

Comprehensive Python Cheatsheet

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Contents

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ToC = {  
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                    NumPy, Image, Animation, Audio, Synthesizer]  
}
```

Main

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

List

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

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

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

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

```

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

```

Dictionary

```

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

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

<dict>.update(<dict>)
<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.

value = <dict>.pop(key)        # Removes item or raises KeyError.
{k: v for k, v in <dict>.items() if k in keys} # Filters dictionary by keys.

```

Counter

```

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

```

Set

```

<set> = set()

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

Named Tuple

Tuple's subclass with named elements.

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

Range

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

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

Enumerate

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

Iterator

```
<iter> = iter(<collection>) # `iter(<iter>)` 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.
```

Itertools

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

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

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

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

Generator

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

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

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

Type

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

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

ABC

An abstract base class introduces virtual subclasses, that don't inherit from it but are still recognized by `isinstance()` and `issubclass()`.

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

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

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

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

String

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

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

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

<str> = <str>.replace(old, new [, count]) # Replaces 'old' with 'new' at most 'count' times.
<bool> = <str>.isnumeric() # True if str contains only numeric characters.
<list> = textwrap.wrap(<str>, width) # Nicely breaks string into lines.
```

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

Char

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

```
>>> ord('0'), ord('9')
(48, 57)
>>> ord('A'), ord('Z')
(65, 90)
>>> ord('a'), ord('z')
(97, 122)
```

Regex

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

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

Match Object

```
<str> = <Match>.group() # Whole match. Also group(0).
<str> = <Match>.group(1) # Part in first bracket.
<tuple> = <Match>.groups() # All bracketed parts.
<int> = <Match>.start() # Start index of a match.
<int> = <Match>.end() # Exclusive end index of a match.
```

Special Sequences

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

```
'\d' == '[0-9]'           # Digit
'\s' == '[\t\n\r\f\v]'   # Whitespace
'\w' == '[a-zA-Z0-9_]'
```

Format

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

Attributes

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

General Options

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

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

Strings

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

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

Numbers

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

Floats

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

Comparison of float presentation types:

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

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

Ints

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

Numbers

Types

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

- '**int(<str>)**' and '**float(<str>)**' raise **ValueError** on malformed strings.
- Decimal numbers can be represented exactly, unlike floats where '**1.1 + 2.2 != 3.3**'.
- Their precision can be adjusted with '**decimal.getcontext().prec = <int>**'.

Basic Functions

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

Math

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

Statistics

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

Random

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

Bin, Hex

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

Bitwise Operators

```
<int>   = <int> & <int>     # And
<int>   = <int> | <int>     # Or
<int>   = <int> ^ <int>     # Xor (0 if both bits equal)
<int>   = <int> << n_bits   # Shift left
<int>   = <int> >> n_bits   # Shift right
<int>   = ~<int>           # Compliment (flips bits)
```

Combinatorics

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

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

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

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

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

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

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

Datetime

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

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


Constructors

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

- Use '`<D/DT>.weekday()`' to get the day of the week (Mon == 0).
- '`fold=1`' means second pass in case of time jumping back for one hour.

Now

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

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

Timezone

```
<tzinfo> = UTC # UTC timezone. London without DST.
<tzinfo> = tzlocal() # Local timezone. Also gettz().
<tzinfo> = gettz('<Cont.>/<City>') # 'Continent/City_Name' timezone or None.
```

```
<DTa> = <DT>.astimezone(<tzinfo>) # Datetime, converted to passed timezone.
<Ta/DTa> = <T/DT>.replace(tzinfo=<tzinfo>) # Unconverted object with new timezone.
```

Encode

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

- ISO strings come in following forms: '`YYYY-MM-DD`', '`HH:MM:SS.ffffff[±<offset>]`', or both separated by a space or a '`T`'. Offset is formatted as: '`HH:MM`'.
- On Unix systems Epoch is '`1970-01-01 00:00 UTC`', '`1970-01-01 01:00 CET`',...

Decode

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

Format

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

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

Arithmetics

```
<TD> = <D/DT> - <D/DT>
<D/DT> = <D/DT> ± <TD>
<TD> = <TD> ± <TD>
<TD> = <TD> * <real>
```

Arguments

Inside Function Call

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

Inside Function Definition

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

Splat Operator

Inside Function Call

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

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

Is the same as:

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

Inside Function Definition

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

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

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

Legal argument combinations:

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

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

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

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

Other Uses

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

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

Inline

Lambda

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

Comprehension

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

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

Is the same as:

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

Map, Filter, Reduce

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

Any, All

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

If - Else

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

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

Namedtuple, Enum, Dataclass

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

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

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

Closure

We have a closure in Python when:

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

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

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

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

Partial

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

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

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

Nonlocal

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

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

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

Decorator

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

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

Debugger Example

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

