



# How To Code in Python 3

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# Introduction

## Why Learn To Code

Software and technology are becoming increasingly integrated into our everyday lives, allowing us to accomplish tasks, navigate to destinations, make purchases, and stay connected with friends. Because of how pervasive software now is to the human experience, it is important for all of us to learn some of the key foundational elements of computer programming. While some may choose to study computer science as part of their formal education, everyone can benefit from an understanding of algorithmic thinking and computational processes. Learning how the software that we use on a daily basis is made can allow us as end users to evaluate how and why these applications are developed, enabling us to think critically about these tools and how to improve them.

Just like any other product, computer programs are designed and developed by people who have unconscious biases, make errors, and may not be considering all aspects of a problem they are trying to solve. Though development teams may do thorough testing and work to create sophisticated and useful programs, they do not always meet the needs and expectations of all users. While not everyone needs to learn to code complex programs, learning how coding works can help shape the future of technology and increase the number of stakeholders, decision makers, and knowledge producers who can work to build better software for everyone.

Some of us may choose to solve challenging problems within the technology sector, but for those of us not working in computer science, a

programming background can still be a great asset to our professional fields. Computer programming provides many applications across domains, and can help us solve problems in specialities such as medicine, economics, sociology, history, and literature, to name a few. By integrating technology's methodologies into our own fields, we can leverage computational logic and software design and development practices in our work. When we synthesize knowledge across spheres and collaborate with people from different backgrounds, we can innovate in new, more inclusive ways that can enact meaningful impact across many communities.

## Why Learn Python

Extremely versatile and popular among developers, Python is a good general-purpose language that can be used in a variety of applications. For those with an understanding of English, Python is a very human-readable programming language, allowing for quick comprehension. Because Python supports multiple styles including scripting and object-oriented programming, it is considered to be a multi-paradigm language that enables programmers to use the most suitable style to complete a project. Increasingly used in industry, Python offers a lot of potential for those who would like to begin coding while also being a good choice for those looking to pick up an additional programming language.

Learning the key concepts of Python can help you understand how programs work while also imparting foundational logic that can serve you in other domains. Understanding what Python and computer programming can offer you both as a user and as a developer is important as technology is further integrated into daily life.



As you work through this book, you will be able to increase your awareness of computer programming, improve your logical thinking, and eventually become a producer of software. Being able to create software that runs is a very rewarding endeavor, and can help you serve those around you by increasing their access and empowering them to become collaborators. The more communities involved in the creation of software development, the more communities there will be whose needs are served by software.

## How To Use This Book

This book is designed to be used in a way that makes sense for you. While it is arranged to ramp up an emerging developer, do not be constrained by the order: feel free to move throughout the book in a way that makes sense for you. Once you are familiar with the concepts, you can continue to use the book as a source of reference.

If you use the book in the order it is laid out, you'll begin your exploration in Python by understanding the key differences between Python 3 and the previous versions of the language. From there, you'll set up a programming environment for your relevant local or server-based system, and begin by learning general Python code structure, syntax, and data types. Along the way, you'll gain a solid grounding in computational logic within Python, which can help you learn other programming languages. While the beginning of the book focuses on scripting in Python, the end of the book will take you through object-oriented coding in Python, which can make your code more modular, flexible, and complex without repetition. By the end of the book, you'll learn how to debug your Python code and finally how to port Python code across versions.

When you are done with the book, we encourage you to look at [project-based tutorials](#) to put your knowledge into play while creating projects that can help you solve problems. While you are working on these projects, you can continue to refer to the chapters in this book as reference material.

As part of your learning process and once you feel comfortable, we recommend that you [contribute to an open-source project](#) to improve programs and drive greater access via software and technical documentation pull requests or repository maintenance. Our community is bigger than just us and building software together can make sure that everyone has an opportunity to participate in the technology we use every day.

# Python 2 vs Python 3: Practical Considerations

Python is an extremely readable and versatile programming language. With a name inspired by the British comedy group Monty Python, it was an important foundational goal of the Python development team to make the language fun to use. Easy to set up, and written in a relatively straightforward style with immediate feedback on errors, Python is a great choice for beginners.

As Python is a multiparadigm language — that is, it supports multiple programming styles including scripting and object-oriented — it is good for general purpose use. Increasingly used in industry by organizations such as United Space Alliance (NASA's main shuttle support contractor), and Industrial Light & Magic (the VFX and animation studio of Lucasfilm), Python offers a lot of potential for those looking to pick up an additional programming language.

Developed in the late 1980s and first published in 1991, Python was authored by Guido van Rossum, who is still very active in the community. Conceived as a successor to the ABC programming language, Python's first iteration already included exception handling, [functions](#), and [classes with inheritance](#). When an important Usenet newsgroup discussion forum called comp.lang.python was formed in 1994, Python's user base grew, paving the way for Python to become one of the most popular programming languages for open source development.

## General Overview

Before looking into potential opportunities related to — and the key programmatic differences between — Python 2 and Python 3, let's take a look into the background of the more recent major releases of Python.

## **Python 2**

Published in late 2000, Python 2 signalled a more transparent and inclusive language development process than earlier versions of Python with the implementation of PEP (Python Enhancement Proposal), a technical specification that either provides information to Python community members or describes a new feature of the language.

Additionally, Python 2 included many more programmatic features including a cycle-detecting garbage collector to automate memory management, increased Unicode support to standardize characters, and list comprehensions to create a list based on existing lists. As Python 2 continued to develop, more features were added, including unifying Python's types and classes into one hierarchy in Python version 2.2.

## **Python 3**

Python 3 is regarded as the future of Python and is the version of the language that is currently in development. A major overhaul, Python 3 was released in late 2008 to address and amend intrinsic design flaws of previous versions of the language. The focus of Python 3 development was to clean up the codebase and remove redundancy, making it clear that there was only one way to perform a given task.

Major modifications to Python 3.0 included changing the `print` statement into a built-in function, improve the way integers are divided, and providing more Unicode support.

At first, Python 3 was slowly adopted due to the language not being backwards compatible with Python 2, requiring people to make a decision as to which version of the language to use. Additionally, many package libraries were only available for Python 2, but as the development team behind Python 3 has reiterated that there is an end of life for Python 2 support, more libraries have been ported to Python 3. The increased adoption of Python 3 can be shown by the number of Python packages that now provide Python 3 support, which at the time of writing includes 339 of the 360 most popular Python packages.

## **Python 2.7**

Following the 2008 release of Python 3.0, Python 2.7 was published on July 3, 2010 and planned as the last of the 2.x releases. The intention behind Python 2.7 was to make it easier for Python 2.x users to port features over to Python 3 by providing some measure of compatibility between the two. This compatibility support included enhanced modules for version 2.7 like `unittest` to support test automation, `argparse` for parsing command-line options, and more convenient classes in `collections`.

Because of Python 2.7's unique position as a version in between the earlier iterations of Python 2 and Python 3.0, it has persisted as a very popular choice for programmers due to its compatibility with many robust libraries. When we talk about Python 2 today, we are typically referring to the Python 2.7 release as that is the most frequently used version.

Python 2.7, however, is considered to be a legacy language and its continued development, which today mostly consists of bug fixes, will cease completely in 2020.

## Key Differences

While Python 2.7 and Python 3 share many similar capabilities, they should not be thought of as entirely interchangeable. Though you can write good code and useful programs in either version, it is worth understanding that there will be some considerable differences in code syntax and handling.

