Comprehensive Python Cheatsheet

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Main

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

List

```
<list> = <list>[<slice>]       # Or: <list>[from_inclusive :
to_exclusive : ±step]
```

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

```
<list>.sort()                  # Sorts in ascending order.
<list>.reverse()               # Reverses the list in-place.
<list> = sorted(<collection>)  # Returns a new sorted list.
<iter> = reversed(<list>)      # Returns reversed iterator.
```

```
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>)
```

- **For details about sorted(), min() and max() see sortable.**
- **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>])    # Removes and returns 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>)        # Returns a dict with
default value of type.
<dict> = collections.defaultdict(lambda: 1)     # Returns 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()                                   # `{}` returns a
dictionary.
```

```
<set>.add(<el>)                                 # Or: <set> |= {<el>}
<set>.update(<collection> [, ...])              # Or: <set> |= <set>
```

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

```
<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> = ()                                # Empty tuple.
<tuple> = (<el>,)                           # Or: <el>,
<tuple> = (<el_1>, <el_2> [, ...])          # 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
```

Range

Immutable and hashable sequence of integers.

```
<range> = range(stop)                      # range(to_exclusive)
<range> = range(start, stop)               # range(from_inclusive,
to_exclusive)
<range> = range(start, stop, ±step)        # range(from_inclusive,
to_exclusive, ±step_size)
```

```
>>> [i for i in range(3)]
[0, 1, 2]
```

Enumerate

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

Iterator

```
<iter> = iter(<collection>)                # `iter(<iter>)` returns
unmodified iterator.
<iter> = iter(<function>, to_exclusive)    # A sequence of return
values until 'to_exclusive'.
<el>   = next(<iter> [, default])          # Raises StopIteration or
returns 'default' on end.
<list> = list(<iter>)                      # 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 (figuratively).
<iter> = chain.from_iterable(<coll>)        # 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`. Indices can be None.
```

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,
ModuleType
```

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 iter(), contains() and len().

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

```
+------------------+------------+------------+------------+
|                  |  Iterable  | Collection |  Sequence  |
+------------------+------------+------------+------------+
| list, range, str |    yes     |    yes     |    yes     |
| dict, set        |    yes     |    yes     |            |
| iter             |    yes     |            |            |
+------------------+------------+------------+------------+
```

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

```
+--------------------+----------+----------+----------+----------+----
------+
|                    |  Number  |  Complex |   Real   | Rational |
Integral |
+--------------------+----------+----------+----------+----------+----
------+
| int                |   yes    |   yes    |   yes    |   yes    |
yes    |
| fractions.Fraction |   yes    |   yes    |   yes    |   yes    |
|
| float              |   yes    |   yes    |   yes    |          |
|
| complex            |   yes    |   yes    |          |          |
|
| decimal.Decimal    |   yes    |          |          |          |
|
+--------------------+----------+----------+----------+----------+----
------+
```

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)    # On [\n\r\f\v\x1c-
\x1e\x85\u2028\u2029] 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
character.
<int>  = ord(<str>)                          # Converts Unicode
character to int.
```

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

Property Methods

```
+---------------+----------+----------+----------+----------+---------
-+
|               | [ !#$%…] | [a-zA-Z] |  [¼½¾]   |  [²³¹]   |  [0-9]
|
+---------------+----------+----------+----------+----------+---------
-+
| isprintable() |   yes    |   yes    |   yes    |   yes    |   yes
|
| isalnum()     |          |   yes    |   yes    |   yes    |   yes
|
| isnumeric()   |          |          |   yes    |   yes    |   yes
|
| isdigit()     |          |          |          |   yes    |   yes
|
| isdecimal()   |          |          |          |          |   yes
|
+---------------+----------+----------+----------+----------+---------
-+
```

Also: `'isspace()'` checks for `'[ \t\n\r\f\v\x1c-\x1f\x85\u2000…]'`.

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.
```

- **Argument 'new' can be a function that accepts a Match object and returns a string.**
- **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 (`'\1'` returns a character with octal code 1).**
- **Add `'?'` after `'*'` and `'+'` to make them non-greedy.**

Match Object

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

Special Sequences

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

- **By default, decimal characters, alphanumerics and whitespaces from all alphabets are matched unless `'flags=re.ASCII'` argument is used.**
- **As shown above, it restricts all special sequence matches to the first 128 characters and prevents `'\s'` from accepting `'[\x1c-\x1f]'` (the so-called separator characters).**
- **Use a capital letter for negation (all non-ASCII characters will be matched when used in combination with ASCII flag).**

Format

```
<str> = f'{<el_1>}, {<el_2>}'            # Curly brackets can also
contain expressions.
<str> = '{}, {}'.format(<el_1>, <el_2>)  # Or: '{0},
{a}'.format(<el_1>, a=<el_2>)
<str> = '%s, %s' % (<el_1>, <el_2>)      # Redundant and inferior C
style formatting.
```

Attributes

```
>>> Person = collections.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>'
```

- **Options can be generated dynamically: `f'{<el>:{<str/int>}[…]}'`.**
- **Adding `'!r'` before the colon converts object to string by calling its repr() method.**

Strings

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

Numbers

```
{123456:10}                              # '    123456'
{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'`.**
- **This rule only effects numbers that can be represented exactly by a float (`.5`, `.25`, …).**

Ints

```
{90:c}                                   # 'Z'
{90:b}                                   # '1011010'
{90:X}                                   # '5A'
```

Numbers

