ITCS 6156/8156
Machine Learning

Python for Programming & ML

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Python Programming Stack

• **Python** = object-oriented, interpreted, scripting language.
  – imperative programming, with functional programming features.

• **NumPy** = package for powerful N-dimensional arrays:
  – sophisticated (broadcasting) functions.
  – useful linear algebra, Fourier transform, and random number capabilities.

• **SciPy** = package for numerical integration and optimization.

• **Matplotlib** = comprehensive 2D and 3D plotting library.
Python Programming Stack

• **PyTorch** = a wrapper of **NumPy** that enables the use of GPUs and automatic differentiation:
  – **Tensors** similar to NumPy’s ndarray, but can also be used on GPU.

• **Jupyter Notebook** = a web app for creating documents that contain live code, equations, visualizations and markdown text.

• **Anaconda** = an open-source distribution of Python and Python packages:
  – Package versions are managed through **Conda**.
  – Install all packages above using Anaconda / Conda install.
Anaconda Install

- **Anaconda**: Installation instructions for various platforms can be found at: [https://docs.anaconda.com/anaconda/install](https://docs.anaconda.com/anaconda/install)
  - For Mac and Linux users, the system PATH must be updated after installation so that ‘conda’ can be used from the command line.
    - **Mac OS X**:
      - For bash users: `export PATH=~/opt/anaconda3/bin:$PATH`
      - For csh/tcsh users: `setenv PATH ~/opt/anaconda3/bin:$PATH`
    - **For Linux**:
      - For bash users: `export PATH=~/opt/anaconda3/bin:$PATH`
      - For csh/tcsh users: `setenv PATH ~/opt/anaconda3/bin:$PATH`
  - It is recommend the above statement be put in the ~/.bashrc or ~/.cshrc file, so that it is executed every time a new terminal window is open.
  - To check that conda was installed, running “conda list” in the terminal should list all packages that come with Anaconda.
Installing Packages with Conda / Anaconda

- A number of tools and libraries that we will use can be configured from Anaconda:
  - PyTorch can be installed from Anaconda, with ‘conda’ from the command line:
    - The actual command line depends on the platform as follows:
      - Using the GUI on pytorch.org, choose the appropriate OS, conda, Python 3.6, CUDA or CPU version.
Python

- Designed by Guido van Rossum in the early 1990s.
- Current development done by the Python Software Foundation.

- Python facilitates multiple programming paradigms:
  - imperative programming.
  - object oriented programming.
  - functional programming.

$\Rightarrow$ multi-paradigm programming language.
Python: Important Features

• Python = object-oriented interpreted “scripting” language:
  – Object oriented:
    • modules, classes, exceptions.
    • dynamically typed, automatic garbage collection.
  – Interpreted, interactive:
    • rapid edit-test-debug cycle.
  – Extensible:
    • can add new functionality by writing modules in C/C++.
  – Standard library:
    • extensive, with hundreds of modules for various services such as regular expressions, TCP/IP sessions, etc.
Scripting Languages

• **Scripts vs. Programs:**
  – interpreted vs. compiled
  – one script = a program
  – many {*.c, *.h} files = a program

• Higher-level “glue” language:
  – glue together larger program/library components, potentially written in different programming languages.
    • orchestrate larger-grained computations.
    • vs. programming fine-grained computations.

  ➢ `grep -i programming *.txt | grep -i python | wc -l`
The Python Interpreter

Running the interpreter

[razvan@ohio ~]$ python3
Python 3.8.2 (default, Dec 21 2020, 15:06:04)
[Clang 12.0.0 (clang-1200.0.32.29)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>>
>>> help()

Welcome to Python 3.8's help utility!

If this is your first time using Python, you should definitely check out the tutorial on the Internet at https://docs.python.org/3.8/tutorial/.

Enter the name of any module, keyword, or topic to get help on writing Python programs and using Python modules. To quit this help utility and return to the interpreter, just type "quit".

