Python Programming for Data Science

Week 36, Monday

- Introduction to programming - our first program
- Variables and types:
  - numeric and boolean
  - strings

Introduction to programming - our first program

Programs

A program is a sequence of instructions to a computer

Example: Assembly (low level language)

```
.MODEL SMALL

.CODE

MOV AH,2    ; COMMAND TO PRINT CHAR
MOV DL,'J'  ; CHARACTER TO PRINT
INT 21h     ; INTERRUPT TO PRINT CHAR
INT 20h     ; RETURN SAFELY

END
```

Programs

Higher-level languages are easier to read:

Python

```
for i in range(10):
    print("i = ", i)
```

Java

```
for (int i=0; i<10; i++) {
    System.out.println("i = " + i);
}
```

Ruby

```
for i in 0..9
    puts "i = #{i}"
end
```

C++

```
for (int i=0; i<10; i++) {
    std::cout << "i = " << i << "\n";
}
```

...and they often share concepts and structure.

Compilation or interpretation

Translation of high-level languages into machine code can be done by either:

- compilation
- interpretation
- both

Compilation

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Not as common as it used to be - typically used by C, C++ and Fortran.

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Results in very slow execution.

Virtually extinct in modern programming languages. Only shell scripting languages (e.g. bash) do this.

Compilation followed by interpretation

Source code is translated from a high-level language into intermediate language and typically saved to a file.

The intermediate language is interpreted statement by statement. This interpreter is called a Virtual Machine.

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The intermediate language is interpreted statement by statement. This interpreter is called a Virtual Machine.

Execution speed depends on the details.

Most modern languages are implemented like this - Java, C#, Perl, Python, Ruby, etc.

Why Python?

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It is (mostly) platform independent.

It is easy to learn

It encourages (enforces) clean, well-structured code

Python limitations

Speed

Python limitations

Speed

...but this can often be overcome by implementing performance-critical parts in C-modules.

Python2 vs Python3

- Almost the same, but not quite
  - Python3 was released in 2008, as a major cleanup of the Python language. It was not backwards compatible.

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  - Used to be the main argument for not switching. But basically all libraries are now ported.

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Library support?

Used to be the main argument for not switching. But basically all libraries are now ported.

"But I don't like Python3"

Get over it. Python2 is dead. Development of Python2 has ceased since 2020.

Python2 vs Python3 (2)

Q: What is the main difference for a beginner like me?

Python2 vs Python3 (2)

Q: What is the main difference for a beginner like me?

