

July 2, 2020 / Jure Šorn

# Comprehensive Python Cheatsheet

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## # Contents

```
ToC = {
    '1. Collections': [List, Dictionary, Set, Tuple, Range, Enumerate, Iterator, Generator],
    '2. Types': [Type, String, Regular_Exp, Format, Numbers, Combinatorics, Datetime],
    '3. Syntax': [Args, Inline, Closure, Decorator, Class, Duck_Type, Enum, Exception],
    '4. System': [Exit, Print, Input, Command_Line_Arguments, Open, Path, OS_Commands],
    '5. Data': [JSON, Pickle, CSV, SQLite, Bytes, Struct, Array, Memory_View, Deque],
    '6. Advanced': [Threading, Operator, Introspection, Metaprogramming, Eval, Coroutine],
    '7. Libraries': [Progress_Bar, Plot, Table, Curses, Logging, Scraping, Web, Profile,
                    NumPy, Image, Audio, Games, Data, Cython]
}
```

## # Main

```
if __name__ == '__main__':      # Runs main() if file wasn't imported.
    main()
```

## # List

```
<list> = <list>[from_inclusive : to_exclusive : ±step_size]

<list>.append(<el>)          # Or: <list> += [<el>]
<list>.extend(<collection>)   # Or: <list> += <collection>

<list>.sort()
<list>.reverse()
<list> = sorted(<collection>)
<iter> = reversed(<list>)

sum_of_elements = sum(<collection>)
elementwise_sum = [sum(pair) for pair in zip(list_a, list_b)]
sorted_by_second = sorted(<collection>, key=lambda el: el[1])
sorted_by_both = sorted(<collection>, key=lambda el: (el[1], el[0]))
flatter_list = list(itertools.chain.from_iterable(<list>))
product_of_elems = functools.reduce(lambda out, el: out * el, <collection>)
list_of_chars = list(<str>)
```

- **Module operator** provides functions `itemgetter()` and `mul()` that offer the same functionality as `lambda` expressions above.

```

<int> = <list>.count(<el>)           # Returns number of occurrences. Also works on strings.
index = <list>.index(<el>)          # Returns index of first occurrence or raises ValueError.
<list>.insert(index, <el>)          # Inserts item at index and moves the rest to the right.
<list>.pop([index])                 # Removes and returns item at index or from the end.
<list>.remove(<el>)                # Removes first occurrence of item or raises ValueError.
<list>.clear()                     # Removes all items. Also works on dictionary and set.

```

## # Dictionary

```

<view> = <dict>.keys()             # Coll. of keys that reflects changes.
<view> = <dict>.values()           # Coll. of values that reflects changes.
<view> = <dict>.items()            # Coll. of key-value tuples that reflects chgs.

value = <dict>.get(key, default=None) # Returns default if key is missing.
value = <dict>.setdefault(key, default=None) # Returns and writes default if key is missing.
<dict> = collections.defaultdict(<type>) # Creates a dict with default value of type.
<dict> = collections.defaultdict(lambda: 1) # Creates a dict with default value 1.

<dict> = dict(<collection>)        # Creates a dict from coll. of key-value pairs.
<dict> = dict(zip(keys, values))    # Creates a dict from two collections.
<dict> = dict.fromkeys(keys [, value]) # Creates a dict from collection of keys.

<dict>.update(<dict>)              # Adds items. Replaces ones with matching keys.
value = <dict>.pop(key)             # Removes item or raises KeyError.
{k for k, v in <dict>.items() if v == value} # Returns set of keys that point to the value.
{k: v for k, v in <dict>.items() if k in keys} # Returns a dictionary, filtered by keys.

```

## Counter

```

>>> from collections import Counter
>>> colors = ['blue', 'blue', 'blue', 'red', 'red']
>>> counter = Counter(colors)
>>> counter['yellow'] += 1
Counter({'blue': 3, 'red': 2, 'yellow': 1})
>>> counter.most_common()[0]
('blue', 3)

```

## # Set

```

<set> = set()                      # Or: <set> |= {<el>}
                                         # Or: <set> |= <set>

<set>.add(<el>)                  # Or: <set> | <set>
<set>.update(<collection>)        # Or: <set> & <set>
                                         # Or: <set> - <set>
                                         # Or: <set> ^ <set>
                                         # Or: <set> <= <set>
                                         # Or: <set> >= <set>

<set> = <set>.union(<coll.>)      # Raises KeyError if empty.
                                         # Raises KeyError if missing.
                                         # Doesn't raise an error.

<set>.union(<coll.>)               # Or: <set> | <set>
<set>.intersection(<coll.>)        # Or: <set> & <set>
<set>.difference(<coll.>)         # Or: <set> - <set>
<set>.symmetric_difference(<coll.>) # Or: <set> ^ <set>
<bool> = <set>.issubset(<coll.>)   # Or: <set> <= <set>
<bool> = <set>.issuperset(<coll.>) # Or: <set> >= <set>

```

## Frozen Set

- Is immutable and hashable.
- That means it can be used as a key in a dictionary or as an element in a set.

```
<frozenset> = frozenset(<collection>)
```

## # Tuple

Tuple is an immutable and hashable list.

```
<tuple> = ()
<tuple> = (<el>, )
<tuple> = (<el_1>, <el_2> [, ...])
```

## Named Tuple

Tuple's subclass with named elements.

```
>>> from collections import namedtuple
>>> Point = namedtuple('Point', 'x y')
>>> p = Point(1, y=2)
Point(x=1, y=2)
>>> p[0]
1
>>> p.x
1
>>> getattr(p, 'y')
2
>>> p._fields # Or: Point._fields
('x', 'y')
```

## # Range

```
<range> = range(to_exclusive)
<range> = range(from_inclusive, to_exclusive)
<range> = range(from_inclusive, to_exclusive, step_size)

from_inclusive = <range>.start
to_exclusive   = <range>.stop
```

## # Enumerate

```
for i, el in enumerate(<collection> [, i_start]):
    ...
```

## # Iterator

```
<iter> = iter(<collection>)
<iter> = iter(<function>, to_exclusive)
<el>   = next(<iter> [, default])
<list> = list(<iter>)                                # `iter(<iter>)` returns unmodified iterator.
                                                        # A sequence of return values until 'to_exclusive'.
                                                        # Raises StopIteration or returns 'default' on end.
                                                        # Returns a list of iterator's remaining elements.
```

## Itertools

```
from itertools import count, repeat, cycle, chain, islice

<iter> = count(start=0, step=1)                      # Returns updated value endlessly. Accepts floats.
<iter> = repeat(<el> [, times])                    # Returns element endlessly or 'times' times.
<iter> = cycle(<collection>)                       # Repeats the sequence endlessly.

<iter> = chain(<coll_1>, <coll_2> [, ...])      # Empties collections in order.
<iter> = chain.from_iterable(<collection>)        # Empties collections inside a collection in order.

<iter> = islice(<collection>, to_exclusive)
<iter> = islice(<collection>, from_inclusive, to_exclusive [, +step_size])
```

## # Generator

- Any function that contains a `yield` statement returns a generator.
- Generators and iterators are interchangeable.

```
def count(start, step):
    while True:
        yield start
        start += step

>>> counter = count(10, 2)
>>> next(counter), next(counter), next(counter)
(10, 12, 14)
```

## # Type

- Everything is an object.
- Every object has a type.
- Type and class are synonymous.

```
<type> = type(<el>)                                # Or: <el>.__class__
<bool> = isinstance(<el>, <type>)                  # Or: issubclass(type(<el>), <type>)

>>> type('a'), 'a'.__class__, str
(<class 'str'>, <class 'str'>, <class 'str'>)
```

Some types do not have built-in names, so they must be imported:

```
from types import FunctionType, MethodType, LambdaType, GeneratorType
```

### Abstract Base Classes

Each abstract base class specifies a set of virtual subclasses. These classes are then recognized by `isinstance()` and `issubclass()` as subclasses of the ABC, although they are really not.

```
>>> from collections.abc import Sequence, Collection, Iterable
>>> isinstance([1, 2, 3], Iterable)
True
```

	Sequence	Collection	Iterable
list, range, str dict, set iter	✓	✓ ✓	✓ ✓ ✓

```
>>> from numbers import Integral, Rational, Real, Complex, Number
>>> isinstance(123, Number)
True
```

	Integral	Rational	Real	Complex	Number
int fractions.Fraction float complex decimal.Decimal	✓	✓ ✓	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓ ✓

## # String

```

<str> = <str>.strip()                                # Strips all whitespace characters from both ends.
<str> = <str>.strip('<chars>')                      # Strips all passed characters from both ends.

<list> = <str>.split()                                # Splits on one or more whitespace characters.
<list> = <str>.split(sep=None, maxsplit=-1)          # Splits on 'sep' str at most 'maxsplit' times.
<list> = <str>.splitlines(keepends=False)             # Splits on \n,\r,\r\n. Keeps them if 'keepends'.
<str> = <str>.join(<coll_of_strings>)                # Joins elements using string as separator.

<bool> = <sub_str> in <str>                          # Checks if string contains a substring.
<bool> = <str>.startswith(<sub_str>)                 # Pass tuple of strings for multiple options.
<bool> = <str>.endswith(<sub_str>)                  # Pass tuple of strings for multiple options.
<int> = <str>.find(<sub_str>)                        # Returns start index of first match or -1.
<int> = <str>.index(<sub_str>)                      # Same but raises ValueError if missing.

<str> = <str>.replace(old, new [, count])            # Replaces 'old' with 'new' at most 'count' times.
<str> = <str>.translate(<table>)                   # Use `str.maketrans(<dict>)` to generate table.

<str> = chr(<int>)                                  # Converts int to Unicode char.
<int> = ord(<str>)                                   # Converts Unicode char to int.

```

- Also: `'lstrip()', 'rstrip()'`.
- Also: `'lower()', 'upper()', 'capitalize()' and 'title()'`.

## Property Methods

	[ !#\$%... ]	[a-zA-Z]	[ <sup>1 1 3</sup> <sub>4 2 4</sub> ]	[ <sup>2 3 1</sup> <sub>3 2 1</sub> ]	[0-9]
isprintable()	✓	✓	✓	✓	✓
isalnum()		✓	✓	✓	✓
isnumeric()			✓	✓	✓
isdigit()				✓	✓
isdecimal()					✓

- Also: `'isspace()'` checks for `'[ \t\n\r\f\v... ]'`.

## # Regex

```

import re
<str> = re.sub(<regex>, new, text, count=0)    # Substitutes all occurrences with 'new'.
<list> = re.findall(<regex>, text)               # Returns all occurrences as strings.
<list> = re.split(<regex>, text, maxsplit=0)      # Use brackets in regex to include the matches.
<Match> = re.search(<regex>, text)                # Searches for first occurrence of the pattern.
<Match> = re.match(<regex>, text)                 # Searches only at the beginning of the text.
<iter> = re.finditer(<regex>, text)              # Returns all occurrences as match objects.

```

- `Search()` and `match()` return `None` if they can't find a match.
- Argument `'flags=re.IGNORECASE'` can be used with all functions.
- Argument `'flags=re.MULTILINE'` makes `'^'` and `'$'` match the start/end of each line.
- Argument `'flags=re.DOTALL'` makes dot also accept the `\n`.
- Use `r'\1'` or `'\\1'` for backreference.
- Add `'?'` after an operator to make it non-greedy.

## Match Object

```

<str> = <Match>.group()                           # Returns the whole match. Also group(0).
<str> = <Match>.group(1)                           # Returns part in the first bracket.
<tuple> = <Match>.groups()                         # Returns all bracketed parts.
<int> = <Match>.start()                           # Returns start index of the match.
<int> = <Match>.end()                            # Returns exclusive end index of the match.

```

## Special Sequences

- By default digits, alphanumerics and whitespaces from all alphabets are matched, unless '`flags=re.ASCII`' argument is used.
- Use a capital letter for negation.

```
'\d' == '[0-9]'                                # Matches any digit.
'\w' == '[a-zA-Z0-9_]'                          # Matches any alphanumeric.
'\s' == '[ \t\n\r\f\v]'                           # Matches any whitespace.
```

## # Format

```
<str> = f'{<el_1>}, {<el_2>}'  
<str> = '{}', {}'.format(<el_1>, <el_2>)
```

### Attributes

```
>>> from collections import namedtuple  
>>> Person = namedtuple('Person', 'name height')  
>>> person = Person('Jean-Luc', 187)  
>>> f'{person.height}'  
'187'  
>>> '{p.height}'.format(p=person)  
'187'
```

### General Options

```
{<el>:<10}                                # '<el>'  
{<el>:^10}                                 # '   <el>'  
{<el>:>10}                                 # '   <el>'  
{<el>:.<10}                                # '<el>....'  
{<el>:<0}                                  # '<el>'
```

## Strings

`'!r'` calls object's `repr()` method, instead of `str()`, to get a string.

```
{'abcde'!r:10}                             # "'abcde'"  
{'abcde':10.3}                            # 'abc'  
{'abcde':.3}                              # 'abc'
```

## Numbers

```
{ 123456:10,}                               # ' 123,456'  
{ 123456:10_}                             # ' 123_456'  
{ 123456:+10}                            # '+123456'  
{-123456:=10}                            # '- 123456'  
{ 123456: }                                # ' 123456'  
{-123456: }                                # '-123456'
```

## FLOATS

```
{1.23456:10.3}                            # '      1.23'  
{1.23456:10.3f}                           # '      1.235'  
{1.23456:10.3e}                           # ' 1.235e+00'  
{1.23456:10.3%}                           # ' 123.456%'
```

