Memory Views

`memoryview` objects allow Python code to access the internal data of an object that supports the buffer protocol without copying.

class **memoryview**(object)

Create a `memoryview` that references *object*. *object* must support the buffer protocol. Built-in objects that support the buffer protocol include `bytes` and `bytearray`.

A `memoryview` has the notion of an *element*, which is the atomic memory unit handled by the originating *object*. For many simple types such as `bytes` and `bytearray`, an element is a single byte, but other types such as `array.array` may have bigger elements.

`len(view)` is equal to the length of `tolist`. If `view.ndim = 0`, the length is 1. If `view.ndim = 1`, the length is equal to the number of elements in the view. For higher dimensions, the length is equal to the length of the nested list representation of the view. The `itemsize` attribute will give you the number of bytes in a single element.

A `memoryview` supports slicing and indexing to expose its data. One-dimensional slicing will result in a subview:

```
>>> v = memoryview(b'abcefg')                                    >>>
>>> v[1]
98
>>> v[-1]
103
>>> v[1:4]
<memory at 0x7f3ddc9f4350>
>>> bytes(v[1:4])
b'bce'
```

If `format` is one of the native format specifiers from the `struct` module, indexing with an integer or a tuple of integers is also supported and returns a single *element* with the correct type. One-dimensional memoryviews can be indexed with an integer or a one-integer tuple. Multi-dimensional memoryviews can be indexed with tuples of exactly *ndim* integers where *ndim* is the number of dimensions. Zero-dimensional memoryviews can be indexed with the empty tuple.

Here is an example with a non-byte format:

```
>>> import array                                                 >>>
>>> a = array.array('l', [-11111111, 22222222, -33333333, 44444444])
>>> m = memoryview(a)
>>> m[0]
-11111111
>>> m[-1]
44444444
>>> m[::2].tolist()
[-11111111, -33333333]
```

If the underlying object is writable, the memoryview supports one-dimensional slice assignment. Resizing is not allowed:

```
>>> data = bytearray(b'abcefg')                                  >>>
>>> v = memoryview(data)
>>> v.readonly
False
>>> v[0] = ord(b'z')
>>> data
```

```
bytearray(b'zbcefg')
>>> v[1:4] = b'123'
>>> data
bytearray(b'z123fg')
>>> v[2:3] = b'spam'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: memoryview assignment: lvalue and rvalue have different structures
>>> v[2:6] = b'spam'
>>> data
bytearray(b'z1spam')
```

One-dimensional memoryviews of hashable (read-only) types with formats 'B', 'b' or 'c' are also hashable. The hash is defined as `hash(m) == hash(m.tobytes())`:

```
>>> v = memoryview(b'abcefg')
>>> hash(v) == hash(b'abcefg')
True
>>> hash(v[2:4]) == hash(b'ce')
True
>>> hash(v[::-2]) == hash(b'abcefg'[::-2])
True
```

Changed in version 3.3: One-dimensional memoryviews can now be sliced. One-dimensional memoryviews with formats 'B', 'b' or 'c' are now hashable.

Changed in version 3.4: memoryview is now registered automatically with `collections.abc.Sequence`

Changed in version 3.5: memoryviews can now be indexed with tuple of integers.

`memoryview` has several methods:

__eq__(exporter)

A memoryview and a **PEP 3118** exporter are equal if their shapes are equivalent and if all corresponding values are equal when the operands' respective format codes are interpreted using `struct` syntax.

For the subset of `struct` format strings currently supported by `tolist()`, `v` and `w` are equal if `v.tolist() == w.tolist()`:

```
>>> import array
>>> a = array.array('I', [1, 2, 3, 4, 5])
>>> b = array.array('d', [1.0, 2.0, 3.0, 4.0, 5.0])
>>> c = array.array('b', [5, 3, 1])
>>> x = memoryview(a)
>>> y = memoryview(b)
>>> x == a == y == b
True
>>> x.tolist() == a.tolist() == y.tolist() == b.tolist()
True
>>> z = y[::-2]
>>> z == c
True
>>> z.tolist() == c.tolist()
True
```

If either format string is not supported by the `struct` module, then the objects will always compare as unequal (even if the format strings and buffer contents are identical):

```
>>> from ctypes import BigEndianStructure, c_long
>>> class BEPoint(BigEndianStructure):
...     _fields_ = [("x", c_long), ("y", c_long)]
...
>>> point = BEPoint(100, 200)
>>> a = memoryview(point)
>>> b = memoryview(point)
>>> a == point
False
>>> a == b
False
```

Note that, as with floating point numbers, `v is w` does *not* imply `v == w` for memoryview objects.

