

FUNCTIONAL PROGRAMMING MODULES

The modules described in this chapter provide functions and classes that support a functional programming style, and general operations on callables.

The following modules are documented in this chapter:

10.1 `itertools` — Functions creating iterators for efficient looping

This module implements a number of *iterator* building blocks inspired by constructs from APL, Haskell, and SML. Each has been recast in a form suitable for Python.

The module standardizes a core set of fast, memory efficient tools that are useful by themselves or in combination. Together, they form an “iterator algebra” making it possible to construct specialized tools succinctly and efficiently in pure Python.

For instance, SML provides a tabulation tool: `tabulate(f)` which produces a sequence `f(0), f(1), ...`. The same effect can be achieved in Python by combining `map()` and `count()` to form `map(f, count())`.

These tools and their built-in counterparts also work well with the high-speed functions in the *operator* module. For example, the multiplication operator can be mapped across two vectors to form an efficient dot-product: `sum(map(operator.mul, vector1, vector2))`.

Infinite iterators:

Iterator	Arguments	Results	Example
<code>count()</code>	start, [step]	start, start+step, start+2*step, ...	<code>count(10) --> 10 11 12 13 14 ...</code>
<code>cycle()</code>	p	p0, p1, ... plast, p0, p1, ...	<code>cycle('ABCD') --> A B C D A B C D ...</code>
<code>repeat()</code>	elem [,n]	elem, elem, elem, ... endlessly or up to n times	<code>repeat(10, 3) --> 10 10 10</code>

Iterators terminating on the shortest input sequence:

Iterator	Arguments	Results	Example
<code>accumulate()</code>	<code>p [,func]</code>	<code>p0, p0+p1, p0+p1+p2, ...</code>	<code>accumulate([1,2,3,4,5]) --> 1 3 6 10 15</code>
<code>chain()</code>	<code>p, q, ...</code>	<code>p0, p1, ... plast, q0, q1, ...</code>	<code>chain('ABC', 'DEF') --> A B C D E F</code>
<code>chain.from_iterable()</code>	iterable	<code>p0, p1, ... plast, q0, q1, ...</code>	<code>chain.from_iterable(['ABC', 'DEF']) --> A B C D E F</code>
<code>compress()</code>	data, selectors	<code>(d[0] if s[0]), (d[1] if s[1]), ...</code>	<code>compress('ABCDEF', [1,0,1,0,1,1]) --> A C E F</code>
<code>dropwhile()</code>	pred, seq	<code>seq[n], seq[n+1], starting when pred fails</code>	<code>dropwhile(lambda x: x<5, [1,4,6,4,1]) --> 6 4 1</code>
<code>filterfalse()</code>	pred, seq	elements of seq where <code>pred(elem)</code> is false	<code>filterfalse(lambda x: x%2, range(10)) --> 0 2 4 6 8</code>
<code>groupby()</code>	iterable[, key]	sub-iterators grouped by value of <code>key(v)</code>	
<code>islice()</code>	seq, [start,] stop [, step]	elements from <code>seq[start:stop:step]</code>	<code>islice('ABCDEFGH', 2, None) --> C D E F G</code>
<code>starmap()</code>	func, seq	<code>func(*seq[0]), func(*seq[1]), ...</code>	<code>starmap(pow, [(2,5), (3,2), (10,3)]) --> 32 9 1000</code>
<code>takewhile()</code>	pred, seq	<code>seq[0], seq[1], until pred fails</code>	<code>takewhile(lambda x: x<5, [1,4,6,4,1]) --> 1 4</code>
<code>tee()</code>	it, n	<code>it1, it2, ... itn</code> splits one iterator into <code>n</code>	
<code>zip_longest()</code>	<code>p, q, ...</code>	<code>(p[0], q[0]), (p[1], q[1]), ...</code>	<code>zip_longest('ABCD', 'xy', fillvalue='-') --> Ax By C- D-</code>

Combinatoric iterators:

Iterator	Arguments	Results
<code>product()</code>	<code>p, q, ... [repeat=1]</code>	cartesian product, equivalent to a nested for-loop
<code>permutations()</code>	<code>p[, r]</code>	<code>r</code> -length tuples, all possible orderings, no repeated elements
<code>combinations()</code>	<code>p, r</code>	<code>r</code> -length tuples, in sorted order, no repeated elements
<code>combinations_with_replacement()</code>	<code>p, r</code>	<code>r</code> -length tuples, in sorted order, with repeated elements
<code>product('ABCD', repeat=2)</code>		AA AB AC AD BA BB BC BD CA CB CC CD DA DB DC DD
<code>permutations('ABCD', 2)</code>		AB AC AD BA BC BD CA CB CD DA DB DC
<code>combinations('ABCD', 2)</code>		AB AC AD BC BD CD
<code>combinations_with_replacement('ABCD', 2)</code>		AA AB AC AD BB BC BD CC CD DD

10.1.1 Itertool functions

The following module functions all construct and return iterators. Some provide streams of infinite length, so they should only be accessed by functions or loops that truncate the stream.

`itertools.accumulate(iterable[, func])`

Make an iterator that returns accumulated sums, or accumulated results of other binary functions (specified via the optional `func` argument). If `func` is supplied, it should be a function of two arguments.

Elements of the input *iterable* may be any type that can be accepted as arguments to *func*. (For example, with the default operation of addition, elements may be any addable type including *Decimal* or *Fraction*.) If the input iterable is empty, the output iterable will also be empty.

Roughly equivalent to:

```
def accumulate(iterable, func=operator.add):
    'Return running totals'
    # accumulate([1,2,3,4,5]) --> 1 3 6 10 15
    # accumulate([1,2,3,4,5], operator.mul) --> 1 2 6 24 120
    it = iter(iterable)
    try:
        total = next(it)
    except StopIteration:
        return
    yield total
    for element in it:
        total = func(total, element)
        yield total
```

There are a number of uses for the *func* argument. It can be set to *min()* for a running minimum, *max()* for a running maximum, or *operator.mul()* for a running product. Amortization tables can be built by accumulating interest and applying payments. First-order recurrence relations can be modeled by supplying the initial value in the iterable and using only the accumulated total in *func* argument:

```
>>> data = [3, 4, 6, 2, 1, 9, 0, 7, 5, 8]
>>> list(accumulate(data, operator.mul))      # running product
[3, 12, 72, 144, 144, 1296, 0, 0, 0, 0]
>>> list(accumulate(data, max))              # running maximum
[3, 4, 6, 6, 6, 9, 9, 9, 9, 9]

# Amortize a 5% loan of 1000 with 4 annual payments of 90
>>> cashflows = [1000, -90, -90, -90, -90]
>>> list(accumulate(cashflows, lambda bal, pmt: bal*1.05 + pmt))
[1000, 960.0, 918.0, 873.9000000000001, 827.5950000000001]

# Chaotic recurrence relation https://en.wikipedia.org/wiki/Logistic_map
>>> logistic_map = lambda x, _: r * x * (1 - x)
>>> r = 3.8
>>> x0 = 0.4
>>> inputs = repeat(x0, 36)                  # only the initial value is used
>>> [format(x, '.2f') for x in accumulate(inputs, logistic_map)]
['0.40', '0.91', '0.30', '0.81', '0.60', '0.92', '0.29', '0.79', '0.63',
 '0.88', '0.39', '0.90', '0.33', '0.84', '0.52', '0.95', '0.18', '0.57',
 '0.93', '0.25', '0.71', '0.79', '0.63', '0.88', '0.39', '0.91', '0.32',
 '0.83', '0.54', '0.95', '0.20', '0.60', '0.91', '0.30', '0.80', '0.60']
```

See *functools.reduce()* for a similar function that returns only the final accumulated value.

