# copy — Duplicate Objects

**Purpose:** Provides functions for duplicating objects using shallow or deep copy semantics.

The copy module includes two functions, `copy()` and `deepcopy()`, for duplicating existing objects.

## Shallow Copies

The *shallow copy* created by `copy()` is a new container populated with references to the contents of the original object. When making a shallow copy of a `list` object, a new `list` is constructed and the elements of the original object are appended to it.

```
# copy_shallow.py

import copy
import functools


@functools.total_ordering
class MyClass:

    def __init__(self, name):
        self.name = name

    def __eq__(self, other):
        return self.name == other.name

    def __gt__(self, other):
        return self.name > other.name


a = MyClass('a')
my_list = [a]
dup = copy.copy(my_list)

print('             my_list:', my_list)
print('                 dup:', dup)
print('      dup is my_list:', (dup is my_list))
print('      dup == my_list:', (dup == my_list))
print('dup[0] is my_list[0]:', (dup[0] is my_list[0]))
print('dup[0] == my_list[0]:', (dup[0] == my_list[0]))
```

For a shallow copy, the `MyClass` instance is not duplicated, so the reference in the dup list is to the same object that is in `my_list`.

```
$ python3 copy_shallow.py

             my_list: [<__main__.MyClass object at 0x101f9c160>]
                 dup: [<__main__.MyClass object at 0x101f9c160>]
      dup is my_list: False
      dup == my_list: True
dup[0] is my_list[0]: True
dup[0] == my_list[0]: True
```

## Deep Copies

The *deep copy* created by `deepcopy()` is a new container populated with copies of the contents of the original object. To make a deep copy of a `list`, a new `list` is constructed, the elements of the original list are copied, and then those copies are appended to the new list.

Replacing the call to `copy()` with `deepcopy()` makes the difference in the output apparent.

```
# copy_deep.py
```

```
import copy
import functools


@functools.total_ordering
class MyClass:

    def __init__(self, name):
        self.name = name

    def __eq__(self, other):
        return self.name == other.name

    def __gt__(self, other):
        return self.name > other.name


a = MyClass('a')
my_list = [a]
dup = copy.deepcopy(my_list)

print('             my_list:', my_list)
print('                 dup:', dup)
print('      dup is my_list:', (dup is my_list))
print('      dup == my_list:', (dup == my_list))
print('dup[0] is my_list[0]:', (dup[0] is my_list[0]))
print('dup[0] == my_list[0]:', (dup[0] == my_list[0]))
```

The first element of the list is no longer the same object reference, but when the two objects are compared they still evaluate as being equal.

```
$ python3 copy_deep.py

             my_list: [<__main__.MyClass object at 0x101e9c160>]
                 dup: [<__main__.MyClass object at 0x1044e1f98>]
      dup is my_list: False
      dup == my_list: True
dup[0] is my_list[0]: False
dup[0] == my_list[0]: True
```

## Customizing Copy Behavior

It is possible to control how copies are made using the `__copy__()` and `__deepcopy__()` special methods.

- `__copy__()` is called without any arguments and should return a shallow copy of the object.
- `__deepcopy__()` is called with a memo dictionary and should return a deep copy of the object. Any member attributes that need to be deep-copied should be passed to `copy.deepcopy()`, along with the memo dictionary, to control for recursion. (The memo dictionary is explained in more detail later.)

The following example illustrates how the methods are called.

```
# copy_hooks.py

import copy
import functools


@functools.total_ordering
class MyClass:

    def __init__(self, name):
        self.name = name

    def __eq__(self, other):
        return self.name == other.name

    def __gt__(self, other):
        return self.name > other.name
```

```
    def __copy__(self):
        print('__copy__()')
        return MyClass(self.name)

    def __deepcopy__(self, memo):
        print('__deepcopy__({})'.format(memo))
        return MyClass(copy.deepcopy(self.name, memo))


a = MyClass('a')

sc = copy.copy(a)
dc = copy.deepcopy(a)
```

The memo dictionary is used to keep track of the values that have been copied already, so as to avoid infinite recursion.

```
$ python3 copy_hooks.py

__copy__()
__deepcopy__({})
```

## Recursion in Deep Copy

To avoid problems with duplicating recursive data structures, `deepcopy()` uses a dictionary to track objects that have already been copied. This dictionary is passed to the `__deepcopy__()` method so it can be examined there as well.