**Comparison of presentation types:**

	{<float>}	{<float>:.f}	{<float>:.e}	{<float>:%}
0.000056789	'5.6789e-05'	'0.000057'	'5.678900e-05'	'0.005679%'
0.00056789	'0.00056789'	'0.000568'	'5.678900e-04'	'0.056789%'
0.0056789	'0.0056789'	'0.005679'	'5.678900e-03'	'0.567890%'
0.056789	'0.056789'	'0.056789'	'5.678900e-02'	'5.678900%'
0.56789	'0.56789'	'0.567890'	'5.678900e-01'	'56.789000%'
5.6789	'5.6789'	'5.678900'	'5.678900e+00'	'567.890000%'
56.789	'56.789'	'56.789000'	'5.678900e+01'	'5678.900000%'
567.89	'567.89'	'567.890000'	'5.678900e+02'	'56789.000000%'

	{<float>:.2}	{<float>:.2f}	{<float>:.2e}	{<float>:.2%}
0.000056789	'5.7e-05'	'0.00'	'5.68e-05'	'0.01%'
0.00056789	'0.00057'	'0.00'	'5.68e-04'	'0.06%'
0.0056789	'0.0057'	'0.01'	'5.68e-03'	'0.57%'
0.056789	'0.057'	'0.06'	'5.68e-02'	'5.68%'
0.56789	'0.57'	'0.57'	'5.68e-01'	'56.79%'
5.6789	'5.7'	'5.68'	'5.68e+00'	'567.89%'
56.789	'5.7e+01'	'56.79'	'5.68e+01'	'5678.90%'
567.89	'5.7e+02'	'567.89'	'5.68e+02'	'56789.00%'

**Ints**

```
{90:c}
{90:b}
{90:X}
```

# 'Z'  
# '1011010'  
# '5A'

**# Numbers****Types**

```
<int>      = int(<float/str/bool>)      # Or: math.floor(<float>)
<float>    = float(<int/str/bool>)     # Or: <real>e±<int>
<complex>  = complex(real=0, imag=0)    # Or: <real> ± <real>j
<Fraction> = fractions.Fraction(0, 1)   # Or: Fraction(numerator=0, denominator=1)
<Decimal>  = decimal.Decimal(<str/int>) # Or: Decimal((sign, digits, exponent))
```

- `'int(<str>)' and 'float(<str>)' raise ValueError on malformed strings.`
- Decimal numbers can be represented exactly, unlike floats where `'1.1 + 2.2 != 3.3'`.
- Precision of decimal operations is set with: `'decimal.getcontext().prec = <int>'.`

**Basic Functions**

```
<num> = pow(<num>, <num>)          # Or: <num> ** <num>
<num> = abs(<num>)                  # <float> = abs(<complex>)
<num> = round(<num> [, ±ndigits])  # `round(126, -1) == 130`
```

**Math**

```
from math import e, pi, inf, nan, isinf, isnan
from math import cos, acos, sin, asin, tan, atan, degrees, radians
from math import log, log10, log2
```

**Statistics**

```
from statistics import mean, median, variance, stdev, pvariance, pstdev
```

## Random

```
from random import random, randint, choice, shuffle
<float> = random()
<int> = randint(from_inclusive, to_inclusive)
<el> = choice(<list>)
shuffle(<list>)
```

## Bin, Hex

```
<int>      = ±0b<bin>
<int>      = int('±<bin>', 2)          # Or: ±0x<hex>
<int>      = int('±0b<bin>', 0)        # Or: int('±<hex>', 16)
'[-]0b<bin>' = bin(<int>)            # Or: hex(<int>)
```

## Bitwise Operators

```
<int>      = <int> & <int>          # And
<int>      = <int> | <int>          # Or
<int>      = <int> ^ <int>          # Xor (0 if both bits equal)
<int>      = <int> << n_bits       # Shift left (>> for right)
<int>      = ~<int>              # Not (also: -<int> - 1)
```

## # Combinatorics

- Every function returns an iterator.
- If you want to print the iterator, you need to pass it to the list() function first!

```
from itertools import product, combinations, combinations_with_replacement, permutations

>>> product([0, 1], repeat=3)
[(0, 0, 0), (0, 0, 1), (0, 1, 0), (0, 1, 1),
 (1, 0, 0), (1, 0, 1), (1, 1, 0), (1, 1, 1)]

>>> product('ab', '12')
[('a', '1'), ('a', '2'),
 ('b', '1'), ('b', '2')]

>>> combinations('abc', 2)
[('a', 'b'), ('a', 'c'),
 ('b', 'c')]

>>> combinations_with_replacement('abc', 2)
[('a', 'a'), ('a', 'b'), ('a', 'c'),
 ('b', 'b'), ('b', 'c'),
 ('c', 'c')]

>>> permutations('abc', 2)
[('a', 'b'), ('a', 'c'),
 ('b', 'a'), ('b', 'c'),
 ('c', 'a'), ('c', 'b')]
```

## # Datetime

- Module 'datetime' provides 'date' <D>, 'time' <T>, 'datetime' <DT> and 'timedelta' <TD> classes. All are immutable and hashable.
- Time and datetime objects can be 'aware' <a>, meaning they have defined timezone, or 'naive' <n>, meaning they don't.
- If object is naive, it is presumed to be in the system's timezone.

```
from datetime import date, time, datetime, timedelta
from dateutil.tz import UTC, tzlocal, gettz, resolve_imaginary
```

### Constructors

```
<D> = date(year, month, day)
<T> = time(hour=0, minute=0, second=0, microsecond=0, tzinfo=None, fold=0)
<DT> = datetime(year, month, day, hour=0, minute=0, second=0, ...)
<TD> = timedelta(days=0, seconds=0, microseconds=0, milliseconds=0,
                  minutes=0, hours=0, weeks=0)
```

- Use '<D/DT>.weekday()' to get the day of the week (Mon == 0).
- 'fold=1' means the second pass in case of time jumping back for one hour.
- '<DTa> = resolve\_imaginary(<DTa>)' fixes DTs that fall into the missing hour.

### Now

```
<D/DTn> = D/DT.today()                                # Current local date or naive datetime.
<DTn>   = DT.utcnow()                                 # Naive datetime from current UTC time.
<DTa>   = DT.now(<tzinfo>)                          # Aware datetime from current tz time.
```

- To extract time use '<DTn>.time()', '<DTa>.time()' or '<DTa>.timetz()'.

### Timezone

```
<tzinfo> = UTC                                         # UTC timezone. London without DST.
<tzinfo> = tzlocal()                                    # Local timezone. Also gettz().
<tzinfo> = gettz('<Continent>/<City>')             # 'Continent/City_Name' timezone or None.
<DTa>   = <DT>.astimezone(<tzinfo>)                 # Datetime, converted to passed timezone.
<Ta/DTa> = <T/DT>.replace(tzinfo=<tzinfo>)          # Unconverted object with new timezone.
```

### Encode

```
<D/T/DT> = D/T/DT.fromisoformat('<iso>')           # Object from ISO string. Raises ValueError.
<DT>     = DT.strptime('<str>', '<format>')        # Datetime from str, according to format.
<D/DTn> = D/DT.fromordinal(<int>)                  # D/DTn from days since Christ, at midnight.
<DTn>   = DT.fromtimestamp(<real>)                 # Local time DTn from seconds since Epoch.
<DTa>   = DT.fromtimestamp(<real>, <tz.>)         # Aware datetime from seconds since Epoch.
```

- ISO strings come in following forms: 'YYYY-MM-DD', 'HH:MM:SS.fffffff[±<offset>]', or both separated by an arbitrary character. Offset is formatted as: 'HH:MM'.
- Epoch on Unix systems is: '1970-01-01 00:00 UTC', '1970-01-01 01:00 CET', ...

### Decode

```
<str>    = <D/T/DT>.isoformat(sep='T')                # Also timespec='auto/hours/minutes/seconds'.
<str>    = <D/T/DT>.strftime('<format>')            # Custom string representation.
<int>    = <D/DT>.toordinal()                         # Days since Christ, ignoring time and tz.
<float>  = <DTn>.timestamp()                          # Seconds since Epoch, from DTn in local tz.
<float>  = <DTa>.timestamp()                          # Seconds since Epoch, from DTa.
```

## Format

```
>>> from datetime import datetime
>>> dt = datetime.strptime('2015-05-14 23:39:00.00 +0200', '%Y-%m-%d %H:%M:%S.%f %z')
>>> dt.strftime("%A, %dth of %B %y, %I:%M%p %Z")
"Thursday, 14th of May '15, 11:39PM UTC+02:00"
```

- When parsing, '%z' also accepts '+HH:MM'.
- For abbreviated weekday and month use '%a' and '%b'.

## Arithmetics

<D/DT> = <D/DT> ± <TD>	# Returned datetime can fall into missing hour.
<TD> = <D/DTn> - <D/DTn>	# Returns the difference, ignoring time jumps.
<TD> = <DTa> - <DTa>	# Ignores time jumps if they share tzinfo object.
<TD> = <DT_UTC> - <DT_UTC>	# Convert DTs to UTC to get the actual delta.

## # Arguments

### Inside Function Call

```
<function>(<positional_args>) # f(0, 0)
<function>(<keyword_args>) # f(x=0, y=0)
<function>(<positional_args>, <keyword_args>) # f(0, y=0)
```

### Inside Function Definition

```
def f(<nondefault_args>): # def f(x, y):
def f(<default_args>): # def f(x=0, y=0):
def f(<nondefault_args>, <default_args>): # def f(x, y=0):
```

## # Splat Operator

### Inside Function Call

Splat expands a collection into positional arguments, while splatty-splat expands a dictionary into keyword arguments.

```
args = (1, 2)
kwargs = {'x': 3, 'y': 4, 'z': 5}
func(*args, **kwargs)
```

Is the same as:

```
func(1, 2, x=3, y=4, z=5)
```

### Inside Function Definition

Splat combines zero or more positional arguments into a tuple, while splatty-splat combines zero or more keyword arguments into a dictionary.

```
def add(*a):
    return sum(a)

>>> add(1, 2, 3)
6
```

**Legal argument combinations:**

```

def f(x, y, z):          # f(x=1, y=2, z=3) | f(1, y=2, z=3) | f(1, 2, z=3) | f(1, 2, 3)
def f(*, x, y, z):      # f(x=1, y=2, z=3)
def f(x, *, y, z):      # f(x=1, y=2, z=3) | f(1, y=2, z=3)
def f(x, y, *, z):      # f(x=1, y=2, z=3) | f(1, y=2, z=3) | f(1, 2, z=3)

def f(*args):            # f(1, 2, 3)
def f(x, *args):         # f(1, 2, 3)
def f(*args, z):         # f(1, 2, z=3)
def f(x, *args, z):      # f(1, 2, z=3)

def f(**kwargs):         # f(x=1, y=2, z=3)
def f(x, **kwargs):      # f(x=1, y=2, z=3) | f(1, y=2, z=3)
def f(*, x, **kwargs):   # f(x=1, y=2, z=3)

def f(*args, **kwargs):   # f(x=1, y=2, z=3) | f(1, y=2, z=3) | f(1, 2, z=3) | f(1, 2, 3)
def f(x, *args, **kwargs):# f(x=1, y=2, z=3) | f(1, y=2, z=3) | f(1, 2, z=3) | f(1, 2, 3)
def f(*args, y, **kwargs):# f(x=1, y=2, z=3) | f(1, y=2, z=3)
def f(x, *args, z, **kwargs):# f(x=1, y=2, z=3) | f(1, y=2, z=3) | f(1, 2, z=3)

```

**Other Uses**

```

<list> = [*<collection> [, ...]]
<set> = {*<collection> [, ...]}
<tuple> = (*<collection>, [...])
<dict> = {**<dict> [, ...]}

```

```
| head, *body, tail = <collection>
```

**# Inline****Lambda**

```

<function> = lambda: <return_value>
<function> = lambda <argument_1>, <argument_2>: <return_value>

```

**Comprehensions**

```

<list> = [i+1 for i in range(10)]           # [1, 2, ..., 10]
<set> = {i for i in range(10) if i > 5}       # {6, 7, 8, 9}
<iter> = (i+5 for i in range(10))           # (5, 6, ..., 14)
<dict> = {i: i*2 for i in range(10)}        # {0: 0, 1: 2, ..., 9: 18}

| out = [i+j for i in range(10) for j in range(10)]

```

**Is the same as:**

```

out = []
for i in range(10):
    for j in range(10):
        out.append(i+j)

```

**Map, Filter, Reduce**

```

from functools import reduce
<iter> = map(lambda x: x + 1, range(10))           # (1, 2, ..., 10)
<iter> = filter(lambda x: x > 5, range(10))         # (6, 7, 8, 9)
<obj> = reduce(lambda out, x: out + x, range(10)) # 45

```

## Any, All

```
<bool> = any(<collection>)                      # False if empty.
<bool> = all(el[1] for el in <collection>)      # True if empty.
```

## If - Else

```
<obj> = <expression_if_true> if <condition> else <expression_if_false>

>>> [a if a else 'zero' for a in (0, 1, 2, 3)]
['zero', 1, 2, 3]
```

## Namedtuple, Enum, Dataclass

```
from collections import namedtuple
Point = namedtuple('Point', 'x y')
point = Point(0, 0)

from enum import Enum
Direction = Enum('Direction', 'n e s w')
direction = Direction.n

from dataclasses import make_dataclass
Creature = make_dataclass('Creature', ['location', 'direction'])
creature = Creature(Point(0, 0), Direction.n)
```

## # Closure

We have a closure in Python when:

- A nested function references a value of its enclosing function and then
- the enclosing function returns the nested function.

```
def get_multiplier(a):
    def out(b):
        return a * b
    return out

>>> multiply_by_3 = get_multiplier(3)
>>> multiply_by_3(10)
30
```

- If multiple nested functions within enclosing function reference the same value, that value gets shared.
- To dynamically access function's first free variable use '`<function>.__closure__[0].cell_contents`'.

## Partial

```
from functools import partial
<function> = partial(<function>, <arg_1>, <arg_2>, ...)

>>> import operator as op
>>> multiply_by_3 = partial(op.mul, 3)
>>> multiply_by_3(10)
30
```

- Partial is also useful in cases when function needs to be passed as an argument, because it enables us to set its arguments beforehand.
- A few examples being: '`defaultdict(<function>)`', '`iter(<function>, to_exclusive)`' and dataclass's '`field(default_factory=<function>)`'.

