



香港中文大學(深圳)
The Chinese University of Hong Kong, Shenzhen



SCHOOL OF
DATA SCIENCE
數據科學學院

Introduction to Computer Science: Programming Methodology

Lecture 2 Python Basics

Tongxin Li
School of Data Science

Last week

Computer Systems

Data Representation and Conversion

This week: Python Basics

Question

Is Von Neumann architecture the only one possible?

Example



Two paradigms for intelligence

Hinton's Slides

The logic-inspired approach

The essence of intelligence is reasoning.

This is done by using symbolic rules to manipulate symbolic expressions.

- Learning can wait. Understanding how knowledge is represented must come first.

The biologically-inspired approach

The essence of intelligence is learning the strengths of the connections in a neural network.

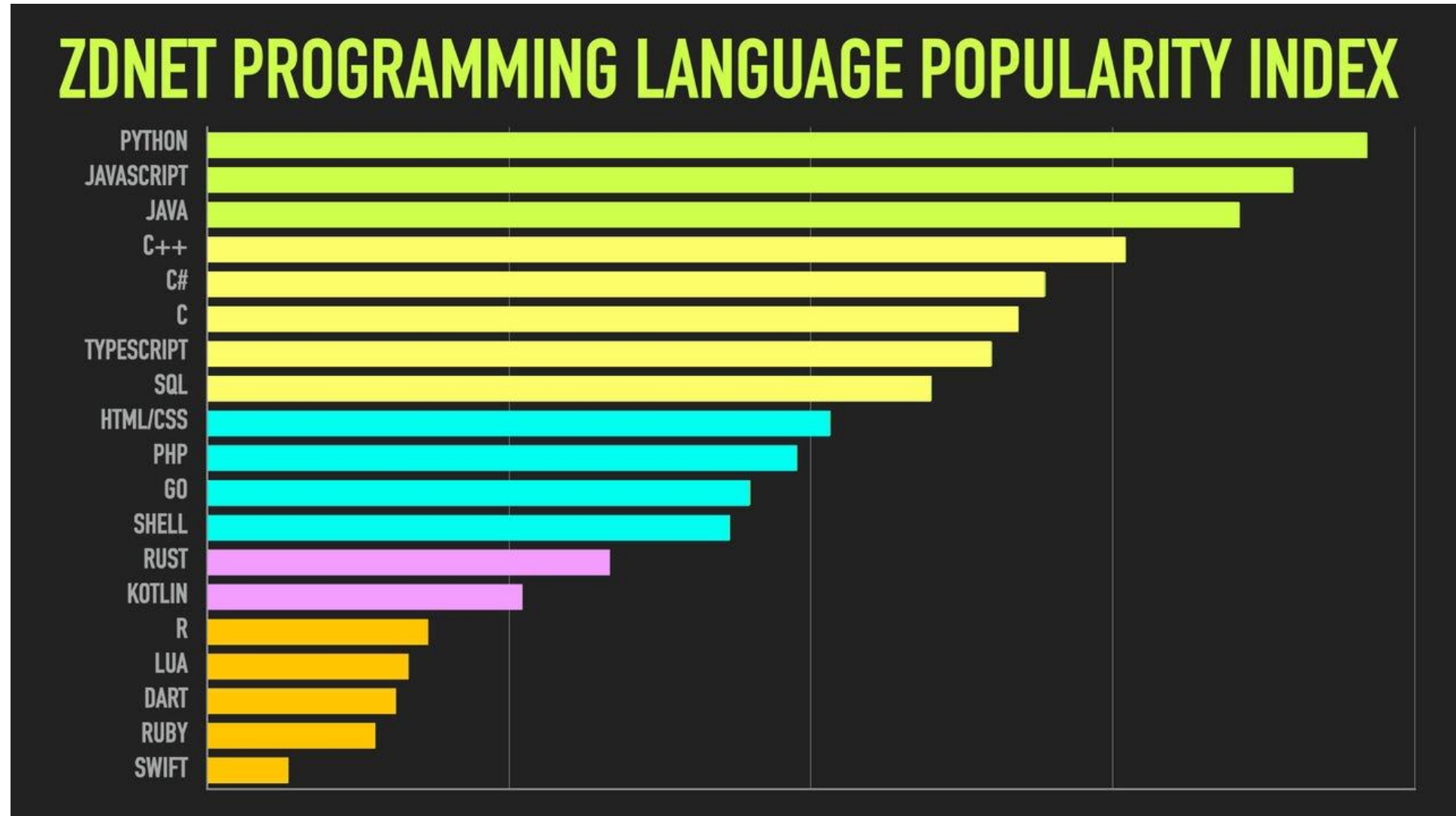
- Reasoning can wait. Understanding how learning works must come first.

Example

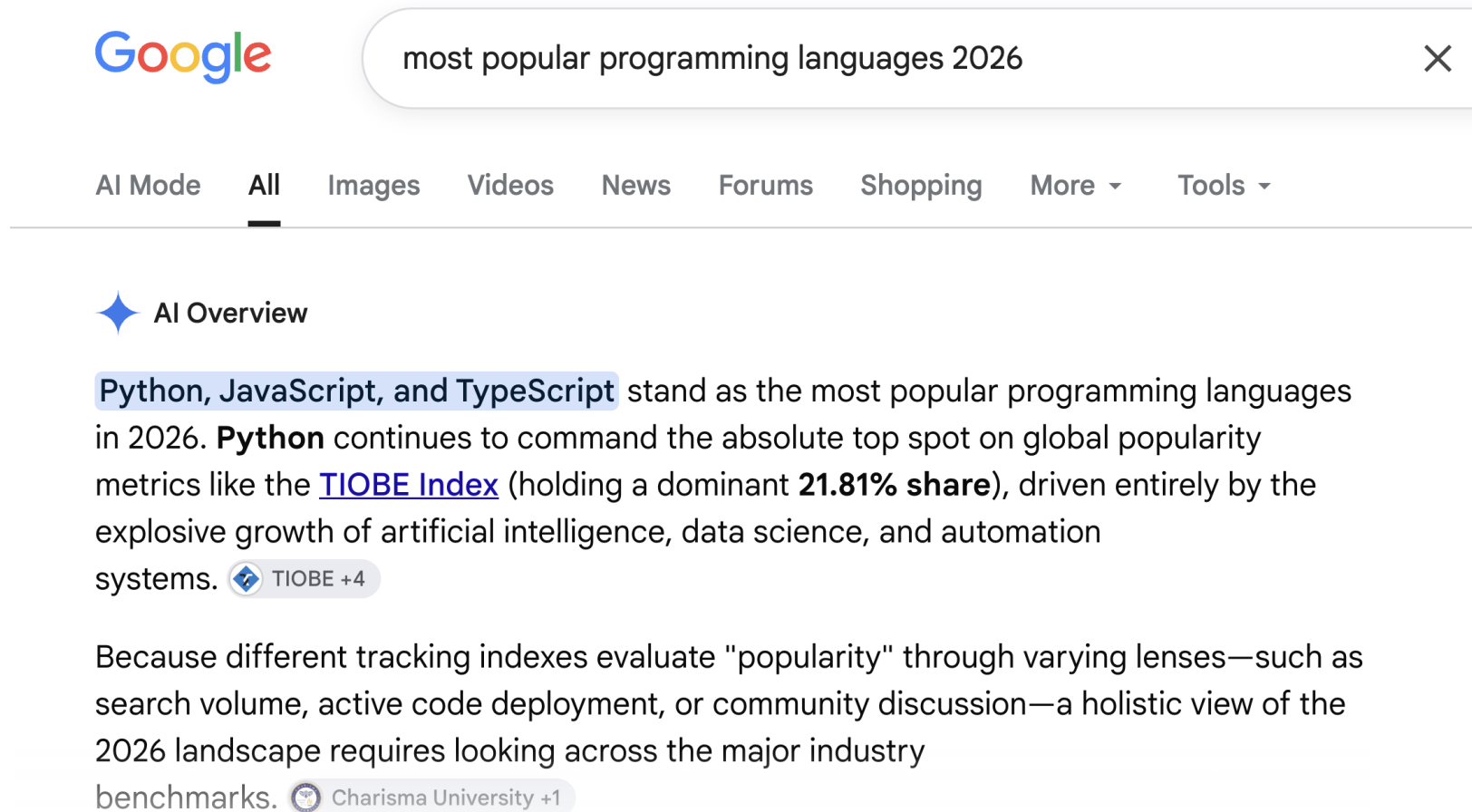
A new type of computer

- Computers were designed to faithfully implement instructions because it was assumed that the only way to get a general purpose computer to solve a specific task was to tell it exactly what to do.
- This is no longer true, but the research community has been slow to realize the implications of deep learning for how computers are built.
 - We will see a completely new type of computer.
 - It will not replace digital computers.

