Python Setup and Usage

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This part of the documentation is devoted to general information on the setup of the Python environment on different platform, the invocation of the interpreter and things that make working with Python easier.

CHAPTER

ONE

COMMAND LINE AND ENVIRONMENT

The CPython interpreter scans the command line and the environment for various settings.

CPython implementation detail: Other implementations' command line schemes may differ. See *implementations* for further resources.

1.1 Command line

When invoking Python, you may specify any of these options:

```
python [-bBdEhiIOqsSuvVWx?] [-c command | -m module-name | script | - ] [args]
```

The most common use case is, of course, a simple invocation of a script:

```
python myscript.py
```

1.1.1 Interface options

The interpreter interface resembles that of the UNIX shell, but provides some additional methods of invocation:

- When called with standard input connected to a tty device, it prompts for commands and executes them until an EOF (an end-of-file character, you can produce that with `Ctrl-D` on UNIX or `Ctrl-Z, Enter` on Windows) is read.
- When called with a file name argument or with a file as standard input, it reads and executes a script from that file.
- When called with a directory name argument, it reads and executes an appropriately named script from that directory.
- When called with `-c command`, it executes the Python statement(s) given as *command*. Here *command* may contain multiple statements separated by newlines. Leading whitespace is significant in Python statements!
- When called with `-m module-name`, the given module is located on the Python module path and executed as a script.

In non-interactive mode, the entire input is parsed before it is executed.

An interface option terminates the list of options consumed by the interpreter, all consecutive arguments will end up in `sys.argv` – note that the first element, subscript zero (`sys.argv[0]`), is a string reflecting the program's source.

-c <command>
: Execute the Python code in *command*. *command* can be one or more statements separated by newlines, with significant leading whitespace as in normal module code.

  If this option is given, the first element of `sys.argv` will be `"-c"` and the current directory will be added to the start of `sys.path` (allowing modules in that directory to be imported as top level modules).

-m <module-name>
Search sys.path for the named module and execute its contents as the __main__ module.

Since the argument is a *module* name, you must not give a file extension (.py). The module-name should be a valid Python module name, but the implementation may not always enforce this (e.g. it may allow you to use a name that includes a hyphen).

Package names (including namespace packages) are also permitted. When a package name is supplied instead of a normal module, the interpreter will execute <pkg>.__main__ as the main module. This behaviour is deliberately similar to the handling of directories and zipfiles that are passed to the interpreter as the script argument.

Note: This option cannot be used with built-in modules and extension modules written in C, since they do not have Python module files. However, it can still be used for precompiled modules, even if the original source file is not available.

If this option is given, the first element of sys.argv will be the full path to the module file (while the module file is being located, the first element will be set to "-m"). As with the *-c* option, the current directory will be added to the start of sys.path.

Many standard library modules contain code that is invoked on their execution as a script. An example is the timeit module:

```
python -mtimeit -s 'setup here' 'benchmarked code here'
python -mtimeit -h # for details
```

See also:

runpy.run_module() Equivalent functionality directly available to Python code

PEP 338 – Executing modules as scripts

Changed in version 3.1: Supply the package name to run a __main__ submodule.

Changed in version 3.4: namespace packages are also supported

-
Read commands from standard input (sys.stdin). If standard input is a terminal, *-i* is implied.

If this option is given, the first element of sys.argv will be "-" and the current directory will be added to the start of sys.path.

<script>
Execute the Python code contained in *script*, which must be a filesystem path (absolute or relative) referring to either a Python file, a directory containing a __main__.py file, or a zipfile containing a __main__.py file.

If this option is given, the first element of sys.argv will be the script name as given on the command line.

If the script name refers directly to a Python file, the directory containing that file is added to the start of sys.path, and the file is executed as the __main__ module.

If the script name refers to a directory or zipfile, the script name is added to the start of sys.path and the __main__.py file in that location is executed as the __main__ module.

See also:

runpy.run_path() Equivalent functionality directly available to Python code

If no interface option is given, *-i* is implied, sys.argv[0] is an empty string ("") and the current directory will be added to the start of sys.path. Also, tab-completion and history editing is automatically enabled, if available on your platform (see *rlcompleter-config*).

See also:

tut-invoking

Changed in version 3.4: Automatic enabling of tab-completion and history editing.

1.1.2 Generic options

-?
-h
--help
Print a short description of all command line options.

-V
--version
Print the Python version number and exit. Example output could be:

```
Python 3.0
```

1.1.3 Miscellaneous options

-b
Issue a warning when comparing str and bytes. Issue an error when the option is given twice (*-bb*).

-B
If given, Python won't try to write `.pyc` or `.pyo` files on the import of source modules. See also PYTHONDONTWRITEBYTECODE.

-d
Turn on parser debugging output (for wizards only, depending on compilation options). See also PYTHONDEBUG.

-E
Ignore all PYTHON* environment variables, e.g. PYTHONPATH and PYTHONHOME, that might be set.

-i
When a script is passed as first argument or the *-c* option is used, enter interactive mode after executing the script or the command, even when `sys.stdin` does not appear to be a terminal. The PYTHONSTARTUP file is not read.

This can be useful to inspect global variables or a stack trace when a script raises an exception. See also PYTHONINSPECT.

-I
Run Python in isolated mode. This also implies -E and -s. In isolated mode `sys.path` contains neither the script's directory nor the user's site-packages directory. All PYTHON* environment variables are ignored, too. Further restrictions may be imposed to prevent the user from injecting malicious code.

New in version 3.4.

-O
Turn on basic optimizations. This changes the filename extension for compiled (*bytecode*) files from `.pyc` to `.pyo`. See also PYTHONOPTIMIZE.

-OO
Discard docstrings in addition to the *-O* optimizations.

-q
Don't display the copyright and version messages even in interactive mode.

New in version 3.2.

-R
Kept for compatibility. On Python 3.3 and greater, hash randomization is turned on by default.

On previous versions of Python, this option turns on hash randomization, so that the `__hash__()` values of str, bytes and datetime are "salted" with an unpredictable random value. Although they remain constant within an individual Python process, they are not predictable between repeated invocations of Python.

Hash randomization is intended to provide protection against a denial-of-service caused by carefully-chosen inputs that exploit the worst case performance of a dict construction, O(n^2) complexity. See http://www.ocert.org/advisories/ocert-2011-003.html for details.

`PYTHONHASHSEED` allows you to set a fixed value for the hash seed secret.

New in version 3.2.3.

-s

Don't add the `user site-packages directory` to `sys.path`.

See also:

PEP 370 – Per user site-packages directory

-S

Disable the import of the module `site` and the site-dependent manipulations of `sys.path` that it entails. Also disable these manipulations if `site` is explicitly imported later (call `site.main()` if you want them to be triggered).

-u

Force the binary layer of the stdout and stderr streams (which is available as their `buffer` attribute) to be unbuffered. The text I/O layer will still be line-buffered if writing to the console, or block-buffered if redirected to a non-interactive file.

See also `PYTHONUNBUFFERED`.

-v

Print a message each time a module is initialized, showing the place (filename or built-in module) from which it is loaded. When given twice (*-vv*), print a message for each file that is checked for when searching for a module. Also provides information on module cleanup at exit. See also `PYTHONVERBOSE`.

-W `arg`

Warning control. Python's warning machinery by default prints warning messages to `sys.stderr`. A typical warning message has the following form:

```
file:line: category: message
```

By default, each warning is printed once for each source line where it occurs. This option controls how often warnings are printed.

Multiple *-W* options may be given; when a warning matches more than one option, the action for the last matching option is performed. Invalid *-W* options are ignored (though, a warning message is printed about invalid options when the first warning is issued).

Warnings can also be controlled from within a Python program using the `warnings` module.

The simplest form of argument is one of the following action strings (or a unique abbreviation):

ignore Ignore all warnings.

default Explicitly request the default behavior (printing each warning once per source line).

all Print a warning each time it occurs (this may generate many messages if a warning is triggered repeatedly for the same source line, such as inside a loop).

module Print each warning only the first time it occurs in each module.

once Print each warning only the first time it occurs in the program.

error Raise an exception instead of printing a warning message.

The full form of argument is:

```
action:message:category:module:line
```

Here, *action* is as explained above but only applies to messages that match the remaining fields. Empty fields match all values; trailing empty fields may be omitted. The *message* field matches the start of the warning message printed; this match is case-insensitive. The *category* field matches the warning category. This must be a class name; the match tests whether the actual warning category of the message is a subclass of the specified warning category. The full class name must be given. The *module* field matches the (fully-qualified) module name; this match is case-sensitive. The *line* field matches the line number, where zero matches all line numbers and is thus equivalent to an omitted line number.

See also:

`warnings` – the warnings module

PEP 230 – Warning framework

`PYTHONWARNINGS`

-x

Skip the first line of the source, allowing use of non-Unix forms of `#!cmd`. This is intended for a DOS specific hack only.

Note: The line numbers in error messages will be off by one.

-X

Reserved for various implementation-specific options. CPython currently defines the following possible values:

- `-X faulthandler` to enable `faulthandler`;
- `-X showrefcount` to enable the output of the total reference count and memory blocks (only works on debug builds);
- `-X tracemalloc` to start tracing Python memory allocations using the `tracemalloc` module. By default, only the most recent frame is stored in a traceback of a trace. Use `-X tracemalloc=NFRAME` to start tracing with a traceback limit of *NFRAME* frames. See the `tracemalloc.start()` for more information.

It also allows to pass arbitrary values and retrieve them through the `sys._xoptions` dictionary.