## Non-Local

If variable is being assigned to anywhere in the scope, it is regarded as a local variable, unless it is declared as a 'global' or a 'nonlocal'.

```
def get_counter():
    i = 0
    def out():
        nonlocal i
        i += 1
        return i
    return out

>>> counter = get_counter()
>>> counter(), counter(), counter()
(1, 2, 3)
```

## # Decorator

A decorator takes a function, adds some functionality and returns it.

```
@decorator_name
def function_that_gets_passed_to_decorator():
    ...
```

### Debugger Example

Decorator that prints function's name every time it gets called.

```
from functools import wraps

def debug(func):
    @wraps(func)
    def out(*args, **kwargs):
        print(func.__name__)
        return func(*args, **kwargs)
    return out

@debug
def add(x, y):
    return x + y
```

- Wraps is a helper decorator that copies the metadata of the passed function (func) to the function it is wrapping (out).
- Without it `'add.__name__'` would return 'out'.

### LRU Cache

Decorator that caches function's return values. All function's arguments must be hashable.

```
from functools import lru_cache

@lru_cache(maxsize=None)
def fib(n):
    return n if n < 2 else fib(n-2) + fib(n-1)
```

- CPython interpreter limits recursion depth to 1000 by default. To increase it use `'sys.setrecursionlimit(<depth>)'.`

## Parametrized Decorator

A decorator that accepts arguments and returns a normal decorator that accepts a function.

```
from functools import wraps

def debug(print_result=False):
    def decorator(func):
        @wraps(func)
        def out(*args, **kwargs):
            result = func(*args, **kwargs)
            print(func.__name__, result if print_result else '')
            return result
        return out
    return decorator

@debug(print_result=True)
def add(x, y):
    return x + y
```

## # Class

```
class <name>:
    def __init__(self, a):
        self.a = a
    def __repr__(self):
        class_name = self.__class__.__name__
        return f'{class_name}({self.a!r})'
    def __str__(self):
        return str(self.a)

    @classmethod
    def get_class_name(cls):
        return cls.__name__
```

- Return value of `repr()` should be unambiguous and of `str()` readable.
- If only `repr()` is defined, it will also be used for `str()`.

`Str()` use cases:

```
print(<el>)
print(f'<el>')
raise Exception(<el>)
loguru.logger.debug(<el>)
csv.writer(<file>).writerow([<el>])
```

`Repr()` use cases:

```
print([<el>])
print(f'<el>!r')
>>> <el>
loguru.logger.exception()
Z = dataclasses.make_dataclass('Z', ['a']); print(Z(<el>))
```

## Constructor Overloading

```
class <name>:
    def __init__(self, a=None):
        self.a = a
```

## Inheritance

```
class Person:
    def __init__(self, name, age):
        self.name = name
        self.age = age

class Employee(Person):
    def __init__(self, name, age, staff_num):
        super().__init__(name, age)
        self.staff_num = staff_num
```

## Multiple Inheritance

```
class A: pass
class B: pass
class C(A, B): pass
```

MRO determines the order in which parent classes are traversed when searching for a method:

```
>>> C.mro()
[<class 'C'>, <class 'A'>, <class 'B'>, <class 'object'>]
```

## Property

Pythonic way of implementing getters and setters.

```
class MyClass:
    @property
    def a(self):
        return self._a

    @a.setter
    def a(self, value):
        self._a = value

>>> el = MyClass()
>>> el.a = 123
>>> el.a
123
```

## Dataclass

Decorator that automatically generates init(), repr() and eq() special methods.

```
from dataclasses import dataclass, field

@dataclass(order=False, frozen=False)
class <class_name>:
    <attr_name_1>: <type>
    <attr_name_2>: <type> = <default_value>
    <attr_name_3>: list/dict/set = field(default_factory=list/dict/set)
```

- Objects can be made sortable with '`order=True`' and/or immutable and hashable with '`frozen=True`'.
- Function `field()` is needed because '`<attr_name>: list = []`' would make a list that is shared among all instances.
- `Default_factory` can be any callable.

**Inline:**

```
from dataclasses import make_dataclass
<class> = make_dataclass('<class_name>', <coll_of_attribute_names>)
<class> = make_dataclass('<class_name>', <coll_of_tuples>)
<tuple> = ('<attr_name>', <type> [, <default_value>])
```

**Slots**

Mechanism that restricts objects to attributes listed in 'slots' and significantly reduces their memory footprint.

```
class MyClassWithSlots:
    __slots__ = ['a']
    def __init__(self):
        self.a = 1
```

**Copy**

```
from copy import copy, deepcopy
<object> = copy(<object>)
<object> = deepcopy(<object>)
```

## # Duck Types

A duck type is an implicit type that prescribes a set of special methods. Any object that has those methods defined is considered a member of that duck type.

**Comparable**

- If `eq()` method is not overridden, it returns '`id(self) == id(other)`', which is the same as '`self is other`'.
- That means all objects compare not equal by default.
- Only the left side object has `eq()` method called, unless it returns `NotImplemented`, in which case the right object is consulted.

```
class MyComparable:
    def __init__(self, a):
        self.a = a
    def __eq__(self, other):
        if isinstance(other, type(self)):
            return self.a == other.a
        return NotImplemented
```

**Hashable**

- Hashable object needs both `hash()` and `eq()` methods and its hash value should never change.
- Hashable objects that compare equal must have the same hash value, meaning default `hash()` that returns '`id(self)`' will not do.
- That is why Python automatically makes classes unhashable if you only implement `eq()`.

```
class MyHashable:
    def __init__(self, a):
        self._a = a
    @property
    def a(self):
        return self._a
    def __eq__(self, other):
        if isinstance(other, type(self)):
            return self.a == other.a
        return NotImplemented
    def __hash__(self):
        return hash(self.a)
```

## Sortable

- With `total_ordering` decorator, you only need to provide `eq()` and one of `lt()`, `gt()`, `le()` or `ge()` special methods.

```
from functools import total_ordering

@total_ordering
class MySortable:
    def __init__(self, a):
        self.a = a
    def __eq__(self, other):
        if isinstance(other, type(self)):
            return self.a == other.a
        return NotImplemented
    def __lt__(self, other):
        if isinstance(other, type(self)):
            return self.a < other.a
        return NotImplemented
```

## Iterator

- Any object that has methods `next()` and `iter()` is an iterator.
- `Next()` should return next item or raise `StopIteration`.
- `Iter()` should return 'self'.

```
class Counter:
    def __init__(self):
        self.i = 0
    def __next__(self):
        self.i += 1
        return self.i
    def __iter__(self):
        return self
```

```
>>> counter = Counter()
>>> next(counter), next(counter), next(counter)
(1, 2, 3)
```

Python has many different iterator objects:

- Iterators returned by the `iter()` function, such as `list_iterator` and `set_iterator`.
- Objects returned by the `itertools` module, such as `count`, `repeat` and `cycle`.
- Generators returned by the `generator functions` and `generator expressions`.
- File objects returned by the `open()` function, etc.

## Callable

- All functions and classes have a `call()` method, hence are callable.
- When this cheatsheet uses '`<function>`' as an argument, it actually means '`<callable>`'.

```
class Counter:
    def __init__(self):
        self.i = 0
    def __call__(self):
        self.i += 1
        return self.i

>>> counter = Counter()
>>> counter(), counter(), counter()
(1, 2, 3)
```

## Context Manager

- Enter() should lock the resources and optionally return an object.
- Exit() should release the resources.
- Any exception that happens inside the with block is passed to the exit() method.
- If it wishes to suppress the exception it must return a true value.

```
class MyOpen:
    def __init__(self, filename):
        self.filename = filename
    def __enter__(self):
        self.file = open(self.filename)
        return self.file
    def __exit__(self, exc_type, exception, traceback):
        self.file.close()

>>> with open('test.txt', 'w') as file:
...     file.write('Hello World!')
>>> with MyOpen('test.txt') as file:
...     print(file.read())
Hello World!
```

## # Iterable Duck Types

### Iterable

- Only required method is iter(). It should return an iterator of object's items.
- Contains() automatically works on any object that has iter() defined.

```
class MyIterable:
    def __init__(self, a):
        self.a = a
    def __iter__(self):
        return iter(self.a)
    def __contains__(self, el):
        return el in self.a

>>> obj = MyIterable([1, 2, 3])
>>> [el for el in obj]
[1, 2, 3]
>>> 1 in obj
True
```

### Collection

- Only required methods are iter() and len().
- This cheatsheet actually means '<iterable>' when it uses '<collection>'.
- I chose not to use the name 'iterable' because it sounds scarier and more vague than 'collection'.

```
class MyCollection:
    def __init__(self, a):
        self.a = a
    def __iter__(self):
        return iter(self.a)
    def __contains__(self, el):
        return el in self.a
    def __len__(self):
        return len(self.a)
```

## Sequence

- Only required methods are `len()` and `getitem()`.
- `Getitem()` should return an item at index or raise `IndexError`.
- `Iter()` and `contains()` automatically work on any object that has `getitem()` defined.
- `Reversed()` automatically works on any object that has `getitem()` and `len()` defined.

```
class MySequence:
    def __init__(self, a):
        self.a = a
    def __iter__(self):
        return iter(self.a)
    def __contains__(self, el):
        return el in self.a
    def __len__(self):
        return len(self.a)
    def __getitem__(self, i):
        return self.a[i]
    def __reversed__(self):
        return reversed(self.a)
```

## ABC Sequence

- It's a richer interface than the basic sequence.
- Extending it generates `iter()`, `contains()`, `reversed()`, `index()` and `count()`.
- Unlike '`abc.Iterable`' and '`abc.Collection`', it is not a duck type. That is why '`issubclass(MySequence, abc.Sequence)`' would return False even if `MySequence` had all the methods defined.

```
from collections import abc

class MyAbcSequence(abc.Sequence):
    def __init__(self, a):
        self.a = a
    def __len__(self):
        return len(self.a)
    def __getitem__(self, i):
        return self.a[i]
```

Table of required and automatically available special methods:

	Iterable	Collection	Sequence	abc.Sequence
<code>iter()</code>	!	!	✓	✓
<code>contains()</code>	✓	✓	✓	✓
<code>len()</code>		!	!	!
<code>getitem()</code>			!	!
<code>reversed()</code>			✓	✓
<code>index()</code>				✓
<code>count()</code>				✓

- Other ABCs that generate missing methods are: `MutableSequence`, `Set`, `MutableSet`, `Mapping` and `MutableMapping`.
- Names of their required methods are stored in '`<abc>.__abstractmethods__`'.

## # Enum

```
from enum import Enum, auto

class <enum_name>(Enum):
    <member_name_1> = <value_1>
    <member_name_2> = <value_2_a>, <value_2_b>
    <member_name_3> = auto()
```

- If there are no numeric values before auto(), it returns 1.
- Otherwise it returns an increment of the last numeric value.

```

<member> = <enum>.<member_name>                                # Returns a member.
<member> = <enum>['<member_name>']                            # Returns a member or raises KeyError.
<member> = <enum>(<value>)                                    # Returns a member or raises ValueError.
<str>     = <member>.name                                     # Returns member's name.
<obj>     = <member>.value                                    # Returns member's value.

list_of_members = list(<enum>)
member_names   = [a.name for a in <enum>]
member_values  = [a.value for a in <enum>]
random_member  = random.choice(list(<enum>))

def get_next_member(member):
    members = list(member.__class__)
    index   = (members.index(member) + 1) % len(members)
    return members[index]

```

## Inline

```

Cutlery = Enum('Cutlery', 'fork knife spoon')
Cutlery = Enum('Cutlery', ['fork', 'knife', 'spoon'])
Cutlery = Enum('Cutlery', {'fork': 1, 'knife': 2, 'spoon': 3})

```

User-defined functions cannot be values, so they must be wrapped:

```

from functools import partial
LogicOp = Enum('LogicOp', {'AND': partial(lambda l, r: l and r),
                           'OR' : partial(lambda l, r: l or r)})

```

- Another solution in this particular case is to use built-in functions and\_() and or\_() from the module operator.

## # Exceptions

### Basic Example

```

try:
    <code>
except <exception>:
    <code>

```

### Complex Example

```

try:
    <code_1>
except <exception_a>:
    <code_2_a>
except <exception_b>:
    <code_2_b>
else:
    <code_2_c>
finally:
    <code_3>

```

- Code inside the 'else' block will only be executed if 'try' block had no exception.
- Code inside the 'finally' block will always be executed.

## Catching Exceptions

```
except <exception>:  
except <exception> as <name>:  
except (<exception>, ...):  
except (<exception>, ...) as <name>:
```

- Also catches subclasses of the exception.
- Use '`traceback.print_exc()`' to print the error message to stderr.