A: print behaves differently

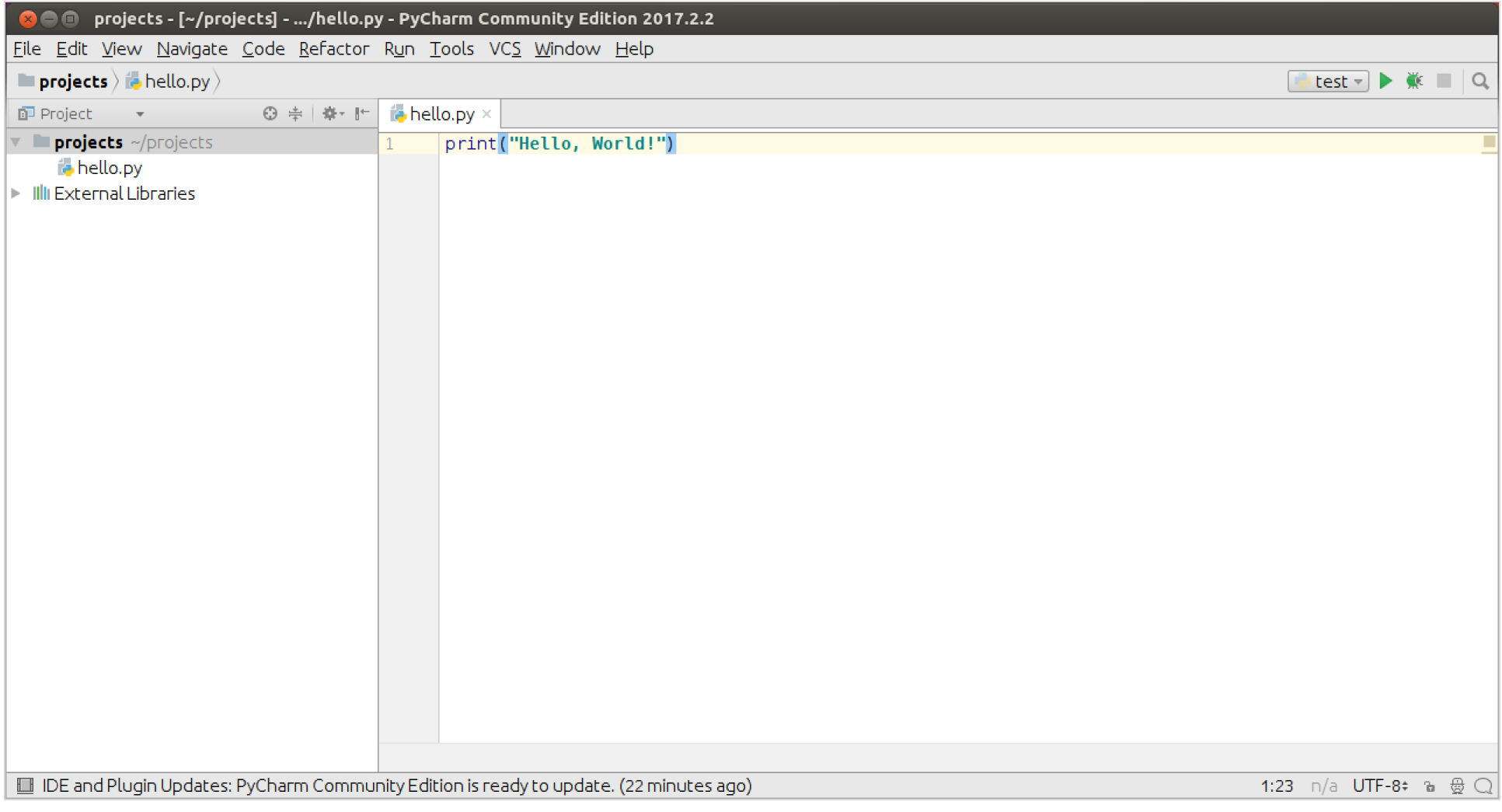
```
print "Hello world!"     # Python 2
print("Hello world!")    # Python 3
```

Jumping in...

Jumping in...

(If you don't have a working Python installation yet - don't worry: you can do today's basic Python exercises in a browser using Google Colab - click on this link to get started.)

