CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Computer Science

http://www.cit.ie

Programming for Data Analytics

Week1: Introduction to programing in Python

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Module Content

- Introduction to Python Programming Concepts
  - Decision Structures, Iteration, Functions, Lists, Dictionaries, Tuples, Files, Objects
- Development of Python Programs for Solving Data Driven Problems
  - NumPy, Pandas, SciPy, Mathplotlib, Seaborn

(Fundamentals are Building Blocks)

Assessment (100% CA)

- Practical Skills Evaluation (20%)
  - Week 6 (2hr Lab Assessment) – (open book)

- Project Work (80%)
  - Project A – Week 7 (Due Week 9) – 30%
  - Project B – Week 9 (Du Week 12) – 50%

Useful Websites

- Python Documentation
  - http://www.python.org/doc/
- A Byte of Python
  - https://www.gitbook.com/book/swaroopch/byte-of-python/details
- New Boston Python Video Tutorials
  - https://thenewboston.com/videos.php?cat=98
- Python Data Analysis Library
  - http://pandas.pydata.org/
- Python Scientific Library
  - http://www.scipy.org/
- Python Numerical Library
  - http://www.numpy.org/
- Continuum Analytics (Download Anaconda)
  - http://continuum.io/downloads

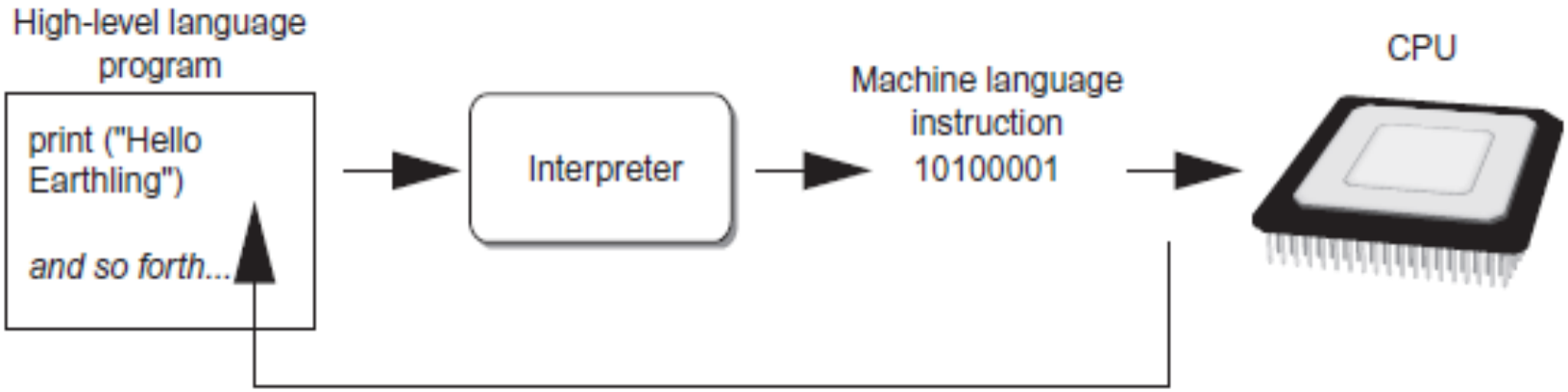
Overview

Overview of Python and its runtime environment

- Input/Out and Processing in Python
- Data Types
- Operators
- Selection
- Iteration

Python is an Interpreted Language

What is a computer program?



The interpreter translates each high-level instruction to its equivalent machine language instructions and immediately executes them.

This process is repeated for each high-level instruction.

Executing a high-level program with an interpreter

Using Python

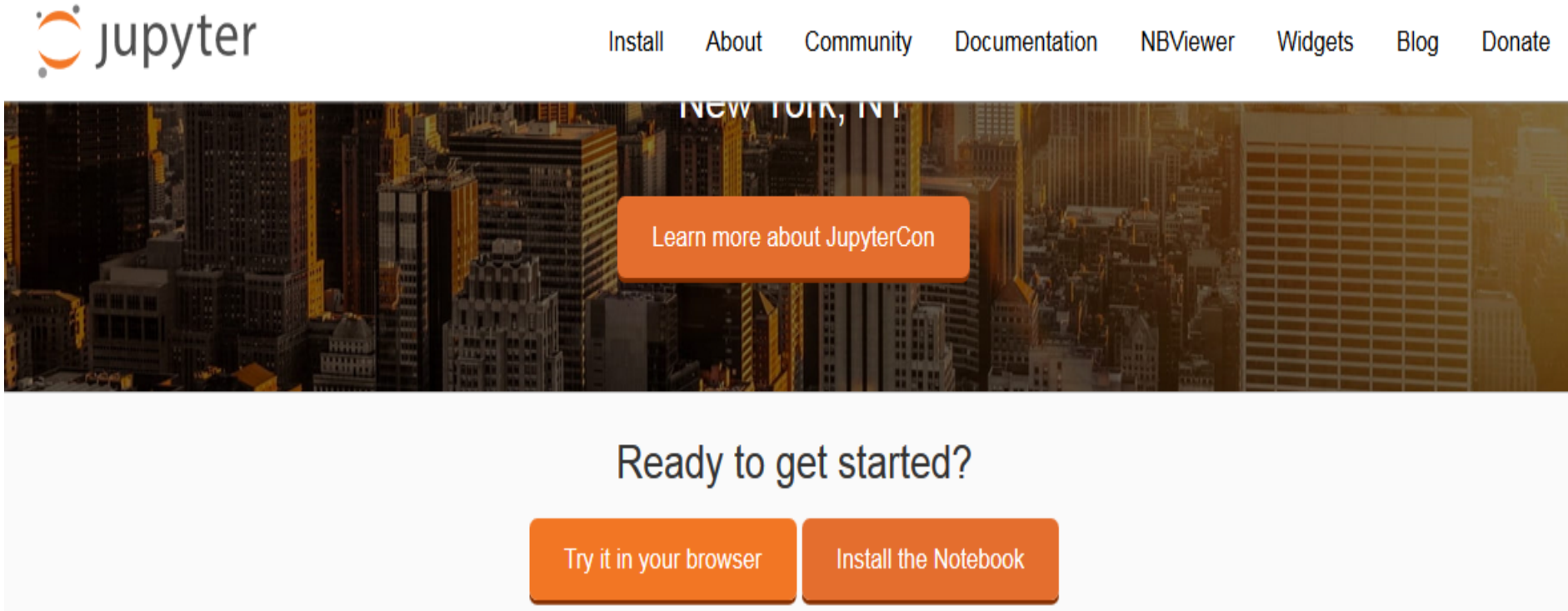
- You can download a version Python at http://www.python.org/download/
  - Current stable version is Python 3.6. (you can use 3.7.0)

- We will be using an integrated development environment. There is a range of IDEs available for Python
  - Sypdr
  - PyCharm
  - Geany
  - DrPython
  - SPE

Aside!

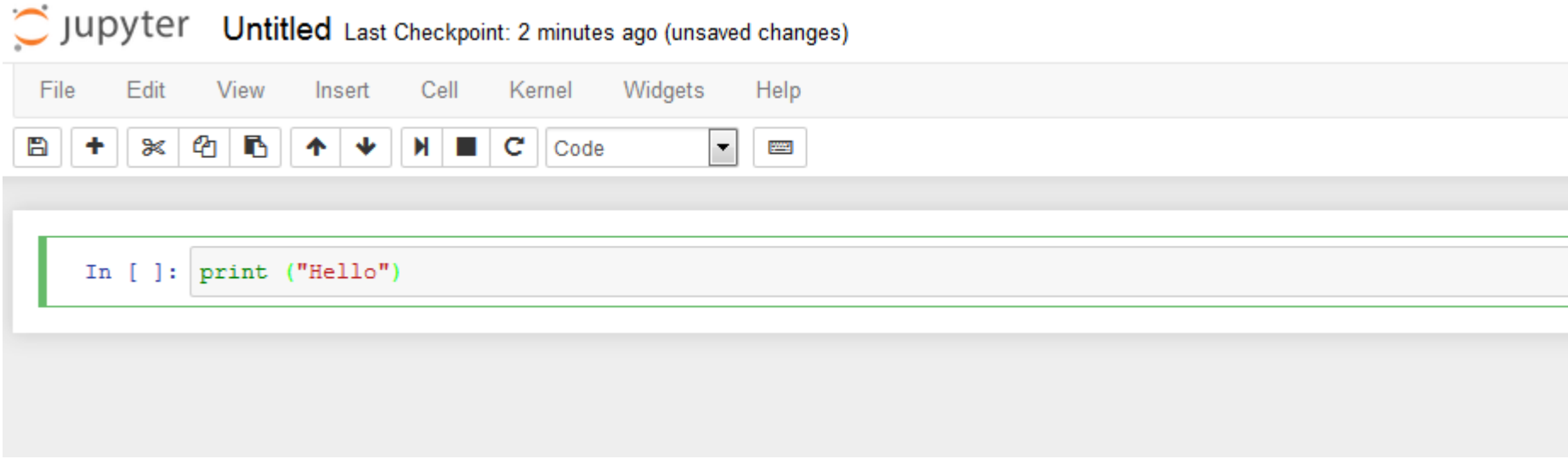
Jupyter Notebooks

- Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code.
- Go to http://jupyter.org/ and click “Try it in your browser” as shown below.