Changed in version 3.3: Previous versions compared the raw memory disregarding the item format and the logical array structure.

tobytes(order='C')

Return the data in the buffer as a bytestring. This is equivalent to calling the `bytes` constructor on the memoryview.

```
>>> m = memoryview(b"abc")
>>> m.tobytes()
b'abc'
>>> bytes(m)
b'abc'
```

For non-contiguous arrays the result is equal to the flattened list representation with all elements converted to bytes. `tobytes()` supports all format strings, including those that are not in `struct` module syntax.

New in version 3.8: order can be {'C', 'F', 'A'}. When *order* is 'C' or 'F', the data of the original array is converted to C or Fortran order. For contiguous views, 'A' returns an exact copy of the physical memory. In particular, in-memory Fortran order is preserved. For non-contiguous views, the data is converted to C first. *order=None* is the same as *order='C'*.

hex([sep[, bytes_per_sep]])

Return a string object containing two hexadecimal digits for each byte in the buffer.

```
>>> m = memoryview(b"abc")
>>> m.hex()
'616263'
```

New in version 3.5.

Changed in version 3.8: Similar to `bytes.hex()`, `memoryview.hex()` now supports optional *sep* and *bytes_per_sep* parameters to insert separators between bytes in the hex output.

tolist()

Return the data in the buffer as a list of elements.

```
>>> memoryview(b'abc').tolist()
[97, 98, 99]
>>> import array
>>> a = array.array('d', [1.1, 2.2, 3.3])
>>> m = memoryview(a)
```

```
>>> m.tolist()
[1.1, 2.2, 3.3]
```

Changed in version 3.3: `tolist()` now supports all single character native formats in `struct` module syntax as well as multi-dimensional representations.

toreadonly()

Return a readonly version of the memoryview object. The original memoryview object is unchanged.

```
>>> m = memoryview(bytearray(b'abc'))
>>> mm = m.toreadonly()
>>> mm.tolist()
[89, 98, 99]
>>> mm[0] = 42
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: cannot modify read-only memory
>>> m[0] = 43
>>> mm.tolist()
[43, 98, 99]
```

New in version 3.8.

release()

Release the underlying buffer exposed by the memoryview object. Many objects take special actions when a view is held on them (for example, a `bytearray` would temporarily forbid resizing); therefore, calling release() is handy to remove these restrictions (and free any dangling resources) as soon as possible.

After this method has been called, any further operation on the view raises a `ValueError` (except `release()` itself which can be called multiple times):

```
>>> m = memoryview(b'abc')
>>> m.release()
>>> m[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operation forbidden on released memoryview object
```

The context management protocol can be used for a similar effect, using the `with` statement:

```
>>> with memoryview(b'abc') as m:
...     m[0]
...
97
>>> m[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operation forbidden on released memoryview object
```

New in version 3.2.

cast(format[, shape])

Cast a memoryview to a new format or shape. *shape* defaults to `[byte_length//new_itemsize]`, which means that the result view will be one-dimensional. The return value is a new memoryview, but the buffer itself is not copied. Supported casts are 1D -> C-contiguous and C-contiguous -> 1D.

The destination format is restricted to a single element native format in `struct` syntax. One of the formats must be a byte format ('B', 'b' or 'c'). The byte length of the result must be the same as the original length.