The IDE: PyCharm



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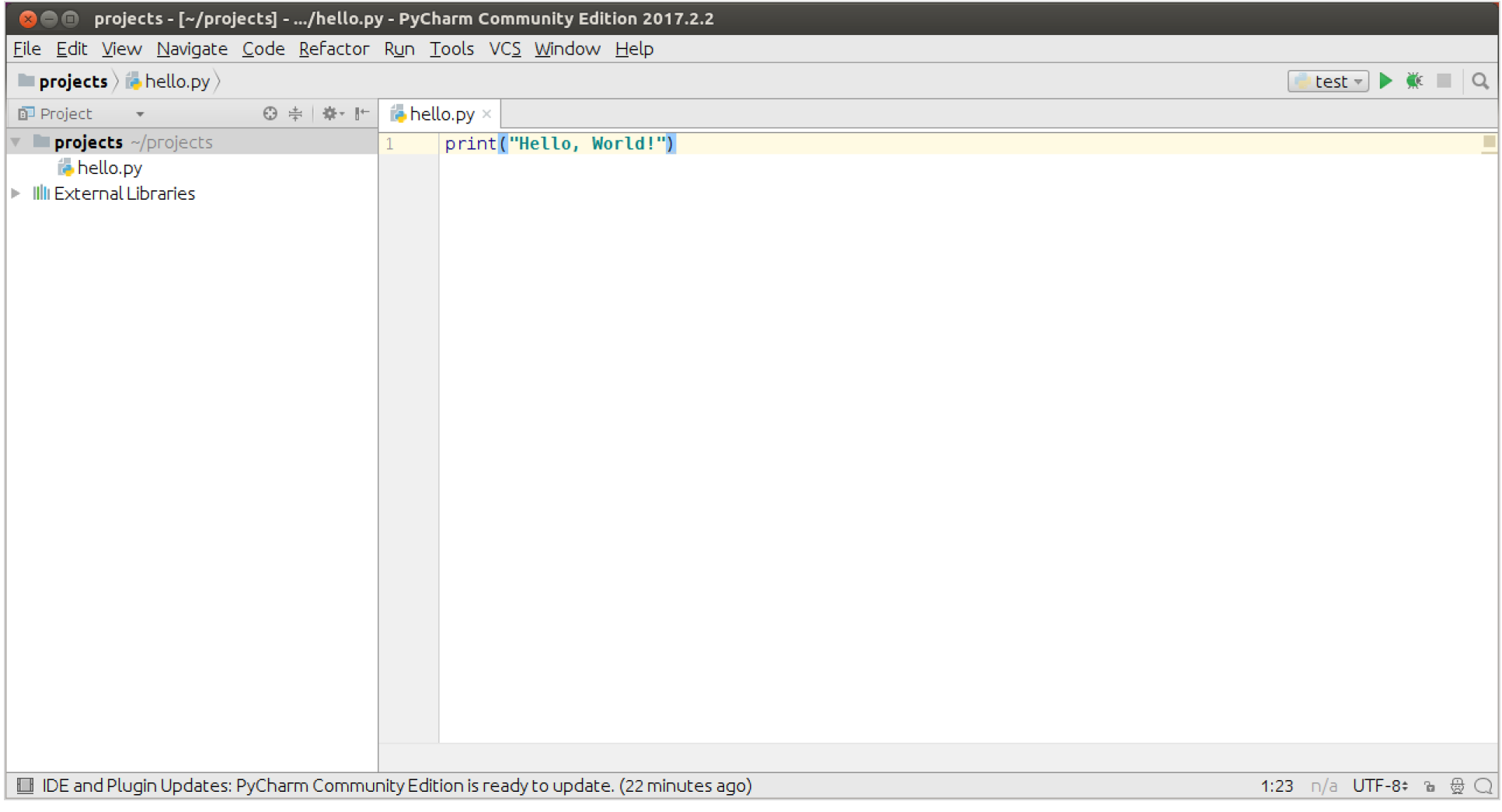
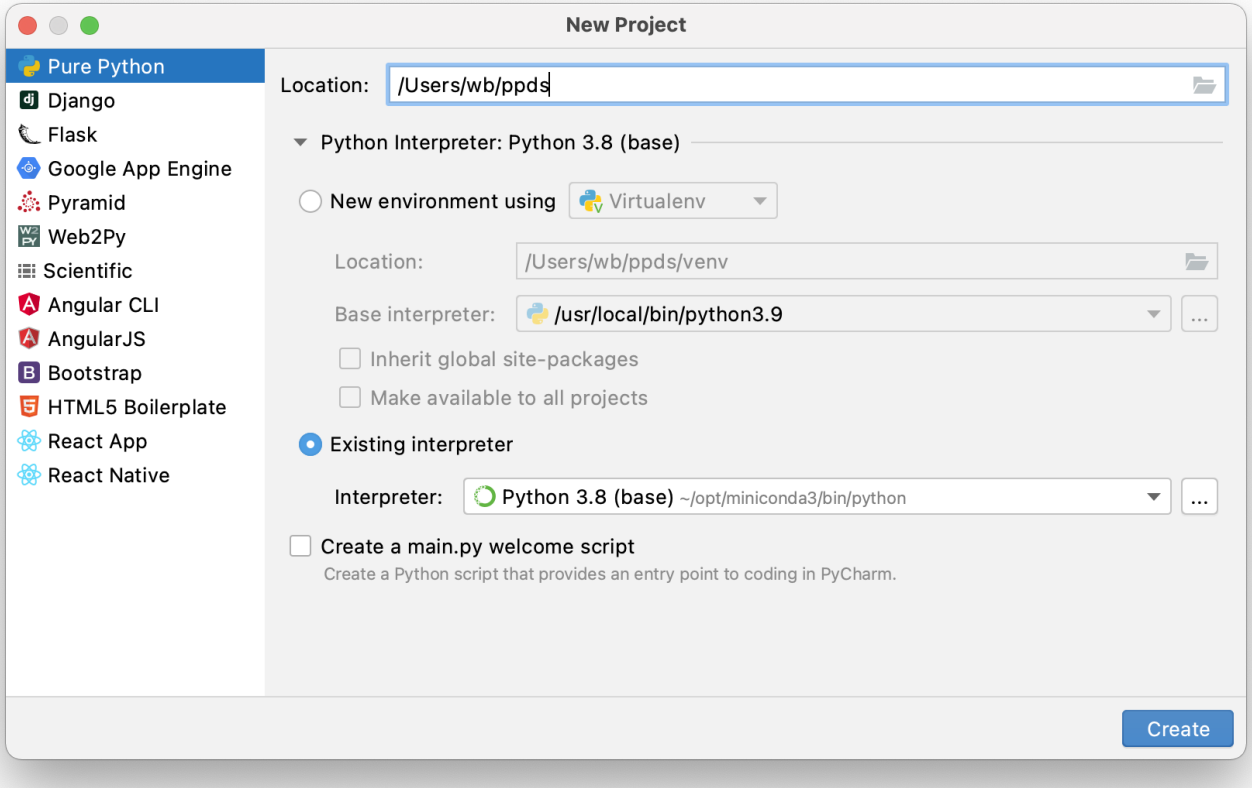