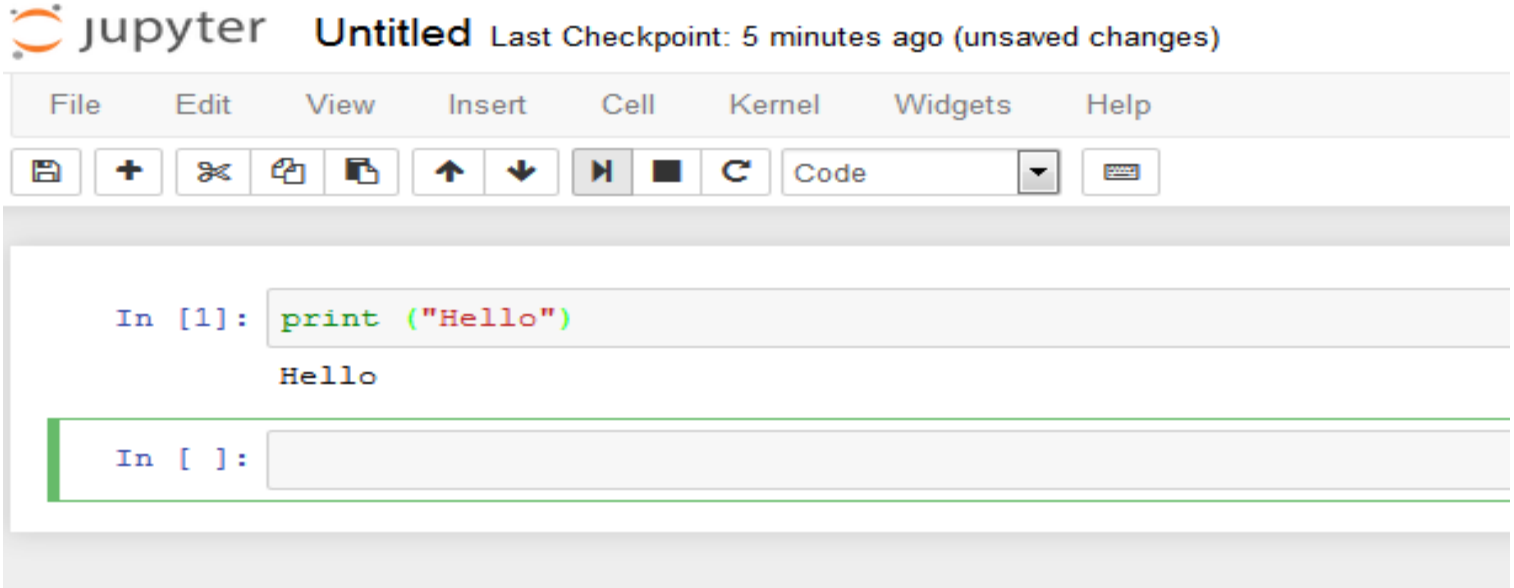


Jupyter Notebooks

- You can create a Jupyter notebook for a range of programming languages as you see below.
- It's a great way for learning a language as it provides you with an interactive shell that allows you to type/run commands and see the output.



- The screenshot above shows my notebook and I've typed a simple command print ("Hello"). I can click the run cell button ( ) and it will run this line of code and display the result. See below.



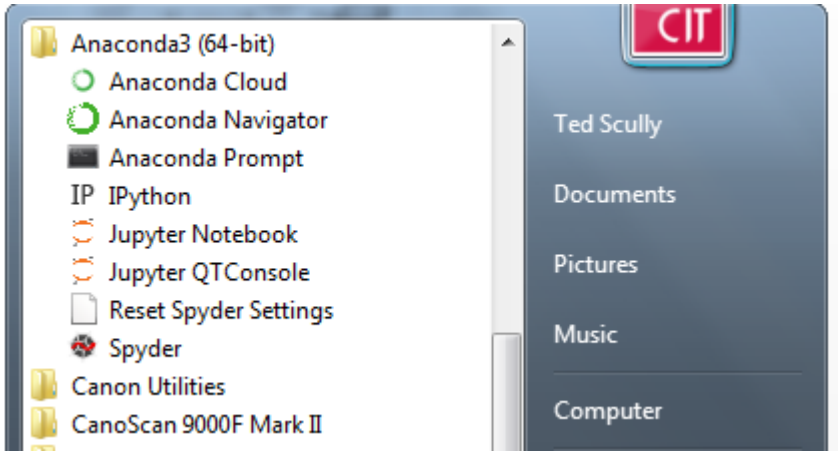
Jupyter Notebooks

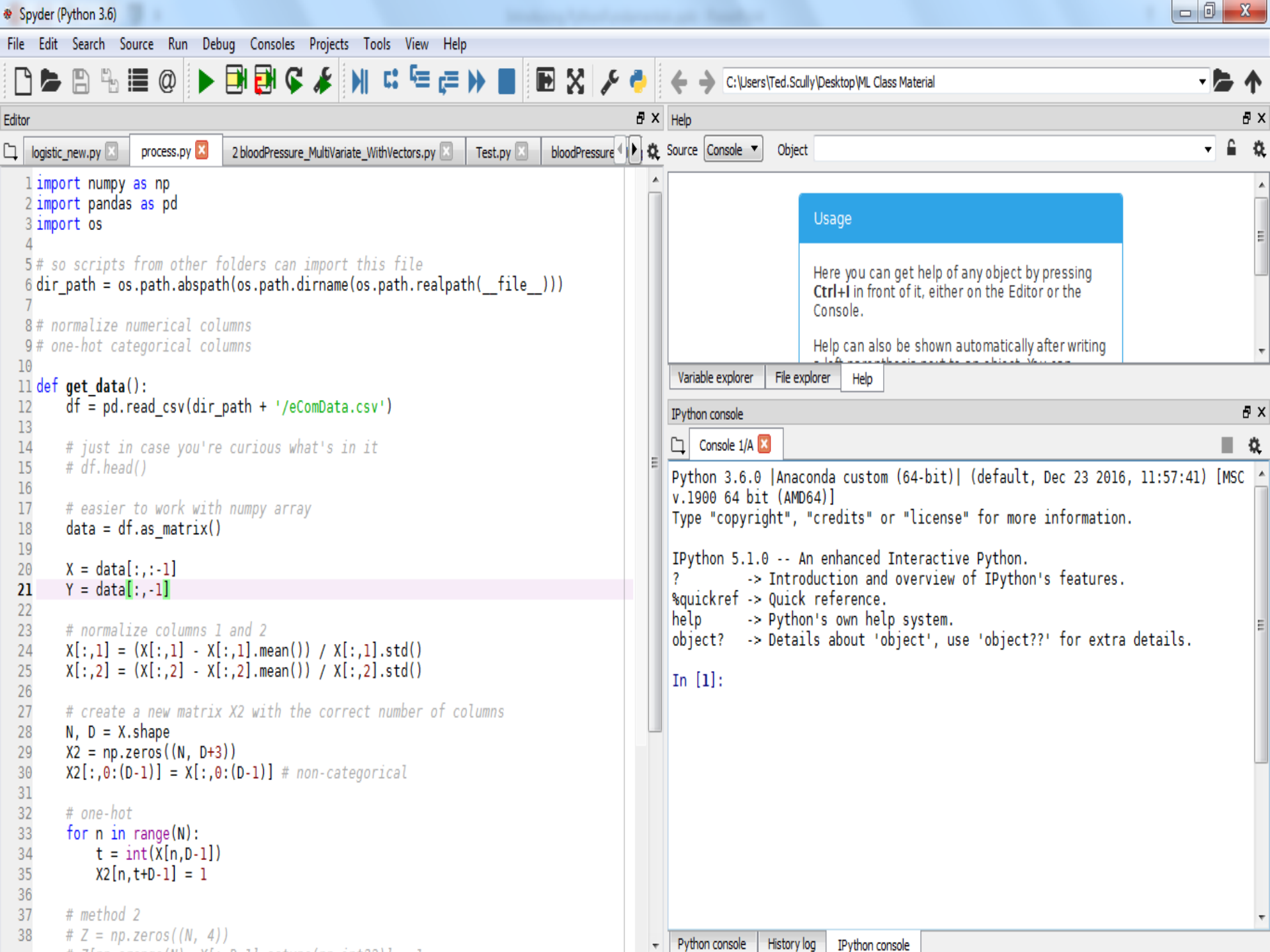
- It’s a simple easy way to learn a new language.
- You can compose an save an entire notebook and share them easily online.
- Very popular online. Useful for running exploratory data analysis.

- Not suitable for serious software development.

Using Python with the Spyder IDE

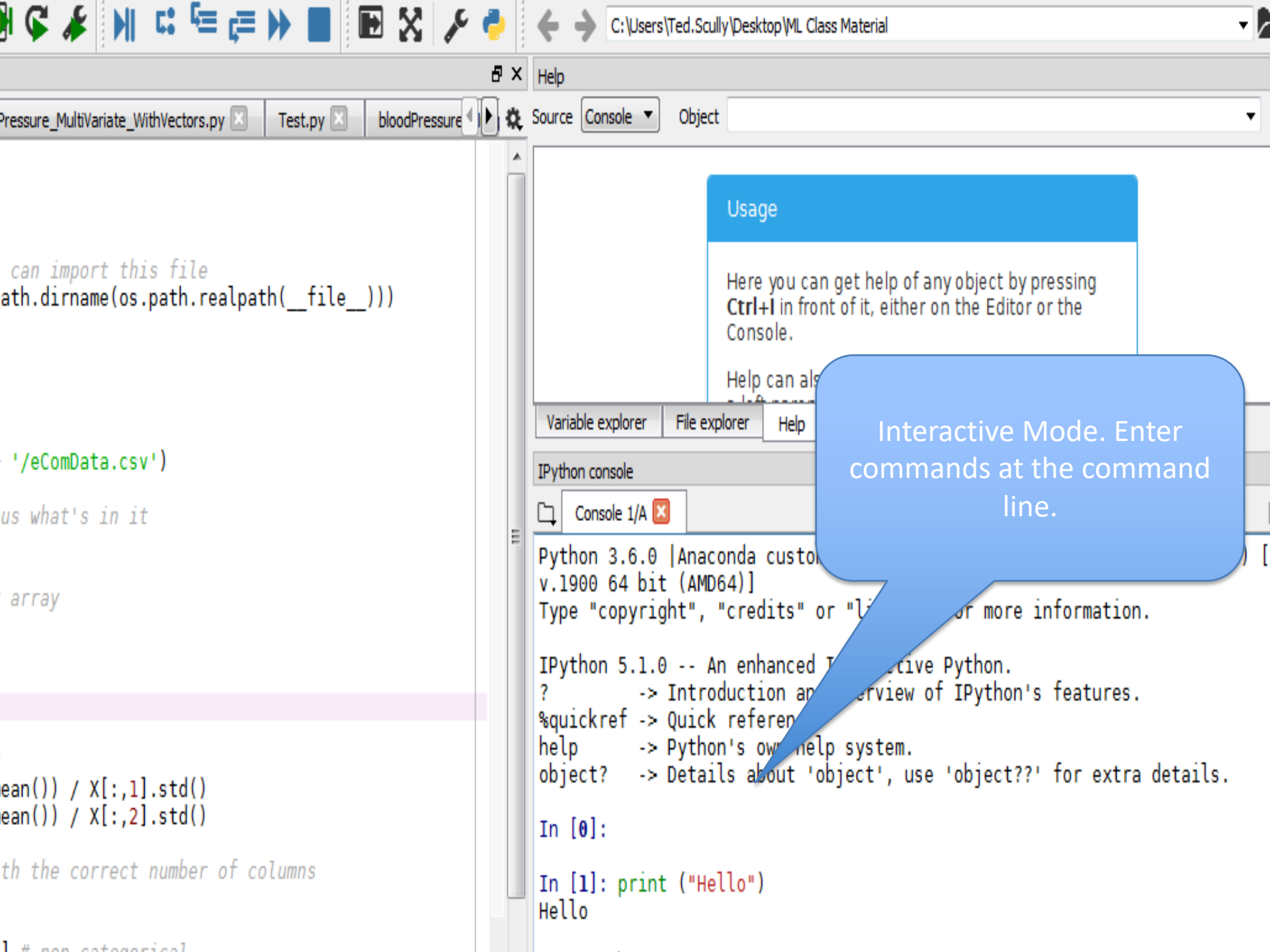
- The IDE we will be using is called Spyder and is part of the Anaconda package.
- https://www.anaconda.com/download/