```
from functools import wraps

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

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

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

LRU Cache

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

```
from functools import lru_cache

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

- Recursion depth is limited to 1000 by default. To increase it use 'sys.setrecursionlimit(<depth>)'.

Parametrized Decorator

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

```
from functools import wraps

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

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

Class

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

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

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

Str() use cases:

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

Repr() use cases:

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

Constructor Overloading

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

Inheritance

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

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

Multiple Inheritance

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

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

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

Property

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

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

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

Dataclass

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

```
from dataclasses import dataclass, field

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

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

Inline:

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

Slots

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

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

Copy

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

Duck Types

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

Comparable

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

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

Hashable

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

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

Sortable

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

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


Iterator

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

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

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

Python has many different iterator objects:

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

Callable

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

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

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

Context Manager

- `Enter()` should lock the resources and return an object.
- `Exit()` should release the resources.

```
class MyOpen():
    def __init__(self, filename):
        self.filename = filename
    def __enter__(self):
        self.file = open(self.filename)
        return self.file
    def __exit__(self, *args):
        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):
        for el in self.a:
            yield el
```

```
>>> z = MyIterable([1, 2, 3])
>>> iter(z)
<generator object MyIterable.__iter__>
>>> 1 in z
True
```

Collection

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

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

Sequence

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

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

Collections.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, collections.abc.Sequence)'` would return `False` even if `MySequence` had all the methods defined.

```
class MyAbcSequence(collections.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 available special methods:

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

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

Enum

```
from enum import Enum, auto

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

    @classmethod
    def get_member_names(cls):
        return [a.name for a in cls.__members__.values()]
```

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

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

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

Inline

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

Functions can not be values, so they must be wrapped:

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

- Another solution in this particular case, is to use `'and_'` and `'or_'` functions from module `operator`.

Exceptions

Basic Example

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

Complex Example

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

Catching Exceptions

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

- Also catches subclasses of the exception.

Raising Exceptions

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

Useful built-in exceptions:

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

Re-raising caught exception:

```
except <exception>:  
    <code>  
    raise
```

Common Built-in Exceptions

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

Collections and their exceptions:

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

User-defined Exceptions

```
class MyError(Exception):  
    pass  
  
class MyInputError(MyError):  
    pass
```

Print

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

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

Pretty Print

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

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

Input

Reads a line from user input or pipe if present.

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

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

Command Line Arguments

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

Argparse

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

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

Open

Opens the file and returns a corresponding file object.

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

- `'encoding=None'` means default encoding is used, which is platform dependent. Best practice is to use `'encoding="utf-8"'` whenever possible.
- `'newline=None'` means all different end of line combinations are converted to `'\n'` on read, while on write all `'\n'` characters are converted to system's default line separator.
- `'newline=""'` means no conversions take place, but input is still broken into chunks by `readline()` and `readlines()` on either `'\n'`, `'\r'` or `'\r\n'`.

Modes

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

Exceptions

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

File

```
<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 pos., 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 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(<coll.>) # Writes a coll. of strings or bytes objects.
<file>.flush() # Flushes write buffer.
```

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

Read Text from File

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

Write Text to File

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

Path

```
from os import path, listdir
from glob import glob
```

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

```
<list> = listdir('<path>') # List of filenames located at path.
<list> = glob('<pattern>') # Filenames matching the wildcard pattern.
```

Pathlib

```
from pathlib import Path
```

```
cwd = Path()
<Path> = Path('<path>' [, '<path>', <Path>, ...])
<Path> = <Path> / '<dir>' / '<file>'
```

```
<bool> = <Path>.exists()
<bool> = <Path>.is_file()
<bool> = <Path>.is_dir()
```

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

```
<str> = str(<Path>) # Path as a string.
<str> = <Path>.name # Final component.
<str> = <Path>.stem # Final component without extension.
<str> = <Path>.suffix # Final component's extension.
<tuple> = <Path>.parts # All components as strings.
```

```
<Path> = <Path>.resolve() # Returns absolute path without symlinks.
<Path> = <Path>.parent # Returns path without final component.
<file> = open(<Path>) # Opens the file and returns a file object.
```

OS Commands

Files and Directories

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

```
import os, shutil
```

```
os.chdir(<path>) # Changes current working directory.
os.mkdir(<path>, mode=0o777) # Creates a directory.
```

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

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

```
shutil.copy(from, to) # Copies the file.
shutil.copytree(from, to) # Copies the entire directory tree.
```

```
<str> = os.getcwd() # Returns the current working directory.
<iter> = os.scandir(path='.') # Returns os.DirEntry objects located at path.
```