Changed in version 3.2: It is now allowed to pass *-X* with CPython.

New in version 3.3: The `-X faulthandler` option.

New in version 3.4: The `-X showrefcount` and `-X tracemalloc` options.

1.1.4 Options you shouldn't use

-J

Reserved for use by Jython.

1.2 Environment variables

These environment variables influence Python's behavior, they are processed before the command-line switches other than -E or -I. It is customary that command-line switches override environmental variables where there is a conflict.

PYTHONHOME

Change the location of the standard Python libraries. By default, the libraries are searched in *prefix*`/lib/python`*version* and *exec_prefix*`/lib/python`*version*, where *prefix* and *exec_prefix* are installation-dependent directories, both defaulting to `/usr/local`.

When `PYTHONHOME` is set to a single directory, its value replaces both *prefix* and *exec_prefix*. To specify different values for these, set `PYTHONHOME` to *prefix*`:`*exec_prefix*.

PYTHONPATH
Augment the default search path for module files. The format is the same as the shell's PATH: one or more directory pathnames separated by os.pathsep (e.g. colons on Unix or semicolons on Windows). Non-existent directories are silently ignored.

In addition to normal directories, individual PYTHONPATH entries may refer to zipfiles containing pure Python modules (in either source or compiled form). Extension modules cannot be imported from zipfiles.

The default search path is installation dependent, but generally begins with *prefix*/lib/python*version* (see PYTHONHOME above). It is *always* appended to PYTHONPATH.

An additional directory will be inserted in the search path in front of PYTHONPATH as described above under *Interface options*. The search path can be manipulated from within a Python program as the variable sys.path.

PYTHONSTARTUP
If this is the name of a readable file, the Python commands in that file are executed before the first prompt is displayed in interactive mode. The file is executed in the same namespace where interactive commands are executed so that objects defined or imported in it can be used without qualification in the interactive session. You can also change the prompts sys.ps1 and sys.ps2 and the hook sys.__interactivehook__ in this file.

PYTHONOPTIMIZE
If this is set to a non-empty string it is equivalent to specifying the *-O* option. If set to an integer, it is equivalent to specifying *-O* multiple times.

PYTHONDEBUG
If this is set to a non-empty string it is equivalent to specifying the *-d* option. If set to an integer, it is equivalent to specifying *-d* multiple times.

PYTHONINSPECT
If this is set to a non-empty string it is equivalent to specifying the *-i* option.

This variable can also be modified by Python code using os.environ to force inspect mode on program termination.

PYTHONUNBUFFERED
If this is set to a non-empty string it is equivalent to specifying the *-u* option.

PYTHONVERBOSE
If this is set to a non-empty string it is equivalent to specifying the *-v* option. If set to an integer, it is equivalent to specifying *-v* multiple times.

PYTHONCASEOK
If this is set, Python ignores case in import statements. This only works on Windows and OS X.

PYTHONDONTWRITEBYTECODE
If this is set to a non-empty string, Python won't try to write .pyc or .pyo files on the import of source modules. This is equivalent to specifying the *-B* option.

PYTHONHASHSEED
If this variable is not set or set to random, a random value is used to seed the hashes of str, bytes and datetime objects.

If PYTHONHASHSEED is set to an integer value, it is used as a fixed seed for generating the hash() of the types covered by the hash randomization.

Its purpose is to allow repeatable hashing, such as for selftests for the interpreter itself, or to allow a cluster of python processes to share hash values.

The integer must be a decimal number in the range [0,4294967295]. Specifying the value 0 will disable hash randomization.

New in version 3.2.3.

PYTHONIOENCODING
If this is set before running the interpreter, it overrides the encoding used for stdin/stdout/stderr, in the

syntax `encodingname:errorhandler`. Both the `encodingname` and the `:errorhandler` parts are optional and have the same meaning as in `str.encode()`.

For stderr, the `:errorhandler` part is ignored; the handler will always be `'backslashreplace'`.

Changed in version 3.4: The `encodingname` part is now optional.

PYTHONNOUSERSITE
If this is set, Python won't add the `user site-packages directory` to `sys.path`.

See also:

PEP 370 – Per user site-packages directory

PYTHONUSERBASE
Defines the `user base directory`, which is used to compute the path of the `user site-packages directory` and *Distutils installation paths* for `python setup.py install --user`.

See also:

PEP 370 – Per user site-packages directory

PYTHONEXECUTABLE
If this environment variable is set, `sys.argv[0]` will be set to its value instead of the value got through the C runtime. Only works on Mac OS X.

PYTHONWARNINGS
This is equivalent to the *-W* option. If set to a comma separated string, it is equivalent to specifying *-W* multiple times.

PYTHONFAULTHANDLER
If this environment variable is set to a non-empty string, `faulthandler.enable()` is called at startup: install a handler for `SIGSEGV`, `SIGFPE`, `SIGABRT`, `SIGBUS` and `SIGILL` signals to dump the Python traceback. This is equivalent to *-X* `faulthandler` option.

New in version 3.3.

PYTHONTRACEMALLOC
If this environment variable is set to a non-empty string, start tracing Python memory allocations using the `tracemalloc` module. The value of the variable is the maximum number of frames stored in a traceback of a trace. For example, `PYTHONTRACEMALLOC=1` stores only the most recent frame. See the `tracemalloc.start()` for more information.

New in version 3.4.

PYTHONASYNCIODEBUG
If this environment variable is set to a non-empty string, enable the *debug mode* of the `asyncio` module.

New in version 3.4.

1.2.1 Debug-mode variables

Setting these variables only has an effect in a debug build of Python, that is, if Python was configured with the `--with-pydebug` build option.

PYTHONTHREADDEBUG
If set, Python will print threading debug info.

PYTHONDUMPREFS
If set, Python will dump objects and reference counts still alive after shutting down the interpreter.

PYTHONMALLOCSTATS
If set, Python will print memory allocation statistics every time a new object arena is created, and on shutdown.

CHAPTER

TWO

USING PYTHON ON UNIX PLATFORMS

2.1 Getting and installing the latest version of Python

2.1.1 On Linux

Python comes preinstalled on most Linux distributions, and is available as a package on all others. However there are certain features you might want to use that are not available on your distro's package. You can easily compile the latest version of Python from source.

In the event that Python doesn't come preinstalled and isn't in the repositories as well, you can easily make packages for your own distro. Have a look at the following links:

See also:

http://www.debian.org/doc/manuals/maint-guide/first.en.html for Debian users

http://en.opensuse.org/Portal:Packaging for OpenSuse users

http://docs.fedoraproject.org/en-US/Fedora_Draft_Documentation/0.1/html/RPM_Guide/ch-creating-rpms.html
for Fedora users

http://www.slackbook.org/html/package-management-making-packages.html for Slackware users

2.1.2 On FreeBSD and OpenBSD

- FreeBSD users, to add the package use:

  ```
  pkg_add -r python
  ```

- OpenBSD users use:

  ```
  pkg_add ftp://ftp.openbsd.org/pub/OpenBSD/4.2/packages/<insert your architecture her
  ```

  For example i386 users get the 2.5.1 version of Python using:

  ```
  pkg_add ftp://ftp.openbsd.org/pub/OpenBSD/4.2/packages/i386/python-2.5.1p2.tgz
  ```

2.1.3 On OpenSolaris

You can get Python from OpenCSW. Various versions of Python are available and can be installed with e.g. `pkgutil -i python27`.

2.2 Building Python

If you want to compile CPython yourself, first thing you should do is get the source. You can download either the latest release's source or just grab a fresh clone. (If you want to contribute patches, you will need a clone.)

The build process consists in the usual

```
./configure
make
make install
```

invocations. Configuration options and caveats for specific Unix platforms are extensively documented in the README file in the root of the Python source tree.

> **Warning:** `make install` can overwrite or masquerade the `python3` binary. `make altinstall` is therefore recommended instead of `make install` since it only installs *exec_prefix*`/bin/python`*version*.

2.3 Python-related paths and files

These are subject to difference depending on local installation conventions; `prefix` (`${prefix}`) and `exec_prefix` (`${exec_prefix}`) are installation-dependent and should be interpreted as for GNU software; they may be the same.

For example, on most Linux systems, the default for both is `/usr`.

File/directory	Meaning
exec_prefix`/bin/python3`	Recommended location of the interpreter.
prefix`/lib/python`*version*, *exec_prefix*`/lib/python`*version*	Recommended locations of the directories containing the standard modules.
prefix`/include/python`*version*, *exec_prefix*`/include/python`*version*	Recommended locations of the directories containing the include files needed for developing Python extensions and embedding the interpreter.

2.4 Miscellaneous

To easily use Python scripts on Unix, you need to make them executable, e.g. with

```
$ chmod +x script
```

and put an appropriate Shebang line at the top of the script. A good choice is usually

```
#!/usr/bin/env python3
```

which searches for the Python interpreter in the whole `PATH`. However, some Unices may not have the **env** command, so you may need to hardcode `/usr/bin/python3` as the interpreter path.

To use shell commands in your Python scripts, look at the `subprocess` module.

2.5 Editors

Vim and Emacs are excellent editors which support Python very well. For more information on how to code in Python in these editors, look at:

- http://www.vim.org/scripts/script.php?script_id=790
- http://sourceforge.net/projects/python-mode

Geany is an excellent IDE with support for a lot of languages. For more information, read: http://www.geany.org/

Komodo edit is another extremely good IDE. It also has support for a lot of languages. For more information, read http://komodoide.com/.

