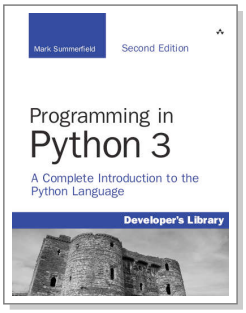
Moving from Python 2 to Python 3

Introduction This document is aimed at Python 2 programmers wishing to start developing using Python 3. The document lists those objects and idioms that have changed between the versions, showing how to change from Python 2-style to Python 3.1-style. It also lists some of the most useful new features in Python 3.1. Note that if you want to convert an existing program or module, the place to start is with the `2to3` tool (`docs.python.org/library/2to3.html`). For a complete introduction to the Python 3 language (covering both 3.0 and 3.1, and vastly more than there's room for here), see *Programming in Python 3* (Second Edition) by Mark Summerfield, ISBN 0321680561 (`www.qtrac.eu/py3book.html`).



Strings and String Formatting

Python 3 strings are Unicode; `unicode()` is gone

Python 2	*Python 3.1*
`s = unicode(x)`	`s = str(x)`
`s = u"\u20AC"`	`s = "\u20AC"`
`s = ur"\w"`	`s = r"\w"`

String `%` operator is deprecated; use `str.format()`

`"%d %s" % (i, s)`	`"{} {}".format(i, s)`
	`"{0} {1}".format(i, s)`
	`"{i} {s}".format(i=i, s=s)`
`"%(i)d %(s)s" % {'i':i, 's':s}`	`"{0[i]} {0[s]}".format({'i':i, 's':s})`
	`"{i} {s}".format(**{'i':i, 's':s})`
`"%(i)d %(s)s" % locals()`	`"{i} {s}".format(**locals())`
`"%s-%s" % ("X", "X")`	`"{0}-{0}".format("X")`
`"%.2f" % 3.142`	`"{:.2f}".format(3.142)`
	`"{0:.2f}".format(3.142)`
	`"{π:.2f}".format(π=3.142)`
`"%.4s" % "Prime"`	`"{:.4}".format("Prime")`
`"{%d%%}" % 20`	`"{{{}%}}".format(20)`
`"%0*d" % (3, 7)`	`"{:0{}}".format(7, 3)`

Representational Form

Backticks are gone; use `repr()` or `str.format()`

Python 2	*Python 3.1*
`s = `x``	`s = repr(x)`
	`s = "{!r}".format(x)`
	`s = "{0!r}".format(x)`
	`s = "{z!r}".format(z=x)`

Force ASCII representation with `ascii()`

`s = `x``	`s = ascii(x)`
	`s = "{!a}".format(x)`

Printing and Executing

New functions `print()`, `exec()`; `execfile()` is gone

Python 2	*Python 3.1*
`print a, b, c`	`print(a, b, c)`
`print "%03d" % 7`	`print("{:03d}".format(7))`
`print x,`	`print(x, end=" ")`
`print>>sys.stderr, x`	`print(x, file=sys.stderr)`
`exec code`	`exec(code)`
`exec code in globals`	`exec(code, globals)`
`exec code in (globals, locals)`	`exec(code, globals, locals)`
`execfile(file)`	`with open(file) as fh:` `  exec(fh.read())`

Numbers

Division doesn't truncate; `long()` is gone; octal literals must start with `0o` (zero-oh)

Python 2	*Python 3.1*
`x = 5 / 2.0 # x==2.5`	`x = 5 / 2  # x==2.5`
`x = 5 / 2  # x==2`	`x = 5 // 2 # x==2`
`i = 2147483648L`	`i = 2147483648`
`j = long(i * 2)`	`j = int(i * 2)`
`x = 0123  # x==83`	`x = 0o123  # x==83`

Iterators

New `next()`; iterators must have `__next__()`

Python 2	*Python 3.1*
`x = iterator.next()`	`x = next(iterator)`

`class Iterator:`
`  def __init__(self):`
`  self.i = -1`
`  def next(self):`
`  self.i += 1`
`  return self.i`
	`class Iterator:`
	`  def __init__(self):`
	`  self.i = -1`
	`  def __next__(self):`
	`  self.i += 1`
	`  return self.i`

