
Python Guide Documentation

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Welcome to The Hitchhiker's Guide to Python.

This guide is currently under heavy active development. If you'd like to help, [fork us on GitHub!](#)

This *opinionated* guide exists to provide both novice and expert Python developers a best-practice handbook to the installation, configuration, and usage of Python on a daily basis.

Getting Started

This part of the guide focuses on setting up your Python environment.

1.1 Picking an Interpreter

1.1.1 The State of Python (2 vs 3)

When choosing a Python interpreter, one looming question is always present: “Should I choose Python 2 or Python 3”? The answer is not as obvious as one might think.

The basic gist of the state of things is as follows:

1. Python 2.7 has been the standard for a *long* time.
2. Python 3 introduced major changes to the language, which many developers are unhappy with.
3. Python 2.7 will receive necessary security updates for a few years.
4. Python 3 is continually evolving, like Python 2 did in years past.

So, you can now see why this is not such an easy decision.

1.1.2 Recommendations

I’ll be blunt:

Use Python 3 if...

- You don’t care.
- You love Python 3.
- You are indifferent towards 2 vs 3.
- You don’t know which one to use.
- You embrace change.

Use Python 2 if...

- You love Python 2 and are saddened by the future being Python 3.
- The stability requirements of your software would be improved by a language and runtime that never changes.
- Software that you depend on requires it.

1.1.3 So... 3?

If you're choosing a Python interpreter to use, and aren't opinionated, then I recommend you use the newest Python 3.x, since every version brings new and improved standard library modules, security and bug fixes. Progress is progress.

Given such, only use Python 2 if you have a strong reason to, such as a Python 2 exclusive library which has no adequate Python 3 ready alternative, or you (like me) absolutely love and are inspired by Python 2.

Check out [Can I Use Python 3?](#) to see if any software you're depending on will block your adoption of Python 3.

Further Reading

It is possible to [write code that works on Python 2.6, 2.7, and 3.3](#). This ranges from trivial to hard depending upon the kind of software you are writing; if you're a beginner there are far more important things to worry about.

1.1.4 Implementations

When people speak of *Python* they often mean not just the language but also the CPython implementation. *Python* is actually a specification for a language that can be implemented in many different ways.

CPython

CPython is the reference implementation of Python, written in C. It compiles Python code to intermediate bytecode which is then interpreted by a virtual machine. CPython provides the highest level of compatibility with Python packages and C extension modules.

If you are writing open-source Python code and want to reach the widest possible audience, targeting CPython is best. To use packages which rely on C extensions to function, CPython is your only implementation option.

All versions of the Python language are implemented in C because CPython is the reference implementation.

PyPy

PyPy is a Python interpreter implemented in a restricted statically-typed subset of the Python language called RPython. The interpreter features a just-in-time compiler and supports multiple back-ends (C, CLI, JVM).

PyPy aims for maximum compatibility with the reference CPython implementation while improving performance.

If you are looking to increase performance of your Python code, it's worth giving PyPy a try. On a suite of benchmarks, it's currently [over 5 times faster than CPython](#).

PyPy supports Python 2.7. PyPy3 ¹, released in beta, targets Python 3.

Jython

Jython is a Python implementation that compiles Python code to Java bytecode which is then executed by the JVM (Java Virtual Machine). Additionally, it is able to import and use any Java class like a Python module.

If you need to interface with an existing Java codebase or have other reasons to need to write Python code for the JVM, Jython is the best choice.

Jython currently supports up to Python 2.7. ²

¹ <http://pypy.org/compat.html>

² <https://hg.python.org/jython/file/412a8f9445f7/NEWS>

IronPython

[IronPython](#) is an implementation of Python for the .NET framework. It can use both Python and .NET framework libraries, and can also expose Python code to other languages in the .NET framework.

[Python Tools for Visual Studio](#) integrates IronPython directly into the Visual Studio development environment, making it an ideal choice for Windows developers.

IronPython supports Python 2.7.³

PythonNet

[Python for .NET](#) is a package which provides near seamless integration of a natively installed Python installation with the .NET Common Language Runtime (CLR). This is the inverse approach to that taken by IronPython (see above), to which it is more complementary than competing with.

In conjunction with Mono, PythonNet enables native Python installations on non-Windows operating systems, such as OS X and Linux, to operate within the .NET framework. It can be run in addition to IronPython without conflict.

PythonNet supports from Python 2.3 up to Python 2.7.⁴

- Properly Install Python

1.2 Installing Python on Mac OS X

The latest version of Mac OS X, Yosemite, **comes with Python 2.7 out of the box**. You do not need to install or configure anything else to use Python. Having said that, I would strongly recommend that you install the tools and libraries described in the next section before you start building Python applications for real-world use. In particular, you should always install Setuptools, as it makes it much easier for you to use other third-party Python libraries. The version of Python that ships with OS X is great for learning but it's not good for development. The version shipped with OS X may be out of date from the [official current Python release](#), which is considered the stable production version.

1.2.1 Doing it Right

Let's install a real version of Python. Before installing Python, you'll need to install GCC. GCC can be obtained by downloading [XCode](#), the smaller [Command Line Tools](#) (must have an Apple account) or the even smaller [OSX-GCC-Installer](#) package.

Note: If you already have XCode installed, do not install OSX-GCC-Installer. In combination, the software can cause issues that are difficult to diagnose.

While OS X comes with a large number of UNIX utilities, those familiar with Linux systems will notice one key component missing: a decent package manager. [Homebrew](#) fills this void. To install Homebrew, open Terminal or your favorite OSX terminal emulator and run

```
$ ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
```

The script will explain what changes it will make and prompt you before the installation begins. Once you've installed Homebrew, insert the Homebrew directory at the top of your PATH environment variable. You can do this by adding the following line at the bottom of your ~/.profile file

³ <http://ironpython.codeplex.com/releases/view/81726>

⁴ <http://pythonnet.github.io/readme.html>

```
export PATH=/usr/local/bin:/usr/local/sbin:$PATH
```

Now, we can install Python 2.7:

```
$ brew install python
```

This will take a minute or two.

1.2.2 Setuptools & Pip

Homebrew installs Setuptools and `pip` for you.

Setuptools enables you to download and install any compliant Python software over a network (usually the Internet) with a single command (`easy_install`). It also enables you to add this network installation capability to your own Python software with very little work.

`pip` is a tool for easily installing and managing Python packages, that is recommended over `easy_install`. It is superior to `easy_install` in [several ways](#), and is actively maintained.

1.2.3 Virtual Environments

A Virtual Environment is a tool to keep the dependencies required by different projects in separate places, by creating virtual Python environments for them. It solves the “Project X depends on version 1.x but, Project Y needs 4.x” dilemma, and keeps your global site-packages directory clean and manageable.

For example, you can work on a project which requires Django 1.3 while also maintaining a project which requires Django 1.0.

To start using and see more information: [Virtual Environments docs](#).

This page is a remixed version of [another guide](#), which is available under the same license.

1.3 Installing Python on Windows

First, download the [latest version](#) of Python 2.7 from the official Website. If you want to be sure you are installing a fully up-to-date version then use the “Windows Installer” link from the home page of the [Python.org web site](#).

The Windows version is provided as an MSI package. To install it manually, just double-click the file. The MSI package format allows Windows administrators to automate installation with their standard tools.

By design, Python installs to a directory with the version number embedded, e.g. Python version 2.7 will install at `C:\Python27\`, so that you can have multiple versions of Python on the same system without conflicts. Of course, only one interpreter can be the default application for Python file types. It also does not automatically modify the `PATH` environment variable, so that you always have control over which copy of Python is run.

Typing the full path name for a Python interpreter each time quickly gets tedious, so add the directories for your default Python version to the `PATH`. Assuming that your Python installation is in `C:\Python27\`, add this to your `PATH`:

```
C:\Python27\;C:\Python27\Scripts\
```

You can do this easily by running the following in powershell:

```
[Environment]::SetEnvironmentVariable("Path", "$env:Path;C:\Python27\;C:\Python27\Scripts\","Us
```

The second (`Scripts`) directory receives command files when certain packages are installed, so it is a very useful addition. You do not need to install or configure anything else to use Python. Having said that, I would strongly recommend that you install the tools and libraries described in the next section before you start building Python applications for real-world use. In particular, you should always install `Setuptools`, as it makes it much easier for you to use other third-party Python libraries.

1.3.1 Setuptools + Pip

The most crucial third-party Python software of all is `Setuptools`, which extends the packaging and installation facilities provided by the `distutils` in the standard library. Once you add `Setuptools` to your Python system you can download and install any compliant Python software product with a single command. It also enables you to add this network installation capability to your own Python software with very little work.

To obtain the latest version of `Setuptools` for Windows, run the Python script available here: [ez_setup.py](#)

You'll now have a new command available to you: **easy_install**. It is considered by many to be deprecated, so we will install its replacement: **pip**. `Pip` allows for uninstallation of packages, and is actively maintained, unlike `easy_install`.

To install `pip`, run the Python script available here: [get-pip.py](#)

1.3.2 Virtual Environments

A Virtual Environment is a tool to keep the dependencies required by different projects in separate places, by creating virtual Python environments for them. It solves the "Project X depends on version 1.x but, Project Y needs 4.x" dilemma, and keeps your global site-packages directory clean and manageable.

For example, you can work on a project which requires Django 1.3 while also maintaining a project which requires Django 1.0.

To start using and see more information: [Virtual Environments docs](#).

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1.4 Installing Python on Linux

The latest versions of Ubuntu and Fedora **come with Python 2.7 out of the box**.

The latest versions of Redhat Enterprise (RHEL) and CentOS come with Python 2.6. Some older versions of RHEL and CentOS come with Python 2.4 which is unacceptable for modern Python development. Fortunately, there are [Extra Packages for Enterprise Linux](#) which include high quality additional packages based on their Fedora counterparts. This repository contains a Python 2.6 package specifically designed to install side-by-side with the system's Python 2.4 installation.

You do not need to install or configure anything else to use Python. Having said that, I would strongly recommend that you install the tools and libraries described in the next section before you start building Python applications for real-world use. In particular, you should always install `Setuptools`, as it makes it much easier for you to use other third-party Python libraries.

1.4.1 Setuptools & Pip

The most crucial third-party Python software of all is Setuptools, which extends the packaging and installation facilities provided by the distutils in the standard library. Once you add Setuptools to your Python system you can download and install any compliant Python software product with a single command. It also enables you to add this network installation capability to your own Python software with very little work.

To obtain the latest version of Setuptools for Linux, refer to the documentation available here: [unix-setuptools](#)

The new `easy_install` command you have available is considered by many to be deprecated, so we will install its replacement: **pip**. Pip allows for uninstallation of packages, and is actively maintained, unlike `easy_install`.

To install pip, simply open a command prompt and run

```
$ easy_install pip
```

1.4.2 Virtual Environments

A Virtual Environment is a tool to keep the dependencies required by different projects in separate places, by creating virtual Python environments for them. It solves the “Project X depends on version 1.x but, Project Y needs 4.x” dilemma, and keeps your global site-packages directory clean and manageable.

For example, you can work on a project which requires Django 1.3 while also maintaining a project which requires Django 1.0.

To start using and see more information: [Virtual Environments docs](#).

You can also use *virtualenvwrapper* to make it easier to manage your virtual environments.

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Writing Great Code

This part of the guide focuses on best practices for writing Python code.

2.1 Structuring Your Project

By “structure” we mean the decisions you make concerning how your project best meets its objective. We need to consider how to best leverage Python’s features to create clean, effective code. In practical terms, “structure” means making clean code whose logic and dependencies are clear as well as how the files and folders are organized in the filesystem.

Which functions should go into which modules? How does data flow through the project? What features and functions can be grouped together and isolated? By answering questions like these you can begin to plan, in a broad sense, what your finished product will look like.

In this section we take a closer look at Python’s module and import systems as they are the central elements to enforcing structure in your project. We then discuss various perspectives on how to build code which can be extended and tested reliably.

2.1.1 Structure is Key

Thanks to the way imports and modules are handled in Python, it is relatively easy to structure a Python project. Easy, here, means that you do not have many constraints and that the module importing model is easy to grasp. Therefore, you are left with the pure architectural task of crafting the different parts of your project and their interactions.

Easy structuring of a project means it is also easy to do it poorly. Some signs of a poorly structured project include:

- **Multiple and messy circular dependencies:** if your classes `Table` and `Chair` in `furn.py` need to import `Carpenter` from `workers.py` to answer a question such as `table.isdoneby()`, and if conversely the class `Carpenter` needs to import `Table` and `Chair`, to answer the question `carpenter.whatdo()`, then you have a circular dependency. In this case you will have to resort to fragile hacks such as using `import` statements inside methods or functions.
- **Hidden coupling:** each and every change in `Table`’s implementation breaks 20 tests in unrelated test cases because it breaks `Carpenter`’s code, which requires very careful surgery to adapt the change. This means you have too many assumptions about `Table` in `Carpenter`’s code or the reverse.
- **Heavy usage of global state or context:** instead of explicitly passing `(height, width, type, wood)` to each other, `Table` and `Carpenter` rely on global variables that can be modified and are modified on the fly by different agents. You need to scrutinize all access to these global variables to understand why a rectangular table became a square, and discover that remote template code is also modifying this context, messing with table dimensions.

- Spaghetti code: multiple pages of nested if clauses and for loops with a lot of copy-pasted procedural code and no proper segmentation are known as spaghetti code. Python’s meaningful indentation (one of its most controversial features) make it very hard to maintain this kind of code. So the good news is that you might not see too much of it.
- Ravioli code is more likely in Python: it consists of hundreds of similar little pieces of logic, often classes or objects, without proper structure. If you never can remember if you have to use `FurnitureTable`, `AssetTable` or `Table`, or even `TableNew` for your task at hand, you might be swimming in ravioli code.

2.1.2 Modules

Python modules are one of the main abstraction layers available and probably the most natural one. Abstraction layers allow separating code into parts holding related data and functionality.

For example, a layer of a project can handle interfacing with user actions, while another would handle low-level manipulation of data. The most natural way to separate these two layers is to regroup all interfacing functionality in one file, and all low-level operations in another file. In this case, the interface file needs to import the low-level file. This is done with the `import` and `from ... import` statements.

As soon as you use *import* statements you use modules. These can be either built-in modules such as `os` and `sys`, third-party modules you have installed in your environment, or your project’s internal modules.

To keep in line with the style guide, keep module names short, lowercase, and be sure to avoid using special symbols like the dot (`.`) or question mark (`?`). So a file name like `my.spam.py` is one you should avoid! Naming this way will interfere with the way Python looks for modules.

In the case of `my.spam.py` Python expects to find a `spam.py` file in a folder named `my` which is not the case. There is an [example](#) of how the dot notation should be used in the Python docs.

If you’d like you could name your module `my_spam.py`, but even our friend the underscore should not be seen often in module names.

Aside from some naming restrictions, nothing special is required for a Python file to be a module, but you need to understand the import mechanism in order to use this concept properly and avoid some issues.

Concretely, the `import modu` statement will look for the proper file, which is `modu.py` in the same directory as the caller if it exists. If it is not found, the Python interpreter will search for `modu.py` in the “path” recursively and raise an `ImportError` exception if it is not found.

Once `modu.py` is found, the Python interpreter will execute the module in an isolated scope. Any top-level statement in `modu.py` will be executed, including other imports if any. Function and class definitions are stored in the module’s dictionary.

Then, the module’s variables, functions, and classes will be available to the caller through the module’s namespace, a central concept in programming that is particularly helpful and powerful in Python.

In many languages, an `include file` directive is used by the preprocessor to take all code found in the file and ‘copy’ it into the caller’s code. It is different in Python: the included code is isolated in a module namespace, which means that you generally don’t have to worry that the included code could have unwanted effects, e.g. override an existing function with the same name.

It is possible to simulate the more standard behavior by using a special syntax of the import statement: `from modu import *`. This is generally considered bad practice. **Using `import *` makes code harder to read and makes dependencies less compartmentalized.**

Using `from modu import func` is a way to pinpoint the function you want to import and put it in the global namespace. While much less harmful than `import *` because it shows explicitly what is imported in the global namespace, its only advantage over a simpler `import modu` is that it will save a little typing.

Very bad

```
[...]
from modu import *
[...]
x = sqrt(4) # Is sqrt part of modu? A builtin? Defined above?
```

Better

```
from modu import sqrt
[...]
x = sqrt(4) # sqrt may be part of modu, if not redefined in between
```

Best

```
import modu
[...]
x = modu.sqrt(4) # sqrt is visibly part of modu's namespace
```

As mentioned in the *Code Style* section, readability is one of the main features of Python. Readability means to avoid useless boilerplate text and clutter, therefore some efforts are spent trying to achieve a certain level of brevity. But terseness and obscurity are the limits where brevity should stop. Being able to tell immediately where a class or function comes from, as in the `modu.func` idiom, greatly improves code readability and understandability in all but the simplest single file projects.

2.1.3 Packages

Python provides a very straightforward packaging system, which is simply an extension of the module mechanism to a directory.

Any directory with an `__init__.py` file is considered a Python package. The different modules in the package are imported in a similar manner as plain modules, but with a special behavior for the `__init__.py` file, which is used to gather all package-wide definitions.

A file `modu.py` in the directory `pack/` is imported with the statement `import pack.modu`. This statement will look for an `__init__.py` file in `pack`, execute all of its top-level statements. Then it will look for a file named `pack/modu.py` and execute all of its top-level statements. After these operations, any variable, function, or class defined in `modu.py` is available in the `pack.modu` namespace.

A commonly seen issue is to add too much code to `__init__.py` files. When the project complexity grows, there may be sub-packages and sub-sub-packages in a deep directory structure. In this case, importing a single item from a sub-sub-package will require executing all `__init__.py` files met while traversing the tree.

Leaving an `__init__.py` file empty is considered normal and even a good practice, if the package's modules and sub-packages do not need to share any code.

Lastly, a convenient syntax is available for importing deeply nested packages: `import very.deep.module as mod`. This allows you to use `mod` in place of the verbose repetition of `very.deep.module`.

2.1.4 Object-oriented programming

Python is sometimes described as an object-oriented programming language. This can be somewhat misleading and needs to be clarified.

In Python, everything is an object, and can be handled as such. This is what is meant when we say, for example, that functions are first-class objects. Functions, classes, strings, and even types are objects in Python: like any objects, they have a type, they can be passed as function arguments, they may have methods and properties. In this understanding, Python is an object-oriented language.