The first time it starts, it might take a while to initialize...

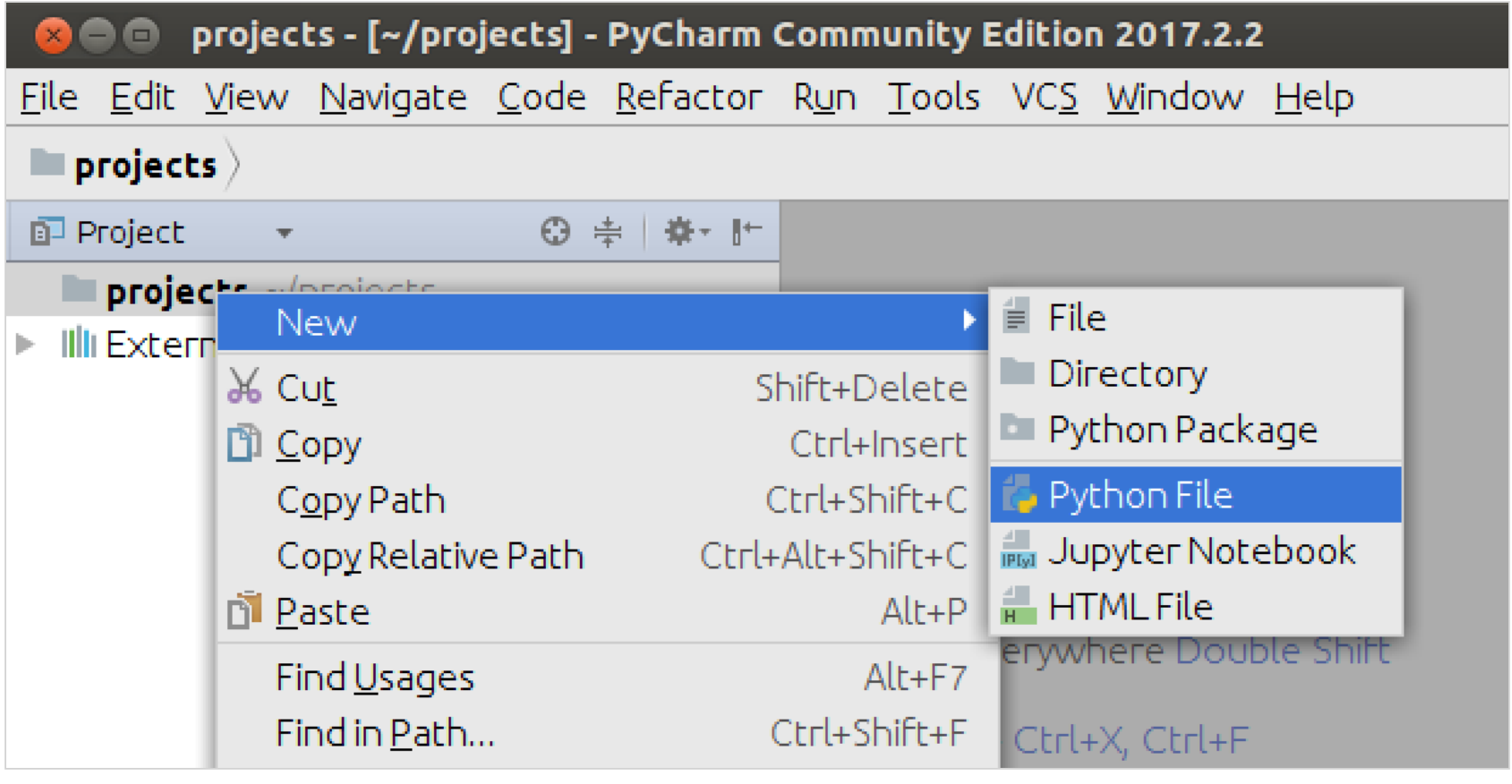
Pycharm: creating a new project

1. Code is organized in projects.
2. When creating a new project, we recommend using the "Existing interpreter" option - and make sure it points to your Anaconda installation



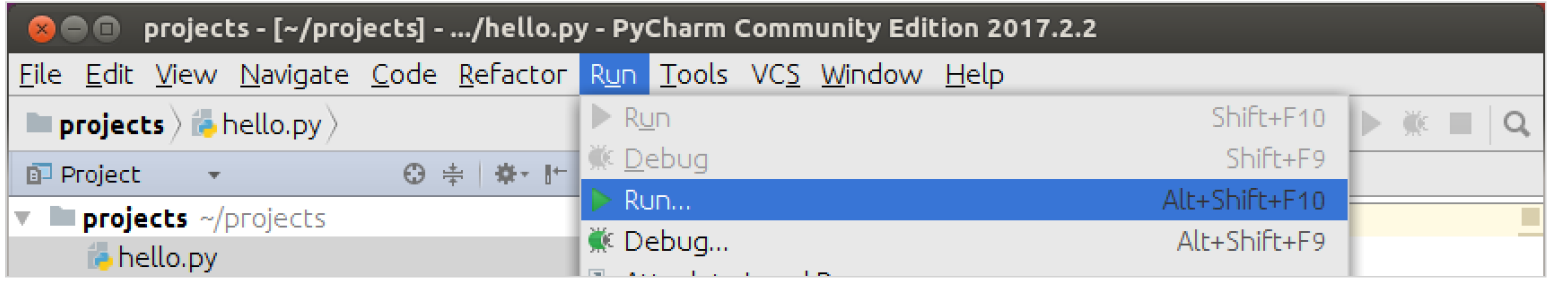
Pycharm: creating a new file

1. Create a new file in the PyCharm IDE.

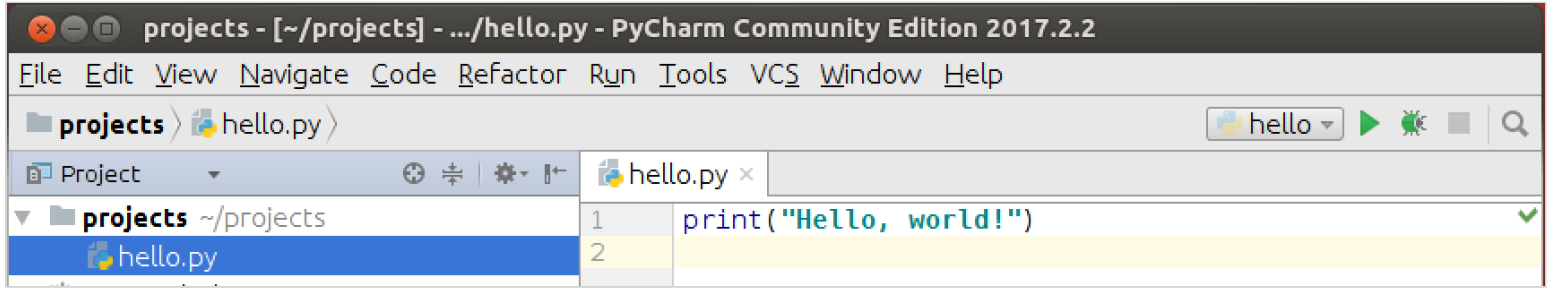


Pycharm: running a script

First time: Select Run from the PyCharm menu



Afterwards: Use the green arrow



Exercise 1: Our first program

1. In PyCharm, create a file called `hello.py`
2. Inside the file, write:

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

3. Run the program twice, once using the menu, and the second time using the green play button

Variables and types: numeric and boolean

Before we start: Python comments

Comments are notes left by the programmer that explain the code.

