

# Comprehensive Python Cheatsheet

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## # Contents

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ToC = {
    '1. Collections': [List, Dictionary, Set, Tuple, Range, Enumerate, Iterator, Generator],
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    '3. Syntax': [Args, Inline, Closure, Decorator, Class, Duck_Type, Enum, Exception],
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    '6. Advanced': [Threading, Operator, Introspection, Metaprogramming, Eval, Coroutine],
    '7. Libraries': [Progress_Bar, Plot, Table, Curses, Logging, Scraping, Web, Profile,
                     NumPy, Image, Audio, Games, Data]
}
```

## # 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.

```

<list>.insert(<int>, <el>)          # Inserts item at index and moves the rest to the right.
<el> = <list>.pop([<int>])        # Returns and removes item at index or from the end.
<int> = <list>.count(<el>)        # Returns number of occurrences. Also works on strings.
<int> = <list>.index(<el>)        # Returns index of the first occurrence or raises ValueError.
<list>.remove(<el>)              # Removes first occurrence of the 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> | <el>
<set>.update(<collection> [, ...]) # Or: <set> &lt;collection>

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

<el> = <set>.pop()                # Raises KeyError if empty.
<set>.remove(<el>)               # Raises KeyError if missing.
<set>.discard(<el>)             # Doesn't raise an error.

```

## 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> [, ...]) # Or: <el>  
 # Or: <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(<coll>, to_exclusive) # Only returns first 'to_exclusive' elements.  
<iter> = islice(<coll>, 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. ABC can also manually decide whether or not a specific class is its virtual subclass, usually based on which methods the class has implemented. For instance, `Iterable` ABC looks for method `iter()` while `Collection` ABC looks for methods `iter()`, `contains()` and `len()`.

```
>>> 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\f\v\x1c\x1d\x1e\x85] and '\r\n'.  
<str> = <str>.join(<coll_of_strings>)                # Joins elements using string as a 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 the 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]	[1134]	[231]	[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().  
<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, decimal characters, alphanumerics and whitespaces from all alphabets are matched unless '`flags=re.ASCII`' argument is used.
- As shown below, it restricts special sequence matches to the first 128 characters and prevents '`\s`' from accepting '`[\x1c-\x1f]`'.
- Use a capital letter for negation.

```
'\d' == '[0-9]'                                # Matches decimal characters.  
'\w' == '[a-zA-Z0-9_]'                          # Matches alphanumerics and underscore.  
'\s' == '[ \t\n\r\f\v]'                           # Matches whitespaces.
```

## # 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>'
```

- Use '`{<el>:{<str/int/float>}[...]}`' to set options dynamically.
- Adding '`!r`' before the colon converts object to string by calling its `repr()` method.

## Strings

```
{'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%'

	{<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%'

- When both rounding up and rounding down are possible, the one that returns result with even last digit is chosen. That makes '{6.5:.0f}' a '6' and '{7.5:.0f}' an '8'.

## Ints

```
{90:c}          # 'Z'
{90:b}          # '1011010'
{90:X}          # '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 sin, cos, tan, asin, acos, 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, gauss, seed

<float> = random()                                # A float inside [0, 1).
<int>   = randint(from_inc, to_inc)               # An int inside [from_inc, to_inc].
<el>    = choice(<list>)                          # Keeps the list intact.
```

## Bin, Hex

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

## Bitwise Operators

```
<int> = <int> & <int>                            # And
<int> = <int> | <int>                            # Or
<int> = <int> ^ <int>                            # Xor (0 if both bits equal)
<int> = <int> << n_bits                         # Left shift (>> 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, 1, 1)]

>>> product('abc', 'abc')                         #   a   b   c
[('a', 'a'), ('a', 'b'), ('a', 'c'),           # a x   x   x
 ('b', 'a'), ('b', 'b'), ('b', 'c'),           # b x   x   x
 ('c', 'a'), ('c', 'b'), ('c', 'c')]          # c x   x   x

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

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

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

## # 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, datetime_exists, 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**

- 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 the passed timezone.
<Ta/DTa> = <T/DT>.replace(tzinfo=<tzinfo>)    # Unconverted object with a 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 the Gregorian NYE 1.  
<DTn>    = DT.fromtimestamp(<real>)          # Local time DTn from seconds since the Epoch.  
<DTa>    = DT.fromtimestamp(<real>, <tz.>)    # Aware datetime from seconds since the 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 Gregorian NYE 1, ignoring time and tz.
<float>   = <DTn>.timestamp()                  # Seconds since the Epoch, from DTn in local tz.
<float>   = <DTa>.timestamp()                  # Seconds since the 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 ' $\pm$ 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> [, ...]}
<tup.> = (*<collection>, [...])
<dict> = {**<dict> [, ...]}
```

