BABEŞ-BOLYAI UNIVERSITY
Faculty of Mathematics and Computer Science

Algorithms and Programming (MIE)
Fundamental Algorithms (IA)
Computer Programming and Programming Languages (II)
Algorithms and Programming (Bioinformatics)

Lecture 1: Introduction

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Outline

- Course organization
  - Objectives
  - Content
  - Activities and evaluation

- Programming process
  - What is programming?
  - Basic elements of Python

Objectives

- Learning the most important concepts of programming
- Getting familiar with software engineering concepts (*architecture, implementation, maintainance*)
- Understanding the basic software elements
- Learning the Python programming language and using it to implement, run, test and debug programmes
- Learning and improving a programming style

Course content

- Introduction & Basic elements of Python
- Procedural programming
- Modular programming
- Abstract data types, exceptions, classes
- Software development principles
- Testing and debugging
- Recursion
- Complexity of algorithms
- Search and sorting algorithms
- Backtracking
- Recap

Course bibliography

1. The Python Programming Language - https://www.python.org/
2. The Python Standard Library - https://docs.python.org/3/library/index.html
3. The Python Tutorial - https://docs.python.org/3/tutorial/
4. M. Frentiu, H.F. Pop, Fundamentals of Programming, Cluj University Press, 2006.
5. M.L. Hetland, Beginning Python: From Novice to Professional, Apress, 2005.
6. MIT OpenCourseWare, Introduction to Computer Science and Programming in Python, https://ocw.mit.edu, 2016.
7. J. Elkner, A.B. Downey, C. Meyers, How to Think Like a Computer Scientist: Learning with Python, Samurai Media Limited, 2016.
8. K. Beck, Test Driven Development: By Example. Addison-Wesley Longman, 2002. http://en.wikipedia.org/wiki/Test-driven_development
9. M. Fowler, Refactoring. Improving the Design of Existing Code, Addison-Wesley, 1999. http://refactoring.com/catalog/index.html

Schedule

- Timetable
  - *Lectures*: **2 hours / week**
  - *Seminars*: **2 hours / week**
  - *Labs*: **2 hours / week**
- Teachers
  - Camelia Chira, camelia.chira@ubbcluj.ro
  - **MIE**: Iulia Ion, Andrei Mihai
  - **AI**: Dragos Dobrean, Mihai Loghin, Iulia Ion
  - **II**: Sara Boanca, Mihai Loghin, Iulia Ion
  - **Bioinformatics:** Raluca Chis
- Microsoft Teams
  - **MIE:** Team 2023_MIE1_AlgorithmsProgramming, Team code: **1wma0jh**
  - **AI:** Team 2023_IA1_FundamentalAlgorithms, Team code: **sqyv1zv**
  - **II**: Team 2023_II1_ComputerProgramming, Team code: **jsoy5p1**
  - **Bioinformatics**: Team 2023_Bioinf_AlgorithmsProgramming, Team code: **449dmtd**

- http://www.cs.ubbcluj.ro/~cchira

Activities and evaluation

- All activities are mandatory
  - Laboratory attendance mandatory: 90%

    Attendance list, upload lab materials online during the lab hours according to instructions received.
  - Seminar attendance mandatory: 75%

    Attendance list, respond to the quiz given during the seminar.

- Lab grading
  - *Lab assignments* are given and they each receive a grade from 1 to 10
    - Each assignment has several iterations with clear deadlines
    - There will be a penalty of 2 points for each lab delay in submitting assignments

Activities and evaluation

- **Lab activities – 30%**
  - Several assignments (work during the lab & homework)
  - **Lab grade = Average of Assignment Grades**
- **Practical exam – 30 %**
  - Practical test in last week of semester – **grade must be at least 5**
- **Final exam – 40%**
  - Conditions
    - Practical exam grade should be at least 5
    - Minimum required attendance at labs and seminars
  - Final exam grade **must be at least 5**
- **Final grade = 0.3 * Lab grade + 0.3 * Practical exam + 0.4 * Exam + Bonus (>= 5)**