Below are a few examples, but you should keep in mind that you will likely encounter more syntactical differences as you continue to learn Python.

### Print

In Python 2, `print` is treated as a statement instead of a function, which was a typical area of confusion as many other actions in Python require arguments inside of parentheses to execute. If you want your console to print out `Sammy the Shark is my favorite sea creature` in Python 2 you can do so with the following `print` statement:

```
print "Sammy the Shark is my favorite sea creature"
```

With Python 3, `print()` is now explicitly treated as a function, so to print out the same string above, you can do so simply and easily using the syntax of a function:

```
print("Sammy the Shark is my favorite sea creature")
```

This change made Python's syntax more consistent and also made it easier to change between different print functions. Conveniently, the

`print()` syntax is also backwards-compatible with Python 2.7, so your Python 3 `print()` functions can run in either version.

## Division with Integers

In Python 2, any number that you type without decimals is treated as the programming type called integer. While at first glance this seems like an easy way to handle programming types, when you try to divide integers together sometimes you expect to get an answer with decimal places (called a float), as in:

```
5 / 2 = 2.5
```

However, in Python 2 integers were strongly typed and would not change to a float with decimal places even in cases when that would make intuitive sense.

When the two numbers on either side of the division `/` symbol are integers, Python 2 does floor division so that for the quotient  $\times$  the number returned is the largest integer less than or equal to  $\times$ . This means that when you write `5 / 2` to divide the two numbers, Python 2.7 returns the largest integer less than or equal to 2.5, in this case 2:

```
a = 5 / 2
print a
```

**Output**

2

To override this, you could add decimal places as in `5.0 / 2.0` to get the expected answer `2.5`.

In Python 3, [integer division](#) became more intuitive, as in:

```
a = 5 / 2
print(a)
```

**Output**

`2.5`

You can still use `5.0 / 2.0` to return `2.5`, but if you want to do floor division you should use the Python 3 syntax of `//`, like this:

```
b = 5 // 2
print(b)
```

**Output**

`2`

This modification in Python 3 made dividing by integers much more intuitive and is a feature that is not backwards compatible with Python 2.7.

## Unicode Support

When programming languages handle the [string](#) type — that is, a sequence of characters — they can do so in a few different ways so that computers can convert numbers to letters and other symbols.



Python 2 uses the ASCII alphabet by default, so when you type "Hello, Sammy!" Python 2 will handle the string as ASCII. Limited to a couple of hundred characters at best in various extended forms, ASCII is not a very flexible method for encoding characters, especially non-English characters.

To use the more versatile and robust Unicode character encoding, which supports over 128,000 characters across contemporary and historic scripts and symbol sets, you would have to type `u"Hello, Sammy!"`, with the `u` prefix standing for Unicode.

Python 3 uses Unicode by default, which saves programmers extra development time, and you can easily type and display many more characters directly into your program. Because Unicode supports greater linguistic character diversity as well as the display of emojis, using it as the default character encoding ensures that mobile devices around the world are readily supported in your development projects.

If you would like your Python 3 code to be backwards-compatible with Python 2, though, you can keep the `u` before your string.

## **Continued Development**

The biggest difference between Python 3 and Python 2 is not a syntactical one, but the fact that Python 2.7 will lose continued support in 2020 and Python 3 will continue to be developed with more features and more bug fixes.

Recent developments have included [formatted string literals](#), simpler customization of [class creation](#), and a cleaner syntactical way to handle matrix multiplication.

Continued development of Python 3 means that developers can rely on having issues fixed in a timely manner, and programs can be more

effective with increased functionality being built in over time.

## Additional Points to Consider

As someone starting Python as a new programmer, or an experienced programmer new to the Python language, you will want to consider what you are hoping to achieve in learning the language.

If you are hoping just to learn without a set project in mind, you will likely most want to take into account that Python 3 will continue to be supported and developed, while Python 2.7 will not.

If, however, you are planning to join an existing project, you will likely most want to see what version of Python the team is using, how a different version may interact with the legacy codebase, if the packages the project uses are supported in a different version, and what the implementation details of the project are.

If you are beginning a project that you have in mind, it would be worthwhile to investigate what packages are available to use and with which version of Python they are compatible. As noted above, though earlier versions of Python 3 had less compatibility with libraries built for versions of Python 2, many have ported over to Python 3 or are committed to doing so in the next four years.

## Conclusion

Python is a versatile and well-documented programming language to learn, and whether you choose to work with Python 2 or Python 3, you will be able to work on exciting software projects.

Though there are several key differences, it is not too difficult to move from Python 3 to Python 2 with a few tweaks, and you will often find that Python 2.7 can easily run Python 3 code, especially when you are

starting out. You can learn more about this process by reading the tutorial [How To Port Python 2 Code to Python 3](#).

It is important to keep in mind that as more developer and community attention focuses on Python 3, the language will become more refined and in-line with the evolving needs of programmers, and less support will be given to Python 2.7.

# How To Install Python 3 and Set Up a Local Programming Environment on Ubuntu 16.04

This tutorial will get you up and running with a local Python 3 programming environment in Ubuntu 16.04.

Python is a versatile programming language that can be used for many different programming projects. First published in 1991 with a name inspired by the British comedy group Monty Python, the development team wanted to make Python a language that was fun to use. Easy to set up, and written in a relatively straightforward style with immediate feedback on errors, Python is a great choice for beginners and experienced developers alike. Python 3 is the most current version of the language and is considered to be the future of Python.

This tutorial will guide you through installing Python 3 on your local Linux machine and setting up a programming environment via the command line. This tutorial will explicitly cover the installation procedures for Ubuntu 16.04, but the general principles apply to any other distribution of Debian Linux.