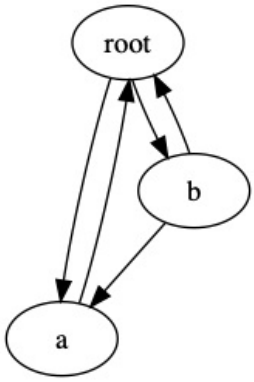
The next example shows how an interconnected data structure such as a directed graph can help protect against recursion by implementing a `__deepcopy__()` method.

```
# copy_recursion.py

import copy


class Graph:

    def __init__(self, name, connections):
        self.name = name
        self.connections = connections

    def add_connection(self, other):
        self.connections.append(other)

    def __repr__(self):
        return 'Graph(name={}, id={})'.format(
            self.name, id(self))

    def __deepcopy__(self, memo):
        print('\nCalling __deepcopy__ for {!r}'.format(self))
        if self in memo:
            existing = memo.get(self)
            print('  Already copied to {!r}'.format(existing))
            return existing
        print('  Memo dictionary:')
        if memo:
            for k, v in memo.items():
                print('    {}: {}'.format(k, v))
        else:
            print('    (empty)')
        dup = Graph(copy.deepcopy(self.name, memo), [])
        print('  Copying to new object {}'.format(dup))
        memo[self] = dup
        for c in self.connections:
            dup.add_connection(copy.deepcopy(c, memo))
        return dup


root = Graph('root', [])
a = Graph('a', [root])
```

```
b = Graph('b', [a, root])
root.add_connection(a)
root.add_connection(b)

dup = copy.deepcopy(root)
```

The `Graph` class includes a few basic directed graph methods. An instance can be initialized with a name and a list of existing nodes to which it is connected. The `add_connection()` method is used to set up bidirectional connections. It is also used by the deep copy operator.

The `__deepcopy__()` method prints messages to show how it is called, and manages the memo dictionary contents as needed. Instead of copying the entire connection list wholesale, it creates a new list and appends copies of the individual connections to it. That ensures that the memo dictionary is updated as each new node is duplicated, and it avoids recursion issues or extra copies of nodes. As before, the method returns the copied object when it is done.




**Deep Copy for an Object Graph with Cycles**

The graph shown in the figure includes several cycles, but handling the recursion with the memo dictionary prevents the traversal from causing a stack overflow error. When the *root* node is copied, it produces the following output.

```
$ python3 copy_recursion.py


Calling __deepcopy__ for Graph(name=root, id=4326183824)
  Memo dictionary:
    (empty)
  Copying to new object Graph(name=root, id=4367233208)

Calling __deepcopy__ for Graph(name=a, id=4326186344)
  Memo dictionary:
    Graph(name=root, id=4326183824): Graph(name=root,
id=4367233208)
  Copying to new object Graph(name=a, id=4367234720)

Calling __deepcopy__ for Graph(name=root, id=4326183824)
  Already copied to Graph(name=root, id=4367233208)

Calling __deepcopy__ for Graph(name=b, id=4326183880)
  Memo dictionary:
    Graph(name=root, id=4326183824): Graph(name=root,
id=4367233208)
    Graph(name=a, id=4326186344): Graph(name=a, id=4367234720)
    4326183824: Graph(name=root, id=4367233208)
    4367217936: [Graph(name=root, id=4326183824), Graph(name=a,
id=4326186344)]
    4326186344: Graph(name=a, id=4367234720)
  Copying to new object Graph(name=b, id=4367235000)
```

The second time the *root* node is encountered, while the *a* node is being copied, `__deepcopy__()` detects the recursion and reuses the existing value from the memo dictionary instead of creating a new object.

## See also

- Standard library documentation for copy

weakref — Impermanent References to Objects

pprint — Pretty-Print Data Structures

**Quick Links**



*This page was last updated 2018-03-18.*

**Navigation**

weakref — Impermanent References to Objects
pprint — Pretty-Print Data Structures



*The output from all the example programs from PyMOTW-3 has been generated with Python 3.7.1, unless otherwise noted. Some of the features described here may not be available in earlier versions of Python.*

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