香 港 中 文 大 學（深 圳）
The Chinese University of Hong Kong, Shenzhen

Introduction to Computer Engineering: Programming and Applications

Lecture 2 Python Basics

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Parseltongue is the language of serpents and those who can converse with them. An individual who can speak Parseltongue is known as a Parselmouth. It is very uncommon skill, and may be hereditary. Nearly all known Parselmouths are descended from Salazar Slytherin.

Http://harrypotter.wikia.com/wiki/Parseltongue

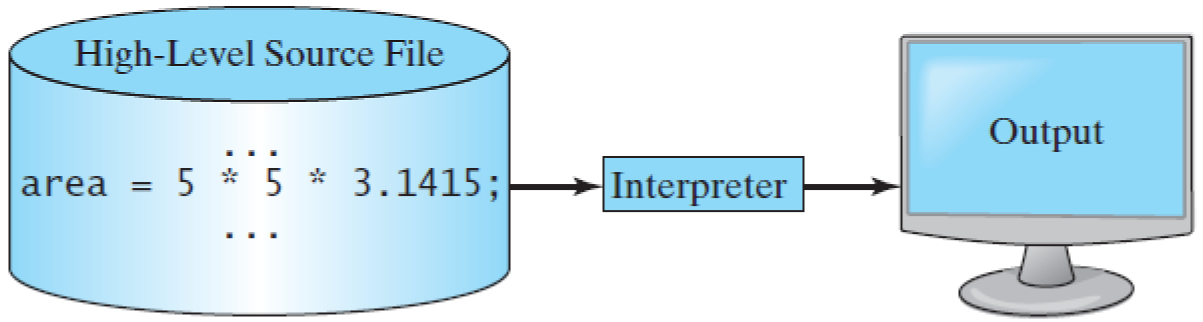
Python is the language of Python interpreter and those who can converse with them. An individual who can speak Python is known as a Pythonista. It is very uncommon skill, and may be hereditary. Nearly all known Pythonistas use software initially developed by Guido van Rossum

Interpreter v.s. compiler

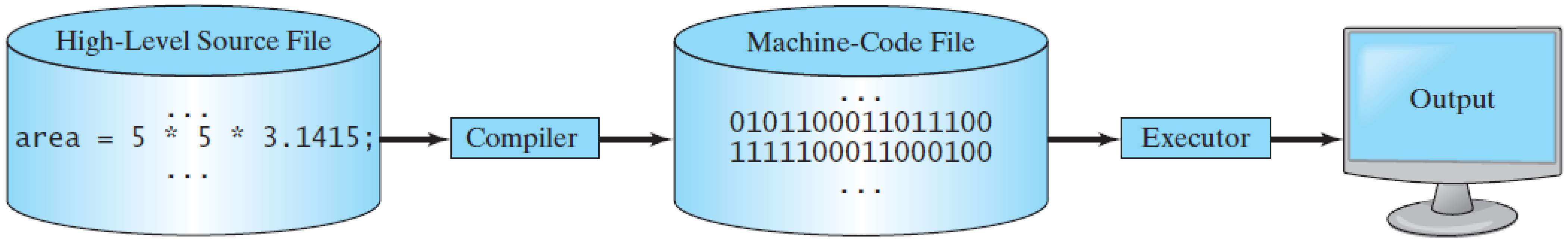
- Interpreter (解释器) is a computer program that directly executes, i.e. performs, instructions written in a programming or scripting language, without previously compiling them into a machine language program

- 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

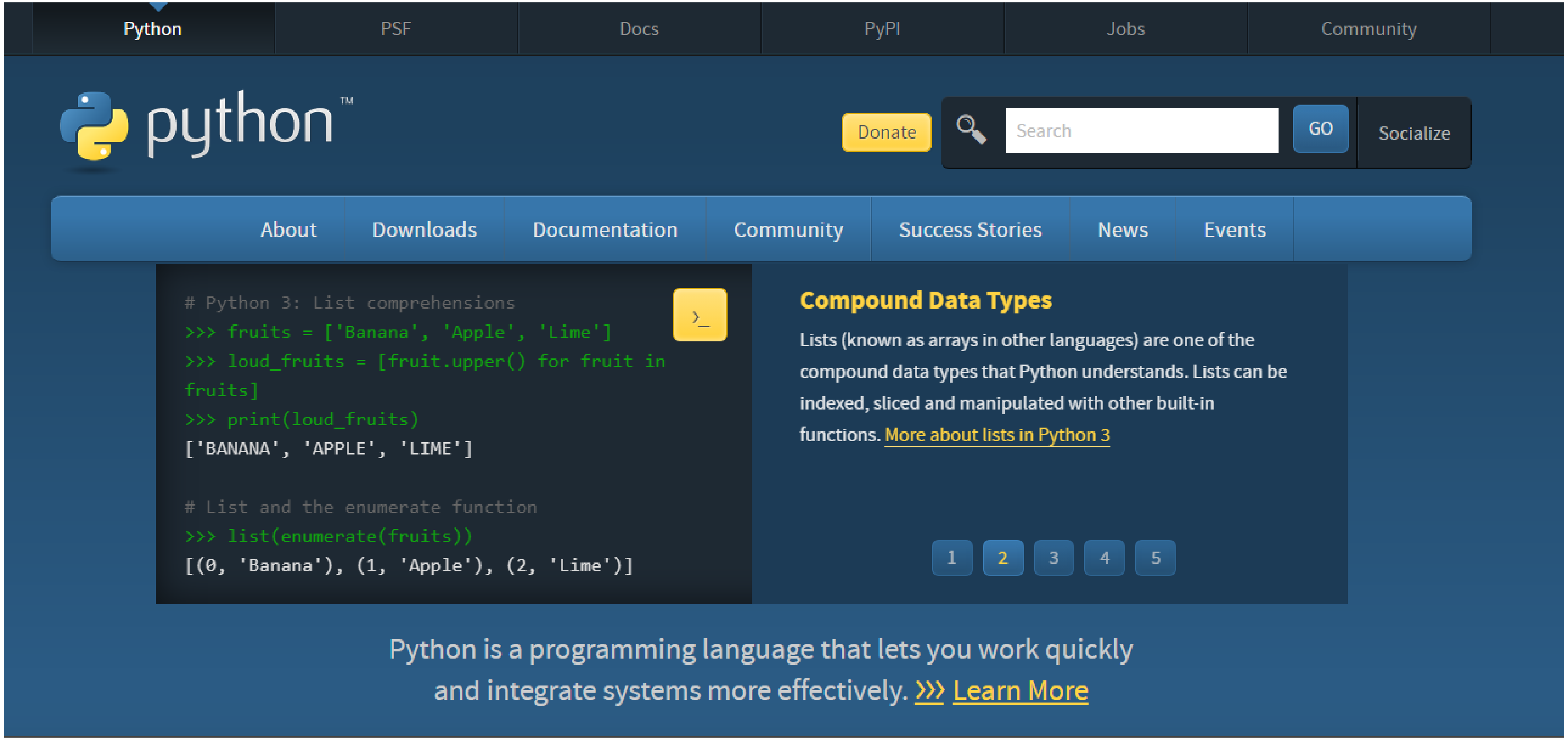


(a)



(b)

Installing Python



```
# Python 3: List comprehensions
>>> fruits = ['Banana', 'Apple', 'Lime']
>>> loud_fruits = [fruit.upper() for fruit in
fruits]
>>> print(loud_fruits)
['BANANA', 'APPLE', 'LIME']

# List and the enumerate function
>>> list(enumerate(fruits))
[(0, 'Banana'), (1, 'Apple'), (2, 'Lime')]
```