Popular programming languages



Popular programming languages



The image is a screenshot of a Google search interface. At the top left is the Google logo. To its right is a search bar containing the text "most popular programming languages 2026". Below the search bar is a horizontal menu with tabs: "AI Mode", "All", "Images", "Videos", "News", "Forums", "Shopping", "More", and "Tools". The "All" tab is currently selected. Below the menu, there is a section titled "AI Overview" with a blue star icon. The main text of the overview states: "Python, JavaScript, and TypeScript stand as the most popular programming languages in 2026. Python continues to command the absolute top spot on global popularity metrics like the TIOBE Index (holding a dominant 21.81% share), driven entirely by the explosive growth of artificial intelligence, data science, and automation systems." Below this text is a small icon of a blue diamond with a white 'T' and the text "TIOBE +4". The text continues: "Because different tracking indexes evaluate 'popularity' through varying lenses—such as search volume, active code deployment, or community discussion—a holistic view of the 2026 landscape requires looking across the major industry benchmarks." Below this is another small icon of a blue circle with a white 'C' and the text "Charisma University +1".

Google

most popular programming languages 2026

AI Mode All Images Videos News Forums Shopping More Tools

✦ AI Overview

Python, JavaScript, and TypeScript stand as the most popular programming languages in 2026. **Python** continues to command the absolute top spot on global popularity metrics like the [TIOBE Index](#) (holding a dominant **21.81% share**), driven entirely by the explosive growth of artificial intelligence, data science, and automation systems.  TIOBE +4

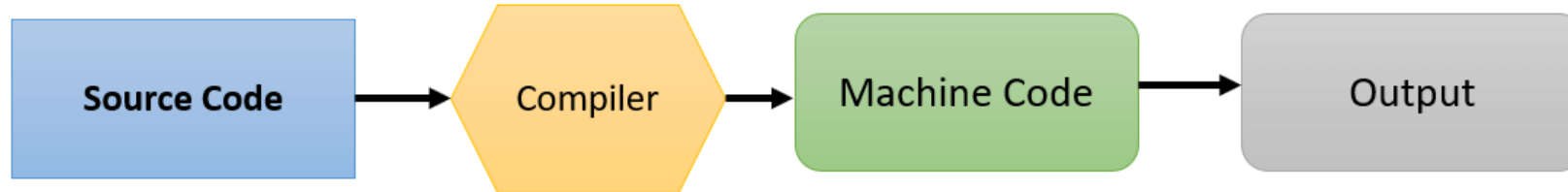
Because different tracking indexes evaluate "popularity" through varying lenses—such as search volume, active code deployment, or community discussion—a holistic view of the 2026 landscape requires looking across the major industry benchmarks.  Charisma University +1

Interpreter v.s. compiler

- **Interpreter (解释器)** is a computer program that **directly** executes, i.e. performs, instructions written in a programming or scripting language, **without previously compiling** them into a machine language program
- **A compiler (编译器)** is a computer program (or a set of programs) that transforms source code written in a programming language (the **source language**) into another computer language (the **target language**), with the latter often having a binary form known as **object code**

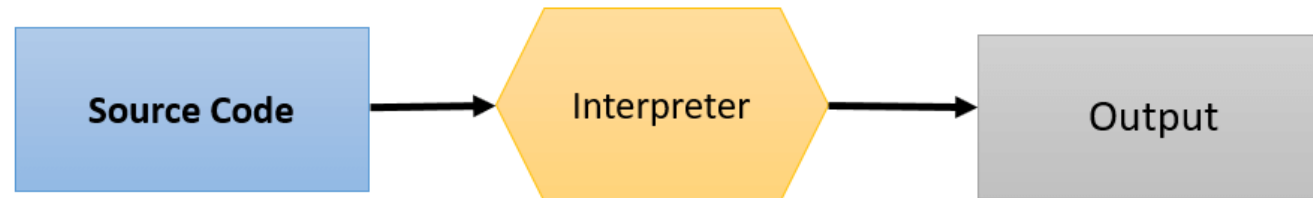
Interpreter v.s. compiler

How Compiler Works



© guru99.com

How Interpreter Works



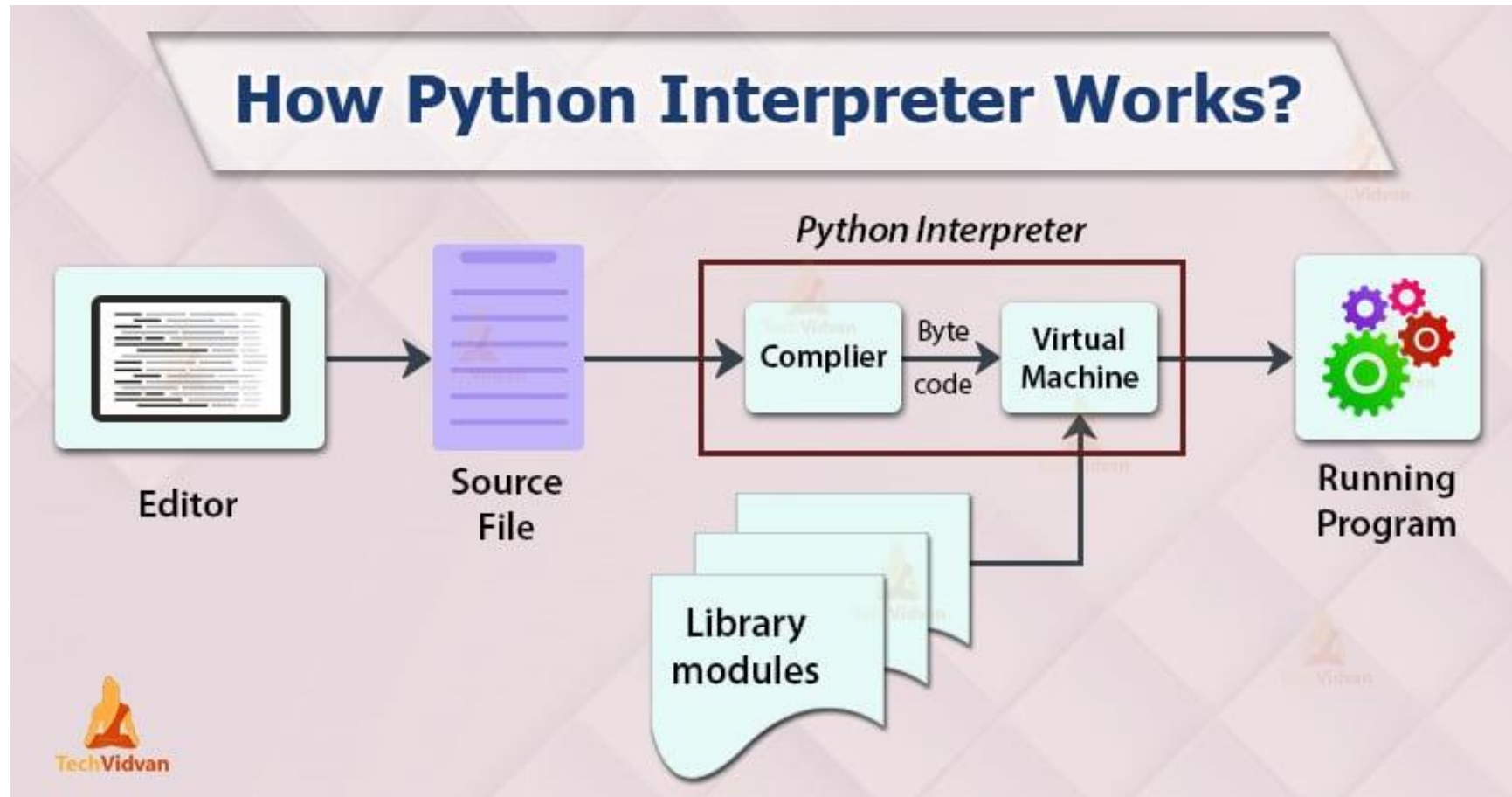
Precisely, Python does not compile to the native machine's code. Instead, it compiles to a byte code that is used by a virtual machine.