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

## # Inline

### Lambda

```
<func> = lambda: <return_value>
<func> = lambda <arg_1>, <arg_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}

|>>> [l+r for l in 'abc' for r in 'abc']
['aa', 'ab', 'ac', ..., 'cc']
```

### Map, Filter, 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
```

- Reduce must be imported from functools module.

### Any, All

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

## Conditional Expression

```
| <obj> = <exp_if_true> if <condition> else <exp_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', ['loc', 'dir'])
| 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 immutable with '`frozen=True`'.
- For object to be hashable, all attributes must be hashable and frozen must be 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:

- Sequence 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 `len()` and `getitem()` 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__():
        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()

<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>)                                 # Returns a list of members.
member_names     = [a.name for a in <enum>]                   # Returns a list of member names.
member_values    = [a.value for a in <enum>]                  # Returns a list of member values.
random_member   = random.choice(list(<enum>))                # Returns a random member.

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 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 exceptions.
- 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.
- Use `'print(<name>)'` to print just the cause of the exception (its arguments).

### 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 = ''.join(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
    └─ 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               # Errors such as "file not found" or "disk full" (see Open).
        └─ 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	Set	Dict
getitem()	IndexError		
pop()	IndexError	KeyError	
remove()	ValueError	KeyError	
index()	ValueError		

### 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
| scripts_path = 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)

```

## # Paths

```

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>)          # Returns final component of the path.
<str> = path.dirname(<path>)          # Returns path without the final component.
<tup.> = path.splitext(<path>)        # Splits on last period of the final component.

<list> = listdir(path='.')             # Returns filenames located at path.
<list> = glob('<pattern>')            # Returns paths matching the wildcard pattern.

<bool> = path.exists(<path>)          # Or: <Path>.exists()
<bool> = path.isfile(<path>)          # Or: <DirEntry/Path>.is_file()
<bool> = path.isdir(<path>)           # 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            # Returns DirEntry objects located at path.
<str> = <DirEntry>.name           # Returns whole path as a string.
<file> = open(<DirEntry>)         # Returns final component as a string.
                                    # Opens the file and returns file object.

```

## Path Object

```

from pathlib import Path

<Path> = Path(<path> [, ...])      # Accepts strings, Paths and DirEntry objects.
<Path> = <path> / <path> [/ ...]    # One of the paths must be a Path object.

<Path> = Path()                   # Returns relative cwd. Also Path('.').
<Path> = Path.cwd()               # Returns absolute cwd. Also Path().resolve().
<Path> = Path.home()              # Returns user's home directory.
<Path> = Path(__file__).resolve() # Returns script's path if cwd wasn't changed.

<Path> = <Path>.parent           # Returns Path without final component.
<str> = <Path>.name              # Returns final component as a string.
<str> = <Path>.stem               # Returns final component without extension.
<str> = <Path>.suffix             # Returns final component's extension.
<tup.> = <Path>.parts            # Returns all components as strings.

<iter> = <Path>.iterdir()        # Returns dir contents as Path objects.
<iter> = <Path>.glob('<pattern>') # Returns Paths matching the wildcard pattern.

<str> = str(<Path>)             # Returns path as a string.
<file> = open(<Path>)           # 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.
os.makedirs(<path>, mode=0o777)     # Creates all directories in the path.