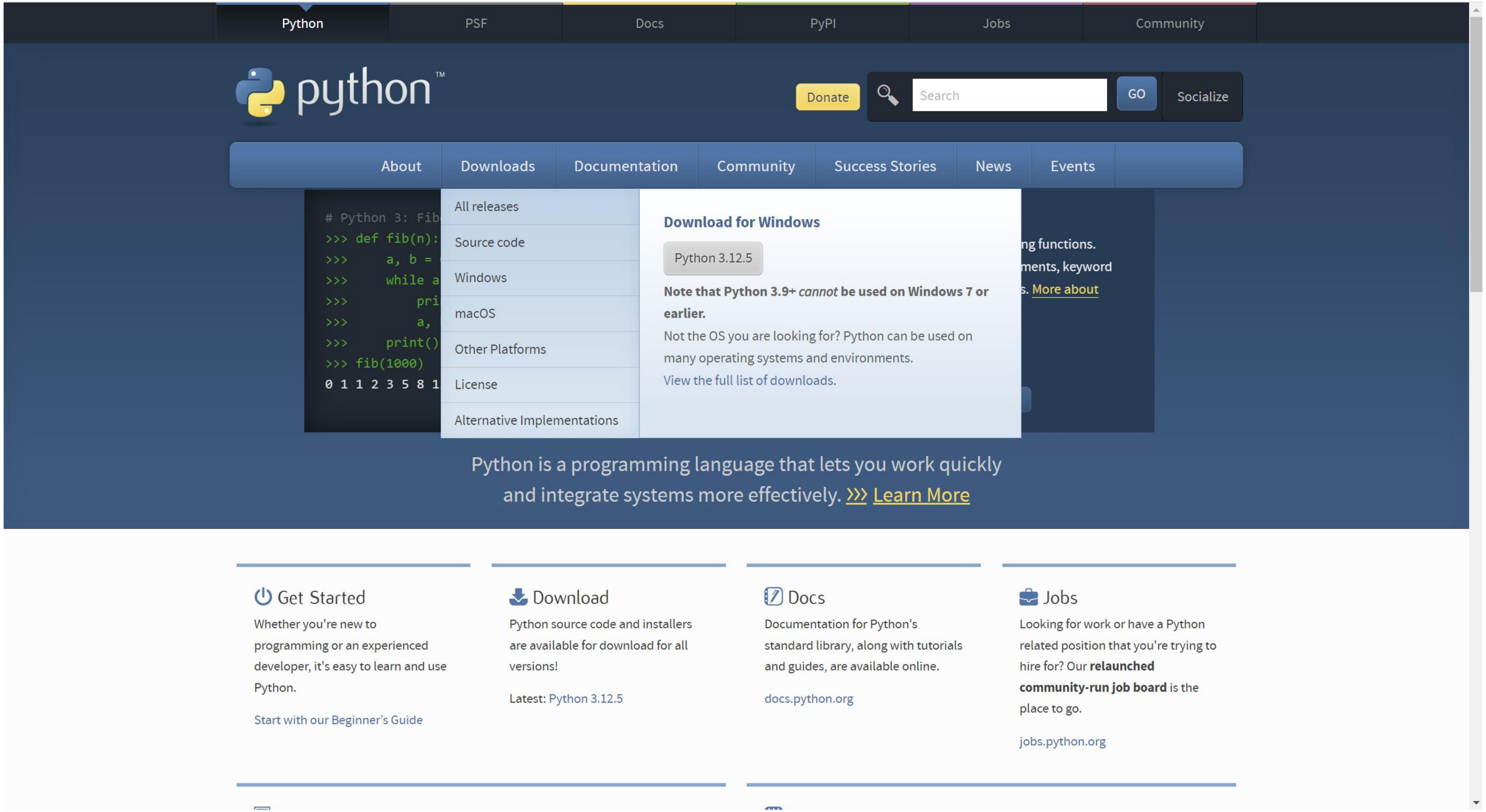
Compound Data Types

Lists (known as arrays in other languages) are one of the compound data types that Python understands. Lists can be indexed, sliced and manipulated with other built-in functions. More about lists in Python 3

Python is a programming language that lets you work quickly and integrate systems more effectively. >>> Learn More

https://www.python.org

Installing Python



```
# Python 3: Fib
>>> def fib(n):
>>>     a, b =
>>>     while a
>>>         pri
>>>         a,
>>>     print()
>>> fib(1000)
0 1 1 2 3 5 8 1
```

Download for Windows

Note that Python 3.9+ *cannot* be used on Windows 7 or earlier.

Not the OS you are looking for? Python can be used on many operating systems and environments.

View the full list of downloads.

ng functions.
ments, keyword
s. More about

Python is a programming language that lets you work quickly and integrate systems more effectively. >>> Learn More

Get Started

Whether you're new to programming or an experienced developer, it's easy to learn and use Python.

Start with our Beginner's Guide

Download

Python source code and installers are available for download for all versions!

Latest: Python 3.12.5

Docs

Documentation for Python's standard library, along with tutorials and guides, are available online.

docs.python.org

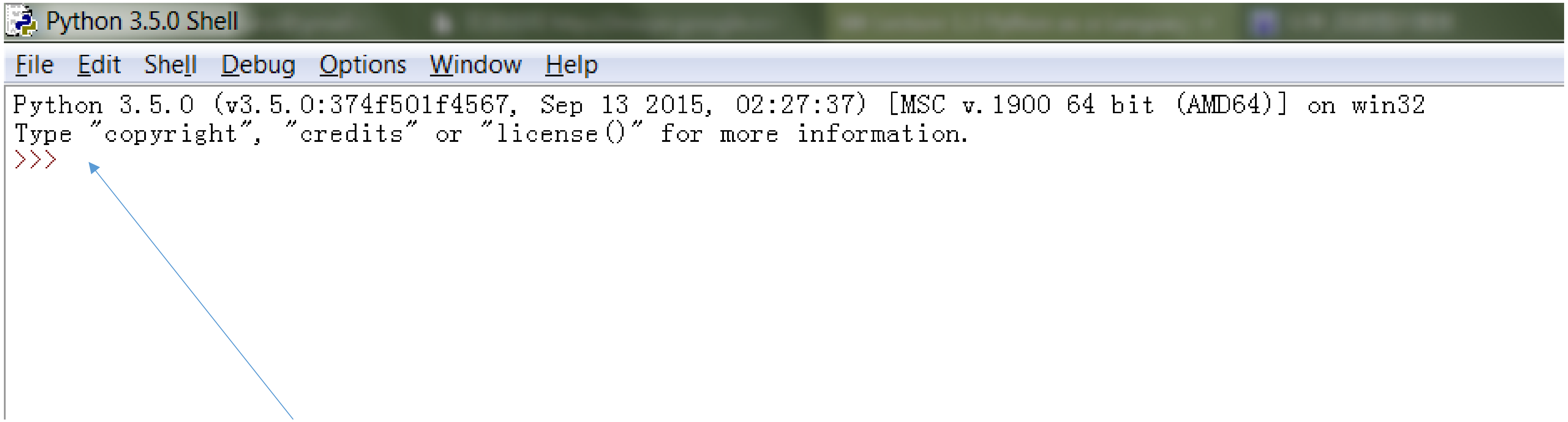
Jobs

Looking for work or have a Python related position that you're trying to hire for? Our **relaunched community-run job board** is the place to go.

jobs.python.org

Python 3 v.s. Python 2 ？

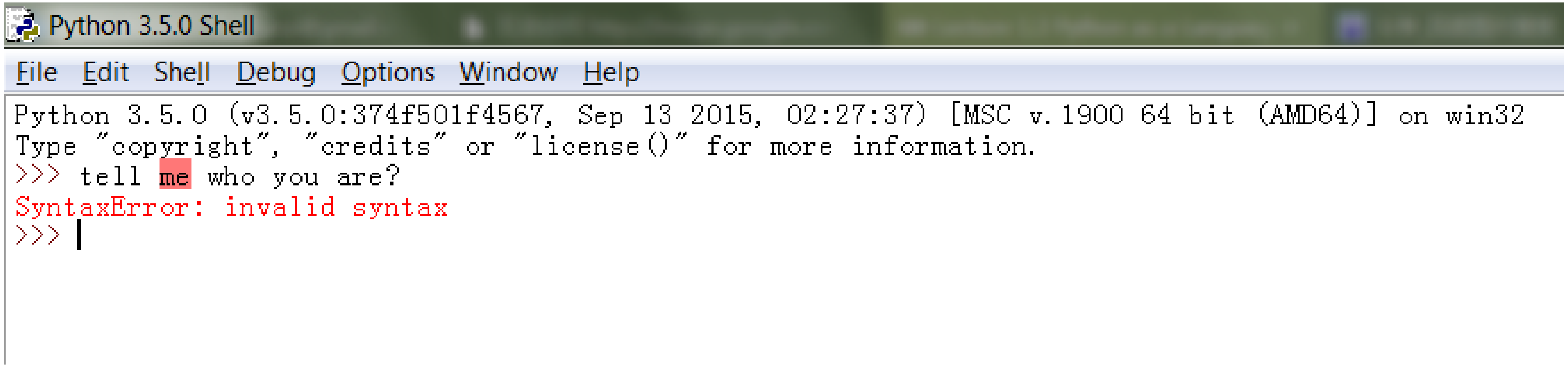
Python Shell



```
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