Spyder (Python 3.6)
File Edit Search Source Run Debug Consoles Projects Tools View Help
C:\Users\Ted.Scully\Desktop\ML Class Material
Editor
logistic_new.py
process.py
2 bloodPressure_MultiVariate_WithVectors.py
Test.py
bloodPressure
import numpy as np
import pandas as pd
import os
# so scripts from other folders can import this file
dir_path = os.path.abspath(os.path.dirname(os.path.realpath(__file__)))
# normalize numerical columns
# one-hot categorical columns
def get_data():
df = pd.read_csv(dir_path + '/eComData.csv')
# just in case you're curious what's in it
# df.head()
# easier to work with numpy array
data = df.as_matrix()
X = data[:,:-1]
Y = data[:,-1]
# normalize columns 1 and 2
X[:,1] = (X[:,1] - X[:,1].mean()) / X[:,1].std()
X[:,2] = (X[:,2] - X[:,2].mean()) / X[:,2].std()
create a new matrix X2 with the correct number of columns
N, D = X.shape
X2 = np.zeros((N, D+3))
X2[:,0:(D-1)] = X[:,0:(D-1)] # non-categorical
# one-hot
for n in range(N):
t = int(X[n,D-1])
X2[n,t+D-1] = 1
method 2
Z = np.zeros((N, 4))
Help
Source Console Object
Usage
Here you can get help of any object by pressing Ctrl+I in front of it, either on the Editor or the Console.
Help can also be shown automatically after writing
Variable explorer File explorer Help
IPython console
Console 1/A
Python 3.6.0 |Anaconda custom (64-bit)| (default, Dec 23 2016, 11:57:41) [MSC v.1900 64 bit (AMD64)]
Type "copyright", "credits" or "license" for more information.
IPython 5.1.0 -- An enhanced Interactive Python.
? -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help -> Python's own help system.
object? -> Details about 'object', use 'object??' for extra details.
In [1]:
Python console History log IPython console

Python Interpreter

- Python interpreter can be used in two modes
  - Interactive mode: enter statements on keyboard
  - Script mode: save statements in Python script


C:\Users\Ted.Scully\Desktop\ML Class Material
Pressure_MultiVariate_WithVectors.py
Test.py
bloodPressure
can import this file
ath.dirname(os.path.realpath(__file__)))
'/eComData.csv')
us what's in it
array
ean()) / X[:,1].std()
ean()) / X[:,2].std()
th the correct number of columns
Help
Source
Console
Object
Usage
Here you can get help of any object by pressing Ctrl+I in front of it, either on the Editor or the Console.
Help can als
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Console 1/A
Python 3.6.0 |Anaconda custo
v.1900 64 bit (AMD64)]
Type "copyright", "credits" or "li
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IPython 5.1.0 -- An enhanced I tive Python.
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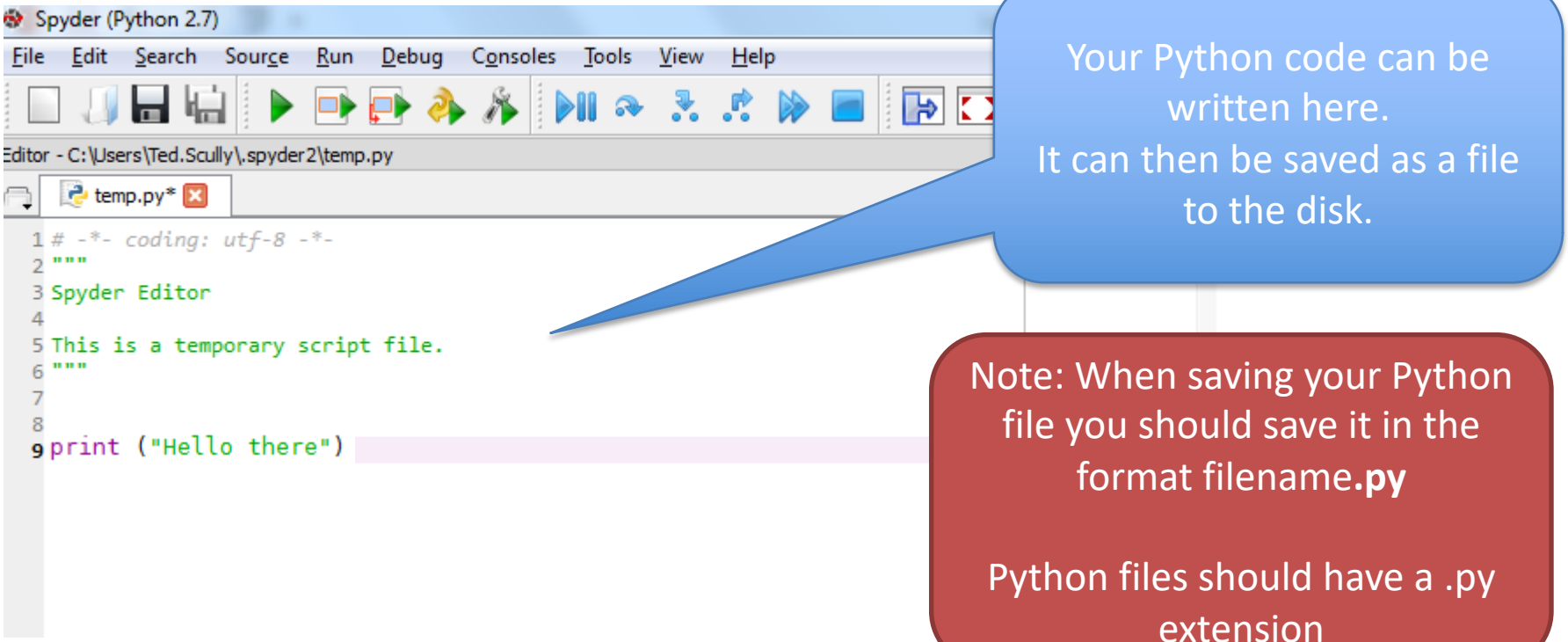
%quickref -> Quick referen
help -> Python's ow help system.
object? -> Details about 'object', use 'object??' for extra details.
In [0]:
In [1]: print ("Hello")
Hello
Interactive Mode. Enter commands at the command line.