Python “Interpreter”

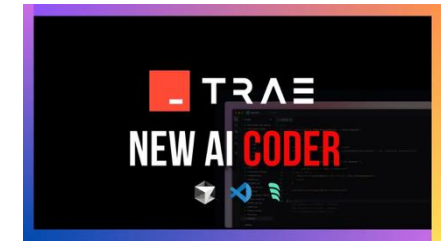
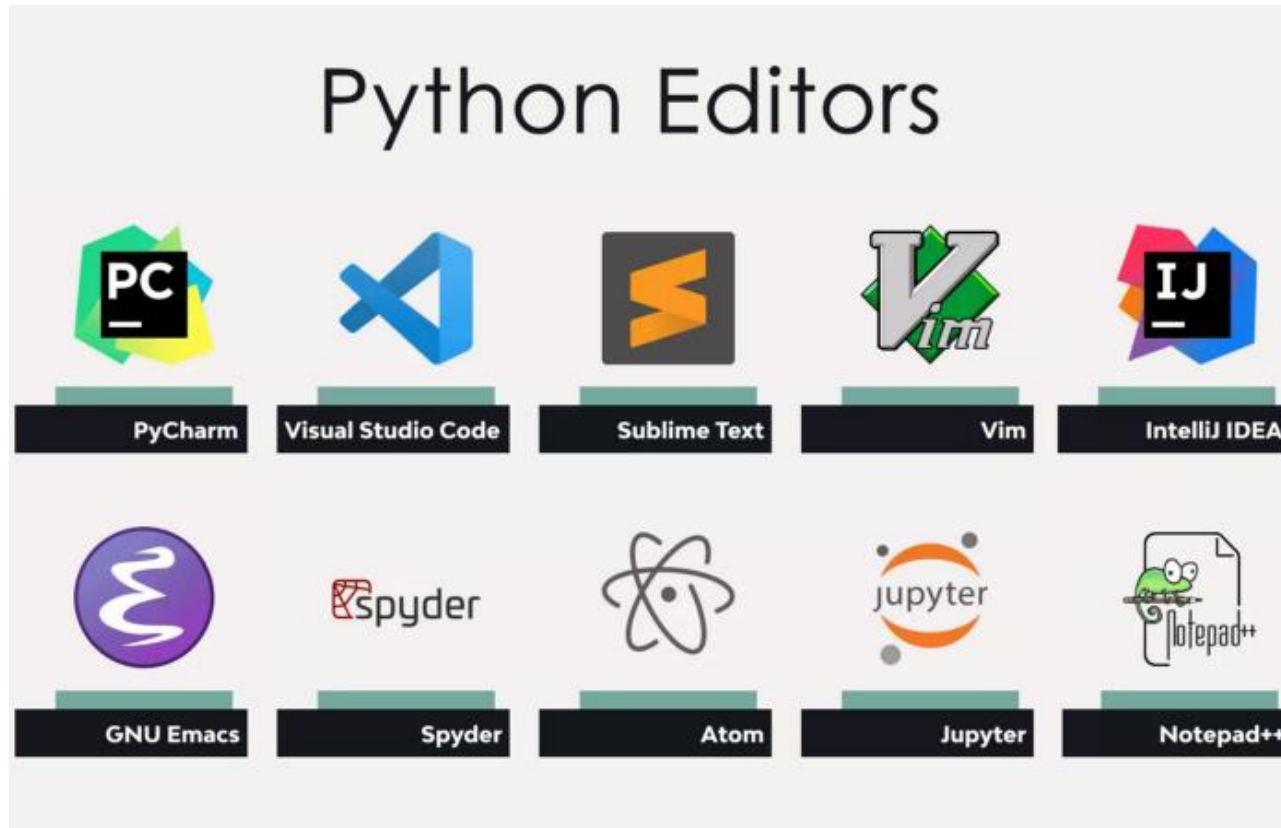
It is called a Python **interpreter** because it translates and executes your code on the fly **during runtime**, acting like a real-world language interpreter translating a conversation line-by-line.

Instead of requiring you to **compile** your entire program into a permanent machine-code file before running it (like C or C++), the **interpreter** allows you to run your source code **directly**.

Python “Interpreter”



Integrated development environment

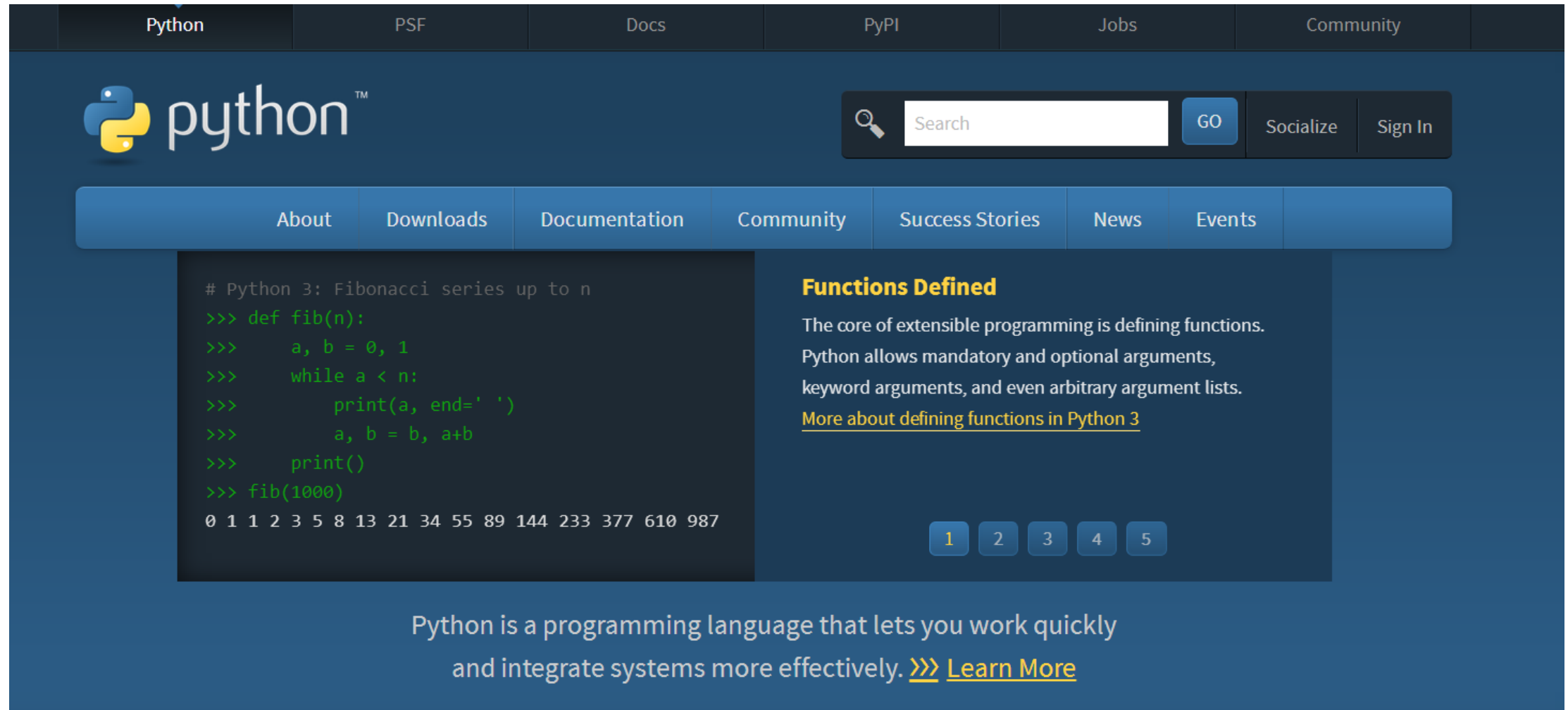


Python Versions

Feel free to use any python version in your assignments/exams as long as it compiles

- [Python 3.13.0rc2](#), documentation released on 6 September 2024. **[pre-release candidate]**
- [Python 3.12.6](#), documentation released on 6 September 2024.
- [Python 3.12.5](#), documentation released on 6 August 2024.
- [Python 3.12.4](#), documentation released on 6 June 2024.
- [Python 3.12.3](#), documentation released on 9 April 2024.
- [Python 3.12.2](#), documentation released on 6 February 2024.
- [Python 3.12.1](#), documentation released on 8 December 2023.
- [Python 3.12.0](#), documentation released on 2 October 2023.
- [Python 3.11.10](#), documentation released on 6 September 2024.
- [Python 3.11.9](#), documentation released on 2 April 2024.
- [Python 3.11.8](#), documentation released on 6 February 2024.
- [Python 3.11.7](#), documentation released on 4 December 2023.
- [Python 3.11.6](#), documentation released on 2 October 2023.