```
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
>>> 
```

Early learner: syntax error

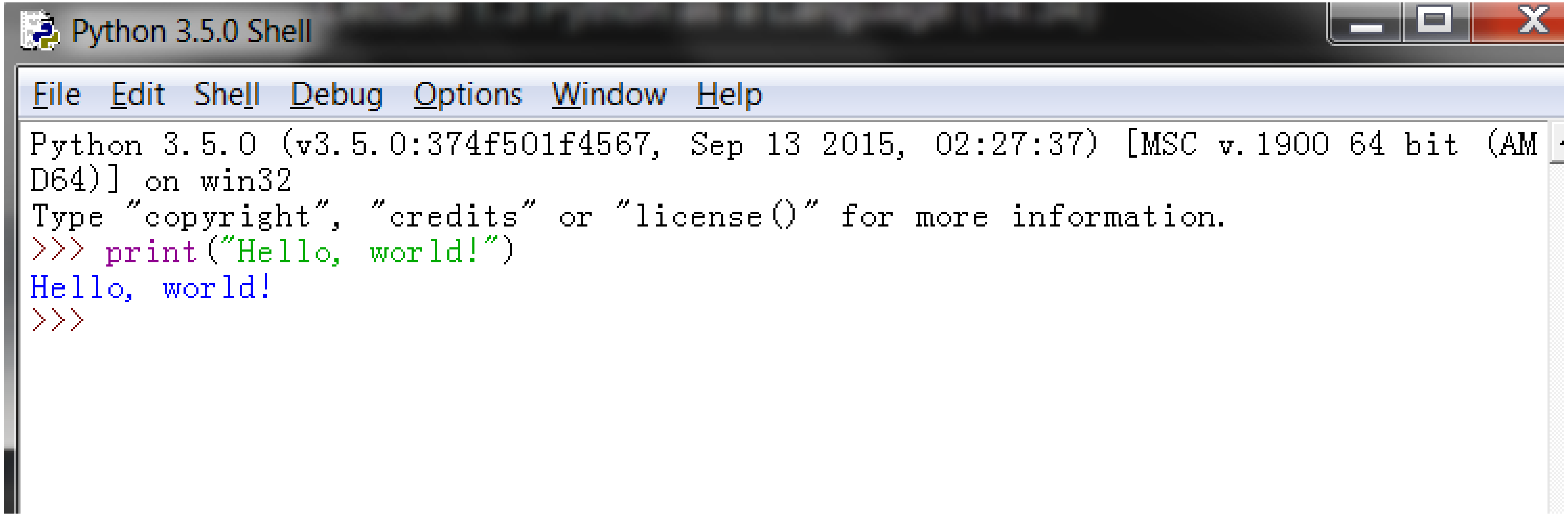
- We need to learn the Python language so we can communicate our instructions to Python. In the beginning we will make lots of mistakes and speak gibberish like small children

- 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

Hello, world!

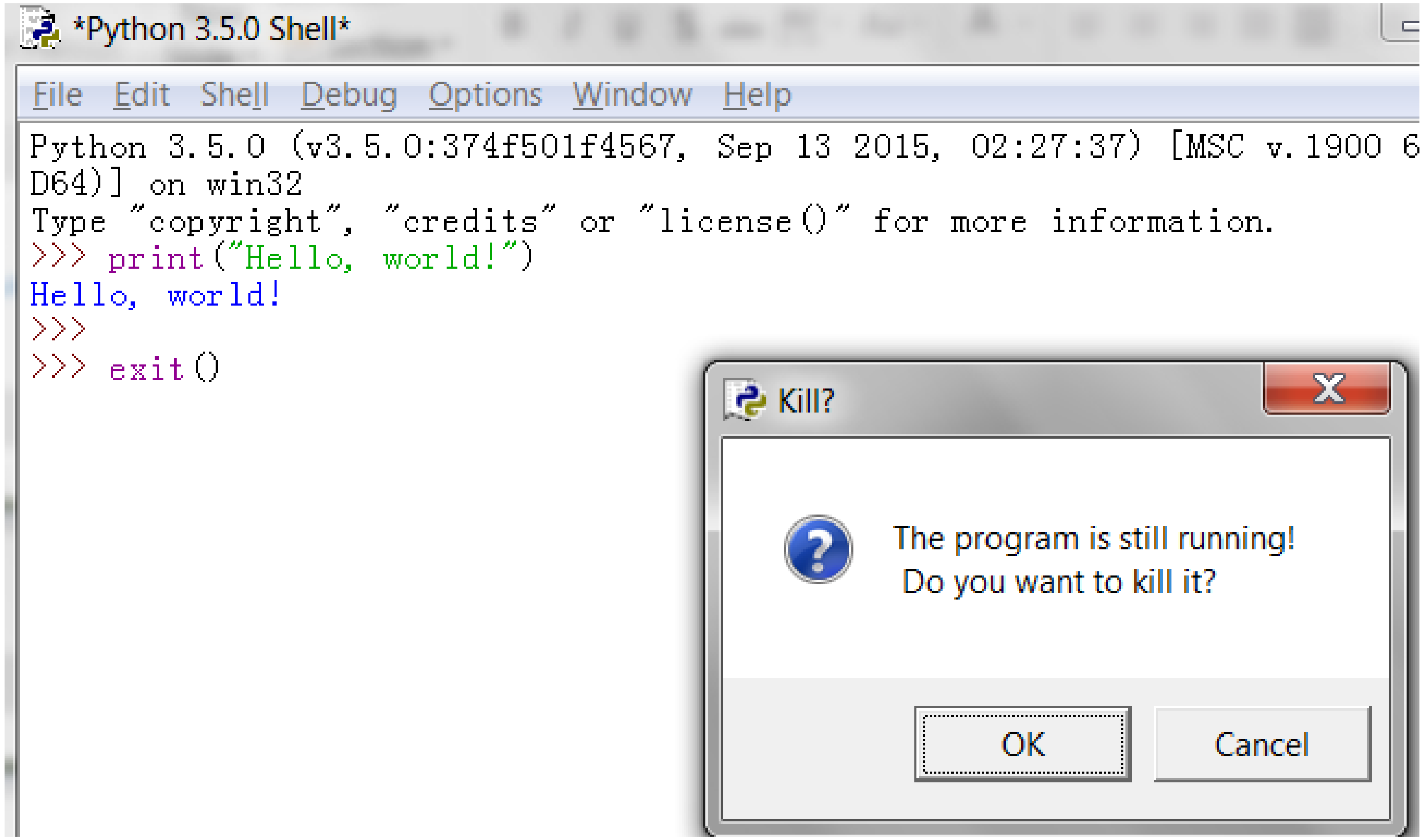


```
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (AM
D64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> print("Hello, world!")
Hello, world!
>>>
```

- You must say something that Python interpreter can understand!!

- Print() is a function in Python

Exit()