However, unlike Java, Python does not impose object-oriented programming as the main programming paradigm. It is perfectly viable for a Python project to not be object-oriented, i.e. to use no or very few class definitions, class inheritance, or any other mechanisms that are specific to object-oriented programming.

Moreover, as seen in the [modules](#) section, the way Python handles modules and namespaces gives the developer a natural way to ensure the encapsulation and separation of abstraction layers, both being the most common reasons to use object-orientation. Therefore, Python programmers have more latitude to not use object-orientation, when it is not required by the business model.

There are some reasons to avoid unnecessary object-orientation. Defining custom classes is useful when we want to glue together some state and some functionality. The problem, as pointed out by the discussions about functional programming, comes from the “state” part of the equation.

In some architectures, typically web applications, multiple instances of Python processes are spawned to respond to external requests that can happen at the same time. In this case, holding some state into instantiated objects, which means keeping some static information about the world, is prone to concurrency problems or race-conditions. Sometimes, between the initialization of the state of an object (usually done with the `__init__()` method) and the actual use of the object state through one of its methods, the world may have changed, and the retained state may be outdated. For example, a request may load an item in memory and mark it as read by a user. If another request requires the deletion of this item at the same time, it may happen that the deletion actually occurs after the first process loaded the item, and then we have to mark as read a deleted object.

This and other issues led to the idea that using stateless functions is a better programming paradigm.

Another way to say the same thing is to suggest using functions and procedures with as few implicit contexts and side-effects as possible. A function’s implicit context is made up of any of the global variables or items in the persistence layer that are accessed from within the function. Side-effects are the changes that a function makes to its implicit context. If a function saves or deletes data in a global variable or in the persistence layer, it is said to have a side-effect.

Carefully isolating functions with context and side-effects from functions with logic (called pure functions) allow the following benefits:

- Pure functions are deterministic: given a fixed input, the output will always be the same.
- Pure functions are much easier to change or replace if they need to be refactored or optimized.
- Pure functions are easier to test with unit-tests: There is less need for complex context setup and data cleaning afterwards.
- Pure functions are easier to manipulate, decorate, and pass around.

In summary, pure functions are more efficient building blocks than classes and objects for some architectures because they have no context or side-effects.

Obviously, object-orientation is useful and even necessary in many cases, for example when developing graphical desktop applications or games, where the things that are manipulated (windows, buttons, avatars, vehicles) have a relatively long life of their own in the computer’s memory.

2.1.5 Decorators

The Python language provides a simple yet powerful syntax called ‘decorators’. A decorator is a function or a class that wraps (or decorates) a function or a method. The ‘decorated’ function or method will replace the original ‘undecorated’ function or method. Because functions are first-class objects in Python, this can be done ‘manually’, but using the `@decorator` syntax is clearer and thus preferred.

```
def foo():
    # do something

def decorator(func):
    # manipulate func
```



```

return func

foo = decorator(foo)  # Manually decorate

@decorator
def bar():
    # Do something
    # bar() is decorated

```

This mechanism is useful for separating concerns and avoiding external un-related logic ‘polluting’ the core logic of the function or method. A good example of a piece of functionality that is better handled with decoration is memoization or caching: you want to store the results of an expensive function in a table and use them directly instead of recomputing them when they have already been computed. This is clearly not part of the function logic.

2.1.6 Dynamic typing

Python is dynamically typed, which means that variables do not have a fixed type. In fact, in Python, variables are very different from what they are in many other languages, specifically statically-typed languages. Variables are not a segment of the computer’s memory where some value is written, they are ‘tags’ or ‘names’ pointing to objects. It is therefore possible for the variable ‘a’ to be set to the value 1, then to the value ‘a string’, then to a function.

The dynamic typing of Python is often considered to be a weakness, and indeed it can lead to complexities and hard-to-debug code. Something named ‘a’ can be set to many different things, and the developer or the maintainer needs to track this name in the code to make sure it has not been set to a completely unrelated object.

Some guidelines help to avoid this issue:

- Avoid using the same variable name for different things.

Bad

```

a = 1
a = 'a string'
def a():
    pass # Do something

```

Good

```

count = 1
msg = 'a string'
def func():
    pass # Do something

```

Using short functions or methods helps reduce the risk of using the same name for two unrelated things.

It is better to use different names even for things that are related, when they have a different type:

Bad

```

items = 'a b c d' # This is a string...
items = items.split(' ') # ...becoming a list
items = set(items) # ...and then a set

```

There is no efficiency gain when reusing names: the assignments will have to create new objects anyway. However, when the complexity grows and each assignment is separated by other lines of code, including ‘if’ branches and loops, it becomes harder to ascertain what a given variable’s type is.

Some coding practices, like functional programming, recommend never reassigning a variable. In Java this is done with the *final* keyword. Python does not have a *final* keyword and it would be against its philosophy anyway. However,

it may be a good discipline to avoid assigning to a variable more than once, and it helps in grasping the concept of mutable and immutable types.

2.1.7 Mutable and immutable types

Python has two kinds of built-in or user-defined types.

Mutable types are those that allow in-place modification of the content. Typical mutables are lists and dictionaries: All lists have mutating methods, like `list.append()` or `list.pop()`, and can be modified in place. The same goes for dictionaries.

Immutable types provide no method for changing their content. For instance, the variable `x` set to the integer 6 has no “increment” method. If you want to compute `x + 1`, you have to create another integer and give it a name.

```
my_list = [1, 2, 3]
my_list[0] = 4
print my_list # [4, 2, 3] <- The same list as changed

x = 6
x = x + 1 # The new x is another object
```

One consequence of this difference in behavior is that mutable types are not “stable”, and therefore cannot be used as dictionary keys.

Using properly mutable types for things that are mutable in nature and immutable types for things that are fixed in nature helps to clarify the intent of the code.

For example, the immutable equivalent of a list is the tuple, created with `(1, 2)`. This tuple is a pair that cannot be changed in-place, and can be used as a key for a dictionary.

One peculiarity of Python that can surprise beginners is that strings are immutable. This means that when constructing a string from its parts, it is much more efficient to accumulate the parts in a list, which is mutable, and then glue (‘join’) the parts together when the full string is needed. One thing to notice, however, is that list comprehensions are better and faster than constructing a list in a loop with calls to `append()`.

Bad

```
# create a concatenated string from 0 to 19 (e.g. "012..1819")
nums = ""
for n in range(20):
    nums += str(n) # slow and inefficient
print nums
```

Good

```
# create a concatenated string from 0 to 19 (e.g. "012..1819")
nums = []
for n in range(20):
    nums.append(str(n))
print "".join(nums) # much more efficient
```

Best

```
# create a concatenated string from 0 to 19 (e.g. "012..1819")
nums = [str(n) for n in range(20)]
print "".join(nums)
```

One final thing to mention about strings is that using `join()` is not always best. In the instances where you are creating a new string from a pre-determined number of strings, using the addition operator is actually faster, but in

cases like above or in cases where you are adding to an existing string, using `join()` should be your preferred method.

```
foo = 'foo'
bar = 'bar'

foobar = foo + bar # This is good
foo += 'ooo' # This is bad, instead you should do:
foo = ''.join([foo, 'ooo'])
```

Note: You can also use the `%` formatting operator to concatenate a pre-determined number of strings besides `str.join()` and `+`. However, **PEP 3101**, discourages the usage of the `%` operator in favor of the `str.format()` method.

```
foo = 'foo'
bar = 'bar'

foobar = '%s%s' % (foo, bar) # It is OK
foobar = '{0}{1}'.format(foo, bar) # It is better
foobar = '{foo}{bar}'.format(foo=foo, bar=bar) # It is best
```

2.1.8 Vendorizing Dependencies

2.1.9 Runners

2.1.10 Further Reading

- <http://docs.python.org/2/library/>
- <http://www.diveintopython.net/toc/index.html>

2.2 Code Style

If you ask Python programmers what they like most in Python, they will often say its high readability. Indeed, a high level of readability is at the heart of the design of the Python language, following the recognised fact that code is read much more often than it is written.

One reason for Python code to be easily read and understood is its relatively complete set of Code Style guidelines and “Pythonic” idioms.

Moreover, when a veteran Python developer (a Pythonista) points to portions of code and says they are not “Pythonic”, it usually means that these lines of code do not follow the common guidelines and fail to express the intent in what is considered the best (hear: most readable) way.

On some border cases, no best way has been agreed upon on how to express an intent in Python code, but these cases are rare.

2.2.1 General concepts

Explicit code

While any kind of black magic is possible with Python, the most explicit and straightforward manner is preferred.

Bad

```
def make_complex(*args):
    x, y = args
    return dict(**locals())
```

Good

```
def make_complex(x, y):
    return {'x': x, 'y': y}
```

In the good code above, `x` and `y` are explicitly received from the caller, and an explicit dictionary is returned. The developer using this function knows exactly what to do by reading the first and last lines, which is not the case with the bad example.

One statement per line

While some compound statements such as list comprehensions are allowed and appreciated for their brevity and their expressiveness, it is bad practice to have two disjoint statements on the same line of code.

Bad

```
print 'one'; print 'two'

if x == 1: print 'one'

if <complex comparison> and <other complex comparison>:
    # do something
```

Good

```
print 'one'
print 'two'

if x == 1:
    print 'one'

cond1 = <complex comparison>
cond2 = <other complex comparison>
if cond1 and cond2:
    # do something
```

Function arguments

Arguments can be passed to functions in four different ways.

1. **Positional arguments** are mandatory and have no default values. They are the simplest form of arguments and they can be used for the few function arguments that are fully part of the function's meaning and their order is natural. For instance, in `send(message, recipient)` or `point(x, y)` the user of the function has no difficulty remembering that those two functions require two arguments, and in which order.

In those two cases, it is possible to use argument names when calling the functions and, doing so, it is possible to switch the order of arguments, calling for instance `send(recipient='World', message='Hello')` and `point(y=2, x=1)` but this reduces readability and is unnecessarily verbose, compared to the more straightforward calls to `send('Hello', 'World')` and `point(1, 2)`.

2. **Keyword arguments** are not mandatory and have default values. They are often used for optional parameters sent to the function. When a function has more than two or three positional parameters, its signature is more

difficult to remember and using keyword arguments with default values is helpful. For instance, a more complete send function could be defined as `send(message, to, cc=None, bcc=None)`. Here `cc` and `bcc` are optional, and evaluate to `None` when they are not passed another value.

Calling a function with keyword arguments can be done in multiple ways in Python, for example it is possible to follow the order of arguments in the definition without explicitly naming the arguments, like in `send('Hello', 'World', 'Cthulhu', 'God')`, sending a blind carbon copy to God. It would also be possible to name arguments in another order, like in `send('Hello again', 'World', bcc='God', cc='Cthulhu')`. Those two possibilities are better avoided without any strong reason to not follow the syntax that is the closest to the function definition: `send('Hello', 'World', cc='Cthulhu', bcc='God')`.

As a side note, following **YAGNI** principle, it is often harder to remove an optional argument (and its logic inside the function) that was added “just in case” and is seemingly never used, than to add a new optional argument and its logic when needed.

3. The **arbitrary argument list** is the third way to pass arguments to a function. If the function intention is better expressed by a signature with an extensible number of positional arguments, it can be defined with the `*args` constructs. In the function body, `args` will be a tuple of all the remaining positional arguments. For example, `send(message, *args)` can be called with each recipient as an argument: `send('Hello', 'God', 'Mom', 'Cthulhu')`, and in the function body `args` will be equal to `('God', 'Mom', 'Cthulhu')`.

However, this construct has some drawbacks and should be used with caution. If a function receives a list of arguments of the same nature, it is often more clear to define it as a function of one argument, that argument being a list or any sequence. Here, if `send` has multiple recipients, it is better to define it explicitly: `send(message, recipients)` and call it with `send('Hello', ['God', 'Mom', 'Cthulhu'])`. This way, the user of the function can manipulate the recipient list as a list beforehand, and it opens the possibility to pass any sequence, including iterators, that cannot be unpacked as other sequences.

4. The **arbitrary keyword argument dictionary** is the last way to pass arguments to functions. If the function requires an undetermined series of named arguments, it is possible to use the `**kwargs` construct. In the function body, `kwargs` will be a dictionary of all the passed named arguments that have not been caught by other keyword arguments in the function signature.

The same caution as in the case of *arbitrary argument list* is necessary, for similar reasons: these powerful techniques are to be used when there is a proven necessity to use them, and they should not be used if the simpler and clearer construct is sufficient to express the function’s intention.

It is up to the programmer writing the function to determine which arguments are positional arguments and which are optional keyword arguments, and to decide whether to use the advanced techniques of arbitrary argument passing. If the advice above is followed wisely, it is possible and enjoyable to write Python functions that are:

- easy to read (the name and arguments need no explanations)
- easy to change (adding a new keyword argument does not break other parts of the code)

Avoid the magical wand

A powerful tool for hackers, Python comes with a very rich set of hooks and tools allowing you to do almost any kind of tricky tricks. For instance, it is possible to do each of the following:

- change how objects are created and instantiated
- change how the Python interpreter imports modules
- it is even possible (and recommended if needed) to embed C routines in Python.

However, all these options have many drawbacks and it is always better to use the most straightforward way to achieve your goal. The main drawback is that readability suffers greatly when using these constructs. Many code analysis tools, such as `pylint` or `pyflakes`, will be unable to parse this “magic” code.

We consider that a Python developer should know about these nearly infinite possibilities, because it instills confidence that no impassable problem will be on the way. However, knowing how and particularly when **not** to use them is very important.

Like a kung fu master, a Pythonista knows how to kill with a single finger, and never to actually do it.

We are all responsible users

As seen above, Python allows many tricks, and some of them are potentially dangerous. A good example is that any client code can override an object's properties and methods: there is no "private" keyword in Python. This philosophy, very different from highly defensive languages like Java, which give a lot of mechanisms to prevent any misuse, is expressed by the saying: "We are all responsible users".

This doesn't mean that, for example, no properties are considered private, and that no proper encapsulation is possible in Python. Rather, instead of relying on concrete walls erected by the developers between their code and other's, the Python community prefers to rely on a set of conventions indicating that these elements should not be accessed directly.

The main convention for private properties and implementation details is to prefix all "internals" with an underscore. If the client code breaks this rule and accesses these marked elements, any misbehavior or problems encountered if the code is modified is the responsibility of the client code.

Using this convention generously is encouraged: any method or property that is not intended to be used by client code should be prefixed with an underscore. This will guarantee a better separation of duties and easier modification of existing code; it will always be possible to publicize a private property, but making a public property private might be a much harder operation.

Returning values

When a function grows in complexity it is not uncommon to use multiple return statements inside the function's body. However, in order to keep a clear intent and a sustainable readability level, it is preferable to avoid returning meaningful values from many output points in the body.

There are two main cases for returning values in a function: the result of the function return when it has been processed normally, and the error cases that indicate a wrong input parameter or any other reason for the function to not be able to complete its computation or task.

If you do not wish to raise exceptions for the second case, then returning a value, such as `None` or `False`, indicating that the function could not perform correctly might be needed. In this case, it is better to return as early as the incorrect context has been detected. It will help to flatten the structure of the function: all the code after the return-because-of-error statement can assume the condition is met to further compute the function's main result. Having multiple such return statements is often necessary.

However, when a function has multiple main exit points for its normal course, it becomes difficult to debug the returned result, so it may be preferable to keep a single exit point. This will also help factoring out some code paths, and the multiple exit points are a probable indication that such a refactoring is needed.

```
def complex_function(a, b, c):
    if not a:
        return None # Raising an exception might be better
    if not b:
        return None # Raising an exception might be better
    # Some complex code trying to compute x from a, b and c
    # Resist temptation to return x if succeeded
    if not x:
        # Some Plan-B computation of x
```

```
return x # One single exit point for the returned value x will help
        # when maintaining the code.
```

2.2.2 Idioms

A programming idiom, put simply, is a way to write code. The notion of programming idioms is discussed amply at [c2](#) and at [Stack Overflow](#).

Idiomatic Python code is often referred to as being *Pythonic*.

Although there usually is one — and preferably only one — obvious way to do it; *the* way to write idiomatic Python code can be non-obvious to Python beginners. So, good idioms must be consciously acquired.

Some common Python idioms follow:

Unpacking

If you know the length of a list or tuple, you can assign names to its elements with unpacking. For example, since `enumerate()` will provide a tuple of two elements for each item in list:

```
for index, item in enumerate(some_list):
    # do something with index and item
```

You can use this to swap variables as well:

```
a, b = b, a
```

Nested unpacking works too:

```
a, (b, c) = 1, (2, 3)
```

In Python 3, a new method of extended unpacking was introduced by [PEP 3132](#):

```
a, *rest = [1, 2, 3]
# a = 1, rest = [2, 3]
a, *middle, c = [1, 2, 3, 4]
# a = 1, middle = [2, 3], c = 4
```

Create an ignored variable

If you need to assign something (for instance, in [Unpacking](#)) but will not need that variable, use `__`:

```
filename = 'foobar.txt'
basename, __, ext = filename.rpartition('.')
```

Note: Many Python style guides recommend the use of a single underscore “`_`” for throwaway variables rather than the double underscore “`__`” recommended here. The issue is that “`_`” is commonly used as an alias for the `gettext()` function, and is also used at the interactive prompt to hold the value of the last operation. Using a double underscore instead is just as clear and almost as convenient, and eliminates the risk of accidentally interfering with either of these other use cases.

Create a length-N list of the same thing

Use the Python list `*` operator:

```
four_nones = [None] * 4
```

Create a length-N list of lists

Because lists are mutable, the `*` operator (as above) will create a list of N references to the *same* list, which is not likely what you want. Instead, use a list comprehension:

```
four_lists = [[] for __ in xrange(4)]
```

A common idiom for creating strings is to use `str.join()` on an empty string.

```
letters = ['s', 'p', 'a', 'm']  
word = ''.join(letters)
```

This will set the value of the variable `word` to 'spam'. This idiom can be applied to lists and tuples.

Sometimes we need to search through a collection of things. Let's look at two options: lists and dictionaries.

Take the following code for example:

```
d = {'s': [], 'p': [], 'a': [], 'm': []}  
l = ['s', 'p', 'a', 'm']  
  
def lookup_dict(d):  
    return 's' in d  
  
def lookup_list(l):  
    return 's' in l
```

Even though both functions look identical, because `lookup_dict` is utilizing the fact that dictionaries in Python are hashtables, the lookup performance between the two is very different. Python will have to go through each item in the list to find a matching case, which is time consuming. By analysing the hash of the dictionary, finding keys in the dictionary can be done very quickly. For more information see this [StackOverflow](#) page.