New in version 3.2.

Changed in version 3.3: Added the optional *func* parameter.

itertools.chain(*iterables)

Make an iterator that returns elements from the first iterable until it is exhausted, then proceeds to the next iterable, until all of the iterables are exhausted. Used for treating consecutive sequences as a single sequence. Roughly equivalent to:

```
def chain(*iterables):
    # chain('ABC', 'DEF') --> A B C D E F
    for it in iterables:
        for element in it:
            yield element
```

`classmethod chain.from_iterable(iterable)`

Alternate constructor for `chain()`. Gets chained inputs from a single iterable argument that is evaluated lazily. Roughly equivalent to:

```
def from_iterable(iterables):
    # chain.from_iterable(['ABC', 'DEF']) --> A B C D E F
    for it in iterables:
        for element in it:
            yield element
```

`itertools.combinations(iterable, r)`

Return *r* length subsequences of elements from the input *iterable*.

Combinations are emitted in lexicographic sort order. So, if the input *iterable* is sorted, the combination tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, there will be no repeat values in each combination.

Roughly equivalent to:

```
def combinations(iterable, r):
    # combinations('ABCD', 2) --> AB AC AD BC BD CD
    # combinations(range(4), 3) --> 012 013 023 123
    pool = tuple(iterable)
    n = len(pool)
    if r > n:
        return
    indices = list(range(r))
    yield tuple(pool[i] for i in indices)
    while True:
        for i in reversed(range(r)):
            if indices[i] != i + n - r:
                break
        else:
            return
        indices[i] += 1
        for j in range(i+1, r):
            indices[j] = indices[j-1] + 1
        yield tuple(pool[i] for i in indices)
```

The code for `combinations()` can be also expressed as a subsequence of `permutations()` after filtering entries where the elements are not in sorted order (according to their position in the input pool):

```
def combinations(iterable, r):
    pool = tuple(iterable)
    n = len(pool)
    for indices in permutations(range(n), r):
        if sorted(indices) == list(indices):
            yield tuple(pool[i] for i in indices)
```

The number of items returned is $n! / r! / (n-r)!$ when $0 \leq r \leq n$ or zero when $r > n$.

`itertools.combinations_with_replacement(iterable, r)`

Return r length subsequences of elements from the input *iterable* allowing individual elements to be repeated more than once.

Combinations are emitted in lexicographic sort order. So, if the input *iterable* is sorted, the combination tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, the generated combinations will also be unique.

Roughly equivalent to:

```
def combinations_with_replacement(iterable, r):
    # combinations_with_replacement('ABC', 2) --> AA AB AC BB BC CC
    pool = tuple(iterable)
    n = len(pool)
    if not n and r:
        return
    indices = [0] * r
    yield tuple(pool[i] for i in indices)
    while True:
        for i in reversed(range(r)):
            if indices[i] != n - 1:
                break
        else:
            return
        indices[i:] = [indices[i] + 1] * (r - i)
        yield tuple(pool[i] for i in indices)
```

The code for `combinations_with_replacement()` can be also expressed as a subsequence of `product()` after filtering entries where the elements are not in sorted order (according to their position in the input pool):

```
def combinations_with_replacement(iterable, r):
    pool = tuple(iterable)
    n = len(pool)
    for indices in product(range(n), repeat=r):
        if sorted(indices) == list(indices):
            yield tuple(pool[i] for i in indices)
```

The number of items returned is $(n+r-1)! / r! / (n-1)!$ when $n > 0$.

New in version 3.1.

`itertools.compress(data, selectors)`

Make an iterator that filters elements from *data* returning only those that have a corresponding element in *selectors* that evaluates to `True`. Stops when either the *data* or *selectors* iterables has been exhausted. Roughly equivalent to:

```
def compress(data, selectors):
    # compress('ABCDEF', [1,0,1,0,1,1]) --> A C E F
    return (d for d, s in zip(data, selectors) if s)
```

New in version 3.1.

`itertools.count(start=0, step=1)`

Make an iterator that returns evenly spaced values starting with number *start*. Often used as an

argument to `map()` to generate consecutive data points. Also, used with `zip()` to add sequence numbers. Roughly equivalent to:

```
def count(start=0, step=1):
    # count(10) --> 10 11 12 13 14 ...
    # count(2.5, 0.5) -> 2.5 3.0 3.5 ...
    n = start
    while True:
        yield n
        n += step
```

When counting with floating point numbers, better accuracy can sometimes be achieved by substituting multiplicative code such as: `(start + step * i for i in count())`.

Changed in version 3.1: Added `step` argument and allowed non-integer arguments.

`itertools.cycle(iterable)`

Make an iterator returning elements from the iterable and saving a copy of each. When the iterable is exhausted, return elements from the saved copy. Repeats indefinitely. Roughly equivalent to:

```
def cycle(iterable):
    # cycle('ABCD') --> A B C D A B C D A B C D ...
    saved = []
    for element in iterable:
        yield element
        saved.append(element)
    while saved:
        for element in saved:
            yield element
```

Note, this member of the toolkit may require significant auxiliary storage (depending on the length of the iterable).

`itertools.dropwhile(predicate, iterable)`

Make an iterator that drops elements from the iterable as long as the predicate is true; afterwards, returns every element. Note, the iterator does not produce *any* output until the predicate first becomes false, so it may have a lengthy start-up time. Roughly equivalent to:

```
def dropwhile(predicate, iterable):
    # dropwhile(lambda x: x<5, [1,4,6,4,1]) --> 6 4 1
    iterable = iter(iterable)
    for x in iterable:
        if not predicate(x):
            yield x
            break
    for x in iterable:
        yield x
```

`itertools.filterfalse(predicate, iterable)`

Make an iterator that filters elements from iterable returning only those for which the predicate is False. If `predicate` is None, return the items that are false. Roughly equivalent to:

```
def filterfalse(predicate, iterable):
    # filterfalse(lambda x: x%2, range(10)) --> 0 2 4 6 8
    if predicate is None:
        predicate = bool
```

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```

for x in iterable:
    if not predicate(x):
        yield x

```

`itertools.groupby(iterable, key=None)`

Make an iterator that returns consecutive keys and groups from the *iterable*. The *key* is a function computing a key value for each element. If not specified or is `None`, *key* defaults to an identity function and returns the element unchanged. Generally, the iterable needs to already be sorted on the same key function.

The operation of `groupby()` is similar to the `uniq` filter in Unix. It generates a break or new group every time the value of the key function changes (which is why it is usually necessary to have sorted the data using the same key function). That behavior differs from SQL's GROUP BY which aggregates common elements regardless of their input order.

The returned group is itself an iterator that shares the underlying iterable with `groupby()`. Because the source is shared, when the `groupby()` object is advanced, the previous group is no longer visible. So, if that data is needed later, it should be stored as a list:

```

groups = []
uniquekeys = []
data = sorted(data, key=keyfunc)
for k, g in groupby(data, keyfunc):
    groups.append(list(g))      # Store group iterator as a list
    uniquekeys.append(k)

```

`groupby()` is roughly equivalent to:

```

class groupby:
    # [k for k, g in groupby('AAAABBBCCDAABBB')] --> A B C D A B
    # [list(g) for k, g in groupby('AAAABBBCCD')] --> AAAA BBB CC D
    def __init__(self, iterable, key=None):
        if key is None:
            key = lambda x: x
        self.keyfunc = key
        self.it = iter(iterable)
        self.tgtkey = self.currkey = self.currvalue = object()
    def __iter__(self):
        return self
    def __next__(self):
        self.id = object()
        while self.currkey == self.tgtkey:
            self.currvalue = next(self.it)      # Exit on StopIteration
            self.currkey = self.keyfunc(self.currvalue)
        self.tgtkey = self.currkey
        return (self.currkey, self._grouper(self.tgtkey, self.id))
    def _grouper(self, tgtkey, id):
        while self.id is id and self.currkey == tgtkey:
            yield self.currvalue
            try:
                self.currvalue = next(self.it)
            except StopIteration:
                return
        self.currkey = self.keyfunc(self.currvalue)

```

`itertools.islice(iterable, stop)`

`itertools.islice(iterable, start, stop[, step])`

Make an iterator that returns selected elements from the iterable. If *start* is non-zero, then elements from the iterable are skipped until *start* is reached. Afterward, elements are returned consecutively unless *step* is set higher than one which results in items being skipped. If *stop* is `None`, then iteration continues until the iterator is exhausted, if at all; otherwise, it stops at the specified position. Unlike regular slicing, *islice()* does not support negative values for *start*, *stop*, or *step*. Can be used to extract related fields from data where the internal structure has been flattened (for example, a multi-line report may list a name field on every third line). Roughly equivalent to:

```
def islice(iterable, *args):
    # islice('ABCDEFGH', 2) --> A B
    # islice('ABCDEFGH', 2, 4) --> C D
    # islice('ABCDEFGH', 2, None) --> C D E F G
    # islice('ABCDEFGH', 0, None, 2) --> A C E G
    s = slice(*args)
    start, stop, step = s.start or 0, s.stop or sys.maxsize, s.step or 1
    it = iter(range(start, stop, step))
    try:
        nexti = next(it)
    except StopIteration:
        # Consume *iterable* up to the *start* position.
        for i, element in zip(range(start), iterable):
            pass
        return
    try:
        for i, element in enumerate(iterable):
            if i == nexti:
                yield element
                nexti = next(it)
    except StopIteration:
        # Consume to *stop*.
        for i, element in zip(range(i + 1, stop), iterable):
            pass
```

If *start* is `None`, then iteration starts at zero. If *step* is `None`, then the step defaults to one.

`itertools.permutations(iterable, r=None)`

Return successive *r* length permutations of elements in the *iterable*.

If *r* is not specified or is `None`, then *r* defaults to the length of the *iterable* and all possible full-length permutations are generated.

Permutations are emitted in lexicographic sort order. So, if the input *iterable* is sorted, the permutation tuples will be produced in sorted order.

Elements are treated as unique based on their position, not on their value. So if the input elements are unique, there will be no repeat values in each permutation.

Roughly equivalent to:

```
def permutations(iterable, r=None):
    # permutations('ABCD', 2) --> AB AC AD BA BC BD CA CB CD DA DB DC
    # permutations(range(3)) --> 012 021 102 120 201 210
    pool = tuple(iterable)
    n = len(pool)
```

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```

r = n if r is None else r
if r > n:
    return
indices = list(range(n))
cycles = list(range(n, n-r, -1))
yield tuple(pool[i] for i in indices[:r])
while n:
    for i in reversed(range(r)):
        cycles[i] -= 1
        if cycles[i] == 0:
            indices[i:] = indices[i+1:] + indices[i:i+1]
            cycles[i] = n - i
        else:
            j = cycles[i]
            indices[i], indices[-j] = indices[-j], indices[i]
            yield tuple(pool[i] for i in indices[:r])
            break
    else:
        return

```

The code for `permutations()` can be also expressed as a subsequence of `product()`, filtered to exclude entries with repeated elements (those from the same position in the input pool):

```

def permutations(iterable, r=None):
    pool = tuple(iterable)
    n = len(pool)
    r = n if r is None else r
    for indices in product(range(n), repeat=r):
        if len(set(indices)) == r:
            yield tuple(pool[i] for i in indices)

```

The number of items returned is $n! / (n-r)!$ when $0 \leq r \leq n$ or zero when $r > n$.

`itertools.product(*iterables, repeat=1)`

Cartesian product of input iterables.

Roughly equivalent to nested for-loops in a generator expression. For example, `product(A, B)` returns the same as `((x,y) for x in A for y in B)`.

The nested loops cycle like an odometer with the rightmost element advancing on every iteration. This pattern creates a lexicographic ordering so that if the input's iterables are sorted, the product tuples are emitted in sorted order.

To compute the product of an iterable with itself, specify the number of repetitions with the optional `repeat` keyword argument. For example, `product(A, repeat=4)` means the same as `product(A, A, A, A)`.

This function is roughly equivalent to the following code, except that the actual implementation does not build up intermediate results in memory:

```

def product(*args, repeat=1):
    # product('ABCD', 'xy') --> Ax Ay Bx By Cx Cy Dx Dy
    # product(range(2), repeat=3) --> 000 001 010 011 100 101 110 111
    pools = [tuple(pool) for pool in args] * repeat
    result = [[]]

```

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```

for pool in pools:
    result = [x+[y] for x in result for y in pool]
for prod in result:
    yield tuple(prod)

```

`itertools.repeat(object[, times])`

Make an iterator that returns *object* over and over again. Runs indefinitely unless the *times* argument is specified. Used as argument to *map()* for invariant parameters to the called function. Also used with *zip()* to create an invariant part of a tuple record.

Roughly equivalent to:

```

def repeat(object, times=None):
    # repeat(10, 3) --> 10 10 10
    if times is None:
        while True:
            yield object
    else:
        for i in range(times):
            yield object

```

A common use for *repeat* is to supply a stream of constant values to *map* or *zip*:

```

>>> list(map(pow, range(10), repeat(2)))
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]

```

`itertools.starmap(function, iterable)`

Make an iterator that computes the function using arguments obtained from the iterable. Used instead of *map()* when argument parameters are already grouped in tuples from a single iterable (the data has been “pre-zipped”). The difference between *map()* and *starmap()* parallels the distinction between *function(a,b)* and *function(*c)*. Roughly equivalent to:

```

def starmap(function, iterable):
    # starmap(pow, [(2,5), (3,2), (10,3)]) --> 32 9 1000
    for args in iterable:
        yield function(*args)

```

`itertools.takewhile(predicate, iterable)`

Make an iterator that returns elements from the iterable as long as the predicate is true. Roughly equivalent to:

```

def takewhile(predicate, iterable):
    # takewhile(lambda x: x<5, [1,4,6,4,1]) --> 1 4
    for x in iterable:
        if predicate(x):
            yield x
        else:
            break

```

`itertools.tee(iterable, n=2)`

Return *n* independent iterators from a single iterable.

The following Python code helps explain what *tee* does (although the actual implementation is more complex and uses only a single underlying FIFO queue).

Roughly equivalent to:

```

def tee(iterable, n=2):
    it = iter(iterable)
    deques = [collections.deque() for i in range(n)]
    def gen(mydeque):
        while True:
            if not mydeque:          # when the local deque is empty
                try:
                    newval = next(it) # fetch a new value and
                except StopIteration:
                    return
            for d in deques:        # load it to all the deques
                d.append(newval)
            yield mydeque.popleft()
    return tuple(gen(d) for d in deques)

```

Once `tee()` has made a split, the original *iterable* should not be used anywhere else; otherwise, the *iterable* could get advanced without the tee objects being informed.

This itertools may require significant auxiliary storage (depending on how much temporary data needs to be stored). In general, if one iterator uses most or all of the data before another iterator starts, it is faster to use `list()` instead of `tee()`.

`itertools.zip_longest(*iterables, fillvalue=None)`

Make an iterator that aggregates elements from each of the iterables. If the iterables are of uneven length, missing values are filled-in with *fillvalue*. Iteration continues until the longest iterable is exhausted. Roughly equivalent to:

```

def zip_longest(*args, fillvalue=None):
    # zip_longest('ABCD', 'xy', fillvalue='-') --> Ax By C- D-
    iterators = [iter(it) for it in args]
    num_active = len(iterators)
    if not num_active:
        return
    while True:
        values = []
        for i, it in enumerate(iterators):
            try:
                value = next(it)
            except StopIteration:
                num_active -= 1
                if not num_active:
                    return
                iterators[i] = repeat(fillvalue)
                value = fillvalue
        values.append(value)
        yield tuple(values)

```

If one of the iterables is potentially infinite, then the `zip_longest()` function should be wrapped with something that limits the number of calls (for example `islice()` or `takewhile()`). If not specified, *fillvalue* defaults to `None`.

10.1.2 Itertools Recipes

This section shows recipes for creating an extended toolset using the existing itertools as building blocks.

The extended tools offer the same high performance as the underlying toolset. The superior memory performance is kept by processing elements one at a time rather than bringing the whole iterable into memory all at once. Code volume is kept small by linking the tools together in a functional style which helps eliminate temporary variables. High speed is retained by preferring “vectorized” building blocks over the use of for-loops and *generators* which incur interpreter overhead.

```
def take(n, iterable):
    "Return first n items of the iterable as a list"
    return list(islice(iterable, n))

def prepend(value, iterator):
    "Prepend a single value in front of an iterator"
    # prepend(1, [2, 3, 4]) -> 1 2 3 4
    return chain([value], iterator)

def tabulate(function, start=0):
    "Return function(0), function(1), ..."
    return map(function, count(start))

def tail(n, iterable):
    "Return an iterator over the last n items"
    # tail(3, 'ABCDEFG') --> E F G
    return iter(collections.deque(iterable, maxlen=n))

def consume(iterator, n=None):
    "Advance the iterator n-steps ahead. If n is None, consume entirely."
    # Use functions that consume iterators at C speed.
    if n is None:
        # feed the entire iterator into a zero-length deque
        collections.deque(iterator, maxlen=0)
    else:
        # advance to the empty slice starting at position n
        next(islice(iterator, n, n), None)

def nth(iterable, n, default=None):
    "Returns the nth item or a default value"
    return next(islice(iterable, n, None), default)

def all_equal(iterable):
    "Returns True if all the elements are equal to each other"
    g = groupby(iterable)
    return next(g, True) and not next(g, False)

def quantify(iterable, pred=bool):
    "Count how many times the predicate is true"
    return sum(map(pred, iterable))

def padnone(iterable):
    """Returns the sequence elements and then returns None indefinitely.
    Useful for emulating the behavior of the built-in map() function.
    """
    return chain(iterable, repeat(None))
```

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```

def ncycles(iterable, n):
    "Returns the sequence elements n times"
    return chain.from_iterable(repeat(tuple(iterable), n))

def dotproduct(vec1, vec2):
    return sum(map(operator.mul, vec1, vec2))

def flatten(listOfLists):
    "Flatten one level of nesting"
    return chain.from_iterable(listOfLists)

def repeatfunc(func, times=None, *args):
    """Repeat calls to func with specified arguments.

    Example: repeatfunc(random.random)
    """
    if times is None:
        return starmap(func, repeat(args))
    return starmap(func, repeat(args, times))

def pairwise(iterable):
    "s -> (s0,s1), (s1,s2), (s2, s3), ..."
    a, b = tee(iterable)
    next(b, None)
    return zip(a, b)

def grouper(iterable, n, fillvalue=None):
    "Collect data into fixed-length chunks or blocks"
    # grouper('ABCDEFG', 3, 'x') --> ABC DEF Gxx"
    args = [iter(iterable)] * n
    return zip_longest(*args, fillvalue=fillvalue)

def roundrobin(*iterables):
    "roundrobin('ABC', 'D', 'EF') --> A D E B F C"
    # Recipe credited to George Sakkis
    num_active = len(iterables)
    nexts = cycle(iter(it).__next__ for it in iterables)
    while num_active:
        try:
            for next in nexts:
                yield next()
        except StopIteration:
            # Remove the iterator we just exhausted from the cycle.
            num_active -= 1
            nexts = cycle(islice(nexts, num_active))

def partition(pred, iterable):
    'Use a predicate to partition entries into false entries and true entries'
    # partition(is_odd, range(10)) --> 0 2 4 6 8 and 1 3 5 7 9
    t1, t2 = tee(iterable)
    return filterfalse(pred, t1), filter(pred, t2)

```

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```

def powerset(iterable):
    "powerset([1,2,3]) --> () (1,) (2,) (3,) (1,2) (1,3) (2,3) (1,2,3)"
    s = list(iterable)
    return chain.from_iterable(combinations(s, r) for r in range(len(s)+1))

def unique_everseen(iterable, key=None):
    "List unique elements, preserving order. Remember all elements ever seen."
    # unique_everseen('AAAABBBCCDAABBB') --> A B C D
    # unique_everseen('ABBCcAD', str.lower) --> A B C D
    seen = set()
    seen_add = seen.add
    if key is None:
        for element in filterfalse(seen.__contains__, iterable):
            seen_add(element)
            yield element
    else:
        for element in iterable:
            k = key(element)
            if k not in seen:
                seen_add(k)
                yield element

def unique_justseen(iterable, key=None):
    "List unique elements, preserving order. Remember only the element just seen."
    # unique_justseen('AAAABBBCCDAABBB') --> A B C D A B
    # unique_justseen('ABBCcAD', str.lower) --> A B C A D
    return map(next, map(itemgetter(1), groupby(iterable, key)))

def iter_except(func, exception, first=None):
    """ Call a function repeatedly until an exception is raised.

    Converts a call-until-exception interface to an iterator interface.
    Like builtins.iter(func, sentinel) but uses an exception instead
    of a sentinel to end the loop.

    Examples:
        iter_except(functools.partial(heapop, h), IndexError) # priority queue
    ↪ iterator
        iter_except(d.popitem, KeyError)                       # non-blocking dict
    ↪ iterator
        iter_except(d.popleft, IndexError)                     # non-blocking deque
    ↪ iterator
        iter_except(q.get_nowait, Queue.Empty)                 # loop over a producer
    ↪ Queue
        iter_except(s.pop, KeyError)                           # non-blocking set
    ↪ iterator

    """
    try:
        if first is not None:
            yield first() # For database APIs needing an initial cast to db.
    ↪ first()

```

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```

        while True:
            yield func()
    except exception:
        pass

def first_true(iterable, default=False, pred=None):
    """Returns the first true value in the iterable.

    If no true value is found, returns *default*

    If *pred* is not None, returns the first item
    for which pred(item) is true.

    """
    # first_true([a,b,c], x) --> a or b or c or x
    # first_true([a,b], x, f) --> a if f(a) else b if f(b) else x
    return next(filter(pred, iterable), default)

def random_product(*args, repeat=1):
    "Random selection from itertools.product(*args, **kwargs)"
    pools = [tuple(pool) for pool in args] * repeat
    return tuple(random.choice(pool) for pool in pools)

def random_permutation(iterable, r=None):
    "Random selection from itertools.permutations(iterable, r)"
    pool = tuple(iterable)
    r = len(pool) if r is None else r
    return tuple(random.sample(pool, r))

def random_combination(iterable, r):
    "Random selection from itertools.combinations(iterable, r)"
    pool = tuple(iterable)
    n = len(pool)
    indices = sorted(random.sample(range(n), r))
    return tuple(pool[i] for i in indices)

def random_combination_with_replacement(iterable, r):
    "Random selection from itertools.combinations_with_replacement(iterable, r)"
    pool = tuple(iterable)
    n = len(pool)
    indices = sorted(random.randrange(n) for i in range(r))
    return tuple(pool[i] for i in indices)

def nth_combination(iterable, r, index):
    'Equivalent to list(combinations(iterable, r))[index]'
    pool = tuple(iterable)
    n = len(pool)
    if r < 0 or r > n:
        raise ValueError
    c = 1
    k = min(r, n-r)
    for i in range(1, k+1):