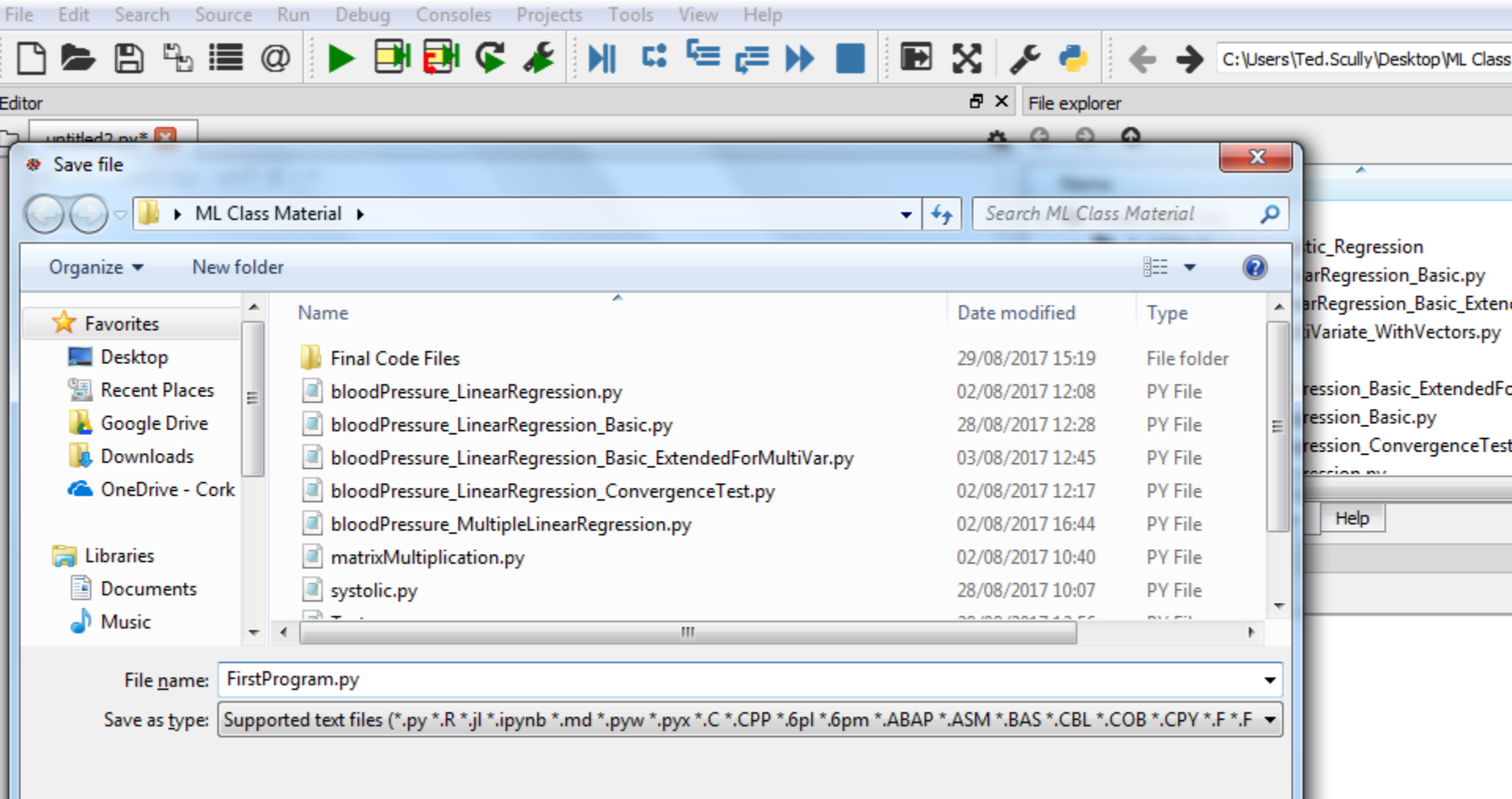
Sypder – Scripting Mode

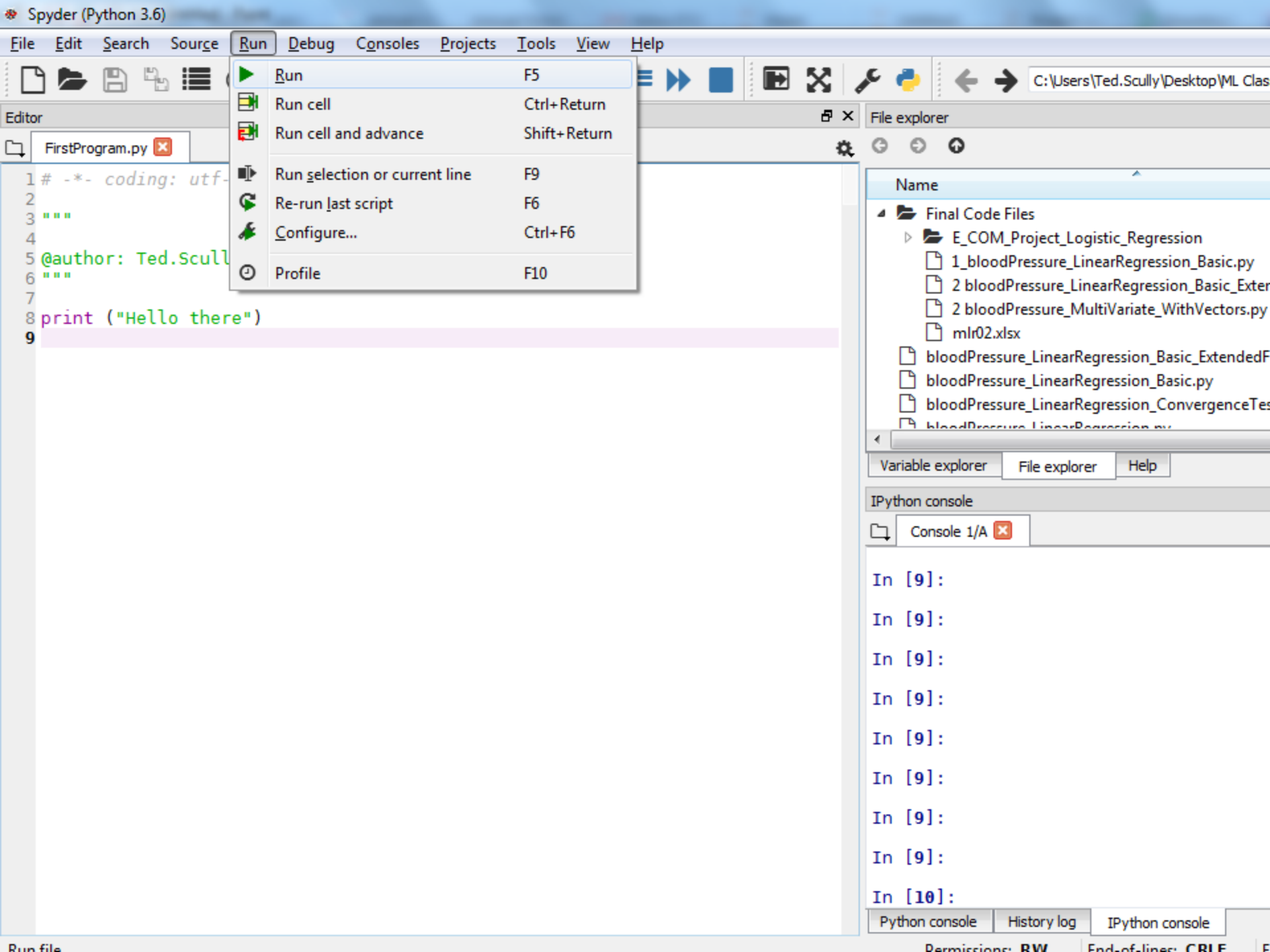
- When you open Sypder initially it will open a Python file (probably called untitled.py or temp.py).
- You can write lines of Python code into this file.