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 a '`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 a '`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
<conn> = sqlite3.connect(<path>)                      # Also ':memory:'.
<conn>.close()                                         # Closes the connection.
```

## Read

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

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

## Write

```
<conn>.execute('<query>')                                # Can raise a subclass of sqlite3.Error.
<conn>.commit()                                         # Saves all changes since the last commit.
<conn>.rollback()                                        # Discards all changes since the last commit.
```

Or:

```
with <conn>:
    <conn>.execute('<query>')                            # Exits the block with commit() or rollback(),
    # depending on whether an exception occurred.
```

## Placeholders

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

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

## Example

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

```
>>> conn = sqlite3.connect('test.db')
>>> conn.execute('CREATE TABLE person (person_id INTEGER PRIMARY KEY, name, height)')
>>> conn.execute('INSERT INTO person VALUES (NULL, ?, ?)', ('Jean-Luc', 187)).lastrowid
1
>>> conn.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
<conn> = connector.connect(host=<str>, ...)      # `user=<str>, password=<str>, database=<str>`.
<cursor> = <conn>.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 as a 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 pairs 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 pairs.
```

## 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.
  - System's 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\x00\x03'
>>> unpack('>hhl', b'\x00\x01\x00\x02\x00\x00\x00\x03')
(1, 2, 3)
```

## Format

**For standard type sizes start format string with:**

- '=' - system's byte order (usually little-endian)
  - '<' - little-endian
  - '>' - big-endian (also '!'')

**Integer types.** Use a capital letter for unsigned type. Minimum and standard sizes are in brackets:

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

## Floating point types:

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

## # Array

**List that can only hold numbers of a predefined type. Available types and their minimum sizes in bytes are listed above. Sizes and byte order are always determined by the system.**

## # 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.
  - Casting only works between char and other types and uses system's sizes and byte order.

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

## Decode

```
<bytes> = bytes(<mview>)
<bytes> = <bytes>.join(<coll_of_mviews>)
<array> = array('<typecode>', <mview>)
<file>.write(<mview>)

<list>  = list(<mview>)
<str>   = str(<mview>, 'utf-8')
<int>   = int.from_bytes(<mview>, ...)
'<hex>' = <mview>.hex()

# Creates a new bytes object.
# Joins mviews using bytes object as sep.
# Treats mview as a sequence of numbers.
# Writes mview to the binary file.

# Returns list of ints or floats.
# Treats mview as a bytes object.
# `byteorder='big/little', signed=False` .
# Treats mview as a bytes object.
```

## # Deque

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

## # 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  
from concurrent.futures import ThreadPoolExecutor
```

## Thread

- 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

Or:

```
with <lock>:  
    ...  
        # Enters the block by calling acquire(),  
        # and exits it with release().
```

## Semaphore, Event, Barrier

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

## Thread Pool Executor

Object that manages thread execution.

```
<Exec> = ThreadPoolExecutor(max_workers=None) # Or: `with ThreadPoolExecutor() as <name>: ...`  
<Exec>.shutdown(wait=True)                   # Blocks until all threads finish executing.  
  
<iter> = <Exec>.map(<func>, <args_1>, ...)      # A multithreaded and non-lazy map().  
<Futr> = <Exec>.submit(<func>, <arg_1>, ...)    # Starts a thread and returns its Future object.  
<bool> = <Futr>.done()                         # Checks if the thread has finished executing.  
<obj>  = <Futr>.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_, xor, 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>)  
union_of_sets = functools.reduce(op.or_, <coll_of_sets>)  
LogicOp = enum.Enum('LogicOp', {'AND': op.and_, 'OR': op.or_})  
last_el = op.methodcaller('pop')(<list>)
```

## # Introspection

Inspecting code at runtime.

### Variables

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

### Attributes

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

### Parameters

```
from inspect import signature  
<Sig> = signature(<function>)  
<dict> = <Sig>.parameters  
<str> = <Param>.name  
<memb> = <Param>.kind  
# Function's Signature object.  
# Dict of function's Parameter objects.  
# Parameter's name.  
# Member of ParameterKind enum.
```

## # 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

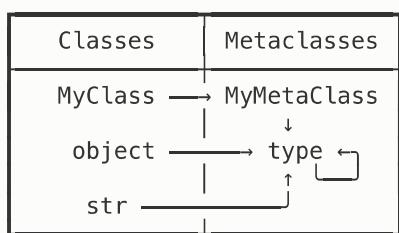
Right before a class is created it checks if it has the 'metaclass' attribute defined. If not, it recursively checks if any of his parents has it defined and eventually comes to `type()`.

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

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

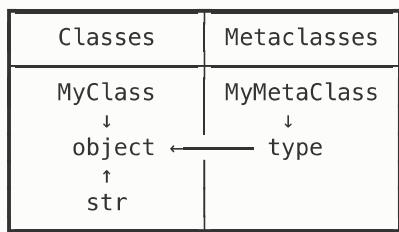
## Type Diagram

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



## Inheritance Diagram