```

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```

    c = c * (n - k + i) // i
    if index < 0:
        index += c
    if index < 0 or index >= c:
        raise IndexError
    result = []
    while r:
        c, n, r = c*r//n, n-1, r-1
        while index >= c:
            index -= c
            c, n = c*(n-r)//n, n-1
        result.append(pool[-1-n])
    return tuple(result)

```

Note, many of the above recipes can be optimized by replacing global lookups with local variables defined as default values. For example, the *dotproduct* recipe can be written as:

```

def dotproduct(vec1, vec2, sum=sum, map=map, mul=operator.mul):
    return sum(map(mul, vec1, vec2))

```

10.2 functools — Higher-order functions and operations on callable objects

Source code: [Lib/functools.py](#)

The *functools* module is for higher-order functions: functions that act on or return other functions. In general, any callable object can be treated as a function for the purposes of this module.

The *functools* module defines the following functions:

functools.cmp_to_key(*func*)

Transform an old-style comparison function to a *key function*. Used with tools that accept key functions (such as *sorted()*, *min()*, *max()*, *heapq.nlargest()*, *heapq.nsmallest()*, *itertools.groupby()*). This function is primarily used as a transition tool for programs being converted from Python 2 which supported the use of comparison functions.

A comparison function is any callable that accept two arguments, compares them, and returns a negative number for less-than, zero for equality, or a positive number for greater-than. A key function is a callable that accepts one argument and returns another value to be used as the sort key.

Example:

```
sorted(iterable, key=cmp_to_key(locale.strcoll)) # locale-aware sort order
```

For sorting examples and a brief sorting tutorial, see [sortinghowto](#).

New in version 3.2.

@functools.lru_cache(*maxsize=128, typed=False*)

Decorator to wrap a function with a memoizing callable that saves up to the *maxsize* most recent calls. It can save time when an expensive or I/O bound function is periodically called with the same arguments.

Since a dictionary is used to cache results, the positional and keyword arguments to the function must be hashable.

Distinct argument patterns may be considered to be distinct calls with separate cache entries. For example, $f(a=1, b=2)$ and $f(b=2, a=1)$ differ in their keyword argument order and may have two separate cache entries.

If *maxsize* is set to `None`, the LRU feature is disabled and the cache can grow without bound. The LRU feature performs best when *maxsize* is a power-of-two.

If *typed* is set to `true`, function arguments of different types will be cached separately. For example, `f(3)` and `f(3.0)` will be treated as distinct calls with distinct results.

To help measure the effectiveness of the cache and tune the *maxsize* parameter, the wrapped function is instrumented with a `cache_info()` function that returns a *named tuple* showing *hits*, *misses*, *maxsize* and *currsz*. In a multi-threaded environment, the hits and misses are approximate.

The decorator also provides a `cache_clear()` function for clearing or invalidating the cache.

The original underlying function is accessible through the `__wrapped__` attribute. This is useful for introspection, for bypassing the cache, or for rewrapping the function with a different cache.

An LRU (least recently used) cache works best when the most recent calls are the best predictors of upcoming calls (for example, the most popular articles on a news server tend to change each day). The cache's size limit assures that the cache does not grow without bound on long-running processes such as web servers.

In general, the LRU cache should only be used when you want to reuse previously computed values. Accordingly, it doesn't make sense to cache functions with side-effects, functions that need to create distinct mutable objects on each call, or impure functions such as `time()` or `random()`.

Example of an LRU cache for static web content:

```
@lru_cache(maxsize=32)
def get_pep(num):
    'Retrieve text of a Python Enhancement Proposal'
    resource = 'http://www.python.org/dev/peps/pep-%04d/' % num
    try:
        with urllib.request.urlopen(resource) as s:
            return s.read()
    except urllib.error.HTTPError:
        return 'Not Found'

>>> for n in 8, 290, 308, 320, 8, 218, 320, 279, 289, 320, 9991:
...     pep = get_pep(n)
...     print(n, len(pep))

>>> get_pep.cache_info()
CacheInfo(hits=3, misses=8, maxsize=32, currsz=8)
```

Example of efficiently computing Fibonacci numbers using a cache to implement a dynamic programming technique:

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

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```
>>> [fib(n) for n in range(16)]
[0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610]

>>> fib.cache_info()
CacheInfo(hits=28, misses=16, maxsize=None, currsize=16)
```

New in version 3.2.

Changed in version 3.3: Added the *typed* option.

`@functools.total_ordering`

Given a class defining one or more rich comparison ordering methods, this class decorator supplies the rest. This simplifies the effort involved in specifying all of the possible rich comparison operations:

The class must define one of `__lt__()`, `__le__()`, `__gt__()`, or `__ge__()`. In addition, the class should supply an `__eq__()` method.

For example:

```
@total_ordering
class Student:
    def _is_valid_operand(self, other):
        return (hasattr(other, "lastname") and
                hasattr(other, "firstname"))
    def __eq__(self, other):
        if not self._is_valid_operand(other):
            return NotImplemented
        return ((self.lastname.lower(), self.firstname.lower()) ==
                (other.lastname.lower(), other.firstname.lower()))
    def __lt__(self, other):
        if not self._is_valid_operand(other):
            return NotImplemented
        return ((self.lastname.lower(), self.firstname.lower()) <
                (other.lastname.lower(), other.firstname.lower()))
```

Note: While this decorator makes it easy to create well behaved totally ordered types, it *does* come at the cost of slower execution and more complex stack traces for the derived comparison methods. If performance benchmarking indicates this is a bottleneck for a given application, implementing all six rich comparison methods instead is likely to provide an easy speed boost.

New in version 3.2.

Changed in version 3.4: Returning `NotImplemented` from the underlying comparison function for unrecognised types is now supported.

`functools.partial(func, *args, **keywords)`

Return a new *partial object* which when called will behave like *func* called with the positional arguments *args* and keyword arguments *keywords*. If more arguments are supplied to the call, they are appended to *args*. If additional keyword arguments are supplied, they extend and override *keywords*. Roughly equivalent to:

```
def partial(func, *args, **keywords):
    def newfunc(*fargs, **fkeywords):
        newkeywords = keywords.copy()
```

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```

    newkeywords.update(fkeywords)
    return func(*args, *fargs, **newkeywords)
newfunc.func = func
newfunc.args = args
newfunc.keywords = keywords
return newfunc

```

The `partial()` is used for partial function application which “freezes” some portion of a function’s arguments and/or keywords resulting in a new object with a simplified signature. For example, `partial()` can be used to create a callable that behaves like the `int()` function where the `base` argument defaults to two:

```

>>> from functools import partial
>>> basetwo = partial(int, base=2)
>>> basetwo.__doc__ = 'Convert base 2 string to an int.'
>>> basetwo('10010')
18

```

class `functools.partialmethod(func, *args, **keywords)`

Return a new `partialmethod` descriptor which behaves like `partial` except that it is designed to be used as a method definition rather than being directly callable.

`func` must be a *descriptor* or a callable (objects which are both, like normal functions, are handled as descriptors).

When `func` is a descriptor (such as a normal Python function, `classmethod()`, `staticmethod()`, `abstractmethod()` or another instance of `partialmethod`), calls to `__get__` are delegated to the underlying descriptor, and an appropriate *partial object* returned as the result.

When `func` is a non-descriptor callable, an appropriate bound method is created dynamically. This behaves like a normal Python function when used as a method: the `self` argument will be inserted as the first positional argument, even before the `args` and `keywords` supplied to the `partialmethod` constructor.

Example:

```

>>> class Cell(object):
...     def __init__(self):
...         self._alive = False
...     @property
...     def alive(self):
...         return self._alive
...     def set_state(self, state):
...         self._alive = bool(state)
...     set_alive = partialmethod(set_state, True)
...     set_dead = partialmethod(set_state, False)
...
>>> c = Cell()
>>> c.alive
False
>>> c.set_alive()
>>> c.alive
True

```

New in version 3.4.

`functools.reduce(function, iterable[, initializer])`

Apply *function* of two arguments cumulatively to the items of *sequence*, from left to right, so as to reduce the sequence to a single value. For example, `reduce(lambda x, y: x+y, [1, 2, 3, 4, 5])` calculates `((((1+2)+3)+4)+5)`. The left argument, *x*, is the accumulated value and the right argument, *y*, is the update value from the *sequence*. If the optional *initializer* is present, it is placed before the items of the sequence in the calculation, and serves as a default when the sequence is empty. If *initializer* is not given and *sequence* contains only one item, the first item is returned.

Roughly equivalent to:

```
def reduce(function, iterable, initializer=None):
    it = iter(iterable)
    if initializer is None:
        value = next(it)
    else:
        value = initializer
    for element in it:
        value = function(value, element)
    return value
```

`@functools singledispatch`

Transform a function into a *single-dispatch generic function*.

To define a generic function, decorate it with the `@singledispatch` decorator. Note that the dispatch happens on the type of the first argument, create your function accordingly:

```
>>> from functools import singledispatch
>>> @singledispatch
... def fun(arg, verbose=False):
...     if verbose:
...         print("Let me just say,", end=" ")
...     print(arg)
```

To add overloaded implementations to the function, use the `register()` attribute of the generic function. It is a decorator. For functions annotated with types, the decorator will infer the type of the first argument automatically:

```
>>> @fun.register
... def _(arg: int, verbose=False):
...     if verbose:
...         print("Strength in numbers, eh?", end=" ")
...     print(arg)
...
>>> @fun.register
... def _(arg: list, verbose=False):
...     if verbose:
...         print("Enumerate this:")
...     for i, elem in enumerate(arg):
...         print(i, elem)
```

For code which doesn't use type annotations, the appropriate type argument can be passed explicitly to the decorator itself:

```
>>> @fun.register(complex)
... def _(arg, verbose=False):
```

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```
...     if verbose:
...         print("Better than complicated.", end=" ")
...     print(arg.real, arg.imag)
...
```

To enable registering lambdas and pre-existing functions, the `register()` attribute can be used in a functional form:

```
>>> def nothing(arg, verbose=False):
...     print("Nothing.")
...
>>> fun.register(type(None), nothing)
```

The `register()` attribute returns the undecorated function which enables decorator stacking, pickling, as well as creating unit tests for each variant independently:

```
>>> @fun.register(float)
... @fun.register(Decimal)
... def fun_num(arg, verbose=False):
...     if verbose:
...         print("Half of your number:", end=" ")
...     print(arg / 2)
...
>>> fun_num is fun
False
```

When called, the generic function dispatches on the type of the first argument:

```
>>> fun("Hello, world.")
Hello, world.
>>> fun("test.", verbose=True)
Let me just say, test.
>>> fun(42, verbose=True)
Strength in numbers, eh? 42
>>> fun(['spam', 'spam', 'eggs', 'spam'], verbose=True)
Enumerate this:
0 spam
1 spam
2 eggs
3 spam
>>> fun(None)
Nothing.
>>> fun(1.23)
0.615
```

Where there is no registered implementation for a specific type, its method resolution order is used to find a more generic implementation. The original function decorated with `@singledispatch` is registered for the base `object` type, which means it is used if no better implementation is found.

To check which implementation will the generic function choose for a given type, use the `dispatch()` attribute:

```
>>> fun.dispatch(float)
<function fun_num at 0x1035a2840>
```

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```
>>> fun.dispatch(dict)    # note: default implementation
<function fun at 0x103fe0000>
```

To access all registered implementations, use the read-only `registry` attribute:

```
>>> fun.registry.keys()
dict_keys([<class 'NoneType'>, <class 'int'>, <class 'object'>,
          <class 'decimal.Decimal'>, <class 'list'>,
          <class 'float'>])
>>> fun.registry[float]
<function fun_num at 0x1035a2840>
>>> fun.registry[object]
<function fun at 0x103fe0000>
```

New in version 3.4.

Changed in version 3.7: The `register()` attribute supports using type annotations.

`functools.update_wrapper(wrapper, wrapped, assigned=WRAPPER_ASSIGNMENTS, updated=WRAPPER_UPDATES)`

Update a *wrapper* function to look like the *wrapped* function. The optional arguments are tuples to specify which attributes of the original function are assigned directly to the matching attributes on the wrapper function and which attributes of the wrapper function are updated with the corresponding attributes from the original function. The default values for these arguments are the module level constants `WRAPPER_ASSIGNMENTS` (which assigns to the wrapper function's `__module__`, `__name__`, `__qualname__`, `__annotations__` and `__doc__`, the documentation string) and `WRAPPER_UPDATES` (which updates the wrapper function's `__dict__`, i.e. the instance dictionary).

To allow access to the original function for introspection and other purposes (e.g. bypassing a caching decorator such as `lru_cache()`), this function automatically adds a `__wrapped__` attribute to the wrapper that refers to the function being wrapped.

The main intended use for this function is in *decorator* functions which wrap the decorated function and return the wrapper. If the wrapper function is not updated, the metadata of the returned function will reflect the wrapper definition rather than the original function definition, which is typically less than helpful.

`update_wrapper()` may be used with callables other than functions. Any attributes named in *assigned* or *updated* that are missing from the object being wrapped are ignored (i.e. this function will not attempt to set them on the wrapper function). `AttributeError` is still raised if the wrapper function itself is missing any attributes named in *updated*.

New in version 3.2: Automatic addition of the `__wrapped__` attribute.

New in version 3.2: Copying of the `__annotations__` attribute by default.

Changed in version 3.2: Missing attributes no longer trigger an `AttributeError`.

Changed in version 3.4: The `__wrapped__` attribute now always refers to the wrapped function, even if that function defined a `__wrapped__` attribute. (see [bpo-17482](#))

`@functools.wraps(wrapped, assigned=WRAPPER_ASSIGNMENTS, updated=WRAPPER_UPDATES)`

This is a convenience function for invoking `update_wrapper()` as a function decorator when defining a wrapper function. It is equivalent to `partial(update_wrapper, wrapped=wrapped, assigned=assigned, updated=updated)`. For example:

```
>>> from functools import wraps
>>> def my_decorator(f):
```

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```

...     @wraps(f)
...     def wrapper(*args, **kwargs):
...         print('Calling decorated function')
...         return f(*args, **kwargs)
...     return wrapper
...
>>> @my_decorator
... def example():
...     """Docstring"""
...     print('Called example function')
...
>>> example()
Calling decorated function
Called example function
>>> example.__name__
'example'
>>> example.__doc__
'Docstring'

```

Without the use of this decorator factory, the name of the example function would have been 'wrapper', and the docstring of the original `example()` would have been lost.