Cast 1D/long to 1D/unsigned bytes:

```
>>> import array
>>> a = array.array('l', [1,2,3])
>>> x = memoryview(a)
>>> x.format
'l'
>>> x.itemsize
8
>>> len(x)
3
>>> x.nbytes
24
>>> y = x.cast('B')
>>> y.format
'B'
>>> y.itemsize
1
>>> len(y)
24
>>> y.nbytes
24
```

Cast 1D/unsigned bytes to 1D/char:

```
>>> b = bytearray(b'zyz')
>>> x = memoryview(b)
>>> x[0] = b'a'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: memoryview: invalid value for format "B"
>>> y = x.cast('c')
>>> y[0] = b'a'
>>> b
bytearray(b'ayz')
```

Cast 1D/bytes to 3D/ints to 1D/signed char:

```
>>> import struct
>>> buf = struct.pack("i"*12, *list(range(12)))
>>> x = memoryview(buf)
>>> y = x.cast('i', shape=[2,2,3])
>>> y.tolist()
[[[0, 1, 2], [3, 4, 5]], [[6, 7, 8], [9, 10, 11]]]
>>> y.format
'i'
>>> y.itemsize
4
>>> len(y)
2
>>> y.nbytes
48
>>> z = y.cast('b')
>>> z.format
'b'
>>> z.itemsize
1
>>> len(z)
```

```
48
>>> z.nbytes
48
```

Cast 1D/unsigned long to 2D/unsigned long:

```
>>> buf = struct.pack("L"*6, *list(range(6)))
>>> x = memoryview(buf)
>>> y = x.cast('L', shape=[2,3])
>>> len(y)
2
>>> y.nbytes
48
>>> y.tolist()
[[0, 1, 2], [3, 4, 5]]
```

New in version 3.3.

Changed in version 3.5: The source format is no longer restricted when casting to a byte view.

There are also several readonly attributes available:

obj

The underlying object of the memoryview:

```
>>> b  = bytearray(b'xyz')
>>> m = memoryview(b)
>>> m.obj is b
True
```

New in version 3.3.

nbytes

`nbytes == product(shape) * itemsize == len(m.tobytes())`. This is the amount of space in bytes that the array would use in a contiguous representation. It is not necessarily equal to `len(m)`:

```
>>> import array
>>> a = array.array('i', [1,2,3,4,5])
>>> m = memoryview(a)
>>> len(m)
5
>>> m.nbytes
20
>>> y = m[::2]
>>> len(y)
3
>>> y.nbytes
12
>>> len(y.tobytes())
12
```

Multi-dimensional arrays:

```
>>> import struct
>>> buf = struct.pack("d"*12, *[1.5*x for x in range(12)])
>>> x = memoryview(buf)
>>> y = x.cast('d', shape=[3,4])
>>> y.tolist()
[[0.0, 1.5, 3.0, 4.5], [6.0, 7.5, 9.0, 10.5], [12.0, 13.5, 15.0, 16.5]]
>>> len(y)
```

```
3
>>> y.nbytes
96
```

New in version 3.3.

readonly

A bool indicating whether the memory is read only.

format

A string containing the format (in `struct` module style) for each element in the view. A memoryview can be created from exporters with arbitrary format strings, but some methods (e.g. `tolist()`) are restricted to native single element formats.

Changed in version 3.3: format `'B'` is now handled according to the struct module syntax. This means that `memoryview(b'abc')[0] == b'abc'[0] == 97`.

itemsize

The size in bytes of each element of the memoryview:

```
>>> import array, struct
>>> m = memoryview(array.array('H', [32000, 32001, 32002]))
>>> m.itemsize
2
>>> m[0]
32000
>>> struct.calcsize('H') == m.itemsize
True
```

ndim

An integer indicating how many dimensions of a multi-dimensional array the memory represents.

shape

A tuple of integers the length of `ndim` giving the shape of the memory as an N-dimensional array.

Changed in version 3.3: An empty tuple instead of `None` when ndim = 0.

strides

A tuple of integers the length of `ndim` giving the size in bytes to access each element for each dimension of the array.

Changed in version 3.3: An empty tuple instead of `None` when ndim = 0.

suboffsets

Used internally for PIL-style arrays. The value is informational only.

c_contiguous

A bool indicating whether the memory is C-contiguous.

New in version 3.3.

f_contiguous

A bool indicating whether the memory is Fortran contiguous.

New in version 3.3.

contiguous

A bool indicating whether the memory is contiguous.

New in version 3.3.