## Raising Exceptions

```
raise <exception>  
raise <exception>()  
raise <exception>(<el> [, ...])
```

**Re-raising caught exception:**

```
except <exception> as <name>:  
...  
raise
```

## Exception Object

```
arguments = <name>.args  
exc_type = <name>.__class__  
filename = <name>.__traceback__.tb_frame.f_code.co_filename  
func_name = <name>.__traceback__.tb_frame.f_code.co_name  
line = linecache.getline(filename, <name>.__traceback__.tb_lineno)  
error_msg = traceback.format_exception(exc_type, <name>, <name>.__traceback__)
```

## Built-in Exceptions

```
BaseException  
└── SystemExit # Raised by the sys.exit() function.  
└── KeyboardInterrupt # Raised when the user hits the interrupt key (ctrl-c).  
└── Exception # User-defined exceptions should be derived from this class.  
    ├── ArithmeticError # Base class for arithmetic errors.  
    │   └── ZeroDivisionError # Raised when dividing by zero.  
    ├── AttributeError # Raised when an attribute is missing.  
    ├── EOFError # Raised by input() when it hits end-of-file condition.  
    ├── LookupError # Raised when a look-up on a collection fails.  
    │   ├── IndexError # Raised when a sequence index is out of range.  
    │   └── KeyError # Raised when a dictionary key or set element is not found.  
    ├── NameError # Raised when a variable name is not found.  
    ├── OSError # Failures such as "file not found" or "disk full".  
    │   └── FileNotFoundError # When a file or directory is requested but doesn't exist.  
    ├── RuntimeError # Raised by errors that don't fall in other categories.  
    │   └── RecursionError # Raised when the maximum recursion depth is exceeded.  
    ├── StopIteration # Raised by next() when run on an empty iterator.  
    ├── TypeError # Raised when an argument is of wrong type.  
    └── ValueError # When an argument is of right type but inappropriate value.  
        └── UnicodeError # Raised when encoding/decoding strings to/from bytes fails.
```

**Collections and their exceptions:**

	list	dict	set
getitem() pop() remove() index()	IndexError IndexError ValueError ValueError	KeyError KeyError	KeyError KeyError

**Useful built-in exceptions:**

```
raise TypeError('Argument is of wrong type!')
raise ValueError('Argument is of right type but inappropriate value!')
raise RuntimeError('None of above!')
```

**User-defined Exceptions**

```
class MyError(Exception):
    pass

class MyInputError(MyError):
    pass
```

**# Exit**

Exits the interpreter by raising SystemExit exception.

```
import sys
sys.exit()                      # Exits with exit code 0 (success).
sys.exit(<el>)                  # Prints to stderr and exits with 1.
sys.exit(<int>)                  # Exits with passed exit code.
```

## # Print

```
| print(<el_1>, ..., sep=' ', end='\n', file=sys.stdout, flush=False)
```

- Use 'file=sys.stderr' for messages about errors.
- Use 'flush=True' to forcibly flush the stream.

## Pretty Print

```
| from pprint import pprint
| pprint(<collection>, width=80, depth=None, compact=False, sort_dicts=True)
```

- Levels deeper than 'depth' get replaced by '...'.

## # Input

Reads a line from user input or pipe if present.

```
| <str> = input(prompt=None)
```

- Trailing newline gets stripped.
- Prompt string is printed to the standard output before reading input.
- Raises EOFError when user hits EOF (ctrl-d/z) or input stream gets exhausted.

## # Command Line Arguments

```
| import sys
| script_name = sys.argv[0]
| arguments   = sys.argv[1:]
```

### Argument Parser

```
| from argparse import ArgumentParser, FileType
| p = ArgumentParser(description=<str>)
| p.add_argument('--<short_name>', '--<name>', action='store_true') # Flag
| p.add_argument('--<short_name>', '--<name>', type=<type>) # Option
| p.add_argument('<name>', type=<type>, nargs=1) # First argument
| p.add_argument('<name>', type=<type>, nargs='+') # Remaining arguments
| p.add_argument('<name>', type=<type>, nargs='*') # Optional arguments
| args = p.parse_args() # Exits on error.
| value = args.<name>
```

- Use 'help=<str>' to set argument description.
- Use 'default=<el>' to set the default value.
- Use 'type=FileType(<mode>)' for files.

## # Open

Opens the file and returns a corresponding file object.

```
| <file> = open('<path>', mode='r', encoding=None, newline=None)
```

- 'encoding=None' means that the default encoding is used, which is platform dependent. Best practice is to use 'encoding="utf-8"' whenever possible.
- 'newline=None' means all different end of line combinations are converted to '\n' on read, while on write all '\n' characters are converted to system's default line separator.

- `'newline=''` means no conversions take place, but input is still broken into chunks by `readline()` and `readlines()` on either `\n`, `\r` or `\r\n`.

## Modes

- `'r'` - Read (default).
- `'w'` - Write (truncate).
- `'x'` - Write or fail if the file already exists.
- `'a'` - Append.
- `'w+'` - Read and write (truncate).
- `'r+'` - Read and write from the start.
- `'a+'` - Read and write from the end.
- `'t'` - Text mode (default).
- `'b'` - Binary mode.

## Exceptions

- `'FileNotFoundException'` can be raised when reading with `'r'` or `'r+'`.
- `'FileExistsError'` can be raised when writing with `'x'`.
- `'IsADirectoryError'` and `'PermissionError'` can be raised by any.
- `'OSError'` is the parent class of all listed exceptions.

## File Object

```

<file>.seek(0)                      # Moves to the start of the file.
<file>.seek(offset)                 # Moves 'offset' chars/bytes from the start.
<file>.seek(0, 2)                   # Moves to the end of the file.
<bin_file>.seek(±offset, <anchor>) # Anchor: 0 start, 1 current position, 2 end.

<str/bytes> = <file>.read(size=-1)   # Reads 'size' chars/bytes or until EOF.
<str/bytes> = <file>.readline()       # Returns a line or empty string/byes on EOF.
<list>      = <file>.readlines()      # Returns a list of remaining lines.
<str/bytes> = next(<file>)          # Returns a line using buffer. Do not mix.

<file>.write(<str/bytes>)           # Writes a string or bytes object.
<file>.writelines(<collection>)    # Writes a coll. of strings or bytes objects.
<file>.flush()                     # Flushes write buffer.

```

- Methods do not add or strip trailing newlines, even `writelines()`.

## Read Text from File

```

def read_file(filename):
    with open(filename, encoding='utf-8') as file:
        return file.readlines()

```

## Write Text to File

```

def write_to_file(filename, text):
    with open(filename, 'w', encoding='utf-8') as file:
        file.write(text)

```

## # Path

```

from os import.getcwd, path, listdir
from glob import glob

<str>  = getcwd()                  # Returns the current working directory.
<str>  = path.join(<path>, ...)    # Joins two or more pathname components.
<str>  = path.abspath(<path>)     # Returns absolute path.

```

```

<str> = path.basename(<path>)
<str> = path.dirname(<path>)
<tup.> = path.splitext(<path>)

<list> = listdir(path='.')
<list> = glob('<pattern>')

<bool> = path.exists(<path>)
<bool> = path.isfile(<path>)
<bool> = path.isdir(<path>)

```

# Returns final component of the path.  
# Returns path without the final component.  
# Splits on last period of the final component.

# Returns filenames located at path.  
# Returns paths matching the wildcard pattern.

# Or: <Path>.exists()  
# Or: <DirEntry/Path>.is\_file()  
# Or: <DirEntry/Path>.is\_dir()

## DirEntry

Using scandir() instead of listdir() can significantly increase the performance of code that also needs file type information.

```

from os import scandir

<iter> = scandir(path='.')
<str> = <DirEntry>.path
<str> = <DirEntry>.name
<file> = open(<DirEntry>)

```

# Returns DirEntry objects located at path.  
# Returns path as a string.  
# Returns final component as a string.  
# Opens the file and returns file object.

## Path Object

```

from pathlib import Path

<Path> = Path(<path> [, ...])
<Path> = <path> / <path> [/ ...]

<Path> = Path()
<Path> = Path.cwd()
<Path> = <Path>.resolve()

<Path> = <Path>.parent
<str> = <Path>.name
<str> = <Path>.stem
<str> = <Path>.suffix
<tup.> = <Path>.parts

<iter> = <Path>.iterdir()
<iter> = <Path>.glob('<pattern>')

<str> = str(<Path>)
<file> = open(<Path>)

```

# Accepts strings, Paths and DirEntry objects.  
# One of the paths must be a Path object.

# Returns relative cwd. Also Path('.').  
# Returns absolute cwd. Also Path().resolve().  
# Returns absolute Path without symlinks.

# Returns Path without final component.  
# Returns final component as a string.  
# Returns final component without extension.  
# Returns final component's extension.  
# Returns all components as strings.

# Returns dir contents as Path objects.  
# Returns Paths matching the wildcard pattern.

# Returns path as a string.  
# Opens the file and returns file object.

## # OS Commands

### Files and Directories

- Paths can be either strings, Paths or DirEntry objects.
- Functions report OS related errors by raising either OSError or one of its subclasses.

```

import os, shutil

os.chdir(<path>)                      # Changes the current working directory.
os.mkdir(<path>, mode=0o777)            # Creates a directory. Mode is in octal.

shutil.copy(from, to)                   # Copies the file. 'to' can exist or be a dir.
shutil.copytree(from, to)               # Copies the directory. 'to' must not exist.

```

```

| os.rename(from, to)           # Renames/moves the file or directory.
| os.replace(from, to)          # Same, but overwrites 'to' if it exists.

| os.remove(<path>)           # Deletes the file.
| os.rmdir(<path>)            # Deletes the empty directory.
| shutil.rmtree(<path>)        # Deletes the directory.

```

## Shell Commands

```

import os
<str> = os.popen('<shell_command>').read()

```

Sends '1 + 1' to the basic calculator and captures its output:

```

>>> from subprocess import run
>>> run('bc', input='1 + 1\n', capture_output=True, encoding='utf-8')
CompletedProcess(args='bc', returncode=0, stdout='2\n', stderr='')

```

Sends test.in to the basic calculator running in standard mode and saves its output to test.out:

```

>>> from shlex import split
>>> os.popen('echo 1 + 1 > test.in')
>>> run(split('bc -s'), stdin=open('test.in'), stdout=open('test.out', 'w'))
CompletedProcess(args=['bc', '-s'], returncode=0)
>>> open('test.out').read()
'2\n'

```

## # JSON

Text file format for storing collections of strings and numbers.

```

import json
<str> = json.dumps(<object>, ensure_ascii=True, indent=None)
<object> = json.loads(<str>)

```

### Read Object from JSON File

```

def read_json_file(filename):
    with open(filename, encoding='utf-8') as file:
        return json.load(file)

```

### Write Object to JSON File

```

def write_to_json_file(filename, an_object):
    with open(filename, 'w', encoding='utf-8') as file:
        json.dump(an_object, file, ensure_ascii=False, indent=2)

```

## # Pickle

Binary file format for storing objects.

```

import pickle
<bytes> = pickle.dumps(<object>)
<object> = pickle.loads(<bytes>)

```

## Read Object from File

```
def read_pickle_file(filename):
    with open(filename, 'rb') as file:
        return pickle.load(file)
```

## Write Object to File

```
def write_to_pickle_file(filename, an_object):
    with open(filename, 'wb') as file:
        pickle.dump(an_object, file)
```

## # CSV

Text file format for storing spreadsheets.

```
import csv
```

### Read

```
<reader> = csv.reader(<file>)      # Also: `dialect='excel', delimiter='`'.
<list>  = next(<reader>)        # Returns next row as a list of strings.
<list>  = list(<reader>)        # Returns list of remaining rows.
```

- File must be opened with '`newline=""`' argument, or newlines embedded inside quoted fields will not be interpreted correctly!

### Write

```
<writer> = csv.writer(<file>)      # Also: `dialect='excel', delimiter='`'.
<writer>.writerow(<collection>)    # Encodes objects using `str(<el>)`.
<writer>.writerows(<coll_of_coll>)  # Appends multiple rows.
```

- File must be opened with '`newline=""`' argument, or '\r' will be added in front of every '\n' on platforms that use '\r\n' line endings!

### Parameters

- `'dialect'` - Master parameter that sets the default values.
- `'delimiter'` - A one-character string used to separate fields.
- `'quotechar'` - Character for quoting fields that contain special characters.
- `'doublequote'` - Whether quotechars inside fields get doubled or escaped.
- `'skipinitialspace'` - Whether whitespace after delimiter gets stripped.
- `'lineterminator'` - Specifies how writer terminates rows.
- `'quoting'` - Controls the amount of quoting: 0 - as necessary, 1 - all.
- `'escapechar'` - Character for escaping 'quotechar' if 'doublequote' is False.

### Dialects

	excel	excel-tab	unix
delimiter	,	\t	,
quotechar	"	"	"
doublequote	True	True	True
skipinitialspace	False	False	False
lineterminator	\r\n	\r\n	\n
quoting	0	0	1
escapechar	None	None	None

## Read Rows from CSV File

```
def read_csv_file(filename):
    with open(filename, encoding='utf-8', newline='') as file:
        return list(csv.reader(file))
```

## Write Rows to CSV File

```
def write_to_csv_file(filename, rows):
    with open(filename, 'w', encoding='utf-8', newline='') as file:
        writer = csv.writer(file)
        writer.writerows(rows)
```

## # SQLite

Server-less database engine that stores each database into a separate file.