Removals and Replacements

An operator, an exception, a constant, some types, several global functions, several dictionary methods, and some `itertools` functions are gone

Python 2	*Python 3.1*
`if a <> b:`	`if a != b:`
`apply(fn, args)`	`fn(*args)`
`apply(fn, args, kwargs)`	`fn(*args, **kwargs)`
`if isinstance(x, basestring):`	`if isinstance(x, str):`
`x = buffer(y)`	`x = memoryview(y)` `# this is similar`
`if callable(x):`	`if hasattr(x, "__call__"):`
`fh = file(fname, mode)`	`fh = open(fname, mode)`
`if d.has_key(k):`	`if k in d:`
`for k, v in \ d.iteritems():`	`for k, v in d.items():`
`for k in d.iterkeys():`	`for k in d.keys():`
	`for k in d:`
`for v in \ d.itervalues():`	`for v in d.values():`
`for line in \ file.xreadlines():`	`for line in file:`
`x = input(msg)`	`x = eval(input(msg))`
`intern(s)`	`sys.intern(s)`
`f = itertools.ifilter( fn, seq)`	`f = filter(fn, seq)`
`m = itertools.imap( fn, seq)`	`m = map(fn, seq)`
`z = itertools.izip( seq1, seq2)`	`z = zip(seq1, seq2)`
`dir = os.getcwdu()`	`dir = os.getcwd()`
`s = raw_input(msg)`	`s = input(msg)`
`r = reduce(fn, seq)`	`r = functools.reduce( fn, seq)`
`reload(module)`	`imp.reload(module)`
`class MyErr( StandardError):`	`class MyErr( Exception):`
`sys.maxint`	`sys.maxsize`
`for i in xrange(n):`	`for i in range(n):`

Renamed Attributes and Methods

Implement `__bool__()` instead of `__nonzero__()` to return a custom class's truth value

Python 2	*Python 3.1*
`fn.func_closure`	`fn.__closure__`
`fn.func_code`	`fn.__code__`
`fn.func_defaults`	`fn.__defaults__`
`fn.func_dict`	`fn.__dict__`
`fn.func_doc`	`fn.__doc__`
`fn.func_globals`	`fn.__globals__`
`fn.func_name`	`fn.__name__`
`obj.method.im_func`	`obj.method.__func__`
`obj.method.im_self`	`obj.method.__self__`
`obj.method.im_class`	`obj.method.__class__`
`string.letters`	`string.ascii_letters`
`string.lowercase`	`string.ascii_lowercase`
`string.uppercase`	`string.ascii_uppercase`
`threading.Lock. \ acquire_lock()`	`threading.Lock. \ acquire()`
`threading.Lock. \ release_lock()`	`threading.Lock. \ release()`

`class Thing:`
`  def __init__(`
`  self, x):`
`  self.x = x`
`  def __nonzero__(`
`  self):`
`  return \`
`  bool(self.x)`
	`class Thing:`
	`  def __init__(`
	`  self, x):`
	`  self.x = x`
	`  def __bool__(self):`
	`  return bool(self.x)`

Exceptions

Catching exception objects requires the `as` keyword; raising exceptions with arguments requires parentheses; strings cannot be used as exceptions

Python 2	*Python 3.1*

`try:`
`  process()`
`except ValueError, \`
`  err:`
`  print err`
	`try:`
	`  process()`
	`except ValueError \`
	`  as err:`
	`  print(err)`

`try:`
`  process()`
`except (MyErr1,`
`  MyErr2), err:`
`  print err`
	`try:`
	`  process()`
	`except (MyErr1,`
	`  MyErr2) as err:`
	`  print(err)`

`raise MyErr, msg`	`raise MyErr(msg)`
`raise MyErr, msg, tb`	`raise MyErr(msg). \ with_traceback(tb)`
`raise "Error"`	`raise Exception( "Error")`
`generator.throw( MyErr, msg)`	`generator.throw( MyErr(msg))`
`generator.throw( "Error")`	`generator.throw( Exception("Error"))`