2.2.3 Zen of Python

Also known as **PEP 20**, the guiding principles for Python's design.

```
>>> import this  
The Zen of Python, by Tim Peters  
  
Beautiful is better than ugly.  
Explicit is better than implicit.  
Simple is better than complex.  
Complex is better than complicated.  
Flat is better than nested.  
Sparse is better than dense.  
Readability counts.  
Special cases aren't special enough to break the rules.  
Although practicality beats purity.  
Errors should never pass silently.  
Unless explicitly silenced.  
In the face of ambiguity, refuse the temptation to guess.
```



```

There should be one-- and preferably only one --obvious way to do it.
Although that way may not be obvious at first unless you're Dutch.
Now is better than never.
Although never is often better than *right* now.
If the implementation is hard to explain, it's a bad idea.
If the implementation is easy to explain, it may be a good idea.
Namespaces are one honking great idea -- let's do more of those!

```

For some examples of good Python style, see [these slides from a Python user group](#).

2.2.4 PEP 8

PEP 8 is the de-facto code style guide for Python.

Conforming your Python code to PEP 8 is generally a good idea and helps make code more consistent when working on projects with other developers. There is a command-line program, `pep8`, that can check your code for conformance. Install it by running the following command in your terminal:

```
$ pip install pep8
```

Then run it on a file or series of files to get a report of any violations.

```

$ pep8 optparse.py
optparse.py:69:11: E401 multiple imports on one line
optparse.py:77:1: E302 expected 2 blank lines, found 1
optparse.py:88:5: E301 expected 1 blank line, found 0
optparse.py:222:34: W602 deprecated form of raising exception
optparse.py:347:31: E211 whitespace before '('
optparse.py:357:17: E201 whitespace after '{'
optparse.py:472:29: E221 multiple spaces before operator
optparse.py:544:21: W601 .has_key() is deprecated, use 'in'

```

2.2.5 Conventions

Here are some conventions you should follow to make your code easier to read.

Check if variable equals a constant

You don't need to explicitly compare a value to `True`, or `None`, or `0` - you can just add it to the `if` statement. See [Truth Value Testing](#) for a list of what is considered false.

Bad:

```

if attr == True:
    print 'True!'

if attr == None:
    print 'attr is None!'

```

Good:

```

# Just check the value
if attr:
    print 'attr is truthy!'

# or check for the opposite

```

```
if not attr:
    print 'attr is falsey!'

# or, since None is considered false, explicitly check for it
if attr is None:
    print 'attr is None!'
```

Access a Dictionary Element

Don't use the `dict.has_key()` method. Instead, use `x in d` syntax, or pass a default argument to `dict.get()`.

Bad:

```
d = {'hello': 'world'}
if d.has_key('hello'):
    print d['hello']    # prints 'world'
else:
    print 'default_value'
```

Good:

```
d = {'hello': 'world'}

print d.get('hello', 'default_value') # prints 'world'
print d.get('thingy', 'default_value') # prints 'default_value'

# Or:
if 'hello' in d:
    print d['hello']
```

Short Ways to Manipulate Lists

List comprehensions provide a powerful, concise way to work with lists. Also, the `map()` and `filter()` functions can perform operations on lists using a different, more concise syntax.

Bad:

```
# Filter elements greater than 4
a = [3, 4, 5]
b = []
for i in a:
    if i > 4:
        b.append(i)
```

Good:

```
a = [3, 4, 5]
b = [i for i in a if i > 4]
# Or:
b = filter(lambda x: x > 4, a)
```

Bad:

```
# Add three to all list members.
a = [3, 4, 5]
for i in range(len(a)):
    a[i] += 3
```

Good:

```
a = [3, 4, 5]
a = [i + 3 for i in a]
# Or:
a = map(lambda i: i + 3, a)
```

Use `enumerate()` keep a count of your place in the list.

```
a = [3, 4, 5]
for i, item in enumerate(a):
    print i, item
# prints
# 0 3
# 1 4
# 2 5
```

The `enumerate()` function has better readability than handling a counter manually. Moreover, it is better optimized for iterators.

Read From a File

Use the `with open` syntax to read from files. This will automatically close files for you.

Bad:

```
f = open('file.txt')
a = f.read()
print a
f.close()
```

Good:

```
with open('file.txt') as f:
    for line in f:
        print line
```

The `with` statement is better because it will ensure you always close the file, even if an exception is raised inside the `with` block.

Line Continuations

When a logical line of code is longer than the accepted limit, you need to split it over multiple physical lines. The Python interpreter will join consecutive lines if the last character of the line is a backslash. This is helpful in some cases, but should usually be avoided because of its fragility: a white space added to the end of the line, after the backslash, will break the code and may have unexpected results.

A better solution is to use parentheses around your elements. Left with an unclosed parenthesis on an end-of-line the Python interpreter will join the next line until the parentheses are closed. The same behavior holds for curly and square braces.

Bad:

```
my_very_big_string = """For a long time I used to go to bed early. Sometimes, \
    when I had put out my candle, my eyes would close so quickly that I had not even \
    time to say "I'm going to sleep."""

from some.deep.module.inside.a.module import a_nice_function, another_nice_function, \
    yet_another_nice_function
```

Good:

```
my_very_big_string = (  
    "For a long time I used to go to bed early. Sometimes, "  
    "when I had put out my candle, my eyes would close so quickly "  
    "that I had not even time to say "I'm going to sleep.""  
)  
  
from some.deep.module.inside.a.module import (  
    a_nice_function, another_nice_function, yet_another_nice_function)
```

However, more often than not, having to split a long logical line is a sign that you are trying to do too many things at the same time, which may hinder readability.

2.3 Reading Great Code

One of the core tenants behind the design of Python is creating readable code. The motivation behind this design is simple: The number one thing that Python programmers do is read code.

One of the secrets of becoming a great Python programmer is to read, understand, and comprehend excellent code.

Excellent code typically follows the guidelines outlined in *Code Style*, and does its best to express a clear and concise intent to the reader.

Included below is a list of recommended Python projects for reading. Each one of these projects is a paragon of Python coding.

- [Howdoi](#) Howdoi is a code search tool, written in Python.
- [Flask](#) Flask is a microframework for Python based on Werkzeug and Jinja2. It's intended for getting started very quickly and was developed with best intentions in mind.
- [Werkzeug](#) Werkzeug started as simple collection of various utilities for WSGI applications and has become one of the most advanced WSGI utility modules. It includes a powerful debugger, full-featured request and response objects, HTTP utilities to handle entity tags, cache control headers, HTTP dates, cookie handling, file uploads, a powerful URL routing system and a bunch of community-contributed addon modules.
- [Requests](#) Requests is an Apache2 Licensed HTTP library, written in Python, for human beings.
- [Tablib](#) Tablib is a format-agnostic tabular dataset library, written in Python.

Todo

Embed and explain YouTube video showing python code reading: <http://www.youtube.com/watch?v=Jc8M9-LoEuo> This may require installing a Sphinx plugin. <https://bitbucket.org/birkenfeld/sphinx-contrib/src/a09f29fc16970f34350ca36ac7f229e00b1b1674/youtube?at=default>

Todo

Include code examples of exemplary code from each of the projects listed. Explain why it is excellent code. Use complex examples.

Todo

Explain techniques to rapidly identify data structures, algorithms and determine what the code is doing.

2.4 Documentation

Readability is a primary focus for Python developers, in both project and code documentation. Following some simple best practices can save both you and others a lot of time.

2.4.1 Project Documentation

A `README` file at the root directory should give general information to both users and maintainers of a project. It should be raw text or written in some very easy to read markup, such as *reStructuredText* or Markdown. It should contain a few lines explaining the purpose of the project or library (without assuming the user knows anything about the project), the url of the main source for the software, and some basic credit information. This file is the main entry point for readers of the code.

An `INSTALL` file is less necessary with Python. The installation instructions are often reduced to one command, such as `pip install module` or `python setup.py install` and added to the `README` file.

A `LICENSE` file should *always* be present and specify the license under which the software is made available to the public.

A `TODO` file or a `TODO` section in `README` should list the planned development for the code.

A `CHANGELOG` file or section in `README` should compile a short overview of the changes in the code base for the latest versions.

2.4.2 Project Publication

Depending on the project, your documentation might include some or all of the following components:

- An *introduction* should show a very short overview of what can be done with the product, using one or two extremely simplified use cases. This is the thirty-second pitch for your project.
- A *tutorial* should show some primary use cases in more detail. The reader will follow a step-by-step procedure to set-up a working prototype.
- An *API reference* is typically generated from the code (see *docstrings*). It will list all publicly available interfaces, parameters, and return values.
- *Developer documentation* is intended for potential contributors. This can include code convention and general design strategy of the project.

Sphinx

`Sphinx` is far and away the most popular Python documentation tool. **Use it.** It converts *reStructuredText* markup language into a range of output formats including HTML, LaTeX (for printable PDF versions), manual pages, and plain text.

There is also **great, free** hosting for your `Sphinx` docs: [Read The Docs](#). Use it. You can configure it with commit hooks to your source repository so that rebuilding your documentation will happen automatically.

Note: `Sphinx` is famous for its API generation, but it also works well for general project documentation. This Guide is built with `Sphinx` and is hosted on [Read The Docs](#)

reStructuredText

Most Python documentation is written with `reStructuredText`. It's like Markdown with all the optional extensions built in.

The `reStructuredText Primer` and the `reStructuredText Quick Reference` should help you familiarize yourself with its syntax.

2.4.3 Code Documentation Advice

Comments clarify the code and they are added with purpose of making the code easier to understand. In Python, comments begin with a hash (number sign) (`#`). In Python, *docstrings* describe modules, classes, and functions:

```
def square_and_rooter(x):
    """Returns the square root of self times self."""
    ...
```

In general, follow the comment section of [PEP 8#comments](#) (the “Python Style Guide”).

Commenting Sections of Code

Do not use triple-quote strings to comment code. This is not a good practice, because line-oriented command-line tools such as `grep` will not be aware that the commented code is inactive. It is better to add hashes at the proper indentation level for every commented line. Your editor probably has the ability to do this easily, and it is worth learning the comment/uncomment toggle.

Docstrings and Magic

Some tools use docstrings to embed more-than-documentation behavior, such as unit test logic. Those can be nice, but you won't ever go wrong with vanilla “here's what this does.”

Docstrings versus Block comments

These aren't interchangeable. For a function or class, the leading comment block is a programmer's note. The docstring describes the *operation* of the function or class:

```
# This function slows down program execution for some reason.
def square_and_rooter(x):
    """Returns the square root of self times self."""
    ...
```

See also:

Further reading on docstrings: [PEP 257](#)

2.4.4 Other Tools

You might see these in the wild. Use *Sphinx*.

Pycco Pycco is a “literate-programming-style documentation generator” and is a port of the node.js `Docco`. It makes code into a side-by-side HTML code and documentation.

Ronn Ronn builds unix manuals. It converts human readable textfiles to roff for terminal display, and also to HTML for the web.

Epydoc Epydoc is discontinued. Use *Sphinx* instead.

MkDocs MkDocs is a fast and simple static site generator that's geared towards building project documentation with Markdown.

2.5 Testing Your Code

Testing your code is very important.

Getting used to writing the testing code and the running code in parallel is now considered a good habit. Used wisely, this method helps you define more precisely your code's intent and have a more decoupled architecture.

Some general rules of testing:

- A testing unit should focus on one tiny bit of functionality and prove it correct.
- Each test unit must be fully independent. Each of them must be able to run alone, and also within the test suite, regardless of the order they are called. The implication of this rule is that each test must be loaded with a fresh dataset and may have to do some cleanup afterwards. This is usually handled by `setUp()` and `tearDown()` methods.
- Try hard to make tests that run fast. If one single test needs more than a few milliseconds to run, development will be slowed down or the tests will not be run as often as is desirable. In some cases, tests can't be fast because they need a complex data structure to work on, and this data structure must be loaded every time the test runs. Keep these heavier tests in a separate test suite that is run by some scheduled task, and run all other tests as often as needed.
- Learn your tools and learn how to run a single test or a test case. Then, when developing a function inside a module, run this function's tests very often, ideally automatically when you save the code.
- Always run the full test suite before a coding session, and run it again after. This will give you more confidence that you did not break anything in the rest of the code.
- It is a good idea to implement a hook that runs all tests before pushing code to a shared repository.
- If you are in the middle of a development session and have to interrupt your work, it is a good idea to write a broken unit test about what you want to develop next. When coming back to work, you will have a pointer to where you were and get back on track faster.
- The first step when you are debugging your code is to write a new test pinpointing the bug. While it is not always possible to do, those bug catching tests are among the most valuable pieces of code in your project.
- Use long and descriptive names for testing functions. The style guide here is slightly different than that of running code, where short names are often preferred. The reason is testing functions are never called explicitly. `square()` or even `sqr()` is ok in running code, but in testing code you would have names such as `test_square_of_number_2()`, `test_square_negative_number()`. These function names are displayed when a test fails, and should be as descriptive as possible.
- When something goes wrong or has to be changed, and if your code has a good set of tests, you or other maintainers will rely largely on the testing suite to fix the problem or modify a given behavior. Therefore the testing code will be read as much as or even more than the running code. A unit test whose purpose is unclear is not very helpful in this case.
- Another use of the testing code is as an introduction to new developers. When someone will have to work on the code base, running and reading the related testing code is often the best they can do. They will or should discover the hot spots, where most difficulties arise, and the corner cases. If they have to add some functionality, the first step should be to add a test and, by this means, ensure the new functionality is not already a working path that has not been plugged into the interface.

2.5.1 The Basics

Unittest

`unittest` is the batteries-included test module in the Python standard library. Its API will be familiar to anyone who has used any of the JUnit/nUnit/CppUnit series of tools.

Creating test cases is accomplished by subclassing `unittest.TestCase`.

```
import unittest

def fun(x):
    return x + 1

class MyTest(unittest.TestCase):
    def test(self):
        self.assertEqual(fun(3), 4)
```

As of Python 2.7 `unittest` also includes its own test discovery mechanisms.

[unittest in the standard library documentation](#)

Doctest

The `doctest` module searches for pieces of text that look like interactive Python sessions in docstrings, and then executes those sessions to verify that they work exactly as shown.

Doctests have a different use case than proper unit tests: they are usually less detailed and don't catch special cases or obscure regression bugs. They are useful as an expressive documentation of the main use cases of a module and its components. However, doctests should run automatically each time the full test suite runs.

A simple doctest in a function:

```
def square(x):
    """Squares x.

    >>> square(2)
    4
    >>> square(-2)
    4
    """
    return x * x

if __name__ == '__main__':
    import doctest
    doctest.testmod()
```

When running this module from the command line as in `python module.py`, the doctests will run and complain if anything is not behaving as described in the docstrings.

2.5.2 Tools

py.test

`py.test` is a no-boilerplate alternative to Python's standard `unittest` module.


```
$ pip install pytest
```

Despite being a fully-featured and extensible test tool, it boasts a simple syntax. Creating a test suite is as easy as writing a module with a couple of functions:

```
# content of test_sample.py
def func(x):
    return x + 1

def test_answer():
    assert func(3) == 5
```

and then running the `py.test` command

```
$ py.test
===== test session starts =====
platform darwin -- Python 2.7.1 -- pytest-2.2.1
collecting ... collected 1 items

test_sample.py F

===== FAILURES =====
_____ test_answer _____

    def test_answer():
>         assert func(3) == 5
E         assert 4 == 5
E         + where 4 = func(3)

test_sample.py:5: AssertionError
===== 1 failed in 0.02 seconds =====
```

is far less work than would be required for the equivalent functionality with the unittest module!

`py.test`

Nose

nose extends unittest to make testing easier.

```
$ pip install nose
```

nose provides automatic test discovery to save you the hassle of manually creating test suites. It also provides numerous plugins for features such as xUnit-compatible test output, coverage reporting, and test selection.

`nose`

tox

tox is a tool for automating test environment management and testing against multiple interpreter configurations

```
$ pip install tox
```

tox allows you to configure complicated multi-parameter test matrices via a simple ini-style configuration file.

`tox`

Unittest2

unittest2 is a backport of Python 2.7's unittest module which has an improved API and better assertions over the one available in previous versions of Python.

If you're using Python 2.6 or below, you can install it with pip

```
$ pip install unittest2
```

You may want to import the module under the name unittest to make porting code to newer versions of the module easier in the future

```
import unittest2 as unittest

class MyTest(unittest.TestCase):
    ...
```

This way if you ever switch to a newer Python version and no longer need the unittest2 module, you can simply change the import in your test module without the need to change any other code.

```
unittest2
```

mock

unittest.mock is a library for testing in Python. As of Python 3.3, it is available in the [standard library](#).

For older versions of Python:

```
$ pip install mock
```

It allows you to replace parts of your system under test with mock objects and make assertions about how they have been used.

For example, you can monkey-patch a method:

```
from mock import MagicMock
thing = ProductionClass()
thing.method = MagicMock(return_value=3)
thing.method(3, 4, 5, key='value')

thing.method.assert_called_with(3, 4, 5, key='value')
```

To mock classes or objects in a module under test, use the patch decorator. In the example below, an external search system is replaced with a mock that always returns the same result (but only for the duration of the test).

```
def mock_search(self):
    class MockSearchQuerySet(SearchQuerySet):
        def __iter__(self):
            return iter(["foo", "bar", "baz"])
    return MockSearchQuerySet()

# SearchForm here refers to the imported class reference in myapp,
# not where the SearchForm class itself is imported from
@mock.patch('myapp.SearchForm.search', mock_search)
def test_new_watchlist_activities(self):
    # get_search_results runs a search and iterates over the result
    self.assertEqual(len(myapp.get_search_results(q="fish")), 3)
```

Mock has many other ways you can configure it and control its behavior.

```
mock
```

2.6 Logging

The `logging` module has been a part of Python's Standard Library since version 2.3. It is succinctly described in [PEP 282](#). The documentation is notoriously hard to read, except for the [basic logging tutorial](#).

Logging serves two purposes:

- **Diagnostic logging** records events related to the application's operation. If a user calls in to report an error, for example, the logs can be searched for context.
- **Audit logging** records events for business analysis. A user's transactions can be extracted and combined with other user details for reports or to optimize a business goal.

2.6.1 ... or Print?