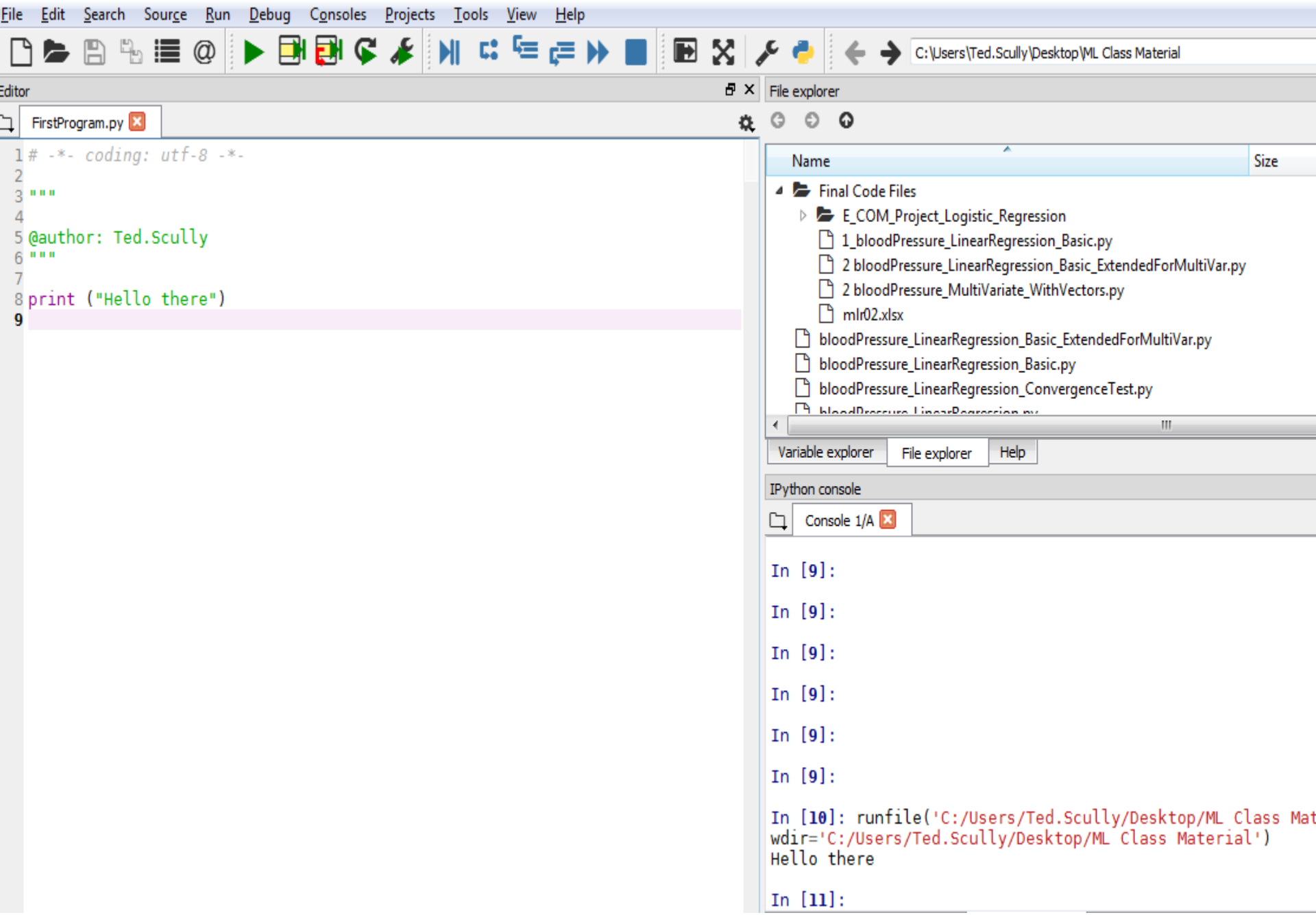


Spyder – Scripting Mode – Saving a File

Click File – Save As

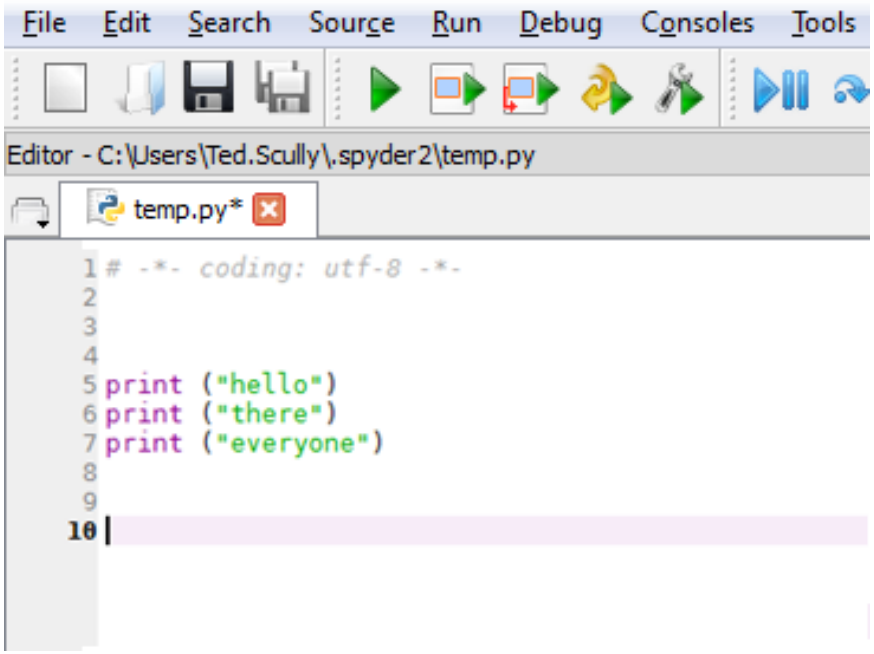



Spyder (Python 3.6)
File Edit Search Source Run Debug Consoles Projects Tools View Help
Run F5
Run cell Ctrl+Return
Run cell and advance Shift+Return
Run selection or current line F9
Re-run last script F6
Configure... Ctrl+F6
Profile F10
C:\Users\Ted.Scully\Desktop\ML Clas
Editor
FirstProgram.py
1 # -*- coding: utf-
2
3 """
4
5 @author: Ted.Scull
6 """
7
8 print ("Hello there")
9
File explorer
Name
Final Code Files
E_COM_Project_Logistic_Regression
1_bloodPressure_LinearRegression_Basic.py
2 bloodPressure_LinearRegression_Basic_Exter
2 bloodPressure_MultiVariate_WithVectors.py
mlr02.xlsx
bloodPressure_LinearRegression_Basic_ExtendedF
bloodPressure_LinearRegression_Basic.py
bloodPressure_LinearRegression_ConvergenceTes
Variable explorer File explorer Help
IPython console
Console 1/A
In [9]:
In [9]:
In [9]:
In [9]:
In [9]:
In [9]:
In [9]:
In [9]:
In [10]:
Python console History log IPython console
Run file


File Edit Search Source Run Debug Consoles Projects Tools View Help
C:\Users\Ted.Scully\Desktop\ML Class Material
Editor
FirstProgram.py
-*- coding: utf-8 -*-
"""
@author: Ted.Scully
"""
print ("Hello there")
File explorer
Name
Size
Final Code Files
E_COM_Project_Logistic_Regression
1_bloodPressure_LinearRegression_Basic.py
2 bloodPressure_LinearRegression_Basic_ExtendedForMultiVar.py
2 bloodPressure_MultiVariate_WithVectors.py
mlr02.xlsx
bloodPressure_LinearRegression_Basic_ExtendedForMultiVar.py
bloodPressure_LinearRegression_Basic.py
bloodPressure_LinearRegression_ConvergenceTest.py
Variable explorer
File explorer
Help
IPython console
Console 1/A
In [9]:
In [9]:
In [9]:
In [9]:
In [9]:
In [9]:
In [10]: runfile('C:/Users/Ted.Scully/Desktop/ML Class Mat
wdir='C:/Users/Ted.Scully/Desktop/ML Class Material')
Hello there
In [11]:

Multiple Lines of Code and Sequence of Execution

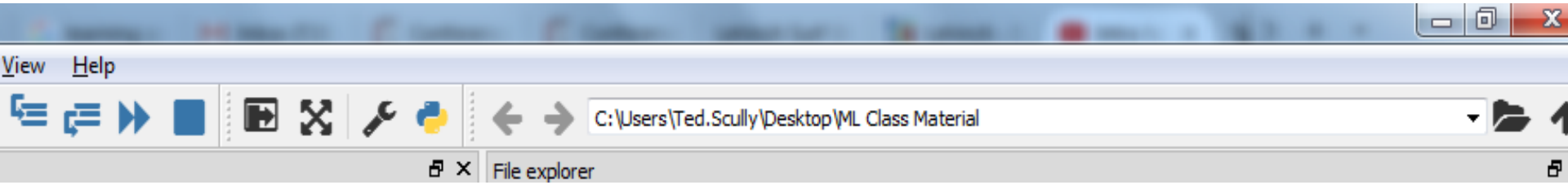
- We can place multiple lines of code into our program.
- When we run the program the interpreter starts at the top of the file and executes statements from top to bottom.



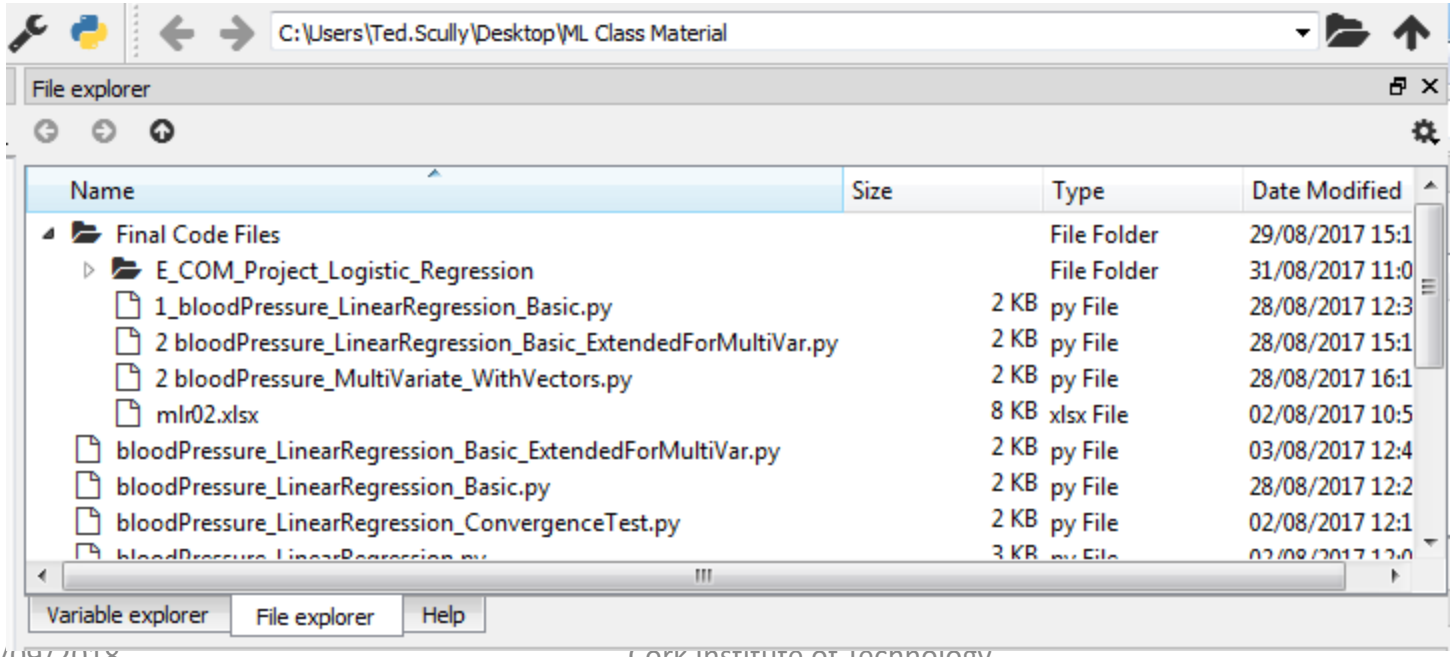

```
>>>
hello
there
everyone
```

Working Directory

- The current working directly is specified in the top right hand corner of the IDE.
- The working directory simply refers to the directory in which the IDE is currently working.
- So for example, if you want to open a file, the first place the IDE will look for this file is in the current working directory.