Software development process

- What is programming?
- Basic elements of Python

Software development

- Hardware
  - Computers (desktops, laptops, etc) and related devices
- Software
  - Programs and systems that run on the hardware
- Programming language
  - Rules and notations to define the syntax and semantics of computer programs
- Python
  - High-level programming language
  - *Python Interpreter:* a program that allows running other programs
  - *Python Libraries:* built-in functions and types

What computers do

- Perform computations and remember results
- Store data and information in:
  - Internal memory
  - External memory (hard, memory stick, etc)
- Operate
  - With the help of the processor
- Communicate
  - Via keyboard, mouse, display
  - Network connections

Data and information

- Information – interpreting some data
  - The number 12
  - The string “abc”
- Data – a collection of symbols stored in the computer (using a certain representation)
  - 12 – 1100
  - “abc” – 97 98 99
- Processing data and information
  - Input devices transform information in data
  - Data are stored in memory
  - Output devices produce information from data
- Basic operations of processors
  - Binary representation
  - Ex. AND, OR, NOT, XOR, etc.

What is programming?

- Telling a computer what to do
  - You have to feed the computer an algorithm in some language it understands
  - Recipes and algorithms consist of ingredients (object, things) and instructions (statements)

- Creating recipes
  - a *programming language* provides a set of primitive operations
  - *expressions* are legal combinations of primitives in a programming language
  - expressions and computations have *values* and meanings

Programming languages

- Primitive constructs
  - English: words
  - Numbers, strings, simple operators
- Syntax
  - English: “Girls cat dog” vs. “Girl hugs dog”
  - 3*5 (syntactically valid)
  - “dog”5 *(not syntactically valid)*
- Semantics (which syntactically valid things have meaning)
  - English: “I are hungry”
  - 3+5
  - “dog”+5 *(semantic error)*

Where things can go wrong…

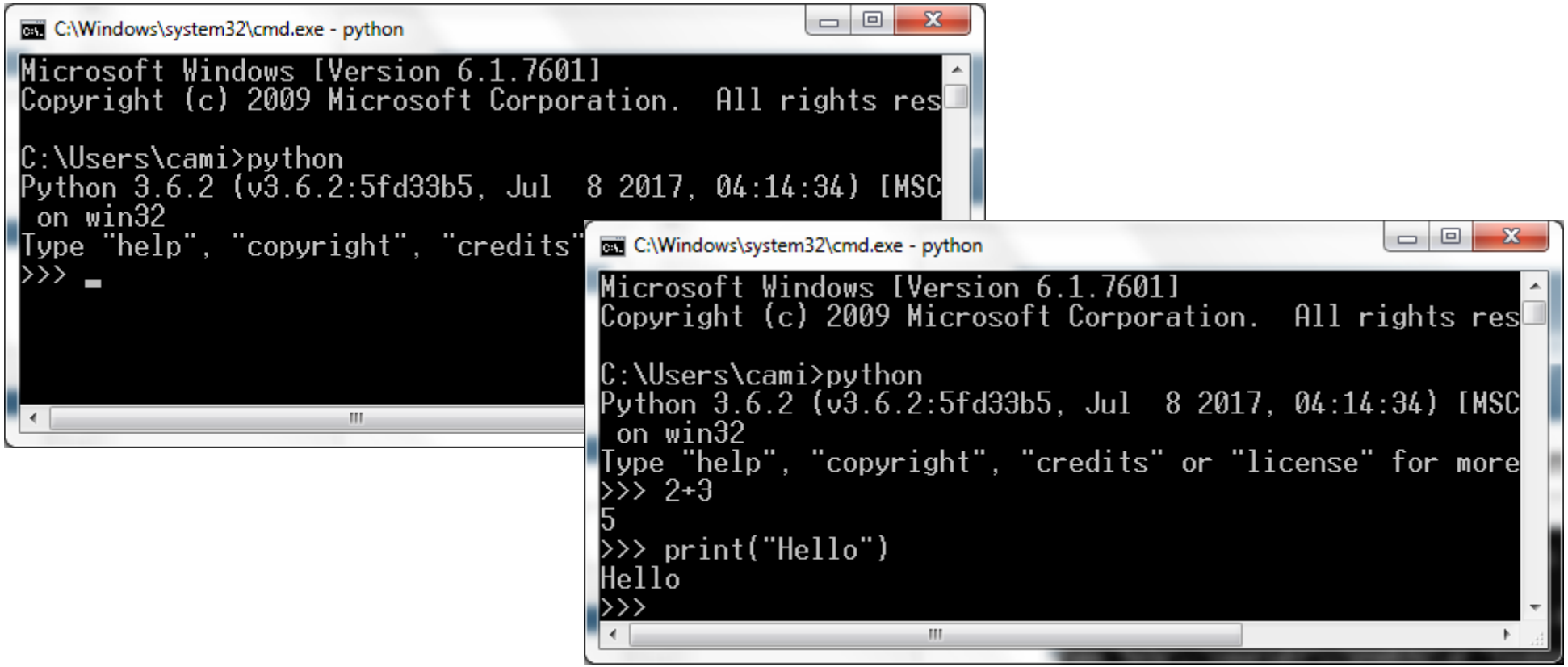
- Syntactic errors
  - Common but easy to identify and fix
- Runtime errors
  - Also called exceptions
- Semantic errors
  - Can sometimes cause unpredictable behavior
- Programming languages: a syntactically correct string of symbols has only one meaning but may not be what programmer intended
  - Different meaning than what the programmer intended
    - Program stops running (crashes)
    - Program runs forever
    - Program gives different answer than the expected one