```
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 6
D64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> print("Hello, world!")
Hello, world!
>>>
>>> exit()
```

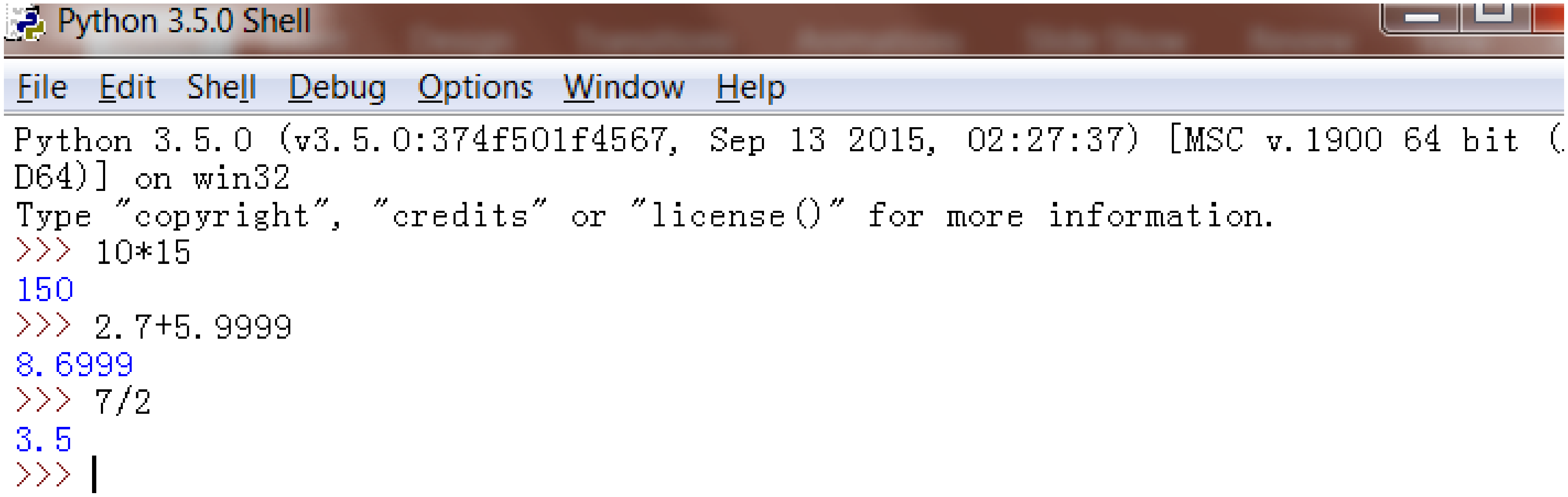
The program is still running!
Do you want to kill it?

What should we say to Python ?

Elements of Python Language

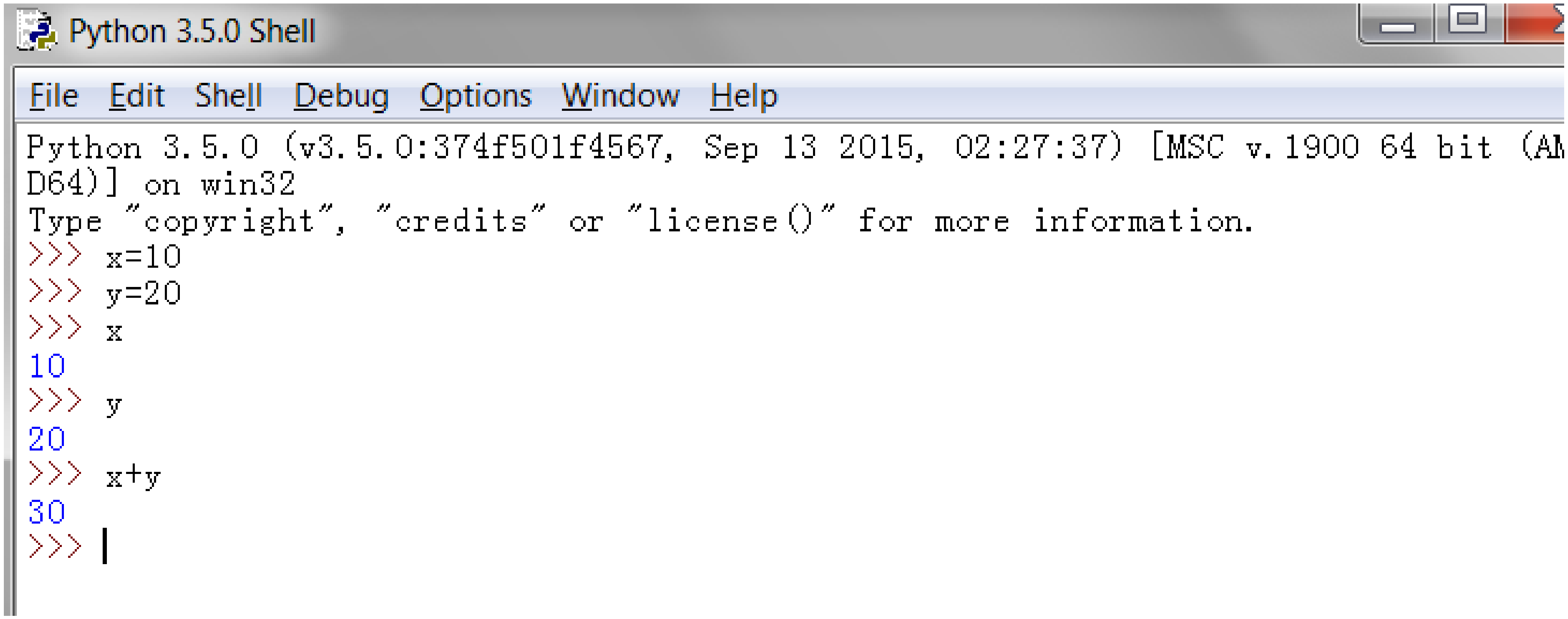
- Vocabulary/words – Variables, Reserved words and Operators
- Sentence structure – valid syntax patterns
- Story structure – constructing a meaningful program for some purposes

Use Python as a calculator



```
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
>>> 
```

Variables



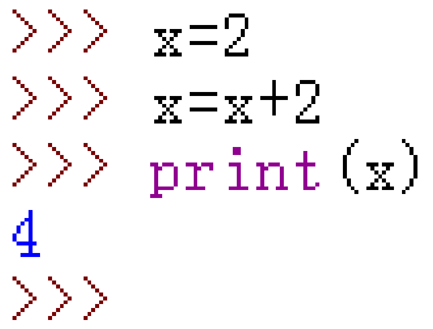
```
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 02:27:37) [MSC v.1900 64 bit (AM
D64)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> x=10
>>> y=20
>>> x
10
>>> y
20
>>> x+y
30
>>> 
```

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
>>> x=x+2
>>> print(x)
4
>>>
```

Assignment statement

Assignment with expressions

Print statement (output statement)