CHAPTER

THREE

USING PYTHON ON WINDOWS

This document aims to give an overview of Windows-specific behaviour you should know about when using Python on Microsoft Windows.

3.1 Installing Python

Unlike most Unix systems and services, Windows does not require Python natively and thus does not pre-install a version of Python. However, the CPython team has compiled Windows installers (MSI packages) with every release for many years.

With ongoing development of Python, some platforms that used to be supported earlier are no longer supported (due to the lack of users or developers). Check **PEP 11** for details on all unsupported platforms.

- Windows CE is still supported.
- The Cygwin installer offers to install the Python interpreter as well (cf. Cygwin package source, Maintainer releases)

See Python for Windows for detailed information about platforms with pre-compiled installers.

See also:

Python on XP "7 Minutes to "Hello World!"" by Richard Dooling, 2006

Installing on Windows in "Dive into Python: Python from novice to pro" by Mark Pilgrim, 2004, ISBN 1-59059-356-1

For Windows users in "Installing Python" in "A Byte of Python" by Swaroop C H, 2003

3.2 Alternative bundles

Besides the standard CPython distribution, there are modified packages including additional functionality. The following is a list of popular versions and their key features:

ActivePython Installer with multi-platform compatibility, documentation, PyWin32

Enthought Python Distribution Popular modules (such as PyWin32) with their respective documentation, tool suite for building extensible Python applications

Notice that these packages are likely to install *older* versions of Python.

3.3 Configuring Python

In order to run Python flawlessly, you might have to change certain environment settings in Windows.

3.3.1 Excursus: Setting environment variables

Windows has a built-in dialog for changing environment variables (following guide applies to XP classical view): Right-click the icon for your machine (usually located on your Desktop and called "My Computer") and choose *Properties* there. Then, open the *Advanced* tab and click the *Environment Variables* button.

In short, your path is:

My Computer → *Properties* → *Advanced* → *Environment Variables*

In this dialog, you can add or modify User and System variables. To change System variables, you need non-restricted access to your machine (i.e. Administrator rights).

Another way of adding variables to your environment is using the **set** command:

```
set PYTHONPATH=%PYTHONPATH%;C:\My_python_lib
```

To make this setting permanent, you could add the corresponding command line to your `autoexec.bat`. **msconfig** is a graphical interface to this file.

Viewing environment variables can also be done more straight-forward: The command prompt will expand strings wrapped into percent signs automatically:

```
echo %PATH%
```

Consult **set /?** for details on this behaviour.

See also:

http://support.microsoft.com/kb/100843 Environment variables in Windows NT

http://support.microsoft.com/kb/310519 How To Manage Environment Variables in Windows XP

http://www.chem.gla.ac.uk/~louis/software/faq/q1.html Setting Environment variables, Louis J. Farrugia

3.3.2 Finding the Python executable

Changed in version 3.3.

Besides using the automatically created start menu entry for the Python interpreter, you might want to start Python in the command prompt. As of Python 3.3, the installer has an option to set that up for you.

At the "Customize Python 3.3" screen, an option called "Add python.exe to search path" can be enabled to have the installer place your installation into the `%PATH%`. This allows you to type **python** to run the interpreter. Thus, you can also execute your scripts with command line options, see *Command line* documentation.

If you don't enable this option at install time, you can always re-run the installer to choose it.

The alternative is manually modifying the `%PATH%` using the directions in *Excursus: Setting environment variables*. You need to set your `%PATH%` environment variable to include the directory of your Python distribution, delimited by a semicolon from other entries. An example variable could look like this (assuming the first two entries are Windows' default):

```
C:\WINDOWS\system32;C:\WINDOWS;C:\Python33
```

3.3.3 Finding modules

Python usually stores its library (and thereby your site-packages folder) in the installation directory. So, if you had installed Python to `C:\Python\`, the default library would reside in `C:\Python\Lib\` and third-party modules should be stored in `C:\Python\Lib\site-packages\`.

This is how `sys.path` is populated on Windows:

- An empty entry is added at the start, which corresponds to the current directory.

- If the environment variable PYTHONPATH exists, as described in *Environment variables*, its entries are added next. Note that on Windows, paths in this variable must be separated by semicolons, to distinguish them from the colon used in drive identifiers (C:\ etc.).
- Additional "application paths" can be added in the registry as subkeys of \SOFTWARE\Python\PythonCore*version*\PythonPath under both the HKEY_CURRENT_USER and HKEY_LOCAL_MACHINE hives. Subkeys which have semicolon-delimited path strings as their default value will cause each path to be added to sys.path. (Note that all known installers only use HKLM, so HKCU is typically empty.)
- If the environment variable PYTHONHOME is set, it is assumed as "Python Home". Otherwise, the path of the main Python executable is used to locate a "landmark file" (Lib\os.py) to deduce the "Python Home". If a Python home is found, the relevant sub-directories added to sys.path (Lib, plat-win, etc) are based on that folder. Otherwise, the core Python path is constructed from the PythonPath stored in the registry.
- If the Python Home cannot be located, no PYTHONPATH is specified in the environment, and no registry entries can be found, a default path with relative entries is used (e.g. .\Lib;.\plat-win, etc).

The end result of all this is:

- When running python.exe, or any other .exe in the main Python directory (either an installed version, or directly from the PCbuild directory), the core path is deduced, and the core paths in the registry are ignored. Other "application paths" in the registry are always read.
- When Python is hosted in another .exe (different directory, embedded via COM, etc), the "Python Home" will not be deduced, so the core path from the registry is used. Other "application paths" in the registry are always read.
- If Python can't find its home and there is no registry (eg, frozen .exe, some very strange installation setup) you get a path with some default, but relative, paths.

3.3.4 Executing scripts

As of Python 3.3, Python includes a launcher which facilitates running Python scripts. See *Python Launcher for Windows* for more information.

3.3.5 Executing scripts without the Python launcher

Without the Python launcher installed, Python scripts (files with the extension .py) will be executed by **python.exe** by default. This executable opens a terminal, which stays open even if the program uses a GUI. If you do not want this to happen, use the extension .pyw which will cause the script to be executed by **pythonw.exe** by default (both executables are located in the top-level of your Python installation directory). This suppresses the terminal window on startup.

You can also make all .py scripts execute with **pythonw.exe**, setting this through the usual facilities, for example (might require administrative rights):

1. Launch a command prompt.
2. Associate the correct file group with .py scripts:

   ```
   assoc .py=Python.File
   ```

3. Redirect all Python files to the new executable:

   ```
   ftype Python.File=C:\Path\to\pythonw.exe "%1" %*
   ```

3.4 Python Launcher for Windows

New in version 3.3.

The Python launcher for Windows is a utility which aids in the location and execution of different Python versions. It allows scripts (or the command-line) to indicate a preference for a specific Python version, and will locate and execute that version.

3.4.1 Getting started

From the command-line

You should ensure the launcher is on your PATH - depending on how it was installed it may already be there, but check just in case it is not.

From a command-prompt, execute the following command:

```
py
```

You should find that the latest version of Python 2.x you have installed is started - it can be exited as normal, and any additional command-line arguments specified will be sent directly to Python.

If you have multiple versions of Python 2.x installed (e.g., 2.6 and 2.7) you will have noticed that Python 2.7 was started - to launch Python 2.6, try the command:

```
py -2.6
```

If you have a Python 3.x installed, try the command:

```
py -3
```

You should find the latest version of Python 3.x starts.

From a script

Let's create a test Python script - create a file called `hello.py` with the following contents

```
#! python
import sys
sys.stdout.write("hello from Python %s\n" % (sys.version,))
```

From the directory in which hello.py lives, execute the command:

```
py hello.py
```

You should notice the version number of your latest Python 2.x installation is printed. Now try changing the first line to be:

```
#! python3
```

Re-executing the command should now print the latest Python 3.x information. As with the above command-line examples, you can specify a more explicit version qualifier. Assuming you have Python 2.6 installed, try changing the first line to `#! python2.6` and you should find the 2.6 version information printed.

From file associations

The launcher should have been associated with Python files (i.e. `.py`, `.pyw`, `.pyc`, `.pyo` files) when it was installed. This means that when you double-click on one of these files from Windows explorer the launcher will be used, and therefore you can use the same facilities described above to have the script specify the version which should be used.

The key benefit of this is that a single launcher can support multiple Python versions at the same time depending on the contents of the first line.

3.4.2 Shebang Lines

If the first line of a script file starts with `#!`, it is known as a "shebang" line. Linux and other Unix like operating systems have native support for such lines and are commonly used on such systems to indicate how a script should be executed. This launcher allows the same facilities to be using with Python scripts on Windows and the examples above demonstrate their use.

To allow shebang lines in Python scripts to be portable between Unix and Windows, this launcher supports a number of 'virtual' commands to specify which interpreter to use. The supported virtual commands are:

- `/usr/bin/env python`
- `/usr/bin/python`
- `/usr/local/bin/python`
- `python`

For example, if the first line of your script starts with

```
#! /usr/bin/python
```

The default Python will be located and used. As many Python scripts written to work on Unix will already have this line, you should find these scripts can be used by the launcher without modification. If you are writing a new script on Windows which you hope will be useful on Unix, you should use one of the shebang lines starting with `/usr`.