### Connect

Opens a connection to the database file. Creates a new file if path doesn't exist.

```
import sqlite3
<con> = sqlite3.connect('<path>')           # Also ':memory:'.
<con>.close()
```

### Read

Returned values can be of type str, int, float, bytes or None.

```
<cursor> = <con>.execute('<query>')
<tuple>  = <cursor>.fetchone()             # Can raise a subclass of sqlite3.Error.
<list>   = <cursor>.fetchall()            # Returns next row. Also next(<cursor>).
                                            # Returns remaining rows. Also list(<cursor>).
```

### Write

```
<con>.execute('<query>')
<con>.commit()
```

Or:

```
with <con>:
    <con>.execute('<query>')
```

### Placeholders

- Passed values can be of type str, int, float, bytes, None, bool, datetime.date or datetime.datetime.
- Bools will be stored and returned as ints and dates as ISO formatted strings.

```
<con>.execute('<query>', <list/tuple>)      # Replaces '?'s in query with values.
<con>.execute('<query>', <dict/namedtuple>)  # Replaces ':<key>'s with values.
<con>.executemany('<query>', <coll_of_above>) # Runs execute() many times.
```

## Example

In this example values are not actually saved because '`con.commit()`' is omitted!

```
>>> con = sqlite3.connect('test.db')
>>> con.execute('create table person (person_id integer primary key, name, height)')
>>> con.execute('insert into person values (null, ?, ?)', ('Jean-Luc', 187)).lastrowid
1
>>> con.execute('select * from person').fetchall()
[(1, 'Jean-Luc', 187)]
```

## MySQL

Has a very similar interface, with differences listed below.

```
# $ pip3 install mysql-connector
from mysql import connector
<con> = connector.connect(host=<str>, ...)           # `user=<str>, password=<str>, database=<str>`.
<cursor> = <con>.cursor()                            # Only cursor has execute method.
<cursor>.execute('<query>')                         # Can raise a subclass of connector.Error.
<cursor>.execute('<query>', <list/tuple>)          # Replaces '%s's in query with values.
<cursor>.execute('<query>', <dict/namedtuple>)       # Replaces '%(<key>)s's with values.
```

## # Bytes

Bytes object is an immutable sequence of single bytes. Mutable version is called bytearray.

```
<bytes> = b'<str>'                                # Only accepts ASCII characters and \x00 – \xff.
<int> = <bytes>[<index>]                          # Returns int in range from 0 to 255.
<bytes> = <bytes>[<slice>]                         # Returns bytes even if it has only one element.
<bytes> = <bytes>.join(<coll_of_bytes>)           # Joins elements using bytes object as separator.
```

## Encode

```
<bytes> = bytes(<coll_of_ints>)                  # Ints must be in range from 0 to 255.
<bytes> = bytes(<str>, 'utf-8')                   # Or: <str>.encode('utf-8')
<bytes> = <int>.to_bytes(n_bytes, ...)            # `byteorder='big/little', signed=False` .
<bytes> = bytes.fromhex('<hex>')                  # Hex numbers can be separated by spaces.
```

## Decode

```
<list> = list(<bytes>)                           # Returns ints in range from 0 to 255.
<str> = str(<bytes>, 'utf-8')                     # Or: <bytes>.decode('utf-8')
<int> = int.from_bytes(<bytes>, ...)              # `byteorder='big/little', signed=False` .
'<hex>' = <bytes>.hex()                           # Returns a string of hexadecimal numbers.
```

## Read Bytes from File

```
def read_bytes(filename):
    with open(filename, 'rb') as file:
        return file.read()
```

## Write Bytes to File

```
def write_bytes(filename, bytes_obj):
    with open(filename, 'wb') as file:
        file.write(bytes_obj)
```

## # Struct

- Module that performs conversions between a sequence of numbers and a bytes object.
- Machine's native type sizes and byte order are used by default.

```
from struct import pack, unpack, iter_unpack
<bytes> = pack('<format>', <num_1>, <num_2>, ...)
<tuple> = unpack('<format>', <bytes>
<tuples> = iter_unpack('<format>', <bytes>)
```

### Example

```
>>> pack('>hhl', 1, 2, 3)
b'\x00\x01\x00\x02\x00\x00\x03'
>>> unpack('>hhl', b'\x00\x01\x00\x02\x00\x00\x03')
(1, 2, 3)
```

### Format

For standard type sizes start format string with:

- '=' - native byte order
- '<' - little-endian
- '>' - big-endian (also '!')

Integer types. Use a capital letter for unsigned type. Standard sizes are in brackets:

- 'x' - pad byte
- 'b' - char (1)
- 'h' - short (2)
- 'i' - int (4)
- 'l' - long (4)
- 'q' - long long (8)

Floating point types:

- 'f' - float (4)
- 'd' - double (8)

## # Array

List that can only hold numbers of a predefined type. Available types and their sizes in bytes are listed above.

```
from array import array
<array> = array('<typecode>', <collection>)      # Array from collection of numbers.
<array> = array('<typecode>', <bytes>)            # Array from bytes object.
<array> = array('<typecode>', <array>)           # Treats array as a sequence of numbers.
<bytes> = bytes(<array>)                          # Or: <array>.tobytes()
```

## # Memory View

- A sequence object that points to the memory of another object.
- Each element can reference a single or multiple consecutive bytes, depending on format.
- Order and number of elements can be changed with slicing.

```
<mvview> = memoryview(<bytes/bytarray/array>)    # Immutable if bytes, else mutable.
<real> = <mvview>[<index>]                      # Returns an int or a float.
<mvview> = <mvview>[<slice>]                     # Mview with rearranged elements.
<mvview> = <mvview>.cast('<typecode>')          # Casts memoryview to the new format.
<mvview>.release()                                # Releases the object's memory buffer.
```

## Decode

```

<bin_file>.write(<mview>)           # Writes mview to the binary file.
<bytes> = bytes(<mview>)          # Creates a new bytes object.
<bytes> = <bytes>.join(<coll_of_mviews>) # Joins mviews using bytes object as sep.
<array> = array('<typecode>', <mview>) # Treats mview as a sequence of numbers.

<list> = list(<mview>)             # Returns list of ints or floats.
<str> = str(<mview>, 'utf-8')       # Treats mview as a bytes object.
<int> = int.from_bytes(<mview>, ...) # `byteorder='big/little', signed=False` .
'<hex>' = <mview>.hex()            # Treats mview as a bytes object.

```

## # Deque

A thread-safe list with efficient appends and pops from either side. Pronounced "deck".

```

from collections import deque
<deque> = deque(<collection>, maxlen=None)

<deque>.appendleft(<el>)           # Opposite element is dropped if full.
<deque>.extendleft(<collection>)    # Collection gets reversed.
<el> = <deque>.popleft()           # Raises IndexError if empty.
<deque>.rotate(n=1)                 # Rotates elements to the right.

```

## # Threading

- CPython interpreter can only run a single thread at a time.
- That is why using multiple threads won't result in a faster execution, unless at least one of the threads contains an I/O operation.

```
from threading import Thread, RLock, Semaphore, Event, Barrier
```

### Thread

```

<Thread> = Thread(target=<function>) # Use `args=<collection>` to set arguments.
<Thread>.start()                   # Starts the thread.
<bool> = <Thread>.is_alive()       # Checks if thread has finished executing.
<Thread>.join()                   # Waits for thread to finish.

```

- Use '**kwargs=<dict>**' to pass keyword arguments to the function.
- Use '**daemon=True**', or the program will not be able to exit while the thread is alive.

### Lock

```

<lock> = RLock()
<lock>.acquire()                  # Waits for lock to be available.
<lock>.release()                 # Makes the lock available again.

```

Or:

```

lock = RLock()
with lock:
    ...

```

### Semaphore, Event, Barrier

```

<Semaphore> = Semaphore(value=1)      # Lock that can be acquired 'value' times.
<Event>     = Event()                # Method wait() blocks until set() is called.
<Barrier>   = Barrier(n_times)      # Method wait() blocks until it's called 'n_times'.

```

## Thread Pool Executor

```
from concurrent.futures import ThreadPoolExecutor
with ThreadPoolExecutor(max_workers=None) as executor:           # Does not exit until done.
    <iter> = executor.map(lambda x: x + 1, range(3))           # (1, 2, 3)
    <iter> = executor.map(lambda x, y: x + y, 'abc', '123')   # ('a1', 'b2', 'c3')
    <Future> = executor.submit(<function>, [, <arg_1>, ...]) # Also visible outside block.
```

### Future:

```
<bool> = <Future>.done()          # Checks if thread has finished executing.
<obj>  = <Future>.result()       # Waits for thread to finish and returns result.
```

## Queue

A thread-safe FIFO queue. For LIFO queue use LifoQueue.

```
from queue import Queue
<Queue> = Queue(maxsize=0)

<Queue>.put(<el>)           # Blocks until queue stops being full.
<Queue>.put_nowait(<el>)    # Raises queue.Full exception if full.
<el> = <Queue>.get()         # Blocks until queue stops being empty.
<el> = <Queue>.get_nowait()  # Raises queue.Empty exception if empty.
```

## # Operator

Module of functions that provide the functionality of operators.

```
from operator import add, sub, mul, truediv, floordiv, mod, pow, neg, abs
from operator import eq, ne, lt, le, gt, ge
from operator import and_, or_, not_
from operator import itemgetter, attrgetter, methodcaller

import operator as op
elementwise_sum = map(op.add, list_a, list_b)
sorted_by_second = sorted(<collection>, key=op.itemgetter(1))
sorted_by_both = sorted(<collection>, key=op.itemgetter(1, 0))
product_of_elems = functools.reduce(op.mul, <collection>)
LogicOp         = enum.Enum('LogicOp', {'AND': op.and_, 'OR' : op.or_})
last_el         = op.methodcaller('pop')(<list>)
```

## # Introspection

Inspecting code at runtime.

### Variables

```
<list> = dir()           # Names of local variables (incl. functions).
<dict> = vars()          # Dict of local variables. Also locals().
<dict> = globals()        # Dict of global variables.
```

### Attributes

```
<list> = dir(<object>)      # Names of object's attributes (incl. methods).
<dict> = vars(<object>)     # Dict of object's fields. Also <obj>.__dict__.
<bool> = hasattr(<object>, '<attr_name>') # Checks if getattr() raises an error.
value = getattr(<object>, '<attr_name>') # Raises AttributeError if attribute is missing.
setattr(<object>, '<attr_name>', value) # Only works on objects with __dict__ attribute.
delattr(<object>, '<attr_name>') # Equivalent to `del <object>.<attr_name>`.
```

## Parameters

```
from inspect import signature
<sig>      = signature(<function>)
no_of_params = len(<sig>.parameters)
param_names = list(<sig>.parameters.keys())
param_kinds = [a.kind for a in <sig>.parameters.values()]
```

## # Metaprogramming

Code that generates code.

### Type

Type is the root class. If only passed an object it returns its type (class). Otherwise it creates a new class.

```
<class> = type('<class_name>', <parents_tuple>, <attributes_dict>)

>>> Z = type('Z', (), {'a': 'abcde', 'b': 12345})
>>> z = Z()
```

### Meta Class

A class that creates classes.

```
def my_meta_class(name, parents, attrs):
    attrs['a'] = 'abcde'
    return type(name, parents, attrs)
```

Or:

```
class MyMetaClass(type):
    def __new__(cls, name, parents, attrs):
        attrs['a'] = 'abcde'
        return type.__new__(cls, name, parents, attrs)
```

- New() is a class method that gets called before init(). If it returns an instance of its class, then that instance gets passed to init() as a 'self' argument.
- It receives the same arguments as init(), except for the first one that specifies the desired type of the returned instance (MyMetaClass in our case).
- Like in our case, new() can also be called directly, usually from a new() method of a child class (def \_\_new\_\_(cls): return super().\_\_new\_\_(cls)).
- The only difference between the examples above is that my\_meta\_class() returns a class of type type, while MyMetaClass() returns a class of type MyMetaClass.

### Metaclass Attribute

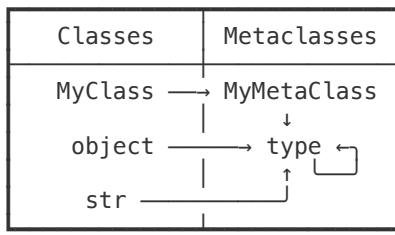
Right before a class is created it checks if it has the 'metaclass' attribute defined. If not, it recursively checks if any of his parents has it defined and eventually comes to type().

```
class MyClass(metaclass=MyMetaClass):
    b = 12345

>>> MyClass.a, MyClass.b
('abcde', 12345)
```

### Type Diagram

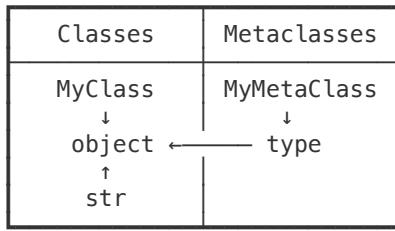
```
type(MyClass) == MyMetaClass      # MyClass is an instance of MyMetaClass.
type(MyMetaClass) == type         # MyMetaClass is an instance of type.
```



## Inheritance Diagram

```
MyClass.__base__ == object
MyMetaClass.__base__ == type
```

# MyClass is a subclass of object.  
# MyMetaClass is a subclass of type.



## # Eval

```
>>> from ast import literal_eval
>>> literal_eval('1 + 2')
3
>>> literal_eval('[1, 2, 3]')
[1, 2, 3]
>>> literal_eval('abs(1)')
ValueError: malformed node or string
```

## # Coroutines

- Coroutines have a lot in common with threads, but unlike threads, they only give up control when they call another coroutine and they don't use as much memory.
- Coroutine definition starts with '`async`' and its call with '`await`'.
- '`asyncio.run(<coroutine>)`' is the main entry point for asynchronous programs.
- Functions `wait()`, `gather()` and `as_completed()` can be used when multiple coroutines need to be started at the same time.
- `asyncio` module also provides its own `Queue`, `Event`, `Lock` and `Semaphore` classes.