Why Python?

- Python is a high-level programming language
  - **Interpreted**: processed at run time by the interpreter
  - **Interactive**: you can directly interact with the interpreter to write programs
  - Supports many paradigms e.g. structured, object-oriented, functional programming
  - Garbage collection
- Features
  - Easy to learn, easy to read, easy to maintain
  - Broad standard libraries
  - Portable, extendable, databases, GUI programming
- Who uses Python?
  - *Linux*: system administration tasks in several Linux distributions
  - *NASA*: as the standard scripting language in its Integrating Planning System
  - *Industrial Light & Magic*: production of special effects for large-budget feature films
  - *Google*: many componets of the Web crawler and search engine
  - Computer games and bioinformatics...etc.*who isn't using it?*

The Interactive Interpreter

- Shell mode (interactive programming)

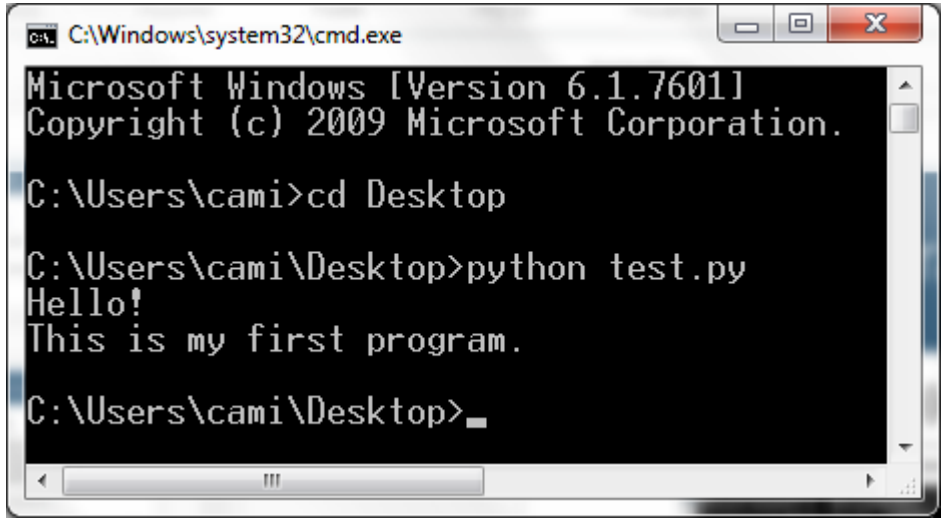