DirEntry:

```
<bool> = <DirEntry>.is_file()
<bool> = <DirEntry>.is_dir()
```

```
<str> = <DirEntry>.path # Path as a string.
<str> = <DirEntry>.name # Final component.
```

```
<Path> = Path(<DirEntry>) # Path object.
<file> = open(<DirEntry>) # File object.
```


Shell Commands

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

Using subprocess:

```
>>> import subprocess, shlex
>>> a = subprocess.run(shlex.split('ls -a'), stdout=subprocess.PIPE)
>>> a.stdout
b'.\n..\nfile1.txt\nfile2.txt\n'
>>> a.returncode
0
```

JSON

Text file format for storing collections of strings and numbers.

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

Read Object from JSON File

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

Write Object to JSON File

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

Pickle

Binary file format for storing objects.

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

Read Object from File

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

Write Object to File

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

CSV

Text file format for storing spreadsheets.

```
import csv
```

Read

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

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

Write

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

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

Parameters

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

Dialects

	excel	excel_tab	unix_dialect
delimiter	','	'\t'	','
quotechar	'\"'	'\"'	'\"'
doublequote	True	True	True
skipinitialspace	False	False	False
lineterminator	'\r\n'	'\r\n'	'\n'
quoting	0	0	1
escapechar	None	None	None

Read Rows from CSV File

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

Write Rows to CSV File

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

SQLite

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

Connect

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

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

Read

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

```
<cursor> = db.execute('<query>')      # Can raise sqlite3.OperationalError.
<tuple>   = <cursor>.fetchone()      # Returns next row. Also next(<cursor>).
<list>    = <cursor>.fetchall()      # Returns remaining rows.
```

Write

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

Or:

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

Placeholders

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

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

Example

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

```
>>> db = sqlite3.connect('test.db')
>>> db.execute('create table t (a, b, c)')
>>> db.execute('insert into t values (1, 2, 3)')
>>> db.execute('select * from t').fetchall()
[(1, 2, 3)]
```

MySQL

Has a very similar interface, with differences listed below.

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

Bytes

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

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

Encode

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

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()
```

Read Bytes from File

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

Write Bytes to File

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

Struct

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

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

Example

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

Format

For standard sizes start format string with:

- '=' - native byte order
- '<' - little-endian
- '>' - big-endian

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

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

Floating point types:

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

Array

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

```
from array import array
<array> = array('<typecode>', <collection>) # Array from coll. of numbers.
<array> = array('<typecode>', <bytes>) # Array from bytes object.
<bytes> = <array>.tobytes()
```

Memory View

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

```
<mview> = memoryview(<bytes bytearray array>)
<num> = <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.
```

```
<bin_file>.write(<mview>) # Appends mview to the binary file.
<bytes> = bytes(<mview>) # Creates a new bytes object.
<bytes> = <bytes>.join(<coll_of_mviews>) # Joins mviews using bytes object as sep.
<list> = list(<mview>) # Returns list of ints or floats.
```

```
<str> = str(<mview>, 'utf-8')
<int> = int.from_bytes(<mview>, byteorder='big|little', signed=False)
'<hex>' = <mview>.hex()
```

Deque

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

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

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

Threading

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

```
from threading import Thread, RLock
```

Thread

```
thread = Thread(target=<function>, args=(<first_arg>, ))
thread.start()
...
<bool> = thread.is_alive()           # Checks if thread has finished executing.
thread.join()                        # Waits for thread to finish.
```

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

Lock

```
lock = RLock()
lock.acquire()                       # Waits for lock to be available.
...
lock.release()
```

Or:

```
lock = RLock()
with lock:
    ...
```

Thread Pool Executor

```
from concurrent.futures import ThreadPoolExecutor
with ThreadPoolExecutor(max_workers=None) as executor:
    <iter> = executor.map(lambda x: x + 1, range(3))           # (1, 2, 3)
    <iter> = executor.map(lambda x, y: x + y, 'abc', '123')  # ('a1', 'b2', 'c3')
    <Future> = executor.submit(<function> [, <arg_1>, ...])

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

Queue

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

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

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

Operator

Module of functions that provide the functionality of operators.

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

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

Introspection

Inspecting code at runtime.

Variables

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

Attributes

```
<dict> = vars(<object>)
<bool> = hasattr(<object>, '<attr_name>')
value = getattr(<object>, '<attr_name>')
setattr(<object>, '<attr_name>', value)
```

Parameters

```
from inspect import signature
<sig> = signature(<function>)
no_of_params = len(<sig>.parameters)
param_names = list(<sig>.parameters.keys())
```

Metaprogramming

Code that generates code.

