-1) \cdot n$
  1. Basic version (only for $f(4)$, i.e. $f(4) = 1 * 2 * 3 * 4 = 24$)
  2. With for loop (only for $f(4)$)
  3. With range (only for $f(4)$)
  4. With input (for $f(n)$)

```
n = 10 # Input
# Algorithm: computes factorial = n! = 1*2*...*(n-2)*(n-1)*n
factorial = 1
for i in range(2, n+1):          # 2, 3, 4, ..., n-2, n-1, n
    factorial = i * factorial # 2=2*1, 6=3*2, 24=4*6, etc.


print(factorial) # Output
```

```
commline> python3 factorial2a.py
3628800
```

# Conditional execution (“alternatives”)

- if statement (“test si”)
  - execute intructions only if a certain condition holds

```
a = 3
b = 4
if (a < b):  # Condition (expression yielding boolean)
    print("a is smaller than b")
if (b <= a): # Condition (expression yielding boolean)
    print("b is smaller than or equal to a")
```

```
commline> python3 ifstatement.py
a is smaller than b
```

# Conditional execution (“alternatives”)

- if statement (“test si”)
  - execute intructions only if a certain condition holds
- if-then-else statement (“test si sinon”): for convencience

```
a = 3
b = 4
if (a < b):  # Condition (expression yielding boolean)
    print("a is smaller than b")
else:        # If condition above doesn't hold
    print("b is smaller than or equal to a")
```

```
commline> python3 ifthenelsestatement.py
a is smaller than b
```

# Conditional execution (“alternatives”)

- if statement (“test si”)
  - execute intructions only if a certain condition holds
- if-then-else statement (“test si sinon”): for convencience
- elif: combines else and if: for convencience

```
a = 3
b = 4
if (a < b):  # Condition (expression yielding boolean)
    print("a is smaller than b")
elif (a > b):  # Condition (expression yielding boolean)
    print("a is larger than b")
else:        # If conditions above do not hold
    print("a is equal to b")
```

```
commline> python3 ifthenelifelsestatement.py
a is smaller than b
```

# Control Flow: while loop (“boucle tant que”)

- Combines a loop with a condition
  - useful when you don’t know number of iterations in advance

```
# Print(the first multiple of 7)
# that is larger than 10000
number = 0
while (number <= 10000):
  number = number + 7
print(number)
```

```
commline> python3 whileloop.py
10003
```

# Outline

# Euclid's algorithm ($\approx$ 300 BC)

- **Specification:** Greatest common divisor ("Plus grand commun diviseur")
  - Divisors of 12: 1, 2, 3, 4, 6, 12
  - Divisors of 16: 1, 2, 4, 8, 16
  - Greatest common divisor of 12 and 16: 4

# Euclid's algorithm ($\approx$ 300 BC)

- **Specification:** Greatest common divisor ("Plus grand commun diviseur")
  - Divisors of 12: 1, 2, 3, 4, 6, 12
  - Divisors of 16: 1, 2, 4, 8, 16
  - Greatest common divisor of 12 and 16: 4
- **Algorithm:** Euclid's algorithm in English
  - Starting with a pair of positive integers, form a new pair consisting of the smaller number and the difference between the larger number and the smaller number. This process repeats until the numbers in the new pair are equal to each other; that value is the greatest common divisor of the original pair. (taken from Wikipedia)

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if (a > b):
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a = 12 # Input
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while (a != b): # continue until 'a' and 'b' are equal
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gcd = a
print(gcd) # Output
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- Why is a $>$ 2 millenia old algorithm still important today?
  - Used in security protocols (e.g. in the RSA algorithm)
  - Any secure communication (e.g. `https://`) will call this algorithm many times

# Sieve of Eratosthenes ($\approx$ 200 BC)

- Prime number ("nombre premier")
  - natural number $\{1, 2, 3, \ldots\}$
  - greater than 1
  - only 2 positive divisors: 1 and itself
- Requested algorithm
  - Input: number $n$
  - Output: all prime numbers $\leq n$

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## Sieve of Eratosthenes

- Eratosthenes of Cyrene, 276 BC – 195 BC
- Found one of the most efficient algorithms
- Explanation will have to wait until CM3...

# Prime factorization

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- Finding a fast algorithm is *really* difficult
  - if you find a fast algorithm, I will pay you 1.000.000EUR for it.

## Summary of this CM

- Algorithm
  - a recipe with input, instructions, and output
  - a set of rules that precisely defines a sequence of operations.
- Programming
  - implement algorithms in a (formal) language that can be written by a human, and executed by a computer
- Python
  - programming language, easy to learn, fun, Monty Python
  - executing instructions in a script: Python interpreter
- Python language
  - variables: names with values
  - types of values: numbers, lists, strings, booleans
  - operators: combining values and variables
  - control flow: for, if, while

## Aims of the upcoming TD

- Write your first Python program, calling the interpreter
- Design your first algorithm
- Program your first algorithms
- Create a clean, comfortable programming environment
  - Choose an editor you are proficient in
- Learn to find solutions yourself, with help from
  - the slides
  - the Python documentation: `https://docs.python.org/3/`
  - your favourite search engine
  - the books that are provided as PDFs

## Part I: Basics

| | | |
|---|---|---|
| CM1 | variables, control flow | a=1, for/if/while |
| CM2 | functions and modules | factorial(6), import math |

## Part II: Data Structures (Built-in)

| | | |
|---|---|---|
| CM3 | lists, arrays, dictionaries | [2, 3, 1] |

## Part III: Search and Sort

| | | |
|---|---|---|
| CM4 | searching/sorting | [2, 3, 1] → [1, 2, 3] |
| CM5 | Exam 1 | |

## Part IV: Linked Data Structures

| | | |
|---|---|---|
| CM6 | objects/classes | circle_object = Circle(0,1,3) |
| CM7 | linked lists | ‘a’ → ‘e’ → ‘b’ → x |
| CM8 | trees | Ψ |
| CM9 | Exam 2 | |

Have fun programming your first algorithms in the first TD!