## Prerequisites

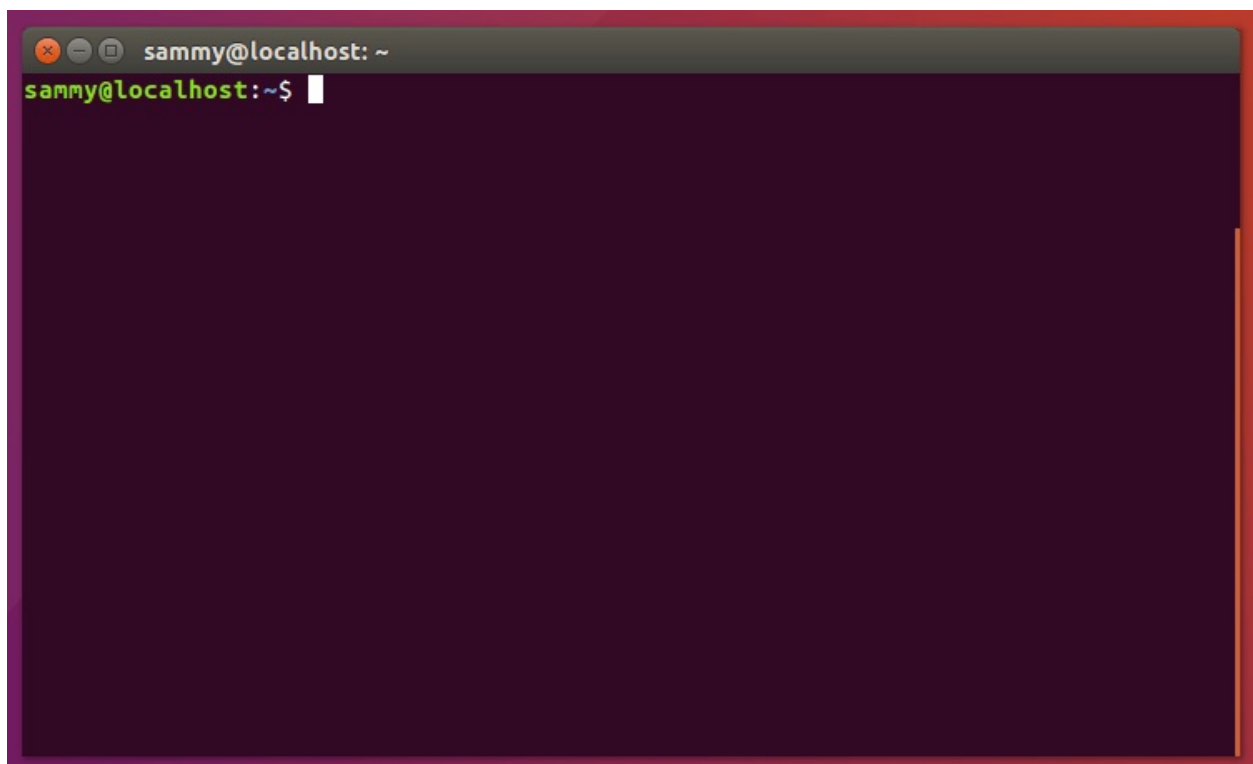
You will need a computer with Ubuntu 16.04 installed, as well as have administrative access to that machine and an internet connection.

## Step 1 — Setting Up Python 3

We'll be completing our installation and setup on the command line, which is a non-graphical way to interact with your computer. That is,

instead of clicking on buttons, you'll be typing in text and receiving feedback from your computer through text as well. The command line, also known as a shell, can help you modify and automate many of the tasks you do on a computer every day, and is an essential tool for software developers. There are many terminal commands to learn that can enable you to do more powerful things. The article "[An Introduction to the Linux Terminal](#)" can get you better oriented with the terminal.

On Ubuntu 16.04, you can find the Terminal application by clicking on the Ubuntu icon in the upper-left hand corner of your screen and typing "terminal" into the search bar. Click on the Terminal application icon to open it. Alternatively, you can hit the CTRL, ALT, and T keys on your keyboard at the same time to open the Terminal application automatically.



Ubuntu Terminal

Ubuntu 16.04 ships with both Python 3 and Python 2 pre-installed. To make sure that our versions are up-to-date, let's update and upgrade the system with `apt-get`:

```
sudo apt-get update
sudo apt-get -y upgrade
```

The `-y` flag will confirm that we are agreeing for all items to be installed, but depending on your version of Linux, you may need to confirm additional prompts as your system updates and upgrades.

Once the process is complete, we can check the version of Python 3 that is installed in the system by typing:

```
python3 -V
```

You will receive output in the terminal window that will let you know the version number. The version number may vary, but it will look similar to this:

#### **Output**

```
Python 3.5.2
```

To manage software packages for Python, let's install `pip`:

```
sudo apt-get install -y python3-pip
```

A tool for use with Python, `pip` installs and manages programming packages we may want to use in our development projects. You can

install Python packages by typing:

```
pip3 install package_name
```

Here, **package\_name** can refer to any Python package or library, such as Django for web development or NumPy for scientific computing. So if you would like to install NumPy, you can do so with the command `pip3 install numpy`.

There are a few more packages and development tools to install to ensure that we have a robust set-up for our programming environment:

```
sudo apt-get install build-essential libssl-dev  
libffi-dev python-dev
```

Once Python is set up, and pip and other tools are installed, we can set up a virtual environment for our development projects.

## Step 2 — Setting Up a Virtual Environment

Virtual environments enable you to have an isolated space on your computer for Python projects, ensuring that each of your projects can have its own set of dependencies that won't disrupt any of your other projects.

Setting up a programming environment provides us with greater control over our Python projects and over how different versions of packages are handled. This is especially important when working with third-party packages.

You can set up as many Python programming environments as you want. Each environment is basically a directory or folder in your

computer that has a few scripts in it to make it act as an environment.

We need to first install the venv module, part of the standard Python 3 library, so that we can create virtual environments. Let's install venv by typing:

```
sudo apt-get install -y python3-venv
```

With this installed, we are ready to create environments. Let's choose which directory we would like to put our Python programming environments in, or we can create a new directory with `mkdir`, as in:

```
mkdir environments  
cd environments
```

Once you are in the directory where you would like the environments to live, you can create an environment by running the following command:

```
python3 -m venv my_env
```

Essentially, this sets up a new directory that contains a few items which we can view with the `ls` command:

```
ls my_env
```

#### Output

```
bin include lib lib64 pyvenv.cfg share
```



Together, these files work to make sure that your projects are isolated from the broader context of your local machine, so that system files and project files don't mix. This is good practice for version control and to ensure that each of your projects has access to the particular packages that it needs. Python Wheels, a built-package format for Python that can speed up your software production by reducing the number of times you need to compile, will be in the Ubuntu 16.04 `share` directory.

To use this environment, you need to activate it, which you can do by typing the following command that calls the activate script:

```
source my_env/bin/activate
```

Your prompt will now be prefixed with the name of your environment, in this case it is called **my\_env**. Your prefix may look somewhat different, but the name of your environment in parentheses should be the first thing you see on your line:

```
(my_env) sammy@sammy:~/environments$
```

This prefix lets us know that the environment **my\_env** is currently active, meaning that when we create programs here they will use only this particular environment's settings and packages.

Note: Within the virtual environment, you can use the command `python` instead of `python3`, and `pip` instead of `pip3` if you would prefer. If you use Python 3 on your machine outside of an environment, you will need to use the `python3` and `pip3` commands exclusively.

After following these steps, your virtual environment is ready to use.

## Step 3 — Creating a Simple Program

Now that we have our virtual environment set up, let's create a simple "Hello, World!" program. This will make sure that our environment is working and gives us the opportunity to become more familiar with Python if we aren't already.

To do this, we'll open up a command-line text editor such as nano and create a new file:

```
(my_env) sammy@sammy:~/environments$ nano hello.py
```

Once the text file opens up in the terminal window we'll type out our program:

```
print("Hello, World!")
```

Exit nano by typing the `control` and `x` keys, and when prompted to save the file press `y`.

Once you exit out of nano and return to your shell, let's run the program:

```
(my_env) sammy@sammy:~/environments$ python hello.py
```

The `hello.py` program that you just created should cause your terminal to produce the following output:

### Output

```
Hello, World!
```

To leave the environment, simply type the command `deactivate` and you will return to your original directory.

## Conclusion

Congratulations! At this point you have a Python 3 programming environment set up on your local Ubuntu machine and can begin a coding project!

To set up Python 3 on another computer, follow the [local programming environment guides](#) for [Debian 8](#), [CentOS 7](#), [Windows 10](#), or [macOS](#). You can also read about [installing Python and setting up a programming environment on an Ubuntu 16.04 server](#), which is especially useful when working on development teams.

With your local machine ready for software development, you can continue to learn more about coding in Python by following “[Understanding Data Types in Python 3](#)” and “[How To Use Variables in Python 3](#)”.