Runs a terminal game where you control an asterisk that must avoid numbers:

```
import asyncio, collections, curses, enum, random

P = collections.namedtuple('P', 'x y')                      # Position
D = enum.Enum('D', 'n e s w')                                # Direction

def main(screen):
    curses.curs_set(0)                                         # Makes cursor invisible.
    screen.nodelay(True)                                       # Makes getch() non-blocking.
    asyncio.run(main_coroutine(screen))                         # Starts running asyncio code.

async def main_coroutine(screen):
    state = {'*': P(0, 0), **{id_: P(30, 10) for id_ in range(10)}}
    moves = asyncio.Queue()
    coros = (*random_controller(id_, moves) for id_ in range(10)),
            human_controller(screen, moves),
            model(moves, state, *screen.getmaxyx()),
            view(state, screen))
    await asyncio.wait(coros, return_when=asyncio.FIRST_COMPLETED)

async def random_controller(id_, moves):
    while True:
        moves.put_nowait((id_, random.choice(list(D))))
        await asyncio.sleep(random.random() / 2)

async def human_controller(screen, moves):
    while True:
        ch = screen.getch()
        key_mappings = {259: D.n, 261: D.e, 258: D.s, 260: D.w}
        if ch in key_mappings:
            moves.put_nowait(( '*', key_mappings[ch] ))
        await asyncio.sleep(0.01)

async def model(moves, state, height, width):
    while state['*'] not in {p for id_, p in state.items() if id_ != '*'}:
        id_, d = await moves.get()
        p      = state[id_]
        deltas = {D.n: P(0, -1), D.e: P(1, 0), D.s: P(0, 1), D.w: P(-1, 0)}
        new_p = P(*[sum(a) for a in zip(p, deltas[d])])
        if 0 <= new_p.x < width-1 and 0 <= new_p.y < height:
            state[id_] = new_p

async def view(state, screen):
    while True:
        screen.clear()
        for id_, p in state.items():
            screen.addstr(p.y, p.x, str(id_))
        await asyncio.sleep(0.01)

curses.wrapper(main)
```

# Libraries

## # Progress Bar

```
# $ pip3 install tqdm
from tqdm import tqdm
from time import sleep
for el in tqdm([1, 2, 3]):
    sleep(0.2)
```

## # Plot

```
# $ pip3 install matplotlib
from matplotlib import pyplot
pyplot.plot(<y_data>, label=<str>)
pyplot.plot(<x_data>, <y_data>
pyplot.legend()                                # Adds a legend.
pyplot.savefig('<path>')                      # Saves the figure.
pyplot.show()                                    # Displays the figure.
pyplot.clf()                                     # Clears the figure.
```

## # Table

Prints a CSV file as an ASCII table:

```
# $ pip3 install tabulate
import csv, tabulate
with open('test.csv', encoding='utf-8', newline='') as file:
    rows = csv.reader(file)
    header = [a.title() for a in next(rows)]
    table = tabulate.tabulate(rows, header)
    print(table)
```

## # Curses

Clears the terminal, prints a message and waits for the ESC key press:

```
from curses import wrapper, curs_set, ascii
from curses import KEY_UP, KEY_RIGHT, KEY_DOWN, KEY_LEFT

def main():
    wrapper(draw)

def draw(screen):
    curs_set(0)                                # Makes cursor invisible.
    screen.nodelay(True)                        # Makes getch() non-blocking.
    screen.clear()
    screen.addstr(0, 0, 'Press ESC to quit.')   # Coordinates are y, x.
    while screen.getch() != ascii.ESC:
        pass

def get_border(screen):
    from collections import namedtuple
    P = namedtuple('P', 'x y')
    height, width = screen.getmaxyx()
    return P(width-1, height-1)

if __name__ == '__main__':
    main()
```

## # Logging

```
# $ pip3 install loguru
from loguru import logger

logger.add('debug_{time}.log', colorize=True) # Connects a log file.
logger.add('error_{time}.log', level='ERROR') # Another file for errors or higher.
logger.<level>('A logging message.')
```

- Levels: 'debug', 'info', 'success', 'warning', 'error', 'critical'.

### Exceptions

Exception description, stack trace and values of variables are appended automatically.

```
try:
    ...
except <exception>:
    logger.exception('An error happened.')
```

### Rotation

Argument that sets a condition when a new log file is created.

```
rotation=<int>|<datetime.timedelta>|<datetime.time>|<str>
```

- '<int>' - Max file size in bytes.
- '<timedelta>' - Max age of a file.
- '<time>' - Time of day.
- '<str>' - Any of above as a string: '100 MB', '1 month', 'monday at 12:00', ...

### Retention

Sets a condition which old log files get deleted.

```
retention=<int>|<datetime.timedelta>|<str>
```

- '<int>' - Max number of files.
- '<timedelta>' - Max age of a file.
- '<str>' - Max age as a string: '1 week, 3 days', '2 months', ...

## # Scraping

Scrapes Python's URL, version number and logo from Wikipedia page:

```
# $ pip3 install requests beautifulsoup4
import requests, sys
from bs4 import BeautifulSoup
URL = 'https://en.wikipedia.org/wiki/Python_(programming_language)'
try:
    html = requests.get(URL).text
    doc = BeautifulSoup(html, 'html.parser')
    table = doc.find('table', class_='infobox veevent')
    rows = table.find_all('tr')
    link = rows[11].find('a')['href']
    ver = rows[6].find('div').text.split()[0]
    url_i = rows[0].find('img')['src']
    image = requests.get(f'https:{url_i}').content
    with open('test.png', 'wb') as file:
        file.write(image)
    print(link, ver)
except requests.exceptions.ConnectionError:
    print("You've got problems with connection.", file=sys.stderr)
```

## # Web

```
# $ pip3 install bottle
from bottle import run, route, static_file, template, post, request, response
import json
```

### Run

```
run(host='localhost', port=8080)           # Runs locally.
run(host='0.0.0.0', port=80)                # Runs globally.
```

### Static Request

```
@route('/img/<image>')
def send_image(image):
    return static_file(image, 'img_dir/', mimetype='image/png')
```

### Dynamic Request

```
@route('/<sport>')
def send_page(sport):
    return template('<h1>{{title}}</h1>', title=sport)
```

### REST Request

```
@post('/odds/<sport>')
def odds_handler(sport):
    team = request.forms.get('team')
    home_odds, away_odds = 2.44, 3.29
    response.headers['Content-Type'] = 'application/json'
    response.headers['Cache-Control'] = 'no-cache'
    return json.dumps([team, home_odds, away_odds])
```

#### Test:

```
# $ pip3 install requests
>>> import requests
>>> url = 'http://localhost:8080/odds/football'
>>> data = {'team': 'arsenal f.c.'}
>>> response = requests.post(url, data=data)
>>> response.json()
['arsenal f.c.', 2.44, 3.29]
```

## # Profiling

### Stopwatch

```
from time import time
start_time = time()                      # Seconds since the Epoch.
...
duration = time() - start_time
```

### High performance:

```
from time import perf_counter
start_time = perf_counter()                # Seconds since restart.
...
duration = perf_counter() - start_time
```

## Timing a Snippet

```
>>> from timeit import timeit
>>> timeit('"-'.join(str(a) for a in range(100))',
...           number=10000, globals=globals(), setup='pass')
0.34986
```

## Profiling by Line

```
# $ pip3 install line_profiler memory_profiler
@profile
def main():
    a = [*range(10000)]
    b = {*range(10000)}
main()

$ kernprof -lv test.py
Line #    Hits      Time  Per Hit   % Time  Line Contents
=====
1                      @profile
2                      def main():
3      1    1128.0    1128.0     27.4      27.4      a = [*range(10000)]
4      1    2994.0    2994.0     72.6      72.6      b = {*range(10000)}

$ python3 -m memory_profiler test.py
Line #      Mem usage      Increment  Line Contents
=====
1      35.387 MiB      35.387 MiB  @profile
2
3      35.734 MiB      0.348 MiB  def main():
4      36.160 MiB      0.426 MiB  a = [*range(10000)]
                                b = {*range(10000)}
```

## Call Graph

Generates a PNG image of a call graph with highlighted bottlenecks:

```
# $ pip3 install pycallgraph
from pycallgraph import output, PyCallGraph
from datetime import datetime
time_str = datetime.now().strftime('%Y%m%d%H%M%S')
filename = f'profile-{time_str}.png'
drawer = output.GraphvizOutput(output_file=filename)
with PyCallGraph(drawer):
    <code_to_be_profiled>
```

## # NumPy

Array manipulation mini-language. It can run up to one hundred times faster than the equivalent Python code.

```
# $ pip3 install numpy
import numpy as np

<array> = np.array(<list>
<array> = np.arange(from_inclusive, to_exclusive, ±step_size)
<array> = np.ones(<shape>)
<array> = np.random.randint(from_inclusive, to_exclusive, <shape>)

<array>.shape = <shape>
<view>  = <array>.reshape(<shape>)
<view>  = np.broadcast_to(<array>, <shape>)

<array> = <array>.sum(axis)
indexes = <array>.argmin(axis)
```

- Shape is a tuple of dimension sizes.
- Axis is the index of a dimension that gets collapsed. The leftmost dimension has index 0.

## Indexing

```

<el>      = <2d_array>[0, 0]          # First element.
<1d_view> = <2d_array>[0]           # First row.
<1d_view> = <2d_array>[:, 0]         # First column. Also [..., 0].
<3d_view> = <2d_array>[None, :, :]   # Expanded by dimension of size 1.

<1d_array> = <2d_array>[<1d_row_indexes>, <1d_column_indexes>]
<2d_array> = <2d_array>[<2d_row_indexes>, <2d_column_indexes>]

<2d_bools> = <2d_array> > 0
<1d_array> = <2d_array>[<2d_bools>]

```

- If row and column indexes differ in shape, they are combined with broadcasting.

## Broadcasting

Broadcasting is a set of rules by which NumPy functions operate on arrays of different sizes and/or dimensions.

```

left  = [[0.1], [0.6], [0.8]]          # Shape: (3, 1)
right = [ 0.1 , 0.6 , 0.8 ]           # Shape: (3)

```

1. If array shapes differ in length, left-pad the shorter shape with ones:

```

left  = [[0.1], [0.6], [0.8]]          # Shape: (3, 1)
right = [[0.1 , 0.6 , 0.8]]           # Shape: (1, 3) <- !

```

2. If any dimensions differ in size, expand the ones that have size 1 by duplicating their elements:

```

left  = [[0.1, 0.1, 0.1], [0.6, 0.6, 0.6], [0.8, 0.8, 0.8]] # Shape: (3, 3) <- !
right = [[0.1, 0.6, 0.8], [0.1, 0.6, 0.8], [0.1, 0.6, 0.8]] # Shape: (3, 3) <- !

```

3. If neither non-matching dimension has size 1, raise an error.

## Example

For each point returns index of its nearest point ([0.1, 0.6, 0.8] => [1, 2, 1]):

```

>>> points = np.array([0.1, 0.6, 0.8])
[ 0.1, 0.6, 0.8]
>>> wrapped_points = points.reshape(3, 1)
[[ 0.1],
 [ 0.6],
 [ 0.8]]
>>> distances = wrapped_points - points
[[ 0. , -0.5, -0.7],
 [ 0.5,  0. , -0.2],
 [ 0.7,  0.2,  0. ]]
>>> distances = np.abs(distances)
[[ 0. ,  0.5,  0.7],
 [ 0.5,  0. ,  0.2],
 [ 0.7,  0.2,  0. ]]
>>> i = np.arange(3)
[0, 1, 2]
>>> distances[i, i] = np.inf
[[ inf,  0.5,  0.7],
 [ 0.5,  inf,  0.2],
 [ 0.7,  0.2,  inf]]
>>> distances.argmin(1)
[1, 2, 1]

```

## # Image

```
# $ pip3 install pillow
from PIL import Image

<Image> = Image.new('<mode>', (width, height))
<Image> = Image.open('<path>')
<Image> = <Image>.convert('<mode>')
<Image>.save('<path>')
<Image>.show()

<tuple/int> = <Image>.getpixel((x, y)) # Returns a pixel.
<Image>.putpixel((x, y), <tuple/int>) # Writes a pixel to the image.
<ImagingCore> = <Image>.getdata() # Returns a sequence of pixels.
<Image>.putdata(<list/ImagingCore>) # Writes a sequence of pixels.
<Image>.paste(<Image>, (x, y)) # Writes an image to the image.

<2d_array> = np.array(<Image>) # Creates NumPy array from greyscale image.
<3d_array> = np.array(<Image>) # Creates NumPy array from color image.
<Image> = Image.fromarray(<array>) # Creates image from NumPy array of floats.
```

### Modes

- '**1**' - 1-bit pixels, black and white, stored with one pixel per byte.
- '**L**' - 8-bit pixels, greyscale.
- '**RGB**' - 3x8-bit pixels, true color.
- '**RGBA**' - 4x8-bit pixels, true color with transparency mask.
- '**HSV**' - 3x8-bit pixels, Hue, Saturation, Value color space.

### Examples

Creates a PNG image of a rainbow gradient:

```
WIDTH, HEIGHT = 100, 100
size = WIDTH * HEIGHT
hues = [255 * i/size for i in range(size)]
img = Image.new('HSV', (WIDTH, HEIGHT))
img.putdata([(int(h), 255, 255) for h in hues])
img.convert('RGB').save('test.png')
```

Adds noise to a PNG image:

```
from random import randint
add_noise = lambda value: max(0, min(255, value + randint(-20, 20)))
img = Image.open('test.png').convert('HSV')
img.putdata([(add_noise(h), s, v) for h, s, v in img.getdata()])
img.convert('RGB').save('test.png')
```

### Drawing

```
from PIL import ImageDraw

<ImageDraw> = ImageDraw.Draw(<Image>)
<ImageDraw>.point((x, y), fill=None)
<ImageDraw>.line((x1, y1, x2, y2 [, ...]), fill=None, width=0, joint=None)
<ImageDraw>.arc((x1, y1, x2, y2), from_deg, to_deg, fill=None, width=0)
<ImageDraw>.rectangle((x1, y1, x2, y2), fill=None, outline=None, width=0)
<ImageDraw>.polygon((x1, y1, x2, y2 [, ...]), fill=None, outline=None)
<ImageDraw>.ellipse((x1, y1, x2, y2), fill=None, outline=None, width=0)
```

- Use '**fill=<color>**' to set the primary color.
- Use '**outline=<color>**' to set the secondary color.
- Color can be specified as a tuple, int, '#rrggb' string or a color name.