Renamed Modules

Data read from a URL, e.g., using `urllib.request.urlopen()` is returned as a `bytes` object; use `bytes.decode(`*`encoding`*`)` to convert it to a string. The `bsddb` (Berkeley DB library) is gone—but is avaliable from `pypi.python.org/pypi/bsddb3`. See PEP 3108 (`www.python.org/dev/peps/pep-3108`) for module renaming details

Python 2	*Python 3.1*
`import anydbm`	`import dbm`
`import whichdb`	
`import BaseHTTPServer`	`import http.server`
`import \` `  SimpleHTTPServer`	
`import CGIHTTPServer`	
`import __builtin__`	`import builtins`
`import commands`	`import subprocess`
`import ConfigParser`	`import configparser`
`import Cookie`	`import http.cookies`
`import cookielib`	`import http.cookiejar`
`import copy_reg`	`import copyreg`
`import dbm`	`import dbm.ndbm`
`import DocXMLRPCServer`	`import xmlrpc.server`
`import \` `  SimpleXMLRPCServer`	
`import dumbdbm`	`import dbm.dumb`
`import gdbm`	`import dbm.gnu`
`import httplib`	`import http.client`
`import Queue`	`import queue`
`import repr`	`import reprlib`
`import robotparser`	`import \` `  urllib.robotparser`
`import SocketServer`	`import socketserver`
`import \` `  test.test_support`	`import test.support`
`import Tkinter`	`import tkinter`

`import urllib`	`import \`
	`  urllib.request, \`
	`  urllib.parse, \`
	`  urllib.error`

`import urllib2`	`import \`
	`  urllib.request, \`
	`  urllib.error`

`import urlparse`	`import urllib.parse`
`import xmlrpclib`	`import xmlrpc.client`

Python 3.1 Idioms

Tuples need parentheses in comprehensions; metaclasses are set with the `metaclass` keyword; import the pickle and string I/O modules directly; `lambda` doesn't unpack tuples; set literals are supported (the empty set is `set()`; `{}` is an empty `dict`); sorting is fastest using a key function; `super()` is better; type-testing is more robust with `isinstance()`; use `True` and `False` rather than `1` and `0`

Python 2	*Python 3.1*
`L = [x for x in 3, 6]`	`L = [x for x in (3, 6)]`

`class A:`
`  __metaclass__ = \`
`  MyMeta`
`class B(MyBase):`
`  __metaclass__ = \`
`  MyMeta`
	`class A(`
	`  metaclass=MyMeta):`
	`  pass`
	`class B(MyBase,`
	`  metaclass=MyMeta):`
	`  pass`

`try:`
`  import cPickle \`
`  as pickle`
`except ImportError:`
`  import pickle`
	`import pickle`

`try:`
`  import cStringIO \`
`  as StringIO`
`except ImportError:`
`  import StringIO`
	`import io`

`fn = lambda (a,): \` `  abs(a)`	`fn = lambda t: \` `  abs(t[0])`
	`fn = lambda a: abs(a)`
`fn = lambda (a, b): \` `  a + b`	`fn = lambda t: \` `  t[0] + t[1]`
	`fn = lambda a, b: a + b`
`S = set((2, 4, 6))`	`S = {2, 4, 6}`
`S = set([2, 4, 6])`	
`L = list(seq)` `L.sort()`	`L = sorted(seq)`

`words.sort(`
`  lambda x, y:`
`  cmp(x.lower(),`
`  y.lower()))`
	`words.sort(`
	`  key=lambda x:`
	`  x.lower())`

`class B(A):`
`  def __init__(self):`
`  super(B, self). \`
`  __init__()`
	`class B(A):`
	`  def __init__(self):`
	`  super(). \`
	`  __init__()`

`if type(x) == X:`	`if isinstance(x, X):`
`if type(x) is X:`	
`while 1:` `  process()`	`while True:` `  process()`

New in Python 3.1

Dictionary and set comprehensions; * unpacking; binary literals; `bytes` and `bytearray` types; `bz2.BZ2File` and `gzip.GzipFile` are context managers; `collections.Counter` dictionary type; `collections.OrderedDict` insertion-ordered dictionary type; `decimal.Decimal`s can be created from `floats`