# How To Install Python 3 and Set Up a Local Programming Environment on macOS

Python is a versatile programming language that can be used for many different programming projects. First published in 1991 with a name inspired by the British comedy group Monty Python, the development team wanted to make Python a language that was fun to use. Easy to set up, and written in a relatively straightforward style with immediate feedback on errors, Python is a great choice for beginners and experienced developers alike. Python 3 is the most current version of the language and is considered to be the future of Python.

This tutorial will guide you through installing Python 3 on your local macOS machine and setting up a programming environment via the command line.

## Prerequisites

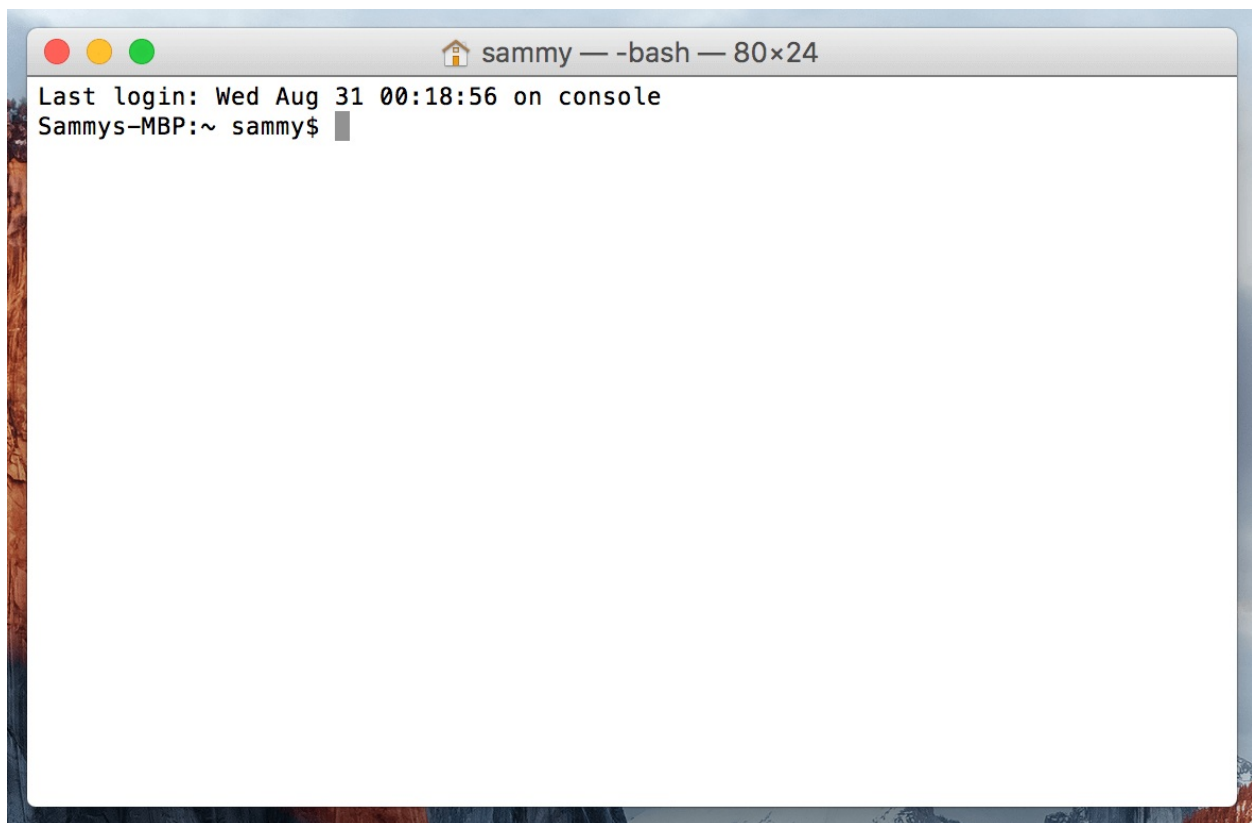
You will need a macOS computer with administrative access that is connected to the internet.

## Step 1 — Opening Terminal

We'll be completing most of our installation and set up on the command line, which is a non-graphical way to interact with your computer. That is, instead of clicking on buttons, you'll be typing in text and receiving feedback from your computer through text as well. The command line, also known as a shell, can help you modify and automate many of the

tasks you do on a computer every day, and is an essential tool for software developers.

The macOS Terminal is an application you can use to access the command line interface. Like any other application, you can find it by going into Finder, navigating to the Applications folder, and then into the Utilities folder. From here, double-click the Terminal like any other application to open it up. Alternatively, you can use Spotlight by holding down the command and spacebar keys to find Terminal by typing it out in the box that appears.



macOS Terminal

There are many more Terminal commands to learn that can enable you to do more powerful things. The article “[An Introduction to the Linux](#)

[Terminal](#)” can get you better oriented with the Linux Terminal, which is similar to the macOS Terminal.

## Step 2 — Installing Xcode

Xcode is an integrated development environment (IDE) that is comprised of software development tools for macOS. You may have Xcode installed already. To check, in your Terminal window, type:

```
xcode-select -p
```

If you receive the following output, then Xcode is installed:

### Output

```
/Library/Developer/CommandLineTools
```

If you received an error, then in your web browser install [Xcode from the App Store](#) and accept the default options.

Once Xcode is installed, return to your Terminal window. Next, you’ll need to install Xcode’s separate Command Line Tools app, which you can do by typing:

```
xcode-select --install
```

At this point, Xcode and its Command Line Tools app are fully installed, and we are ready to install the package manager Homebrew.

## Step 3 — Installing and Setting Up Homebrew

While the OS X Terminal has a lot of the functionality of Linux Terminals and other Unix systems, it does not ship with a good package manager. A package manager is a collection of software tools that work to automate installation processes that include initial software installation, upgrading and configuring of software, and removing software as needed. They keep installations in a central location and can maintain all software packages on the system in formats that are commonly used. Homebrew provides OS X with a free and open source software package managing system that simplifies the installation of software on OS X.

To install Homebrew, type this into your Terminal window:

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

Homebrew is made with Ruby, so it will be modifying your computer's Ruby path. The `curl` command pulls a script from the specified URL. This script will explain what it will do and then pauses the process to prompt you to confirm. This provides you with a lot of feedback on what the script is going to be doing to your system and gives you the opportunity to verify the process.

If you need to enter your password note that your keystrokes will not display in the Terminal window but they will be recorded, simply press the `return` key once you've entered your password. Otherwise press the letter `y` for "yes" whenever you are prompted to confirm the installation.

Let's walk through the flags that are associated with the `curl` command:

- The `-f` or `--fail` flag tells the Terminal window to give no HTML document output on server errors.
- The `-s` or `--silent` flag mutes `curl` so that it does not show the progress meter, and combined with the `-S` or `--show-error` flag it will ensure that `curl` shows an error message if it fails.
- The `-L` or `--location` flag will tell `curl` to redo the request to a new place if the server reports that the requested page has moved to a different location.

Once the installation process is complete, we'll put the Homebrew directory at the top of the `PATH` environment variable. This will ensure that Homebrew installations will be called over the tools that Mac OS X may select automatically that could run counter to the development environment we're creating.

