November 29, 2023 / Jure Šorn

Comprehensive Python Cheatsheet

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# Contents

# 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 `<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 if missing.
{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

```
import itertools as it
```

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

```
<iter> = it.chain(<coll>, <coll> [, ...])  # Empties collections in order (figuratively).
<iter> = it.chain.from_iterable(<coll>)    # Empties collections inside a collection in order.
```

```
<iter> = it.islice(<coll>, to_exclusive)   # Only returns first 'to_exclusive' elements.
<iter> = it.islice(<coll>, from_inc, …)    # `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	✓	✓	✓
dict, set	✓	✓	
iter	✓		

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

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

# String

Immutable sequence of characters.

```
<str>  = <str>.strip()                       # Strips all whitespace characters from both ends.
<str>  = <str>.strip('<chars>')              # Strips passed characters. Also lstrip/rstrip().
```

```
<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 the 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>.lower()                       # Changes the case. Also upper/capitalize/title().
<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.
```

- **Use `'unicodedata.normalize("NFC", <str>)'` on strings that may contain characters like `'Ö'` before comparing them, because they can be stored as one or two characters.**

Property Methods

```
<bool> = <str>.isdecimal()                   # Checks for [0-9].
<bool> = <str>.isdigit()                     # Checks for [²³¹] and isdecimal().
<bool> = <str>.isnumeric()                   # Checks for [¼½¾] and isdigit().
<bool> = <str>.isalnum()                     # Checks for [a-zA-Z] and isnumeric().
<bool> = <str>.isprintable()                 # Checks for [ !#$%…] and isalnum().
<bool> = <str>.isspace()                     # Checks for [ \t\n\r\f\v\x1c-\x1f\x85\xa0…].
```

# Regex

Functions for regular expression matching.

```
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)  # Add brackets around regex to include matches.
<Match> = re.search(<regex>, text)             # First occurrence of the pattern or None.
<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.**
- **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 `'.'` 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 the part inside first brackets.
<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.
```

Example

```
>>> Person = collections.namedtuple('Person', 'name height')
>>> person = Person('Jean-Luc', 187)
>>> f'{person.name} is {person.height / 100} meters tall.'
'Jean-Luc is 1.87 meters tall.'
```

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 `'='` to the expression prepends it to the output: `f'{1+1=}'` returns `'1+1=2'`.**
- **Adding `'!r'` to the expression 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%'

- **`'{<float>:g}'` is `'{<float>:.6}'` with stripped zeros, exponent starting at `'1e+06'`.**
- **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: <int/float>e±<int>
<complex>  = complex(real=0, imag=0)         # Or: <int/float> ± <int/float>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    # `<el> == nan` is always False.
from math import sin, cos, tan, asin, acos, atan  # Also: degrees, radians.
from math import log, log10, log2                 # Log can accept base as second arg.
```

Statistics

```
from statistics import mean, median, variance     # Also: stdev, quantiles, groupby.
```

Random

```
from random import random, randint, choice        # Also: shuffle, gauss, triangular, 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

```
import itertools as it
```

```
>>> list(it.product([0, 1], repeat=3))
[(0, 0, 0), (0, 0, 1), (0, 1, 0), (0, 1, 1),
 (1, 0, 0), (1, 0, 1), (1, 1, 0), (1, 1, 1)]
```

```
>>> list(it.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
```

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

```
>>> list(it.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
```

```
>>> list(it.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

Provides 'date', 'time', 'datetime' and 'timedelta' classes. All are immutable and hashable.

```
# pip3 install python-dateutil
from datetime import date, time, datetime, timedelta, timezone
from dateutil.tz import tzlocal, gettz
```

```
<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, microseconds=0`.
```

- **Aware `<a>` time and datetime objects have defined timezone, while naive `<n>` don't. If object is naive, it is presumed to be in the system's timezone!**
- **`'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).**
- **Use `'<D/DT>.weekday()'` to get the day of the week as an int, with Monday being 0.**

Now

```
<D/DTn>  = D/DT.today()                     # Current local date or naive DT. Also DT.now().
<DTa>    = DT.now(<tzinfo>)                 # Aware DT from current time in passed timezone.
```

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

Timezone

```
<tzinfo> = timezone.utc                     # London without daylight saving time (DST).
<tzinfo> = timezone(<timedelta>)            # Timezone with fixed offset from UTC.
<tzinfo> = tzlocal()                        # Local tz with dynamic offset. Also gettz().
<tzinfo> = gettz('<Continent>/<City>')      # 'Continent/City_Name' timezone or None.
<DTa>    = <DT>.astimezone([<tzinfo>])      # Converts DT to the passed or local fixed zone.
<Ta/DTa> = <T/DT>.replace(tzinfo=<tzinfo>)  # Changes object's timezone without conversion.
```

- **Timezones returned by gettz(), tzlocal(), and implicit local timezone of naive objects have offsets that vary through time due to DST and historical changes of the zone's base offset.**
- **Standard library's zoneinfo.ZoneInfo() can be used instead of gettz() on Python 3.9 and later. It requires 'tzdata' package on Windows. It doesn't return local tz if arg. is omitted.**