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

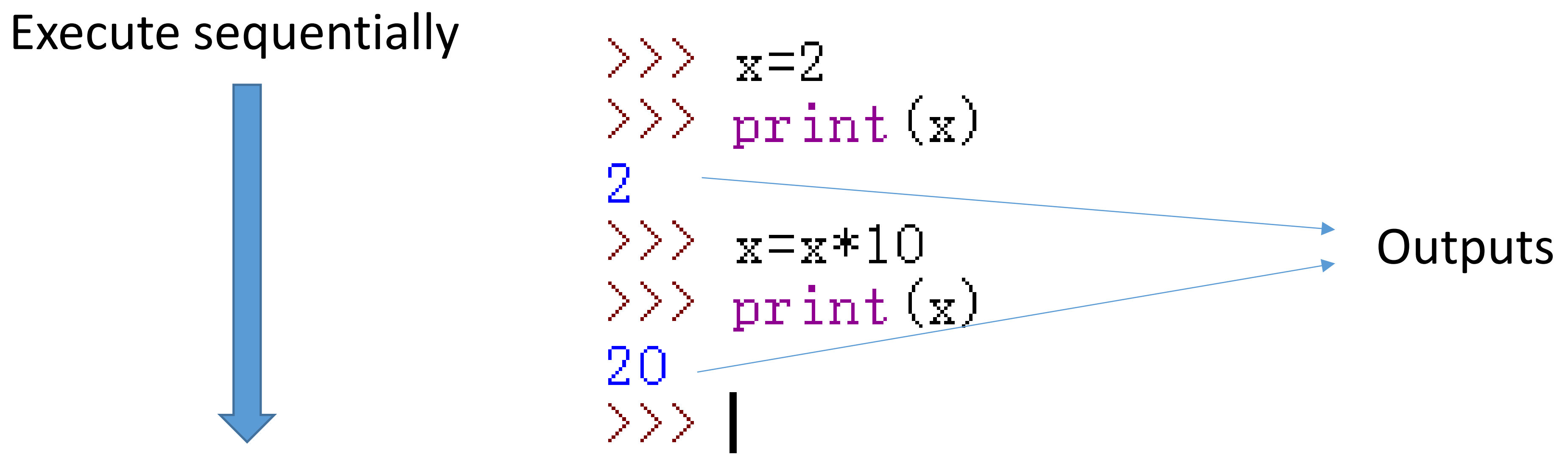
- Script

✓ 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



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

- 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

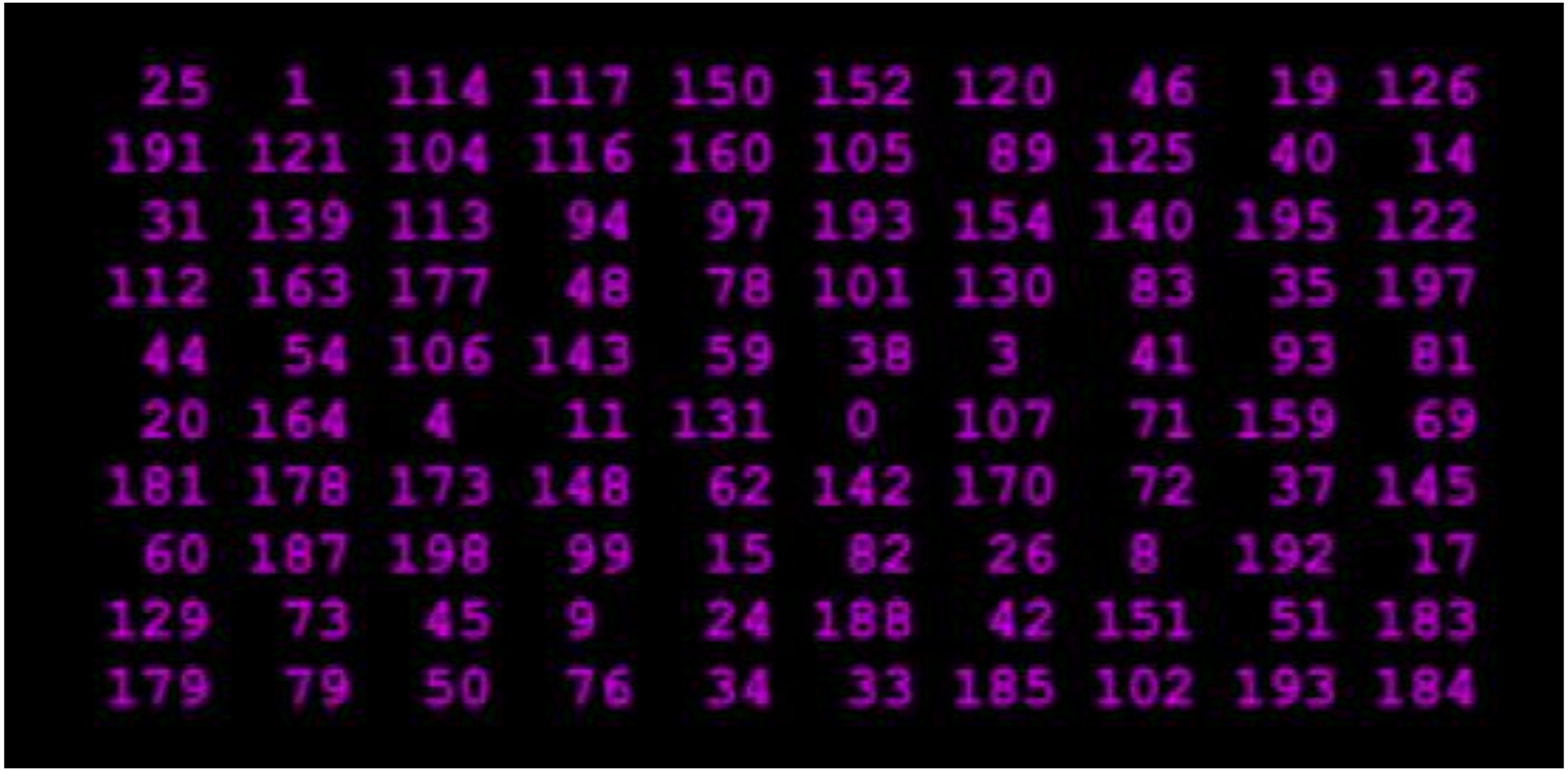
```
n=5
while n>0:
    print(n)
    n = n - 1
print("Finish")
```

Outputs

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

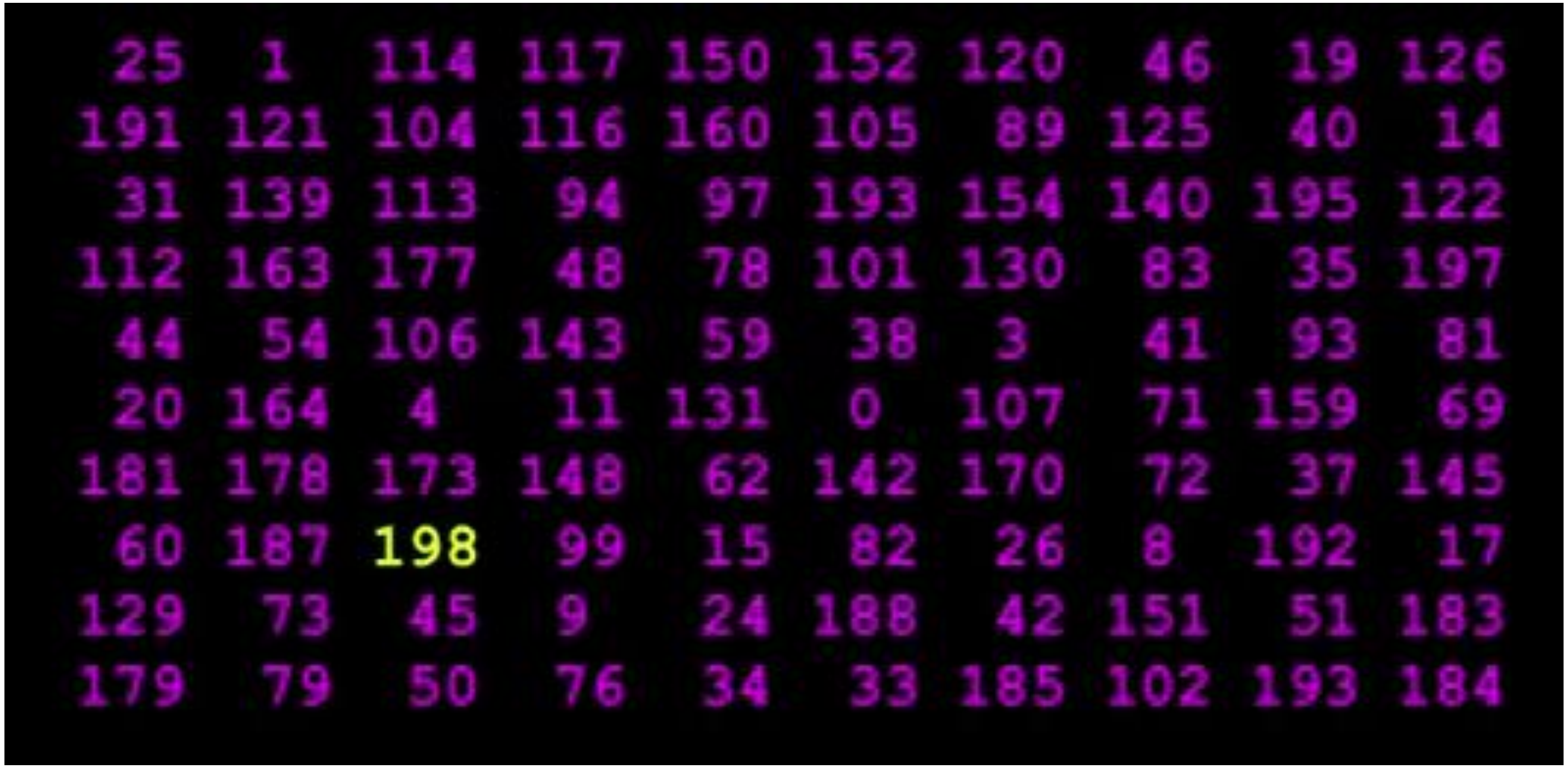
- Loops (repeated steps) have iterative variables that change each time through a loop
- Often these iterative variables go through a sequence of numbers

What the largest number is?