You should create or open the `~/.bash_profile` file with the command-line text editor `nano` using the `nano` command:

```
nano ~/.bash_profile
```

Once the file opens up in the Terminal window, write the following:

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

To save your changes, hold down the `control` key and the letter `o`, and when prompted press the `return` key. Now you can exit `nano` by holding the `control` key and the letter `x`.

For these changes to activate, in the Terminal window, type:



```
source ~/.bash_profile
```

Once you have done this, the changes you have made to the `PATH` environment variable will be effective.

We can make sure that Homebrew was successfully installed by typing:

```
brew doctor
```

If no updates are required at this time, the Terminal output will read:

#### **Output**

```
Your system is ready to brew.
```

Otherwise, you may get a warning to run another command such as `brew update` to ensure that your installation of Homebrew is up to date.

Once Homebrew is ready, you can install Python 3.

## **Step 4 — Installing Python 3**

You can use Homebrew to search for everything you can install with the `brew search` command, but to provide us with a shorter list, let's instead search for just the available Python-related packages or modules:

```
brew search python
```

The Terminal will output a list of what you can install, like this:

## Output

```
app-engine-python          micropython
python3
boost-python              python
wxpython
gst-python                python-markdown
zpython
homebrew/apache/mod_python
homebrew/versions/gst-python010
homebrew/python/python-dbus
Caskroom/cask/kk7ds-python-runtime
homebrew/python/vpython
Caskroom/cask/mysql-connector-python
```

Python 3 will be among the items on the list. Let's go ahead and install it:

```
brew install python3
```

The Terminal window will give you feedback regarding the installation process of Python 3, it may take a few minutes before installation is complete.

Along with Python 3, Homebrew will install pip, setuptools and wheel.

A tool for use with Python, we will use pip to install and manage programming packages we may want to use in our development projects. You can install Python packages by typing:

```
pip3 install package_name
```

Here, **package\_name** can refer to any Python package or library, such as Django for web development or NumPy for scientific computing. So if you would like to install NumPy, you can do so with the command `pip3 install numpy`.

setuptools facilitates packaging Python projects, and wheel is a built-package format for Python that can speed up your software production by reducing the number of times you need to compile.

To check the version of Python 3 that you installed, you can type:

```
python3 --version
```

This will output the specific version of Python that is currently installed, which will by default be the most up-to-date stable version of Python 3 that is available.

To update your version of Python 3, you can first update Homebrew and then update Python:

```
brew update  
brew upgrade python3
```

It is good practice to ensure that your version of Python is up-to-date.

## Step 5 — Creating a Virtual Environment

Now that we have Xcode, Homebrew, and Python installed, we can go on to create our programming environment.

Virtual environments enable you to have an isolated space on your computer for Python projects, ensuring that each of your projects can have its own set of dependencies that won't disrupt any of your other projects.

Setting up a programming environment provides us with greater control over our Python projects and over how different versions of packages are handled. This is especially important when working with third-party packages.

You can set up as many Python programming environments as you would like. Each environment is basically a directory or folder in your computer that has a few scripts in it to make it act as an environment.

Choose which directory you would like to put your Python programming environments in, or create a new directory with `mkdir`, as in:

```
mkdir Environments  
cd Environments
```

Once you are in the directory where you would like the environments to live, you can create an environment by running the following command:

```
python3.6 -m venv my_env
```

Essentially, this command creates a new directory (in this case called **my\_env**) that contains a few items: - The `pyvenv.cfg` file points to the Python installation that you used to run the command. - The `lib` subdirectory contains a copy of the Python version and has a `site-`

packages subdirectory inside it that starts out empty but will eventually hold the relevant third-party modules that you install. - The `include` subdirectory compiles packages. - The `bin` subdirectory has a copy of the Python binary along with the activate shell script that is used to set up the environment.

Together, these files work to make sure that your projects are isolated from the broader context of your local machine, so that system files and project files don't mix. This is good practice for version control and to ensure that each of your projects has access to the particular packages that it needs.

To use this environment, you need to activate it, which you can do by typing the following command that calls the activate script:

```
source my_env/bin/activate
```

Your prompt will now be prefixed with the name of your environment, in this case it is called `my_env`:

```
(my_env) Sammys-MBP:~ sammy$
```

This prefix lets us know that the environment `my_env` is currently active, meaning that when we create programs here they will use only this particular environment's settings and packages.

Note: Within the virtual environment, you can use the command `python` instead of `python3`, and `pip` instead of `pip3` if you would prefer. If you use Python 3 on your machine outside of an environment, you'll need to use the `python3` and `pip3` commands exclusively, as `python` and `pip` will call an earlier version of Python.

After following these steps, your virtual environment is ready to use.

## Step 6 — Creating a Simple Program

Now that we have our virtual environment set up, let's create a simple "Hello, World!" program. This will make sure that our environment is working and gives us the opportunity to become more familiar with Python if we aren't already.

To do this, we'll open up a command-line text editor such as nano and create a new file:

```
(my_env) Sammys-MBP:~ sammy$ nano hello.py
```

Once the text file opens up in Terminal we'll type out our program:

```
print("Hello, World!")
```

Exit nano by typing the `control` and `x` keys, and when prompted to save the file press `y`.

Once you exit out of nano and return to your shell, let's run the program:

```
(my_env) Sammys-MBP:~ sammy$ python hello.py
```

The `hello.py` program that you just created should cause Terminal to produce the following output:

### Output

```
Hello, World!
```

To leave the environment, simply type the command `deactivate` and you'll return to your original directory.

## Conclusion

Congratulations! At this point you have a Python 3 programming environment set up on your local Mac OS X machine and can begin a coding project!

To set up Python 3 on another computer, follow the [local programming environment guides](#) for [Ubuntu 16.04](#), [Debian 8](#), [CentOS 7](#), or [Windows 10](#). You can also read about [installing Python and setting up a programming environment on an Ubuntu 16.04 server](#), which is especially useful when working on development teams.

With your local machine ready for software development, you can continue to learn more about coding in Python by following "[Understanding Data Types in Python 3](#)" and "[How To Use Variables in Python 3](#)".

# How To Install Python 3 and Set Up a Local Programming Environment on Windows 10

Python is a versatile programming language that can be used for many different programming projects. First published in 1991 with a name inspired by the British comedy group Monty Python, the development team wanted to make Python a language that was fun to use. Easy to set up, and written in a relatively straightforward style with immediate feedback on errors, Python is a great choice for beginners and experienced developers alike. Python 3 is the most current version of the language and is considered to be the future of Python.

This tutorial will guide you through installing Python 3 on your local Windows 10 machine and setting up a programming environment via the command line.

## Prerequisites

You will need a Windows 10 computer with administrative access that is connected to the internet.