To get a list of available modules, keywords, symbols, or topics, type "modules", "keywords", "symbols", or "topics". Each module also comes with a one-line summary of what it does; to list the modules whose name or summary contain a given string such as "spam", type "modules spam".

help>
The Python Interpreter: Keywords

help> keywords

Here is a list of the Python keywords. Enter any keyword to get more help.

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

Lambdas
******

lambda_expr ::= "lambda" [parameter_list]: expression
lambda_expr_nocond ::= "lambda" [parameter_list]: expression_nocond

Lambda expressions (sometimes called lambda forms) have the same syntactic position as expressions. They are a shorthand to create anonymous functions; the expression "lambda arguments: expression" yields a function object. The unnamed object behaves like a function object defined with

    def <lambda>(arguments):
        return expression

See section *Function definitions* for the syntax of parameter lists. Note that functions created with lambda expressions cannot contain statements or annotations.
help> modules

**commands:**
execute shell commands via os.popen() and return status, output.

**compiler:**
package for parsing and compiling Python source code.

**gzip:**
functions that read and write gzipped files.

**HTMLParser:**
a parser for HTML and XHTML (defines a class HTMLParser).

**math:**
access to the mathematical functions defined by the C standard.

**exceptions:**
Python’s standard exception class hierarchy.
The Python Interpreter: Modules

help> modules

**os:**
OS routines for Mac, NT, or Posix depending on what system we’re on.

**re:**
support for regular expressions (RE).

**string:**
a collection of string operations (most are no longer used).

**sys:**
access to some objects used or maintained by the interpreter and to functions that interact strongly with the interpreter:

- `sys.argv`: command line arguments.
- `sys.stdin, sys.stdout, sys.stderr`: standard input, output, error file objects.

**threading:**
thread modules emulating a subset of Java’s threading model.
The Python Interpreter: Integer Precision

```python
>>> def fib(n):
...     a, b, i = 0, 1, 0
...     while i < n:
...         a, b, i = b, a+b, i+1
...     return a

>>> fib(10)
55
>>> fib(100)
354224848179261915075
>>> fib(1000)
4346655768693745643568852767504062580256466051737178040248172908953655541
4905189040387984007925516929592259308032263477520968962323987332247116164
996440906533187938298969649928516003704476137795166849228875
```
Built-in Types: Basic

- **integers**, with unlimited precision – int().
  - decimal, octal and hex literals.
- **floating point numbers**, implemented using double in C – float().
- **complex numbers**, real and imaginary as double in C – complex().
  - 10+5j, 1j
  - z.real, z.imag
- **boolean values**, True and False – bool().
  - False is: None, False, 0, 0L, 0.0, 0j, ‘’, (), [], {},
  - user defined class defines methods nonzero() or len().
- **strings** – str(), class, function, …
  - “Hello world”, ‘Hello world’
Built-in Types: Composite

• **lists:**
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• **tuples:**
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• **dictionaries:**
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• **sets:**
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• **files**
Integers

>>> int
<class 'int'>
>>> 1024
1024
>>> int(1024)
1024
>>> repr(1024)
'1024'
>>> eval('1024')
1024
>>> str(1111)
'1111'
>>> int('1111')
1111

>>> a = 100
>>> b = 200
>>> a + 1, b + 1  # this is a tuple
(101, 201)

>>> a + 1, b + 1
(101, 201)

>>> print(a, b + 1)
100 201

>>> int(3.6), abs(-10), 11%3, 11//3, 11/3, 2**3
(3, 10, 2, 3, 3.6666666666666665, 8)

>>> int(3.6), abs(-10), 11%3, 11//3, 11/3, 2**3
(3, 10, 2, 3, 3.6666666666666665, 8)

>>> int('1110',2), int('170',8), int('40',16)
(14, 120, 64)

>>> [170, 0170, 0x40]  # this is a list
[170, 120, 64]