Comments begin with the # character and continue to the end of the line.

```
# square of the average of all prime numbers between 0 and 10
((2+3+5+7)/4.0)**2
```

Before we start: Python comments

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```
# square of the average of all prime numbers between 0 and 10
((2+3+5+7)/4.0)**2
```

In this course, we expect you to hand-in well-documented code. This means that non-trivial lines should have comments.

Variables

Variables are labels that we assign to objects in memory.

Create an integer object and label it as 'a':

```
a = 2
```

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Create an integer object and label it as 'a':

```
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```

Refer to that memory location:

```
print(a)
print(a * 2)
```

output

```
2
4
```

Variables (2)

In Python, variables do not need to be declared before being assigned a value.

When variables are assigned a new value, the label just starts referring to the new object.

```
a = 2
a = "hello"
print(a)
```

```
hello
```
output

Variables (3)

Name your variables responsibly!

If you are using a well known formula, let's say x = a + b, then you can use 'a' and 'b' as names. Otherwise, be more descriptive:

```
drink_limit = 4
```

Types - Numeric

Three types of numbers:

- Integer - 42
- Float - 42.0
- Complex - 42.0+3.0j

Python arithmetic operators

Python supports the following arithmetic operators:

+	addition	//	integer division
-	subtraction	%	modulo (remainder of division)
*	multiplication	**	exponentiation
/	division	-	negative (unary)

Python2 note: division can be tricky

NOTE: In Python2, the / operator acts as integer division if both operands are integers. If you want normal division, cast one of them as a real number:

```
print(7/2)              # python2: integer division. python3: no problem
print(7/2.0)            # normal division
print(7/float(2))
```

output

```
3    # In python2
3.5
3.5
```

This is NOT a problem in python3

Types - Numeric - comparisons

We can compare two numeric values

```
x = 3
y = 4
print(x < y)
print(x > y)
print(x == y)
```

output

```
True
False
False
```

Types - Numeric - assignment operators

We can perform an operation on a variable and assign the result back to the same variable

The assignment operators are based on the basic arithmetic operators:

```
x = 4
x += 1    # same as x = x+1
x -= 2    # same as x = x-2
x *= 3    # same as x = x*3
x //= 2   # same as x = x//2
x **= 2   # same as x = x**2
x %= 5    # same as x = x%5
```

Types - Boolean

Can take the values of True and False

Operations: 'and', 'or', 'not'

```
x = 1
print((x > 0) and (x < 10))
print((x > 0) or (x < 10))
print((x > 0) and (x > 10))
```

```
True and True    # -> True
True or True     # -> True
```

output

```
True
True
False
```

Types - Boolean

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Operations: 'and', 'or', 'not'

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True and True    # -> True
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output

```
True
True
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```

Note that the two columns are equivalent (for x=1). What would be the right-column equivalent for the third case?

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print((x > 0) and (x > 10))
```

```
True and True    # -> True
True or True     # -> True
True and False   # -> False
```

output

```
True
True
False
```

Note that the two columns are equivalent (for x=1). What would be the right-column equivalent for the third case?

Numeric and Boolean types - exercise

1. I want to calculate the average of 4 and 6. What's wrong with the following expression:

```
4+6 / 2
```

2. What is x after executing these lines (try without Python first):

```
x = 4
x += 1
x -= 2
x *= 3
x //= 2
x **= 2
x %= 5
print(x)
```

3. This expression is equivalent to one of the expressions on the previous slide. Which one?

```
(not (not (x > 0) or not (x < 10)))
```

Types - Numeric - Answer

1.
```
(4+6) / 2    # operator precedence: / binds stronger than +.
```

2.
```
x = 4                                  # 4
x += 1
x -= 2
x *= 3
x //= 2
x **= 2
x %= 5
print(x)
```

3.
```
(not (not (x > 0) or not (x < 10)))
(not ((x <= 0) or (x >= 10)))
(x > 0 and x < 10)
```