The Interactive Interpreter

- Script mode programming

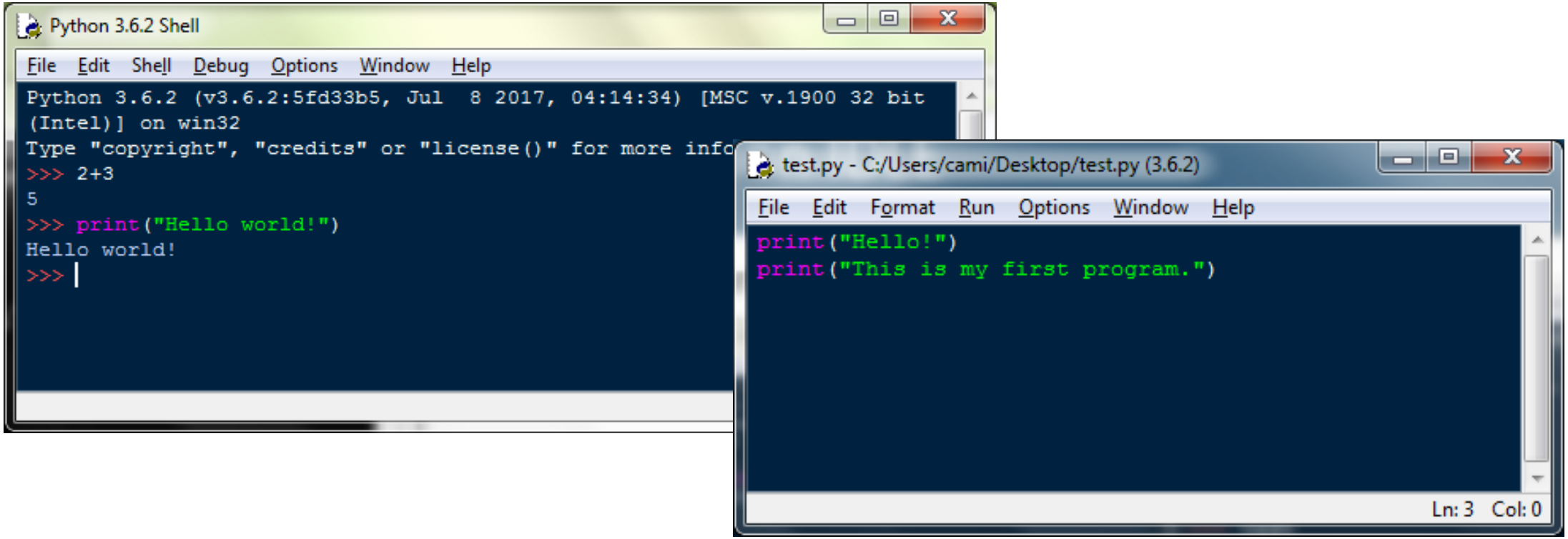
test.py

```
print("Hello!")
print("This is my first program.")
```



Python IDLE (Integrated DeveLopment Environment)

- IDLE is the standard Python development environment
- Use interactive mode or script mode programming



Python programs

- A sequence of definitions and statements. Example:

```
# takes two integers and prints their sum
a = 3
b = 4
c = a + b
print("The sum of ", a, " and ", b, " is ", c)
```

- **Lexical elements** – a Python program can have several lines
- **Comments**
  - Start with # and last to the end of line
  - Start with ’’’ and last several lines until another ’’’
- **Identifiers**
  - Name used to identify a variable, function, class, module
  - Character sequences (letters, numbers, _) starting with a letter or _
- **Literals**
  - Notations for constant values or user-defined types