## # Animation

Creates a GIF of a bouncing ball:

```
# $ pip3 install pillow imageio
from PIL import Image, ImageDraw
import imageio
WIDTH, R = 126, 10
frames = []
for velocity in range(15):
    y = sum(range(velocity+1))
    frame = Image.new('L', (WIDTH, WIDTH))
    draw = ImageDraw.Draw(frame)
    draw.ellipse((WIDTH/2-R, y, WIDTH/2+R, y+R*2), fill='white')
    frames.append(frame)
frames += reversed(frames[1:-1])
imageio.mimsave('test.gif', frames, duration=0.03)
```

## # Audio

```
import wave
```

<Wave_read> = wave.open('<path>', 'rb')	# Opens the WAV file.
framerate = <Wave_read>.getframerate()	# Number of frames per second.
nchannels = <Wave_read>.getnchannels()	# Number of samples per frame.
sampwidth = <Wave_read>.getsampwidth()	# Sample size in bytes.
nframes = <Wave_read>.getnframes()	# Number of frames.
<params> = <Wave_read>.getparams()	# Immutable collection of above.
<bytes> = <Wave_read>.readframes(nframes)	# Returns next 'nframes' frames.
<Wave_write> = wave.open('<path>', 'wb')	# Truncates existing file.
<Wave_write>.setframerate(<int>)	# 44100 for CD, 48000 for video.
<Wave_write>.setnchannels(<int>)	# 1 for mono, 2 for stereo.
<Wave_write>.setsampwidth(<int>)	# 2 for CD quality sound.
<Wave_write>.setparams(<params>)	# Sets all parameters.
<Wave_write>.writeframes(<bytes>)	# Appends frames to the file.

- Bytes object contains a sequence of frames, each consisting of one or more samples.
- In a stereo signal, the first sample of a frame belongs to the left channel.
- Each sample consists of one or more bytes that, when converted to an integer, indicate the displacement of a speaker membrane at a given moment.
- If sample width is one, then the integer should be encoded unsigned.
- For all other sizes, the integer should be encoded signed with little-endian byte order.

### Sample Values

sampwidth	min	zero	max
1	0	128	255
2	-32768	0	32767
3	-8388608	0	8388607
4	-2147483648	0	2147483647

### Read Float Samples from WAV File

```
def read_wav_file(filename):
    def get_int(a_bytes):
        an_int = int.from_bytes(a_bytes, 'little', signed=width!=1)
        return an_int - 128 * (width == 1)
    with wave.open(filename, 'rb') as file:
        width = file.getsampwidth()
        frames = file.readframes(-1)
        byte_samples = (frames[i:i + width] for i in range(0, len(frames), width))
    return [get_int(b) / pow(2, width * 8 - 1) for b in byte_samples]
```

## Write Float Samples to WAV File

```
def write_to_wav_file(filename, float_samples, nchannels=1, sampwidth=2, framerate=44100):
    def get_bytes(a_float):
        a_float = max(-1, min(1 - 2e-16, a_float))
        a_float += sampwidth == 1
        a_float *= pow(2, sampwidth * 8 - 1)
        return int(a_float).to_bytes(sampwidth, 'little', signed=sampwidth!=1)
    with wave.open(filename, 'wb') as file:
        file.setnchannels(nchannels)
        file.setsampwidth(sampwidth)
        file.setframerate(framerate)
        file.writeframes(b''.join(get_bytes(f) for f in float_samples))
```

## Examples

Saves a sine wave to a mono WAV file:

```
from math import pi, sin
samples_f = (sin(i * 2 * pi * 440 / 44100) for i in range(100000))
write_to_wav_file('test.wav', samples_f)
```

Adds noise to a mono WAV file:

```
from random import random
add_noise = lambda value: value + (random() - 0.5) * 0.03
samples_f = (add_noise(f) for f in read_wav_file('test.wav'))
write_to_wav_file('test.wav', samples_f)
```

Plays a WAV file:

```
# $ pip3 install simpleaudio
from simpleaudio import play_buffer
with wave.open('test.wav', 'rb') as file:
    p = file.getparams()
    frames = file.readframes(-1)
    play_buffer(frames, p.nchannels, p.sampwidth, p.framerate)
```

## Text to Speech

```
# $ pip3 install pyttsx3
import pyttsx3
engine = pyttsx3.init()
engine.say('Sally sells seashells by the seashore.')
engine.runAndWait()
```

## # Synthesizer

Plays Popcorn by Gershon Kingsley:

```
# $ pip3 install simpleaudio
import simpleaudio, math, struct
from itertools import chain, repeat
F = 44100
P1 = '71,69,,71,66,,62,66,,59,,,'
P2 = '71,73,,74,73,,74,,71,,73,69,,71,69,,71,,67,,71,,,'
get_pause = lambda seconds: repeat(0, int(seconds * F))
sin_f = lambda i, hz: math.sin(i * 2 * math.pi * hz / F)
get_wave = lambda hz, seconds: (sin_f(i, hz) for i in range(int(seconds * F)))
get_hz = lambda key: 8.176 * 2 ** (int(key) / 12)
parse_note = lambda note: (get_hz(note[:2]), 0.25 if ']' in note else 0.125)
get_samples = lambda note: get_wave(*parse_note(note)) if note else get_pause(0.125)
samples_f = chain.from_iterable(get_samples(n) for n in f'{P1}{P1}{P2}'.split(','))
samples_b = b''.join(struct.pack('<h', int(f * 30000)) for f in samples_f)
simpleaudio.play_buffer(samples_b, 1, 2, F)
```

## # Pygame

### Basic Example

```
# $ pip3 install pygame
import pygame as pg
pg.init()
screen = pg.display.set_mode((500, 500))
rect = pg.Rect(240, 240, 20, 20)
while all(event.type != pg.QUIT for event in pg.event.get()):
    deltas = {pg.K_UP: (0, -3), pg.K_RIGHT: (3, 0), pg.K_DOWN: (0, 3), pg.K_LEFT: (-3, 0)}
    for delta in (deltas.get(i) for i, on in enumerate(pg.key.get_pressed()) if on):
        rect = rect.move(delta) if delta else rect
    screen.fill((0, 0, 0))
    pg.draw.rect(screen, (255, 255, 255), rect)
    pg.display.flip()
```

### Rectangle

Object for storing rectangular coordinates.

<Rect> = pg.Rect(x, y, width, height) <int> = <Rect>.x/y/centerx/centery/... <tup.> = <Rect>.topleft/center/... <Rect> = <Rect>.move((x, y))	# X and y are coordinates of topleft corner. # Top, right, bottom, left. # Topright, bottomright, bottomleft. # Use move_ip() to move in place.
<bool> = <Rect>.collidepoint((x, y)) <bool> = <Rect>.colliderect(<Rect>) <int> = <Rect>.collidelist(<list_of_Rect>) <list> = <Rect>.collidelistall(<list_of_Rect>)	# Tests if a point is inside a rectangle. # Tests if two rectangles overlap. # Returns index of first colliding Rect or -1. # Returns indexes of all colliding Rects.

### Surface

Object for representing images.

<Surf> = pg.display.set_mode((width, height)) <Surf> = pg.Surface((width, height)) <Surf> = pg.image.load('<path>') <Surf> = <Surf>.subsurface(<Rect>)	# Returns the display surface. # Creates a new surface. # Loads the image. # Returns a subsurface.
<Surf>.fill(color) <Surf>.set_at((x, y), color) <Surf>.blit(<Surface>, (x, y))	# Fills the whole surface. # Updates pixel. # Draws passed surface to the surface.
<Surf> = pg.transform.flip(<Surf>, xbool, ybool) <Surf> = pg.transform.rotate(<Surf>, degrees) <Surf> = pg.transform.scale(<Surf>, (width, height))	
pg.draw.line(<Surf>, color, (x1, y1), (x2, y2), width) pg.draw.arc(<Surf>, color, <Rect>, from_radians, to_radians) pg.draw.rect(<Surf>, color, <Rect>) pg.draw.polygon(<Surf>, color, points) pg.draw.ellipse(<Surf>, color, <Rect>)	

### Font

```
<Font> = pg.font.SysFont('<name>', size, bold=False, italic=False)  

<Font> = pg.font.Font('<path>', size)  

<Surf> = <Font>.render(text, antialias, color [, background])
```

### Sound

```
<Sound> = pg.mixer.Sound('<path>')  

<Sound>.play() # Loads the WAV file.  

# Starts playing the sound.
```

## Basic Mario Brothers Example

```

import collections, dataclasses, enum, io, pygame, urllib.request, itertools as it
from random import randint

P = collections.namedtuple('P', 'x y')                                # Position
D = enum.Enum('D', 'n e s w')                                         # Direction
SIZE, MAX_SPEED = 50, P(5, 10)                                         # Screen size, Speed limit

def main():
    def get_screen():
        pygame.init()
        return pygame.display.set_mode(2 * [SIZE*16])
    def get_images():
        url = 'https://gto76.github.io/python-cheatsheet/web/mario_bros.png'
        img = pygame.image.load(io.BytesIO(urllib.request.urlopen(url).read()))
        return [img.subsurface(get_rect(x, 0)) for x in range(img.get_width() // 16)]
    def get_mario():
        Mario = dataclasses.make_dataclass('Mario', 'rect spd facing_left frame_cycle'.split())
        return Mario(get_rect(1, 1), P(0, 0), False, it.cycle(range(3)))
    def get_tiles():
        positions = [p for p in it.product(range(SIZE), repeat=2) if {*p} & {0, SIZE-1}] + \
                    [(randint(1, SIZE-2), randint(2, SIZE-2)) for _ in range(SIZE**2 // 10)]
        return [get_rect(*p) for p in positions]
    def get_rect(x, y):
        return pygame.Rect(x*16, y*16, 16, 16)
    run(get_screen(), get_images(), get_mario(), get_tiles())

    def run(screen, images, mario, tiles):
        clock = pygame.time.Clock()
        while all(event.type != pygame.QUIT for event in pygame.event.get()):
            keys = {pygame.K_UP: D.n, pygame.K_RIGHT: D.e, pygame.K_DOWN: D.s, pygame.K_LEFT: D.w}
            pressed = {keys.get(i) for i, on in enumerate(pygame.key.get_pressed()) if on}
            update_speed(mario, tiles, pressed)
            update_position(mario, tiles)
            draw(screen, images, mario, tiles, pressed)
            clock.tick(28)

        def update_speed(mario, tiles, pressed):
            x, y = mario.spd
            x += 2 * ((D.e in pressed) - (D.w in pressed))
            x -= x // abs(x) if x else 0
            y += 1 if D.s not in get_boundaries(mario.rect, tiles) else (-10 if D.n in pressed else 0)
            mario.spd = P(*[max(-limit, min(limit, s)) for limit, s in zip(MAX_SPEED, P(x, y))])

        def update_position(mario, tiles):
            new_p = mario.rect.topleft
            larger_speed = max(abs(s) for s in mario.spd)
            for _ in range(larger_speed):
                mario.spd = stop_on_collision(mario.spd, get_boundaries(mario.rect, tiles))
                new_p = P(*[a + s/larger_speed for a, s in zip(new_p, mario.spd)])
            mario.rect.topleft = new_p

        def get_boundaries(rect, tiles):
            deltas = {D.n: P(0, -1), D.e: P(1, 0), D.s: P(0, 1), D.w: P(-1, 0)}
            return {d for d, delta in deltas.items() if rect.move(delta).collidelist(tiles) != -1}

        def stop_on_collision(spd, bounds):
            return P(x=0 if (D.w in bounds and spd.x < 0) or (D.e in bounds and spd.x > 0) else spd.x,
                    y=0 if (D.n in bounds and spd.y < 0) or (D.s in bounds and spd.y > 0) else spd.y)

        def draw(screen, images, mario, tiles, pressed):
            def get_frame_index():
                if D.s not in get_boundaries(mario.rect, tiles):
                    return 4
                return next(mario.frame_cycle) if {D.w, D.e} & pressed else 6
            screen.fill((85, 168, 255))
            mario.facing_left = (D.w in pressed) if {D.w, D.e} & pressed else mario.facing_left
            screen.blit(images[get_frame_index() + mario.facing_left * 9], mario.rect)
            for rect in tiles:
                screen.blit(images[18 if {*rect.topleft} & {0, (SIZE-1)*16} else 19], rect)
            pygame.display.flip()

    if __name__ == '__main__':
        main()

```

## # Pandas

```
# $ pip3 install pandas
import pandas as pd
from pandas import Series, DataFrame
```

## Series

Ordered dictionary with a name.

```
>>> Series([1, 2], index=['x', 'y'], name='a')
x    1
y    2
Name: a, dtype: int64
```

```
<Sr> = Series(<list>)           # Assigns RangeIndex starting at 0.
<Sr> = Series(<dict>)           # Takes dictionary's keys for index.
<Sr> = Series(<dict/Series>, index=<list>) # Only keeps items with keys specified in index.

<el> = <Sr>.loc[key]            # Or: <Sr>.iloc[index]
<Sr> = <Sr>.loc[keys]          # Or: <Sr>.iloc[indexes]
<Sr> = <Sr>.loc[from_key : to_key_inclusive] # Or: <Sr>.iloc[from_i : to_i_exclusive]

<el> = <Sr>[key/index]         # Or: <Sr>.key
<Sr> = <Sr>[keys/indexes]     # Or: <Sr>[<key_range/range>]
<Sr> = <Sr>[bools]             # Or: <Sr>.i/loc[bools]

<Sr> = <Sr> >== <el/Sr>      # Returns a Series of bools.
<Sr> = <Sr> +*/ <el/Sr>        # Non-matching keys get value NaN.

<Sr> = <Sr>.append(<Sr>)       # Or: pd.concat(<coll_of_Sr>)
<Sr> = <Sr>.combine_first(<Sr>) # Adds items that are not yet present.
<Sr>.update(<Sr>)              # Updates items that are already present.
```

## Aggregate, Transform, Map:

```
<el> = <Sr>.sum/max/mean/idxmax/all()      # Or: <Sr>.aggregate(<agg_func>)
<Sr> = <Sr>.rank/diff/cumsum/ffill/interpl() # Or: <Sr>.agg/transform(<trans_func>)
<Sr> = <Sr>.fillna(<el>)                  # Or: <Sr>.apply/agg/transform/map(<map_func>)
```

- The way '**aggregate()**' and '**transform()**' find out whether a function accepts an element or the whole Series is by passing it a single value at first and if it raises an error, then they pass it the whole Series.

```
>>> sr = Series([1, 2], index=['x', 'y'])
x    1
y    2
```

	'sum'	['sum']	{'s': 'sum'}
sr.apply(...) sr.agg(...)	3	sum 3	s 3

	'rank'	['rank']	{'r': 'rank'}
sr.apply(...) sr.agg(...) sr.trans(...)	x 1 y 2	rank y 2	r x 1 y 2

- Last result has a hierarchical index. Use '**<Sr>[key\_1, key\_2]**' to get its values.