The only time that `print` is a better option than logging is when the goal is to display a help statement for a command line application. Other reasons why logging is better than `print`:

- The `log record`, which is created with every logging event, contains readily available diagnostic information such as the file name, full path, function, and line number of the logging event.
- Events logged in included modules are automatically accessible via the root logger to your application's logging stream, unless you filter them out.
- Logging can be selectively silenced by using the method `logging.Logger.setLevel()` or disabled by setting the attribute `logging.Logger.disabled` to `True`.

2.6.2 Logging in a Library

Notes for [configuring logging for a library](#) are in the [logging tutorial](#). Because the *user*, not the library, should dictate what happens when a logging event occurs, one admonition bears repeating:

Note: It is strongly advised that you do not add any handlers other than `NullHandler` to your library's loggers.

Best practice when instantiating loggers in a library is to only create them using the `__name__` global variable: the `logging` module creates a hierarchy of loggers using dot notation, so using `__name__` ensures no name collisions.

Here is an example of best practice from the [requests source](#) – place this in your `__init__.py`

```
# Set default logging handler to avoid "No handler found" warnings.
import logging
try: # Python 2.7+
    from logging import NullHandler
except ImportError:
    class NullHandler(logging.Handler):
        def emit(self, record):
            pass

logging.getLogger(__name__).addHandler(NullHandler())
```

2.6.3 Logging in an Application

The [twelve factor app](#), an authoritative reference for good practice in application development, contains a section on [logging best practice](#). It emphatically advocates for treating log events as an event stream, and for sending that event stream to standard output to be handled by the application environment.

There are at least three ways to configure a logger:

- **Using an INI-formatted file:**
 - **Pro:** possible to update configuration while running using the function `logging.config.listen()` to listen on a socket.
 - **Con:** less control (*e.g.* custom subclassed filters or loggers) than possible when configuring a logger in code.
- **Using a dictionary or a JSON-formatted file:**
 - **Pro:** in addition to updating while running, it is possible to load from a file using the `json` module, in the standard library since Python 2.6.
 - **Con:** less control than when configuring a logger in code.
- **Using code:**
 - **Pro:** complete control over the configuration.
 - **Con:** modifications require a change to source code.

Example Configuration via an INI File

Let us say the file is named `logging_config.ini`. More details for the file format are in the `logging` configuration section of the `logging` tutorial.

```
[loggers]
keys=root

[handlers]
keys=stream_handler

[formatters]
keys=formatter

[logger_root]
level=DEBUG
handlers=stream_handler

[handler_stream_handler]
class=StreamHandler
level=DEBUG
formatter=formatter
args=(sys.stderr,)

[formatter_formatter]
format=%(asctime)s %(name)-12s %(levelname)-8s %(message)s
```

Then use `logging.config.fileConfig()` in the code:

```
import logging
from logging.config import fileConfig

fileConfig('logging_config.ini')
logger = logging.getLogger()
logger.debug('often makes a very good meal of %s', 'visiting tourists')
```

Example Configuration via a Dictionary

As of Python 2.7, you can use a dictionary with configuration details. [PEP 391](#) contains a list of the mandatory and optional elements in the configuration dictionary.

```
import logging
from logging.config import dictConfig

logging_config = dict(
    version = 1,
    formatters = {
        'f': {'format':
              '%(asctime)s %(name)-12s %(levelname)-8s %(message)s'}
    },
    handlers = {
        'h': {'class': 'logging.StreamHandler',
              'formatter': 'f',
              'level': logging.DEBUG}
    },
    loggers = {
        'root': {'handlers': ['h'],
                 'level': logging.DEBUG}
    }
)

dictConfig(logging_config)

logger = logging.getLogger()
logger.debug('often makes a very good meal of %s', 'visiting tourists')
```

Example Configuration Directly in Code

```
import logging

logger = logging.getLogger()
handler = logging.StreamHandler()
formatter = logging.Formatter(
    '%(asctime)s %(name)-12s %(levelname)-8s %(message)s')
handler.setFormatter(formatter)
logger.addHandler(handler)
logger.setLevel(logging.DEBUG)

logger.debug('often makes a very good meal of %s', 'visiting tourists')
```

2.7 Common Gotchas

For the most part, Python aims to be a clean and consistent language that avoids surprises. However, there are a few cases that can be confusing to newcomers.

Some of these cases are intentional but can be potentially surprising. Some could arguably be considered language warts. In general though, what follows is a collection of potentially tricky behavior that might seem strange at first glance, but is generally sensible once you're aware of the underlying cause for the surprise.

2.7.1 Mutable Default Arguments

Seemingly the *most* common surprise new Python programmers encounter is Python’s treatment of mutable default arguments in function definitions.

What You Wrote

```
def append_to(element, to=[]):
    to.append(element)
    return to
```

What You Might Have Expected to Happen

```
my_list = append_to(12)
print my_list

my_other_list = append_to(42)
print my_other_list
```

A new list is created each time the function is called if a second argument isn’t provided, so that the output is:

```
[12]
[42]
```

What Does Happen

```
[12]
[12, 42]
```

A new list is created *once* when the function is defined, and the same list is used in each successive call.

Python’s default arguments are evaluated *once* when the function is defined, not each time the function is called (like it is in say, Ruby). This means that if you use a mutable default argument and mutate it, you *will* and have mutated that object for all future calls to the function as well.

What You Should Do Instead

Create a new object each time the function is called, by using a default arg to signal that no argument was provided (`None` is often a good choice).

```
def append_to(element, to=None):
    if to is None:
        to = []
    to.append(element)
    return to
```

When the Gotcha Isn’t a Gotcha

Sometimes you can specifically “exploit” (read: use as intended) this behavior to maintain state between calls of a function. This is often done when writing a caching function.

2.7.2 Late Binding Closures

Another common source of confusion is the way Python binds its variables in closures (or in the surrounding global scope).

What You Wrote

```
def create_multipliers():
    return [lambda x : i * x for i in range(5)]
```

What You Might Have Expected to Happen

```
for multiplier in create_multipliers():
    print multiplier(2)
```

A list containing five functions that each have their own closed-over `i` variable that multiplies their argument, producing:

```
0
2
4
6
8
```

What Does Happen

```
8
8
8
8
8
```

Five functions are created; instead all of them just multiply `x` by 4.

Python's closures are *late binding*. This means that the values of variables used in closures are looked up at the time the inner function is called.

Here, whenever *any* of the returned functions are called, the value of `i` is looked up in the surrounding scope at call time. By then, the loop has completed and `i` is left with its final value of 4.

What's particularly nasty about this gotcha is the seemingly prevalent misinformation that this has something to do with `lambdas` in Python. Functions created with a `lambda` expression are in no way special, and in fact the same exact behavior is exhibited by just using an ordinary `def`:

```
def create_multipliers():
    multipliers = []

    for i in range(5):
        def multiplier(x):
            return i * x
        multipliers.append(multiplier)

    return multipliers
```

What You Should Do Instead

The most general solution is arguably a bit of a hack. Due to Python's aforementioned behavior concerning evaluating default arguments to functions (see *Mutable Default Arguments*), you can create a closure that binds immediately to its arguments by using a default arg like so:

```
def create_multipliers():
    return [lambda x, i=i : i * x for i in range(5)]
```

Alternatively, you can use the `functools.partial` function:

```
from functools import partial
from operator import mul

def create_multipliers():
    return [partial(mul, i) for i in range(5)]
```

When the Gotcha Isn't a Gotcha

Sometimes you want your closures to behave this way. Late binding is good in lots of situations. Looping to create unique functions is unfortunately a case where they can cause hiccups.

2.8 Choosing a License

Your source publication *needs* a license. In the US, if no license is specified, users have no legal right to download, modify, or distribute. Furthermore, people can't contribute to your code unless you tell them what rules to play by. Choosing a license is complicated, so here are some pointers:

Open source. There are plenty of [open source licenses](#) available to choose from.

In general, these licenses tend to fall into one of two categories:

1. licenses that focus more on the user's freedom to do with the software as they please (these are the more permissive open source licenses such as the MIT, BSD, & Apache).
2. licenses that focus more on making sure that the code itself — including any changes made to it and distributed along with it — always remains free (these are the less permissive free software licenses such as the GPL and LGPL).

The latter are less permissive in the sense that they don't permit someone to add code to the software and distribute it without also including the source code for their changes.

To help you choose one for your project, there's a [license chooser](#), **use it**.

More Permissive

- PSFL (Python Software Foundation License) – for contributing to Python itself
- MIT / BSD / ISC
 - MIT (X11)
 - New BSD
 - ISC
- Apache

Less Permissive:

- LGPL
- GPL
 - GPLv2
 - GPLv3

A good overview of licenses with explanations of what one can, cannot, and must do using a particular software can be found at [tl;drLegal](#).

Scenario Guide

This part of the guide focuses on tool and module advice based on different scenarios.

3.1 Network Applications

3.1.1 HTTP

The Hypertext Transfer Protocol (HTTP) is an application protocol for distributed, collaborative, hypermedia information systems. HTTP is the foundation of data communication for the World Wide Web.

Requests

Python's standard `urllib2` module provides most of the HTTP capabilities you need, but the API is thoroughly broken. It was built for a different time — and a different web. It requires an enormous amount of work (even method overrides) to perform the simplest of tasks.

`Requests` takes all of the work out of Python HTTP — making your integration with web services seamless. There's no need to manually add query strings to your URLs, or to form-encode your POST data. Keep-alive and HTTP connection pooling are 100% automatic, powered by `urllib3`, which is embedded within `Requests`.

- [Documentation](#)
- [PyPi](#)
- [GitHub](#)

3.1.2 Distributed Systems

ZeroMQ

`ØMQ` (also spelled `ZeroMQ`, `0MQ` or `ZMQ`) is a high-performance asynchronous messaging library aimed at use in scalable distributed or concurrent applications. It provides a message queue, but unlike message-oriented middleware, a `ØMQ` system can run without a dedicated message broker. The library is designed to have a familiar socket-style API.

RabbitMQ

RabbitMQ is an open source message broker software that implements the Advanced Message Queuing Protocol (AMQP). The RabbitMQ server is written in the Erlang programming language and is built on the Open Telecom Platform framework for clustering and failover. Client libraries to interface with the broker are available for all major programming languages.

- [Homepage](#)
- [GitHub Organization](#)

3.2 Web Applications

As a powerful scripting language adapted to both fast prototyping and bigger projects, Python is widely used in web application development.

3.2.1 Context

WSGI

The Web Server Gateway Interface (or “WSGI” for short) is a standard interface between web servers and Python web application frameworks. By standardizing behavior and communication between web servers and Python web frameworks, WSGI makes it possible to write portable Python web code that can be deployed in any *WSGI-compliant web server*. WSGI is documented in [PEP 3333](#).

3.2.2 Frameworks

Broadly speaking, a web framework consists of a set of libraries and a main handler within which you can build custom code to implement a web application (i.e. an interactive web site). Most web frameworks include patterns and utilities to accomplish at least the following:

URL Routing Matches an incoming HTTP request to a particular piece of Python code to be invoked

Request and Response Objects Encapsulate the information received from or sent to a user’s browser

Template Engine Allows for separating Python code implementing an application’s logic from the HTML (or other) output that it produces

Development Web Server Runs an HTTP server on development machines to enable rapid development; often automatically reloads server-side code when files are updated

Django

Django is a “batteries included” web application framework. By providing many utilities and patterns out of the box, Django aims to make it possible to build complex, database-backed web applications quickly, while encouraging best practices in code written using it.

Django has a large and active community, and many pre-built [re-usable modules](#) that can be incorporated into a new project as-is, or customized to fit your needs.

There are annual Django conferences [in the United States](#) and [in Europe](#).

Flask

Flask is a “microframework” for Python. Rather than aiming to provide everything you could possibly need, Flask implements the most commonly-used core components of a web application framework, like URL routing, request and response objects, and templates. As a user of Flask, it is therefore up to you to choose and integrate other components you may need, such as database access or form generation and validation. For many popular modules, [Extensions](#) may already exist to suit your needs.

Support for flask can best be found in its mailing list. Just shoot an email to flask@librelist.com and reply to the confirmation email.

Werkzeug

Werkzeug is not actually a real framework, but rather a very powerful set of tools for building web applications. It provides URL routing utilities, request and response objects and a basic development server. It is mostly used where users need more flexibility for their application than is commonly found in other web frameworks.

Support can be found on its [mailing list](#).

Tornado

Tornado is a scalable, non-blocking web server and web application framework with a relative simple usage. Tornado is known for its high performance. It was initially developed for [friendfeed](#), a real time chat and blog system.

In the Jinja2 template engine example it is used to serve the rendered pages.

Pyramid

Pyramid lies somewhere between a big framework like Django and the microframeworks: It comes with a lot of libraries and functionality and can thus not be considered lightweight. On the other hand, it does not provide all the functionality Django does. Instead Pyramid brings basic support for most regular tasks and provides a great deal of extensibility. Additionally, Pyramid has a huge focus on complete [documentation](#). As a little extra it comes with the Werkzeug Debugger which allows you to debug a running web application in the browser.

Support can also be found in the [documentation](#).

3.2.3 Web Servers

Nginx

Nginx (pronounced “engine-x”) is a web server and reverse-proxy for HTTP, SMTP and other protocols. It is known for its high performance, relative simplicity, and compatibility with many application servers (like WSGI servers). It also includes handy features like load-balancing, basic authentication, streaming, and others. Designed to serve high-load websites, Nginx is gradually becoming quite popular.

3.2.4 WSGI Servers

Stand-alone WSGI servers typically use less resources than traditional web servers and provide top performance ¹.

¹ Benchmark of Python WSGI Servers

Gunicorn

Gunicorn (Green Unicorn) is a WSGI server used to serve Python applications. It is a Python interpretation of the Ruby **Unicorn** server. Unicorn is designed to be lightweight, easy to use, and uses many UNIX idioms. Gunicorn is not designed to face the internet – it was designed to run behind Nginx which buffers slow requests and takes care of other important considerations. A sample setup for Nginx + Gunicorn can be found in the [Gunicorn help](#).

uWSGI

uWSGI is a full stack for building hosting services. In addition to process management, process monitoring, and other functionality, uWSGI acts as an application server for various programming languages and protocols - including Python and WSGI. uWSGI can either be run as a stand-alone web router, or be run behind a full web server (such as Nginx or Apache). In the latter case, a web server can configure uWSGI and an application's operation over the `uwsgi` protocol. uWSGI's web server support allows for dynamically configuring Python, passing environment variables and further tuning. For full details, see [uWSGI magic variables](#).

3.2.5 Server Best Practices

The majority of self-hosted Python applications today are hosted with a WSGI server such as *Gunicorn*, either directly or behind a lightweight web server such as *nginx*.

The WSGI servers serve the Python applications while the web server handles tasks better suited for it such as static file serving, request routing, DDoS protection, and basic authentication.

3.2.6 Hosting

Platform-as-a-Service

Platform-as-a-Service (PaaS) is a type of cloud computing infrastructure which abstracts and manages infrastructure, routing, and scaling of web applications. When using a PaaS, application developers can focus on writing application code rather than needing to be concerned with deployment details.

Most PaaS services offer a command-line interface that developers can use to set up and interrogate configuration, and to deploy new releases of an application to the service.

PaaS services and their partners offer add-on functionality which is well integrated into the platform, such as database hosting, email services, logging, scheduled and background tasks, billing and payment, etc.

Heroku

Heroku's [Cedar stack](#) offers first class support for Python 2.7 applications.

Heroku allows you to run as many Python web applications as you like, 24/7 and free of charge. Heroku is best described as a horizontal scaling platform. They start to charge you once you “scale” your application to run on more than one Dyno (abstracted servers) at a time.

Heroku maintains [articles](#) on using Python with Heroku as well as [step-by-step instructions](#) on how to set up your first application.

DotCloud

DotCloud supports WSGI applications and background/worker tasks natively on their platform. Web applications run Python version 2.6, use *nginx* and *uWSGI*, and allow custom configuration of both for advanced users.

DotCloud uses a custom command-line API client which can work with applications managed in git repositories or any other version control system.

DotCloud has a free plan with limited database size, and without extra services (caching...).

See the [DotCloud documentation on Python](#) for more information and help getting started.

Gondor

Gondor is a PaaS specialized for deploying Django and Pinax applications. Gondor recommends Django version 1.6 and supports any WSGI application on Python version 2.7. Gondor can automatically configure your Django site if you use `local_settings.py` for site-specific configuration information.

Gondor has a guide on deploying [Django projects](#).

3.2.7 Templating

Most WSGI applications are responding to HTTP requests to serve content in HTML or other markup languages. Instead of generating directly textual content from Python, the concept of separation of concerns advises us to use templates. A template engine manages a suite of template files, with a system of hierarchy and inclusion to avoid unnecessary repetition, and is in charge of rendering (generating) the actual content, filling the static content of the templates with the dynamic content generated by the application.

As template files are sometimes written by designers or front-end developers, it can be difficult to handle increasing complexity.

Some general good practices apply to the part of the application passing dynamic content to the template engine, and to the templates themselves.

- Template files should be passed only the dynamic content that is needed for rendering the template. Avoid the temptation to pass additional content “just in case”: it is easier to add some missing variable when needed than to remove a likely unused variable later.
- Many template engines allow for complex statements or assignments in the template itself, and many allow some Python code to be evaluated in the templates. This convenience can lead to uncontrolled increase in complexity, and often make it harder to find bugs.
- It is often necessary to mix JavaScript templates with HTML templates. A sane approach to this design is to isolate the parts where the HTML template passes some variable content to the JavaScript code.

Jinja2

Jinja2 is a template engine which is similar to the Django template system with some extra features. It is a text-based template language and thus can be used to generate any markup. It allows customization of filters, tags, tests and globals, and unlike the template system implemented in the Django Framework, also allows calling functions. Jinja2 is released under the BSD license.