```
MyClass.__base__ == object           # MyClass is a subclass of object.
MyMetaClass.__base__ == type         # MyMetaClass is a subclass of type.
```



## # Eval

```
>>> from ast import literal_eval
>>> literal_eval('[1, 2, 3]')
[1, 2, 3]
>>> literal_eval('1 + 2')
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:
        d = random.choice(list(D))
        moves.put_nowait((id_, 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(p.x + deltas[d].x, p.y + deltas[d].y)
        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)

if __name__ == '__main__':
    curses.wrapper(main)
```

# Libraries

## # Progress Bar

```
# $ pip3 install tqdm
>>> from tqdm import tqdm
>>> from time import sleep
>>> for el in tqdm([1, 2, 3], desc='Processing'):
...     sleep(1)
Processing: 100%|██████████| 3/3 [00:03<00:00,  1.00s/it]
```

## # Plot

```
# $ pip3 install matplotlib
import matplotlib.pyplot as plt
plt.plot(<x_data>, <y_data> [, label=<str>])    # Or: plt.plot(<y_data>)
plt.legend()                                         # Adds a legend.
plt.savefig(<path>)                                # Saves the figure.
plt.show()                                           # Displays the figure.
plt.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

Runs a basic file explorer in the terminal:

```
from curses import wrapper, ascii, A_REVERSE, KEY_UP, KEY_DOWN, KEY_LEFT, KEY_RIGHT, KEY_ENTER
from os import listdir, path, chdir

def main(screen):
    ch, first, selected, paths = 0, 0, 0, listdir()
    while ch != ascii.ESC:
        height, _ = screen.getmaxyx()
        screen.clear()
        for y, a_path in enumerate(paths[first : first+height]):
            screen.addstr(y, 0, a_path, A_REVERSE * (selected == first + y))
        ch = screen.getch()
        selected += (ch == KEY_DOWN) - (ch == KEY_UP)
        selected = max(0, min(len(paths)-1, selected))
        first += (first <= selected - height) - (first > selected)
        if ch in [KEY_LEFT, KEY_RIGHT, KEY_ENTER, 10, 13]:
            new_dir = '..' if ch == KEY_LEFT else paths[selected]
            if path.isdir(new_dir):
                chdir(new_dir)
                first, selected, paths = 0, 0, listdir()

if __name__ == '__main__':
    wrapper(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 its Wikipedia page:

```
# $ pip3 install requests beautifulsoup4
import requests, bs4, sys

WIKI_URL = 'https://en.wikipedia.org/wiki/Python_(programming_language)'
try:
    html      = requests.get(WIKI_URL).text
    document  = bs4.BeautifulSoup(html, 'html.parser')
    table     = document.find('table', class_='infobox vevent')
    python_url = table.find('th', text='Website').next_sibling.a['href']
    version   = table.find('th', text='Stable release').next_sibling.strings.__next__()
    logo_url  = table.find('img')['src']
    logo      = requests.get(f'https:{logo_url}').content
    with open('test.png', 'wb') as file:
        file.write(logo)
    print(python_url, version)
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('/<sport>/odds')
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 threading, requests
>>> threading.Thread(target=run, daemon=True).start()
>>> url = 'http://localhost:8080/football/odds'
>>> 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 the restart.
...
duration = perf_counter() - start_time
```

## Timing a Snippet

```
>>> from timeit import timeit
>>> timeit("''.join(str(i) for i 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    955.0    955.0     43.7      0.349
  4      1   1231.0   1231.0     56.3      0.650

$ python3 -m memory_profiler test.py
Line #      Mem usage      Increment  Line Contents
=====
  1      37.668 MiB      37.668 MiB  @profile
  2
  3      38.012 MiB      0.344 MiB    a = [*range(10000)]
  4      38.477 MiB      0.465 MiB    b = {*range(10000)}
```

## Call Graph

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

```
# $ pip3 install pycallgraph2
from pycallgraph2 import output, PyCallGraph
from datetime import datetime
filename = f'profile-{datetime.now():%Y%m%d%H%M%S}.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. An even faster alternative that runs on a GPU is called CuPy.

```
# $ 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 an index of the dimension that gets collapsed. Leftmost dimension has index 0.

## Indexing

```

<el>      = <2d_array>[row_index, column_index]
<1d_view> = <2d_array>[row_index]
<1d_view> = <2d_array>[:, column_index]