```
<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 are stored exactly, unlike most floats where `'1.1 + 2.2 != 3.3'`.**
- **Floats can be compared with: `'math.isclose(<float>, <float>)'`.**
- **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, quantiles, 
groupby
```

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(<sequence>)             # Keeps the sequence 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 (0b1100 & 0b1010 ==
0b1000).
<int> = <int> | <int>                    # Or  (0b1100 | 0b1010 ==
0b1110).
<int> = <int> ^ <int>                    # Xor (0b1100 ^ 0b1010 ==
0b0110).
<int> = <int> << n_bits                  # Left shift. Use >> 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)               # Only accepts valid dates
from 1 to 9999 AD.
<T>  = time(hour=0, minute=0, second=0)     # Also: `microsecond=0,
tzinfo=None, fold=0`.
<DT> = datetime(year, month, day, hour=0)   # Also: `minute=0,
second=0, microsecond=0, …`.
<TD> = timedelta(weeks=0, days=0, hours=0)  # Also: `minutes=0,
seconds=0, microsecond=0`.
```

- **Use `'<D/DT>.weekday()'` to get the day of the week as an int, with Monday being 0.**
- **`'fold=1'` means the second pass in case of time jumping back for one hour.**
- **Timedelta normalizes arguments to ±days, seconds (< 86 400) and microseconds (< 1M).**

Now

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

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

Timezone

```
<tzinfo> = UTC                             # UTC timezone. London
without DST.
<tzinfo> = tzlocal()                       # Local timezone. Also
gettz().
<tzinfo> = gettz('<Continent>/<City>')     # 'Continent/City_Name'
timezone or None.
<DTa>    = <DT>.astimezone(<tzinfo>)       # Datetime, converted to
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.mmmuuu[±HH:MM]'`, or both separated by an arbitrary character. All parts following hours are optional.**
- **Python uses the Unix Epoch: `'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 aware datetime.
```

Format

```
>>> dt = datetime.strptime('2015-05-14 23:39:00.00 +2000', '%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"
```

- **`'%Z'` only accepts `'UTC/GMT'` and local timezone's code. `'%z'` also accepts `'±HH:MM'`.**
- **For abbreviated weekday and month use `'%a'` and `'%b'`.**

Arithmetics

```
<D/DT>   = <D/DT>  ± <TD>                   # Returned datetime can
fall into missing hour.
<TD>     = <D/DTn> - <D/DTn>                # Returns the difference,
ignoring time jumps.
<TD>     = <DTa>   - <DTa>                  # Ignores time jumps if
they share tzinfo object.
<TD>     = <TD>    * <real>                 # Also: <TD> = abs(<TD>)
and <TD> = <TD> ±% <TD>.
<float>  = <TD>    / <TD>                   # How many weeks/years
there are in TD. Also //.
```

Arguments

Inside Function Call

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

Inside Function Definition

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

- **Default values are evaluated when function is first encountered in the scope.**
- **Any mutation of a mutable default value will persist between invocations.**

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)
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(**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)
```

Other Uses

```
<list>  = [*<coll.> [, ...]]    # Or: list(<collection>) [+ ...]
<tuple> = (*<coll.>, [...])     # Or: tuple(<collection>) [+ ...]
<set>   = {*<coll.> [, ...]}    # Or: set(<collection>) [| ...]
<dict>  = {**<dict> [, ...]}    # Or: dict(**<dict> [, ...])
```

```
head, *body, tail = <coll.>     # Head or tail can be omitted.
```

Inline

Lambda

```
<func> = lambda: <return_value>                     # A single
statement function.
<func> = lambda <arg_1>, <arg_2>: <return_value>    # Also accepts
default arguments.
```

Comprehensions

```
<list> = [i+1 for i in range(10)]                   # Or: [1, 2, ...,
10]
<iter> = (i for i in range(10) if i > 5)            # Or: iter([6, 7,
8, 9])
<set>  = {i+5 for i in range(10)}                   # Or: {5, 6, ...,
14}
<dict> = {i: i*2 for i in range(10)}                # Or: {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))            # Or: iter([1, 2,
..., 10])
<iter> = filter(lambda x: x > 5, range(10))         # Or: iter([6, 7,
8, 9])
<obj>  = reduce(lambda out, x: out + x, range(10))  # Or: 45
```

Reduce must be imported from the functools module.

Any, All

```
<bool> = any(<collection>)                          # Is `bool(el)`
True for any element.
<bool> = all(<collection>)                          # Is True for all
elements or empty.
```

Conditional Expression

```
<obj> = <exp> if <condition> else <exp>             # Only one
expression gets evaluated.
```

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

Named Tuple, Enum, Dataclass

```
from collections import namedtuple
Point = namedtuple('Point', 'x y')                  # Creates a
tuple's subclass.
point = Point(0, 0)                                 # Returns its
instance.
```

```
from enum import Enum
Direction = Enum('Direction', 'n e s w')            # Creates an enum.
direction = Direction.n                             # Returns its
member.
```

```
from dataclasses import make_dataclass
Player = make_dataclass('Player', ['loc', 'dir'])   # Creates a class.
player = Player(point, direction)                   # Returns its
instance.
```

Imports

```
import <module>            # Imports a built-in or '<module>.py'.
import <package>           # Imports a built-in or
'<package>/__init__.py'.
import <package>.<module>  # Imports a built-in or
'<package>/<module>.py'.
```

- **Package is a collection of modules, but it can also define its own objects.**
- **On a filesystem this corresponds to a directory of Python files with an optional init script.**
- **Running `'import <package>'` does not automatically provide access to the package's modules unless they are explicitly imported in its init script.**

Closure

We have/get 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.**
- **It can be any callable, but is usually implemented as a function that returns a closure.**

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

Debugger Example

Decorator that prints function's name every time the function is 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)
```

- **Default size of the cache is 128 values. Passing `'maxsize=None'` makes it unbounded.**
- **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
```

> **Using only `'@debug'` to decorate the add() function would not work here, because debug would then receive the add() function as a 'print_result' argument. Decorators can however manually check if the argument they received is a function and act accordingly.**

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().**
- **Methods decorated with `'@staticmethod'` do not receive 'self' nor 'cls' as their first arg.**

Str() use cases:

```
print(<el>)
f'{<el>}'
logging.warning(<el>)
csv.writer(<file>).writerow([<el>])
raise Exception(<el>)
```

Repr() use cases:

```
print/str/repr([<el>])
f'{<el>!r}'
Z = dataclasses.make_dataclass('Z', ['a']); print/str/repr(Z(<el>))
>>> <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 or an attribute:

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

Property

Pythonic way of implementing getters and setters.

```
class Person:
    @property
    def name(self):
        return ' '.join(self._name)

    @name.setter
    def name(self, value):
        self._name = value.split()
```

```
>>> person = Person()
>>> person.name = '\t Guido  van Rossum \n'
>>> person.name
'Guido van Rossum'
```

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. Its 'default_factory' argument can be any callable.**
- **For attributes of arbitrary type use `'typing.Any'`.**

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>])
```

Rest of type annotations (CPython interpreter ignores them all):

```
def func(<arg_name>: <type> [= <obj>]) -> <type>: ...
<var_name>: typing.List/Set/Iterable/Sequence/Optional[<type>]
<var_name>: typing.Dict/Tuple/Union[<type>, ...]
```

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. False is returned if both return NotImplemented.**
- **Ne() automatically works on any object that has eq() defined.**

```
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 and the rest will be automatically generated.**
- **Functions sorted() and min() only require lt() method, while max() only requires gt(). However, it is best to define them all so that confusion doesn't arise in other contexts.**
- **When two lists, strings or dataclasses are compared, their values get compared in order until a pair of unequal values is found. The comparison of this two values is then returned. The shorter sequence is considered smaller in case of all values being equal.**

```
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(). Len() should return the number of items.**
- **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'. The only drawback of this decision is that a reader could think a certain function doesn't accept iterators when it does, since iterators are the only built-in objects that are iterable but are not collections.**

```
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 the passed 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)
```

Discrepancies between glossary definitions and abstract base classes:

- **Glossary defines iterable as any object with iter() or getitem() and sequence as any object with getitem() and len(). It does not define collection.**
- **Passing ABC Iterable to isinstance() or issubclass() checks whether object/class has method iter(), while ABC Collection checks for iter(), contains() and len().**

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. It however recognizes list, tuple, range, str, bytes, bytearray, memoryview and deque, because they are registered as Sequence's virtual subclasses.**

```
from collections import abc

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

Table of required and automatically available special methods:

```
+------------+------------+------------+------------+--------------+
|            |  Iterable  | Collection |  Sequence  | abc.Sequence |
+------------+------------+------------+------------+--------------+
| iter()     |    REQ     |    REQ     |    Yes     |     Yes      |
| contains() |    Yes     |    Yes     |    Yes     |     Yes      |
| len()      |            |    REQ     |    REQ     |     REQ      |
| getitem()  |            |            |    REQ     |     REQ      |
| reversed() |            |            |    Yes     |     Yes      |
| index()    |            |            |            |     Yes      |
| count()    |            |            |            |     Yes      |
+------------+------------+------------+------------+--------------+
```

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

Enum

```
from enum import Enum, auto
```

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

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

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

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

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

Inline

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

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

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

> **Member names are in all caps because trying to access a member that is named after a reserved keyword raises SyntaxError.**

Exceptions

```
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 (unless a signal is received).**

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).**
- **Use `'logging.exception(<message>)'` to log the exception.**

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)
traceback = ''.join(traceback.format_tb(<name>.__traceback__))
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                    # User-defined exceptions should be
derived from this class.
      +-- ArithmeticError         # Base class for arithmetic errors.
      |    +-- ZeroDivisionError  # Raised when dividing by zero.
      +-- AssertionError          # Raised by `assert <exp>` if
expression returns false value.
      +-- 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 missing.
      +-- MemoryError             # Out of memory. Could be too late
to start deleting vars.
      +-- NameError               # Raised when an object is missing.
      +-- 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
into 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 |            |  KeyError  |
| pop()     | IndexError |  KeyError  |  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/ctrl-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 that will be displayed in help message.**
- **Use `'default=<el>'` to set the default value.**
- **Use `'type=FileType(<mode>)'` for files. Accepts 'encoding', but 'newline' is None.**

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 every '\n', '\r' and '\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 (`'br'`, `'bw'`, `'bx'`, …).

Exceptions

- `'FileNotFoundError'` 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/bytes 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. Runs every
4096/8192 B.
```

> 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, scandir
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()
```

```
<stat> = os.stat(<path>)            # Or: <DirEntry/Path>.stat()
<real> = <stat>.st_mtime/st_size/…  # Modification time, size in
bytes, …
```

DirEntry

Unlike listdir(), scandir() returns DirEntry objects that cache isfile, isdir and on Windows also stat information, thus significantly increasing the performance of code that requires it.

```
<iter> = scandir(path='.')          # Returns DirEntry objects located
at path.
<str>  = <DirEntry>.path            # Returns whole path as a string.
<str>  = <DirEntry>.name            # Returns final component as a
string.
<file> = open(<DirEntry>)           # Opens the file and returns a
file object.
```

Path Object

```
from pathlib import Path
```

```
<Path> = Path(<path> [, ...])       # Accepts strings, Paths and
DirEntry objects.
<Path> = <path> / <path> [/ ...]    # First or second path 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
(absolute).
<Path> = Path(__file__).resolve()   # Returns script's path if cwd
wasn't changed.
```

```
<Path> = <Path>.parent              # Returns Path without the 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 directory 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>)               # Also
<Path>.read/write_text/bytes().
```

OS Commands

```
import os, shutil, subprocess
```

```
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 path's dirs. Also:
`exist_ok=False`.
```

```
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.
```

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

Shell Commands

```
<pipe> = os.popen('<command>')   # Executes command in sh/cmd and
returns its stdout pipe.
<str>  = <pipe>.read(size=-1)    # Reads 'size' chars or until EOF.
Also readline/s().
<int>  = <pipe>.close()          # Closes the pipe. Returns None on
success, int on error.
```

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

```
>>> subprocess.run('bc', input='1 + 1\n', capture_output=True,
text=True)
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')
>>> subprocess.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>)    # Converts object to JSON string.
<object> = json.loads(<str>)       # Converts JSON string to object.
```

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 Python objects.