Here some important html tags in Jinja2:

```
{# This is a comment #}

{# The next tag is a variable output: #}
{{title}}

{# Tag for a block, can be replaced through inheritance with other html code #}
{% block head %}
<h1>This is the head!</h1>
{% endblock %}

{# Output of an array as an iteration #}
{% for item in list %}
<li>{{ item }}</li>
{% endfor %}
```

The next listings is an example of a web site in combination with the Tornado web server. Tornado is not very complicated to use.

```
# import Jinja2
from jinja2 import Environment, FileSystemLoader

# import Tornado
import tornado.ioloop
import tornado.web

# Load template file templates/site.html
TEMPLATE_FILE = "site.html"
templateLoader = FileSystemLoader( searchpath="templates/" )
templateEnv = Environment( loader=templateLoader )
template = templateEnv.get_template(TEMPLATE_FILE)

# List for famous movie rendering
movie_list = [[1,"The Hitchhiker's Guide to the Galaxy"],[2,"Back to future"],[3,"Matrix"]]

# template.render() returns a string which contains the rendered html
html_output = template.render(list=movie_list,
                             title="Here is my favorite movie list")

# Handler for main page
class MainHandler(tornado.web.RequestHandler):
    def get(self):
        # Returns rendered template string to the browser request
        self.write(html_output)

# Assign handler to the server root (127.0.0.1:PORT/)
application = tornado.web.Application([
    (r"/", MainHandler),
])
PORT=8884
if __name__ == "__main__":
    # Setup the server
    application.listen(PORT)
    tornado.ioloop.IOLoop.instance().start()
```

The base.html file can be used as base for all site pages which are for example implemented in the content block.

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN">
<html lang="en">
<html xmlns="http://www.w3.org/1999/xhtml">
```



```

<head>
  <link rel="stylesheet" href="style.css" />
  <title>{{title}} - My Webpage</title>
</head>
<body>
<div id="content">
  {# In the next line the content from the site.html template will be added #}
  {% block content %}{% endblock %}
</div>
<div id="footer">
  {% block footer %}
  &copy; Copyright 2013 by <a href="http://domain.invalid/">you</a>.
  {% endblock %}
</div>
</body>

```

The next listing is our site page (`site.html`) loaded in the Python app which extends `base.html`. The content block is automatically set into the corresponding block in the `base.html` page.

```

<{% extends "base.html" %}
{% block content %}
  <p class="important">
    <div id="content">
      <h2>{{title}}</h2>
      <p>{{ list_title }}</p>
      <ul>
        {% for item in list %}
        <li>{{ item[0] }} : {{ item[1] }}</li>
        {% endfor %}
      </ul>
    </div>
  </p>
{% endblock %}

```

Chameleon

Chameleon Page Templates are an HTML/XML template engine implementation of the Template Attribute Language (TAL), TAL Expression Syntax (TALES), and Macro Expansion TAL (Metal) syntaxes.

Chameleon is available for Python 2.5 and up (including 3.x and pypy), and is commonly used by the Pyramid Framework.

Page Templates add within your document structure special element attributes and text markup. Using a set of simple language constructs, you control the document flow, element repetition, text replacement and translation. Because of the attribute-based syntax, unrendered page templates are valid HTML and can be viewed in a browser and even edited in WYSIWYG editors. This can make round-trip collaboration with designers and prototyping with static files in a browser easier.

The basic TAL language is simple enough to grasp from an example:

```

<html>
  <body>
    <h1>Hello, <span tal:replace="context.name">World</span>!</h1>
    <table>
      <tr tal:repeat="row 'apple', 'banana', 'pineapple'">
        <td tal:repeat="col 'juice', 'muffin', 'pie'">
          <span tal:replace="row.capitalize()" /> <span tal:replace="col" />
        </td>
      </tr>
    </table>
  </body>
</html>

```

```
</tr>
</table>
</body>
</html>
```

The `` pattern for text insertion is common enough that if you do not require strict validity in your unrendered templates, you can replace it with a more terse and readable syntax that uses the pattern `#{expression}`, as follows:

```
<html>
<body>
  <h1>Hello, #{world}!</h1>
  <table>
    <tr tal:repeat="row 'apple', 'banana', 'pineapple'">
      <td tal:repeat="col 'juice', 'muffin', 'pie'">
        ${row.capitalize()} ${col}
      </td>
    </tr>
  </table>
</body>
</html>
```

But keep in mind that the full `Default Text` syntax also allows for default content in the unrendered template.

References

3.3 HTML Scraping

3.3.1 Web Scraping

Web sites are written using HTML, which means that each web page is a structured document. Sometimes it would be great to obtain some data from them and preserve the structure while we're at it. Web sites don't always provide their data in comfortable formats such as `csv` or `json`.

This is where web scraping comes in. Web scraping is the practice of using a computer program to sift through a web page and gather the data that you need in a format most useful to you while at the same time preserving the structure of the data.

3.3.2 lxml and Requests

`lxml` is a pretty extensive library written for parsing XML and HTML documents very quickly, even handling messed up tags in the process. We will also be using the `Requests` module instead of the already built-in `urllib2` module due to improvements in speed and readability. You can easily install both using `pip install lxml` and `pip install requests`.

Let's start with the imports:

```
from lxml import html
import requests
```

Next we will use `requests.get` to retrieve the web page with our data, parse it using the `html` module and save the results in `tree`:

```
page = requests.get('http://econpy.pythonanywhere.com/ex/001.html')
tree = html.fromstring(page.text)
```

tree now contains the whole HTML file in a nice tree structure which we can go over two different ways: XPath and CSSSelect. In this example, we will focus on the former.

XPath is a way of locating information in structured documents such as HTML or XML documents. A good introduction to XPath is on [W3Schools](#).

There are also various tools for obtaining the XPath of elements such as FireBug for Firefox or the Chrome Inspector. If you're using Chrome, you can right click an element, choose 'Inspect element', highlight the code, right click again and choose 'Copy XPath'.

After a quick analysis, we see that in our page the data is contained in two elements - one is a div with title 'buyer-name' and the other is a span with class 'item-price':

```
<div title="buyer-name">Carson Busses</div>
<span class="item-price">$29.95</span>
```

Knowing this we can create the correct XPath query and use the lxml xpath function like this:

```
#This will create a list of buyers:
buyers = tree.xpath('//div[@title="buyer-name"]/text()')
#This will create a list of prices
prices = tree.xpath('//span[@class="item-price"]/text()')
```

Let's see what we got exactly:

```
print 'Buyers: ', buyers
print 'Prices: ', prices
```

```
Buyers: ['Carson Busses', 'Earl E. Byrd', 'Patty Cakes',
'Derri Anne Connecticut', 'Moe Dess', 'Leda Doggslife', 'Dan Druff',
'Al Fresco', 'Ido Hoe', 'Howie Kisses', 'Len Lease', 'Phil Meup',
'Ira Pent', 'Ben D. Rules', 'Ave Sectomy', 'Gary Shattire',
'Bobbi Soks', 'Sheila Takya', 'Rose Tattoo', 'Moe Tell']

Prices: ['$29.95', '$8.37', '$15.26', '$19.25', '$19.25',
'$13.99', '$31.57', '$8.49', '$14.47', '$15.86', '$11.11',
'$15.98', '$16.27', '$7.50', '$50.85', '$14.26', '$5.68',
'$15.00', '$114.07', '$10.09']
```

Congratulations! We have successfully scraped all the data we wanted from a web page using lxml and Requests. We have it stored in memory as two lists. Now we can do all sorts of cool stuff with it: we can analyze it using Python or we can save it to a file and share it with the world.

Some more cool ideas to think about are modifying this script to iterate through the rest of the pages of this example dataset, or rewriting this application to use threads for improved speed.

3.4 Command-line Applications

Command-line applications, also referred to as [Console Applications](#), are computer programs designed to be used from a text interface, such as a [shell](#). Command-line applications usually accept various inputs as arguments, often referred to as parameters or sub-commands, as well as options, often referred to as flags or switches.

Some popular command-line applications include:

- [Grep](#) - A plain-text data search utility

- `curl` - A tool for data transfer with URL syntax
- `httplib` - A command line HTTP client, a user-friendly cURL replacement
- `git` - A distributed version control system
- `mercurial` - A distributed version control system primarily written in Python

3.4.1 Clint

`clint` is a Python module which is filled with very useful tools for developing command-line applications. It supports features such as; CLI colors and indents, simple and powerful column printer, iterator based progress bars and implicit argument handling.

3.4.2 Click

`click` is an upcoming Python package for creating command-line interfaces in a composable way with as little code as possible. This “Command-line Interface Creation Kit” is highly configurable but comes with good defaults out of the box.

3.4.3 docopt

`docopt` is a lightweight, highly Pythonic package that allows creating command-line interfaces easily and intuitively, by parsing POSIX-style usage instructions.

3.4.4 Plac

`Plac` is a simple wrapper over the Python standard library `argparse`, which hides most of its complexity by using a declarative interface: the argument parser is inferred rather than written down by imperatively. This module targets especially unsophisticated users, programmers, sys-admins, scientists and in general people writing throw-away scripts for themselves, who choose to create a command-line interface because it is quick and simple.

3.4.5 Cliff

`Cliff` is a framework for building command-line programs. It uses `setuptools` entry points to provide subcommands, output formatters, and other extensions. The framework is meant to be used to create multi-level commands such as `subversion` and `git`, where the main program handles some basic argument parsing and then invokes a sub-command to do the work.

3.5 GUI Applications

Alphabetical list of GUI Applications.

3.5.1 Camelot

`Camelot` provides components for building applications on top of Python, `SQLAlchemy` and `Qt`. It is inspired by the Django admin interface.

The main resource for information is the website: <http://www.python-camelot.com> and the mailing list <https://groups.google.com/forum/#!forum/project-camelot>

3.5.2 Cocoa

Note: The Cocoa framework is only available on OS X. Don't pick this if you're writing a cross-platform application!

3.5.3 GTK

PyGTK provides Python bindings for the GTK+ toolkit. Like the GTK+ library itself, it is currently licensed under the GNU LGPL. It is worth noting that PyGTK only currently supports the Gtk-2.X API (NOT Gtk-3.0). It is currently recommended that PyGTK not be used for new projects and that existing applications be ported from PyGTK to PyGObject.

3.5.4 Kivy

Kivy is a Python library for development of multi-touch enabled media rich applications. The aim is to allow for quick and easy interaction design and rapid prototyping, while making your code reusable and deployable.

Kivy is written in Python, based on OpenGL and supports different input devices such as: Mouse, Dual Mouse, TUIO, WiiMote, WM_TOUCH, HIDtouch, Apple's products and so on.

Kivy is actively being developed by a community and is free to use. It operates on all major platforms (Linux, OSX, Windows, Android).

The main resource for information is the website: <http://kivy.org>

3.5.5 PyObjC

Note: Only available on OS X. Don't pick this if you're writing a cross-platform application.

3.5.6 PySide

PySide is a Python binding of the cross-platform GUI toolkit Qt.

<http://developer.qt.nokia.com/wiki/PySideDownloads/>

3.5.7 PyQt

Note: If your software does not fully comply with the GPL you will need a commercial license!

PyQt provides Python bindings for the Qt Framework (see below).

<http://www.riverbankcomputing.co.uk/software/pyqt/download>

3.5.8 PyjamasDesktop (pyjs Desktop)

PyjamasDesktop is a port of Pyjamas. PyjamasDesktop is application widget set for desktop and a cross-platform framework. (After release v0.6 PyjamasDesktop is a part of Pyjamas (Pyjs)). Briefly, it allows the exact same Python web application source code to be executed as a standalone desktop application.

[Python Wiki for PyjamasDesktop](#).

The main website; [pyjs Desktop](#).

3.5.9 Qt

Qt is a cross-platform application framework that is widely used for developing software with a GUI but can also be used for non-GUI applications.

3.5.10 Tk

Tkinter is a thin object-oriented layer on top of Tcl/Tk. **It has the advantage of being included with the Python standard library, making it the most convenient and compatible toolkit to program with.**

Both Tk and Tkinter are available on most Unix platforms, as well as on Windows and Macintosh systems. Starting with the 8.0 release, Tk offers native look and feel on all platforms.

There's a good multi-language Tk tutorial with Python examples at [TkDocs](#). There's more information available on the [Python Wiki](#).

3.5.11 wxPython

wxPython is a GUI toolkit for the Python programming language. It allows Python programmers to create programs with a robust, highly functional graphical user interface, simply and easily. It is implemented as a Python extension module (native code) that wraps the popular wxWidgets cross platform GUI library, which is written in C++.

Install (Stable) wxPython go to <http://www.wxpython.org/download.php#stable> and download the appropriate package for your OS.

3.6 Databases

3.6.1 DB-API

The Python Database API (DB-API) defines a standard interface for Python database access modules. It's documented in [PEP 249](#). Nearly all Python database modules such as *sqlite3*, *psycopy* and *mysql-python* conform to this interface.

Tutorials that explain how to work with modules that conform to this interface can be found [here](#) and [here](#).

3.6.2 SQLAlchemy

SQLAlchemy is a commonly used database toolkit. Unlike many database libraries it not only provides an ORM layer but also a generalized API for writing database-agnostic code without SQL.

```
$ pip install sqlalchemy
```

3.6.3 Django ORM

The Django ORM is the interface used by [Django](#) to provide database access.

It's based on the idea of [models](#), an abstraction that makes it easier to manipulate data in Python.

The basics:

- Each model is a Python class that subclasses `django.db.models.Model`.
- Each attribute of the model represents a database field.
- Django gives you an automatically-generated database-access API; see [Making queries](#).

3.6.4 peewee

[peewee](#) is another ORM with a focus on being lightweight with support for Python 2.6+ and 3.2+ which supports SQLite, MySQL and Postgres by default. The [model layer](#) is similar to that of the Django ORM and it has [SQL-like methods](#) to query data. While SQLite, MySQL and Postgres are supported out-of-the-box, there is a [collection of add-ons](#) available.

3.6.5 PonyORM

[PonyORM](#) is an ORM that takes a different approach to querying the database. Instead of writing an SQL-like language or boolean expressions, Python's generator syntax is used. There's also a graphical schema editor that can generate PonyORM entities for you. It supports Python 2.6+ and Python 3.3+ and can connect to SQLite, MySQL, Postgres & Oracle

3.6.6 SQLAlchemy

[SQLAlchemy](#) is yet another ORM. It supports a wide variety of databases: Common database systems MySQL, Postgres and SQLite and more exotic systems like SAP DB, SyBase and MSSQL. It only supports Python 2 from Python 2.6 upwards.

3.7 Networking

3.7.1 Twisted

[Twisted](#) is an event-driven networking engine. It can be used to build applications around many different networking protocols, including http servers and clients, applications using SMTP, POP3, IMAP or SSH protocols, instant messaging and [much more](#).

3.7.2 PyZMQ

[PyZMQ](#) is the Python binding for [ZeroMQ](#), which is a high-performance asynchronous messaging library. One great advantage of ZeroMQ is that it can be used for message queuing without a message broker. The basic patterns for this are:

- request-reply: connects a set of clients to a set of services. This is a remote procedure call and task distribution pattern.
- publish-subscribe: connects a set of publishers to a set of subscribers. This is a data distribution pattern.

- push-pull (or pipeline): connects nodes in a fan-out / fan-in pattern that can have multiple steps, and loops. This is a parallel task distribution and collection pattern.

For a quick start, read the [ZeroMQ guide](#).

3.7.3 gevent

[gevent](#) is a coroutine-based Python networking library that uses greenlets to provide a high-level synchronous API on top of the libev event loop.

3.8 Systems Administration

3.8.1 Fabric

[Fabric](#) is a library for simplifying system administration tasks. While Chef and Puppet tend to focus on managing servers and system libraries, Fabric is more focused on application level tasks such as deployment.

Install Fabric:

```
$ pip install fabric
```

The following code will create two tasks that we can use: `memory_usage` and `deploy`. The former will output the memory usage on each machine. The latter will ssh into each server, `cd` to our project directory, activate the virtual environment, pull the newest codebase, and restart the application server.

```
from fabric.api import cd, env, prefix, run, task

env.hosts = ['my_server1', 'my_server2']

@task
def memory_usage():
    run('free -m')

@task
def deploy():
    with cd('/var/www/project-env/project'):
        with prefix('. ../bin/activate'):
            run('git pull')
            run('touch app.wsgi')
```

With the previous code saved in a file named `fabfile.py`, we can check memory usage with:

```
$ fab memory_usage
[my_server1] Executing task 'memory'
[my_server1] run: free -m
[my_server1] out:
              total      used      free   shared  buffers   cached
[my_server1] out: Mem:          6964      1897      5067         0        166        222
[my_server1] out: -/+ buffers/cache:      1509      5455
[my_server1] out: Swap:           0         0         0

[my_server2] Executing task 'memory'
[my_server2] run: free -m
[my_server2] out:
              total      used      free   shared  buffers   cached
[my_server2] out: Mem:          1666         902         764         0         180         572
[my_server2] out: -/+ buffers/cache:         148      1517
[my_server2] out: Swap:           895         1         894
```


and we can deploy with:

```
$ fab deploy
```

Additional features include parallel execution, interaction with remote programs, and host grouping.

[Fabric Documentation](#)

3.8.2 Salt

Salt is an open source infrastructure management tool. It supports remote command execution from a central point (master host) to multiple hosts (minions). It also supports system states which can be used to configure multiple servers using simple template files.

Salt supports Python versions 2.6 and 2.7 and can be installed via pip:

```
$ pip install salt
```

After configuring a master server and any number of minion hosts, we can run arbitrary shell commands or use pre-built modules of complex commands on our minions.

The following command lists all available minion hosts, using the ping module.

```
$ salt '*' test.ping
```

The host filtering is accomplished by matching the minion id, or using the grains system. The [grains](#) system uses static host information like the operating system version or the CPU architecture to provide a host taxonomy for the Salt modules.

The following command lists all available minions running CentOS using the grains system:

```
$ salt -G 'os:CentOS' test.ping
```

Salt also provides a state system. States can be used to configure the minion hosts.

For example, when a minion host is ordered to read the following state file, it will install and start the Apache server:

```
apache:
  pkg:
    - installed
  service:
    - running
    - enable: True
    - require:
      - pkg: apache
```

State files can be written using YAML, the Jinja2 template system or pure Python.

[Salt Documentation](#)

3.8.3 Psutil

Psutil is an interface to different system information (e.g. CPU, memory, disks, network, users and processes).

Here is an example to be aware of some server overload. If any of the tests (net, CPU) fail, it will send an email.