Python programs

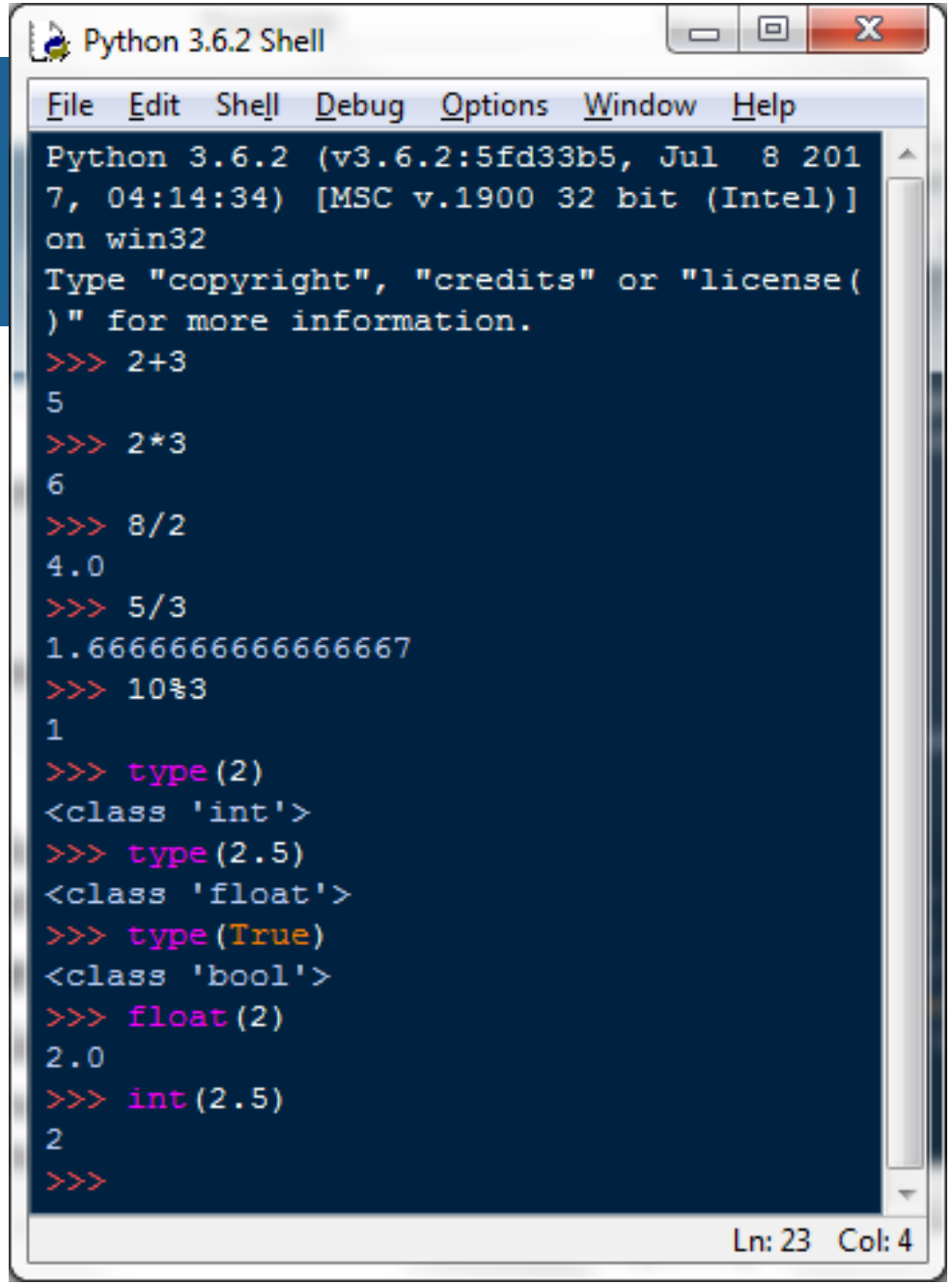
- Programs manipulate data objects
- Objects have:
  - An identity – address of the object in the memory
  - A type – determines the values the object can take and the operations possible on that object
  - A value
- Once created, the identity and type of the object can not be changed
- The value of some objects can be modified
  - Mutable objects
  - Immutable objects

Data types

- Domain – set of values
- Operations
- **Standard data types**
  - Number
  - String
  - List
  - Tuple
  - Dictionary
- **Taxonomy**
  - ***Numbers*** - immutable
  - ***Sequences*** – mutable and immutable
    - Let **s** be a sequence:
      - **len(s)** returns the number of elements in **s**
      - **s[0], s[1],...,s[len(s)-1]** are the elements of **s**
      - Example: **s=[1, 'a', 23, "abc"]**