```
import pickle
<bytes>  = pickle.dumps(<object>)  # Converts object to bytes object.
<object> = pickle.loads(<bytes>)   # Converts bytes object to object.
```

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 a list of remaining
rows.
```

- **File must be opened with a `'newline=""'` argument, or newlines embedded inside quoted fields will not be interpreted correctly!**
- **To print the spreadsheet to the console use Tabulate library.**
- **For XML and binary Excel files (xlsx, xlsm and xlsb) use Pandas library.**

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. String or a Dialect object.**
- `'delimiter'` **- A one-character string used to separate fields.**
- `'quotechar'` **- Character for quoting fields that contain special characters.**
- `'doublequote'` **- Whether quotechars inside fields are/get doubled or escaped.**

- `'skipinitialspace'` - **Is space character at the start of the field stripped by the reader.**
- `'lineterminator'` - **How writer terminates rows. Reader is hardcoded to '\n', '\r', '\r\n'.**
- `'quoting'` - **0: As necessary, 1: All, 2: All but numbers which are read as floats, 3: None.**
- `'escapechar'` - **Character for escaping quotechars 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, dialect='excel'):
    with open(filename, encoding='utf-8', newline='') as file:
        return list(csv.reader(file, dialect))
```

Write Rows to CSV File

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

SQLite

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

Placeholders

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

```
<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

Values are not actually saved in this example 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 an 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='little/big',
signed=False`.
<bytes> = bytes.fromhex('<hex>')            # Hex pairs can be
separated by whitespaces.
```

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='little/big',
signed=False`.
'<hex>' = <bytes>.hex()                     # Returns hex pairs.
Accepts `sep=<str>`.
```

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, byte order, and alignment rules are used by default.**

```
from struct import pack, unpack
<bytes> = pack('<format>', <el_1> [, ...])  # Packages arguments into
bytes object.
<tuple> = unpack('<format>', <bytes>)       # Use iter_unpack() for
iterator of tuples.
```

```
>>> 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 and manual alignment (padding) start format string with:

- `'='` - System's byte order (usually little-endian).
- `'<'` - Little-endian.
- `'>'` - Big-endian (also `'!'`).

Besides numbers, pack() and unpack() also support bytes objects as part of the sequence:

- `'c'` - A bytes object with a single element. For pad byte use `'x'` .
- `'<n>s'` - A bytes object with n elements.

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

- `'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.

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

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.**
- **Byte order is always determined by the system.**

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

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

Deque

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

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

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

Threading

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

```
from threading import Thread, RLock, Semaphore, Event, Barrier
from concurrent.futures import ThreadPoolExecutor
```

Thread

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

- **Use `'kwargs=<dict>'` to pass keyword arguments to the function.**

- **Use `'daemon=True'`, or the program will not be able to exit while the thread is alive.**

Lock

```
<lock> = RLock()                               # Lock that can only be
released by acquirer.
<lock>.acquire()                               # Waits for the lock to
be available.
<lock>.release()                               # Makes the lock
available again.
```

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.**
- **An object with the same interface called ProcessPoolExecutor provides true parallelism by running a separate interpreter in each process. All arguments must be pickable.**

```
<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.

```
import operator as op
<el>      = op.add/sub/mul/truediv/floordiv/mod(<el>, <el>)  # +, -,
*, /, //, %
<int/set> = op.and_/or_/xor(<int/set>, <int/set>)            # &, |, ^
<bool>    = op.eq/ne/lt/le/gt/ge(<sortable>, <sortable>)     # ==, !=,
<, <=, >, >=
<func>    = op.itemgetter/attrgetter/methodcaller(<obj>)     #
[index/key], .name, .name()
```

```
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>)
first_element    = op.methodcaller('pop', 0)(<list>)
```

- **Binary operators require objects to have and(), or(), xor() and invert() special methods, unlike logical operators that work on all types of objects.**
- **Also: `'<bool> = <bool> &|^ <bool>'` and `'<int> = <bool> &|^ <int>'`.**

Introspection

Inspecting code at runtime.

Variables

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

Attributes

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

Parameters

```
<Sig>  = inspect.signature(<function>)     # Function's Signature
object.
<dict> = <Sig>.parameters                  # Dict of Parameter
objects.
<memb> = <Param>.kind                      # Member of ParameterKind
enum.
<obj>  = <Param>.default                   # Default value or
<Param>.empty.
<type> = <Param>.annotation                # Type or <Param>.empty.
```

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>', <tuple_of_parents>,
<dict_of_class_attributes>)
```

```
>>> 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.
```

```
+-------------+-------------+
|   Classes   | Metaclasses |
+-------------+-------------|
|   MyClass --> MyMetaClass |
|             |     v       |
|    object -----> type <+  |
|             |     ^ +--+  |
|     str ----------+       |
+-------------+-------------+
```

Inheritance Diagram

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