Encode

```
<D/T/DT> = D/T/DT.fromisoformat(<str>)      # 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(<float>)        # Local time DTn from seconds since the Epoch.
<DTa>    = DT.fromtimestamp(<float>, <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 the 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 of the object.
<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('2025-08-14 23:39:00.00 +0200', '%Y-%m-%d %H:%M:%S.%f %z')
>>> dt.strftime("%dth of %B '%y (%a), %I:%M %p %Z")
"14th of August '25 (Thu), 11:39 PM UTC+02:00"
```

- **`'%z'` accepts `'±HH[:]MM'` and returns `'±HHMM'` or empty string if datetime is naive.**
- **`'%Z'` accepts `'UTC/GMT'` and local timezone's code and returns timezone's name, `'UTC[±HH:MM]'` if timezone is nameless, or an empty string if datetime is naive.**

Arithmetics

```
<bool>   = <D/T/DTn> > <D/T/DTn>            # Ignores time jumps (fold attribute). Also ==.
<bool>   = <DTa>     > <DTa>                # Ignores time jumps if they share tzinfo object.
<TD>     = <D/DTn>   - <D/DTn>              # Ignores jumps. Convert to UTC for actual delta.
<TD>     = <DTa>     - <DTa>                # Ignores time jumps if they share tzinfo object.
<D/DT>   = <D/DT>    ± <TD>                 # Returned datetime can fall into missing hour.
<TD>     = <TD>      * <float>              # 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.

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

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

Legal argument combinations:

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

```python
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)
```

```python
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)
```

```python
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)
```

Other Uses

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

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

# Inline

Lambda

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

Comprehensions

```python
<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}
```

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

Map, Filter, Reduce

```python
from functools import 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
```

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)]      # `any([0, '', [], None]) == False`
['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>, ...])
```

```
>>> def multiply(a, b):
...     return a * b
>>> multiply_by_3 = partial(multiply, 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(<func>)'`, `'iter(<func>, to_exc)'` and dataclass's `'field(default_factory=<func>)'`.**

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.**

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

Debugger Example

Decorator that prints function's name every time the function is called.

```python
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.

```python
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.

```python
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.**

Expressions that call the str() method:

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

Expressions that call the repr() method:

```
print/str/repr([<el>])
print/str/repr({<el>: <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>: <type>
    <attr_name>: <type> = <default_value>
    <attr_name>: 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):

```
import collections.abc as abc, typing as tp
<var_name>: list/set/abc.Iterable/abc.Sequence/tp.Optional[<type>] [= <obj>]
<var_name>: dict/tuple/tp.Union[<type>, ...] [= <obj>]
def func(<arg_name>: <type> [= <obj>]) -> <type>: ...
```

Slots

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

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

Copy

```python
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.**

```python
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().**

```python
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.
- For proper alphabetical order pass `'key=locale.strxfrm'` to sorted() after running `'locale.setlocale(locale.LC_COLLATE, "en_US.UTF-8")'`.

```python
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 exception.
- Iter() should return 'self'.

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

```python
>>> 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>'`.

```python
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

- With statements only work with objects that have enter() and exit() special methods.
- 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.
- The exit() method can suppress the exception by returning 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 the 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 getitem() and len().
- 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 getitem() and len() defined.

```python
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, array, memoryview and deque, because they are registered as its virtual subclasses.

```python
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()	!	!	✓	✓
contains()	✓	✓	✓	✓
len()		!	!	!
getitem()			!	!
reversed()			✓	✓
index()				✓
count()				✓

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

# Enum

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

```python
class <enum_name>(Enum):
    <member_name> = auto()
    <member_name> = <value>
    <member_name> = <value>, <value>
```

- **Function auto() returns an increment of the last numeric value or 1.**
- **Accessing a member named after a reserved keyword causes SyntaxError.**
- **Methods receive the member they were called on as the 'self' argument.**

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

```python
<list>   = list(<enum>)                   # Returns enum's members.
<list>   = [a.name for a in <enum>]       # Returns enum's member names.
<list>   = [a.value for a in <enum>]      # Returns enum's member values.
<member> = random.choice(list(<enum>))    # Returns a random member.
```

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

Inline

```python
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:

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

# Exceptions

```python
try:
    <code>
except <exception>:
    <code>
```

Complex Example

```python
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).**
- **All variables that are initialized in executed blocks are also visible in all subsequent blocks, as well as outside the try/except clause (only function block delimits scope).**
- **To catch signals use `'signal.signal(signal_number, <func>)'`.**

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 passed message, followed by the full error message of the caught 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)
trace_str = ''.join(traceback.format_tb(<name>.__traceback__))
error_msg = ''.join(traceback.format_exception(type(<name>), <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 such as ZeroDivisionError.
      ├── AssertionError          # Raised by `assert <exp>` if expression returns false value.
      ├── AttributeError          # Raised when object doesn't have requested attribute/method.
      ├── EOFError                # Raised by input() when it hits an end-of-file condition.
      ├── LookupError             # Base class for errors when a collection can't find an item.
      │    ├── 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 nonexistent name (variable/func/class) is used.
      │    └── UnboundLocalError  # Raised when local name is used before it's being defined.
      ├── OSError                 # Errors such as FileExistsError/PermissionError (see #Open).
      │    └── ConnectionError    # Errors such as BrokenPipeError/ConnectionAbortedError.
      ├── RuntimeError            # Raised by errors that don't fall into other categories.
      │    ├── NotImplementedErr  # Can be raised by abstract methods or by unfinished code.
      │    └── 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 the wrong type.
      └── ValueError              # When argument has the right type but inappropriate value.
```