## Step 1 — Opening and Configuring PowerShell

We'll be completing most of our installation and setup on a command-line interface, which is a non-graphical way to interact with your computer. That is, instead of clicking on buttons, you'll be typing in text and receiving feedback from your computer through text as well. The command line, also known as a shell, can help you modify and automate

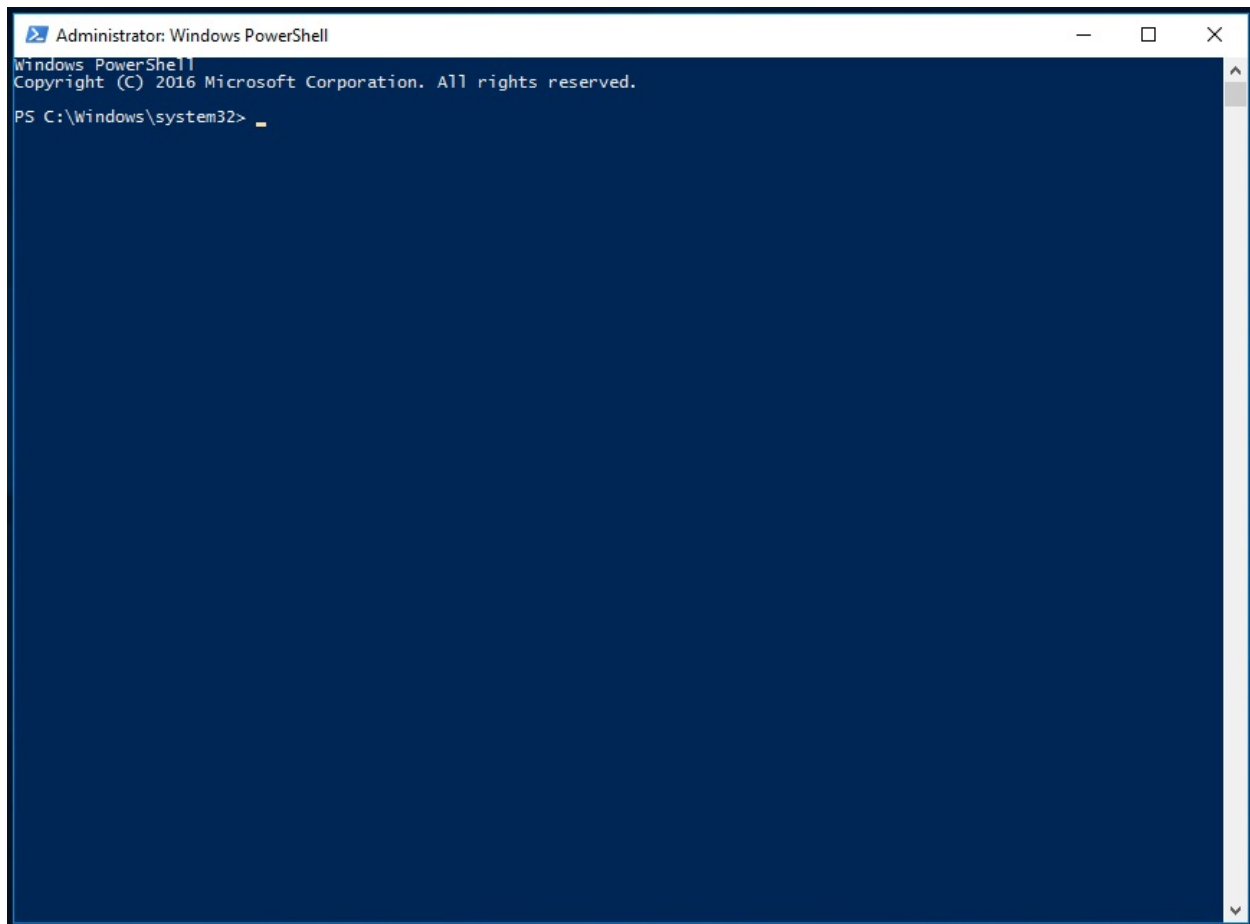


many of the tasks you do on a computer every day, and is an essential tool for software developers.

PowerShell is a program from Microsoft that provides a command-line shell interface. Administrative tasks are performed by running cmdlets, which are pronounced command-lets, specialized classes of the .NET software framework that can carry out operations. Open-sourced in August 2016, PowerShell is now available across platforms, for both Windows and UNIX systems (including Mac and Linux).

To find Windows PowerShell, you can right-click on the Start menu icon on the lower left-hand corner of your screen. When the menu pops up, you should click on “Search,” then type “PowerShell” into the search bar. When you are presented with options, right-click on “Windows PowerShell,” the Desktop app. For our purposes, we’ll select “Run as Administrator.” When you are prompted with a dialogue box that asks “Do you want to allow this app to make changes to your PC?” click on “Yes.”

Once you do this, you’ll see a text-based interface that has a string of words that looks like this:



Windows 10 PowerShell

We can switch out of the system folder by typing the following command:

```
cd ~
```

Then we'll be in a directory such as PS C:\Users\**Sammy**.

To continue with our installation process, we are going to set up some permissions through PowerShell. Configured to run in the most secure mode by default, there are a few levels of permissions that you can set up as an administrator:

- Restricted is the default execution policy, under this mode you will not be able to run scripts, and PowerShell will work only as an interactive shell.
- AllSigned will enable you to run all scripts and configuration files that are signed by a trusted publisher, meaning that you could potentially open your machine up to the risk of running malicious scripts that happen to be signed by a trusted publisher.
- RemoteSigned will let you run scripts and configuration files downloaded from the internet signed by trusted publishers, again opening your machine up to vulnerabilities if these trusted scripts are actually malicious.
- Unrestricted will run all scripts and configuration files downloaded from the internet as soon as you confirm that you understand that the file was downloaded from the internet. In this case no digital signature is required so you could be opening your machine up to the risk of running unsigned and potentially malicious scripts downloaded from the internet.

We are going to use the RemoteSigned execution policy to set the permission for the current user that allows the PowerShell to accept downloaded scripts that we trust without making the permissions as broad as they would be with an Unrestricted permission. In the PowerShell, let's type:

```
Set-ExecutionPolicy -Scope CurrentUser
```

PowerShell will then prompt us to provide an execution policy, and since we want to use RemoteSigned, we'll type:

RemoteSigned

Once we press `enter` we'll be asked if we do want to change the execution policy. Type the letter `y` for "yes," and allow the changes to take effect. We can confirm that this worked by asking for the current permissions across the machine by typing:

```
Get-ExecutionPolicy -List
```

You should receive output that looks something like this:

#### Output

| Scope         | ExecutionPolicy |
|---------------|-----------------|
| -----         | -----           |
| MachinePolicy | Undefined       |
| UserPolicy    | Undefined       |
| Process       | Undefined       |
| CurrentUser   | RemoteSigned    |
| LocalMachine  | Undefined       |

This confirms that the current user can run trusted scripts downloaded from the internet. We can now move on to downloading the files we will need to set up our Python programming environment.

## Step 2 — Installing the Package Manager Chocolatey

A package manager is a collection of software tools that work to automate installation processes that include the initial installation, upgrading and configuring of software, and removing software as

needed. They keep software installations in a central location and can maintain all software packages on the system in formats that are commonly used.

Chocolatey is a command-line package manager built for Windows that works like `apt-get` does on Linux. Available in an open-source version, Chocolatey will help you quickly install applications and tools, and we will be using it to download what we need for our development environment.

Before we install the script, let's read it to confirm that we are happy with the changes it will make to our machine. To do this, we will use the .NET scripting framework to download and display the Chocolatey script within the terminal window. We'll create a `WebClient` object called `$script` (you can call it whatever you want as long as you use `$` as the first character), that shares Internet connection settings with Internet Explorer:

```
$script = New-Object Net.WebClient
```

Let's look at the options that we have available to us by piping the object to the `Get-Member` class to return all members (properties and methods) of this `WebClient` object:

```
$script | Get-Member
```

#### Snippet of Output

```
. . .  
DownloadFileAsync          Method          void  
DownloadFileAsync(uri address, string fileName), void
```

```

DownloadFileAsync(ur...
DownloadFileTaskAsync      Method
System.Threading.Tasks.Task
DownloadFileTaskAsync(string address, string fileName...
DownloadString              Method      string
DownloadString(string address), string
DownloadString(uri address) #method we will use
DownloadStringAsync         Method      void
DownloadStringAsync(uri address), void
DownloadStringAsync(uri address, Sy...
DownloadStringTaskAsync     Method
System.Threading.Tasks.Task[string]
DownloadStringTaskAsync(string address), Sy...
. . .