```
+-------------+-------------+
|   Classes   | Metaclasses |
+-------------+-------------|
|   MyClass   | MyMetaClass |
|      v      |     v       |
|    object <----- type     |
|      ^      |             |
|     str     |             |
+-------------+-------------+
```

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, curses.textpad, enum, random

P = collections.namedtuple('P', 'x y')         # Position
D = enum.Enum('D', 'n e s w')                  # Direction
W, H = 15, 7                                   # Width, Height

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(W//2, H//2) 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),
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.triangular(0.01, 0.65))

async def human_controller(screen, moves):
    while True:
        ch = screen.getch()
        key_mappings = {258: D.s, 259: D.n, 260: D.w, 261: D.e}
        if ch in key_mappings:
            moves.put_nowait(('*', key_mappings[ch]))
        await asyncio.sleep(0.005)

async def model(moves, state):
    while state['*'] not in (state[id_] for id_ in range(10)):
        id_, d = await moves.get()
        x, y   = state[id_]
        deltas = {D.n: P(0, -1), D.e: P(1, 0), D.s: P(0, 1), D.w:
P(-1, 0)}
        state[id_] = P((x + deltas[d].x) % W, (y + deltas[d].y) % H)

async def view(state, screen):
    offset = P(curses.COLS//2 - W//2, curses.LINES//2 - H//2)
    while True:
        screen.erase()
        curses.textpad.rectangle(screen, offset.y-1, offset.x-1,
offset.y+H, offset.x+W)
        for id_, p in state.items():
            screen.addstr(offset.y + (p.y - state['*'].y + H//2) % H,
                          offset.x + (p.x - state['*'].x + W//2) % W,
str(id_))
        await asyncio.sleep(0.005)
```

```
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 = 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_DOWN, KEY_UP,
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.erase()
        for y, filename in enumerate(paths[first : first+height]):
            screen.addstr(y, 0, filename, 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.')           # Logs to file/s and
prints to stderr.
```

> **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, os, 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
    filename   = os.path.basename(logo_url)
    with open(filename, 'wb') as file:
        file.write(logo)
    print(f'{python_url}, {version},
file://{os.path.abspath(filename)}')
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/<filename>')
def send_file(filename):
    return static_file(filename, root='img_dir/')
```

Dynamic Request

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

REST Request

```
@post('/<sport>/odds')
def send_json(sport):
    team = request.forms.get('team')
    response.headers['Content-Type'] = 'application/json'
    response.headers['Cache-Control'] = 'no-cache'
    return json.dumps({'team': team, 'odds': [2.09, 3.74, 3.68]})
```

Test:

```
# $ pip3 install requests
>>> import threading, requests
>>> threading.Thread(target=run, daemon=True).start()
>>> url = 'http://localhost:8080/football/odds'
>>> request_data = {'team': 'arsenal f.c.'}
>>> response = requests.post(url, data=request_data)
>>> response.json()
{'team': 'arsenal f.c.', 'odds': [2.09, 3.74, 3.68]}
```

Profiling

Stopwatch

```
from time import perf_counter
start_time = perf_counter()
...
duration_in_seconds = 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      a = [*range(10000)]
     4      1   1231.0   1231.0     56.3      b = {*range(10000)}
```

```
$ python3 -m memory_profiler test.py
Line #         Mem usage      Increment   Line Contents
=======================================================
     1        37.668 MiB     37.668 MiB   @profile
     2                                    def main():
     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 the call graph with highlighted bottlenecks:

```
# $ pip3 install pycallgraph2; apt/brew install graphviz
import pycallgraph2 as cg, datetime

filename = f'profile-{datetime.datetime.now():%Y%m%d_%H%M%S}.png'
drawer = cg.output.GraphvizOutput(output_file=filename)
with cg.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/list_of_lists>)               # Returns
1d/2d NumPy array.
<array> = np.zeros/ones(<shape>)                       # Also
np.full(<shape>, <el>).
<array> = np.arange(from_inc, to_exc, ±step)           # Also
np.linspace(start, stop, num).
<array> = np.random.randint(from_inc, to_exc, <shape>)  # Also
np.random.random(<shape>).
```

```
<view>  = <array>.reshape(<shape>)                     # Also
`<array>.shape = <shape>`.
<array> = <array>.flatten()                            # Collapses
array into one dimension.
<view>  = <array>.squeeze()                            # Removes
dimensions of length one.
```

```
<array> = <array>.sum/min/mean/var/std(axis)           # Passed
dimension gets aggregated.
<array> = <array>.argmin(axis)                         # Returns
indexes of smallest elements.
<array> = np.apply_along_axis(<func>, axis, <array>)    # Func can
return a scalar or array.
```

- **Shape is a tuple of dimension sizes. A 100x50 RGB image has shape (50, 100, 3).**
- **Axis is an index of the dimension that gets aggregated. Leftmost dimension has index 0. Summing the RGB image along axis 2 will return a greyscale image with shape (50, 100).**
- **Passing a tuple of axes will chain the operations like this: `'<array>.<method>(axis_1, keepdims=True).<method>(axis_2).squeeze()'`.**

Indexing

```
<el>       = <2d_array>[row_index, column_index]        # <3d_a>
[table_i, row_i, column_i]
<1d_view>  = <2d_array>[row_index]                      # <3d_a>
[table_i, row_i]
<1d_view>  = <2d_array>[:, column_index]                # <3d_a>
[table_i, :, column_i]
```

```
<1d_array> = <2d_array>[row_indexes, column_indexes]    # <3d_a>
[table_is, row_is, column_is]
<2d_array> = <2d_array>[row_indexes]                    # <3d_a>
[table_is, row_is]
<2d_array> = <2d_array>[:, column_indexes]              # <3d_a>
[table_is, :, column_is]
```

```
<2d_bools> = <2d_array> ><== <el>                       # <3d_array> >
<== <1d_array>
<1d_array> = <2d_array>[<2d_bools>]                     # <3d_array>
[<2d_bools>]
```

> **All examples also allow assignments.**

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],                         # Shape: (3,
3) <- !
         [0.6,  0.6,  0.6],
         [0.8,  0.8,  0.8]]