Installing Python



The image is a screenshot of the Python.org homepage. At the top, there is a dark blue navigation bar with links for Python, PSF, Docs, PyPI, Jobs, and Community. Below this is a large blue banner. On the left of the banner is the Python logo. To the right of the logo is a search bar with a magnifying glass icon, a 'GO' button, and links for 'Socialize' and 'Sign In'. Below the search bar is a horizontal menu with links for About, Downloads, Documentation, Community, Success Stories, News, and Events. The main content area is divided into two columns. The left column contains a code snippet for a Fibonacci series generator. The right column has a section titled 'Functions Defined' with a paragraph about defining functions and a link to 'More about defining functions in Python 3'. At the bottom of the banner, there is a statement about Python being a programming language that lets you work quickly and integrate systems more effectively, followed by a link to 'Learn More'.

```
# Python 3: Fibonacci series up to n
>>> def fib(n):
>>>     a, b = 0, 1
>>>     while a < n:
>>>         print(a, end=' ')
>>>         a, b = b, a+b
>>>     print()
>>> fib(1000)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 987
```

Functions Defined

The core of extensible programming is defining functions. Python allows mandatory and optional arguments, keyword arguments, and even arbitrary argument lists.

[More about defining functions in Python 3](#)

1 2 3 4 5

Python is a programming language that lets you work quickly and integrate systems more effectively. [>>> Learn More](#)

<https://www.python.org>

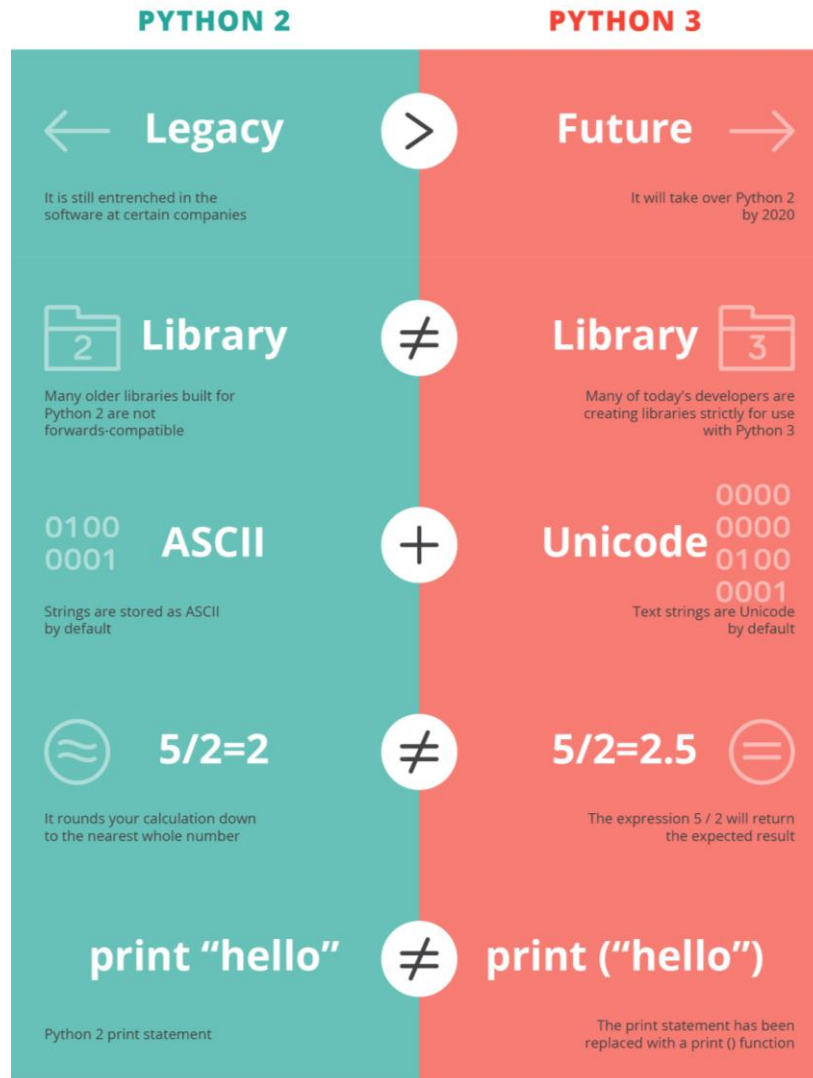
Installing Python



Looking for a specific release?

Python releases by version number:

Python 3 vs Python 2



Range function

Unicode support

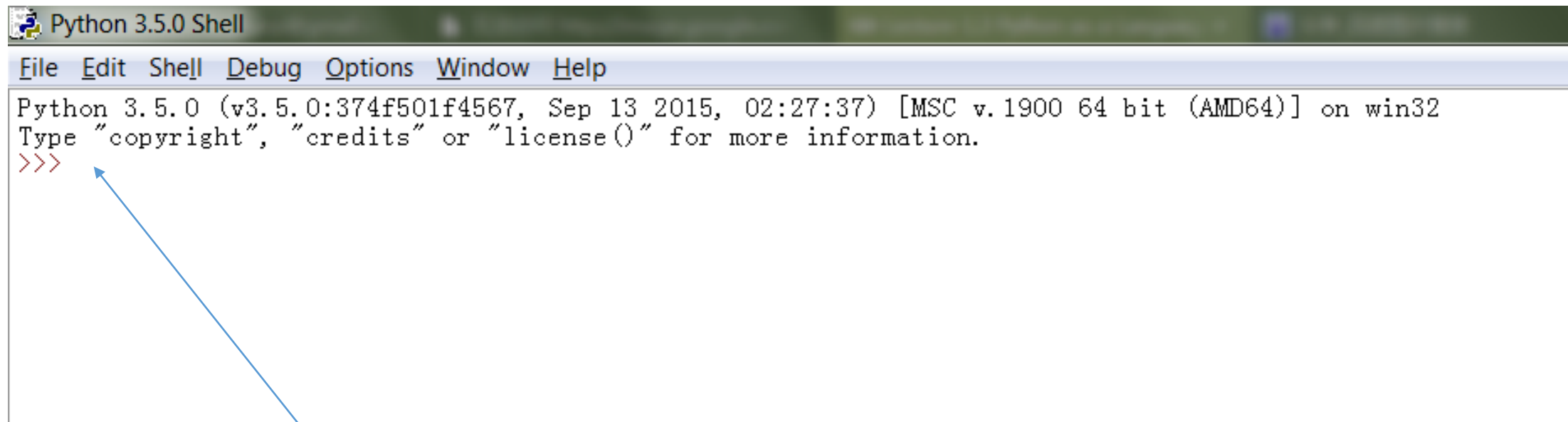
Integer division

The new `print()` function

Python beginner: syntax error

- We need to learn the Python language so we can communicate our instructions to Python. In the beginning we will make lots of mistakes and speak gibberish like small children
- When you make a mistake, the computer does not think you are “cute”. It says “**syntax error**” – given that it “knows” the language and you are just learning it. It seems like Python is cruel and unfeeling
- You must remember that **you are intelligent and can learn**, while the computer is simple and very fast – **but cannot learn**
- It is **easier** for you to learn Python than for the computer to learn human language