<1d_array> = <2d_array>[row_indexes, column_indexes]
<2d_array> = <2d_array>[row_indexes]
<2d_array> = <2d_array>[:, column_indexes]

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

```

## 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)) # Also: `color=<int/tuple/str>`.
<Image> = Image.open(<path>) # Identifies format based on file contents.
<Image> = <Image>.convert('<mode>') # Converts image to the new mode.
<Image>.save(<path>) # Selects format based on the path extension.
<Image>.show() # Opens image in default preview app.

<int/tuple> = <Image>.getpixel((x, y)) # Returns a pixel.
<Image>.putpixel((x, y), <int/tuple>) # 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_L>) # Creates NumPy array from greyscale image.
<3d_array> = np.array(<Image_RGB>) # 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')
```

## Image Draw

```
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 an int, tuple, '#rrggbbaa' string or a color name.

## # Animation

Creates a GIF of a bouncing ball:

```
# $ pip3 install imageio
from PIL import Image, ImageDraw
import imageio
WIDTH, R = 126, 10
frames = []
for velocity in range(1, 16):
    y = sum(range(velocity))
    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(bytes_obj):
        an_int = int.from_bytes(bytes_obj, 'little', signed=sampwidth!=1)
        return an_int - 128 * (sampwidth == 1)
    with wave.open(filename, 'rb') as file:
        sampwidth = file.getsampwidth()
        frames = file.readframes(-1)
    bytes_samples = (frames[i : i+sampwidth] for i in range(0, len(frames), sampwidth))
    return [get_int(b) / pow(2, sampwidth * 8 - 1) for b in bytes_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 math, struct, simpleaudio
from itertools import repeat, chain
F = 44100
P1 = '71,,69,,71,,66,,62,,66,,59,,,'
P2 = '71,,73,,74,,73,,74,,71,,73,,71,,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]), 1/4 if 'J' in note else 1/8)
get_samples = lambda note: get_wave(*parse_note(note)) if note else get_pause(1/8)
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, -1), pg.K_RIGHT: (1, 0), pg.K_DOWN: (0, 1), pg.K_LEFT: (-1, 0)}
    for key_code, is_pressed in enumerate(pg.key.get_pressed()):
        rect = rect.move(deltas[key_code]) if key_code in deltas and is_pressed 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)          # Floats get truncated into ints.  
<int> = <Rect>.x/y/centerx/centery/...      # Top, right, bottom, left. Allows assignments.  
<tup.> = <Rect>.topleft/center/...           # Topright, bottomright, bottomleft.  
<Rect> = <Rect>.move((x, y))                 # Use move_ip() to move in place.  
  
<bool> = <Rect>.collidepoint((x, y))         # Checks if rectangle contains a point.  
<bool> = <Rect>.colliderect(<Rect>)          # Checks if two rectangles overlap.  
<int> = <Rect>.collidelist(<list_of_Rect>)    # Returns index of first colliding Rect or -1.  
<list> = <Rect>.collidelistall(<list_of_Rect>) # Returns indexes of all colliding Rects.
```

## Surface

## Object for representing images.

```
<Surf> = pg.display.set_mode((width, height)) # Returns display surface.
<Surf> = pg.Surface((width, height), ...) # New RGB surface. Add `pg.SRCALPHA` for RGBA.
<Surf> = pg.image.load('<path>') # Loads the image. Format depends on source.
<Surf> = <Surf>.subsurface(<Rect>) # Returns a subsurface.

<Surf>.fill(color) # Tuple, Color('#rrggbbaa') or Color(<name>).
<Surf>.set_at((x, y), color) # Updates pixel.
<Surf>.blit(<Surf>, (x, y)) # Draws passed surface to the surface.

from pygame.transform import scale, ... # Returns scaled surface.
<Surf> = scale(<Surf>, (width, height)) # Returns rotated and scaled surface.
<Surf> = rotate(<Surf>, degrees) # Returns flipped surface.
<Surf> = flip(<Surf>, x_bool, y_bool)

from pygame.draw import line, ... # Draws a line to the surface.
line(<Surf>, color, (x1, y1), (x2, y2), width) # Also: ellipse(<Surf>, color, <Rect>)
arc(<Surf>, color, <Rect>, from_rad, to_rad) # Also: polygon(<Surf>, color, points)
rect(<Surf>, color, <Rect>)
```

## Font