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

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 flattened
sequence of pixels.
<Image>.putdata(<list/ImagingCore>)              # Writes a flattened
sequence of pixels.
<Image>.paste(<Image>, (x, y))                   # Writes passed image
to the image.
```

```
<2d_array> = np.array(<Image_L>)                 # Creates NumPy array
from greyscale image.
<3d_array> = np.array(<Image_RGB/A>)             # Creates NumPy array
from color image.
<Image>    = Image.fromarray(np.uint8(<array>))  # Use <array>.clip(0,
255) to clip the values.
```

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
n_pixels = WIDTH * HEIGHT
hues = (255 * i/n_pixels for i in range(n_pixels))
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))                         # Truncates floats
into ints.
<ImageDraw>.line((x1, y1, x2, y2 [, ...]))        # To get anti-
aliasing use Image's resize().
<ImageDraw>.arc((x1, y1, x2, y2), deg1, deg2)     # Always draws in
clockwise direction.
<ImageDraw>.rectangle((x1, y1, x2, y2))           # To rotate use
Image's rotate() and paste().
<ImageDraw>.polygon((x1, y1, x2, y2, ...))        # Last point gets
connected to the first.
<ImageDraw>.ellipse((x1, y1, x2, y2))             # To rotate use
Image's rotate() and paste().
```

- **Use `'fill=<color>'` to set the primary color.**
- **Use `'width=<int>'` to set the width of lines or contours.**
- **Use `'outline=<color>'` to set the color of the contours.**
- **Color can be an int, tuple, `'#rrggbb[aa]'` string or a color name.**

Animation

Creates a GIF of a bouncing ball:

```
# $ pip3 install imageio
from PIL import Image, ImageDraw
import imageio

WIDTH, HEIGHT, R = 126, 126, 10
frames = []
for velocity in range(1, 16):
    y = sum(range(velocity))
    frame = Image.new('L', (WIDTH, HEIGHT))
    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 byte, 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 |
+-----------+-----------+------+-----------+
```

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 440 Hz 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 itertools as it, math, struct, simpleaudio

F  = 44100
P1 = '71♩,69♪,,71♩,66♪,,62♩,66♪,,59♩,,'
P2 =
'71♩,73♪,,74♩,73♪,,74♪,,71♪,,73♩,71♪,,73♪,,69♪,,71♩,69♪,,71♪,,67♪,,

get_pause   = lambda seconds: it.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 '♩' in note else
1/8)
get_samples = lambda note: get_wave(*parse_note(note)) if note else
get_pause(1/8)
samples_f   = it.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

```
# $ 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 ch, is_pressed in enumerate(pg.key.get_pressed()):
        rect = rect.move(deltas[ch]) if ch 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. Same.
<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 rectangles.
```

Surface

Object for representing images.

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

```
<Surf>.fill(color)                              # Tuple,
Color('#rrggbb[aa]') 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, ...
<Surf> = scale(<Surf>, (width, height))         # Returns scaled
surface.
<Surf> = rotate(<Surf>, anticlock_degrees)      # Returns rotated and
scaled surface.
<Surf> = flip(<Surf>, x_bool, y_bool)           # Returns flipped
surface.
```

```
from pygame.draw import line, ...
line(<Surf>, color, (x1, y1), (x2, y2), width)  # Draws a line to the
surface.
arc(<Surf>, color, <Rect>, from_rad, to_rad)    # Also:
ellipse(<Surf>, color, <Rect>, width=0)
rect(<Surf>, color, <Rect>, width=0)            # Also:
polygon(<Surf>, color, points, width=0)
```

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
W, H, MAX_S = 50, 50, P(5, 10)                  # Width, Height, Max
speed

def main():
    def get_screen():
        pg.init()
        return pg.display.set_mode((W*16, H*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():
        border = [(x, y) for x in range(W) for y in range(H) if x in
[0, W-1] or y in [0, H-1]]
        platforms = [(randint(1, W-2), randint(2, H-2)) for _ in
range(W*H // 10)]
        return [get_rect(x, y) for x, y in border + platforms]
    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(ch) for ch, is_prsd in
enumerate(pg.key.get_pressed()) if is_prsd}
        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 > 0) - (x < 0)
    y += 1 if D.s not in get_boundaries(mario.rect, tiles) else (D.n
in pressed) * -10
    mario.spd = P(x=max(-MAX_S.x, min(MAX_S.x, x)), y=max(-MAX_S.y,
min(MAX_S.y, 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).collidelist(tiles) != -1}

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

def draw(screen, images, mario, tiles, pressed):
    def get_marios_image_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_marios_image_index() + mario.facing_left *
9], mario.rect)
    for t in tiles:
        screen.blit(images[18 if t.x in [0, (W-1)*16] or t.y in [0,
(H-1)*16] else 19], t)
    pg.display.flip()

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

Pandas

```
# $ pip3 install pandas matplotlib
import pandas as pd
from pandas import Series, DataFrame
import matplotlib.pyplot as plt
```

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.
```

```
<Sr>.plot.line/area/bar/pie/hist()          # Generates a
Matplotlib plot.
plt.show()                                  # Displays the plot.
Also plt.savefig(<path>).
```

Series — Aggregate, Transform, Map:

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

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

```
+-----------------+-------------+-------------+---------------+
|                 |    'sum'    |   ['sum']   | {'s': 'sum'}  |
+-----------------+-------------+-------------+---------------+
| sr.apply(…)     |      3      |    sum  3   |     s  3      |
| sr.agg(…)       |             |             |               |
+-----------------+-------------+-------------+---------------+
```