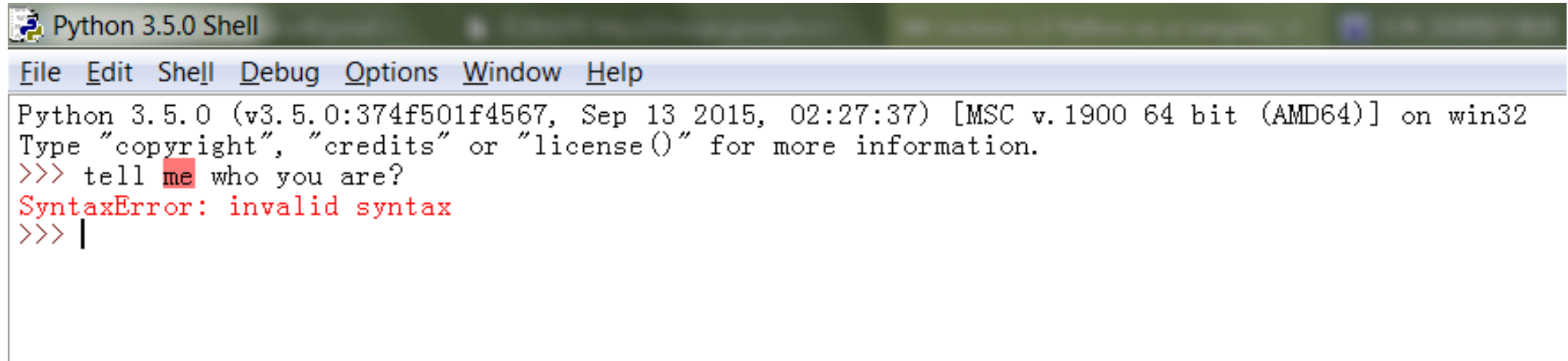
Python Shell



```
Python 3.5.0 Shell
File Edit Shell Debug Options Window Help
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>>
```

What is next?

Syntax Error

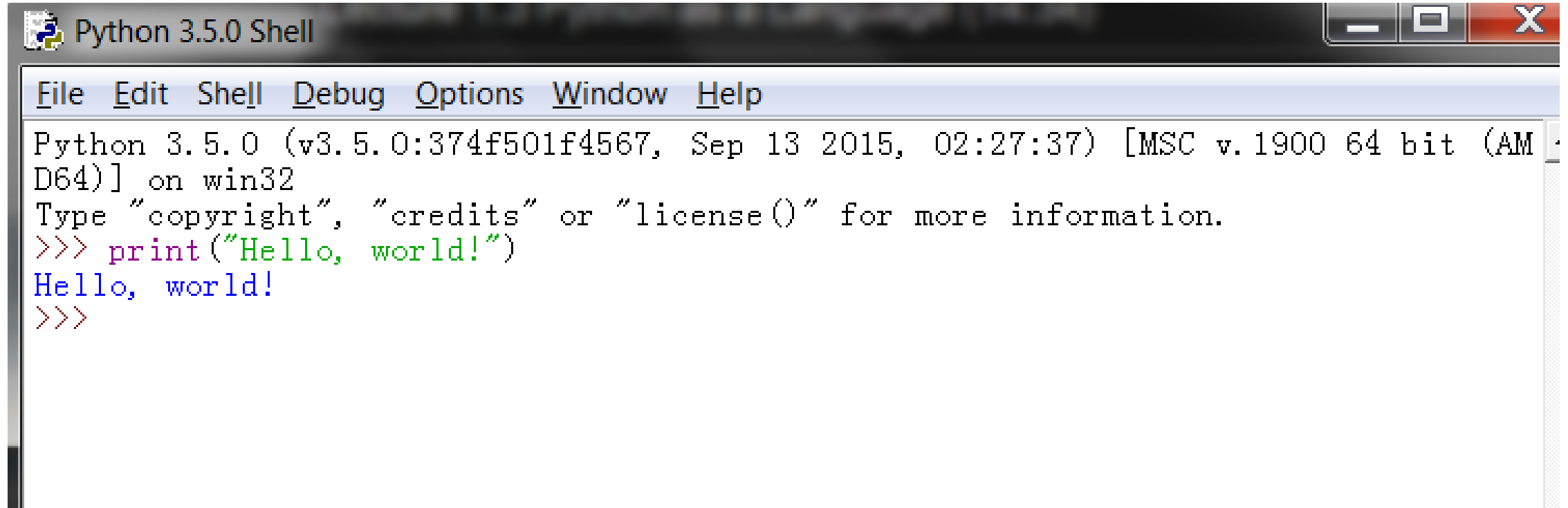


The image shows a screenshot of a Python 3.5.0 Shell window. The window has a title bar that says "Python 3.5.0 Shell". Below the title bar is a menu bar with the following options: File, Edit, Shell, Debug, Options, Window, and Help. The main area of the window displays the following text:

```
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> tell me who you are?
SyntaxError: invalid syntax
>>> |
```

The text "SyntaxError: invalid syntax" is displayed in red, indicating an error. The prompt ">>> |" shows that the user has entered a line of code that is not valid Python syntax.

Hello, world!

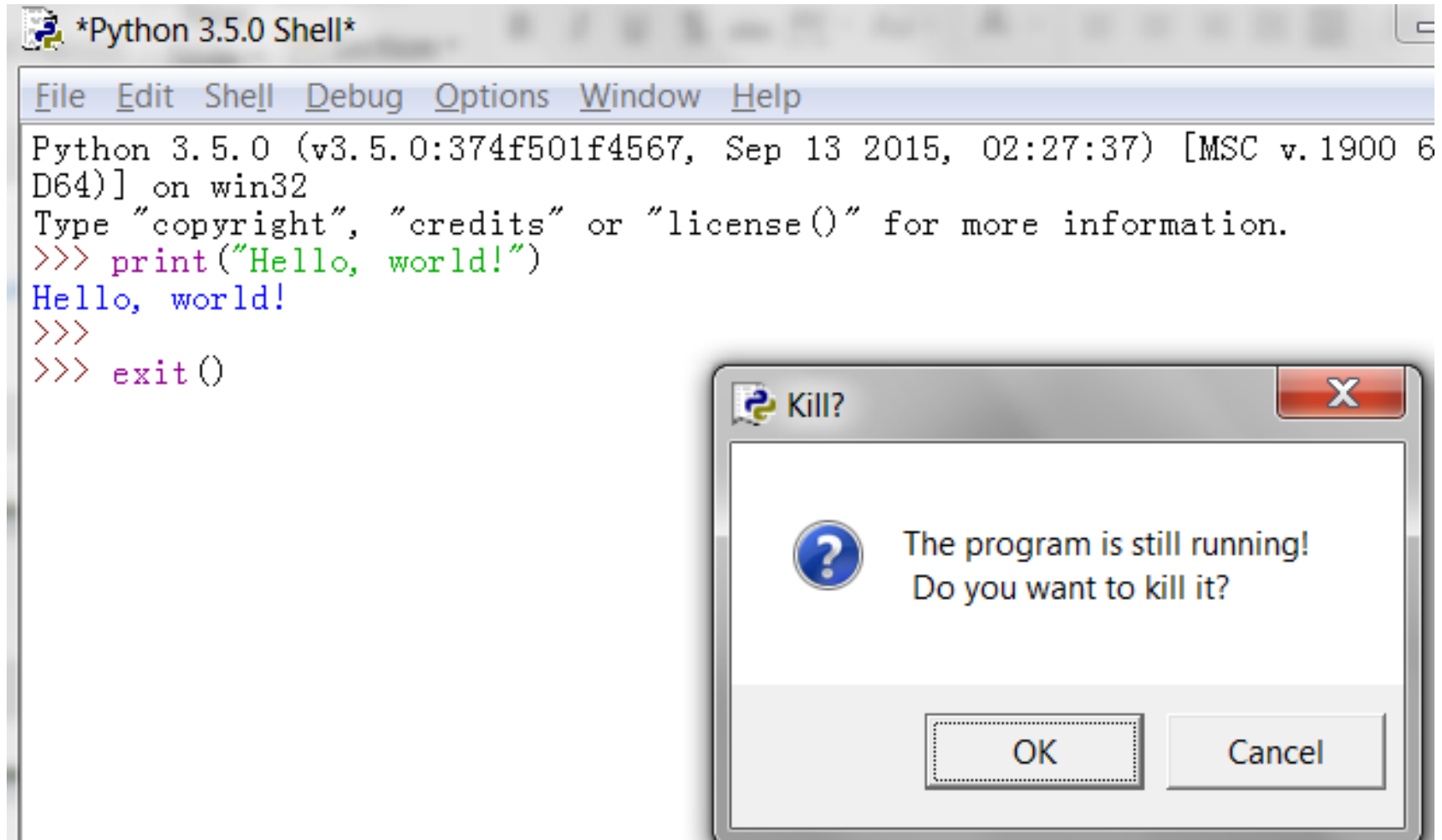


The screenshot shows a window titled "Python 3.5.0 Shell". The menu bar includes "File", "Edit", "Shell", "Debug", "Options", "Window", and "Help". The main text area displays the following content:

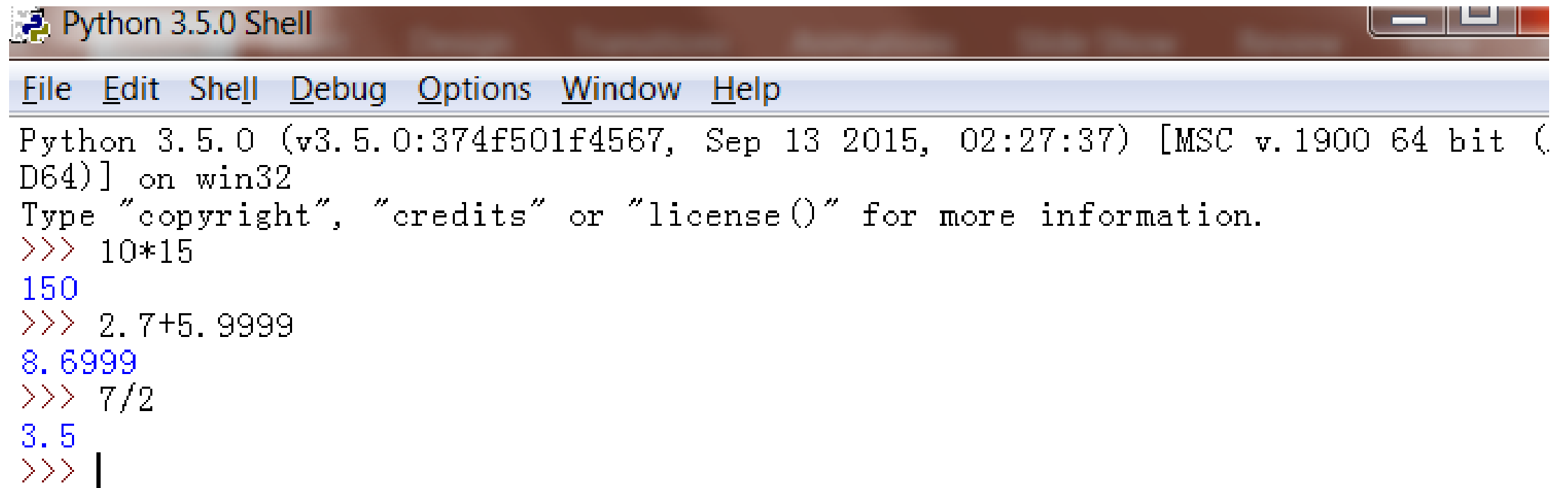
```
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> print("Hello, world!")
Hello, world!
>>>
```

- You must say something that Python interpreter can understand!!
- `Print()` is a **function** in Python

Exit()



Use Python as a calculator

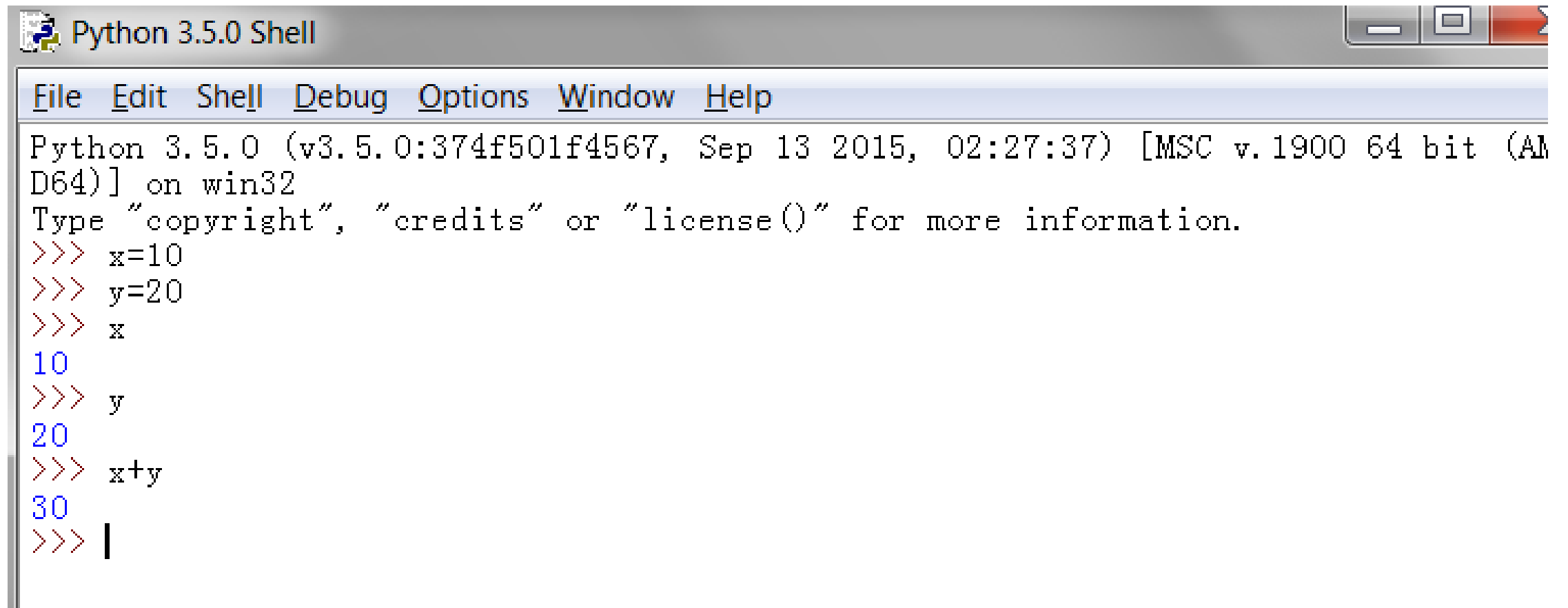


```
Python 3.5.0 Shell
File Edit Shell Debug Options Window Help
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (
D64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> 10*15
150
>>> 2.7+5.9999
8.6999
>>> 7/2
3.5
>>> |
```

Elements of Python Language

- Vocabulary/words – Variables and Reserved words
- Sentence structure – valid syntax patterns
- Story structure – constructing a meaningful program for some purposes

Variables



```
Python 3.5.0 Shell
File Edit Shell Debug Options Window Help
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (AMD64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> x=10
>>> y=20
>>> x
10
>>> y
20
>>> x+y
30
>>> |
```

Reserved words

- You **cannot** use the following words as **variables**

False	None	True	and	as	assert	break
class	continue	def	del	elif	else	except
finally	for	from	global	if	import	in
is	lambda	nonlocal	not	or	pass	raise
return	try	while	with	yield		

Sentences or lines

>>> x=2	←	Assignment statement
>>> x=x+2	←	Assignment with expressions
>>> print(x)	←	Print statement (output statement)
4		
>>>		

Programming scripts

- **Interactive Python** is good for experiments and programs of 3-4 lines long
- Most programs are **much longer**, so we have to type them **in a file** and **execute them all together**
- In this sense, we are giving Python a **script**
- As convention, “.py” is added as the **suffix** on the end of these files

Interactive v.s. script

- Interactive

- ✓ You type directly to Python one line at a time and it responds

- Script

- ✓ You enter a sequence of statements (lines) into a file using a text editor and tell Python to execute the file

Program steps or program flow

- Like a recipe, a program is a sequence of steps to be done in pre-determined order
- Some steps are conditional, i.e. they may be skipped
- Sometimes, we will repeat some steps
- Sometimes, we store a set of steps to be used over and over again in future as needed

Sequential flow

Execute sequentially



```
>>> x=2
>>> print(x)
2
>>> x=x*10
>>> print(x)
20
>>> |
```