## DataFrame

Table with labeled rows and columns.

```
>>> DataFrame([[1, 2], [3, 4]], index=['a', 'b'], columns=['x', 'y'])
   x  y
a  1  2
b  3  4

<DF> = DataFrame(<list_of_rows>)          # Rows can be either lists, dicts or series.
<DF> = DataFrame(<dict_of_columns>)        # Columns can be either lists, dicts or series.

<el> = <DF>.loc[row_key, column_key]       # Or: <DF>.iloc[row_index, column_index]
<Sr/DF> = <DF>.loc[row_key/s]              # Or: <DF>.iloc[row_index/es]
<Sr/DF> = <DF>.loc[:, column_key/s]        # Or: <DF>.iloc[:, column_index/es]
<DF> = <DF>.loc[row_bools, column_bools]  # Or: <DF>.iloc[row_bools, column_bools]

<Sr/DF> = <DF>[column_key/s]             # Or: <DF>.column_key
<DF> = <DF>[row_bools]                  # Keeps rows as specified by bools.
<DF> = <DF>[<DF>_of_bools>]            # Assigns NaN to False values.

<DF> = <DF> ><= <el/Sr/DF>           # Returns DataFrame of bools.
<DF> = <DF> +-* / <el/Sr/DF>         # Non-matching keys get value NaN.

<DF> = <DF>.set_index(column_key)        # Replaces row keys with values from a column.
<DF> = <DF>.reset_index()               # Moves row keys to their own column.
<DF> = <DF>.filter('<regex>', axis=1)  # Only keeps columns whose key matches the regex.
<DF> = <DF>.melt(id_vars=column_key/s) # Converts DF from wide to long format.
```

Merge, Join, Concat:

```
>>> l = DataFrame([[1, 2], [3, 4]], index=['a', 'b'], columns=['x', 'y'])
   x  y
a  1  2
b  3  4
>>> r = DataFrame([[4, 5], [6, 7]], index=['b', 'c'], columns=['y', 'z'])
   y  z
b  4  5
c  6  7
```

how/join	'outer'	'inner'	'left'	description
l.merge(r, on='y', how=...)	x  y  z 0  1  2  . 1  3  4  5 2  .  6  7	x  y  z 3  4  5	x  y  z 1  2  . 3  4  5	Joins/merges on column. Also accepts left_on and right_on parameters. Uses 'inner' by default.
l.join(r, lsuffix='l', rsuffix='r', how=...)	x  yl  yr  z a  1  2  .  . b  3  4  4  5 c  .  .  6  7	x  yl  yr  z 3  4  4  5	x  yl  yr  z 1  2  .  . 3  4  4  5	Joins/merges on row keys. Uses 'left' by default.
pd.concat([l, r], axis=0, join=...)	x  y  z a  1  2  . b  3  4  . b  .  4  5 c  .  6  7	y 2 4 4 6		Adds rows at the bottom. Uses 'outer' by default. By default works the same as `l.append(r)`.
pd.concat([l, r], axis=1, join=...)	x  y  y  z a  1  2  .  . b  3  4  4  5 c  .  .  6  7	x  y  y  z 3  4  4  5		Adds columns at the right end. Uses 'outer' by default.
l.combine_first(r)	x  y  z a  1  2  . b  3  4  5 c  .  6  7			Adds missing rows and columns.

**Aggregate, Transform, Map:**

```
<Sr> = <DF>.sum/max/mean/idxmax/all()          # Or: <DF>.apply/agg/transform(<agg_func>)
<DF> = <DF>.rank/diff/cumsum/ffill/interpl()   # Or: <DF>.apply/agg/transform(<trans_func>)
<DF> = <DF>.fillna(<el>)                      # Or: <DF>.applymap(<map_func>)
```

- All operations operate on columns by default. Use '**axis=1**' parameter to process the rows instead.

```
>>> df = DataFrame([[1, 2], [3, 4]], index=['a', 'b'], columns=['x', 'y'])
      x  y
a  1  2
b  3  4
```

	'sum'	['sum']	{'x': 'sum'}
df.apply(...) df.agg(...)	x 4 y 6	sum 4 6	x 4

	'rank'	['rank']	{'x': 'rank'}
df.apply(...) df.agg(...) df.trans(...)	a 1 1 b 2 2	x y rank rank a 1 1 b 2 2	x a 1 b 2

- Use '**<DF>[col\_key\_1, col\_key\_2][row\_key]**' to get the fifth result's values.

**Encode, Decode:**

```
<DF> = pd.read_json/html('<str/path/url>')
<DF> = pd.read_csv/pickle/excel('<path/url>')
<DF> = pd.read_sql('<query>', <connection>)
<DF> = pd.read_clipboard()
```

```
<dict> = <DF>.to_dict(['d/l/s/sp/r/i'])
<str> = <DF>.to_json/html/csv/markdown/latex([<path>])
<DF>.to_pickle/excel(<path>)
<DF>.to_sql('<table_name>', <connection>)
```

**GroupBy**

Object that groups together rows of a dataframe based on the value of the passed column.

```
>>> df = DataFrame([[1, 2, 3], [4, 5, 6], [7, 8, 6]], index=list('abc'), columns=list('xyz'))
>>> df.groupby('z').get_group(3)
      x  y
a  1  2
>>> df.groupby('z').get_group(6)
      x  y
b  4  5
c  7  8
```

```
<GB> = <DF>.groupby(column_key/s)           # DF is split into groups based on passed column.
<DF> = <GB>.get_group(group_key)            # Selects a group by value of grouping column.
```

**Aggregate, Transform, Map:**

```
<DF> = <GB>.sum/max/mean/idxmax/all()          # Or: <GB>.apply/agg(<agg_func>)
<DF> = <GB>.rank/diff/cumsum/ffill()           # Or: <GB>.aggregate(<trans_func>)
<DF> = <GB>.fillna(<el>)                     # Or: <GB>.transform(<map_func>)
```

```
>>> gb = df.groupby('z')
      x  y  z
3: a  1  2  3
6: b  4  5  6
c   7  8  6
```

	'sum'	'rank'	['rank']	{'x': 'rank'}
gb.agg(...)	x y z 3 1 2 6 11 13	x y a 1 1 b 1 1 c 2 2	x y rank rank a 1 1 b 1 1 c 2 2	x a 1 b 1 c 2
gb.transform(...)	x y a 1 2 b 11 13 c 11 13	x y a 1 1 b 1 1 c 1 1		

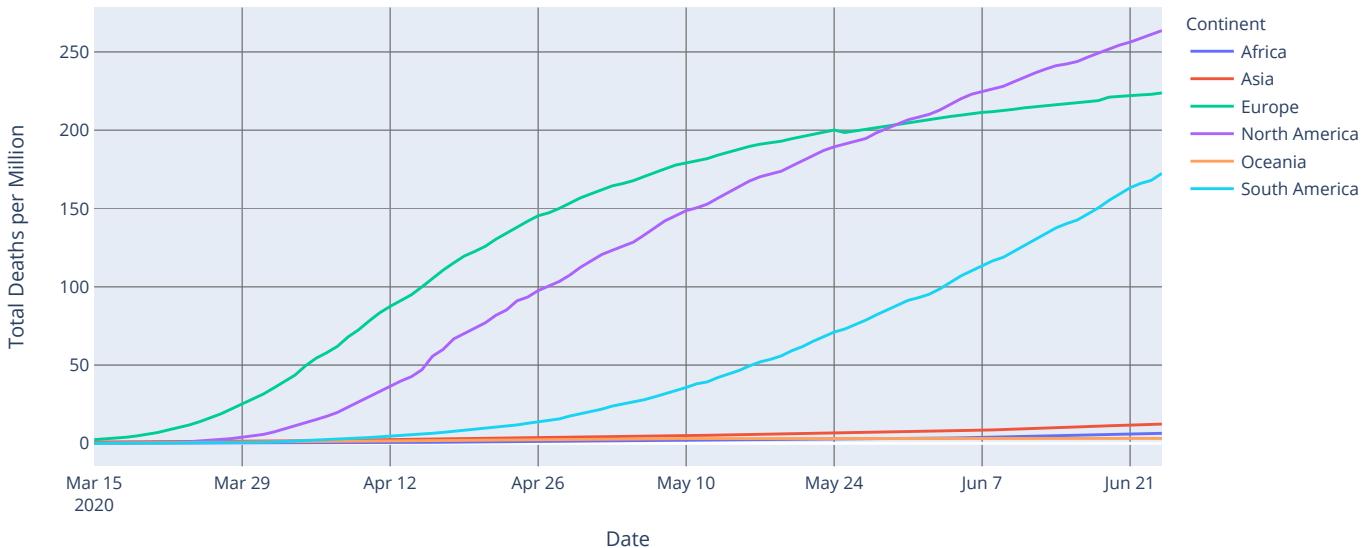
## Rolling

Object for rolling window calculations.

```
<R_Sr/R_DF/R_GB> = <Sr/DF/GB>.rolling(window_size) # Also: `min_periods=None, center=False` .
<R_Sr/R_DF>       = <R_DF/R_GB>[column_key/s]          # Or: <R>.column_key
<Sr/DF/DF>         = <R_Sr/R_DF/R_GB>.sum/max/mean() # Or: <R>.apply/agg(<agg_func/str>)
```

## # Plotly

### Covid Deaths by Continent



```
# $ pip3 install pandas plotly
import pandas as pd
import plotly.express

covid = pd.read_csv('https://covid.ourworldindata.org/data/owid-covid-data.csv',
                    usecols=['iso_code', 'date', 'total_deaths', 'population'])
continents = pd.read_csv('https://datahub.io/JohnSnowLabs/country-and-continent-codes-' + \
                        'list/r/country-and-continent-codes-list-csv.csv',
                        usecols=['Three_Letter_Country_Code', 'Continent_Name'])
df = pd.merge(covid, continents, left_on='iso_code', right_on='Three_Letter_Country_Code')
df = df.groupby(['Continent_Name', 'date']).sum().reset_index()
df['Total Deaths per Million'] = df.total_deaths * 1e6 / df.population
df = df[(‘2020-03-14’ < df.date) & (df.date < ‘2020-06-25’)]
df = df.rename({'date': 'Date', 'Continent_Name': 'Continent'}, axis='columns')
plotly.express.line(df, x='Date', y='Total Deaths per Million', color='Continent').show()
```

## Confirmed Covid Cases, Dow Jones, Gold, and Bitcoin Price



```
# $ pip3 install pandas plotly
import pandas, datetime
import plotly.graph_objects as go

def main():
    display_data(wrangle_data(*scrape_data()))

def scrape_data():
    def scrape_yahoo(id_):
        BASE_URL = 'https://query1.finance.yahoo.com/v7/finance/download/'
        now = int(datetime.datetime.now().timestamp())
        url = f'{BASE_URL}{id_}?period1=1579651200&period2={now}&interval=1d&events=history'
        return pandas.read_csv(url, usecols=['Date', 'Close']).set_index('Date').Close
    covid = pd.read_csv('https://covid.ourworldindata.org/data/owid-covid-data.csv',
                        usecols=['date', 'total_cases'])
    covid = covid.groupby('date').sum()
    dow, gold, bitcoin = [scrape_yahoo(id_) for id_ in ('^DJI', 'GC=F', 'BTC-USD')]
    dow.name, gold.name, bitcoin.name = 'Dow Jones', 'Gold', 'Bitcoin'
    return covid, dow, gold, bitcoin

def wrangle_data(covid, dow, gold, bitcoin):
    df = pandas.concat([covid, dow, gold, bitcoin], axis=1)
    df = df.loc['2020-02-23':].iloc[:-2]
    df = df.interpolate()
    df.iloc[:, 1:] = df.rolling(10, min_periods=1, center=True).mean().iloc[:, 1:]
    df.iloc[:, 1:] = df.iloc[:, 1:] / df.iloc[0, 1:] * 100
    return df

def display_data(df):
    def get_trace(col_name):
        return go.Scatter(x=df.index, y=df[col_name], name=col_name, yaxis='y2')
    traces = [get_trace(col_name) for col_name in df.columns[1:]]
    traces.append(go.Scatter(x=df.index, y=df.total_cases, name='Total Cases', yaxis='y1'))
    figure = go.Figure()
    figure.add_traces(traces)
    figure.update_layout(
        yaxis1=dict(title='Total Cases', rangemode='tozero'),
        yaxis2=dict(title='%', rangemode='tozero', overlaying='y', side='right'),
        legend=dict(x=1.1)
    ).show()

if __name__ == '__main__':
    main()
```

## # Cython

Library that compiles Python code into C.

```
# $ pip3 install cython
import pyximport; pyximport.install()
import <cython_script>
<cython_script>.main()
```

### Definitions

- All '**cdef**' definitions are optional, but they contribute to the speed-up.
- Script needs to be saved with a '**.pyx**' extension.

```
cdef <type> <var_name> = <el>
cdef <type>[n_elements] <var_name> = [<el_1>, <el_2>, ...]
cdef <type/void> <func_name>(<type> <arg_name_1>, ...):

cdef class <class_name>:
    cdef public <type> <attr_name>
    def __init__(self, <type> <arg_name>):
        self.<attr_name> = <arg_name>

cdef enum <enum_name>: <member_name_1>, <member_name_2>, ...
```

## # Basic Script Template

```
#!/usr/bin/env python3
#
# Usage: .py
#
from collections import namedtuple
from dataclasses import make_dataclass
from enum import Enum
from sys import argv
import re

def main():
    pass

"""
## UTIL
#
def read_file(filename):
    with open(filename, encoding='utf-8') as file:
        return file.readlines()

if __name__ == '__main__':
    main()
```