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 the wrong type!')
raise ValueError('Argument has the right type but an 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 the 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 the 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 argument's 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, not 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

```
import os, glob
from pathlib import Path
```

```
<str>  = os.getcwd()                # Returns the current working directory.
<str>  = os.path.join(<path>, ...)  # Joins two or more pathname components.
<str>  = os.path.realpath(<path>)   # Resolves symlinks and calls path.abspath().
```

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

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

```
<bool> = os.path.exists(<path>)     # Or: <Path>.exists()
<bool> = os.path.isfile(<path>)     # Or: <DirEntry/Path>.is_file()
<bool> = os.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> = os.scandir(path='.')       # Returns DirEntry objects located at the path.
<str>  = <DirEntry>.path            # Returns the 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

```
<Path> = Path(<path> [, ...])       # Accepts strings, Paths and DirEntry objects.
<Path> = <path> / <path> [/ ...]    # First or second path must be a Path object.
<Path> = <Path>.resolve()           # Returns absolute path with resolved symlinks.
```

```
<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. Permissions are 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.copy2(from, to)              # Also copies creation and modification time.
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 file 'to' even on Windows.
shutil.move(from, to)               # Rename() that moves into 'to' if it's a dir.
```

```
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. 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 (returncode 0).
```

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.**
- **Reader accepts any iterator of strings, not just files.**

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!
- Open existing file with `'mode="w"'` to overwrite it or `'mode="a"'` to append to it.

Parameters

- `'dialect'` - Master parameter that sets the default values. String or a 'csv.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', **params):
    with open(filename, encoding='utf-8', newline='') as file:
        return list(csv.reader(file, dialect, **params))
```

Write Rows to CSV File

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

# SQLite

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

```
import sqlite3
<conn> = sqlite3.connect(<path>)                # Opens existing or new file. Also ':memory:'.
<conn>.close()                                  # Closes the connection.
```

Read

```
<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

```
<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.
```

- **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.**

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)]
```

SqlAlchemy

```
# $ pip3 install sqlalchemy
from sqlalchemy import create_engine, text
<engine> = create_engine('<url>')               # Url: 'dialect://user:password@host/dbname'.
<conn>   = <engine>.connect()                   # Creates a connection. Also <conn>.close().
<cursor> = <conn>.execute(text('<query>'), …)   # Replaces ':<key>'s with keyword arguments.
with <conn>.begin(): ...                        # Exits the block with commit or rollback.
```

Dialect	pip3 install	import	Dependencies
mysql	mysqlclient	MySQLdb	www.pypi.org/project/mysqlclient
postgresql	psycopg2	psycopg2	www.pypi.org/project/psycopg2
mssql	pyodbc	pyodbc	www.pypi.org/project/pyodbc
oracle	oracledb	oracledb	www.pypi.org/project/oracledb

# 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='big/little', 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='big/little', 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 or raises struct.error.
<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 (struct always uses standard sizes):

- `'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. Type sizes and byte order are always determined by the system, however bytes of each element can be swapped with byteswap() method.

```
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 bytes-like 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.
```

```
<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='big/little', signed=False`.
'<hex>' = <mview>.hex()                        # Treats mview as a bytes object.
```

# Deque

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

```
from collections import deque
<deque> = deque(<collection>)                  # Also `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. 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, Timer, RLock, Semaphore, Event, Barrier
from concurrent.futures import ThreadPoolExecutor, as_completed
```

### 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.**
- **To delay thread execution use `'Timer(seconds, <func>)'` instead of Thread().**

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(), even on error.
```

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.
```

Queue

```
<Queue> = queue.Queue(maxsize=0)               # A thread-safe first-in-first-out queue.
<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.
```

Thread Pool Executor

```
<Exec> = ThreadPoolExecutor(max_workers=None)  # Or: `with ThreadPoolExecutor() as <name>: ...`
<iter> = <Exec>.map(<func>, <args_1>, ...)     # Multithreaded and non-lazy map(). Keeps order.
<Futr> = <Exec>.submit(<func>, <arg_1>, ...)   # Creates a thread and returns its Future obj.
<Exec>.shutdown()                              # Blocks until all threads finish executing.
```

```
<bool> = <Future>.done()                       # Checks if the thread has finished executing.
<obj>  = <Future>.result(timeout=None)         # Waits for thread to finish and returns result.
<bool> = <Future>.cancel()                     # Cancels or returns False if running/finished.
<iter> = as_completed(<coll_of_Futures>)       # Next() waits for next completed Future.
```

- **Map() and as_completed() also accept 'timeout' argument that causes TimeoutError if result isn't available in 'timeout' seconds after next() is called.**
- **Exceptions that happen inside threads are raised when next() is called on map's iterator or when result() is called on a Future. Its exception() method returns exception or None.**

- **ProcessPoolExecutor provides true parallelism, but everything sent to/from workers must be pickable. Queues must be sent using executor's 'initargs' and 'initializer' parameters.**

# Operator

Module of functions that provide the functionality of operators. Functions are ordered by operator precedence, starting with least binding.

```
import operator as op
<bool> = op.not_(<obj>)                                        # or, and, not (or/and missing)
<bool> = op.eq/ne/lt/le/gt/ge/contains/is_(<obj>, <obj>)       # ==, !=, <, <=, >, >=, in, is
<obj>  = op.or_/xor/and_(<int/set>, <int/set>)                 # |, ^, &
<int>  = op.lshift/rshift(<int>, <int>)                        # <<, >>
<obj>  = op.add/sub/mul/truediv/floordiv/mod(<obj>, <obj>)     # +, -, *, /, //, %
<num>  = op.neg/invert(<num>)                                  # -, ~
<num>  = op.pow(<num>, <num>)                                  # **
<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>)
first_element    = op.methodcaller('pop', 0)(<list>)
```