10.2.1 partial Objects

partial objects are callable objects created by *partial()*. They have three read-only attributes:

partial.func

A callable object or function. Calls to the *partial* object will be forwarded to *func* with new arguments and keywords.

partial.args

The leftmost positional arguments that will be prepended to the positional arguments provided to a *partial* object call.

partial.keywords

The keyword arguments that will be supplied when the *partial* object is called.

partial objects are like *function* objects in that they are callable, weak referencable, and can have attributes. There are some important differences. For instance, the `__name__` and `__doc__` attributes are not created automatically. Also, *partial* objects defined in classes behave like static methods and do not transform into bound methods during instance attribute look-up.

10.3 operator — Standard operators as functions

Source code: [Lib/operator.py](#)

The *operator* module exports a set of efficient functions corresponding to the intrinsic operators of Python. For example, `operator.add(x, y)` is equivalent to the expression `x+y`. Many function names are those used for special methods, without the double underscores. For backward compatibility, many of these have a variant with the double underscores kept. The variants without the double underscores are preferred for clarity.

The functions fall into categories that perform object comparisons, logical operations, mathematical operations and sequence operations.

The object comparison functions are useful for all objects, and are named after the rich comparison operators they support:

```
operator.lt(a, b)
operator.le(a, b)
operator.eq(a, b)
operator.ne(a, b)
operator.ge(a, b)
operator.gt(a, b)
operator.__lt__(a, b)
operator.__le__(a, b)
operator.__eq__(a, b)
operator.__ne__(a, b)
operator.__ge__(a, b)
operator.__gt__(a, b)
```

Perform “rich comparisons” between *a* and *b*. Specifically, `lt(a, b)` is equivalent to `a < b`, `le(a, b)` is equivalent to `a <= b`, `eq(a, b)` is equivalent to `a == b`, `ne(a, b)` is equivalent to `a != b`, `gt(a, b)` is equivalent to `a > b` and `ge(a, b)` is equivalent to `a >= b`. Note that these functions can return any value, which may or may not be interpretable as a Boolean value. See comparisons for more information about rich comparisons.

The logical operations are also generally applicable to all objects, and support truth tests, identity tests, and boolean operations:

```
operator.not_(obj)
operator.__not__(obj)
```

Return the outcome of `not obj`. (Note that there is no `__not__()` method for object instances; only the interpreter core defines this operation. The result is affected by the `__bool__()` and `__len__()` methods.)

```
operator.truth(obj)
```

Return `True` if *obj* is true, and `False` otherwise. This is equivalent to using the `bool` constructor.

```
operator.is_(a, b)
```

Return `a is b`. Tests object identity.

```
operator.is_not(a, b)
```

Return `a is not b`. Tests object identity.

The mathematical and bitwise operations are the most numerous:

```
operator.abs(obj)
operator.__abs__(obj)
```

Return the absolute value of *obj*.

```
operator.add(a, b)
```

```
operator.__add__(a, b)
```

Return `a + b`, for *a* and *b* numbers.

```
operator.and_(a, b)
```

```
operator.__and__(a, b)
```

Return the bitwise and of *a* and *b*.

```
operator.floordiv(a, b)
```

```
operator.__floordiv__(a, b)
```

Return `a // b`.

```
operator.index(a)
```

```
operator.__index__(a)
    Return a converted to an integer. Equivalent to a.__index__().
```

```
operator.inv(obj)
operator.invert(obj)
operator.__inv__(obj)
operator.__invert__(obj)
    Return the bitwise inverse of the number obj. This is equivalent to ~obj.
```

```
operator.lshift(a, b)
operator.__lshift__(a, b)
    Return a shifted left by b.
```

```
operator.mod(a, b)
operator.__mod__(a, b)
    Return a % b.
```

```
operator.mul(a, b)
operator.__mul__(a, b)
    Return a * b, for a and b numbers.
```

```
operator.matmul(a, b)
operator.__matmul__(a, b)
    Return a @ b.

    New in version 3.5.
```

```
operator.neg(obj)
operator.__neg__(obj)
    Return obj negated (-obj).
```

```
operator.or_(a, b)
operator.__or__(a, b)
    Return the bitwise or of a and b.
```

```
operator.pos(obj)
operator.__pos__(obj)
    Return obj positive (+obj).
```

```
operator.pow(a, b)
operator.__pow__(a, b)
    Return a ** b, for a and b numbers.
```

```
operator.rshift(a, b)
operator.__rshift__(a, b)
    Return a shifted right by b.
```

```
operator.sub(a, b)
operator.__sub__(a, b)
    Return a - b.
```

```
operator.truediv(a, b)
operator.__truediv__(a, b)
    Return a / b where 2/3 is .66 rather than 0. This is also known as “true” division.
```

```
operator.xor(a, b)
operator.__xor__(a, b)
    Return the bitwise exclusive or of a and b.
```

Operations which work with sequences (some of them with mappings too) include:

```
operator.concat(a, b)
```

`operator.__concat__(a, b)`

Return `a + b` for `a` and `b` sequences.

`operator.contains(a, b)`

`operator.__contains__(a, b)`

Return the outcome of the test `b in a`. Note the reversed operands.

`operator.countOf(a, b)`

Return the number of occurrences of `b` in `a`.

`operator.delitem(a, b)`

`operator.__delitem__(a, b)`

Remove the value of `a` at index `b`.

`operatorgetitem(a, b)`

`operator.__getitem__(a, b)`

Return the value of `a` at index `b`.

`operator.indexOf(a, b)`

Return the index of the first of occurrence of `b` in `a`.

`operator.setitem(a, b, c)`

`operator.__setitem__(a, b, c)`

Set the value of `a` at index `b` to `c`.

`operator.length_hint(obj, default=0)`

Return an estimated length for the object `o`. First try to return its actual length, then an estimate using `object.__length_hint__()`, and finally return the default value.

New in version 3.4.

The `operator` module also defines tools for generalized attribute and item lookups. These are useful for making fast field extractors as arguments for `map()`, `sorted()`, `itertools.groupby()`, or other functions that expect a function argument.

`operator.attrgetter(attr)`

`operator.attrgetter(*attrs)`

Return a callable object that fetches `attr` from its operand. If more than one attribute is requested, returns a tuple of attributes. The attribute names can also contain dots. For example:

- After `f = attrgetter('name')`, the call `f(b)` returns `b.name`.
- After `f = attrgetter('name', 'date')`, the call `f(b)` returns `(b.name, b.date)`.
- After `f = attrgetter('name.first', 'name.last')`, the call `f(b)` returns `(b.name.first, b.name.last)`.

Equivalent to:

```
def attrgetter(*items):
    if any(not isinstance(item, str) for item in items):
        raise TypeError('attribute name must be a string')
    if len(items) == 1:
        attr = items[0]
        def g(obj):
            return resolve_attr(obj, attr)
    else:
        def g(obj):
            return tuple(resolve_attr(obj, attr) for attr in items)
    return g
```

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```
def resolve_attr(obj, attr):
    for name in attr.split("."):
        obj = getattr(obj, name)
    return obj
```

`operator.itemgetter(item)`

`operator.itemgetter(*items)`

Return a callable object that fetches *item* from its operand using the operand's `__getitem__()` method. If multiple items are specified, returns a tuple of lookup values. For example:

- After `f = itemgetter(2)`, the call `f(r)` returns `r[2]`.
- After `g = itemgetter(2, 5, 3)`, the call `g(r)` returns `(r[2], r[5], r[3])`.

Equivalent to:

```
def itemgetter(*items):
    if len(items) == 1:
        item = items[0]
        def g(obj):
            return obj[item]
    else:
        def g(obj):
            return tuple(obj[item] for item in items)
    return g
```

The items can be any type accepted by the operand's `__getitem__()` method. Dictionaries accept any hashable value. Lists, tuples, and strings accept an index or a slice:

```
>>> itemgetter(1)('ABCDEFGH')
'B'
>>> itemgetter(1,3,5)('ABCDEFGH')
('B', 'D', 'F')
>>> itemgetter(slice(2,None))('ABCDEFGH')
'CDEFGH'
```

```
>>> soldier = dict(rank='captain', name='dotterbart')
>>> itemgetter('rank')(soldier)
'captain'
```

Example of using `itemgetter()` to retrieve specific fields from a tuple record:

```
>>> inventory = [('apple', 3), ('banana', 2), ('pear', 5), ('orange', 1)]
>>> getcount = itemgetter(1)
>>> list(map(getcount, inventory))
[3, 2, 5, 1]
>>> sorted(inventory, key=getcount)
[('orange', 1), ('banana', 2), ('apple', 3), ('pear', 5)]
```

`operator.methodcaller(name[, args...])`

Return a callable object that calls the method *name* on its operand. If additional arguments and/or keyword arguments are given, they will be given to the method as well. For example:

- After `f = methodcaller('name')`, the call `f(b)` returns `b.name()`.
- After `f = methodcaller('name', 'foo', bar=1)`, the call `f(b)` returns `b.name('foo', bar=1)`.

Equivalent to:

```
def methodcaller(name, *args, **kwargs):
    def caller(obj):
        return getattr(obj, name)(*args, **kwargs)
    return caller
```

10.3.1 Mapping Operators to Functions

This table shows how abstract operations correspond to operator symbols in the Python syntax and the functions in the `operator` module.

Operation	Syntax	Function
Addition	<code>a + b</code>	<code>add(a, b)</code>
Concatenation	<code>seq1 + seq2</code>	<code>concat(seq1, seq2)</code>
Containment Test	<code>obj in seq</code>	<code>contains(seq, obj)</code>
Division	<code>a / b</code>	<code>truediv(a, b)</code>
Division	<code>a // b</code>	<code>floordiv(a, b)</code>
Bitwise And	<code>a & b</code>	<code>and_(a, b)</code>
Bitwise Exclusive Or	<code>a ^ b</code>	<code>xor(a, b)</code>
Bitwise Inversion	<code>~ a</code>	<code>invert(a)</code>
Bitwise Or	<code>a b</code>	<code>or_(a, b)</code>
Exponentiation	<code>a ** b</code>	<code>pow(a, b)</code>
Identity	<code>a is b</code>	<code>is_(a, b)</code>
Identity	<code>a is not b</code>	<code>is_not(a, b)</code>
Indexed Assignment	<code>obj[k] = v</code>	<code>setitem(obj, k, v)</code>
Indexed Deletion	<code>del obj[k]</code>	<code>delitem(obj, k)</code>
Indexing	<code>obj[k]</code>	<code>getitem(obj, k)</code>
Left Shift	<code>a << b</code>	<code>lshift(a, b)</code>
Modulo	<code>a % b</code>	<code>mod(a, b)</code>
Multiplication	<code>a * b</code>	<code>mul(a, b)</code>
Matrix Multiplication	<code>a @ b</code>	<code>matmul(a, b)</code>
Negation (Arithmetic)	<code>- a</code>	<code>neg(a)</code>
Negation (Logical)	<code>not a</code>	<code>not_(a)</code>
Positive	<code>+ a</code>	<code>pos(a)</code>
Right Shift	<code>a >> b</code>	<code>rshift(a, b)</code>
Slice Assignment	<code>seq[i:j] = values</code>	<code>setitem(seq, slice(i, j), values)</code>
Slice Deletion	<code>del seq[i:j]</code>	<code>delitem(seq, slice(i, j))</code>
Slicing	<code>seq[i:j]</code>	<code>getitem(seq, slice(i, j))</code>
String Formatting	<code>s % obj</code>	<code>mod(s, obj)</code>
Subtraction	<code>a - b</code>	<code>sub(a, b)</code>
Truth Test	<code>obj</code>	<code>truth(obj)</code>
Ordering	<code>a < b</code>	<code>lt(a, b)</code>
Ordering	<code>a <= b</code>	<code>le(a, b)</code>
Equality	<code>a == b</code>	<code>eq(a, b)</code>
Difference	<code>a != b</code>	<code>ne(a, b)</code>
Ordering	<code>a >= b</code>	<code>ge(a, b)</code>
Ordering	<code>a > b</code>	<code>gt(a, b)</code>

10.3.2 Inplace Operators

Many operations have an “in-place” version. Listed below are functions providing a more primitive access to in-place operators than the usual syntax does; for example, the *statement* `x += y` is equivalent to `x = operator.iadd(x, y)`. Another way to put it is to say that `z = operator.iadd(x, y)` is equivalent to the compound statement `z = x; z += y`.

In those examples, note that when an in-place method is called, the computation and assignment are performed in two separate steps. The in-place functions listed below only do the first step, calling the in-place method. The second step, assignment, is not handled.

For immutable targets such as strings, numbers, and tuples, the updated value is computed, but not assigned back to the input variable:

```
>>> a = 'hello'
>>> iadd(a, ' world')
'hello world'
>>> a
'hello'
```

For mutable targets such as lists and dictionaries, the inplace method will perform the update, so no subsequent assignment is necessary:

```
>>> s = ['h', 'e', 'l', 'l', 'o']
>>> iadd(s, [' ', 'w', 'o', 'r', 'l', 'd'])
['h', 'e', 'l', 'l', 'o', ' ', 'w', 'o', 'r', 'l', 'd']
>>> s
['h', 'e', 'l', 'l', 'o', ' ', 'w', 'o', 'r', 'l', 'd']
```

`operator.iadd(a, b)`

`operator.__iadd__(a, b)`

`a = iadd(a, b)` is equivalent to `a += b`.

`operator.iand(a, b)`

`operator.__iand__(a, b)`

`a = iand(a, b)` is equivalent to `a &= b`.

`operator.iconcat(a, b)`

`operator.__iconcat__(a, b)`

`a = iconcat(a, b)` is equivalent to `a += b` for *a* and *b* sequences.

`operator.ifloordiv(a, b)`

`operator.__ifloordiv__(a, b)`

`a = ifloordiv(a, b)` is equivalent to `a //= b`.

`operator.ilshift(a, b)`

`operator.__ilshift__(a, b)`

`a = ilshift(a, b)` is equivalent to `a <<= b`.

`operator.imod(a, b)`

`operator.__imod__(a, b)`

`a = imod(a, b)` is equivalent to `a %= b`.

`operator.imul(a, b)`

`operator.__imul__(a, b)`

`a = imul(a, b)` is equivalent to `a *= b`.

`operator.imatmul(a, b)`

`operator.__imatmul__(a, b)`

`a = imatmul(a, b)` is equivalent to `a @= b`.

New in version 3.5.

`operator.ior(a, b)`

`operator.__ior__(a, b)`

`a = ior(a, b)` is equivalent to `a |= b`.

`operator.ipow(a, b)`

`operator.__ipow__(a, b)`

`a = ipow(a, b)` is equivalent to `a **= b`.

`operator.irshift(a, b)`

`operator.__irshift__(a, b)`

`a = irshift(a, b)` is equivalent to `a >>= b`.

`operator.isub(a, b)`

`operator.__isub__(a, b)`

`a = isub(a, b)` is equivalent to `a -= b`.

`operator.itruediv(a, b)`

`operator.__itruediv__(a, b)`

`a = itrueidiv(a, b)` is equivalent to `a /= b`.

`operator.ixor(a, b)`

`operator.__ixor__(a, b)`

`a = ixor(a, b)` is equivalent to `a ^= b`.