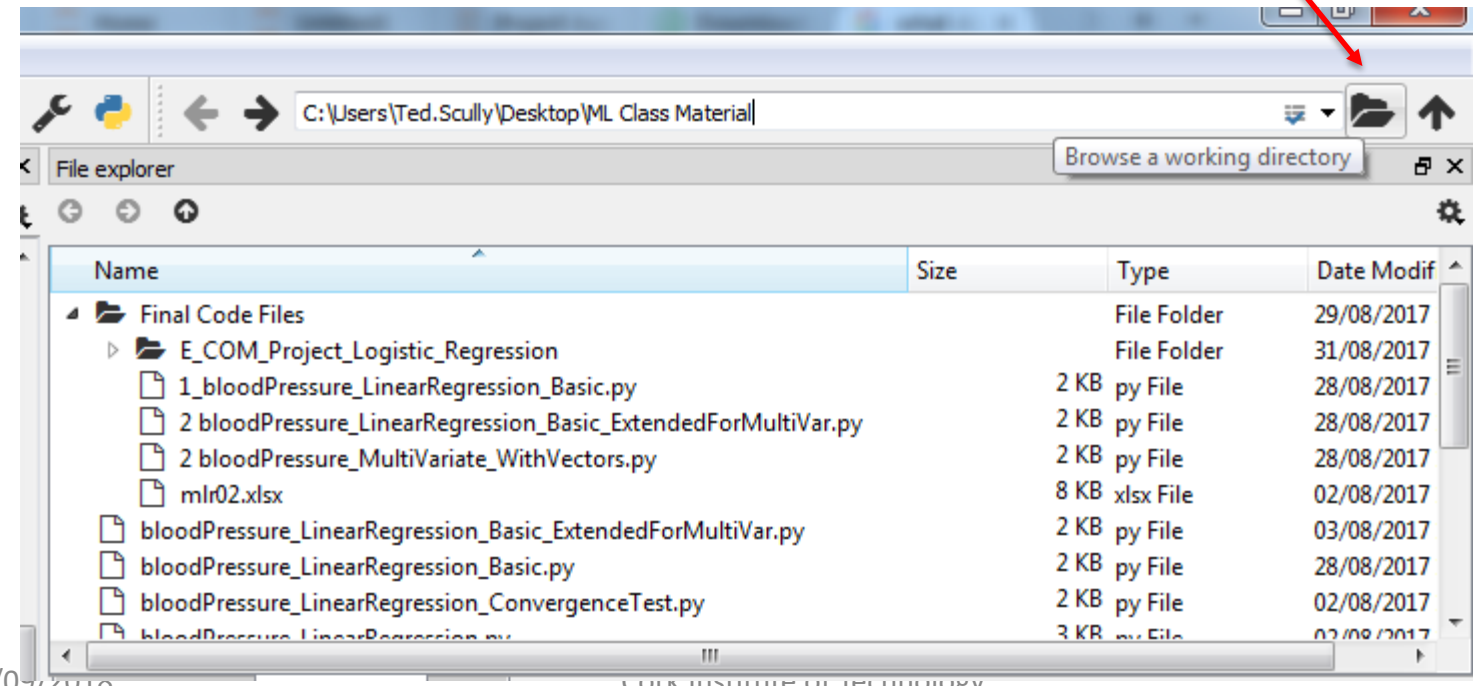


- You will also notice that you can select the file explorer tab (underneath the current working directory).
- The is a useful tab that shows you all the files in the current working directory.
- If you double click on any of these files it will open the file in the IDE.



Working Directory

- You can easily change the current working directory by clicking the folder symbol below.



Some Useful Shortcuts

- F5 executes the current file
- F9 executes the currently highlighted code: If nothing is selected F9 executes the current line.
- Auto-completes commands are very useful.
  - Tab enables auto complete for function names and variable names in the Console (both Python and IPython) and in the Editor.

Overview

- Overview of Python and its runtime environment

Input/Output and Processing in Python

- Data Types
- Operators
- Selection
- Iteration

Input, Processing, and Output

- Typically, computer programs perform a three-step process
  - Receive input
    - Input: any data that the program receives while it is running
  - Perform some process on the input
    - Example: mathematical calculation
  - Produce output

Displaying Output with the `print` Function

- As we have already seen one of the most fundamental actions of a program is to display a message on the computer screen.

  - `print ("Hello there")`

- Simply an instruction to the interpreter to print the **String** "Hello there"

- String: sequence of characters that are used as data (example 'Hello There')
  - Must be enclosed in single (') or double (") quotation marks
  - 'hello there' is equivalent to "hello there"

Note: The following statements are not equivalent and cause the interpreter to take different actions.

print (hello)

print ('hello')

Comments

- Comments: notes of explanation within a program
  - Ignored by Python interpreter
    - Intended for a person reading the program's code

- There are two ways of commenting your code in Python:
  - In Python a comment begins with a # character. Everything after the # on the same line is ignored by the interpreter
  - Comments spanning more than one line are achieved by inserting a multi-line string (with """ as the delimiter one each end)

Comments

```
# This program displays a person's
# Christian name and surname.
print ('Ted')
print ("Scully")       # This line prints the surname
```

```
"""
This purpose of the code below is
to .....
"""
print ("hello")
print ("there")
```

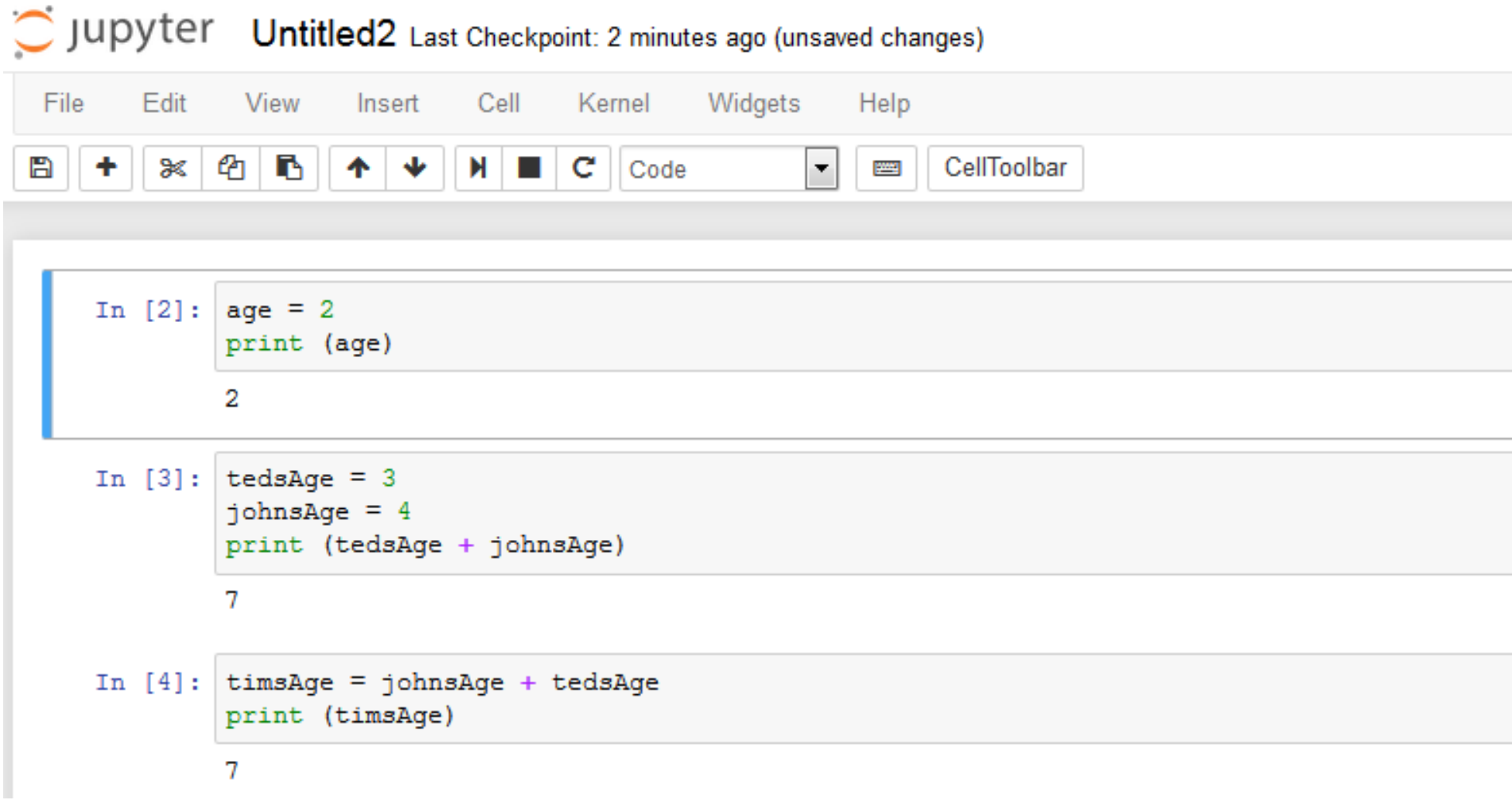
Variables

- **Variable**: name that represents a value stored in the computer memory
  - Used to access and manipulate data stored in memory
  - Labelled box analogy

- Assignment of a value to a variable: used to create a variable and make it reference data
  - General format is ***variable = expression***
  - Example: age = 29
  - Assignment operator: the equal sign (=)
  - Variable receiving value must be on left side
  - Variables are case sensitive (number is not the same variable as Number)

Variables

- A variable references the value it represents



Variable Naming Rules

- Rules for naming variables in Python:
  - Variable name cannot be a **Python keywords**
  - Variable name cannot contain **spaces**
  - First character must be a **letter** (or an underscore)
  - Variables names are **case sensitive**

- camelCase naming convention
  - The variable name begins with lowercase letters.
  - The first character of the second and subsequent words is written in uppercase.

- Variable name should reflect its use
  - User bankBalance as opposed to b or bba

Displaying Multiple Items with the `print` Function

- Python allows you to display multiple items with a single call to `print`
  - Items are separated by commas when passed as arguments
  - Arguments displayed in the order they are passed to the function
  - Items are automatically separated by a space when displayed on screen

```
In [7]: age = 105
        name = "ted"
        print ("name is ", name, " age is ", age)

        name is  ted  age is  105
```

Printing on the same line

- By default the execution of a print command will move the cursor on to the next line
- It can sometimes be useful to suspend this behaviour so that the cursor stays on the same line.
- In python you can override the newline behaviour and specify directly what you wish to happen after the print statement.
- You can do this using the *end* argument.