```
# Functions to get system values:
from psutil import cpu_percent, net_io_counters
# Functions to take a break:
from time import sleep
```

```

# Package for email services:
import smtplib
import string
MAX_NET_USAGE = 400000
MAX_ATTACKS = 4
attack = 0
counter = 0
while attack <= MAX_ATTACKS:
    sleep(4)
    counter = counter + 1
    # Check the cpu usage
    if cpu_percent(interval = 1) > 70:
        attack = attack + 1
    # Check the net usage
    neti1 = net_io_counters()[1]
    neto1 = net_io_counters()[0]
    sleep(1)
    neti2 = net_io_counters()[1]
    neto2 = net_io_counters()[0]
    # Calculate the bytes per second
    net = ((neti2+neto2) - (neti1+neto1))/2
    if net > MAX_NET_USAGE:
        attack = attack + 1
    if counter > 25:
        attack = 0
        counter = 0
# Write a very important email if attack is higher than 4
TO = "you@your_email.com"
FROM = "webmaster@your_domain.com"
SUBJECT = "Your domain is out of system resources!"
text = "Go and fix your server!"
BODY = string.join(("From: %s" %FROM, "To: %s" %TO, "Subject: %s" %SUBJECT, "",text), "\r\n")
server = smtplib.SMTP('127.0.0.1')
server.sendmail(FROM, [TO], BODY)
server.quit()

```

A full terminal application like a widely extended top which is based on psutil and with the ability of a client-server monitoring is [glance](#).

3.8.4 Ansible

[Ansible](#) is an open source system automation tool. The biggest advantage over Puppet or Chef is it does not require an agent on the client machine. Playbooks are Ansible's configuration, deployment, and orchestration language and are written in in YAML with Jinja2 for templating.

Ansible supports Python versions 2.6 and 2.7 and can be installed via pip:

```
$ pip install ansible
```

Ansible requires an inventory file that describes the hosts to which it has access. Below is an example of a host and playbook that will ping all the hosts in the inventory file.

Here is an example inventory file: `hosts.yml`

```
[server_name]
127.0.0.1
```

Here is an example playbook: `ping.yml`

```

---
- hosts: all

  tasks:
    - name: ping
      action: ping

```

To run the playbook:

```
$ ansible-playbook ping.yml -i hosts.yml --ask-pass
```

The Ansible playbook will ping all of the servers in the `hosts.yml` file. You can also select groups of servers using Ansible. For more information about Ansible, read the [Ansible Docs](#).

3.8.5 Chef

Todo

Write about Chef

[Chef Documentation](#)

3.8.6 Puppet

Puppet is IT Automation and configuration management software from Puppet Labs that allows System Administrators to define the state of their IT Infrastructure, thereby providing an elegant way to manage their fleet of physical and virtual machines.

Puppet is available both as an Open Source and an Enterprise variant. Modules are small, shareable units of code written to automate or define the state of a system. [Puppet Forge](#) is a repository for modules written by the community for Open Source and Enterprise Puppet.

Puppet Agents are installed on nodes whose state needs to be monitored or changed. A designated server known as the Puppet Master is responsible for orchestrating the agent nodes.

Agent nodes send basic facts about the system such as to the operating system, kernel, architecture, ip address, host-name etc. to the Puppet Master. The Puppet Master then compiles a catalog with information provided by the agents on how each node should be configured and sends it to the agent. The agent enforces the change as prescribed in the catalog and sends a report back to the Puppet Master.

Facter is an interesting tool that ships with Puppet that pulls basic facts about the system. These facts can be referenced as a variable while writing your Puppet modules.

```
$ facter kernel
Linux
```

```
$ facter operatingsystem
Ubuntu
```

Writing Modules in Puppet is pretty straight forward. Puppet Manifests together form Puppet Modules. Puppet manifest end with an extension of `.pp`. Here is an example of 'Hello World' in Puppet.

```

notify { 'This message is getting logged into the agent node':
  #As nothing is specified in the body the resource title
  #the notification message by default.
}

```

Here is another example with system based logic. Note how the `operatingsystem` fact is being used as a variable prepended with the `$` sign. Similarly, this holds true for other facts such as `hostname` which can be referenced by `$hostname`

```
notify{ 'Mac Warning':
  message => $operatingsystem ? {
    'Darwin' => 'This seems to be a Mac.',
    default  => 'I am a PC.',
  },
}
```

There are several resource types for Puppet but the package-file-service paradigm is all you need for undertaking majority of the configuration management. The following Puppet code makes sure that the OpenSSH-Server package is installed in a system and the `sshd` service is notified to restart everytime the `sshd` configuration file is changed.

```
package { 'openssh-server':
  ensure => installed,
}

file { ['/etc/ssh/sshd_config':
  source  => 'puppet:///modules/sshd/sshd_config',
  owner   => 'root',
  group   => 'root',
  mode    => '640',
  notify  => Service['sshd'], # sshd will restart
                                     # whenever you edit this
                                     # file
  require => Package['openssh-server'],
}

service { 'sshd':
  ensure    => running,
  enable    => true,
  hasstatus => true,
  hasrestart=> true,
}
```

For more information, refer to the [Puppet Labs Documentation](#)

3.8.7 Blueprint

Todo

Write about Blueprint

3.8.8 Buildout

Todo

Write about Buildout

[Buildout Website](#)

3.9 Continuous Integration

3.9.1 Why?

Martin Fowler, who first wrote about [Continuous Integration](#) (short: CI) together with Kent Beck, describes the CI as follows:

Continuous Integration is a software development practice where members of a team integrate their work frequently, usually each person integrates at least daily - leading to multiple integrations per day. Each integration is verified by an automated build (including test) to detect integration errors as quickly as possible. Many teams find that this approach leads to significantly reduced integration problems and allows a team to develop cohesive software more rapidly.

3.9.2 Jenkins

Jenkins CI is an extensible continuous integration engine. Use it.

3.9.3 Buildbot

Buildbot is a Python system to automate the compile/test cycle to validate code changes.

3.9.4 Mule

Mule is a lightweight integration platform that enables you to connect anything, anywhere. You can use Mule to intelligently manage message routing, data mapping, orchestration, reliability, security and scalability between nodes. Plug other systems and applications into Mule and let it handle all the communication between systems, enabling you to track and monitor everything that happens.

3.9.5 Tox

tox is an automation tool providing packaging, testing and deployment of Python software right from the console or CI server. It is a generic virtualenv management and test command line tool which provides the following features:

- Checking that packages install correctly with different Python versions and interpreters
- Running tests in each of the environments, configuring your test tool of choice
- Acting as a front-end to Continuous Integration servers, reducing boilerplate and merging CI and shell-based testing.

3.9.6 Travis-CI

Travis-CI is a distributed CI server which builds tests for open source projects for free. It provides multiple workers to run Python tests on and seamlessly integrates with GitHub. You can even have it comment on your Pull Requests whether this particular changeset breaks the build or not. So if you are hosting your code on GitHub, travis-ci is a great and easy way to get started with Continuous Integration.

In order to get started, add a `.travis.yml` file to your repository with this example content:

```
language: python
python:
  - "2.6"
  - "2.7"
  - "3.2"
  - "3.3"
# command to install dependencies
script: python tests/test_all_of_the_units.py
branches:
  only:
    - master
```

This will get your project tested on all the listed Python versions by running the given script, and will only build the master branch. There are a lot more options you can enable, like notifications, before and after steps and much more. The [travis-ci docs](#) explain all of these options, and are very thorough.

In order to activate testing for your project, go to the [travis-ci site](#) and login with your GitHub account. Then activate your project in your profile settings and you're ready to go. From now on, your project's tests will be run on every push to GitHub.

3.10 Speed

CPython, the most commonly used implementation of Python, is slow for CPU bound tasks. PyPy is fast.

Using a slightly modified version of [David Beazleys CPU bound test code](#) (added loop for multiple tests), you can see the difference between CPython and PyPy's processing.

```
# PyPy
$ ./pypy -V
Python 2.7.1 (7773f8fc4223, Nov 18 2011, 18:47:10)
[PyPy 1.7.0 with GCC 4.4.3]
$ ./pypy measure2.py
0.0683999061584
0.0483210086823
0.0388588905334
0.0440690517426
0.0695300102234
```

```
# CPython
$ ./python -V
Python 2.7.1
$ ./python measure2.py
1.06774401665
1.45412397385
1.51485204697
1.54693889618
1.60109114647
```

3.10.1 Context

The GIL

The **GIL** (Global Interpreter Lock) is how Python allows multiple threads to operate at the same time. Python's memory management isn't entirely thread-safe, so the GIL is required to prevent multiple threads from running the same Python code at once.

David Beazley has a [great guide](#) on how the GIL operates. He also covers the [new GIL](#) in Python 3.2. His results show that maximizing performance in a Python application requires a strong understanding of the GIL, how it affects your specific application, how many cores you have, and where your application bottlenecks are.

C Extensions

The GIL

Special care must be taken when writing C extensions to make sure you register your threads with the interpreter.

3.10.2 C Extensions

Cython

Cython implements a superset of the Python language with which you are able to write C and C++ modules for Python. Cython also allows you to call functions from compiled C libraries. Using Cython allows you to take advantage of Python's strong typing of variables and operations.

Here's an example of strong typing with Cython:

```
def primes(int kmax):
    """Calculation of prime numbers with additional
    Cython keywords"""

    cdef int n, k, i
    cdef int p[1000]
    result = []
    if kmax > 1000:
        kmax = 1000
    k = 0
    n = 2
    while k < kmax:
        i = 0
        while i < k and n % p[i] != 0:
            i = i + 1
        if i == k:
            p[k] = n
            k = k + 1
            result.append(n)
        n = n + 1
    return result
```

This implementation of an algorithm to find prime numbers has some additional keywords compared to the next one, which is implemented in pure Python:

```
def primes(kmax):
    """Calculation of prime numbers in standard Python syntax"""

    p= range(1000)
    result = []
    if kmax > 1000:
        kmax = 1000
    k = 0
    n = 2
    while k < kmax:
        i = 0
```

```

while i < k and n % p[i] != 0:
    i = i + 1
if i == k:
    p[k] = n
    k = k + 1
    result.append(n)
n = n + 1
return result

```

Notice that in the Cython version you declare integers and integer arrays to be compiled into C types while also creating a Python list:

```

def primes(int kmax):
    """Calculation of prime numbers with additional
    Cython keywords"""

    cdef int n, k, i
    cdef int p[1000]
    result = []

```

```

def primes(kmax):
    """Calculation of prime numbers in standard Python syntax"""

    p= range(1000)
    result = []

```

What is the difference? In the upper Cython version you can see the declaration of the variable types and the integer array in a similar way as in standard C. For example `cdef int n,k,i` in line 3. This additional type declaration (i.e. integer) allows the Cython compiler to generate more efficient C code from the second version. While standard Python code is saved in `*.py` files, Cython code is saved in `*.pyx` files.

What's the difference in speed? Let's try it!

```

import time
#activate pyx compiler
import pyximport
pyximport.install()
#primes implemented with Cython
import primesCy
#primes implemented with Python
import primes

print "Cython:"
t1= time.time()
print primesCy.primes(500)
t2= time.time()
print "Cython time: %s" %(t2-t1)
print ""
print "Python"
t1= time.time()
print primes.primes(500)
t2= time.time()
print "Python time: %s" %(t2-t1)

```

These lines both need a remark:

```

import pyximport
pyximport.install()

```


The `pyximport` module allows you to import `*.pyx` files (e.g., `primesCy.pyx`) with the Cython-compiled version of the `primes` function. The `pyximport.install()` command allows the Python interpreter to start the Cython compiler directly to generate C-code, which is automatically compiled to a `*.so` C-library. Cython is then able to import this library for you in your Python code, easily and efficiently. With the `time.time()` function you are able to compare the time between these 2 different calls to find 500 prime numbers. On a standard notebook (dual core AMD E-450 1.6 GHz), the measured values are:

```
Cython time: 0.0054 seconds
Python time: 0.0566 seconds
```

And here the output of an embedded [ARM beaglebone](#) machine:

```
Cython time: 0.0196 seconds
Python time: 0.3302 seconds
```

Pyrex

Shedskin?

Numba

Todo

Write about Numba and the autojit compiler for NumPy

3.10.3 Threading

Threading

Spawning Processes

Multiprocessing

3.11 Scientific Applications

3.11.1 Context

Python is frequently used for high-performance scientific applications. It is widely used in academia and scientific projects because it is easy to write and performs well.

Due to its high performance nature, scientific computing in Python often utilizes external libraries, typically written in faster languages (like C, or FORTRAN for matrix operations). The main libraries used are [NumPy](#), [SciPy](#) and [Matplotlib](#). Going into detail about these libraries is beyond the scope of the Python guide. However, a comprehensive introduction to the scientific Python ecosystem can be found in the [Python Scientific Lecture Notes](#)

3.11.2 Tools

IPython

IPython is an enhanced version of Python interpreter, which provides features of great interest to scientists. The *inline mode* allows graphics and plots to be displayed in the terminal (Qt based version). Moreover, the *notebook* mode supports literate programming and reproducible science generating a web-based Python notebook. This notebook allows you to store chunks of Python code along side the results and additional comments (HTML, LaTeX, Markdown). The notebook can then be shared and exported in various file formats.

3.11.3 Libraries

NumPy

NumPy is a low level library written in C (and FORTRAN) for high level mathematical functions. NumPy cleverly overcomes the problem of running slower algorithms on Python by using multidimensional arrays and functions that operate on arrays. Any algorithm can then be expressed as a function on arrays, allowing the algorithms to be run quickly.

NumPy is part of the SciPy project, and is released as a separate library so people who only need the basic requirements can use it without installing the rest of SciPy.

NumPy is compatible with Python versions 2.4 through to 2.7.2 and 3.1+.

Numba

Numba is a NumPy aware Python compiler (just-in-time (JIT) specializing compiler) which compiles annotated Python (and NumPy) code to LLVM (Low Level Virtual Machine) through special decorators. Briefly, Numba uses a system that compiles Python code with LLVM to code which can be natively executed at runtime.

SciPy

SciPy is a library that uses NumPy for more mathematical functions. SciPy uses NumPy arrays as the basic data structure, and comes with modules for various commonly used tasks in scientific programming, including linear algebra, integration (calculus), ordinary differential equation solving and signal processing.

Matplotlib

Matplotlib is a flexible plotting library for creating interactive 2D and 3D plots that can also be saved as manuscript-quality figures. The API in many ways reflects that of **MATLAB**, easing transition of MATLAB users to Python. Many examples, along with the source code to re-create them, are available in the [matplotlib gallery](#).

Pandas

Pandas is data manipulation library based on Numpy which provides many useful functions for accessing, indexing, merging and grouping data easily. The main data structure (DataFrame) is close to what could be found in the R statistical package; that is, heterogeneous data tables with name indexing, time series operations and auto-alignment of data.

Rpy2

Rpy2 is a Python binding for the R statistical package allowing the execution of R functions from Python and passing data back and forth between the two environments. Rpy2 is the object oriented implementation of the [Rpy](#) bindings.

PsychoPy

PsychoPy is a library for cognitive scientists allowing the creation of cognitive psychology and neuroscience experiments. The library handles presentation of stimuli, scripting of experimental design and data collection.

3.11.4 Resources

Installation of scientific Python packages can be troublesome, as many of these packages are implemented as Python C extensions which need to be compiled. This section lists various so-called scientific Python distributions which provide precompiled and easy-to-install collections of scientific Python packages.

Unofficial Windows Binaries for Python Extension Packages

Many people who do scientific computing are on Windows, yet many of the scientific computing packages are notoriously difficult to build and install on this platform. [Christoph Gohlke](#) however, has compiled a list of Windows binaries for many useful Python packages. The list of packages has grown from a mainly scientific Python resource to a more general list. If you're on Windows, you may want to check it out.

Anaconda

[Continuum Analytics](#) offers the [Anaconda Python Distribution](#) which includes all the common scientific Python packages as well as many packages related to data analytics and big data. Anaconda itself is free, and Continuum sells a number of proprietary add-ons. Free licenses for the add-ons are available for academics and researchers.

Canopy

Canopy is another scientific Python distribution, produced by [Enthought](#). A limited 'Canopy Express' variant is available for free, but Enthought charges for the full distribution. Free licenses are available for academics.

3.12 Image Manipulation

Todo

Add introduction about image manipulation and its Python libraries.

3.12.1 Python Imaging Library

The [Python Imaging Library](#), or PIL for short, is *the* library for image manipulation in Python. Unfortunately, its development has stagnated, with its last release in 2009.

Luckily for you, there's an actively-developed fork of PIL called [Pillow](#) - it's easier to install, runs on all operating systems, and supports Python 3.

Installation

Before installing Pillow, you'll have to install Pillow's prerequisites. Find the instructions for your platform [here](#).

After that, it's straightforward:

```
$ pip install Pillow
```

3.13 XML parsing

3.13.1 untangle

`untangle` is a simple library which takes an XML document and returns a Python object which mirrors the nodes and attributes in its structure.

For example, an XML file like this:

```
<?xml version="1.0"?>
<root>
  <child name="child1">
</root>
```

can be loaded like this:

```
import untangle
obj = untangle.parse('path/to/file.xml')
```

and then you can get the child elements name like this:

```
obj.root.child['name']
```

`untangle` also supports loading XML from a string or an URL.

3.13.2 xmldict

`xmldict` is another simple library that aims at making XML feel like working with JSON.

An XML file like this:

```
<mydocument has="an attribute">
  <and>
    <many>elements</many>
    <many>more elements</many>
  </and>
  <plus a="complex">
    element as well
  </plus>
</mydocument>
```

can be loaded into a Python dict like this:

```
import xmldict

with open('path/to/file.xml') as fd:
    obj = xmldict.parse(fd.read())
```

and then you can access elements, attributes and values like this:

```
doc['mydocument']['@has'] # == u'an attribute'
doc['mydocument']['and']['many'] # == [u'elements', u'more elements']
doc['mydocument']['plus']['@a'] # == u'complex'
doc['mydocument']['plus']['#text'] # == u'element as well'
```

xmltodict also lets you roundtrip back to XML with the `unparse` function, has a streaming mode suitable for handling files that don't fit in memory and supports namespaces.

3.14 JSON

The `json` library can parse JSON from strings or files. The library parses JSON into a Python dictionary or list. It can also convert Python dictionaries or lists into JSON strings.

3.14.1 Parsing JSON

Take the following string containing JSON data:

```
json_string = '{"first_name": "Guido", "last_name": "Rossum"}'
```

It can be parsed like this:

```
import json
parsed_json = json.loads(json_string)
```

and can now be used as a normal dictionary:

```
print(parsed_json['first_name'])
"Guido"
```

You can also convert the following to JSON:

```
d = {
    'first_name': 'Guido',
    'second_name': 'Rossum',
    'titles': ['BDFL', 'Developer'],
}

print(json.dumps(d))
'{"first_name": "Guido", "last_name": "Rossum", "titles": ["BDFL", "Developer"]}'
```

3.14.2 simplejson

The JSON library was added to Python in version 2.6. If you're using an earlier version of Python, the `simplejson` library is available via PyPI.

`simplejson` mimics the `json` standard library. It is available so that developers that use older versions of Python can use the latest features available in the `json` lib.

You can start using `simplejson` when the `json` library is not available by importing `simplejson` under a different name:

```
import simplejson as json
```

After importing `simplejson` as `json`, the above examples will all work as if you were using the standard `json` library.

3.15 Cryptography

3.15.1 Cryptography

[Cryptography](#) is an actively developed library that provides cryptographic recipes and primitives. It supports Python 2.6-2.7, Python 3.2+ and PyPy.

Cryptography is divided into two layers of recipes and hazardous materials (hazmat). The recipes layer provides simple API for proper symmetric encryption and the hazmat layer provides low-level cryptographic primitives.

Installation

```
$ pip install cryptography
```

Example

Example code using high level symmetric encryption recipe:

```
from cryptography.fernet import Fernet
key = Fernet.generate_key()
cipher_suite = Fernet(key)
cipher_text = cipher_suite.encrypt(b"A really secret message. Not for prying eyes.")
plain_text = cipher_suite.decrypt(cipher_text)
```

3.15.2 PyCrypto

[PyCrypto](#) is another library, which provides secure hash functions and various encryption algorithms. It supports Python version 2.1 through 3.3.

Installation

```
$ pip install pycrypto
```

Example

```
from Crypto.Cipher import AES
# Encryption
encryption_suite = AES.new('This is a key123', AES.MODE_CBC, 'This is an IV456')
cipher_text = encryption_suite.encrypt("A really secret message. Not for prying eyes.")