>>> float(8), 2**3, pow(2,3)
(8.0, 8, 8)
Booleans

```python
>>> bool
<class 'bool'>
```

```python
>>> [bool(0), bool(0.0), bool(0j), bool([]), bool(), bool({}), bool(''), bool(None)]
[False, False, False, False, False, False, False, False]
```

```python
>>> [bool(1), bool(1.0), bool(1j), bool([1]), bool((1,)), bool({1:’one’}), bool(‘1’)]
[True, True, True, True, True, True, True]
```

```python
>>> str(True), repr(True)
(‘True’, ‘True’)
```

```python
>>> True and True, True and False, False and False
(True, False, False)
```

```python
>>> True or True, True or False, False or False
(True, True, False)
```

```python
>>> not True, not False
(False, True)
```
Floating Point

>>> float
<class ‘float’>
>>> 3.14, 3.1400000000000001
(3.14, 3.14)
>>> repr(3.1400000000000001)
3.14
>>> 3.14/2, 3.14//2
(1.5, 1.0)
>>> import math
>>> math.pi, math.e
(3.1415926535897931, 2.7182818284590451)
>>> help(‘math’)

############ Python ############
>>> sum = 0.0
>>> for i in range(10):
...    sum += 0.1
...     
...     
>>> sum
0.99999999999999989

############ C++ ############
float sum = 0.0;
for (int i = 0; i < 10; i++)
    sum += 0.1;
cout.precision(17);
cout << sum << endl;
⇒ 1.0000001192092896

http://docs.python.org/3/tutorial/introduction.html#numbers
IEEE 754 Standard

\[
\text{value} = (-1)^{\text{sign}} \times 2^{(E-127)} \times \left(1 + \sum_{i=1}^{23} b_{23-i} 2^{-i}\right).
\]
Strings (Immutable)

- **Immutable Sequences of Unicode Characters:**

  ```python
  >>> str
  <class 'str'>
  >>> s = "object oriented"
  >>> len(s), s.find('ct'), s.split()
  (15, 4, ['object', 'oriented'])
  >>> s[0], s[1], s[4:6], s[7:]
  ('o', 'b', 'ct', 'oriented')
  >>> s[7:100]
  'oriented'
  >>> "functional {0} lang".format('programming')
  'functional programming'
  >>> "object oriented “ + “programming”
  'object oriented programming’
  >>> 'orient' in 'object oriented', 'orient' in 'Object Oriented'
  (True, False)
  ```

  [http://docs.python.org/3/tutorial/introduction.html#strings](http://docs.python.org/3/tutorial/introduction.html#strings)
List (Mutable)

>>> []  #empty list
[]

>>> x = [3.14, “hello”, True]
[3.14, 'hello', True]

>>> x + [10, [], len(x)]
[3.14, 'hello', True, 10, [], 3]

>>> x.append(0.0)

>>> x.reverse()

>>> x
[0.0, True, 3.14]

>>> x.sort()

>>> x
[0.0, True, 'hello', 3.14]

>>> x * 2
[0.0, True, 'hello', 3.14, 0.0, True, 'hello', 3.14]

>>> help(‘list’)
>>> tuple
<class 'tuple'>
>>> ()  # empty tuple
()
>>> (10)  # not a one element tuple!
10
>>> (10,) # a one element tuple
(10,)
>>> (1, 2) + (3, 4)
(1, 2, 3, 4)
>>> (1, 2) * 2
(1, 2, 1, 2)
>>> x = (0, 1, ‘x’, ‘y’)

>>> x[0], x[1], x[:,-1]
(0, 1, (0, 1, ‘x’))
>>> y = (13, 20, -13, -5, 0)
>>> temp = list(y)
>>> temp.sort()
>>> y = tuple(temp)
>>> y
(-13, -5, 0, 13, 20)

>>> help('tuple')