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

# Introspection

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

Attributes

```
<list> = dir(<object>)                     # Names of object's attributes (including 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 Parameter.empty.
<type> = <Param>.annotation                # Type or Parameter.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 its 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 ┃
┃             │     ↑       ┃
┃    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 ┃
┃      ↑      │      ↑      ┃
┃    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() start multiple coroutines 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:

```python
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):
    moves = asyncio.Queue()
    state = {'*': P(0, 0), **{id_: P(W//2, H//2) for id_ in range(10)}}
    ai    = [random_controller(id_, moves) for id_ in range(10)]
    mvc   = [human_controller(screen, moves), model(moves, state), view(state, screen)]
    tasks = [asyncio.create_task(cor) for cor in ai + mvc]
    await asyncio.wait(tasks, 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:
        key_mappings = {258: D.s, 259: D.n, 260: D.w, 261: D.e}
        if d := key_mappings.get(screen.getch()):
            moves.put_nowait(('*', d))
        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_))
        screen.refresh()
        await asyncio.sleep(0.005)

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

Libraries

# Progress Bar

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

# Plot

```
# $ pip3 install matplotlib
import matplotlib.pyplot as plt
plt.plot/bar/scatter(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 console:

```
# pip3 install windows-curses
import curses, os
from curses import A_REVERSE, KEY_DOWN, KEY_UP, KEY_LEFT, KEY_RIGHT, KEY_ENTER

def main(screen):
    ch, first, selected, paths = 0, 0, 0, os.listdir()
    while ch != ord('q'):
        height, width = screen.getmaxyx()
        screen.erase()
        for y, filename in enumerate(paths[first : first+height]):
            color = A_REVERSE if filename == paths[selected] else 0
            screen.addnstr(y, 0, filename, width-1, color)
        ch = screen.getch()
        selected += (ch == KEY_DOWN) - (ch == KEY_UP)
        selected = max(0, min(len(paths)-1, selected))
        first += (selected >= first + height) - (selected < first)
        if ch in [KEY_LEFT, KEY_RIGHT, KEY_ENTER, ord('\n'), ord('\r')]:
            new_dir = '..' if ch == KEY_LEFT else paths[selected]
            if os.path.isdir(new_dir):
                os.chdir(new_dir)
                first, selected, paths = 0, 0, os.listdir()

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

# Logging

```
import logging
```

```
logging.basicConfig(filename=<path>, level='DEBUG')  # Configures the root logger (see Setup).
logging.debug/info/warning/error/critical(<str>)     # Logs to the root logger.
<Logger> = logging.getLogger(__name__)               # Logger named after the module.
<Logger>.<level>(<str>)                              # Logs to the logger.
<Logger>.exception(<str>)                            # Calls error() with caught exception.
```

Setup

```
logging.basicConfig(
    filename=None,                                   # Logs to console (stderr) by default.
    format='%(levelname)s:%(name)s:%(message)s',     # Add '%(asctime)s' for local datetime.
    level=logging.WARNING,                           # Drops messages with lower priority.
    handlers=[logging.StreamHandler(sys.stderr)]     # Uses FileHandler if filename is set.
)
```

```
<Formatter> = logging.Formatter('<format>')          # Creates a Formatter.
<Handler> = logging.FileHandler(<path>, mode='a')    # Creates a Handler. Also `encoding=None`.
<Handler>.setFormatter(<Formatter>)                  # Adds Formatter to the Handler.
<Handler>.setLevel(<int/str>)                        # Processes all messages by default.
<Logger>.addHandler(<Handler>)                       # Adds Handler to the Logger.
<Logger>.setLevel(<int/str>)                         # What is sent to its/ancestor's handlers.
```

- **Parent logger can be specified by naming the child logger `'<parent>.<name>'`.**
- **If logger doesn't have a set level it inherits it from the first ancestor that does.**
- **Formatter also accepts: pathname, filename, funcName, lineno, thread and process.**
- **A `'handlers.RotatingFileHandler'` creates and deletes log files based on 'maxBytes' and 'backupCount' arguments.**

Creates a logger that writes all messages to file and sends them to the root's handler that prints warnings or higher:

```
>>> logger = logging.getLogger('my_module')
>>> handler = logging.FileHandler('test.log', encoding='utf-8')
>>> formatter = logging.Formatter('%(asctime)s %(levelname)s:%(name)s:%(message)s')
>>> handler.setFormatter(formatter)
>>> logger.addHandler(handler)
>>> logging.basicConfig(level='DEBUG')
>>> logging.root.handlers[0].setLevel('WARNING')
>>> logger.critical('Running out of disk space.')
CRITICAL:my_module:Running out of disk space.
>>> print(open('test.log').read())
2023-02-07 23:21:01,430 CRITICAL:my_module:Running out of disk space.
```

# Scraping

Scrapes Python's URL and logo from its Wikipedia page:

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

try:
    response   = requests.get('https://en.wikipedia.org/wiki/Python_(programming_language)')
    document   = bs4.BeautifulSoup(response.text, 'html.parser')
    table      = document.find('table', class_='infobox vevent')
    python_url = table.find('th', text='Website').next_sibling.a['href']
    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}, file://{os.path.abspath(filename)}')
except requests.exceptions.ConnectionError:
    print("You've got problems with connection.", file=sys.stderr)
```

# Web

Flask is a micro web framework/server. If you just want to open a html file in a web browser use `'webbrowser.open(<path>)'` instead.