Outputs

- When a program is running, it flows from one step to the next
- We as programmers, set up “**paths**” for the program to follow

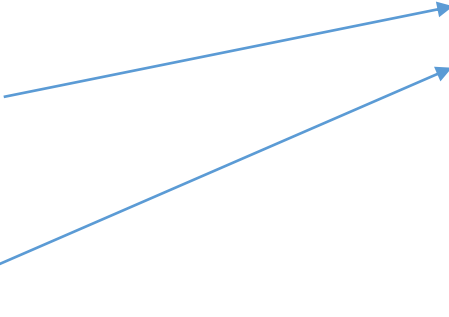
Conditional flow

Program

```
x=5
if x<10:
    print("smaller")
if x>20:
    print("bigger")
print("finished")
```

Outputs

```
smaller
finished
>>> |
```



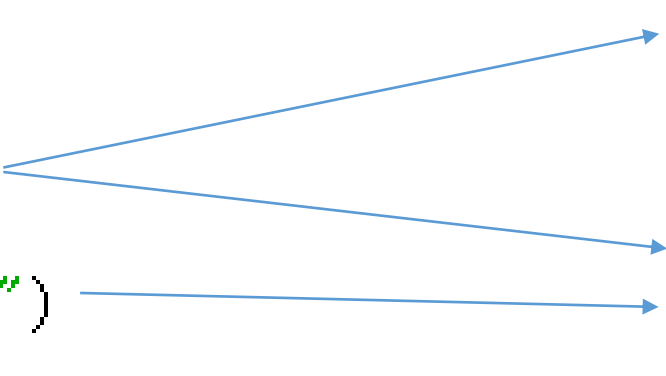
Repeated flow

Program

```
n=5
while n>0:
    print(n)
    n = n - 1
print("Finish")
```

Outputs

```
5
4
3
2
1
Finish
>>>
```



- Loops (repeated steps) have iterative variables that change each time through a loop
- Often these iterative variables go through a sequence of numbers

What the largest number is?

25	1	114	117	150	152	120	46	19	126
191	121	104	116	160	105	89	125	40	14
31	139	113	94	97	193	154	140	195	122
112	163	177	48	78	101	130	83	35	197
44	54	106	143	59	38	3	41	93	81
20	164	4	11	131	0	107	71	159	69
181	178	173	148	62	142	170	72	37	145
60	187	198	99	15	82	26	8	192	17
129	73	45	9	24	188	42	151	51	183
179	79	50	76	34	33	185	102	193	184

What the largest number is?

25	1	114	117	150	152	120	46	19	126
191	121	104	116	160	105	89	125	40	14
31	139	113	94	97	193	154	140	195	122
112	163	177	48	78	101	130	83	35	197
44	54	106	143	59	38	3	41	93	81
20	164	4	11	131	0	107	71	159	69
181	178	173	148	62	142	170	72	37	145
60	187	198	99	15	82	26	8	192	17
129	73	45	9	24	188	42	151	51	183
179	79	50	76	34	33	185	102	193	184

Constants

- Fixed values such as numbers and letters are called **constants**, since their values won't change
- **String** constants use single-quotes (') or double-quotes (")

Variable

- A variable is a **named space** in the **memory** where a programmer can store **data** and later retrieve the data using the **variable name**
- Variable names are determined by programmers
- The **value** of a variable can be **changed later** in a program

Rules for defining variables in Python

- Must start with a letter or underscore _
- Can **only** contain letters, numbers and underscore
- Case **sensitive**
- **Good**: apple, car, myNumber123, _light
- **Bad**: 456aaa, #ab, var.12
- **Different**: apple, Apple, APPLE

Personal tips

- Use **meaningful words** as variable names
- Start with a **lower letter**
- Capitalize the **first letter** of each word
- **Example**: myBankAccountID, numOfCards, salaryAtYear1995...

What is this code doing?

```
x1q3z9ocd = 35.0  
x1q3z9afd = 12.50  
x1q3p9afd = x1q3z9ocd * x1q3z9afd  
print x1q3p9afd
```

Reserved words

- You **cannot** use the following words as **variables**

False	None	True	and	as	assert	break
class	continue	def	del	elif	else	except
finally	for	from	global	if	import	in
is	lambda	nonlocal	not	or	pass	raise
return	try	while	with	yield		

Sentences or lines

>>> x=2	←	Assignment statement
>>> x=x+2	←	Assignment with expressions
>>> print(x)	←	Print statement (output statement)
4		
>>>		

Variable Operator Constant Reserved words

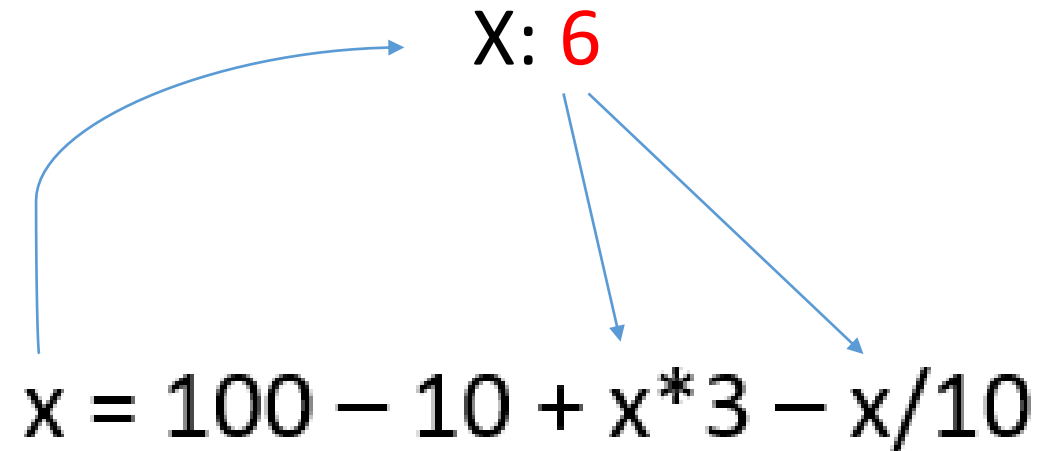
Assignment statement

- We assign a value to a variable using the **assignment operator (=)**
- An assignment statement consists of an **expression on the right-hand side**, and a **variable** to store the result

Example: $x = 100 - 10 + x * 3 - x / 10$

Assignment statement

- There is a location in the memory for x
- Whenever the value of x is needed, it can be retrieved from the memory
- After the expression is evaluated, the result will be put back into x



Cascaded assignment

- We can set multiple variables into the same value using a single assignment statement

Example

```
>>> z = y = x = 2 + 7 + 2
>>> x, y, z
(11, 11, 11)
```

Simultaneous assignment

- The values of two variables can be exchanged using simultaneous assignment

Example

```
>>> c = "deepSecret"           # Set current password.
>>> o = "you'll never guess"    # Set old password.
>>> c, o                        # See what passwords are.
('deepSecret', 'you'll never guess')
>>> c, o = o, c                # Exchange the passwords.
```

Practice

- Write a program to exchange the values of two variables **without** using simultaneous assignment

Bad use of simultaneous assignment

```
>>> # A bad use of simultaneous assignment.
>>> x, y = (45 + 34) / (21 - 4), 56 * 57 * 58 * 59
>>> x, y
(4.647058823529412, 10923024)
>>> # A better way to set the values of x and y.
>>> x = (45 + 34) / (21 - 4)
>>> y = 56 * 57 * 58 * 59
>>> x, y
(4.647058823529412, 10923024)
```

Order evaluation

- When we put operators together, Python needs to know which one to do first
- This is called “operator precedence”
- Which operator “takes precedence” over the others

Example: $X = 1 + 2 * 3 - 4 / 5 ** 6$

Numeric expression and operators

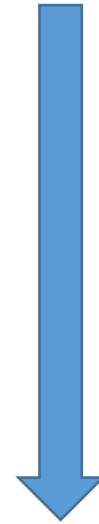
- We use some keys we have on the keyboard to denote the classic math operators
- **Asterisk** (*) is the multiplication operator
- **Double asterisk** (**) is used to denote Exponentiation (raise to a power)

Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Power
%	Remainder

Operator precedence rules

- **Highest to lowest precedence rule**

- ✓ Parenthesis are always with highest priority
- ✓ Power
- ✓ Multiplication, division and remainder
- ✓ Addition and subtraction
- ✓ Left to right