# Decryption
decryption_suite = AES.new('This is a key123', AES.MODE_CBC, 'This is an IV456')
plain_text = decryption_suite.decrypt(cipher_text)
```

Shipping Great Code

This part of the guide focuses on deploying your Python code.

4.1 Packaging Your Code

Packaging your code is important.

You'll need to package your code first before sharing it with other developers.

The [Python Packaging Guide](#) provides an extensive guide on creating and maintaining Python packages.

4.1.1 For Python Developers

If you're writing an open source Python module, [PyPI](#), more properly known as *The Cheeseshop*, is the place to host it.

Pip vs. easy_install

Use [pip](#). More details [here](#)

Personal PyPI

If you want to install packages from a source other than PyPI, (say, if your packages are *proprietary*), you can do it by hosting a simple http server, running from the directory which holds those packages which need to be installed.

Showing an example is always beneficial

For example, if you want to install a package called `MyPackage.tar.gz`, and assuming this is your directory structure:

- **archive**
 - **MyPackage**
 - * `MyPackage.tar.gz`

Go to your command prompt and type:

```
$ cd archive
$ python -m SimpleHTTPServer 9000
```

This runs a simple http server running on port 9000 and will list all packages (like **MyPackage**). Now you can install **MyPackage** using any Python package installer. Using Pip, you would do it like:

```
$ pip install --extra-index-url=http://127.0.0.1:9000/ MyPackage
```

Having a folder with the same name as the package name is **crucial** here. I got fooled by that, one time. But if you feel that creating a folder called `MyPackage` and keeping `MyPackage.tar.gz` inside that, is *redundant*, you can still install `MyPackage` using:

```
$ pip install http://127.0.0.1:9000/MyPackage.tar.gz
```

pypiserver

`pypiserver` is a minimal PyPI compatible server. It can be used to serve a set of packages to `easy_install` or `pip`. It includes helpful features like an administrative command (`-U`) which will update all its packages to their latest versions found on PyPI.

S3-Hosted PyPi

One simple option for a personal PyPi server is to use Amazon S3. A prerequisite for this is that you have an Amazon AWS account with an S3 bucket.

1. **Install all your requirements from PyPi or another source**

2. **Install pip2pi**

- `pip install git+https://github.com/wolever/pip2pi.git`

3. **Follow pip2pi README for pip2tgz and dir2pi commands**

- `pip2tgz packages/ YourPackage (or pip2tgz packages/ -r requirements.txt)`
- `dir2pi packages/`

4. **Upload the new files**

- Use a client like Cyberduck to sync the entire `packages` folder to your s3 bucket
- Make sure you upload `packages/simple/index.html` as well as all new files and directories

5. **Fix new file permissions**

- By default, when you upload new files to the S3 bucket, they will have the wrong permissions set.
- Use the Amazon web console to set the READ permission of the files to EVERYONE.
- If you get HTTP 403 when trying to install a package, make sure you've set the permissions correctly.

6. **All done**

- You can now install your package with `pip install --index-url=http://your-s3-bucket/packages/simple YourPackage`

4.1.2 For Linux Distributions

- [Fedora](#)
- [Debian and Ubuntu](#)
- [Arch](#)

Useful Tools

- `fpm`
- `alien`

4.2 Freezing Your Code

An alternative to shipping your code is freezing it — shipping it as an executable with a bundled Python interpreter.

Many applications you use every day do this:

- Dropbox
- BitTorrent
- ...

Todo

Fill in “Freezing Your Code” stub

4.2.1 Comparison

Solutions and platforms/features supported:

Solu- tion	Win- dows	Linux	OS X	Python 3	Li- cense	One-file mode	Zipfile import	Eggs	pkg_resources support
bbFreeze	yes	yes	yes	no	MIT	no	yes	yes	yes
py2exe	yes	no	no	yes	MIT	yes	yes	no	no
pyIn- staller	yes	yes	yes	no	GPL	yes	no	yes	no
cx_Freeze	yes	yes	yes	yes	PSF	no	yes	yes	no
py2app	no	no	yes	yes	MIT	no	yes	yes	yes

Note: Freezing Python code on Linux into a Windows executable was only once supported in PyInstaller and later dropped..

Note: All solutions need MS Visual C++ dll to be installed on target machine, except py2app. Only Pyinstaller makes self-executable exe that bundles the dll when passing `--onefile` to `Configure.py`.

4.2.2 Windows

bbFreeze

Prerequisite is to install *Python, Setuptools and pywin32 dependency on Windows*.

Todo

Write steps for most basic .exe

py2exe

Prerequisite is to install *Python on Windows*.

1. Download and install <http://sourceforge.net/projects/py2exe/files/py2exe/>
2. Write `setup.py` (List of configuration options):

```
from distutils.core import setup
import py2exe

setup(
    windows=[{'script': 'foobar.py'}],
)
```

3. (Optionally) include icon
4. (Optionally) one-file mode
5. Generate `.exe` into `dist` directory:

```
$ python setup.py py2exe
```

6. Provide the Microsoft Visual C runtime DLL. Two options: globally install dll on target machine or distribute dll alongside with `.exe`.

PyInstaller

Prerequisite is to have installed *Python, Setuptools and pywin32 dependency on Windows*.

- Most basic tutorial
- Manual

4.2.3 OS X

py2app

PyInstaller

4.2.4 Linux

bbFreeze

PyInstaller

Development Environment

5.1 Your Development Environment

5.1.1 Text Editors

Just about anything that can edit plain text will work for writing Python code, however, using a more powerful editor may make your life a bit easier.

Vim

Vim is a text editor which uses keyboard shortcuts for editing instead of menus or icons. There are a couple of plugins and settings for the Vim editor to aid Python development. If you only develop in Python, a good start is to set the default settings for indentation and line-wrapping to values compliant with **PEP 8**. In your home directory, open a file called `.vimrc` and add the following lines:

```
set textwidth=79 " lines longer than 79 columns will be broken
set shiftwidth=4 " operation >> indents 4 columns; << unindents 4 columns
set tabstop=4    " a hard TAB displays as 4 columns
set expandtab    " insert spaces when hitting TABs
set softtabstop=4 " insert/delete 4 spaces when hitting a TAB/BACKSPACE
set shiftround  " round indent to multiple of 'shiftwidth'
set autoindent  " align the new line indent with the previous line
```

With these settings, newlines are inserted after 79 characters and indentation is set to 4 spaces per tab. If you also use Vim for other languages, there is a handy plugin called `indent`, which handles indentation settings for Python source files.

There is also a handy syntax plugin called `syntax` featuring some improvements over the syntax file included in Vim 6.1.

These plugins supply you with a basic environment for developing in Python. To get the most out of Vim, you should continually check your code for syntax errors and PEP8 compliance. Luckily `PEP8` and `Pyflakes` will do this for you. If your Vim is compiled with `+python` you can also utilize some very handy plugins to do these checks from within the editor.

For PEP8 checking and pyflakes, you can install `vim-flake8`. Now you can map the function `Flake8` to any hotkey or action you want in Vim. The plugin will display errors at the bottom of the screen, and provide an easy way to jump to the corresponding line. It's very handy to call this function whenever you save a file. In order to do this, add the following line to your `.vimrc`:

```
autocmd BufWritePost *.py call Flake8()
```

If you are already using `syntastic`, you can set it to run Pyflakes on write and show errors and warnings in the quickfix window. An example configuration to do that which also shows status and warning messages in the statusbar would be:

```
set statusline+=%#warningmsg#
set statusline+=%{SyntasticStatuslineFlag()}
set statusline+=%*
let g:syntastic_auto_loc_list=1
let g:syntastic_loc_list_height=5
```

Python-mode

`Python-mode` is a complex solution for working with Python code in Vim. It has:

- Asynchronous Python code checking (`pylint`, `pyflakes`, `pep8`, `mccabe`) in any combination
- Code refactoring and autocompletion with `Rope`
- Fast Python folding
- `Virtualenv` support
- Search through Python documentation and run Python code
- Auto `PEP8` error fixes

And more.

SuperTab

`SuperTab` is a small Vim plugin that makes code completion more convenient by using `<Tab>` key or any other customized keys.

Emacs

Emacs is another powerful text editor. It is fully programmable (lisp), but it can be some work to wire up correctly. A good start if you're already an Emacs user is [Python Programming in Emacs](#) at EmacsWiki.

1. Emacs itself comes with a Python mode.
2. Python ships with an alternate version: `python-mode.el`
3. Fabián Ezequiel Gallina's `python.el` provides nice functionality and behavior out of the box

TextMate

`TextMate` brings Apple's approach to operating systems into the world of text editors. By bridging UNIX underpinnings and GUI, `TextMate` cherry-picks the best of both worlds to the benefit of expert scripters and novice users alike.

Sublime Text

[Sublime Text](#) is a sophisticated text editor for code, markup and prose. You'll love the slick user interface, extraordinary features and amazing performance.

Sublime Text has excellent support for editing Python code and uses Python for its plugin API. It also has a diverse variety of plugins, [some of which](#) allow for in-editor PEP8 checking and code “linting”.

Atom

[Atom](#) is a hackable text editor for the 21st century, built on atom-shell, and based on everything we love about our favorite editors.

Atom is web native (HTML, CSS, JS), focusing on modular design and easy plugin development. It comes with native package control and plethora of packages. Recommended for Python development is [Linter](#) combined with [linter-flake8](#).

5.1.2 IDEs

PyCharm / IntelliJ IDEA

[PyCharm](#) is developed by JetBrains, also known for IntelliJ IDEA. Both share the same code base and most of PyCharm's features can be brought to IntelliJ with the free [Python Plug-In](#). There are two versions of PyCharm: Professional Edition (Free 30-day trial) and Community Edition (Apache 2.0 License) with fewer features.

Eclipse

The most popular Eclipse plugin for Python development is Aptana's [PyDev](#).

Komodo IDE

[Komodo IDE](#) is developed by ActiveState and is a commercial IDE for Windows, Mac, and Linux. [KomodoEdit](#) is the open source alternative.

Spyder

[Spyder](#) is an IDE specifically geared toward working with scientific Python libraries (namely [Scipy](#)). It includes integration with [pyflakes](#), [pylint](#) and [rope](#).

Spyder is open-source (free), offers code completion, syntax highlighting, a class and function browser, and object inspection.

WingIDE

[WingIDE](#) is a Python specific IDE. It runs on Linux, Windows and Mac (as an X11 application, which frustrates some Mac users).

WingIDE offers code completion, syntax highlighting, source browser, graphical debugger and support for version control systems.

NINJA-IDE

NINJA-IDE (from the recursive acronym: “Ninja-IDE Is Not Just Another IDE”) is a cross-platform IDE, specially designed to build Python applications, and runs on Linux/X11, Mac OS X and Windows desktop operating systems. Installers for these platforms can be downloaded from the website.

NINJA-IDE is open-source software (GPLv3 licence) and is developed in Python and Qt. The source files can be downloaded from [GitHub](#).

Eric (The Eric Python IDE)

Eric is a full featured Python IDE offering sourcecode autocompletion, syntax highlighting, support for version control systems, python 3 support, integrated web browser, python shell, integrated debugger and a flexible plug-in system. Written in python, it is based on the Qt gui toolkit, integrating the Scintilla editor control. Eric is an open-source software project (GPLv3 licence) with more than ten years of active development.

5.1.3 Interpreter Tools

Virtual Environments

A Virtual Environment is a tool to keep the dependencies required by different projects in separate places, by creating virtual Python environments for them. It solves the “Project X depends on version 1.x but, Project Y needs 4.x” dilemma, and keeps your global site-packages directory clean and manageable.

For example, you can work on a project which requires Django 1.3 while also maintaining a project which requires Django 1.0.

To start using and see more information: [Virtual Environments docs](#).

5.1.4 Other Tools

IDLE

IDLE is an integrated development environment that is part of Python standard library. It is completely written in Python and uses the Tkinter GUI toolkit. Though IDLE is not suited for full-blown development using Python, it is quite helpful to try out small Python snippets and experiment with different features in Python.

It provides the following features:

- Python Shell Window (interpreter)
- Multi window text editor that colorizes Python code
- Minimal debugging facility

IPython

IPython provides a rich toolkit to help you make the most out of using Python interactively. Its main components are:

- Powerful Python shells (terminal- and Qt-based).
- A web-based notebook with the same core features but support for rich media, text, code, mathematical expressions and inline plots.
- Support for interactive data visualization and use of GUI toolkits.

- Flexible, embeddable interpreters to load into your own projects.
- Tools for high level and interactive parallel computing.

```
$ pip install ipython
```

BPython

`bpython` is an alternative interface to the Python interpreter for Unix-like operating systems. It has the following features:

- In-line syntax highlighting.
- Readline-like autocomplete with suggestions displayed as you type.
- Expected parameter list for any Python function.
- “Rewind” function to pop the last line of code from memory and re-evaluate.
- Send entered code off to a pastebin.
- Save entered code to a file.
- Auto-indentation.
- Python 3 support.

```
$ pip install bpython
```

5.2 Virtual Environments

A Virtual Environment is a tool to keep the dependencies required by different projects in separate places, by creating virtual Python environments for them. It solves the “Project X depends on version 1.x but, Project Y needs 4.x” dilemma, and keeps your global site-packages directory clean and manageable.

For example, you can work on a project which requires Django 1.3 while also maintaining a project which requires Django 1.0.

5.2.1 virtualenv

`virtualenv` is a tool to create isolated Python environments. `virtualenv` creates a folder which contains all the necessary executables to use the packages that a Python project would need.

Install `virtualenv` via `pip`:

```
$ pip install virtualenv
```

Basic Usage

1. Create a virtual environment for a project:

```
$ cd my_project_folder
$ virtualenv venv
```

`virtualenv venv` will create a folder in the current directory which will contain the Python executable files, and a copy of the `pip` library which you can use to install other packages. The name of the virtual environment (in this case, it was `venv`) can be anything; omitting the name will place the files in the current directory instead.

This creates a copy of Python in whichever directory you ran the command in, placing it in a folder named `venv`.

You can also use a Python interpreter of your choice.

```
$ virtualenv -p /usr/bin/python2.7 venv
```

This will use the Python interpreter in `/usr/bin/python2.7`

2. To begin using the virtual environment, it needs to be activated:

```
$ source venv/bin/activate
```

The name of the current virtual environment will now appear on the left of the prompt (e.g. `(venv)Your-Computer:your_project Username$`) to let you know that it's active. From now on, any package that you install using `pip` will be placed in the `venv` folder, isolated from the global Python installation.

Install packages as usual, for example:

```
$ pip install requests
```

3. If you are done working in the virtual environment for the moment, you can deactivate it:

```
$ deactivate
```

This puts you back to the system's default Python interpreter with all its installed libraries.

To delete a virtual environment, just delete its folder. (In this case, it would be `rm -rf venv`.)

After a while, though, you might end up with a lot of virtual environments littered across your system, and its possible you'll forget their names or where they were placed.

Other Notes

Running `virtualenv` with the option `--no-site-packages` will not include the packages that are installed globally. This can be useful for keeping the package list clean in case it needs to be accessed later. [This is the default behavior for `virtualenv` 1.7 and later.]

In order to keep your environment consistent, it's a good idea to "freeze" the current state of the environment packages. To do this, run

```
$ pip freeze > requirements.txt
```

This will create a `requirements.txt` file, which contains a simple list of all the packages in the current environment, and their respective versions. Later it will be easier for a different developer (or you, if you need to re-create the environment) to install the same packages using the same versions:

```
$ pip install -r requirements.txt
```

This can help ensure consistency across installations, across deployments, and across developers.

Lastly, remember to exclude the virtual environment folder from source control by adding it to the ignore list.

5.2.2 virtualenvwrapper

`virtualenvwrapper` provides a set of commands which makes working with virtual environments much more pleasant. It also places all your virtual environments in one place.

To install (make sure **virtualenv** is already installed):

```
$ pip install virtualenvwrapper
$ export WORKON_HOME=~/.Envs
$ source /usr/local/bin/virtualenvwrapper.sh
```

(Full `virtualenvwrapper` install instructions.)

For Windows, you can use the `virtualenvwrapper-win`.

To install (make sure **virtualenv** is already installed):

```
$ pip install virtualenvwrapper-win
```

In Windows, the default path for `WORKON_HOME` is `%USERPROFILE%Envs`

Basic Usage

1. Create a virtual environment:

```
$ mkvirtualenv venv
```

This creates the `venv` folder inside `~/Envs`.

2. Work on a virtual environment:

```
$ workon venv
```

Alternatively, you can make a project, which creates the virtual environment, and also a project directory inside `$PROJECT_HOME`, which is `cd -ed` into when you `workon myproject`.