Printing on the same line

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Printing on the same line

- By default the execution of a print command will move the cursor on to the next line
- It can sometimes be useful to suspend this behaviour so that the cursor stays on the same line.
- You can do this by placing a comma at the end of the print line

```
print ("Welcome to", end= " ")
print ("Analytical Programming")
```

```
Welcome to Analytical Programming
```

Error Messages in Python

- When you execute a Python program the interpreter takes each line in turn, turns it into machine code, which is then executed.
- If the interpreter encounters an error it will **output an error message**.
- It is important to be able to interpret these errors as they will help you debug your program.

```
number = 5
print (Number + 3)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-10-9a7e20361ef9> in <module>()
      1 number = 5
----> 2 print (Number + 3)

NameError: name 'Number' is not defined
```

Sample Error Messages

- You cannot use a variable until you have assigned a value to it.
- Clearly the problem on the previous slide is that I'm trying to print the variable Number but I haven't assigned it a value
  - Always look for the line number
  - Gives a basic description of error
  - Takes practice in order to identify the source

Sample Error Messages

Some errors can be difficult to identify and this process takes practice

```
num = 4
print ("The value of num is " num)
```

```
  File "<ipython-input-11-a8b2df75ee99>", line 2
    print ("The value of num is " num)
                                    ^
SyntaxError: invalid syntax
```

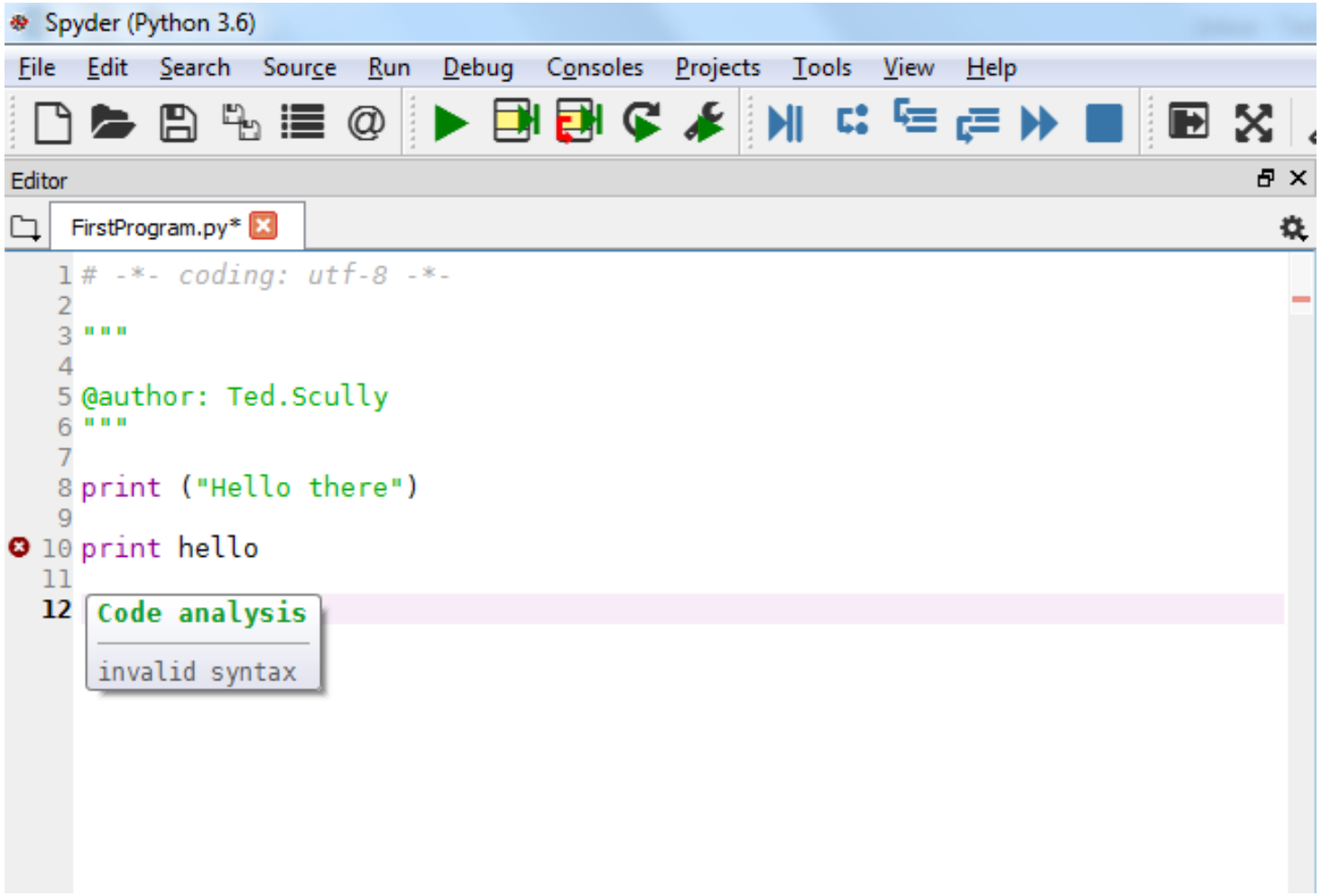
Sample Error Messages

Some errors can be difficult to identify and this process takes practice

```
num = 4
print ("The value of num is ", num)
```

```
The value of num is  4
```

- The IDE will provide some basic error checking and will highlight lines that contains errors.



Overview

- Overview of Python and its runtime environment
- Input/Out and Processing in Python

Data Types

- Operators
- Selection
- Iteration

Data Types

- In your program you may need to use different types of data such as integer numbers, strings, real numbers etc.
  - Some of the code you will use only variables of a particular type

- Python reserves space in memory to store a particular value. However, based on the type of the variable the space allocated can vary.

- So how does Python decide the type of a variable?
  - Python is not a strongly typed language

Data Types

- When the Python interpreter creates a variable it reads the value being assigned to the variable from the program code.
- It then determines the data type of the variable based on this value.

- If I create a numeric variable it determines its data type according to the following rules:

  - A numeric literal that is written as a whole number with no decimal point is considered an int . Examples are 7, 12 4, and - 9.

  - A numeric literal that is written with a decimal point is considered a float. Examples are 1.5, 3.14159, and 5.0.

Data Types (int and float)

- So, the following statement causes the number 503 to be stored in memory as an int
  - ***room = 503***
- The following statement causes the number 2.75 to be stored in memory as a float:
  - ***dollars = 2.75***
- Python also has a data type named str, which is used for storing strings in memory.
- The following will store the String John to be stored in memory as a String
  - ***firstName = 'John'***
  - ***secondName = "Tim"***

When you store an item in memory, it is important for you to be aware of the item's data type. As you will see, some operations behave differently depending on the type of data involved, and some operations can only be performed on values of a specific data type.

Data Types

- Once you create a variable, that variable is not permanently tied to a specific data type.
- The same Python variable can be assigned to different variables

```
# A variable is not permanently tied to a specific data type.

timsAge = "five"
print (timsAge)

timsAge = 5
print (timsAge)

timsAge = 5.5
print (timsAge)
```

```
five
5
5.5
```

Boolean Data Type

- Python also provides a boolean datatype, that is a variable that is either True or False (True and False are both **keywords** in Python)
  - isOverAge = True
  - enrolledInModule = False

Checking a Variable Datatype

- If you are unsure of the data type of a variable you can use a in-built function called *type()*.

```
number = 15
name = "scully"

print (type(number))
print (type(name))
```

```
<class 'int'>
<class 'str'>
```

Reading User Input from the Keyboard

- Most programs need to read input from the user
- Python's input function is useful for reading input from the keyboard.
- It reads input as a String
- Format: ***variable* = input(*prompt*)**
    - `prompt` is typically a string instructing user to enter a value

```
name = input("What is your name?")
print (name)
print ( type(name))
```

```
What is your name?Ted
Ted
<class 'str'>
```

Reading String Input

- The problem with the input function is that we may not always want to read string variables in from the user.
- Have a look at the following code and see if you can determine the source of the problem.

```
age = input("What is your age")
print (age+2)
```

```
What is your age 13

---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-17-38672b2b662f> in <module>()
      1 age = input("What is your age")
----> 2 print (age+2)

TypeError: must be str, not int
```

Reading String Input

- The problem is the code below is that we have read in the user input as a string value.
- The variable age stores the string value “13”.
- We then attempt to add the numerical value 2 to the string value “13”. You cannot add a string and an int.

```
age = input("What is your age")
print (age+2)
```

```
What is your age 13

---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-17-38672b2b662f> in <module>()
      1 age = input("What is your age")
----> 2 print (age+2)

TypeError: must be str, not int
```

Reading String Input

- Python has a number of methods that allows us to force the conversation from one data type to another. This process is also called casting.
- It provides the following:
  - int(), which converts a value to an int (for example, it can convert a string to an int)
  - flt(), converts a value to a float (for example, it can convert a int to a float)
  - str(), converts to a string data type

- For each of the methods above you put the value you want to convert between the open and close brackets.

- So lets try to fix the problem on the previous slide.

Reading String Input

- Notice we pass the String variable age to the int function and it returns a new int value for age.

```
# Notice we convert age from being a string variable to an int variable using the int function.
age = input("What is your age")
age = int(age)
print (age+2)
```

```
What is your age 13
15
```

Data Conversion

- Notice below we initially create a variable called number that has a float data type.
- We then use the int function to convert it from a float to an int data type.

```
number = 15.456
number = int(number)
print (number)
print (type(number))
```

```
15
<class 'int'>
```

Data Conversion

- In the example below we create a int variable called number and cast (force it's conversion) to a float data type)

```
number = 15
number = float(number)
print (number)
print (type(number))
```

```
15.0
<class 'float'>
```

Programming Task

- Write a simple program that will ask for the user for two numbers and add them together. It should then print out the result.