Types - Numeric - Answer

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2.
```
x = 4                                  # 4
x += 1   # same as x = x+1            # 5
x -= 2
x *= 3
x //= 2
x **= 2
x %= 5
print(x)
```

3.
```
(not (not (x > 0) or not (x < 10)))
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```

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2.
```
x = 4                                   # 4
x += 1  # same as x = x+1              # 5
x -= 2  # same as x = x-2              # 3
x *= 3
x //= 2
x **= 2
x %= 5
print(x)
```

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Types - Numeric - Answer

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```
(4+6) / 2   # operator precedence: / binds stronger than +.
```

2.
```
x = 4                                   # 4
x += 1  # same as x = x+1              # 5
x -= 2  # same as x = x-2              # 3
x *= 3  # same as x = x*3              # 9
x //= 2
x **= 2
x %= 5
print(x)
```

3.
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(not (not (x > 0) or not (x < 10)))
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x = 4                                   # 4
x += 1  # same as x = x+1              # 5
x -= 2  # same as x = x-2              # 3
x *= 3  # same as x = x*3              # 9
x //= 2 # same as x = x/2              # 4
x **= 2
x %= 5
print(x)
```

3.
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(not (not (x > 0) or not (x < 10)))
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x = 4                                   # 4
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x -= 2  # same as x = x-2              # 3
x *= 3  # same as x = x*3              # 9
x //= 2 # same as x = x/2              # 4
x **= 2 # same as x = x**2             # 16
x %= 5
print(x)
```

3.
```
(not (not (x > 0) or not (x < 10)))
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```

Types - Numeric - Answer

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```
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x = 4                                   # 4
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x //= 2 # same as x = x/2              # 4
x **= 2 # same as x = x**2             # 16
x %= 5  # same as x = x%5              # 1
print(x)
```

3.
```
(not (not (x > 0) or not (x < 10)))
(not ((x <= 0) or (x >= 10)))
(x > 0 and x < 10)
```

Strings

Types - Strings

A string is a sequence of characters. It is specified using either:

- single quotes (')
- double quotes(")
- triple quotes(''' or """).

The first two are exactly the same, while the last one is for strings spanning several lines:

```
str1 = "Hello"
str2 = 'Hello'
str3 = '''Hello,
World!'''
```

Types - Strings - operators

Operators for strings work a little differently

+	concatenation
*	repetition
in	test if an element occurs in the string
[]	extract character from string (indexing)

```
str1 = "Linux"
str2 = 'Python'
print(str1 + str2)
print(str1 * 10)
print('ux' in str1)
```

output

```
'LinuxPython'
'LinuxLinuxLinuxLinuxLinuxLinuxLinuxLinuxLinuxLinux'
True
```

Types - Strings - comparisons

Comparisons from strings are done based on how they would appear in a phone book (lexicographically):

>	after
>=	after or equal
<	before
<=	before or equal

```
print("hell" < "hello")
```

```
True
```
output

Types - Strings - special characters

A string can contain combinations of characters that have a special meaning.

They start with the backslash character - \

\n	new line
\t	tab
\'	single quote
\"	double quote
\\	backslash

```
print("1\t2\n3")
```

output

```
1	2
3
```

Converting things to string

Often, you will want to convert values of different types to string — for instance when printing them to screen.

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This can be done using:

```
str(value)
```

Example:

```
number_of_apples = 6
print("I have " + str(number_of_apples) + " apples.")
```

```
I have 6 apples.
```
output

Types - Strings - exercise 1

1. Create three variables. One called `firstname` with your first name, one called `lastname` with your last name and one called `age` with your age.
2. Merge these strings into one string. When the string is printed to the screen, the output should look like:

```
Name: myfirstname mylastname
Age: age
```

Types - Strings - exercise 1 - solution

- Create three variables. One called firstname with your first name, one called lastname with your last name and one called age with your age.

```
firstname = "Barack"
lastname = "Obama"
age = 60
```

- Merge these strings into one string

Types - Strings - exercise 1 - solution

- Create three variables. One called firstname with your first name, one called lastname with your last name and one called age with your age.

```
firstname = "Barack"
lastname = "Obama"
age = 60
```

- Merge these strings into one string

```
print("Name: " + firstname + " " + lastname + "\nAge: " + str(age))
```

output

```
Name: Barack Obama
Age: 60
```

Types: Strings — indexing

You can index in strings using square brackets:

```
stringname[n]
```

this will return the n+1’th character in the string.

```
s = "hello"
print(s[1])
```

```
’e’
```
output

Note: sequences types in python are zero indexed. The first element has index 0.