Numeric data types

- **int**
  - represent integers ex. 1, 23
  - +, -, *, /
- **float**
  - represent real numbers ex. 3.27
  - +, -, *, /
- **bool**
  - represent Boolean values ex. True, False
  - Logic operations (and, or, not,...)
- type() - to see the type of an object
- Type conversions (cast)
  - float(2)
  - int(2.5)



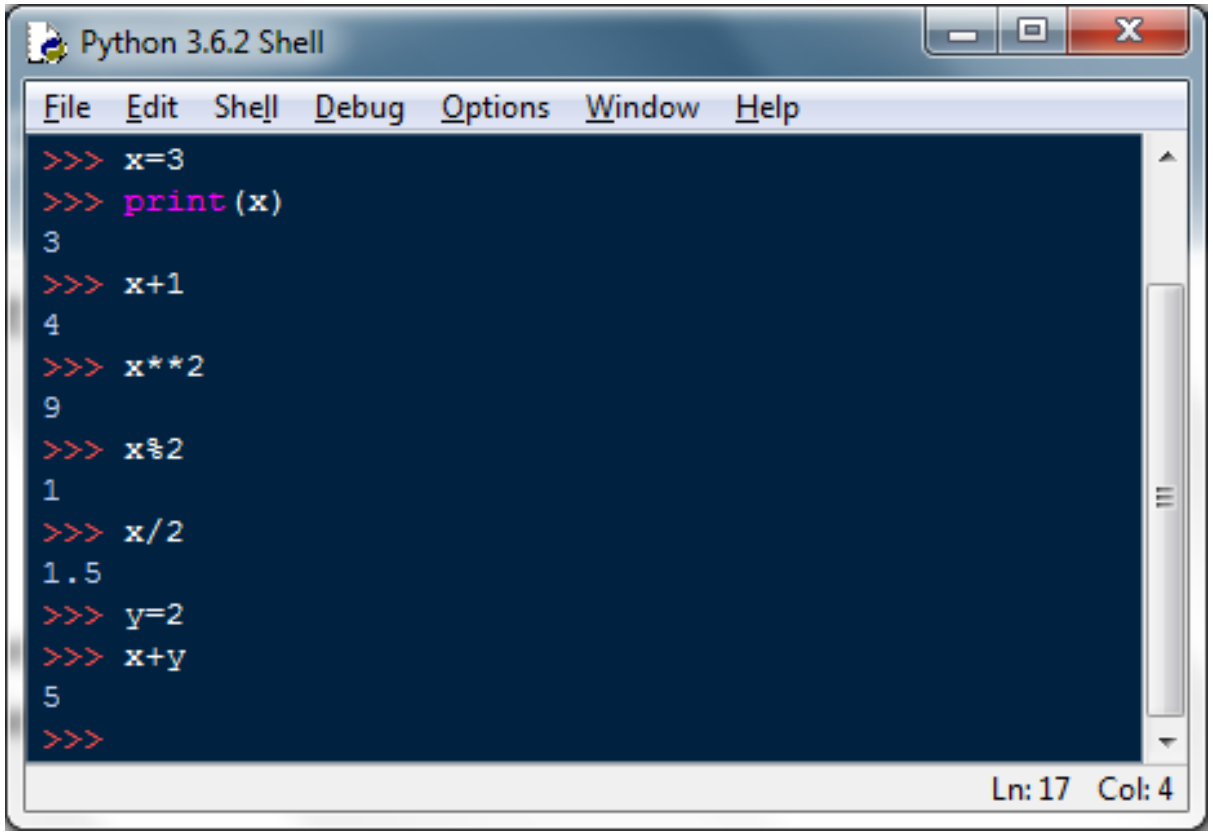
Basic elements of a Python program

- Variables
  - Locations in memory where data is stored
  - Have a name, a datatype and a value
  - Introducing a variable in a program – assignment
- Expressions
  - A combination of values, constants, variables, operators and functions which are interpreted according to precedence rules, computed and evaluated to a value
  - Examples
    - Numerical expression: 1 + 2
    - Boolean expression : 1 < 2
    - String expression : “1” + ”2”
- Statements