3.4.3 Arguments in shebang lines

The shebang lines can also specify additional options to be passed to the Python interpreter. For example, if you have a shebang line:

```
#! /usr/bin/python -v
```

Then Python will be started with the `-v` option

3.4.4 Customization

Customization via INI files

Two .ini files will be searched by the launcher - `py.ini` in the current user's "application data" directory (i.e. the directory returned by calling the Windows function SHGetFolderPath with CSIDL_LOCAL_APPDATA) and `py.ini` in the same directory as the launcher. The same .ini files are used for both the 'console' version of the launcher (i.e. py.exe) and for the 'windows' version (i.e. pyw.exe)

Customization specified in the "application directory" will have precedence over the one next to the executable, so a user, who may not have write access to the .ini file next to the launcher, can override commands in that global .ini file)

Customizing default Python versions

In some cases, a version qualifier can be included in a command to dictate which version of Python will be used by the command. A version qualifier starts with a major version number and can optionally be followed by a period ('.') and a minor version specifier. If the minor qualifier is specified, it may optionally be followed by "-32" to indicate the 32-bit implementation of that version be used.

For example, a shebang line of `#!python` has no version qualifier, while `#!python3` has a version qualifier which specifies only a major version.

If no version qualifiers are found in a command, the environment variable PY_PYTHON can be set to specify the default version qualifier - the default value is "2". Note this value could specify just a major version (e.g. "2") or a major.minor qualifier (e.g. "2.6"), or even major.minor-32.

If no minor version qualifiers are found, the environment variable PY_PYTHON{major} (where {major} is the current major version qualifier as determined above) can be set to specify the full version. If no such option is found, the launcher will enumerate the installed Python versions and use the latest minor release found for the major version, which is likely, although not guaranteed, to be the most recently installed version in that family.

On 64-bit Windows with both 32-bit and 64-bit implementations of the same (major.minor) Python version installed, the 64-bit version will always be preferred. This will be true for both 32-bit and 64-bit implementations of the launcher - a 32-bit launcher will prefer to execute a 64-bit Python installation of the specified version if available. This is so the behavior of the launcher can be predicted knowing only what versions are installed on the PC and without regard to the order in which they were installed (i.e., without knowing whether a 32 or 64-bit version of Python and corresponding launcher was installed last). As noted above, an optional "-32" suffix can be used on a version specifier to change this behaviour.

Examples:

- If no relevant options are set, the commands python and python2 will use the latest Python 2.x version installed and the command python3 will use the latest Python 3.x installed.
- The commands python3.1 and python2.7 will not consult any options at all as the versions are fully specified.
- If PY_PYTHON=3, the commands python and python3 will both use the latest installed Python 3 version.
- If PY_PYTHON=3.1-32, the command python will use the 32-bit implementation of 3.1 whereas the command python3 will use the latest installed Python (PY_PYTHON was not considered at all as a major version was specified.)
- If PY_PYTHON=3 and PY_PYTHON3=3.1, the commands python and python3 will both use specifically 3.1

In addition to environment variables, the same settings can be configured in the .INI file used by the launcher. The section in the INI file is called [defaults] and the key name will be the same as the environment variables without the leading PY_ prefix (and note that the key names in the INI file are case insensitive.) The contents of an environment variable will override things specified in the INI file.

For example:

- Setting PY_PYTHON=3.1 is equivalent to the INI file containing:

```
[defaults]
python=3.1
```

- Setting PY_PYTHON=3 and PY_PYTHON3=3.1 is equivalent to the INI file containing:

```
[defaults]
python=3
python3=3.1
```

3.4.5 Diagnostics

If an environment variable PYLAUNCH_DEBUG is set (to any value), the launcher will print diagnostic information to stderr (i.e. to the console). While this information manages to be simultaneously verbose *and* terse, it should allow you to see what versions of Python were located, why a particular version was chosen and the exact command-line used to execute the target Python.

3.5 Additional modules

Even though Python aims to be portable among all platforms, there are features that are unique to Windows. A couple of modules, both in the standard library and external, and snippets exist to use these features.

The Windows-specific standard modules are documented in *mswin-specific-services*.

3.5.1 PyWin32

The PyWin32 module by Mark Hammond is a collection of modules for advanced Windows-specific support. This includes utilities for:

- Component Object Model (COM)
- Win32 API calls
- Registry
- Event log
- Microsoft Foundation Classes (MFC) user interfaces

PythonWin is a sample MFC application shipped with PyWin32. It is an embeddable IDE with a built-in debugger.

See also:

Win32 How Do I...? by Tim Golden

Python and COM by David and Paul Boddie

3.5.2 cx_Freeze

cx_Freeze is a `distutils` extension (see *extending-distutils*) which wraps Python scripts into executable Windows programs (`*.exe` files). When you have done this, you can distribute your application without requiring your users to install Python.

3.5.3 WConio

Since Python's advanced terminal handling layer, `curses`, is restricted to Unix-like systems, there is a library exclusive to Windows as well: Windows Console I/O for Python.

WConio is a wrapper for Turbo-C's `CONIO.H`, used to create text user interfaces.

3.6 Compiling Python on Windows

If you want to compile CPython yourself, first thing you should do is get the source. You can download either the latest release's source or just grab a fresh checkout.

The source tree contains a build solution and project files for Microsoft Visual C++, which is the compiler used to build the official Python releases. View the `readme.txt` in their respective directories:

Directory	MSVC version	Visual Studio version
`PC/VS9.0/`	9.0	2008
`PCbuild/`	10.0	2010

Note that any build directories within the `PC` directory are not necessarily fully supported. The `PCbuild` directory contains the files for the compiler used to build the official release.

Check `PCbuild/readme.txt` for general information on the build process.

For extension modules, consult *building-on-windows*.

See also:

Python + Windows + distutils + SWIG + gcc MinGW or "Creating Python extensions in C/C++ with SWIG and compiling them with MinGW gcc under Windows" or "Installing Python extension with distutils and without Microsoft Visual C++" by Sébastien Sauvage, 2003

MingW – Python extensions by Trent Apted et al, 2007

3.7 Other resources

See also:

Python Programming On Win32 "Help for Windows Programmers" by Mark Hammond and Andy Robinson, O'Reilly Media, 2000, ISBN 1-56592-621-8

A Python for Windows Tutorial by Amanda Birmingham, 2004

PEP 397 - Python launcher for Windows The proposal for the launcher to be included in the Python distribution.

CHAPTER

FOUR

USING PYTHON ON A MACINTOSH

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Python on a Macintosh running Mac OS X is in principle very similar to Python on any other Unix platform, but there are a number of additional features such as the IDE and the Package Manager that are worth pointing out.

4.1 Getting and Installing MacPython

Mac OS X 10.8 comes with Python 2.7 pre-installed by Apple. If you wish, you are invited to install the most recent version of Python 3 from the Python website (https://www.python.org). A current "universal binary" build of Python, which runs natively on the Mac's new Intel and legacy PPC CPU's, is available there.

What you get after installing is a number of things:

- A `MacPython 3.4` folder in your `Applications` folder. In here you find IDLE, the development environment that is a standard part of official Python distributions; PythonLauncher, which handles double-clicking Python scripts from the Finder; and the "Build Applet" tool, which allows you to package Python scripts as standalone applications on your system.
- A framework `/Library/Frameworks/Python.framework`, which includes the Python executable and libraries. The installer adds this location to your shell path. To uninstall MacPython, you can simply remove these three things. A symlink to the Python executable is placed in /usr/local/bin/.

The Apple-provided build of Python is installed in `/System/Library/Frameworks/Python.framework` and `/usr/bin/python`, respectively. You should never modify or delete these, as they are Apple-controlled and are used by Apple- or third-party software. Remember that if you choose to install a newer Python version from python.org, you will have two different but functional Python installations on your computer, so it will be important that your paths and usages are consistent with what you want to do.

IDLE includes a help menu that allows you to access Python documentation. If you are completely new to Python you should start reading the tutorial introduction in that document.

If you are familiar with Python on other Unix platforms you should read the section on running Python scripts from the Unix shell.

4.1.1 How to run a Python script

Your best way to get started with Python on Mac OS X is through the IDLE integrated development environment, see section *The IDE* and use the Help menu when the IDE is running.

If you want to run Python scripts from the Terminal window command line or from the Finder you first need an editor to create your script. Mac OS X comes with a number of standard Unix command line editors, **vim** and **emacs** among them. If you want a more Mac-like editor, **BBEdit** or **TextWrangler** from Bare Bones Software (see http://www.barebones.com/products/bbedit/index.html) are good choices, as is **TextMate** (see http://macromates.com/). Other editors include **Gvim** (http://macvim.org) and **Aquamacs** (http://aquamacs.org/).

To run your script from the Terminal window you must make sure that `/usr/local/bin` is in your shell search path.

To run your script from the Finder you have two options:

- Drag it to **PythonLauncher**
- Select **PythonLauncher** as the default application to open your script (or any .py script) through the finder Info window and double-click it. **PythonLauncher** has various preferences to control how your script is launched. Option-dragging allows you to change these for one invocation, or use its Preferences menu to change things globally.

4.1.2 Running scripts with a GUI

With older versions of Python, there is one Mac OS X quirk that you need to be aware of: programs that talk to the Aqua window manager (in other words, anything that has a GUI) need to be run in a special way. Use **pythonw** instead of **python** to start such scripts.

With Python 3.4, you can use either **python** or **pythonw**.

4.1.3 Configuration

Python on OS X honors all standard Unix environment variables such as `PYTHONPATH`, but setting these variables for programs started from the Finder is non-standard as the Finder does not read your `.profile` or `.cshrc` at startup. You need to create a file `~/.MacOSX/environment.plist`. See Apple's Technical Document QA1067 for details.