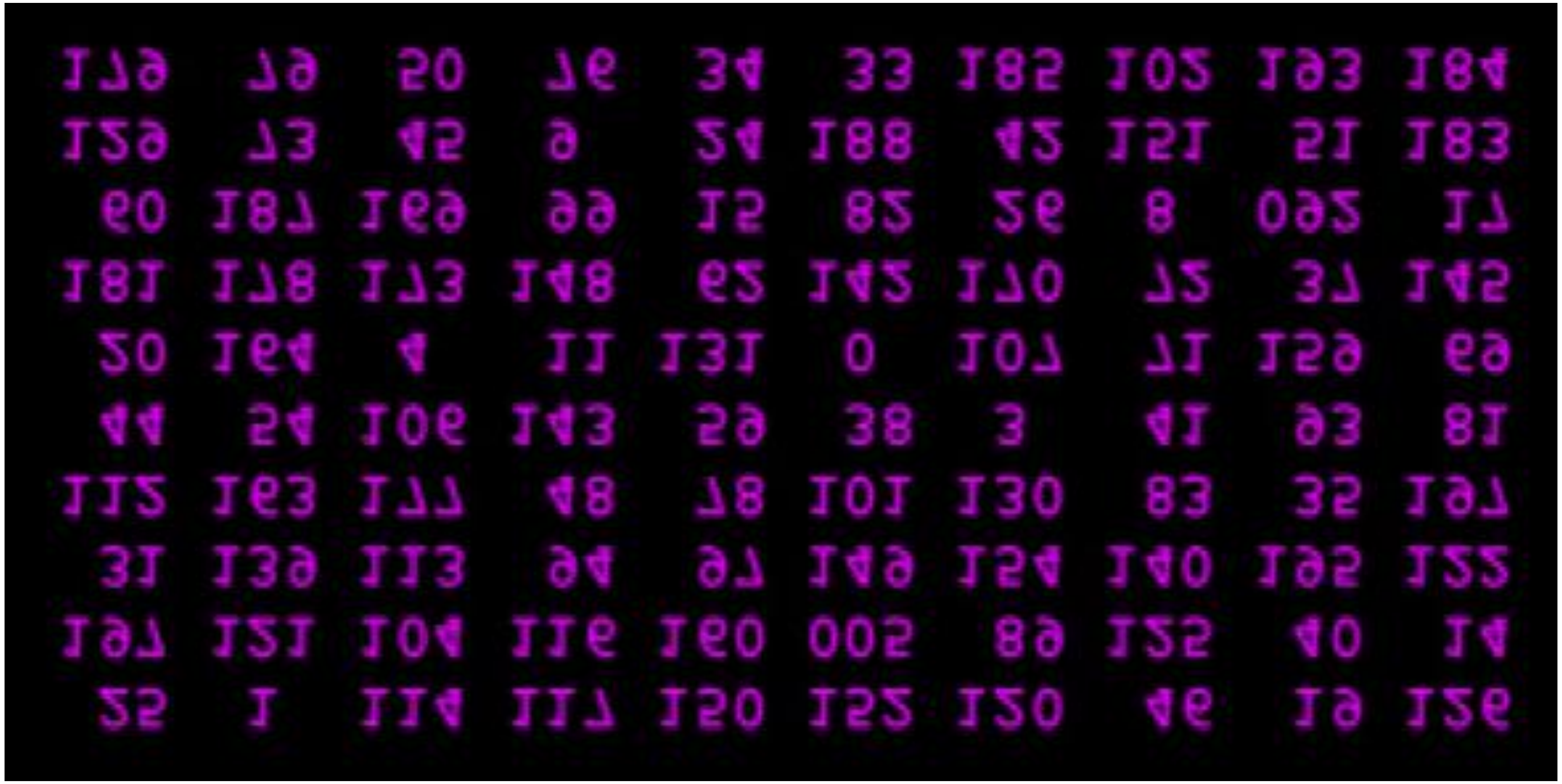
25	1	114	117	150	152	120	46	19	126
191	121	104	116	160	105	89	125	40	14
31	139	113	94	97	193	154	140	195	122
112	163	177	48	78	101	130	83	35	197
44	54	106	143	59	38	3	41	93	81
20	164	4	11	131	0	107	71	159	69
181	178	173	148	62	142	170	72	37	145
60	187	198	99	15	82	26	8	192	17
129	73	45	9	24	188	42	151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

What the largest number is?

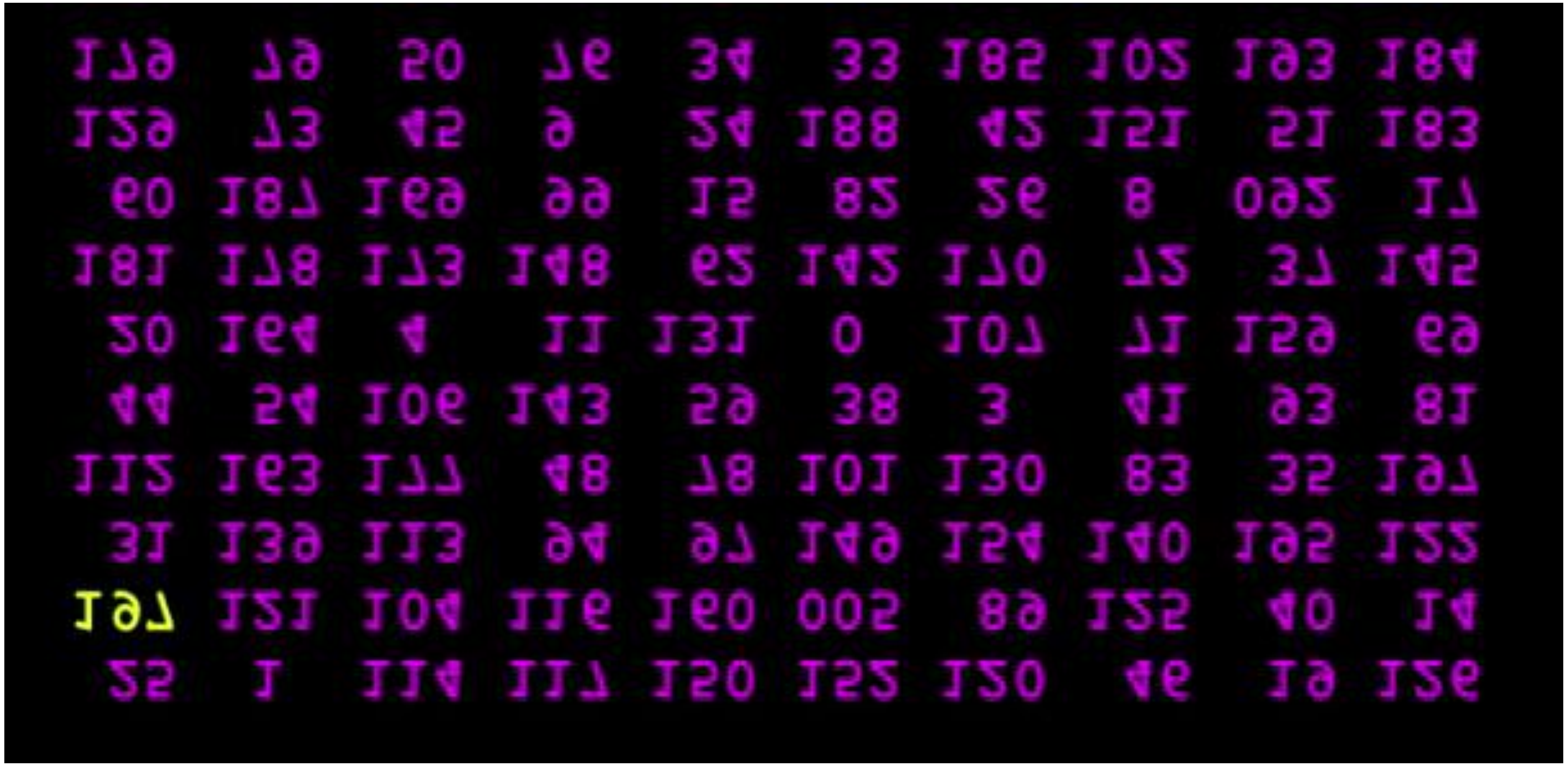


25	1	114	117	150	152	120	46	19	126
191	121	104	116	160	105	89	125	40	14
31	139	113	94	97	193	154	140	195	122
112	163	177	48	78	101	130	83	35	197
44	54	106	143	59	38	3	41	93	81
20	164	4	11	131	0	107	71	159	69
181	178	173	148	62	142	170	72	37	145
60	187	198	99	15	82	26	8	192	17
129	73	45	9	24	188	42	151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

What is the largest number – again?