Variables and expressions

- A variable is a name that represents some value
- Assignment: x=3
- Expressions
  - Combine objects and operators
  - An expression has a value -> type
  - Ex. x+1, x**2

x+y	sum (result is int if both x and y are int, float if x or y is float)
x-y	Difference
x*y	Product
x/y	division (result is float)
x%y	remainder
xy**	power



Statements

- The basic operations of a program
- Taxonomy
  - Assignments
    - (Re-)binding variable names to values and changing the value of mutable objects
    - Binding: `x = 1, s = [1, 2]`
    - Re-binding: `x = x + 2, s[0] = 3`
  - Blocks
    - Part of a program executed as a unit
    - Sequence of statements
    - Identified using identation
  - Conditional statements
  - Loops

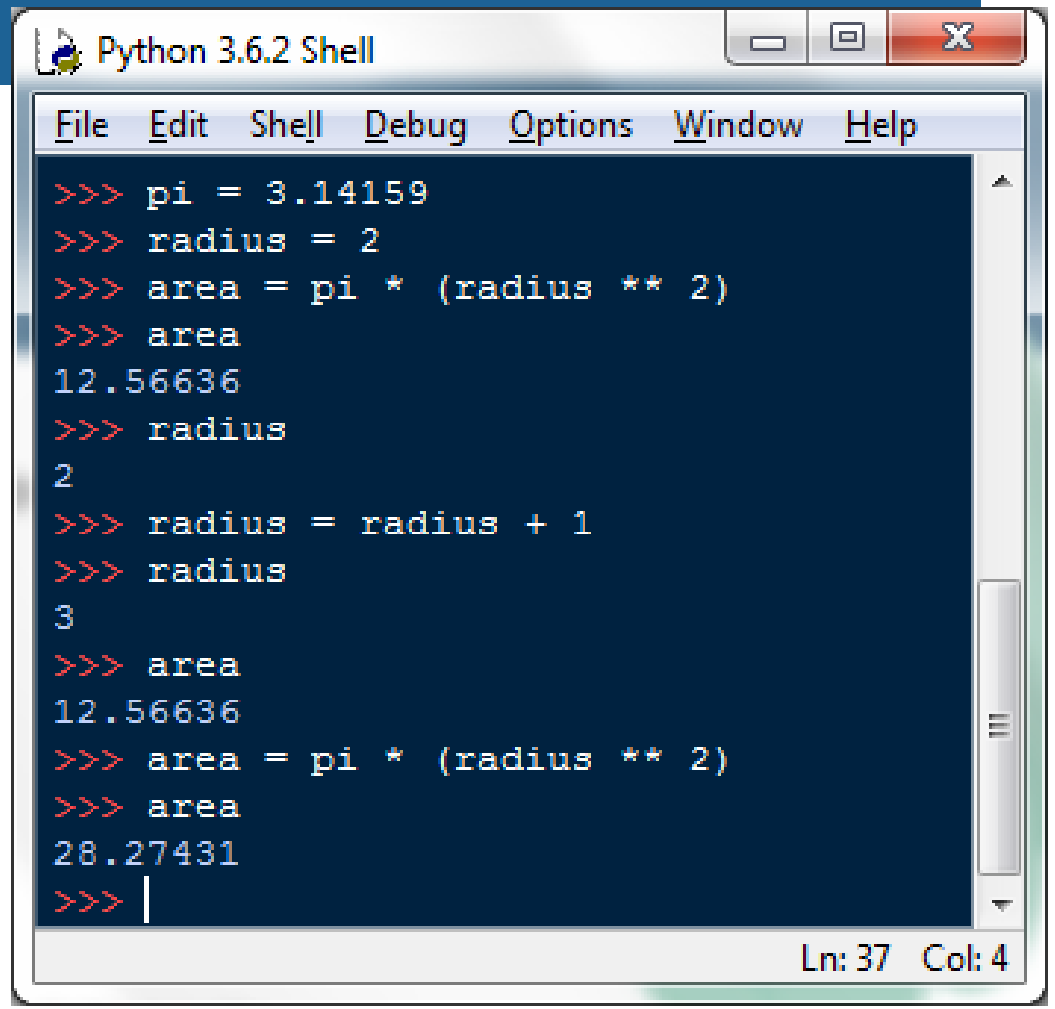
Assignments

- *On the left:* variable name
- *On the right:* expression, evaluated to a value

```
pi = 3.14159
radius = 2
# area of circle
area = pi * (radius ** 2)
radius = radius + 1
```