For more information on installation Python packages in MacPython, see section *Installing Additional Python Packages*.

4.2 The IDE

MacPython ships with the standard IDLE development environment. A good introduction to using IDLE can be found at https://hkn.eecs.berkeley.edu/~dyoo/python/idle_intro/index.html.

4.3 Installing Additional Python Packages

There are several methods to install additional Python packages:

- Packages can be installed via the standard Python distutils mode (`python setup.py install`).
- Many packages can also be installed via the **setuptools** extension or **pip** wrapper, see https://pip.pypa.io/.

4.4 GUI Programming on the Mac

There are several options for building GUI applications on the Mac with Python.

PyObjC is a Python binding to Apple's Objective-C/Cocoa framework, which is the foundation of most modern Mac development. Information on PyObjC is available from https://pythonhosted.org/pyobjc/.

The standard Python GUI toolkit is `tkinter`, based on the cross-platform Tk toolkit (http://www.tcl.tk). An Aqua-native version of Tk is bundled with OS X by Apple, and the latest version can be downloaded and installed from http://www.activestate.com; it can also be built from source.

wxPython is another popular cross-platform GUI toolkit that runs natively on Mac OS X. Packages and documentation are available from http://www.wxpython.org.

PyQt is another popular cross-platform GUI toolkit that runs natively on Mac OS X. More information can be found at http://www.riverbankcomputing.co.uk/software/pyqt/intro.

4.5 Distributing Python Applications on the Mac

The "Build Applet" tool that is placed in the MacPython 3.4 folder is fine for packaging small Python scripts on your own machine to run as a standard Mac application. This tool, however, is not robust enough to distribute Python applications to other users.

The standard tool for deploying standalone Python applications on the Mac is **py2app**. More information on installing and using py2app can be found at http://undefined.org/python/#py2app.

4.6 Other Resources

The MacPython mailing list is an excellent support resource for Python users and developers on the Mac:

https://www.python.org/community/sigs/current/pythonmac-sig/

Another useful resource is the MacPython wiki:

https://wiki.python.org/moin/MacPython

CHAPTER

FIVE

ADDITIONAL TOOLS AND SCRIPTS

5.1 pyvenv - Creating virtual environments

Creation of *virtual environments* is done by executing the `pyvenv` script:

```
pyvenv /path/to/new/virtual/environment
```

Running this command creates the target directory (creating any parent directories that don't exist already) and places a `pyvenv.cfg` file in it with a `home` key pointing to the Python installation the command was run from. It also creates a `bin` (or `Scripts` on Windows) subdirectory containing a copy of the `python` binary (or binaries, in the case of Windows). It also creates an (initially empty) `lib/pythonX.Y/site-packages` subdirectory (on Windows, this is `Lib\site-packages`).

See also:

Python Packaging User Guide: Creating and using virtual environments

On Windows, you may have to invoke the `pyvenv` script as follows, if you don't have the relevant PATH and PATHEXT settings:

```
c:\Temp>c:\Python34\python c:\Python34\Tools\Scripts\pyvenv.py myenv
```

or equivalently:

```
c:\Temp>c:\Python34\python -m venv myenv
```

The command, if run with `-h`, will show the available options:

```
usage: venv [-h] [--system-site-packages] [--symlinks] [--clear]
            [--upgrade] [--without-pip] ENV_DIR [ENV_DIR ...]

Creates virtual Python environments in one or more target directories.

positional arguments:
  ENV_DIR             A directory to create the environment in.

optional arguments:
  -h, --help            show this help message and exit
  --system-site-packages Give access to the global site-packages dir to the
                        virtual environment.
  --symlinks            Try to use symlinks rather than copies, when symlinks
                        are not the default for the platform.
  --copies              Try to use copies rather than symlinks, even when
                        symlinks are the default for the platform.
  --clear               Delete the environment directory if it already exists.
                        If not specified and the directory exists, an error is
                        raised.
  --upgrade             Upgrade the environment directory to use this version
                        of Python, assuming Python has been upgraded in-place.
```

```
--without-pip           Skips installing or upgrading pip in the virtual
                        environment (pip is bootstrapped by default)
```

Depending on how the `venv` functionality has been invoked, the usage message may vary slightly, e.g. referencing `pyvenv` rather than `venv`.

Changed in version 3.4: Installs pip by default, added the `--without-pip` and `--copies` options

Changed in version 3.4: In earlier versions, if the target directory already existed, an error was raised, unless the `--clear` or `--upgrade` option was provided. Now, if an existing directory is specified, its contents are removed and the directory is processed as if it had been newly created.

The created `pyvenv.cfg` file also includes the `include-system-site-packages` key, set to `true` if `venv` is run with the `--system-site-packages` option, `false` otherwise.

Unless the `--without-pip` option is given, `ensurepip` will be invoked to bootstrap `pip` into the virtual environment.

Multiple paths can be given to `pyvenv`, in which case an identical virtualenv will be created, according to the given options, at each provided path.

Once a venv has been created, it can be "activated" using a script in the venv's binary directory. The invocation of the script is platform-specific:

Platform	Shell	Command to activate virtual environment
Posix	bash/zsh	$ source <venv>/bin/activate
	fish	$. <venv>/bin/activate.fish
	csh/tcsh	$ source <venv>/bin/activate.csh
Windows	cmd.exe	C:> <venv>/Scripts/activate.bat
	PowerShell	PS C:> <venv>/Scripts/Activate.ps1

You don't specifically *need* to activate an environment; activation just prepends the venv's binary directory to your path, so that "python" invokes the venv's Python interpreter and you can run installed scripts without having to use their full path. However, all scripts installed in a venv should be runnable without activating it, and run with the venv's Python automatically.

You can deactivate a venv by typing "deactivate" in your shell. The exact mechanism is platform-specific: for example, the Bash activation script defines a "deactivate" function, whereas on Windows there are separate scripts called `deactivate.bat` and `Deactivate.ps1` which are installed when the venv is created.

New in version 3.4: `fish` and `csh` activation scripts.

APPENDIX

A

GLOSSARY

>>> The default Python prompt of the interactive shell. Often seen for code examples which can be executed interactively in the interpreter.

... The default Python prompt of the interactive shell when entering code for an indented code block or within a pair of matching left and right delimiters (parentheses, square brackets or curly braces).

2to3 A tool that tries to convert Python 2.x code to Python 3.x code by handling most of the incompatibilities which can be detected by parsing the source and traversing the parse tree.

2to3 is available in the standard library as `lib2to3`; a standalone entry point is provided as `Tools/scripts/2to3`. See *2to3-reference*.

abstract base class Abstract base classes complement *duck-typing* by providing a way to define interfaces when other techniques like `hasattr()` would be clumsy or subtly wrong (for example with *magic methods*). ABCs introduce virtual subclasses, which are classes that don't inherit from a class but are still recognized by `isinstance()` and `issubclass()`; see the `abc` module documentation. Python comes with many built-in ABCs for data structures (in the `collections.abc` module), numbers (in the `numbers` module), streams (in the `io` module), import finders and loaders (in the `importlib.abc` module). You can create your own ABCs with the `abc` module.

argument A value passed to a *function* (or *method*) when calling the function. There are two kinds of argument:

- *keyword argument*: an argument preceded by an identifier (e.g. `name=`) in a function call or passed as a value in a dictionary preceded by `**`. For example, `3` and `5` are both keyword arguments in the following calls to `complex()`:

```
complex(real=3, imag=5)
complex(**{'real': 3, 'imag': 5})
```

- *positional argument*: an argument that is not a keyword argument. Positional arguments can appear at the beginning of an argument list and/or be passed as elements of an *iterable* preceded by `*`. For example, `3` and `5` are both positional arguments in the following calls:

```
complex(3, 5)
complex(*(3, 5))
```

Arguments are assigned to the named local variables in a function body. See the *calls* section for the rules governing this assignment. Syntactically, any expression can be used to represent an argument; the evaluated value is assigned to the local variable.

See also the *parameter* glossary entry, the FAQ question on *the difference between arguments and parameters*, and **PEP 362**.

attribute A value associated with an object which is referenced by name using dotted expressions. For example, if an object *o* has an attribute *a* it would be referenced as *o.a*.

BDFL Benevolent Dictator For Life, a.k.a. Guido van Rossum, Python's creator.

binary file A *file object* able to read and write *bytes-like objects*.

See also:

A *text file* reads and writes `str` objects.

bytes-like object An object that supports the *bufferobjects*, like `bytes`, `bytearray` or `memoryview`. Bytes-like objects can be used for various operations that expect binary data, such as compression, saving to a binary file or sending over a socket. Some operations need the binary data to be mutable, in which case not all bytes-like objects can apply.

bytecode Python source code is compiled into bytecode, the internal representation of a Python program in the CPython interpreter. The bytecode is also cached in `.pyc` and `.pyo` files so that executing the same file is faster the second time (recompilation from source to bytecode can be avoided). This "intermediate language" is said to run on a *virtual machine* that executes the machine code corresponding to each bytecode. Do note that bytecodes are not expected to work between different Python virtual machines, nor to be stable between Python releases.