What is the largest number – again?



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

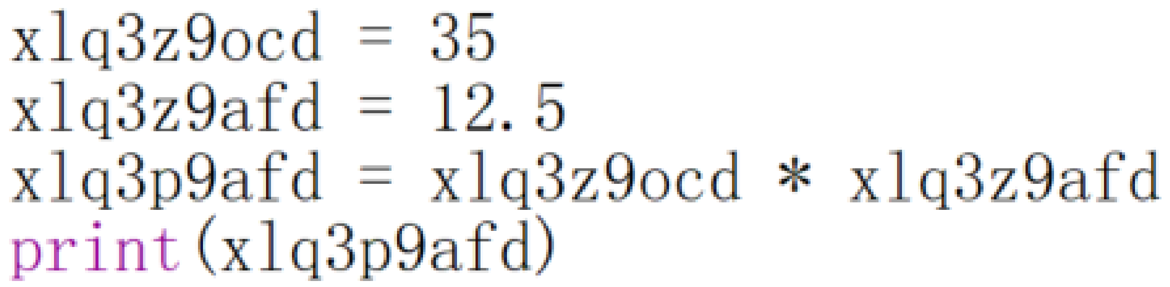
- Use meaningful words as variable names

- Start with a lower letter

- Capitalize the first letter of each word

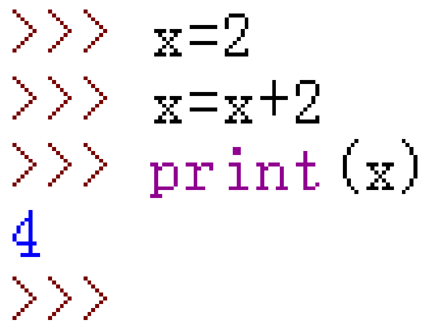
- Example: myBankAccountID, numOfCards, salaryAtYear1995…

What is this code doing?



```
xlq3z9ocd = 35
xlq3z9afd = 12.5
xlq3p9afd = xlq3z9ocd * xlq3z9afd
print(xlq3p9afd)
```

Sentences or lines



```
>>> x=2
>>> x=x+2
>>> print(x)
4
>>>
```

Assignment statement

Assignment with expressions

Print statement (output statement)

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

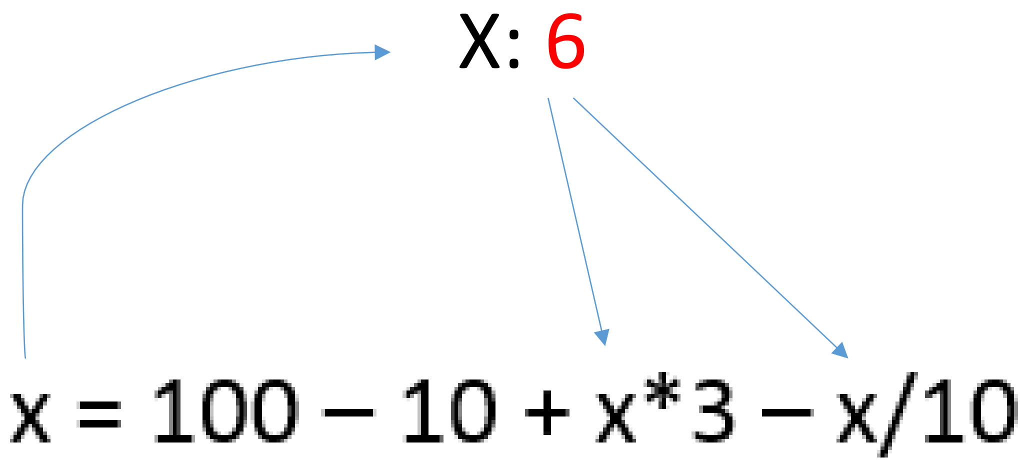
Example: x = 100 – 10 + x*3 – x/10

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

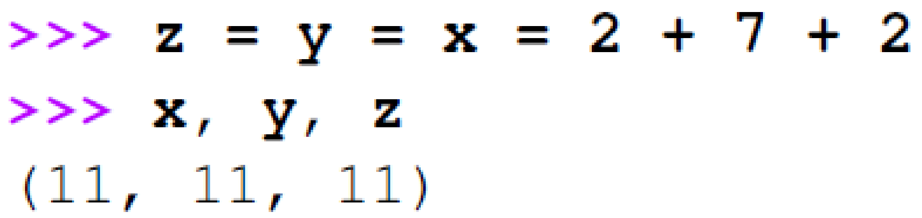
- After the expression is evaluated, the result will be put back into x



Cascaded assignment

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

Example

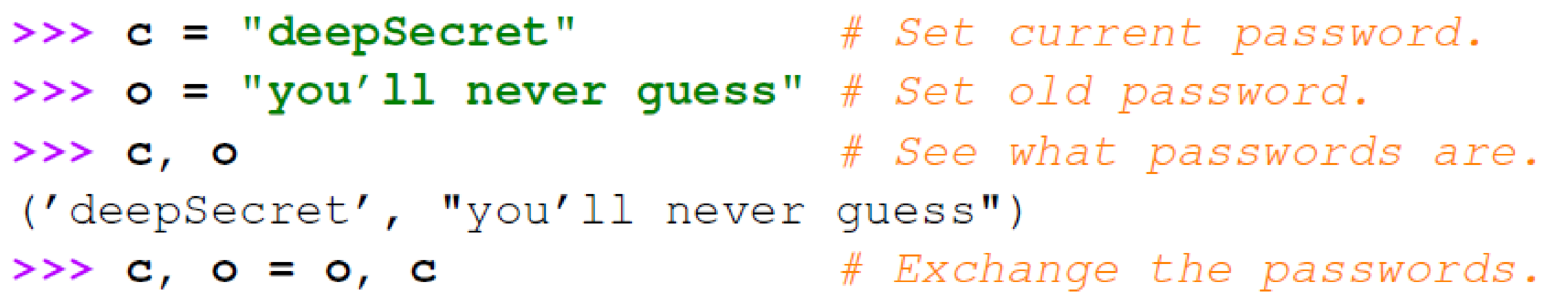


```
>>> z = y = x = 2 + 7 + 2
>>> x, y, z
(11, 11, 11)
```