- Changing bindings:
  - Re-bind variables using new assignment statements
  - Previous value may still be stored – no handle to it
- Multiple assignments:

```
a = b = c = 1
a, b, c = 1, 2, "Zara"
```



Comparison and logic operators

- Comparison operators (int, float, string)
  - `a > b`
  - `a >= b`
  - `a < b`
  - `a <= b`
  - `a == b` (equality test, `True` if `a` is the same as `b`)
  - `a != b` (inequality test, `True` if `a` is not the same as `b`)
- Logic operators (bool)
  - **`not`** a (True if a is False, False if a is True)
  - a **`and`** b (True if both are True)
  - a **`or`** b (True if either or both are True)

```
my_age = 40
your_age = 20
print(my_age < your_age) # False

age = my_age >= 18 # True
license = False

b = age and license
print(b) # False
```

Conditional statements

```
if <condition>:
        <expression>
        <expression>
        ...
```

- Control flow – branching

```
# takes two integers and prints their max
a = 3
b = 4
if (a < b):
    c = b
else:
    c = a
print("The max of ", a, " and ", b, " is ", c)
```

```
if <condition>:
        <expression>
        ...
else:
        <expression>
        ...
```

```
if <condition>:
        <expression>
        ...
elif <condition>:
        <expression>
        ...
else:
        <expression>
        ...
```

Indentation

- Important in Python
- Blocks of code are identified using indentation

```
if a == b:
    print("a and b are equal")
    if b != 0:
        print(", meaning a/b =", a/b)
elif (a < b):
    print("a = ", a, " is smaller")
else:
    print("b = ", b, " is smaller")
print("The end")
```

Control flow: while and for Loops

- while

```
i = 0
while i < 10:
    print(i)
    i = i + 1
```

```
while <condition>:
        <expression>
        <expression>
        ...
```

- for

```
for i in range(10):
    print(i)
```

```
for <variable> in range(<some_num>):
        <expression>
        <expression>
        ...
```

range(start, stop, step)

- Starts with `value = start` (default `start = 0`)
- Each step, `value = value + step` (default `step = 1`)
- Loops until `value = stop - 1`

```
s = 0
for i in range(5):
    s += i
print(s)
```

```
s = 0
for i in range(1, 5, 2):
    s += i
print(s)
```

Example

```
# computes the gcd of two numbers
a = 42
b = 18
if a == 0:
    gcd = b
else:
    if b == 0:
        gcd = a
    else:
        while a != b:
            if a > b:
                a = a - b
            else:
                b = b - a
        gcd = a
print("gcd = ", gcd)
```

break Statement

- Exits a loop and skips the rest of the block

```
while <condition_1>:
        while <condition_2>:
                <expression_a>
                break
                <expression_b>
        <expression_c>
```

```
s = 0
for i in range(2, 10, 2):
    s += i
    if s == 2:
        break
        s = s + 1
    s += 10
```

Recap today

- Programming process
  - What is programming?
  - Basic elements of Python

Next time

- More on Python basics

- Procedural programming
  - Functions
  - Variables
  - Parameters
  - Testing

Reading materials and useful links

1. The Python Programming Language - https://www.python.org/
2. The Python Standard Library - https://docs.python.org/3/library/index.html
3. The Python Tutorial - https://docs.python.org/3/tutorial/
4. M. Frentiu, H.F. Pop, Fundamentals of Programming, Cluj University Press, 2006.
5. M.L. Hetland, Beginning Python: From Novice to Professional, Apress, 2005.
6. MIT OpenCourseWare, Introduction to Computer Science and Programming in Python, https://ocw.mit.edu, 2016.
7. J. Elkner, A.B. Downey, C. Meyers, How to Think Like a Computer Scientist: Learning with Python, Samurai Media Limited, 2016.