A list of bytecode instructions can be found in the documentation for *the dis module*.

class A template for creating user-defined objects. Class definitions normally contain method definitions which operate on instances of the class.

coercion The implicit conversion of an instance of one type to another during an operation which involves two arguments of the same type. For example, `int(3.15)` converts the floating point number to the integer `3`, but in `3+4.5`, each argument is of a different type (one int, one float), and both must be converted to the same type before they can be added or it will raise a `TypeError`. Without coercion, all arguments of even compatible types would have to be normalized to the same value by the programmer, e.g., `float(3)+4.5` rather than just `3+4.5`.

complex number An extension of the familiar real number system in which all numbers are expressed as a sum of a real part and an imaginary part. Imaginary numbers are real multiples of the imaginary unit (the square root of `-1`), often written `i` in mathematics or `j` in engineering. Python has built-in support for complex numbers, which are written with this latter notation; the imaginary part is written with a `j` suffix, e.g., `3+1j`. To get access to complex equivalents of the `math` module, use `cmath`. Use of complex numbers is a fairly advanced mathematical feature. If you're not aware of a need for them, it's almost certain you can safely ignore them.

context manager An object which controls the environment seen in a `with` statement by defining `__enter__()` and `__exit__()` methods. See **PEP 343**.

CPython The canonical implementation of the Python programming language, as distributed on python.org. The term "CPython" is used when necessary to distinguish this implementation from others such as Jython or IronPython.

decorator A function returning another function, usually applied as a function transformation using the `@wrapper` syntax. Common examples for decorators are `classmethod()` and `staticmethod()`.

The decorator syntax is merely syntactic sugar, the following two function definitions are semantically equivalent:

```
def f(...):
    ...
f = staticmethod(f)

@staticmethod
def f(...):
    ...
```

The same concept exists for classes, but is less commonly used there. See the documentation for *function definitions* and *class definitions* for more about decorators.

descriptor Any object which defines the methods `__get__()`, `__set__()`, or `__delete__()`. When a class attribute is a descriptor, its special binding behavior is triggered upon attribute lookup. Normally, using *a.b* to get, set or delete an attribute looks up the object named *b* in the class dictionary for *a*, but if *b* is a descriptor, the respective descriptor method gets called. Understanding descriptors is a key to a deep understanding of Python because they are the basis for many features including functions, methods, properties, class methods, static methods, and reference to super classes.

For more information about descriptors' methods, see *descriptors*.

dictionary An associative array, where arbitrary keys are mapped to values. The keys can be any object with `__hash__()` and `__eq__()` methods. Called a hash in Perl.

dictionary view The objects returned from `dict.keys()`, `dict.values()`, and `dict.items()` are called dictionary views. They provide a dynamic view on the dictionary's entries, which means that when the dictionary changes, the view reflects these changes. To force the dictionary view to become a full list use `list(dictview)`. See *dict-views*.

docstring A string literal which appears as the first expression in a class, function or module. While ignored when the suite is executed, it is recognized by the compiler and put into the `__doc__` attribute of the enclosing class, function or module. Since it is available via introspection, it is the canonical place for documentation of the object.

duck-typing A programming style which does not look at an object's type to determine if it has the right interface; instead, the method or attribute is simply called or used ("If it looks like a duck and quacks like a duck, it must be a duck.") By emphasizing interfaces rather than specific types, well-designed code improves its flexibility by allowing polymorphic substitution. Duck-typing avoids tests using `type()` or `isinstance()`. (Note, however, that duck-typing can be complemented with *abstract base classes*.) Instead, it typically employs `hasattr()` tests or *EAFP* programming.

EAFP Easier to ask for forgiveness than permission. This common Python coding style assumes the existence of valid keys or attributes and catches exceptions if the assumption proves false. This clean and fast style is characterized by the presence of many `try` and `except` statements. The technique contrasts with the *LBYL* style common to many other languages such as C.

expression A piece of syntax which can be evaluated to some value. In other words, an expression is an accumulation of expression elements like literals, names, attribute access, operators or function calls which all return a value. In contrast to many other languages, not all language constructs are expressions. There are also *statement*s which cannot be used as expressions, such as `if`. Assignments are also statements, not expressions.

extension module A module written in C or C++, using Python's C API to interact with the core and with user code.

file object An object exposing a file-oriented API (with methods such as `read()` or `write()`) to an underlying resource. Depending on the way it was created, a file object can mediate access to a real on-disk file or to another type of storage or communication device (for example standard input/output, in-memory buffers, sockets, pipes, etc.). File objects are also called *file-like objects* or *streams*.

There are actually three categories of file objects: raw *binary files*, buffered *binary files* and *text files*. Their interfaces are defined in the `io` module. The canonical way to create a file object is by using the `open()` function.

file-like object A synonym for *file object*.

finder An object that tries to find the *loader* for a module. It must implement either a method named `find_loader()` or a method named `find_module()`. See **PEP 302** and **PEP 420** for details and `importlib.abc.Finder` for an *abstract base class*.

floor division Mathematical division that rounds down to nearest integer. The floor division operator is `//`. For example, the expression `11 // 4` evaluates to `2` in contrast to the `2.75` returned by float true division. Note that `(-11) // 4` is `-3` because that is `-2.75` rounded *downward*. See **PEP 238**.

function A series of statements which returns some value to a caller. It can also be passed zero or more *arguments* which may be used in the execution of the body. See also *parameter*, *method*, and the *function* section.

function annotation An arbitrary metadata value associated with a function parameter or return value. Its syntax is explained in section *function*. Annotations may be accessed via the `__annotations__` special attribute of a function object.

Python itself does not assign any particular meaning to function annotations. They are intended to be interpreted by third-party libraries or tools. See **PEP 3107**, which describes some of their potential uses.

__future__ A pseudo-module which programmers can use to enable new language features which are not compatible with the current interpreter.

By importing the __future__ module and evaluating its variables, you can see when a new feature was first added to the language and when it becomes the default:

```
>>> import __future__
>>> __future__.division
_Feature((2, 2, 0, 'alpha', 2), (3, 0, 0, 'alpha', 0), 8192)
```

garbage collection The process of freeing memory when it is not used anymore. Python performs garbage collection via reference counting and a cyclic garbage collector that is able to detect and break reference cycles.

generator A function which returns an iterator. It looks like a normal function except that it contains `yield` statements for producing a series of values usable in a for-loop or that can be retrieved one at a time with the `next()` function. Each `yield` temporarily suspends processing, remembering the location execution state (including local variables and pending try-statements). When the generator resumes, it picks-up where it left-off (in contrast to functions which start fresh on every invocation).

generator expression An expression that returns an iterator. It looks like a normal expression followed by a `for` expression defining a loop variable, range, and an optional `if` expression. The combined expression generates values for an enclosing function:

```
>>> sum(i*i for i in range(10))         # sum of squares 0, 1, 4, ... 81
285
```

generic function A function composed of multiple functions implementing the same operation for different types. Which implementation should be used during a call is determined by the dispatch algorithm.

See also the *single dispatch* glossary entry, the `functools.singledispatch()` decorator, and **PEP 443**.

GIL See *global interpreter lock*.

global interpreter lock The mechanism used by the *CPython* interpreter to assure that only one thread executes Python *bytecode* at a time. This simplifies the CPython implementation by making the object model (including critical built-in types such as `dict`) implicitly safe against concurrent access. Locking the entire interpreter makes it easier for the interpreter to be multi-threaded, at the expense of much of the parallelism afforded by multi-processor machines.

However, some extension modules, either standard or third-party, are designed so as to release the GIL when doing computationally-intensive tasks such as compression or hashing. Also, the GIL is always released when doing I/O.

Past efforts to create a "free-threaded" interpreter (one which locks shared data at a much finer granularity) have not been successful because performance suffered in the common single-processor case. It is believed that overcoming this performance issue would make the implementation much more complicated and therefore costlier to maintain.

hashable An object is *hashable* if it has a hash value which never changes during its lifetime (it needs a `__hash__()` method), and can be compared to other objects (it needs an `__eq__()` method). Hashable objects which compare equal must have the same hash value.

Hashability makes an object usable as a dictionary key and a set member, because these data structures use the hash value internally.

All of Python's immutable built-in objects are hashable, while no mutable containers (such as lists or dictionaries) are. Objects which are instances of user-defined classes are hashable by default; they all compare unequal (except with themselves), and their hash value is derived from their `id()`.

IDLE An Integrated Development Environment for Python. IDLE is a basic editor and interpreter environment which ships with the standard distribution of Python.

immutable An object with a fixed value. Immutable objects include numbers, strings and tuples. Such an object cannot be altered. A new object has to be created if a different value has to be stored. They play an important role in places where a constant hash value is needed, for example as a key in a dictionary.

import path A list of locations (or *path entries*) that are searched by the *path based finder* for modules to import. During import, this list of locations usually comes from `sys.path`, but for subpackages it may also come from the parent package's `__path__` attribute.

importing The process by which Python code in one module is made available to Python code in another module.

importer An object that both finds and loads a module; both a *finder* and *loader* object.

interactive Python has an interactive interpreter which means you can enter statements and expressions at the interpreter prompt, immediately execute them and see their results. Just launch `python` with no arguments (possibly by selecting it from your computer's main menu). It is a very powerful way to test out new ideas or inspect modules and packages (remember `help(x)`).

interpreted Python is an interpreted language, as opposed to a compiled one, though the distinction can be blurry because of the presence of the bytecode compiler. This means that source files can be run directly without explicitly creating an executable which is then run. Interpreted languages typically have a shorter development/debug cycle than compiled ones, though their programs generally also run more slowly. See also *interactive*.

iterable An object capable of returning its members one at a time. Examples of iterables include all sequence types (such as `list`, `str`, and `tuple`) and some non-sequence types like `dict`, *file objects*, and objects of any classes you define with an `__iter__()` or `__getitem__()` method. Iterables can be used in a `for` loop and in many other places where a sequence is needed (`zip()`, `map()`, ...). When an iterable object is passed as an argument to the built-in function `iter()`, it returns an iterator for the object. This iterator is good for one pass over the set of values. When using iterables, it is usually not necessary to call `iter()` or deal with iterator objects yourself. The `for` statement does that automatically for you, creating a temporary unnamed variable to hold the iterator for the duration of the loop. See also *iterator*, *sequence*, and *generator*.

iterator An object representing a stream of data. Repeated calls to the iterator's `__next__()` method (or passing it to the built-in function `next()`) return successive items in the stream. When no more data are available a `StopIteration` exception is raised instead. At this point, the iterator object is exhausted and any further calls to its `__next__()` method just raise `StopIteration` again. Iterators are required to have an `__iter__()` method that returns the iterator object itself so every iterator is also iterable and may be used in most places where other iterables are accepted. One notable exception is code which attempts multiple iteration passes. A container object (such as a `list`) produces a fresh new iterator each time you pass it to the `iter()` function or use it in a `for` loop. Attempting this with an iterator will just return the same exhausted iterator object used in the previous iteration pass, making it appear like an empty container.