Immutable types are hashable!
Set (Mutable) & Frozenset (Immutable)

```python
g1 = set()  # empty set
g1
>>> type(set())
<class 'set'>
>>> {}  # not an empty set!
{}
>>> type({})
<class 'dict'>
s = {1, 3, 3, 2}
s
>>> frozenset({1, 3, 3, 2})
frozenset({1, 2, 3})
>>> 3 in s, 4 in s
(True, False)
s = set('yellow')
t = set('hello')
s
defs['e', 'o', 'l', 'w', 'y']
t
defs['h', 'e', 'l', 'o']
s
>>> s - t, s | t
({'w', 'y'}, {'h', 'e', 'o', 'l', 'w', 'y'})
>>> s & t, s ^ t
({'e', 'l', 'o'}, {'h', 'w', 'y'})
>>> {1, 3} <= {1, 2, 3, 2}
True
>>> help(set) >>>help(frozenset)
```
Mutable Operations on Sets

```python
>>> s = set(['abba', 'dada', 'lola', 'bama'])
>>> s
{'abba', 'bama', 'dada', 'lola'}
>>> s |= {'bama', 'lily'}
>>> s
{'abba', 'bama', 'dada', 'lily', 'lola'}
>>> s -= {'lola', 'abba', 'mama'}
>>> s
{'bama', 'dada', 'lily'}
>>> s &= {'lily', 'dodo', 'bama'}
>>> s
{'bama', 'lily'}
```

How can we prove the actual set object changes and not a new one is created?

Hint: are `s -= t` and `s = s − t` equivalent for sets? How about strings?

```python
>>> s = {[1]}
>>> s = {1}
TypeErro: unhashable type: 'list'
```
Dictionaries (Mutable)

```python
>>> dict
<class 'dict'>
>>> {}  # empty dictionary
{}
>>> d = {'john':23, 'alex':25, 'bill':99}
>>> d['alex']
25
>>> d['alex'] = 26
>>> del d['john']
>>> d['tammy'] = 35
>>> d
{'alex':26, 'bill':99, 'tammy':35}
>>> d.items()  # this is a view
dict_items[('alex',26), ('bill',99), ('tammy',35)]
>>> d.keys()  # this is a view
dict_keys['alex', 'bill', 'tammy']
>>> d.values()  # this is a view
dict_values[26, 99, 35]
>>> for x, y in d.items():
>>>     ... print (x, y)
'alex' 26
'bill' 99
'tammy' 35
>>> d.keys() | ['alex', 'john']  # set ops.
{'alex', 'bill', 'john', 'tammy'}
>>> d['mary'] = 10
>>> d.keys()
dict_keys['alex', 'bill', 'tammy', 'mary']
```
Dictionaries (Mutable)

```python
>>> dict
<class 'dict'>
>>> {}
# empty dictionary
{}
>>> d = {'john':23, 'alex':25, 'bill':99}
>>> d['alex']
25
>>> d['alex'] = 26
>>> del d['john']
>>> d['tammy'] = 35
>>> d
{'alex':26, 'bill':99, 'tammy':35}
>>> d['mary'] = 10
>>> d.keys() | ['alex', 'john']  # set ops.
{'alex', 'bill', 'john', 'tammy', 'mary'}
>>> d.items()  # this is a view
dict_items[('alex',26), ('bill',99), ('tammy',35)]
>>> d.keys()  # this is a view
dict_keys['alex', 'bill', 'tammy']
>>> d.values()  # this is a view
dict_values[26, 99, 35]
>>> for x, y in d.items():
... print (x, y)
'alex' 26
'bill' 99
'tammy' 35
>>> for key in d:
... print(key, end = ' ')  # print keys
'alex' 'bill' 'tammy'
```

28
Dictionaries (Mutable)

>>> dict
<class 'dict'>

>>> d.items()  # this is a view
dict_items[('alex'.26), ('bill'.99), ('tammy'.35)]

>>> {}  # empty dictionary
{}

dict_keys['alex', 'bill', 'tammy']

>>> d = {'john':23, 'alex':25, 'bill':99}

>>> d.values()  # this is a view

>>> d['alex']
25

>>> for x, y in d.items():
...
>>> d['alex'] = 26

>>> … print (x, y)

>>> del d['john']