```
# $ pip3 install flask
import flask
```

```
app = flask.Flask(__name__)
app.run(host=None, port=None, debug=None)
```

- **Starts the app at `'http://localhost:5000'`. Use `'host="0.0.0.0"'` to run externally.**
- **Install a WSGI server like Waitress and a HTTP server such as Nginx for better security.**
- **Debug mode restarts the app whenever script changes and displays errors in the browser.**

Static Request

```
@app.route('/img/<path:filename>')
def serve_file(filename):
    return flask.send_from_directory('dirname/', filename)
```

Dynamic Request

```
@app.route('/<sport>')
def serve_html(sport):
    return flask.render_template_string('<h1>{{title}}</h1>', title=sport)
```

- **Use `'render_template(filename, <kwargs>)'` to render file located in templates dir.**
- **To return an error code use `'abort(<int>)'` and to redirect use `'redirect(<url>)'`.**
- **`'request.args[<str>]'` returns parameter from the query string (URL part after '?').**
- **Use `'session[key] = value'` to store session data like username, etc.**

REST Request

```
@app.post('/<sport>/odds')
def serve_json(sport):
    team = flask.request.form['team']
    return {'team': team, 'odds': [2.09, 3.74, 3.68]}
```

Starts the app in its own thread and queries its REST API:

```
# $ pip3 install requests
>>> import threading, requests
>>> threading.Thread(target=app.run, daemon=True).start()
>>> url = 'http://localhost:5000/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

```
from time import perf_counter
start_time = perf_counter()
...
duration_in_seconds = perf_counter() - start_time
```

Timing a Snippet

```
>>> from timeit import timeit
>>> timeit('list(range(10000))', number=1000, globals=globals(), setup='pass')
0.19373
```

Profiling by Line

```
$ pip3 install line_profiler
$ echo '@profile
def main():
    a = list(range(10000))
    b = set(range(10000))
main()' > test.py
$ kernprof -lv test.py
Line #      Hits         Time  Per Hit   % Time  Line Contents
==============================================================
     1                                           @profile
     2                                           def main():
     3         1        253.4    253.4     32.2      a = list(range(10000))
     4         1        534.1    534.1     67.8      b = set(range(10000))
```

Call and Flame Graphs

```
$ pip3 install gprof2dot snakeviz; apt/brew install graphviz
$ tail -n 4 test.py > test.py
$ python3 -m cProfile -o test.prof test.py
$ gprof2dot -f pstats test.prof | dot -T png -o test.png; xdg-open/open test.png
$ snakeviz test.prof
```

Sampling and Memory Profilers

pip3 install	Type	Target	How to run	Live
pyinstrument	Sampling	CPU	pyinstrument test.py	×
py-spy	Sampling	CPU	py-spy top -- python3 test.py	✓
scalene	Sampling	CPU+Memory	scalene test.py	×
memray	Tracing	Memory	memray run --live test.py	✓

# 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 a 1d/2d/… NumPy array.
<array> = np.zeros/ones/empty(<shape>)                  # Also np.full(<shape>, <el>).
<array> = np.arange(from_inc, to_exc, ±step)            # Also np.linspace(start, stop, len).
<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()                             # Also `<view> = <array>.ravel()`.
<view>  = <array>.transpose()                           # Or: <array>.T
```

```
<array> = np.copy/abs/sqrt/log/int64(<array>)           # Returns new array of the same shape.
<array> = <array>.sum/max/mean/argmax/all(axis)         # Passed dimension gets aggregated.
<array> = np.apply_along_axis(<func>, axis, <array>)    # Func can return a scalar or array.
```

```
<array> = np.concatenate(<list_of_arrays>, axis=0)      # Links arrays along first axis (rows).
<array> = np.row_stack/column_stack(<list_of_arrays>)   # Treats 1d arrays as rows or columns.
<array> = np.tile/repeat(<array>, <int/list>)           # Tiles array or repeats its elements.
```

- **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).**

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]
<2d_view>  = <2d_array>[rows_slice, columns_slice]      # <3d_a>[table_i, rows_s, columns_s]
```

```
<2d_array> = <2d_array>[row_indexes]                    # <3d_a>[table_i/is, row_is]
<2d_array> = <2d_array>[:, column_indexes]              # <3d_a>[table_i/is, :, column_is]
<1d_array> = <2d_array>[row_indexes, column_indexes]    # <3d_a>[table_i/is, row_is, column_is]
<1d_array> = <2d_array>[row_indexes, column_index]      # <3d_a>[table_i/is, row_is, column_i]
```

```
<2d_bools> = <2d_array> > <el/1d/2d_array>              # 1d_array must have size of a row.
<1d/2d_a>  = <2d_array>[<2d/1d_bools>]                  # 1d_bools must have size of a column.
```