```
+-----------------+-------------+-------------+---------------+
|                 |    'rank'   |   ['rank']  | {'r': 'rank'} |
+-----------------+-------------+-------------+---------------+
| sr.apply(…)     |             |      rank   |               |
| sr.agg(…)       |     x  1    |   x     1   |    r  x  1    |
| sr.transform(…) |     y  2    |   y     2   |       y  2    |
+-----------------+-------------+-------------+---------------+
```

> **Last result has a hierarchical index. Use `'<Sr>[key_1, key_2]'` to get its values.**

DataFrame

Table with labeled rows and columns.

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

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

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

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

```
<DF>    = <DF> ><== <el/Sr/DF>                 # Returns DF of bools.
Sr is treated as a row.
<DF>    = <DF> +-*/ <el/Sr/DF>                 # 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>.sort_index(ascending=True)      # Sorts rows by row
keys.
<DF>    = <DF>.sort_values(column_key/s)       # Sorts rows by the
passed column/s.
```

DataFrame — 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         |
+------------------------+---------------+------------+------------+--
------------------------+
| l.merge(r, on='y',     |    x   y   z  | x   y   z  | x   y   z  |
Joins/merges on column.  |
|             how=…)     | 0  1   2   .  | 3   4   5  | 1   2   .  |
Also accepts left_on and |
|                        | 1  3   4   5  |            | 3   4   5  |
right_on parameters.     |
|                        | 2  .   6   7  |            |            |
Uses 'inner' by default. |
+------------------------+---------------+------------+------------+--
------------------------+
| l.join(r, lsuffix='l', |    x yl yr  z |            | x yl yr  z |
Joins/merges on row keys.|
|            rsuffix='r', | a  1  2  .  . | x yl yr  z | 1  2  .  . |
Uses 'left' by default.  |
|            how=…)      | b  3  4  4  5 | 3  4  4  5 | 3  4  4  5 |
If r is a Series, it is  |
|                        | c  .  .  6  7 |            |            |
treated as a column.     |
+------------------------+---------------+------------+------------+--
------------------------+
| pd.concat([l, r],      |    x   y   z  |     y      |            |
Adds rows at the bottom. |
|            axis=0,     | a  1   2   .  |     2      |            |
Uses 'outer' by default. |
|            join=…)     | b  3   4   .  |     4      |            | A
Series is treated as a |
|                        | b  .   4   5  |     4      |            |
column. Use l.append(sr) |
|                        | c  .   6   7  |     6      |            |
to add a row instead.    |
+------------------------+---------------+------------+------------+--
------------------------+
| pd.concat([l, r],      |    x  y  y  z |            |            |
Adds columns at the      |
|            axis=1,     | a  1  2  .  . | x  y  y  z |            |
right end. Uses 'outer'  |
|            join=…)     | b  3  4  4  5 | 3  4  4  5 |            |
by default. A Series is  |
|                        | c  .  .  6  7 |            |            |
treated as a column.     |
+------------------------+---------------+------------+------------+--
------------------------+
| l.combine_first(r)     |    x   y   z  |            |            |
Adds missing rows and    |
|                        | a  1   2   .  |            |            |
columns. Also updates    |
|                        | b  3   4   5  |            |            |
items that contain NaN.  |
|                        | c  .   6   7  |            |            | R
must be a DataFrame.   |
+------------------------+---------------+------------+------------+--
------------------------+
```

DataFrame — Aggregate, Transform, Map:

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

> **All operations operate on columns by default. Pass `'axis=1'` 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(…)     |             |       x  y  |               |
| df.agg(…)       |     x  4    |  sum  4  6  |     x  4      |
|                 |     y  6    |             |               |
+-----------------+-------------+-------------+---------------+
```

```
+-----------------+-------------+-------------+---------------+
|                 |    'rank'   |   ['rank']  | {'x': 'rank'} |
+-----------------+-------------+-------------+---------------+
| df.apply(…)     |      x  y   |      x    y |        x      |
| df.agg(…)       |   a  1  1   |   rank rank |     a  1      |
| df.transform(…) |   b  2  2   | a    1    1 |     b  2      |
|                 |             | b    2    2 |               |
+-----------------+-------------+-------------+---------------+
```

> **Use `'<DF>[col_key_1, col_key_2][row_key]'` to get the fifth result's values.**

DataFrame — Plot, Encode, Decode:

```
<DF>.plot.line/bar/hist/scatter/box()          # Also: `x=column_key,
y=column_key/s`.
plt.show()                                     # Displays the plot.
Also plt.savefig(<path>).
```

```
<DF> = pd.read_json/html('<str/path/url>')     # Run `$ pip3 install
beautifulsoup4 lxml`.
<DF> = pd.read_csv/pickle/excel('<path/url>')  # Use `sheet_name=None`
to get all Excel sheets.
<DF> = pd.read_sql('<table/query>', <conn.>)   # Accepts SQLite3 or
SQLAlchemy connection.
<DF> = pd.read_clipboard()                     # Reads a copied table
from the clipboard.
```

```
<dict> = <DF>.to_dict(['d/l/s/…'])             # Returns columns as
dicts, lists or series.
<str>  = <DF>.to_json/html/csv([<path>])       # Also
to_markdown/latex([<path>]).
<DF>.to_pickle/excel(<path>)                   # Run `$ pip3 install
openpyxl` for xlsx files.
<DF>.to_sql('<table_name>', <connection>)      # Accepts SQLite3 or
SQLAlchemy 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(6)
   x  y
b  4  5
c  7  8
```

```
<GB> = <DF>.groupby(column_key/s)              # Splits DF into groups
based on passed column.
<DF> = <GB>.apply(<func>)                      # Maps each group. Func
can return DF, Sr or el.
<GB> = <GB>[column_key]                        # Single column GB. All
operations return a Sr.
```

GroupBy — Aggregate, Transform, Map:

```
<DF> = <GB>.sum/max/mean/idxmax/all()          # Or: <GB>.agg(lambda
<Sr>: <el>)
<DF> = <GB>.rank/diff/cumsum/ffill()           # Or:
<GB>.transform(lambda <Sr>: <Sr>)
<DF> = <GB>.fillna(<el>)                       # Or:
<GB>.transform(lambda <Sr>: <Sr>)
```