Simultaneous assignment

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

Example

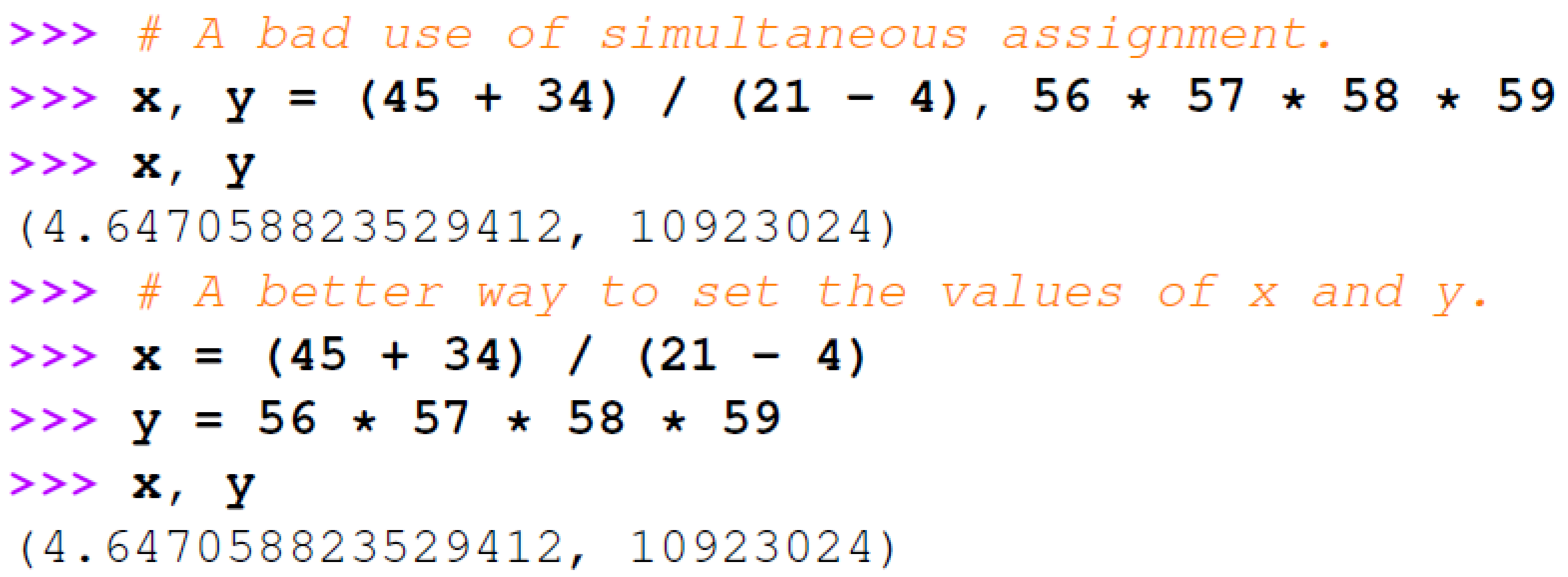


```
>>> c = "deepSecret"              # Set current password.
>>> o = "you'll never guess"      # Set old password.
>>> c, o                          # See what passwords are.
('deepSecret', "you'll never guess")
>>> c, o = o, c                   # Exchange the passwords.
```

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)
```

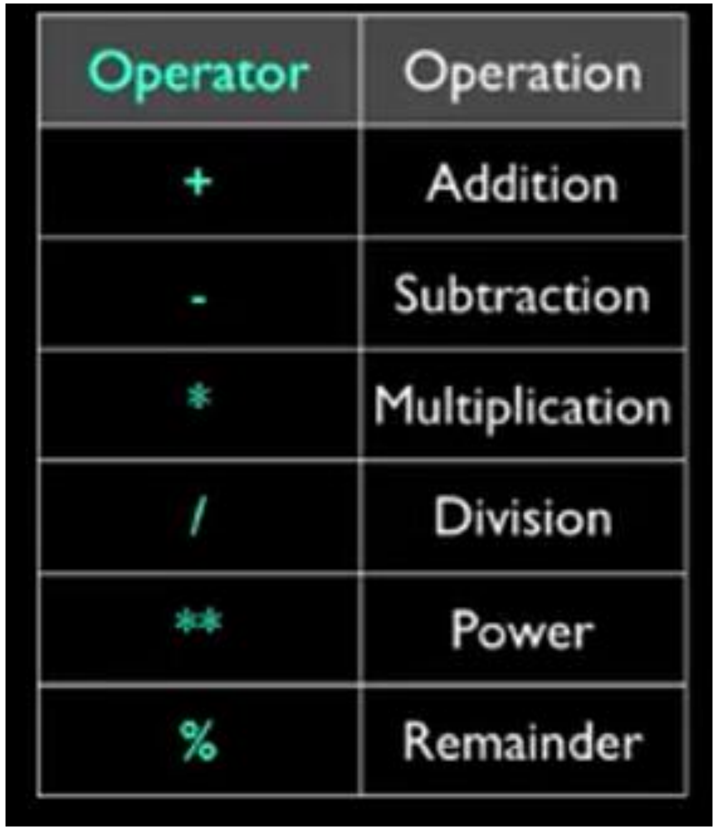
Order evaluation

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

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

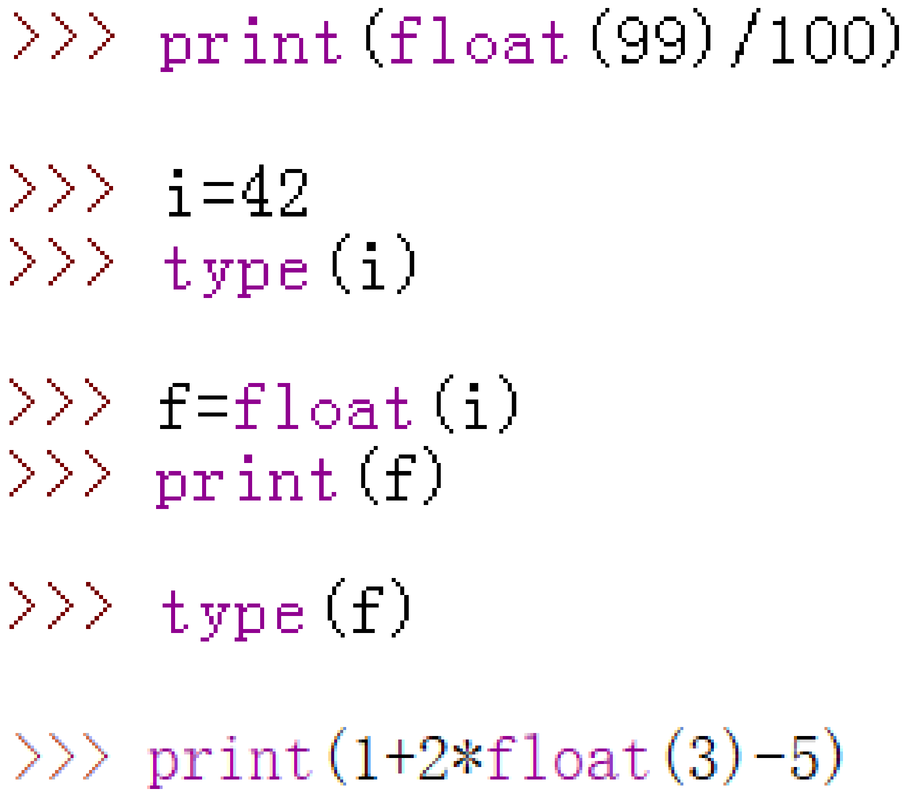
```
>>> x = 7 * 3 * 2
>>> y = "is the answer to the ultimate question of life"
>>> print(x, y)          # Check what x and y are.
42 is the answer to the ultimate question of life
>>> x, y                 # Quicker way to check x and y.
(42, ’is the answer to the ultimate question of life’)
>>> type(x), type(y)     # Check types of x and y.
(<class ’int’>, <class ’str’>)
>>> # Set x and y to new values.
>>> x = x + 3.14159
>>> y = 1232121321312312312 * 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)-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

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

Practice

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

BMI = weight (kg) ÷ height ^ 2 (m)

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

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","Junhua Zhao")

>>> print("I","am","Junhua Zhao",sep="")

>>> print("I","am","Junhua Zhao",sep=",")
```

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")
```

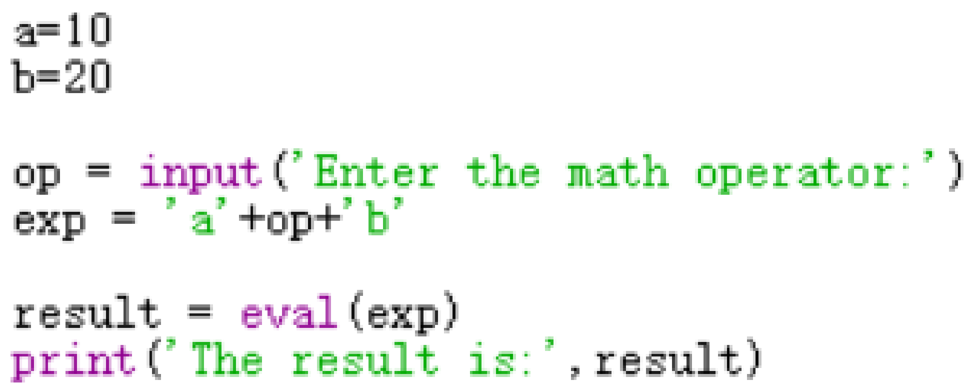
A powerful function - eval()

- 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” input

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



```
a=10
b=20

op = input(’Enter the math operator:’)
exp = ’a’+op+’b’

result = eval(exp)
print(’The result is:’,result)
```

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)
```