>>> d['tammy'] = 35

>>> d
dict{'alex':26, 'bill':99, 'tammy':35}

>>> d.keys() | \['alex', 'john']  # set ops.

dict_keys['alex', 'bill', 'john', 'tammy']

>>>  for key in d:
...    … print(key, end = ' ')

>>> d['mary'] = 10

>>> d

dict{'alex':26, 'bill':99, 'tammy':35, 'mary':10}

>>> d.keys() | \['alex', 'bill', 'tammy', 'mary']

dict_keys['alex', 'bill', 'tammy', 'mary']

Immutable types are hashable, mutable types are not:

>>> d = dict(abba=1, dada=2)

>>> d[frozenset({1, 2, 3})] = 3

>>> d

dict{'abba':1, 'dada':2, frozenset({1, 2, 3}):3}

>>> d[{1, 2, 3, 4}] = 4

Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    TypeError: unhashable type: 'set'
Files

>>> file
<type ‘file’>

>>> output = open(‘/tmp/output.txt’, ‘w’)      # open tmp file for writing
>>> input = open(‘/etc/passwd’, ‘r’)           # open Unix passwd file for reading
>>> s = input.read()                           # read entire file into string s
>>> line = input.readline()                    # read next line
>>> lines = input.readlines()                  # read entire file into list of line strings
>>> output.write(s)                            # write string S into output file
>>> output.write(lines)                        # write all lines in ‘lines’
>>> output.close()
>>> input.close()

>>> from urllib import urlopen
>>> html = urlopen(‘http://www.ohio.edu’)

>>> help(‘file’)

>>> lines = [line[:-1] for line in html.readlines()]

30
Statements & Functions

• Assignment Statements
• Compound Statements
• Control Flow:
  – Conditionals
  – Loops
• Functions:
  – Defining Functions
  – Lambda Expressions
  – Documentation Strings
  – Generator Functions
Assignment Forms

• Basic form:
  – x = 1
  – y = ‘John’

• Tuple positional assignment:
  – x, y = 1, ‘John’
  – x == 1, b == ‘John’ => (True, True)

• List positional assignment:
  – [x, y] = [1, ‘John’]

• Multiple assignment:
  – x = y = 10
Compound Statements

- Python does not use block markers (e.g. ‘begin .. end’ or ‘{ … }’) to denote a compound statements.
  - Need to indent statements at the same level in order to place them in the same block.
  - Can be annoying, until you get used to it; intelligent editors can help.
  - Example:
    ```python
    if n == 0:
        return 1
    else:
        return n * fact(n - 1)
    ```
Conditional Statements

```python
if <bool_expr_1>:
    <block_1>
elif <bool_expr_2>:
    <block_2>
...
else:
    <block_n>
```

- There can be zero or more `elif` branches.
- The `else` branch is optional.
- “`Elif`“ is short for “`else if`” and helps in reducing indentation.
Conditional Statements: Example

```python
name = 'John'
...
if name == 'Mary':
    sex = 'female'
elif name == 'John':
    sex = 'male'
elif name == 'Alex':
    sex = 'either'
elif name == 'Paris':
    sex = 'either'
else:
    sex = 'unknown'
```
Conditional Statements

• **Python 3.10** added a `match ... case` statement.

• Same behavior can be achieved using:
  – `if ... elif ... elif` sequences.
  – dictionaries:

```python
name = 'John'
dict = {'Mary':'female', 'John': 'male',
        'Alex':'either', 'Paris':'either'}
if name in dict:
    print(dict[name])
else:
    print('unknown')
```
While Loops

```python
x = 'university'
while x:
    print(x, end = ' ')
    x = x[1:]

a, b = 1, 1
while b <= 23:
    print(a, end = ' ')
    a, b = b, a + b
```
For Loops

sum = 0
for x in [1, 2, 3, 4]
    sum += x
print(sum)

D = {1:'a', 2:'b', 3:'c', 4:'d'}
for x, y in D.items():
    print(x, y)
Names and Scopes

- Static scoping rules.
  - If $x$ is a variable name that is only read, its variable is found in the closest enclosing scope that contains a defining write.
  - A variable $x$ that is written is assumed to be local, unless it is explicitly imported.
  - Use `global` and `nonlocal` keywords to override these rules.