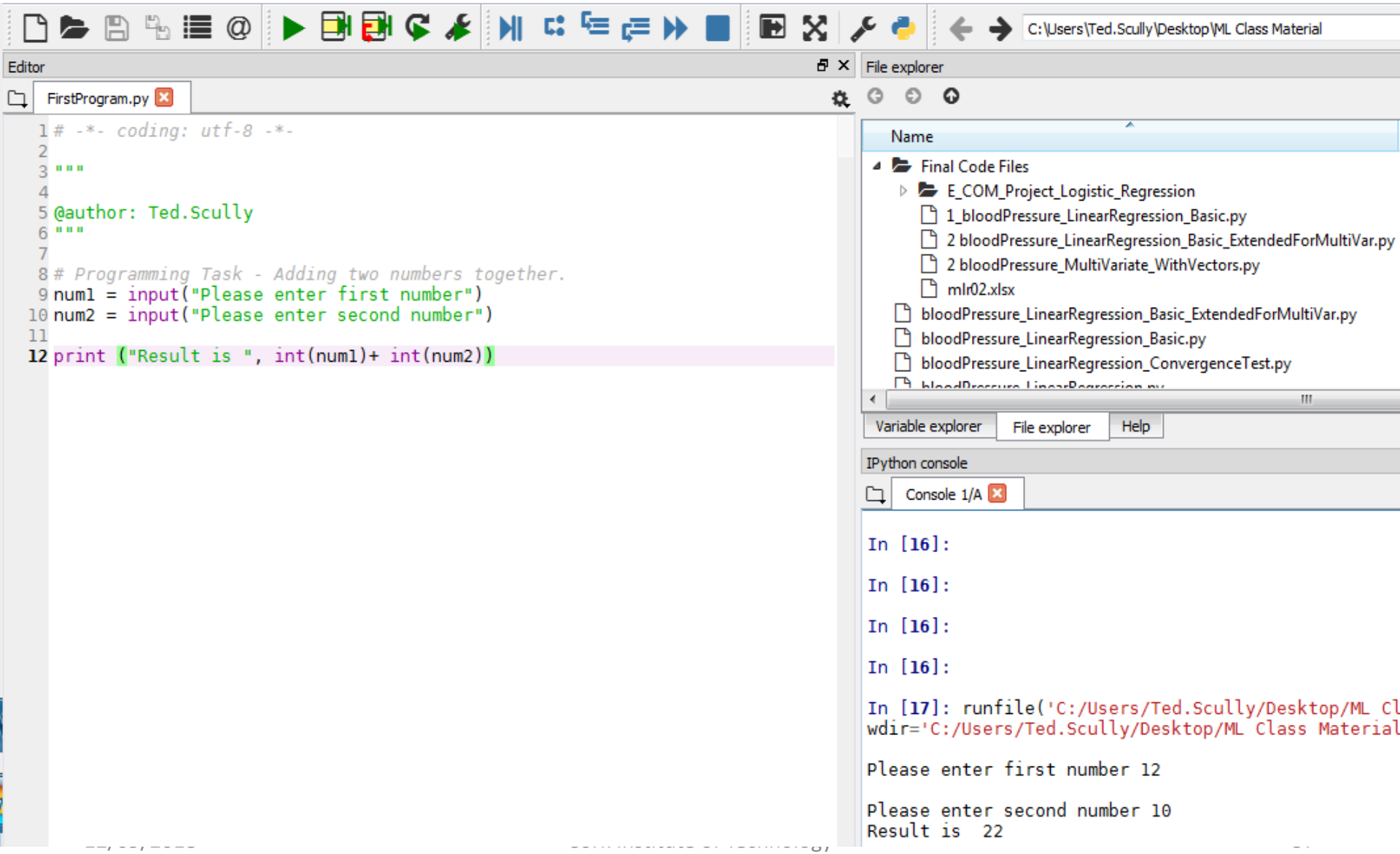
```
# Programming Task - Adding two numbers together.
num1 = input("Please enter first number")
num2 = input("Please enter second number")

print ("Result is ", int(num1)+ int(num2))
```

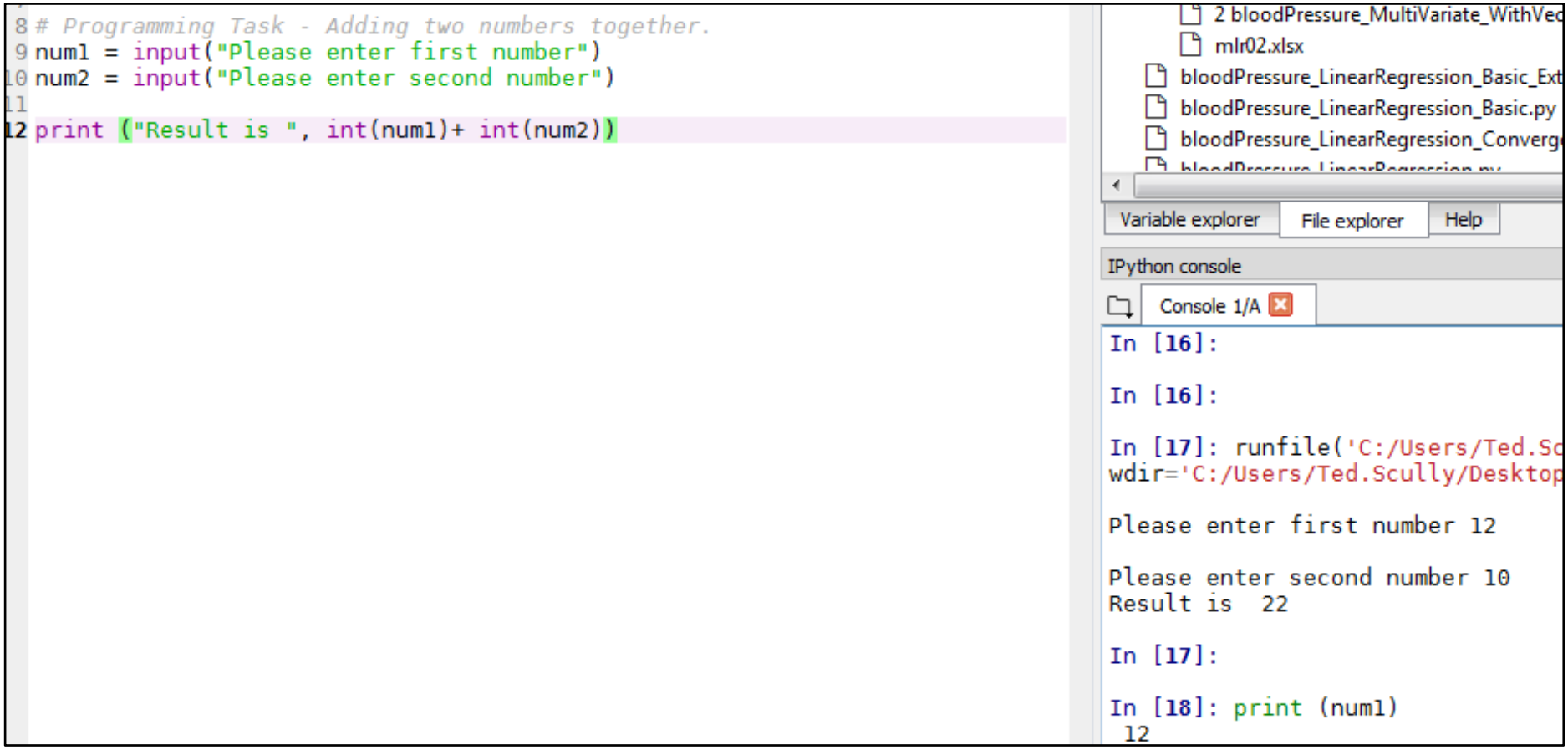
```
Please enter first number  14
Please enter second number  13
Result is  27
```

Programming Task

- So now lets implement the same program in Sypder.



- When we run a program using the console (it is an Ipython console) the variable are loaded into the console when the code is run. We can then access these variables from the console by printing them directly (see below).



Revision Overview

- Overview of Python and its runtime environment
- Input/Out and Processing in Python
- Data Types
-  Operators
- Decision Structures
- Iteration

Performing Calculations

- Math expression: performs calculation and returns a value

Symbol	Operation	Description
+	Addition	Adds two numbers
-	Subtraction	Subtracts one number from another
*	Multiplication	Multiplies one number by another
/	Division	Divides one number by another and gives the quotient
%	Remainder	Divides one number by another and gives the remainder
**	Exponent	Raises a number to a power

- Exponent operator (`**`): Raises a number to a power
  - `x ** y` = x^y
- Remainder operator (`%`): Performs division and returns the remainder
  - a.k.a. modulus operator
  - e.g., `4%2=0, 5%2=1`
  - Typically used to convert times and distances, and to detect odd or even numbers

Mixed-Type Expressions

- Data types resulting from math operations depends on the data types of operands
  - Two `int` values: result is an `int`
    - `There is an exception to the above rule. If dividing an int by an int the result is a float. This is a change introduced in Python 3`
  - Two `float` values: result is a `float`
  - `int` and `float`: `int` temporarily converted to `float`, result of the operation is a `float`
    - Mixed-type expression

Example of Precedence

```
>>> 12.0 + 6.0 / 3.0

>>> 1+2*2%3
```

Operator Precedence and Grouping with Parentheses

- Python operator precedence:
  1. Operations enclosed in parentheses
     - Forces operations to be performed before others
  2. Exponent (**)
  3. Multiplication (*), division (/), and remainder (%)
  4. Addition (+) and subtraction (-)

- Higher precedence performed first
  - Same precedence operators execute from left to right

Example of Precedence

```
>>> 12.0 + 6.0 / 3.0

>>> 1+2*2%3
```

1. Division
2. Sum

1. Multiplication
2. Modulus
3. Sum

Example of Precedence
Use of Parenthesis

Typically parts of a mathematical expression may be grouped with parentheses to force some operations
to be performed before others.

```
>>> (12.0 + 6.0) / 3.0

>>> (1+2)*2%3
```

1. Sum
2. Division

Result is 6.0

1. Sum
2. Multiplication
3. Modulus

Result is 0

Task

- Write a program that will ask a user
  - how many books do you want to read
  - how many months will it take you to read them

- The program should then tell the user how many books they will read per month

```
# Get the number of books the user plans to read.
books = int(input("How many books do you want to read? "))

# Get the number of months it will take to read them.
months = int(input("How many months will it take? " ))

# Calculate the number of books per month.
perMonth = books / months

# Display the result.
print ("You will read", perMonth, "books per month.")
```

```
How many books do you want to read?  19
How many months will it take? 4
You will read 4.75 books per month.
```

More About Data Output (cont'd.)

- Special characters appearing in string literal
  - Preceded by backslash (\)
    - Examples: newline (\n), horizontal tab (\t)
  - Treated as commands embedded in string

- When + operator used on two strings it performs string concatenation
  - Useful for breaking up a long string literal

```
name = input('Type your full name')
rest = " \n goes to college at \n CIT "
print (name+rest)
```

```
Type your full name Ted Scully
 Ted Scully
 goes to college at
 CIT
```

Discussion

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Computer Science

http://www.cit.ie

Thank you

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