```

Looking over the output, we can identify the `DownloadString` method that we can use to display the script and signature in the PowerShell window. Let's implement this method:

```
$script.DownloadString("https://chocolatey.org/install
.ps1")
```

After we inspect the script, we can install Chocolatey by typing the following into PowerShell:

```
iwr https://chocolatey.org/install.ps1 -
UseBasicParsing | iex
```

The `cmdlet iwr` or `Invoke-WebRequest` allows us to extract data from the web. This will pass the script to the `iex` or `Invoke-Expression` cmdlet, which will execute the contents of the script, running the installation script for the Chocolatey package manager.

Allow PowerShell to install Chocolatey. Once it is fully installed, we can begin installing additional tools with the `choco` command.

If we need to upgrade Chocolatey at any time in the future, we can run the following command:

```
choco upgrade chocolatey
```

With our package manager installed, we can go on to install the rest of what we need for our Python 3 programming environment.

### Step 3 — Installing the Text Editor nano (Optional)

We are now going to install nano, a text editor that uses a command line interface, which we can use to write programs directly within PowerShell. This is not a compulsory step, as you can alternatively use a text editor with a graphical user interface such as Notepad, but nano will get us more accustomed to using PowerShell.

Let's use Chocolatey to install nano:

```
choco install -y nano
```

Here we used the `-y` flag so that we confirm automatically that we want to run the script without being prompted.

Once nano is installed, we will be able to use the `nano` command to create new text files and will eventually use it to write our first Python

program.

## Step 4 — Installing Python 3

Just like we did with nano above, we will use Chocolatey to install Python 3:

```
choco install -y python3
```

PowerShell will now install Python 3, generating output within PowerShell during that process.

Once the process is completed, you should see the following output:

### Output

```
Environment Vars (like PATH) have changed.
```

```
Close/reopen your shell to
```

```
See the changes (or in powershell/cmd.exe just type  
'refreshenv').
```

```
The install of python3 was successful.
```

```
Software installed as 'EXE', install location is  
likely default.
```

```
Chocolatey installed 1/1 packages. 0 packages failed.
```

```
See the log for details
```

```
(C:\ProgramData\chocolatey\logs\chocolatey.log).
```

With the installation is finished, you'll want to confirm that Python is installed and ready to go. To see the changes, use the command



`refreshenv` or close and re-open PowerShell as an Administrator, then check the version of Python available to you on your local machine:

```
python -V
```

You should get output such as:

**Output**

```
Python 3.5.1
```

Alongside Python, `pip` will be installed, which will manage software packages for Python. Let's ensure that `pip` is up-to-date by upgrading it:

```
python -m pip install --upgrade pip
```

With Chocolatey, we can call Python 3 with the `python` command. We will use the `-m` flag to run the library module as a script, terminating the option list, and from there use `pip` to install its upgrade.

Once Python is installed and `pip` updated, we can set up a virtual environment for our development projects.

## Step 5 — Setting Up a Virtual Environment

Now that we have Chocolatey, nano, and Python installed, we can go on to create our programming environment with the `venv` module.

Virtual environments enable you to have an isolated space on your computer for Python projects, ensuring that each of your projects can have its own set of dependencies that won't disrupt any of your other projects.

Setting up a programming environment provides us with greater control over our Python projects and over how different versions of packages are handled. This is especially important when working with third-party packages.

You can set up as many Python programming environments as you want. Each environment is basically a directory or folder in your computer that has a few scripts in it to make it act as an environment.

Choose which directory you would like to put your Python programming environments in, or create a new directory with `mkdir`, as in:

```
mkdir Environments  
cd Environments
```

Once you are in the directory where you would like the environments to live, you can create an environment by running the following command:

```
python -m venv my_env
```

Using the `python` command, we will run the `venv` library module to create the virtual environment that in this case we have called `my_env`.

Essentially, `venv` sets up a new directory that contains a few items which we can view with the `ls` command:

```
ls my_env
```

**Output**

| Mode       | LastWriteTime     | Length | Name |
|------------|-------------------|--------|------|
| ----       | -----             | -----  | ---- |
| d-----     | 8/22/2016 2:20 PM |        |      |
| Include    |                   |        |      |
| d-----     | 8/22/2016 2:20 PM |        | Lib  |
| d-----     | 8/22/2016 2:20 PM |        |      |
| Scripts    |                   |        |      |
| -a-----    | 8/22/2016 2:20 PM | 107    |      |
| pyvenv.cfg |                   |        |      |

Together, these files work to make sure that your projects are isolated from the broader context of your local machine, so that system files and project files don't mix. This is good practice for version control and to ensure that each of your projects has access to the particular packages that it needs.

To use this environment, you need to activate it, which you can do by typing the following command that calls the activate script in the `Scripts` directory:

```
my_env\Scripts\activate
```

Your prompt will now be prefixed with the name of your environment, in this case it is called **my\_env**:

```
(my_env) PS C:\Users\Sammy\Environments>
```

This prefix lets us know that the environment **my\_env** is currently active, meaning that when we create programs here they will use only

this particular environment's settings and packages.

## Step 6 — Creating a Simple Program

Now that we have our virtual environment set up, let's create a simple "Hello, World!" program. This will make sure that our environment is working and gives us the opportunity to become more familiar with Python if we aren't already.

To do this, we'll open up nano and create a new file:

```
(my_env) PS C:\Users\Sammy> nano hello.py
```

Once the text file opens up in Terminal we'll type out our program:

```
print("Hello, World!")
```

Exit nano by typing the `control` and `x` keys, and when prompted to save the file press `y` then the `enter` key.

Once you exit out of nano and return to your shell, let's run the program:

```
(my_env) PS C:\Users\Sammy> python hello.py
```

The `hello.py` program that you just created should cause Terminal to produce the following output:

### Output

```
Hello, World!
```

To leave the environment, simply type the command `deactivate` and you will return to your original directory.

## Conclusion

Congratulations! At this point you should have a Python 3 programming environment set up on your local Windows 10 machine and can begin a coding project!

To set up Python 3 on another computer, follow the [local programming environment guides](#) for [Ubuntu 16.04](#), [Debian 8](#), [CentOS 7](#), or [macOS](#). You can also read about [installing Python and setting up a programming environment on an Ubuntu 16.04 server](#), which is especially useful when working on development teams.

With your local machine ready for software development, you can continue to learn more about coding in Python by following “[Understanding Data Types in Python 3](#)” and “[How To Use Variables in Python 3](#)”.

# How To Install Python 3 and Set Up a Local Programming Environment on CentOS 7

Python is a versatile programming language that can be used for many different programming projects. First published in 1991 with a name inspired by the British comedy group Monty Python, the development team wanted to make Python a language that was fun to use. Easy to set up, and written in a relatively straightforward style with immediate feedback on errors, Python is a great choice for beginners and experienced developers alike. Python 3 is the most current version of the language and is considered to be the future of Python.