- Example:
Functions

def mul(x, y):
    return x * y

mul(2, 5) => ?
mul(math.pi, 2.0) => ?
mul([1, 2, 3], 2) => ?
mul(('a', 'b'), 3) => ?
mul('ou', 5) => ?
def f(a, b, c): print(a, b, c)
f(1, 2, 3) => 1 2 3
f(b = 1, c = 2, a = 3) => 3 1 2

def f(*args): print(args)
f(“one argument”) => (‘one argument’)  
f(1, 2, 3) => (1, 2, 3)

def f(**args): print args
f(a=2, b=4, c=8) => {‘a’:2, ‘b’:4, ‘c’:8}
Lambda Expressions

• **Scheme:**
  ```scheme
  >(define (make-adder (num)
       (lambda (x)
          (+ x num)))
  ```

• **Python:**
  ```python
  >>> def make_adder(num):
      ...    return lambda x: x + num
  ...
  >>> f = make_adder(10)
  >>> f(9)
  19
  ```
>>> formula = lambda x, y: x *x + x*y + y*y
>>> formula
<function <lambda> at 0xb32f213ac320>
>>> apply(formula, (2,3))
19
>>> list(map(lambda x: 2*x, [1, 2, 3]))
[2, 4, 6]
>>> list(filter(lambda x: x>0, [1, -1, 2, -2, 3, 4, -3, -4]))
[1, 2, 3, 4]
>>> from functools import reduce
>>> reduce(lambda x,y:x*y, [1, 2, 3, 4, 5])
120
>>> def fact(n): return reduce (lambda x, y: x*y, range(1, n+1))
>>> fact(5)
120
Iterators

• An **iterator** is an object representing a stream of data:
  – to get the next element in the stream:
    • call `__next__()` method.
    • pass the iterator to the built-in function `next()`.
  – to create an iterator:
    • call `iter(collection)`.
    • some functions create iterators/iterables instead of collections:
      – `map()`, `filter()`, `zip()`, ...
      – `range()`, `dict.keys()`, `dict.items()`, ...
    – **why create iterators/iterables instead of collections?**

• Examples:
Iterators

for x in range(5):
    print(x)

Internally, this is implemented as:

it = iter(range(5))
while True:
    try:
        x = next(it)
        print(x)
    except StopIteration:
        break

an iterable (provides the __iter__() method)
A Convenient Shortcut to Building Iterators: Generator Functions/Expressions

def squares(n):
    for i in range(n):
        yield i*i

>>> for i in squares(5):
...
...    print(i, end = ' ')
0 1 4 9 16

>>> s = squares(5)
>>> next(s) => 0
>>> next(s) => 1
>>> next(s) => 4

Equivalent generator expression:

>>> (i * i for i in range(n))
Generator Functions

def fib():  # generate Fibonacci series
    a, b = 0, 1
    while 1:
        yield b
        a, b = b, a+b

>>> it = fib()
>>> next(it) => 1
>>> next(it) => 1
>>> next(it) => 1
>>> next(it) => 2
List/Set/Dict Comprehensions

- Mapping operations over sequences is a very common task in Python coding:

  ⇒ introduce a new language feature called list comprehensions.