```
>>> 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  |      x  y   |      x    y |        x
|
|                 |  z          |   a  1  1   |   rank rank |     a  1
|
|                 |  3   1   2  |   b  1  1   | a    1    1 |     b  1
|
|                 |  6  11  13  |   c  2  2   | b    1    1 |     c  2
|
|                 |             |             | c    2    2 |
|
+-----------------+-------------+-------------+-------------+---------
------+
| gb.transform(…) |      x   y  |      x  y   |             |
|
|                 |  a   1   2  |   a  1  1   |             |
|
|                 |  b  11  13  |   b  1  1   |             |
|
|                 |  c  11  13  |   c  2  2   |             |
|
+-----------------+-------------+-------------+-------------+---------
------+
```

Rolling

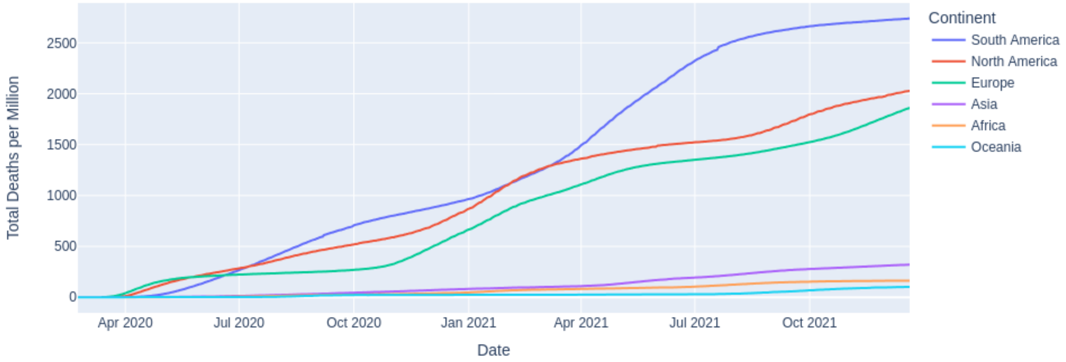
Object for rolling window calculations.

```
<RSr/RDF/RGB> = <Sr/DF/GB>.rolling(win_size)   # Also:
`min_periods=None, center=False`.
<RSr/RDF/RGB> = <RDF/RGB>[column_key/s]        # Or:
<RDF/RGB>.column_key
<Sr/DF>       = <R>.mean/sum/max()             # 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()
```

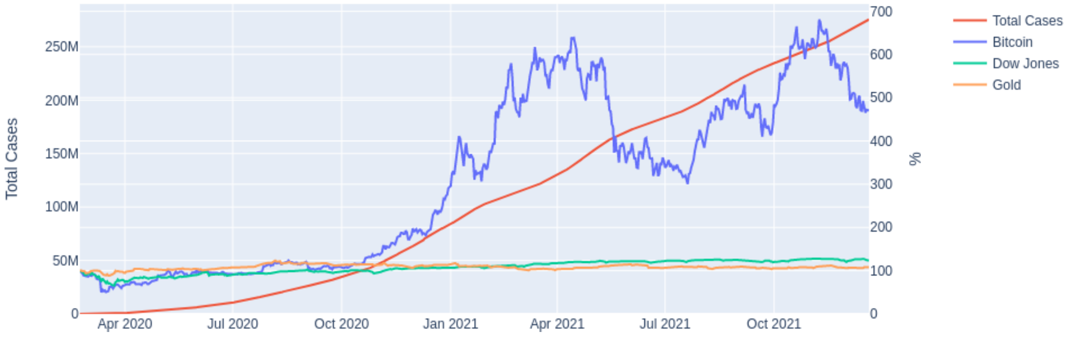
Covid deaths by continent:



```
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://gist.githubusercontent.com/stevewithington/20a69c

                         '846ea5d35e5fc47f26c/raw/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[df.date > '2020-03-14']
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:


Total Cases
250M
200M
150M
100M
50M
0
Apr 2020
Jul 2020
Oct 2020
Jan 2021
Apr 2021
Jul 2021
Oct 2021
700
600
500
400
300
200
100
0
%
Total Cases
Bitcoin
Dow Jones
Gold

```
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=9999999999&interval=1d&events=history'
        df = pd.read_csv(url, usecols=['Date', 'Close'])
        return df.set_index('Date').Close
    out = scrape_covid(), scrape_yahoo('BTC-USD'),
scrape_yahoo('GC=F'), scrape_yahoo('^DJI')
    return map(pd.Series.rename, out, ['Total Cases', 'Bitcoin',
'Gold', 'Dow Jones'])

def wrangle_data(covid, bitcoin, gold, dow):
    df = pd.concat([bitcoin, gold, dow], axis=1)  # Joins columns on
dates.
    df = df.sort_index().interpolate()            # Sorts by date and
interpolates NaN-s.
    df = df.loc['2020-02-23':]                    # Discards rows
before '2020-02-23'.
    df = (df / df.iloc[0]) * 100                  # Calculates
percentages relative to day 1.
    df = df.join(covid)                           # Adds column with
covid cases.
    return df.sort_values(df.index[-1], axis=1)   # Sorts columns by
last day's value.

def display_data(df):
    figure = go.Figure()
    for col_name in reversed(df.columns):
        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),
        height=450
    ).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 <ctype> <var_name> = <el>
cdef <ctype>[n_elements] <var_name> = [<el_1>, <el_2>, ...]
cdef <ctype/void> <func_name>(<ctype> <arg_name>): ...


cdef class <class_name>:
    cdef public <ctype> <attr_name>
    def __init__(self, <ctype> <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()
```