More information can be found in *typeiter*.

key function A key function or collation function is a callable that returns a value used for sorting or ordering. For example, `locale.strxfrm()` is used to produce a sort key that is aware of locale specific sort conventions.

A number of tools in Python accept key functions to control how elements are ordered or grouped. They include `min()`, `max()`, `sorted()`, `list.sort()`, `heapq.nsmallest()`, `heapq.nlargest()`, and `itertools.groupby()`.

There are several ways to create a key function. For example. the `str.lower()` method can serve as a key function for case insensitive sorts. Alternatively, an ad-hoc key function can be built from a `lambda` expression such as `lambda r: (r[0], r[2])`. Also, the `operator` module provides three key function constructors: `attrgetter()`, `itemgetter()`, and `methodcaller()`. See the *Sorting HOW TO* for examples of how to create and use key functions.

keyword argument See *argument*.

lambda An anonymous inline function consisting of a single *expression* which is evaluated when the function is called. The syntax to create a lambda function is `lambda [arguments]: expression`

LBYL Look before you leap. This coding style explicitly tests for pre-conditions before making calls or lookups. This style contrasts with the *EAFP* approach and is characterized by the presence of many `if` statements.

In a multi-threaded environment, the LBYL approach can risk introducing a race condition between "the looking" and "the leaping". For example, the code, `if key in mapping: return`

`mapping[key]` can fail if another thread removes *key* from *mapping* after the test, but before the lookup. This issue can be solved with locks or by using the EAFP approach.

list A built-in Python *sequence*. Despite its name it is more akin to an array in other languages than to a linked list since access to elements are O(1).

list comprehension A compact way to process all or part of the elements in a sequence and return a list with the results. `result = ['{:#04x}'.format(x) for x in range(256) if x % 2 == 0]` generates a list of strings containing even hex numbers (0x..) in the range from 0 to 255. The `if` clause is optional. If omitted, all elements in `range(256)` are processed.

loader An object that loads a module. It must define a method named `load_module()`. A loader is typically returned by a *finder*. See **PEP 302** for details and `importlib.abc.Loader` for an *abstract base class*.

mapping A container object that supports arbitrary key lookups and implements the methods specified in the `Mapping` or `MutableMapping` *abstract base classes*. Examples include `dict`, `collections.defaultdict`, `collections.OrderedDict` and `collections.Counter`.

meta path finder A finder returned by a search of `sys.meta_path`. Meta path finders are related to, but different from *path entry finders*.

metaclass The class of a class. Class definitions create a class name, a class dictionary, and a list of base classes. The metaclass is responsible for taking those three arguments and creating the class. Most object oriented programming languages provide a default implementation. What makes Python special is that it is possible to create custom metaclasses. Most users never need this tool, but when the need arises, metaclasses can provide powerful, elegant solutions. They have been used for logging attribute access, adding thread-safety, tracking object creation, implementing singletons, and many other tasks.

More information can be found in *metaclasses*.

method A function which is defined inside a class body. If called as an attribute of an instance of that class, the method will get the instance object as its first *argument* (which is usually called `self`). See *function* and *nested scope*.

method resolution order Method Resolution Order is the order in which base classes are searched for a member during lookup. See The Python 2.3 Method Resolution Order.

module An object that serves as an organizational unit of Python code. Modules have a namespace containing arbitrary Python objects. Modules are loaded into Python by the process of *importing*.

See also *package*.

module spec A namespace containing the import-related information used to load a module.

MRO See *method resolution order*.

mutable Mutable objects can change their value but keep their `id()`. See also *immutable*.

named tuple Any tuple-like class whose indexable elements are also accessible using named attributes (for example, `time.localtime()` returns a tuple-like object where the *year* is accessible either with an index such as `t[0]` or with a named attribute like `t.tm_year`).

A named tuple can be a built-in type such as `time.struct_time`, or it can be created with a regular class definition. A full featured named tuple can also be created with the factory function `collections.namedtuple()`. The latter approach automatically provides extra features such as a self-documenting representation like `Employee(name='jones', title='programmer')`.

namespace The place where a variable is stored. Namespaces are implemented as dictionaries. There are the local, global and built-in namespaces as well as nested namespaces in objects (in methods). Namespaces support modularity by preventing naming conflicts. For instance, the functions `builtins.open` and `os.open()` are distinguished by their namespaces. Namespaces also aid readability and maintainability by making it clear which module implements a function. For instance, writing `random.seed()` or `itertools.islice()` makes it clear that those functions are implemented by the `random` and `itertools` modules, respectively.

namespace package A **PEP 420** *package* which serves only as a container for subpackages. Namespace packages may have no physical representation, and specifically are not like a *regular package* because they have no `__init__.py` file.

See also *module*.

nested scope The ability to refer to a variable in an enclosing definition. For instance, a function defined inside another function can refer to variables in the outer function. Note that nested scopes by default work only for reference and not for assignment. Local variables both read and write in the innermost scope. Likewise, global variables read and write to the global namespace. The `nonlocal` allows writing to outer scopes.

new-style class Old name for the flavor of classes now used for all class objects. In earlier Python versions, only new-style classes could use Python's newer, versatile features like `__slots__`, descriptors, properties, `__getattribute__()`, class methods, and static methods.

object Any data with state (attributes or value) and defined behavior (methods). Also the ultimate base class of any *new-style class*.

package A Python *module* which can contain submodules or recursively, subpackages. Technically, a package is a Python module with an `__path__` attribute.

See also *regular package* and *namespace package*.

parameter A named entity in a *function* (or method) definition that specifies an *argument* (or in some cases, arguments) that the function can accept. There are five kinds of parameter:

- *positional-or-keyword*: specifies an argument that can be passed either *positionally* or as a *keyword argument*. This is the default kind of parameter, for example *foo* and *bar* in the following:

  ```
  def func(foo, bar=None): ...
  ```

- *positional-only*: specifies an argument that can be supplied only by position. Python has no syntax for defining positional-only parameters. However, some built-in functions have positional-only parameters (e.g. `abs()`).

- *keyword-only*: specifies an argument that can be supplied only by keyword. Keyword-only parameters can be defined by including a single var-positional parameter or bare `*` in the parameter list of the function definition before them, for example *kw_only1* and *kw_only2* in the following:

  ```
  def func(arg, *, kw_only1, kw_only2): ...
  ```

- *var-positional*: specifies that an arbitrary sequence of positional arguments can be provided (in addition to any positional arguments already accepted by other parameters). Such a parameter can be defined by prepending the parameter name with `*`, for example *args* in the following:

  ```
  def func(*args, **kwargs): ...
  ```

- *var-keyword*: specifies that arbitrarily many keyword arguments can be provided (in addition to any keyword arguments already accepted by other parameters). Such a parameter can be defined by prepending the parameter name with `**`, for example *kwargs* in the example above.

Parameters can specify both optional and required arguments, as well as default values for some optional arguments.

See also the *argument* glossary entry, the FAQ question on *the difference between arguments and parameters*, the `inspect.Parameter` class, the *function* section, and **PEP 362**.

path entry A single location on the *import path* which the *path based finder* consults to find modules for importing.

path entry finder A *finder* returned by a callable on `sys.path_hooks` (i.e. a *path entry hook*) which knows how to locate modules given a *path entry*.

path entry hook A callable on the `sys.path_hook` list which returns a *path entry finder* if it knows how to find modules on a specific *path entry*.

path based finder One of the default *meta path finders* which searches an *import path* for modules.

portion A set of files in a single directory (possibly stored in a zip file) that contribute to a namespace package, as defined in **PEP 420**.

positional argument See *argument*.

provisional API A provisional API is one which has been deliberately excluded from the standard library's backwards compatibility guarantees. While major changes to such interfaces are not expected, as long as they are marked provisional, backwards incompatible changes (up to and including removal of the interface) may occur if deemed necessary by core developers. Such changes will not be made gratuitously – they will occur only if serious fundamental flaws are uncovered that were missed prior to the inclusion of the API.

Even for provisional APIs, backwards incompatible changes are seen as a "solution of last resort" - every attempt will still be made to find a backwards compatible resolution to any identified problems.

This process allows the standard library to continue to evolve over time, without locking in problematic design errors for extended periods of time. See **PEP 411** for more details.

provisional package See *provisional API*.

Python 3000 Nickname for the Python 3.x release line (coined long ago when the release of version 3 was something in the distant future.) This is also abbreviated "Py3k".