>>> [x**2 for x in range(5)]
[0, 1, 4, 9, 25]

>>> [x for x in range(5) if x % 2 == 0]
[0, 2, 4]

>>> [x+y for x in [1, 2, 3] for y in [-1,0,1]]
[0,1,2,1,2,3,2,3,4]

>>> [(x,y) for x in range(5) if x%2 == 0 for y in range(5) if y%2=1]
[(0,1), (0,3), (2,1), (2,3), (4,1), (4,3)]
List/Set/Dict Comprehensions

\[
\left[ \{ \text{expression} \quad \text{for } \text{target}_1 \text{ in } \text{iterable}_1 \quad \text{[if condition]} \right.
\]

\[
\text{for } \text{target}_2 \text{ in } \text{iterable}_2 \quad \text{[if condition]}
\]

\[
\quad \ldots
\]

\[
\left. \quad \text{for } \text{target}_n \text{ in } \text{iterable}_n \quad \text{[if condition]} \right] \}
\]

```python
>>> [line[1:-1] for line in open('myfile')]
```  
```python
>>> {x for x in 'ohio' if x not in 'hawaii'}
```  
```python
>>> {x:2*x for x in 'ohio'}
```  
```python
>>> {x:y for x in [1, 2] for y in [3, 4]}
```
Errors & Exceptions

- **Syntax errors:**
  ```python
  while True print 'True'
  File "<stdin>", line 1
    while True print 'True'
    ^
  SyntaxError: invalid syntax
  ```

- **Exceptions: errors detected during execution:**
  ```python
  1 / 0
  Traceback (most recent call last):
    File "<stdin>", line 1, in ?
  ZeroDivisionError: integer division or modulo by zero
  ```
for arg in sys.argv[1:]:
    try:
        f = open(arg, 'r')
    except IOError:
        print('cannot open', arg)
    else:
        print(arg, 'has', len(f.readlines()), 'lines')
    f.close()
• Python has a way to put definitions in a file and use them in a script or in an interactive instance of the interpreter.

• A module is a file containing Python definitions and statements.

• The file name is the module name with the suffix .py appended.

• Within a module, the module's name (as a string) is available as the value of the global variable __name__
# Fibonacci numbers module

def fib(n):  # write Fibonacci series up to n
    a, b = 0, 1
    while b < n:
        print b,
        a, b = b, a+b

>>> import fibo
>>> fibo.fib(100)
1 1 2 3 5 8 13 21 34 55 89
How to write and run Python code

• Interactively:
  1. Terminal: run `python`, type code at the interpreter prompt `>>>`.  
  2. Browser: run `jupyter-notebook`, type code and markdown. 
     • Can File / Download as Python (.py) source code.

• Editor or IDE:
  1. `emacs`, `vi`, …
  2. `VSCode`, `Spyder`, `PyCharm`, …
     • Smart editors and IDE can also offer interactive features in parallel with code development.
How to write and run Python code

- Explicit interpreter invocation:
  
  ```
  > python main.py arg_1 ... arg_n
  ```

- Implicit interpreter invocation:
  
  ```
  > ./main.py arg_1 ... arg_n
  ```

  - Need to specify the path to the python interpreter on the first line of main.py:
    ```
    #!/opt/anaconda3/bin/python
    ```

  - Need to give execution rights to main.py:
    ```
    > chmod 0755 main.py
    ```
Readings

• More about Python:
  – [https://docs.python.org/3/tutorial](https://docs.python.org/3/tutorial)
    • [https://docs.python.org/3/tutorial/classes.html#iterators](https://docs.python.org/3/tutorial/classes.html#iterators)
    • [https://docs.python.org/3/tutorial/classes.html#generators](https://docs.python.org/3/tutorial/classes.html#generators)
  – [https://docs.python.org/3/library/functions](https://docs.python.org/3/library/functions)
  – [https://docs.python.org/3/library/stdtypes](https://docs.python.org/3/library/stdtypes)
  – [https://docs.python.org/3/whatsnew/3.0.html](https://docs.python.org/3/whatsnew/3.0.html)
  – [https://docs.python.org/3/howto/regex.html](https://docs.python.org/3/howto/regex.html)

• Matplotlib and NumPy:
  – [https://matplotlib.org/3.1.1/tutorials/index.html](https://matplotlib.org/3.1.1/tutorials/index.html)
  – [https://docs.scipy.org/doc/numpy/user/quickstart.html](https://docs.scipy.org/doc/numpy/user/quickstart.html)