```

<Font> = pg.font.SysFont('<name>', size)      # Loads the system font or default if missing.
<Font> = pg.font.Font('<path>', size)          # Loads the TTF file. Pass None for default.
<Surf> = <Font>.render(text, antialias, color)  # Background color can be specified at the end.

```

## Sound

```
<Sound> = pg.mixer.Sound('<path>') # Loads the WAV file.  
<Sound>.play() # Starts playing the sound.
```

## Basic Mario Brothers Example

```
import collections, dataclasses, enum, io, itertools as it, pygame as pg, urllib.request
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():
        pg.init()
        return pg.display.set_mode(2 * [SIZE*16])
    def get_images():
        url = 'https://gto76.github.io/python-cheatsheet/web/mario_bros.png'
        img = pg.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 pg.Rect(x*16, y*16, 16, 16)
    run(get_screen(), get_images(), get_mario(), get_tiles())

    def run(screen, images, mario, tiles):
        clock = pg.time.Clock()
        while all(event.type != pg.QUIT for event in pg.event.get()):
            keys = {pg.K_UP: D.n, pg.K_RIGHT: D.e, pg.K_DOWN: D.s, pg.K_LEFT: D.w}
            pressed = {keys.get(i) for i, on in enumerate(pg.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 (D.n in pressed) * -10
            mario.spd = P(*[max(-limit, min(limit, s)) for limit, s in zip(MAX_SPEED, P(x, y))])

        def update_position(mario, tiles):
            x, y = mario.rect.topleft
            n_steps = max(abs(s) for s in mario.spd)
            for _ in range(n_steps):
                mario.spd = stop_on_collision(mario.spd, get_boundaries(mario.rect, tiles))
                x, y = x + mario.spd.x/n_steps, y + mario.spd.y/n_steps
                mario.rect.topleft = x, y

        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).collideable(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):
            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)
            pg.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>       # Items with 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 the passed 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>
<DF>  = <DF> +-*> <el/Sr/DF>         # Returns DF of bools. Sr is treated as a row.
                                            # Items with 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 a column named index.
<DF>  = <DF>.filter('<regex>', axis=1) # Only keeps columns whose key matches the regex.
<DF>  = <DF>.melt(id_vars=column_key/s) # Converts DataFrame 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
```

	'outer'	'inner'	'left'	Description
<code>l.merge(r, on='y', how=...)</code>	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.
<code>l.join(r, lsuffix='l', rsuffix='r', how=...)</code>	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. If r is a series, it is treated as a column.
<code>pd.concat([l, r], axis=0, join=...)</code>	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. A series is treated as a column. Use l.append(r) to add a row instead.
<code>pd.concat([l, r], axis=1, join=...)</code>	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. A series is treated as a column.
<code>l.combine_first(r)</code>	x  y  z a  1  2  . b  3  4  5 c  .  6  7			Adds missing rows and columns. Also updates items that contain NaN. R must be a DataFrame.

## 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(...)	x y 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('<table_name/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/s)        # 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

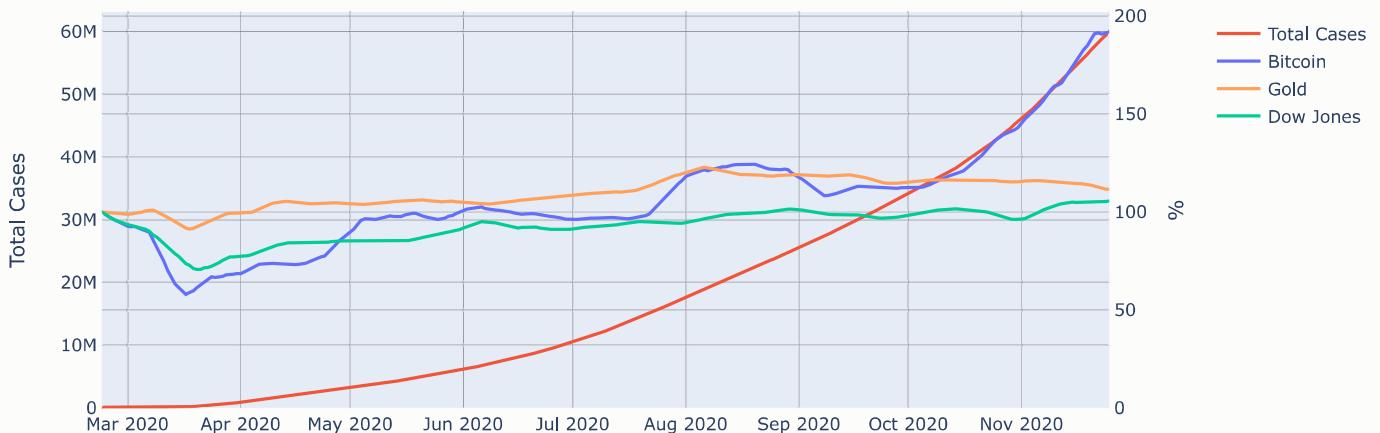
```
# $ pip3 install plotly kaleido  
from plotly.express import line  
<Figure> = line(<DF>, x=<col_name>, y=<col_name>)           # Or: line(x=<list>, y=<list>)  
<Figure>.update_layout(margin=dict(t=0, r=0, b=0, l=0)) # Or: paper_bgcolor='rgba(0, 0, 0, 0)'  
<Figure>.write_html/json/image('<path>')                      # Also: <Figure>.show()
```

Covid deaths by continent:



```
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 < '2020-11-25')]  
df = df.rename({'date': 'Date', 'Continent_Name': 'Continent'}, axis='columns')  
line(df, x='Date', y='Total Deaths per Million', color='Continent').show()
```

## Confirmed covid cases, Dow Jones, gold, and Bitcoin price:



```
import pandas as pd
import plotly.graph_objects as go

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

def scrape_data():
    def scrape_covid():
        url = 'https://covid.ourworldindata.org/data/owid-covid-data.csv'
        df = pd.read_csv(url, usecols=['location', 'date', 'total_cases'])
        return df[df.location == 'World'].set_index('date').total_cases
    def scrape_yahoo(slug):
        url = f'https://query1.finance.yahoo.com/v7/finance/download/{slug}' + \
              '?period1=1579651200&period2=1608850800&interval=1d&events=history'
        df = pd.read_csv(url, usecols=['Date', 'Close'])
        return df.set_index('Date').Close
    return scrape_covid(), scrape_yahoo('BTC-USD'), scrape_yahoo('GC=F'), scrape_yahoo('^DJI')

def wrangle_data(covid, bitcoin, gold, dow):
    df = pd.concat([bitcoin, gold, dow], axis=1)
    df = df.sort_index().interpolate()
    df = df.rolling(10, min_periods=1, center=True).mean()
    df = df.loc['2020-02-23':'2020-11-25']
    df = (df / df.iloc[0]) * 100
    return pd.concat([covid, df], axis=1, join='inner')

def display_data(df):
    df.columns = ['Total Cases', 'Bitcoin', 'Gold', 'Dow Jones']
    figure = go.Figure()
    for col_name in df:
        yaxis = 'y1' if col_name == 'Total Cases' else 'y2'
        trace = go.Scatter(x=df.index, y=df[col_name], name=col_name, yaxis=yaxis)
        figure.add_trace(trace)
    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()
```

## # PySimpleGUI

```
# $ pip3 install PySimpleGUI
import PySimpleGUI as sg
layout = [[sg.Text("What's your name?")], [sg.Input()], [sg.Button('Ok')]]
window = sg.Window('Window Title', layout)
event, values = window.read()
print(f'Hello {values[0]}!' if event == 'Ok' else '')
```

## # Appendix

### 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>, ...
```

### PyInstaller

```
$ pip3 install pyinstaller
$ pyinstaller script.py                                # Compiles into './dist/script' directory.
$ pyinstaller script.py --onefile                      # Compiles into './dist/script' console app.
$ pyinstaller script.py --windowed                   # Compiles into './dist/script' windowed app.
$ pyinstaller script.py --add-data '<path>::.'      # Adds file to the root of the executable.
```

- File paths need to be updated to '**os.path.join(sys.\_MEIPASS, <path>)**'.

### Basic Script Template

```
#!/usr/bin/env python3
#
# Usage: .py
#
from sys import argv, exit
from collections import defaultdict, namedtuple
from dataclasses import make_dataclass
from enum import Enum
import functools as ft, itertools as it, operator as op, re

def main():
    pass

#####
## UTIL
##

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

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

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