- **Indexes should not be tuples because Python converts `'obj[i, j]'` to `'obj[(i, j)]'`!**
- **`':'` returns a slice of all dimension's indexes. Omitted dimensions default to `':'`.**
- **Any value that is broadcastable to the indexed shape can be assigned to the selection.**

Broadcasting

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]]
```

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. ]]
>>> distances[range(3), range(3)] = 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, ImageFilter, ImageEnhance
```

```
<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 the default preview app.
```

```
<int/tuple> = <Image>.getpixel((x, y))            # Returns pixel's color.
<Image>.putpixel((x, y), <int/tuple>)             # Changes pixel's color.
<ImagingCore> = <Image>.getdata()                 # Returns a flattened view of all pixels.
<Image>.putdata(<list/ImagingCore>)               # Updates pixels with a copy of the sequence.
<Image>.paste(<Image>, (x, y))                    # Draws passed image at specified location.
```

```
<Image> = <Image>.filter(<Filter>)                # `<Filter> = ImageFilter.<name>([<args>])`
<Image> = <Enhance>.enhance(<float>)              # `<Enhance> = ImageEnhance.<name>(<Image>)`
```

```
<array> = np.array(<Image>)                       # Creates a NumPy array from the image.
<Image> = Image.fromarray(np.uint8(<array>))      # Use <array>.clip(0, 255) to clip values.
```

Modes

- `'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 the PNG image and displays it:

```
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.show()
```

Image Draw

```
from PIL import ImageDraw, ImageFont
<ImageDraw> = ImageDraw.Draw(<Image>)          # Object for adding 2D graphics to the image.
<ImageDraw>.point((x, y))                      # Draws a point. 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().
<ImageDraw>.text((x, y), text, font=<Font>)    # `<Font> = ImageFont.truetype(<path>, size)`
```

- 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

```python
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

```python
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:

```python
from math import pi, sin
samples_f = (sin(i * 2 * pi * 440 / 44100) for i in range(100_000))
write_to_wav_file('test.wav', samples_f)
```

Adds noise to the mono WAV file:

```python
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 the WAV file:

```python
# $ 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).wait_done()
```

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 array, itertools as it, math, 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♪,,71♩,,'
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_i   = array.array('h', (int(f * 30000) for f in samples_f))
simpleaudio.play_buffer(samples_i, 1, 2, F).wait_done()
```

# 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 not pg.event.get(pg.QUIT):
    deltas = {pg.K_UP: (0, -20), pg.K_RIGHT: (20, 0), pg.K_DOWN: (0, 20), pg.K_LEFT: (-20, 0)}
    for event in pg.event.get(pg.KEYDOWN):
        dx, dy = deltas.get(event.key, (0, 0))
        rect = rect.move((dx, dy))
    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((delta_x, delta_y))        # Use move_ip() to move in-place.
```

```
<bool> = <Rect>.collidepoint((x, y))            # Checks if rectangle contains the 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))   # Opens new window and returns its surface.
<Surf> = pg.Surface((width, height))            # New RGB surface. RGBA if `flags=pg.SRCALPHA`.
<Surf> = pg.image.load(<path/file>)             # Loads the image. Format depends on source.
<Surf> = pg.surfarray.make_surface(<np_array>)  # Also `<np_arr> = surfarray.pixels3d(<Surf>)`.
<Surf> = <Surf>.subsurface(<Rect>)              # Creates a new surface from the cutout.
```

```
<Surf>.fill(color)                              # Tuple, Color('#rrggbb[aa]') or Color(<name>).
<Surf>.set_at((x, y), color)                    # Updates pixel. Also <Surf>.get_at((x, y)).
<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.Font(<path/file>, size)        # Loads TTF file. Pass None for default font.
<Surf> = <Font>.render(text, antialias, color)  # Background color can be specified at the end.
```

Sound

```
<Sound> = pg.mixer.Sound(<path/file/bytes>)     # WAV file or bytes/array of signed shorts.
<Sound>.play/stop()                             # Also <Sound>.set_volume(<float>).
```

Basic Mario Brothers Example

```python
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()
    pressed = set()
    while not pg.event.get(pg.QUIT) and clock.tick(28):
        keys = {pg.K_UP: D.n, pg.K_RIGHT: D.e, pg.K_DOWN: D.s, pg.K_LEFT: D.w}
        pressed |= {keys.get(e.key) for e in pg.event.get(pg.KEYDOWN)}
        pressed -= {keys.get(e.key) for e in pg.event.get(pg.KEYUP)}
        update_speed(mario, tiles, pressed)
        update_position(mario, tiles)
        draw(screen, images, mario, tiles, pressed)

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))
        mario.rect.topleft = x, y = x + (mario.spd.x / n_steps), y + (mario.spd.y / n_steps)

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, matplotlib.pyplot as plt
```

Series

Ordered dictionary with a name.

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

```
<Sr> = pd.Series(<list>)                       # Assigns RangeIndex starting at 0.
<Sr> = pd.Series(<dict>)                       # Takes dictionary's keys for index.
<Sr> = pd.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>[<keys_slice/slice>]
<Sr> = <Sr>[bools]                             # Or: <Sr>.loc/iloc[bools]
```

```
<Sr> = <Sr> > <el/Sr>                          # Returns a Series of bools.
<Sr> = <Sr> + <el/Sr>                          # Items with non-matching keys get value NaN.
```