Operator precedence

Example: $x = 1 + 2^{**}3 / 4^{*}5$

Floor division

```
>>> time = 257                # Time in seconds.  
>>> minutes = time // 60      # Number of complete minutes in time.  
>>> print("There are", minutes, "complete minutes in", time, "seconds.")  
There are 4 complete minutes in 257 seconds.  
>>> 143 // 25  
5  
>>> 143.4 // 25  
5.0  
>>> 9 // 2.5  
3.0
```

divmod()

```
>>> time = 257          # Initialize time.
>>> SEC_PER_MIN = 60    # Use a "named constant" for 60.
>>> divmod(time, SEC_PER_MIN) # See what divmod() returns.
(4, 17)
>>> # Use simultaneous assignment to obtain minutes and seconds.
>>> minutes, seconds = divmod(time, SEC_PER_MIN)
>>> # Attempt to display the minutes and seconds in "standard" form.
>>> print(minutes, ":", seconds)
4 : 17
>>> # Successful attempt to display time "standard" form.
>>> print(minutes, ":", seconds, sep="")
4:17
>>> # Obtain number of quarters and leftover change in 143 pennies.
>>> quarters, cents = divmod(143, 25)
>>> quarters, cents
(5, 18)
```

Augmented assignment

- The general form of augmented assignment looks like

`<lvalue> <op>= <expression>`

Example

```
>>> x = 22          # Initialize x to 22.
>>> x += 7          # Equivalent to: x = x + 7
>>> x
29
>>> x -= 2 * 7      # Equivalent to: x = x - (2 * 7)
>>> x
15
```

Personal tips

- Use parentheses
- Keep mathematical expressions simple so that they are easy to understand
- Break up long series of math expressions to make them easy to understand

Integer division in Python

- In Python 2, Integer division **truncates**
- Integer division produces floating point numbers in Python 3
- The **conversion** between integer and floating point numbers is done **automatically** in Python 3
- Things change between Python 2 and Python 3

Data Type

- In Python, variables and constants have an associated “**type**”
- Python **knows the difference** between a number and a string
- **Example:**

```
>>> a = 100 + 200
>>> print(a)

>>> b = "100" + "200"
>>> print(b)
```

Type matters

- Python knows what type everything is
- Some operations are **prohibited** on certain types
- You cannot “**add 1**” to a string
- We can **check the type** of something using function **type()**

Types of numbers

- Numbers in Python generally have **two types**:
 - ✓ Integers: 1, 2, 100, -20394209
 - ✓ Floating point numbers: 2.5, 3.7, 11.32309, -30.999
- There are other number types, which are variations on float and integer

Type can change

- The type of a variable can be **dynamically changed**
- A variable's type is determined by the value that is **last assigned to the variable**

```
>>> x = 7 * 3 * 2
>>> y = "is the answer to the ultimate question of life"
>>> print(x, y)           # Check what x and y are.
42 is the answer to the ultimate question of life
>>> x, y                  # Quicker way to check x and y.
(42, 'is the answer to the ultimate question of life')
>>> type(x), type(y)     # Check types of x and y.
(<class 'int'>, <class 'str'>)
>>> # Set x and y to new values.
>>> x = x + 3.14159
>>> y = 1232121321312312312312 * 9873423789237438297
>>> print(x, y)          # Check what x and y are.
45.14159 12165255965071649871208683630735493412664
>>> type(x), type(y)     # Check types of x and y.
(<class 'float'>, <class 'int'>)
```

Type conversion

- When an expression contains both integer and float, integers will be converted into float **implicitly**
- You can control this using functions `int()` and `float()`

- **Example:**

```
>>> print(float(99)/100)
```

```
>>> i=42
```

```
>>> type(i)
```

```
>>> f=float(i)
```

```
>>> print(f)
```

```
>>> type(f)
```

```
>>> print(1+2*float(3)/4-5)
```

String conversions

- You can also use `int()` and `float()` to convert strings into numbers
- You will **get an error** if the string contains characters other than numbers

Converting numbers into string

- We can convert numbers into string using function `str()`

```
>>> str(5)                # Convert int to a string.
'5'

>>> str(1 + 10 + 100)     # Convert int expression to a string.
'111'

>>> str(-12.34)           # Convert float to a string.
'-12.34'

>>> str("Hello World!")   # str() accepts string arguments.
'Hello World!'

>>> str(divmod(14, 9))     # Convert tuple to a string.
'(1, 5)'

>>> x = 42

>>> str(x)                # Convert int variable to a string.
'42'
```

User input

- We can instruct Python to **stop and take user inputs** using function `input()`
- The `input()` function returns a **string**

Practice

- The BMI (body mass index) of a human can be calculated using the following equation:

$$\text{BMI} = \text{weight (kg)} \div \text{height}^2 \text{ (m)}$$

- Write a program to input a user's weight and height, and then output his BMI



Converting user input

- If we want to read a number using `input()`, we must then convert the input into a number using `int()` or `float()`
- Later we will deal with bad input data

Comments

- Anything after a “#” is ignored by Python
- Why comment?
 - ✓ Describe **what is going to happen** in a sequence of code
 - ✓ Document **who wrote the code** and other important information
 - ✓ **Turn off** a line of code – usually temporarily

String operations

- Some operators **apply to strings**

- ✓ **“+”**: concatenation

- ✓ **“*”**: multiple concatenation

- Python **knows** whether it is dealing with a number or a string

Practice

- Write a program to instruct the user to input two of his friends' names, and then output a sentence "I am the friend of XX and XX."

Output using Print()

```
>>> print(42, "42") # An int and a str that looks like an int.  
42 42  
>>> print('3.14') # A str that looks like a float.  
3.14  
>>> print(3.14) # A float.  
3.14
```

More details on print()

```
print(...)  
    print(value, ..., sep=' ', end='\n', file=sys.stdout, flush=False)
```

Prints the values to a stream, or to sys.stdout by default.

Optional keyword arguments:

file: a file-like object (stream); defaults to the current sys.stdout.

sep: string inserted between values, default a space.

end: string appended after the last value, default a newline.

flush: whether to forcibly flush the stream.

Examples

```
>>> print("I", "am", "Daniel")
```

```
>>> print("I", "am", "Daniel", sep=" ")
```

```
>>> print("I", "am", "Daniel", sep=", ")
```

Examples

```
>>> print("I", "am", "Daniel")
```

```
I am Daniel
```

```
>>> print("I", "am", "Daniel", sep=" ")
```

```
IamDaniel
```

```
>>> print("I", "am", "Daniel", sep=", ")
```

```
I,am,Daniel
```

Example

```
print("Test line 1")  
print("Test line 2")
```

```
print("Test line 1", end = " ")  
print("Test line 2")
```

```
print("Test line 1", end = "---")  
print("Test line 2")
```

A powerful function - eval()

- The eval() function takes a string argument and evaluates that string **as a Python expression**, i.e., just as if the programmer had directly entered the expression as code
- The function returns **the result of that expression**
- Eval() gives the programmers the **flexibility** to determine what to execute **at run-time**
- One should be **cautious** about using it in situations where users could potentially cause problems with “inappropriate” inputs

Example

```
>>> string = "5 + 12" # Create a string.
>>> print(string)      # Print the string.
5 + 12
>>> eval(string)       # Evaluate the string.
17
>>> print(string, "=", eval(string))
5 + 12 = 17
>>> eval("print('Hello World!')") # Can call functions from eval().
Hello World!
>>> # Using eval() we can accept all kinds of input...
>>> age = eval(input("Enter your age: "))
Enter your age: 57.5
>>> age
57.5
>>> age = eval(input("Enter your age: "))
Enter your age: 57
>>> age
57
>>> age = eval(input("Enter your age: "))
Enter your age: 40 + 17 + 0.5
>>> age
57.5
```

Example

```
>>> eval("10, 32")           # String with comma-separated values.
(10, 32)
>>> x, y = eval("10, 20 + 12") # Use simultaneous assignment.
>>> x, y
(10, 32)
>>> # Prompt for multiple values. Must separate values with a comma.
>>> x, y = eval(input("Enter x and y: "))
Enter x and y: 5 * 2, 32
>>> x, y
(10, 32)
```