Type

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

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

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

Meta Class

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 class of returned instance (MyMetaClass 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)), in which case init() is not called.

Metaclass Attribute

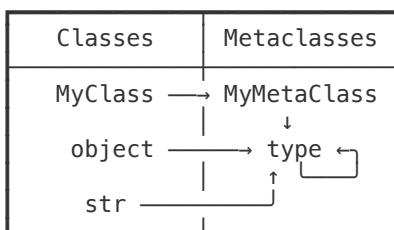
Right before a class is created it checks if it has a 'metaclass' attribute defined. If not, it recursively checks if any of his parents has it defined and eventually comes to type().

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

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

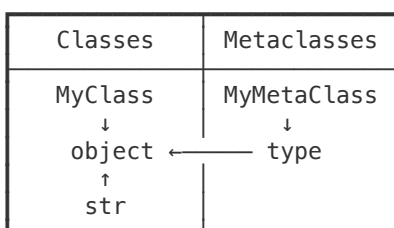
Type Diagram

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



Inheritance Diagram

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



Eval

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

Coroutine

- Any function that contains a '**yield**' expression returns a coroutine.
- Coroutines are similar to iterators, but data needs to be pulled out of an iterator by calling '**next(<iter>)**', while we push data into the coroutine by calling '**<coroutine>.send(<el>)**'.
- Coroutines provide more powerful data routing possibilities than iterators.

Helper Decorator

- All coroutines must first be "primed" by calling '**next(<coroutine>)**'.
- Remembering to call next() is easy to forget.
- Solved by wrapping coroutine functions with the following decorator:

```
def coroutine(func):
    def out(*args, **kwargs):
        cr = func(*args, **kwargs)
        next(cr)
        return cr
    return out
```

Pipeline Example

```
def reader(target):
    for i in range(10):
        target.send(i)
    target.close()

@coroutine
def adder(target):
    while True:
        value = (yield)
        target.send(value + 100)

@coroutine
def printer():
    while True:
        value = (yield)
        print(value, end=' ')
```

```
>>> reader(adder(printer()))
100 101 102 103 104 105 106 107 108 109
```

Libraries

Progress Bar

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

Plot

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

Table

Prints a CSV file as an ASCII table:

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

Curses

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

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

def main():
    wrapper(draw)

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

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

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

Logging

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

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

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

Exceptions

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

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

Rotation

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

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

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

Retention

Sets a condition which old log files get deleted.

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

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

Scraping

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

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

Web

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

Run

```
run(host='localhost', port=8080)
run(host='0.0.0.0', port=80, server='cherryPy')
```

Static Request

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

Dynamic Request

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

REST Request

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

Test:

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

Profiling

Stopwatch

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

High performance:

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

Timing a Snippet

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

Profiling by Line

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

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

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

Call Graph

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

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

NumPy

Array manipulation mini language. Can run up to one hundred times faster than equivalent Python code.

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

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

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

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

- Shape is a tuple of dimension sizes.
- Axis is an index of dimension that gets collapsed. Leftmost dimension has index 0.

Indexing

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

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

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

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

Broadcasting

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

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

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

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

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

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

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

Example

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

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

Image

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

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

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

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

Modes

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

Examples

Creates a PNG image of a rainbow gradient:

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

Adds noise to a PNG image:

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

ImageDraw

```
from PIL import ImageDraw
```

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

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

Animation

Creates a GIF of a bouncing ball:

```
# $ pip3 install pillow imageio
from PIL import Image, ImageDraw
import imageio
WIDTH, R = 126, 10
frames = []
for velocity in range(15):
    y = sum(range(velocity+1))
    frame = Image.new('L', (WIDTH, WIDTH))
    draw = ImageDraw.Draw(frame)
    draw.ellipse((WIDTH/2-R, y, WIDTH/2+R, y+2*R), 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')
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.
<bytes> = <Wave_read>.readframes(nframes) # Returns next 'nframes' frames.
```

```
<Wave_write> = wave.open('<path>', 'wb')
<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>.writeframes(<bytes>) # Appends frames to file.
```

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

Sample Values

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

Read Float Samples from WAV File

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


Write Float Samples to WAV File

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

Examples

Saves a sine wave to a mono WAV file:

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

Adds noise to a mono WAV file:

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

Synthesizer

Plays Popcorn by Gershon Kingsley:

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

Basic Script Template

```
#!/usr/bin/env python3
#
# Usage: .py
#

from collections import namedtuple
from dataclasses import make_dataclass
from enum import Enum
from sys import argv
import re

def main():
    pass

###
## UTIL
#

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

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

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