Types: Strings — indexing

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stringname[n]
```

this will return the n+1'th character in the string.

```
s = "hello"
print(s[1])
```

```
'e'
```
output

Note: sequences types in python are zero indexed. The first element has index 0.

Use a negative index to count from the end of the string:

```
print(s[-1])        # will print 'o'
```

Types are associated with functionality

In an object oriented language, types are typically associated with specific functionality.

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In order to introduce this associated functionality, we need to very briefly introduce the concepts of *function* and *method*.

Types are associated with functionality

In an object oriented language, types are typically associated with specific functionality.

For instance, for the string-type, it makes sense to have associated functionality for search and replace.

In order to introduce this associated functionality, we need to very briefly introduce the concepts of *function* and *method*.

We'll cover this in much more detail later in the course.

Interlude: functions and methods

A *function* is a piece of code that has a name, and can be *called* from anywhere in the program as:

```
functionname(argument-list)
```

Example:

```
len('hello') # function taking 1 argument
```

```
5
```
output

Interlude: functions and methods

A *function* is a piece of code that has a name, and can be *called* from anywhere in the program as:

```
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```

Example:

```
len('hello') # function taking 1 argument
```

```
5
```
output

A *method* is similar to a function, but it belongs to an *object*. It is called like this:

```
object.methodname(argument-list)
```

```
l = 'hello'
print(l.replace('llo', 'y')) # method taking 2 arguments
```

```
'hey'
```
output

Types: Strings — methods

Commonly used string methods:

`capitalize`	capitalize string
`lstrip`	removing leading whitespace
`center`	center justify
`replace`	replace substring
`count`	count substring occurrences
`rjust`	right justify
`find`	find index of substring
`rstrip`	Remove traling whitespace
`join`	join list of strings
`split`	split into list of smaller strings
`ljust`	left justify
`strip`	`lstrip` and `rstrip`
`lower`	convert to lowercase
`upper`	convert to uppercase

Types: Strings — methods

Examples:

```
s = 'hello'
print(s.upper())
print('hello'.find('ll'))
print('hello'.replace('ll', 'ct'))
print('one two three'.split(' '))
```

output

```
'HELLO'
2
'hecto'
['one', 'two', 'three']
# we'll get back to this last one
```

Types: Strings — exercise 2

1. Create a variable containing a DNA sequence (e.g. AAGCAGAATGCTTAGGACTAGTTAC).
2. Turn it into a RNA sequence ('T' → 'U').
3. Print out the letter in the middle of the sequence.

Types: Strings — exercise 2 — solution

1. Create a variable containing a DNA sequence (e.g. AAGCAGAATGCTTAGGACTAGTTAC).

```
dna_seq = 'AAGCAGAATGCTTAGGACTAGTTAC'
```

2. Turn it into a RNA sequence (’T’ → ’U’).

3. Print out the letter in the middle of the sequence.

Types: Strings — exercise 2 — solution

1. Create a variable containing a DNA sequence (e.g. AAGCAGAATGCTTAGGACTAGTTAC).

```
dna_seq = 'AAGCAGAATGCTTAGGACTAGTTAC'
```

2. Turn it into a RNA sequence (’T’ → ’U’).

```
rna_seq = dna_seq.replace('T', 'U')
print(rna_seq)
```

output

```
AAGCAGAAUGCUUAGGACUAGUUAC
```

3. Print out the letter in the middle of the sequence.

Types: Strings — exercise 2 — solution

1. Create a variable containing a DNA sequence (e.g. AAGCAGAATGCTTAGGACTAGTTAC).

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```

2. Turn it into a RNA sequence (’T’ → ’U’).

```
rna_seq = dna_seq.replace('T', 'U')
print(rna_seq)
```

```
AAGCAGAAUGCUUAGGACUAGUUAC
```
output

3. Print out the letter in the middle of the sequence.

```
print(rna_seq[len(rna_seq)/2])
```

```
U
```
output