```
$ mkproject myproject
```

virtualenvwrapper provides tab-completion on environment names. It really helps when you have a lot of environments and have trouble remembering their names.

`workon` also deactivates whatever environment you are currently in, so you can quickly switch between environments.

3. Deactivating is still the same:

```
$ deactivate
```

4. To delete:

```
$ rmvirtualenv venv
```

Other useful commands

lsvirtualenv List all of the environments.

cdvirtualenv Navigate into the directory of the currently activated virtual environment, so you can browse its `site-packages`, for example.

cdsitepackages Like the above, but directly into `site-packages` directory.

lssitepackages Shows contents of `site-packages` directory.

[Full list of `virtualenvwrapper` commands.](#)

5.2.3 autoenv

When you `cd` into a directory containing a `.env`, `autoenv` automatically activates the environment.

Install it on Mac OS X using `brew`:

```
$ brew install autoenv
```

And on Linux:

```
$ git clone git://github.com/kennethreitz/autoenv.git ~/.autoenv
$ echo 'source ~/.autoenv/activate.sh' >> ~/.bashrc
```

Additional Notes

This part of the guide, which is mostly prose, begins with some background information about Python, then focuses on next steps.

6.1 Introduction

From the [official Python website](#):

Python is a general-purpose, high-level programming language similar to Tcl, Perl, Ruby, Scheme, or Java. Some of its main key features include:

- **very clear, readable syntax**

Python's philosophy focuses on readability, from code blocks delineated with significant whitespace to intuitive keywords in place of inscrutable punctuation.

- **extensive standard libraries and third party modules for virtually any task**

Python is sometimes described with the words “batteries included” because of its extensive [standard library](#), which includes modules for regular expressions, file IO, fraction handling, object serialization, and much more.

Additionally, the [Python Package Index](#) is available for users to submit their packages for widespread use, similar to Perl's [CPAN](#). There is a thriving community of very powerful Python frameworks and tools like the [Django](#) web framework and the [NumPy](#) set of math routines.

- **integration with other systems**

Python can integrate with [Java libraries](#), enabling it to be used with the rich Java environment that corporate programmers are used to. It can also be [extended by C or C++ modules](#) when speed is of the essence.

- **ubiquity on computers**

Python is available on Windows, *nix, and Mac. It runs wherever the Java virtual machine runs, and the reference implementation CPython can help bring Python to wherever there is a working C compiler.

- **friendly community**

Python has a vibrant and large [community](#) which maintains wikis, conferences, countless repositories, mailing lists, IRC channels, and so much more. Heck, the Python community is even helping to write this guide!

6.1.1 About This Guide

Purpose

The Hitchhiker’s Guide to Python exists to provide both novice and expert Python developers a best-practice handbook to the installation, configuration, and usage of Python on a daily basis.

By the Community

This guide is architected and maintained by [Kenneth Reitz](#) in an open fashion. This is a community-driven effort that serves one purpose: to serve the community.

For the Community

All contributions to the Guide are welcome, from Pythonistas of all levels. If you think there’s a gap in what the Guide covers, fork the Guide on GitHub and submit a pull request.

Contributions are welcome from everyone, whether they’re an old hand or a first-time Pythonista, and the authors to the Guide will gladly help if you have any questions about the appropriateness, completeness, or accuracy of a contribution.

To get started working on The Hitchhiker’s Guide, see the [Contribute](#) page.

6.2 The Community

6.2.1 BDFL

Guido van Rossum, the creator of Python, is often referred to as the BDFL — the Benevolent Dictator For Life.

6.2.2 Python Software Foundation

The mission of the Python Software Foundation is to promote, protect, and advance the Python programming language, and to support and facilitate the growth of a diverse and international community of Python programmers.

[Learn More about the PSF.](#)

6.2.3 PEPs

PEPs are *Python Enhancement Proposals*. They describe changes to Python itself, or the standards around it.

There are three different types of PEPs (as defined by [PEP 1](#)):

Standards Describes a new feature or implementation.

Informational Describes a design issue, general guidelines, or information to the community.

Process Describes a process related to Python.

Notable PEPs

There are a few PEPs that could be considered required reading:

- **PEP 8: The Python Style Guide.** Read this. All of it. Follow it.
- **PEP 20: The Zen of Python.** A list of 19 statements that briefly explain the philosophy behind Python.
- **PEP 257: Docstring Conventions.** Gives guidelines for semantics and conventions associated with Python docstrings.

You can read more at [The PEP Index](#).

Submitting a PEP

PEPs are peer-reviewed and accepted/rejected after much discussion. Anyone can write and submit a PEP for review.

Here's an overview of the PEP acceptance workflow:

6.2.4 Python Conferences

The major events for the Python community are developer conferences. The two most notable conferences are PyCon, which is held in the US, and its European sibling, EuroPython.

A comprehensive list of conferences is maintained at pycon.org.

6.2.5 Python User Groups

User Groups are where a bunch of Python developers meet to present or talk about Python topics of interest. A list of local user groups is maintained at the [Python Software Foundation Wiki](#).

6.3 Learning Python

6.3.1 Beginner

The Python Tutorial

This is the official tutorial. It covers all the basics, and offers a tour of the language and the standard library. Recommended for those who need a quickstart guide to the language.

[The Python Tutorial](#)

Learn Python Interactive Tutorial

Learnpython.org is an easy non-intimidating way to get introduced to Python. The website takes the same approach used on the popular [Try Ruby](#) website, it has an interactive Python interpreter built into the site that allows you to go through the lessons without having to install Python locally.

[Learn Python](#)

If you want a more traditional book, *Python For You and Me* is an excellent resource for learning all aspects of the language.

[Python for You and Me](#)

Invent Your Own Computer Games with Python

This beginner's book is for those with no programming experience at all. Each chapter has the source code to a small game, using these example programs to demonstrate programming concepts to give the reader an idea of what programs "look like".

[Invent Your Own Computer Games with Python](#)

Hacking Secret Ciphers with Python

This book teaches Python programming and basic cryptography for absolute beginners. The chapters provide the source code for various ciphers, as well as programs that can break them.

[Hacking Secret Ciphers with Python](#)

Learn Python the Hard Way

This is an excellent beginner programmer's guide to Python. It covers "hello world" from the console to the web.

[Learn Python the Hard Way](#)

Crash into Python

Also known as *Python for Programmers with 3 Hours*, this guide gives experienced developers from other languages a crash course on Python.

[Crash into Python](#)

Dive Into Python 3

Dive Into Python 3 is a good book for those ready to jump in to Python 3. It's a good read if you are moving from Python 2 to 3 or if you already have some experience programming in another language.

[Dive Into Python 3](#)

Think Python: How to Think Like a Computer Scientist

Think Python attempts to give an introduction to basic concepts in computer science through the use of the Python language. The focus was to create a book with plenty of exercises, minimal jargon and a section in each chapter devoted to the subject of debugging.

While exploring the various features available in the Python language the author weaves in various design patterns and best practices.

The book also includes several case studies which have the reader explore the topics discussed in the book in greater detail by applying those topics to real-world examples. Case studies include assignments in GUI and Markov Analysis.

[Think Python](#)

Python Koans

Python Koans is a port of Edgcase's Ruby Koans. It uses a test-driven approach, q.v. TEST DRIVEN DESIGN SECTION to provide an interactive tutorial teaching basic Python concepts. By fixing assertion statements that fail in a test script, this provides sequential steps to learning Python.

For those used to languages and figuring out puzzles on their own, this can be a fun, attractive option. For those new to Python and programming, having an additional resource or reference will be helpful.

[Python Koans](#)

More information about test driven development can be found at these resources:

[Test Driven Development](#)

A Byte of Python

A free introductory book that teaches Python at the beginner level, it assumes no previous programming experience.

[A Byte of Python for Python 2.x](#) [A Byte of Python for Python 3.x](#)

Learn to Program in Python with Codecademy

A Codecademy course for the absolute Python beginner. This free and interactive course provides and teaches the basics (and beyond) of Python programming whilst testing the user's knowledge in between progress.

[Learn to Program in Python with Codecademy](#)

6.3.2 Advanced

Pro Python

This book is for intermediate to advanced Python programmers who are looking to understand how and why Python works the way it does and how they can take their code to the next level.

[Pro Python](#)

Expert Python Programming

Expert Python Programming deals with best practices in programming Python and is focused on the more advanced crowd.

It starts with topics like decorators (with caching, proxy, and context manager case-studies), method resolution order, using `super()` and meta-programming, and general **PEP 8** best practices.

It has a detailed, multi-chapter case study on writing and releasing a package and eventually an application, including a chapter on using `zc.buildout`. Later chapters detail best practices such as writing documentation, test-driven development, version control, optimization and profiling.

[Expert Python Programming](#)

A Guide to Python's Magic Methods

This is a collection of blog posts by Rafe Kettler which explain ‘magic methods’ in Python. Magic methods are surrounded by double underscores (i.e. `__init__`) and can make classes and objects behave in different and magical ways.

[A Guide to Python's Magic Methods](#)

6.3.3 For Engineers and Scientists

A Primer on Scientific Programming with Python

A Primer on Scientific Programming with Python, written by Hans Petter Langtangen, mainly covers Python's usage in the scientific field. In the book, examples are chosen from mathematics and the natural sciences.

[A Primer on Scientific Programming with Python](#)

Numerical Methods in Engineering with Python

Numerical Methods in Engineering with Python, written by Jaan Kiusalaas, puts the emphasis on numerical methods and how to implement them in Python.

[Numerical Methods in Engineering with Python](#)

6.3.4 Miscellaneous topics

Problem Solving with Algorithms and Data Structures

Problem Solving with Algorithms and Data Structures covers a range of data structures and algorithms. All concepts are illustrated with Python code along with interactive samples that can be run directly in the browser.

[Problem Solving with Algorithms and Data Structures](#)

Programming Collective Intelligence

Programming Collective Intelligence introduces a wide array of basic machine learning and data mining methods. The exposition is not very mathematically formal, but rather focuses on explaining the underlying intuition and shows how to implement the algorithms in Python.

[Programming Collective Intelligence](#)

6.3.5 References

Python in a Nutshell

Python in a Nutshell, written by Alex Martelli, covers most cross-platform Python's usage, from its syntax to built-in libraries to advanced topics such as writing C extensions.

[Python in a Nutshell](#)

The Python Language Reference

This is Python’s reference manual, it covers the syntax and the core semantics of the language.

[The Python Language Reference](#)

Python Pocket Reference

Python Pocket Reference, written by Mark Lutz, is an easy to use reference to the core language, with descriptions of commonly used modules and toolkits. It covers Python 3 and 2.6 versions.

[Python Pocket Reference](#)

Python Cookbook

Python Cookbook, written by David Beazley and Brian K. Jones, is packed with practical recipes. This book covers the core python language as well as tasks common to a wide variety of application domains.

[Python Cookbook](#)

Writing Idiomatic Python

“Writing Idiomatic Python”, written by Jeff Knupp, contains the most common and important Python idioms in a format that maximizes identification and understanding. Each idiom is presented as a recommendation of a way to write some commonly used piece of code, followed by an explanation of why the idiom is important. It also contains two code samples for each idiom: the “Harmful” way to write it and the “Idiomatic” way.

[For Python 2.7.3+](#)

[For Python 3.3+](#)

6.4 Documentation

6.4.1 Official Documentation

The official Python Language and Library documentation can be found here:

- [Python 2.x](#)
- [Python 3.x](#)

6.4.2 Read the Docs

Read the Docs is a popular community project that hosts documentation for open source software. It holds documentation for many Python modules, both popular and exotic.

[Read the Docs](#)

6.4.3 pydoc

pydoc is a utility that is installed when you install Python. It allows you to quickly retrieve and search for documentation from your shell. For example, if you needed a quick refresher on the `time` module, pulling up documentation would be as simple as

```
$ pydoc time
```

The above command is essentially equivalent to opening the Python REPL and running

```
>>> help(time)
```

6.5 News

6.5.1 Planet Python

This is an aggregate of Python news from a growing number of developers.

[Planet Python](#)

6.5.2 /r/python

`/r/python` is the Reddit Python community where users contribute and vote on Python-related news.

[/r/python](#)

6.5.3 Pycoder's Weekly

Pycoder's Weekly is a free weekly Python newsletter for Python developers by Python developers (Projects, Articles, News, and Jobs).

[Pycoder's Weekly](#)

6.5.4 Python Weekly

Python Weekly is a free weekly newsletter featuring curated news, articles, new releases, jobs, etc. related to Python.

[Python Weekly](#)

6.5.5 Python News

Python News is the news section in the official Python web site (www.python.org). It briefly highlights the news from the Python community.

[Python News](#)

6.5.6 Import Python Weekly

Weekly Python Newsletter containing Python Articles, Projects, Videos, Tweets delivered in your inbox. Keep Your Python Programming Skills Updated.

[Import Python Weekly Newsletter](#)

Contribution notes and legal information are here (for those interested).

6.6 Contribute

Python-guide is under active development, and contributors are welcome.

If you have a feature request, suggestion, or bug report, please open a new issue on [GitHub](#). To submit patches, please send a pull request on [GitHub](#). Once your changes get merged back in, you'll automatically be added to the [Contributors List](#).

6.6.1 Style Guide

For all contributions, please follow the *The Guide Style Guide*.

6.6.2 Todo List

If you'd like to contribute, there's plenty to do. Here's a short `todo` list.

- Establish “use this” vs “alternatives are....” recommendations

Todo

Write about Chef

[Chef Documentation](#)

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/scenarios/admin.rst`, line 239.)

Todo

Write about Blueprint

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/scenarios/admin.rst`, line 343.)

Todo

Write about Buildout

[Buildout Website](#)

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/scenarios/admin.rst`, line 348.)

Todo

Add introduction about image manipulation and its Python libraries.

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/scenarios/imaging.rst`, line 5.)

Todo

Write about Numba and the autojit compiler for NumPy

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/scenarios/speed.rst`, line 227.)

Todo

Fill in “Freezing Your Code” stub

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/shipping/freezing.rst`, line 13.)

Todo

Write steps for most basic .exe

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/shipping/freezing.rst`, line 50.)

Todo

Embed and explain YouTube video showing python code reading: <http://www.youtube.com/watch?v=Jc8M9-LoEuo> This may require installing a Sphinx plugin. <https://bitbucket.org/birkenfeld/sphinx-contrib/src/a09f29fc16970f34350ca36ac7f229e00b1b1674/youtube?at=default>

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/writing/reading.rst`, line 41.)

Todo

Include code examples of exemplary code from each of the projects listed. Explain why it is excellent code. Use complex examples.

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/writing/reading.rst`, line 43.)

Todo

Explain techniques to rapidly identify data structures, algorithms and determine what the code is doing.

(The original entry is located in `/home/docs/checkouts/readthedocs.org/user_builds/python-guide/checkouts/latest/docs/writing/reading.rst`, line 45.)

6.7 License

The Guide is licensed under the [Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported license](https://creativecommons.org/licenses/by-nc-sa/3.0/).

6.8 The Guide Style Guide

As with all documentation, having a consistent format helps make the document more understandable. In order to make The Guide easier to digest, all contributions should fit within the rules of this style guide where appropriate.

The Guide is written as *reStructuredText*.

Note: Parts of The Guide may not yet match this style guide. Feel free to update those parts to be in sync with The Guide Style Guide

Note: On any page of the rendered HTML you can click “Show Source” to see how authors have styled the page.

6.8.1 Relevancy

Strive to keep any contributions relevant to the *purpose of The Guide*.

- Avoid including too much information on subjects that don’t directly relate to Python development.
- Prefer to link to other sources if the information is already out there. Be sure to describe what and why you are linking.
- Cite references where needed.
- If a subject isn’t directly relevant to Python, but useful in conjunction with Python (e.g., Git, GitHub, Databases), reference by linking to useful resources, and describe why it’s useful to Python.
- When in doubt, ask.

6.8.2 Headings

Use the following styles for headings.

Chapter title:

```
#####
Chapter 1
#####
```

Page title:

```
=====
Time is an Illusion
=====
```

Section headings:

```
Lunchtime Doubly So
-----
```

Sub section headings:

```
Very Deep
~~~~~
```

6.8.3 Prose

Wrap text lines at 78 characters. Where necessary, lines may exceed 78 characters, especially if wrapping would make the source text more difficult to read.

6.8.4 Code Examples

Wrap all code examples at 70 characters to avoid horizontal scrollbars.

Command line examples:

```
.. code-block:: console

    $ run command --help
    $ ls ..
```

Be sure to include the \$ prefix before each line.

Python interpreter examples:

```
Label the example::

.. code-block:: python

    >>> import this
```

Python examples:

```
Descriptive title::

.. code-block:: python

    def get_answer():
        return 42
```

6.8.5 Externally Linking

- Prefer labels for well known subjects (ex: proper nouns) when linking:

```
Sphinx_ is used to document Python.

.. _Sphinx: http://sphinx.pocoo.org
```

- Prefer to use descriptive labels with inline links instead of leaving bare links:

```
Read the `Sphinx Tutorial <http://sphinx.pocoo.org/tutorial.html>`_
```

- Avoid using labels such as “click here”, “this”, etc. preferring descriptive labels (SEO worthy) instead.

6.8.6 Linking to Sections in The Guide

To cross-reference other parts of this documentation, use the `:ref:` keyword and labels.

To make reference labels more clear and unique, always add a `-ref` suffix:

```
.. \_some-section-ref:
```

```
Some Section  
-----
```

6.8.7 Notes and Warnings

Make use of the appropriate [admonitions directives](#) when making notes.

Notes:

```
.. note::  
    The Hitchhiker's Guide to the Galaxy has a few things to say  
    on the subject of towels. A towel, it says, is about the most  
    massively useful thing an interstellar hitch hiker can have.
```

Warnings:

```
.. warning:: DON'T PANIC
```

6.8.8 TODOs

Please mark any incomplete areas of The Guide with a [todo directive](#). To avoid cluttering the *Todo List*, use a single `todo` for stub documents or large incomplete sections.

```
.. todo::  
    Learn the Ultimate Answer to the Ultimate Question  
    of Life, The Universe, and Everything
```


E

environment variable
 PATH, 5, 6

P

PATH, 5, 6

Python Enhancement Proposals

- PEP 1, 80
- PEP 20, 20, 81
- PEP 249, 50
- PEP 257, 26, 81
- PEP 282, 31
- PEP 3101, 15
- PEP 3132, 19
- PEP 3333, 40
- PEP 391, 33
- PEP 8, 21, 71, 81, 83
- PEP 8#comments, 26