Pythonic An idea or piece of code which closely follows the most common idioms of the Python language, rather than implementing code using concepts common to other languages. For example, a common idiom in Python is to loop over all elements of an iterable using a `for` statement. Many other languages don't have this type of construct, so people unfamiliar with Python sometimes use a numerical counter instead:

```
for i in range(len(food)):
    print(food[i])
```

As opposed to the cleaner, Pythonic method:

```
for piece in food:
    print(piece)
```

qualified name A dotted name showing the "path" from a module's global scope to a class, function or method defined in that module, as defined in **PEP 3155**. For top-level functions and classes, the qualified name is the same as the object's name:

```
>>> class C:
...     class D:
...         def meth(self):
...             pass
...
>>> C.__qualname__
'C'
>>> C.D.__qualname__
'C.D'
>>> C.D.meth.__qualname__
'C.D.meth'
```

When used to refer to modules, the *fully qualified name* means the entire dotted path to the module, including any parent packages, e.g. `email.mime.text`:

```
>>> import email.mime.text
>>> email.mime.text.__name__
'email.mime.text'
```

reference count The number of references to an object. When the reference count of an object drops to zero, it is deallocated. Reference counting is generally not visible to Python code, but it is a key element of the *CPython* implementation. The `sys` module defines a `getrefcount()` function that programmers can call to return the reference count for a particular object.

regular package A traditional *package*, such as a directory containing an `__init__.py` file.

See also *namespace package*.

__slots__ A declaration inside a class that saves memory by pre-declaring space for instance attributes and eliminating instance dictionaries. Though popular, the technique is somewhat tricky to get right and is best reserved for rare cases where there are large numbers of instances in a memory-critical application.

sequence An *iterable* which supports efficient element access using integer indices via the `__getitem__()` special method and defines a `__len__()` method that returns the length of the sequence. Some built-in sequence types are `list`, `str`, `tuple`, and `bytes`. Note that `dict` also supports `__getitem__()` and `__len__()`, but is considered a mapping rather than a sequence because the lookups use arbitrary *immutable* keys rather than integers.

The `collections.abc.Sequence` abstract base class defines a much richer interface that goes beyond just `__getitem__()` and `__len__()`, adding `count()`, `index()`, `__contains__()`, and `__reversed__()`. Types that implement this expanded interface can be registered explicitly using `register()`.

single dispatch A form of *generic function* dispatch where the implementation is chosen based on the type of a single argument.

slice An object usually containing a portion of a *sequence*. A slice is created using the subscript notation, `[]` with colons between numbers when several are given, such as in `variable_name[1:3:5]`. The bracket (subscript) notation uses `slice` objects internally.

special method A method that is called implicitly by Python to execute a certain operation on a type, such as addition. Such methods have names starting and ending with double underscores. Special methods are documented in *specialnames*.

statement A statement is part of a suite (a "block" of code). A statement is either an *expression* or one of several constructs with a keyword, such as `if`, `while` or `for`.

struct sequence A tuple with named elements. Struct sequences expose an interface similar to *named tuple* in that elements can either be accessed either by index or as an attribute. However, they do not have any of the named tuple methods like `_make()` or `_asdict()`. Examples of struct sequences include `sys.float_info` and the return value of `os.stat()`.

text encoding A codec which encodes Unicode strings to bytes.

text file A *file object* able to read and write `str` objects. Often, a text file actually accesses a byte-oriented datastream and handles the *text encoding* automatically.

See also:

A *binary file* reads and write `bytes` objects.

triple-quoted string A string which is bound by three instances of either a quotation mark (") or an apostrophe ('). While they don't provide any functionality not available with single-quoted strings, they are useful for a number of reasons. They allow you to include unescaped single and double quotes within a string and they can span multiple lines without the use of the continuation character, making them especially useful when writing docstrings.

type The type of a Python object determines what kind of object it is; every object has a type. An object's type is accessible as its `__class__` attribute or can be retrieved with `type(obj)`.

universal newlines A manner of interpreting text streams in which all of the following are recognized as ending a line: the Unix end-of-line convention `'\n'`, the Windows convention `'\r\n'`, and the old Macintosh convention `'\r'`. See **PEP 278** and **PEP 3116**, as well as `bytes.splitlines()` for an additional use.

virtual environment A cooperatively isolated runtime environment that allows Python users and applications to install and upgrade Python distribution packages without interfering with the behaviour of other Python applications running on the same system.

See also *pyvenv - Creating virtual environments*.

virtual machine A computer defined entirely in software. Python's virtual machine executes the *bytecode* emitted by the bytecode compiler.

Zen of Python Listing of Python design principles and philosophies that are helpful in understanding and using the language. The listing can be found by typing "`import this`" at the interactive prompt.

APPENDIX

B

ABOUT THESE DOCUMENTS

These documents are generated from reStructuredText sources by Sphinx, a document processor specifically written for the Python documentation.

Development of the documentation and its toolchain is an entirely volunteer effort, just like Python itself. If you want to contribute, please take a look at the *reporting-bugs* page for information on how to do so. New volunteers are always welcome!

Many thanks go to:

- Fred L. Drake, Jr., the creator of the original Python documentation toolset and writer of much of the content;
- the Docutils project for creating reStructuredText and the Docutils suite;
- Fredrik Lundh for his Alternative Python Reference project from which Sphinx got many good ideas.

B.1 Contributors to the Python Documentation

Many people have contributed to the Python language, the Python standard library, and the Python documentation. See Misc/ACKS in the Python source distribution for a partial list of contributors.

It is only with the input and contributions of the Python community that Python has such wonderful documentation – Thank You!

APPENDIX

C

HISTORY AND LICENSE

C.1 History of the software

Python was created in the early 1990s by Guido van Rossum at Stichting Mathematisch Centrum (CWI, see http://www.cwi.nl/) in the Netherlands as a successor of a language called ABC. Guido remains Python's principal author, although it includes many contributions from others.

In 1995, Guido continued his work on Python at the Corporation for National Research Initiatives (CNRI, see http://www.cnri.reston.va.us/) in Reston, Virginia where he released several versions of the software.

In May 2000, Guido and the Python core development team moved to BeOpen.com to form the BeOpen PythonLabs team. In October of the same year, the PythonLabs team moved to Digital Creations (now Zope Corporation; see http://www.zope.com/). In 2001, the Python Software Foundation (PSF, see https://www.python.org/psf/) was formed, a non-profit organization created specifically to own Python-related Intellectual Property. Zope Corporation is a sponsoring member of the PSF.

All Python releases are Open Source (see http://opensource.org/ for the Open Source Definition). Historically, most, but not all, Python releases have also been GPL-compatible; the table below summarizes the various releases.

Release	Derived from	Year	Owner	GPL compatible?
0.9.0 thru 1.2	n/a	1991-1995	CWI	yes
1.3 thru 1.5.2	1.2	1995-1999	CNRI	yes
1.6	1.5.2	2000	CNRI	no
2.0	1.6	2000	BeOpen.com	no
1.6.1	1.6	2001	CNRI	no
2.1	2.0+1.6.1	2001	PSF	no
2.0.1	2.0+1.6.1	2001	PSF	yes
2.1.1	2.1+2.0.1	2001	PSF	yes
2.1.2	2.1.1	2002	PSF	yes
2.1.3	2.1.2	2002	PSF	yes
2.2 and above	2.1.1	2001-now	PSF	yes

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Thanks to the many outside volunteers who have worked under Guido's direction to make these releases possible.

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C.3.1 Mersenne Twister

The `_random` module includes code based on a download from http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/MT2002/emt19937ar.html. The following are the verbatim comments from the original code:

```
A C-program for MT19937, with initialization improved 2002/1/26.
Coded by Takuji Nishimura and Makoto Matsumoto.

Before using, initialize the state by using init_genrand(seed)
or init_by_array(init_key, key_length).

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```
Any feedback is very welcome.
http://www.math.sci.hiroshima-u.ac.jp/~m-mat/MT/emt.html
email: m-mat @ math.sci.hiroshima-u.ac.jp (remove space)
```

C.3.2 Sockets

The `socket` module uses the functions, `getaddrinfo()`, and `getnameinfo()`, which are coded in separate source files from the WIDE Project, http://www.wide.ad.jp/.

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```

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Modified by Jack Jansen, CWI, July 1995:
- Use binascii module to do the actual line-by-line conversion
  between ascii and binary. This results in a 1000-fold speedup. The C
  version is still 5 times faster, though.
- Arguments more compliant with Python standard
```

C.3.8 XML Remote Procedure Calls

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```

C.3.11 SipHash24

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Original location:
   https://github.com/majek/csiphash/

Solution inspired by code from:
   Samuel Neves (supercop/crypto_auth/siphash24/little)
   djb (supercop/crypto_auth/siphash24/little2)
   Jean-Philippe Aumasson (https://131002.net/siphash/siphash24.c)
```

C.3.12 strtod and dtoa

The file `Python/dtoa.c`, which supplies C functions dtoa and strtod for conversion of C doubles to and from strings, is derived from the file of the same name by David M. Gay, currently available from http://www.netlib.org/fp/. The original file, as retrieved on March 16, 2009, contains the following copyright and licensing notice:

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```

C.3.17 cfuhash

The implementation of the hash table used by the `tracemalloc` is based on the cfuhash project:

```
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```

C.3.18 libmpdec

The `_decimal` Module is built using an included copy of the libmpdec library unless the build is configured `--with-system-libmpdec`:

```
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D

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