```
<Sr> = pd.concat(<coll_of_Sr>)                 # Concats multiple series into one long Series.
<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 = pd.Series([2, 3], index=['x', 'y'])
x    2
y    3
```

	'sum'	['sum']	{'s': 'sum'}

sr.apply(…)
sr.agg(…)
	5	sum 5	s 5

	'rank'	['rank']	{'r': 'rank'}

sr.apply(…)
sr.agg(…)
	x 1
	y 2
		rank
		x 1
		y 2
			r x 1
			y 2

- **Keys/indexes/bools can't be tuples because `'obj[x, y]'` is converted to `'obj[(x, y)]'`!**
- **Methods ffill(), interpolate(), fillna() and dropna() accept `'inplace=True'`.**
- **Last result has a hierarchical index. Use `'<Sr>[key_1, key_2]'` to get its values.**

DataFrame

Table with labeled rows and columns.

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

```
<DF>    = pd.DataFrame(<list_of_rows>)         # Rows can be either lists, dicts or series.
<DF>    = pd.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 items that are False in bools.
```

```
<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 the column.
<DF>    = <DF>.reset_index(drop=False)         # Drops or moves row keys to column named index.
<DF>    = <DF>.sort_index(ascending=True)      # Sorts rows by row keys. Use `axis=1` for cols.
<DF>    = <DF>.sort_values(column_key/s)       # Sorts rows by passed column/s. Also `axis=1`.
```

DataFrame — Merge, Join, Concat:

```
>>> l = pd.DataFrame([[1, 2], [3, 4]], index=['a', 'b'], columns=['x', 'y'])
   x  y
a  1  2
b  3  4
>>> r = pd.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', how=…)`	`   x  y  z`
	`0  1  2  .`
	`1  3  4  5`
	`2  .  6  7`
		`x  y  z`
		`3  4  5`
			`x  y  z`
			`1  2  .`
			`3  4  5`
				Merges on column if 'on' or 'left/right_on' are set, else on shared cols. Uses 'inner' by default.

`l.join(r, lsuffix='l', rsuffix='r', how=…)`	`   x yl yr  z`
	`a  1  2  .  .`
	`b  3  4  4  5`
	`c  .  .  6  7`
		`x yl yr  z`
		`3  4  4  5`
			`x yl yr  z`
			`1  2  .  .`
			`3  4  4  5`
				Merges on row keys. Uses 'left' by default. If r is a Series, it is treated as a column.

`pd.concat([l, r], axis=0, join=…)`	`   x  y  z`
	`a  1  2  .`
	`b  3  4  .`
	`b  .  4  5`
	`c  .  6  7`
		`y`
		`2`
		`4`
		`4`
		`6`
				Adds rows at the bottom. Uses 'outer' by default. A Series is treated as a column. To add a row use pd.concat([l, DF([sr])]).

`pd.concat([l, r], axis=1, join=…)`	`   x  y  y  z`
	`a  1  2  .  .`
	`b  3  4  4  5`
	`c  .  .  6  7`
		`x  y  y  z`
		`3  4  4  5`
				Adds columns at the right end. Uses 'outer' by default. A Series is treated as a column.

`l.combine_first(r)`	`   x  y  z`
	`a  1  2  .`
	`b  3  4  5`
	`c  .  6  7`
				Adds missing rows and columns. Also updates items that contain NaN. Argument r must be a DF.

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

	`'sum'`	`['sum']`	`{'x': 'sum'}`

`df.apply(…)`
`df.agg(…)`
	`x  4`
	`y  6`
		`     x  y`
		`sum  4  6`
			`x  4`

	`'rank'`	`['rank']`	`{'x': 'rank'}`

`df.apply(…)`
`df.agg(…)`
`df.transform(…)`
	`   x  y`
	`a  1  1`
	`b  2  2`
		`      x     y`
		`   rank  rank`
		`a     1     1`
		`b     2     2`
			`   x`
			`a  1`
			`b  2`

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

DataFrame — Plot, Encode, Decode:

```
<DF>.plot.line/area/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('<path/url>')               # Also `names=<list>, parse_dates=False`.
<DF> = pd.read_pickle/excel('<path/url>')      # Use `sheet_name=None` to get all Excel sheets.
<DF> = pd.read_sql('<table/query>', <conn.>)   # SQLite3/SQLAlchemy connection (see #SQLite).
```

```
<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 "pandas[excel]" odfpy`.
<DF>.to_sql('<table_name>', <connection>)      # Also `if_exists='fail/replace/append'`.
```

GroupBy

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

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

```
<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.
<Sr> = <GB>.size()                             # A Sr of group sizes. Keys are group "names".
```