Python 2	*Python 3.1*

`d = {}`
`for x in range(5):`
`  d[x] = x**3`
	`d = {x: x**3`
	`  for x in range(5)}`

`S = set(` `  [x for x in seq])`	`S = {x for x in seq}`

Python 3.1

```
a, *b = (1, 2, 3)       # a==1; b==[2, 3]
*a, b = (1, 2, 3)       # a==[1, 2]; b==3
a, *b, c = (1, 2, 3, 4) # a==1; b==[2, 3]; c==4
x = 0b1001001           # x==73
s = bin(97)             # s=='0b1100001'
y = int(s, 2)           # y==97
u = "The €" # or: u = "The \u20ac"
            # or: u = "The \N{euro sign}"
v = u.encode("utf8") # v==b'The \xe2\x82\xac'
w = v.decode("utf8") # w=='The €'
x = bytes.fromhex("54 68 65 20 E2 82 AC")
    # x==b'The \xe2\x82\xac'
y = x.decode("utf8") # y=='The €'
z = bytearray(y)
z[-3:] = b"$"        # z==bytearray(b'The $')
with bz2.BZ2File(filename) as fh:
  data = fh.read()
counts = collections.Counter("alphabetical")
# counts.most_common(2)==[('a', 3), ('l', 2)]
d = collections.OrderedDict(
  (("x", 1), ("k", 2), ("q", 3)))
# list(d.keys())==['x', 'k', 'q']
dec = decimal.Decimal.from_float(3.75)
# dec==Decimal('3.75')
```

Special Methods

The slice methods (`__delslice()__`, `__getslice()__`, `__setslice__`) are gone; instead `__delitem()__`, `__getitem()__`, and `__setitem__` are called with a `slice` object.

The methods `__hex__()` and `__oct__()` are gone; use `hex()` and `oct()`. To provide an integer, implement `__index__()`.

General Notes

Python 3 often returns iterables where Python 2 returned lists. This is usually fine, but if a list is really needed, use the `list()` factory function. For example, given dictionary, `d`, `list(d.keys())` returns its keys as a list. Affected functions and methods include `dict.items()`, `dict.keys()`, `dict.values()`, `filter()`, `map()`, `range()`, and `zip()`.

Most of the `types` module's types (such as `types.LongType`) have gone. Use the factory function instead. For example, replace `if isinstance(x, types.IntType)` with `if isinstance(x, int)`.

Comparisons are strict—`x < y` will work for compatible types (e.g., `x` and `y` are both numbers or both strings); otherwise raises a `TypeError`.

Some doctests involving floating point numbers might break because Python 3.1 uses David Gay's algorithm to show the shortest representation that preserves the number's value. For example, 1.1 in Python 2 and 3.0 is displayed as `1.1000000000000001`, and in Python 3.1 as `1.1`.

String Format Specifications

`str.format()` strings have one or more replacement fields of form: {*Name*!*Conv*:*Spec*}. *Name* identifies the object to format. Optional !*Conv* is: `!a` (ASCII `repr()` format), `!r` (`repr()` format), or `!s` (string format). Optional :*Spec* is of form:

: *Fill Align Sign* # `0` *Width* , .*Prec Type*

Fill is any character except }. *Align* is: < (left), > (right), ^ (center), or = (pad between sign and number). *Sign* is: + (force), – (- if needed), or " " (space or -). # prefixes `int`s with `0b`, `0o`, or `0x`. `0` means 0-pad numbers. *Width* is the minimum width. The , means use grouping commas. .*Prec* is the maximum width for `str`s and number of decimal places for `float`s. *Type* is: `%` (percent), `b` (binary), `d` (decimal), `e` or `E` (exponential), `f` (`float`) `g` or `G` (general `float`) `n` (localized) `o` (octal), `x` or `X` (hex). Everything is optional, except that *Fill* requires *Align*.

```
"{:*=+10.1f}".format(12345.67) # '+**12345.7'
"{:*>+10.1f}".format(12345.67) # '**+12345.7'
"{:+010.1f}".format(12345.67)  # '+0012345.7'
"{:,.2f}".format(12345.678)    # '12,345.68'
```

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