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'); gb.apply(print)
   x  y  z
a  1  2  3
   x  y  z
b  4  5  6
c  7  8  6
```

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

Rolling

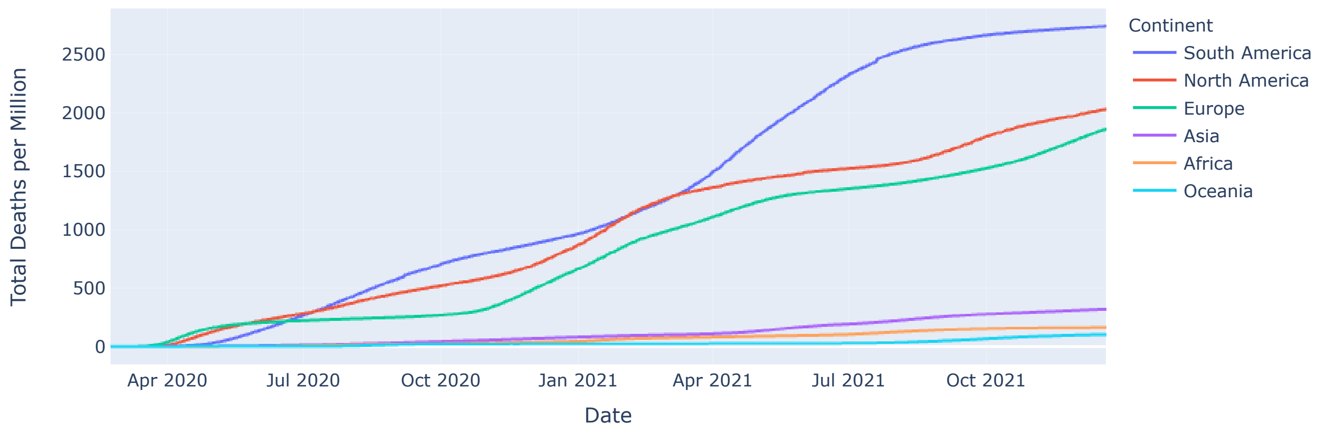
Object for rolling window calculations.

```
<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

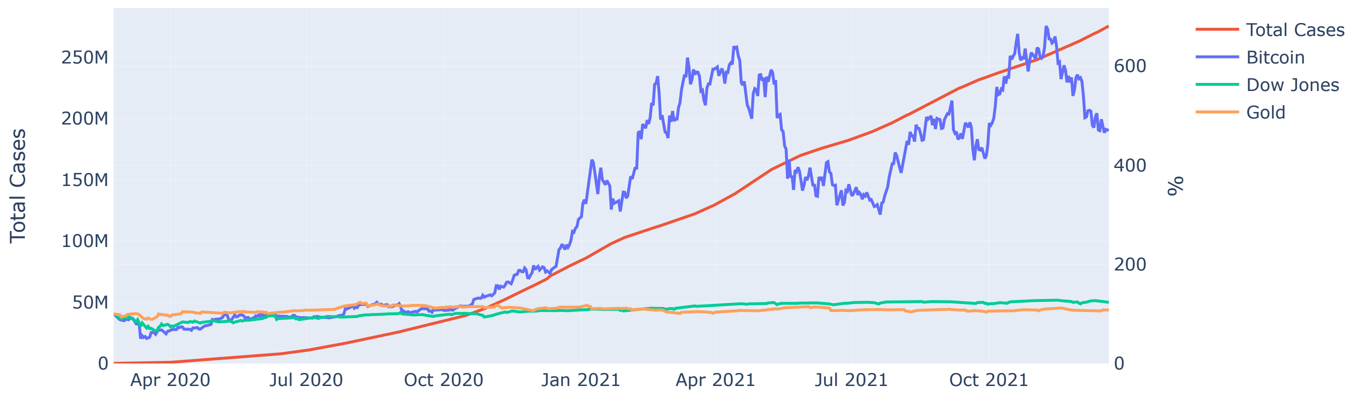
```
# $ pip3 install pandas plotly kaleido
import pandas as pd, plotly.express as ex
<Figure> = ex.line(<DF>, x=<col_name>, y=<col_name>)        # Or: ex.line(x=<list>, y=<list>)
<Figure>.update_layout(margin=dict(t=0, r=0, b=0, l=0), …)  # `paper_bgcolor='rgb(0, 0, 0)'`.
<Figure>.write_html/json/image('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

Displays a line chart of total coronavirus deaths per million grouped 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/20a69c0b6d2ff'
                         '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')
ex.line(df, x='Date', y='Total Deaths per Million', color='Continent').show()
```

Displays a multi-axis line chart of total coronavirus cases and changes in prices of Bitcoin, Dow Jones and gold:



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

def main():
    covid, bitcoin, gold, dow = scrape_data()
    display_data(wrangle_data(covid, bitcoin, gold, dow))

def scrape_data():
    def get_covid_cases():
        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 get_ticker(symbol):
        url = (f'https://query1.finance.yahoo.com/v7/finance/download/{symbol}?'
               'period1=1579651200&period2=9999999999&interval=1d&events=history')
        df = pd.read_csv(url, usecols=['Date', 'Close'])
        return df.set_index('Date').Close
    out = get_covid_cases(), get_ticker('BTC-USD'), get_ticker('GC=F'), get_ticker('^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)  # Creates table by joining columns on dates.
    df = df.sort_index().interpolate()            # Sorts table 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=1.08),
        width=944,
        height=423
    )
    figure.show()

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

# PySimpleGUI

```python
# $ 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>, <el>, ...]
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>, <member_name>, ...
```

Virtual Environments

System for installing libraries directly into project's directory.

```
$ python3 -m venv <name>      # Creates virtual environment in current directory.
$ source <name>/bin/activate  # Activates venv. On Windows run `<name>\Scripts\activate`.
$ pip3 install <library>      # Installs the library into active environment.
$ python3 <path>              # Runs the script in active environment. Also `./<path>`.
$ deactivate                  # Deactivates the active virtual environment.
```

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()
```

# Index

- **Only available in the PDF.**
- **Ctrl+F / ⌘F is usually sufficient.**
- **Searching `'#<title>'` will limit the search to the titles.**

November 29, 2023 / Jure Šorn