This tutorial will guide you through installing Python 3 on your local CentOS 7 machine and setting up a programming environment via the command line.

## Prerequisites

You will need a CentOS 7 computer with a non-root superuser account that is connected to the internet.

## Step 1 — Preparing the System

We will be completing this installation through the command line. If your CentOS 7 computer starts up with a Graphical User Interface (GUI) desktop, you can gain access to the command line interface through the Menu, by navigating to Applications, then Utilities, and then clicking on Terminal. If you need more guidance on the terminal, be sure to read through the article “[An Introduction to the Linux Terminal](#).”

Before we begin with the installation, let's make sure to update the default system applications to have the latest versions available.

We will be using the open-source package manager tool yum, which stands for Yellowdog Updater Modified. This is a commonly used tool for working with software packages on Red Hat based Linux systems like CentOS. It will let you easily install and update, as well as remove software packages on your computer.

Let's first make sure that yum is up to date by running this command:

```
sudo yum -y update
```

The `-y` flag is used to alert the system that we are aware that we are making changes, preventing the terminal from prompting us to confirm.

Next, we will install yum-utils, a collection of utilities and plugins that extend and supplement yum:

```
sudo yum -y install yum-utils
```

Finally, we'll install the CentOS Development Tools, which are used to allow you to build and compile software from source code:

```
sudo yum -y groupinstall development
```

Once everything is installed, our setup is in place and we can go on to install Python 3.

## Step 2 — Installing and Setting Up Python 3

CentOS is derived from RHEL (Red Hat Enterprise Linux), which has stability as its primary focus. Because of this, tested and stable versions of applications are what is most commonly found on the system and in downloadable packages, so on CentOS you will only find Python 2.

Since instead we would like to install the most current upstream stable release of Python 3, we will need to install IUS, which stands for Inline with Upstream Stable. A community project, IUS provides Red Hat Package Manager (RPM) packages for some newer versions of select software.

To install IUS, let's install it through yum:

```
sudo yum -y install  
https://centos7.iuscommunity.org/ius-release.rpm
```

Once IUS is finished installing, we can install the most recent version of Python:

```
sudo yum -y install python36u
```

When the installation process of Python is complete, we can check to make sure that the installation was successful by checking for its version number with the `python3.6` command:

```
python3.6 -V
```

With a version of Python 3.6 successfully installed, we will receive the following output:



## Output

Python **3.6.1**

We will next install `pip`, which will manage software packages for Python:

```
sudo yum -y install python36u-pip
```

A tool for use with Python, we will use `pip` to install and manage programming packages we may want to use in our development projects. You can install Python packages by typing:

```
sudo pip3.6 install package_name
```

Here, **package\_name** can refer to any Python package or library, such as Django for web development or NumPy for scientific computing. So if you would like to install NumPy, you can do so with the command `pip3.6 install numpy`.

Finally, we will need to install the IUS package `python36u-devel`, which provides us with libraries and header files we will need for Python 3 development:

```
sudo yum -y install python36u-devel
```

The `venv` module will be used to set up a virtual environment for our development projects in the next step.

## Step 3 — Setting Up a Virtual Environment

Now that we have Python installed and our system set up, we can go on to create our programming environment with venv.

Virtual environments enable you to have an isolated space on your computer for Python projects, ensuring that each of your projects can have its own set of dependencies that won't disrupt any of your other projects.

Setting up a programming environment provides us with greater control over our Python projects and over how different versions of packages are handled. This is especially important when working with third-party packages.

You can set up as many Python programming environments as you want. Each environment is basically a directory or folder in your computer that has a few scripts in it to make it act as an environment.

Choose which directory you would like to put your Python programming environments in, or create a new directory with `mkdir`, as in:

```
mkdir environments  
cd environments
```

Once you are in the directory where you would like the environments to live, you can create an environment by running the following command:

```
python3.6 -m venv my_env
```

Essentially, this command creates a new directory (in this case called `my_env`) that contains a few items that we can see with the `ls` command:

```
bin include lib lib64 pyvenv.cfg
```

Together, these files work to make sure that your projects are isolated from the broader context of your local machine, so that system files and project files don't mix. This is good practice for version control and to ensure that each of your projects has access to the particular packages that it needs.

To use this environment, you need to activate it, which you can do by typing the following command that calls the activate script in the `bin` directory:

```
source my_env/bin/activate
```

Your prompt will now be prefixed with the name of your environment, in this case it is called **my\_env**:

```
(my_env) [sammy@localhost environments]$
```

This prefix lets us know that the environment **my\_env** is currently active, meaning that when we create programs here they will use only this particular environment's settings and packages.

Note: Within the virtual environment, you can use the command `python` instead of `python3.6`, and `pip` instead of `pip3.6` if you would prefer. If you use Python 3 on your machine outside of an environment, you will need to use the `python3.6` and `pip3.6` commands exclusively.

After following these steps, your virtual environment is ready to use.

## Step 4 — Creating a Simple Program

Now that we have our virtual environment set up, let's create a simple "Hello, World!" program. This will make sure that our environment is working and gives us the opportunity to become more familiar with Python if we aren't already.

To do this, we'll open up a command-line text editor such as vim and create a new file:

```
(my_env) [sammy@localhost] environments]$ vi hello.py
```

Once the text file opens up in our terminal window, we will have to type `i` to enter insert mode, and then we can write our first program:

```
print("Hello, World!")
```

Now press `ESC` to leave insert mode. Next, type `:x` then `ENTER` to save and exit the file.

We are now ready to run our program:

```
(my_env) [sammy@localhost] environments]$ python  
hello.py
```

The `hello.py` program that you just created should cause the terminal to produce the following output:

#### **Output**

```
Hello, World!
```

To leave the environment, simply type the command `deactivate` and you'll return to your original directory.

## Conclusion

Congratulations! At this point you have a Python 3 programming environment set up on your local CentOS 7 machine and can begin a coding project!

To set up Python 3 on another computer, follow the [local programming environment guides](#) for [Ubuntu 16.04](#), [Debian 8](#), [macOS](#), or [Windows 10](#). You can also read about [installing Python and setting up a programming environment on an Ubuntu 16.04 server](#), which is especially useful when working on development teams.

With your local machine ready for software development, you can continue to learn more about coding in Python by following “[Understanding Data Types in Python 3](#)” and “[How To Use Variables in Python 3](#)”.

# How To Install Python 3 and Set Up a Programming Environment on an Ubuntu 16.04 Server

This tutorial will get your Ubuntu 16.04 or Debian 8 server set up with a Python 3 programming environment. Programming on a server has many advantages and makes it easier for teams to collaborate on a development project. The general principles of this tutorial will apply to any distribution of Debian Linux.

Python is a versatile programming language that can be used for many different programming projects. First published in 1991 with a name inspired by the British comedy group Monty Python, the development team wanted to make Python a language that was fun to use. Easy to set up, and written in a relatively straightforward style with immediate feedback on errors, Python is a great choice for beginners and experienced developers alike. [Python 3 is the most current version](#) of the language and is considered to be the future of Python.

This tutorial will guide you through installing Python 3 on a Debian Linux server and setting up a programming environment.

## Prerequisites

Before you begin, you'll need a server with Ubuntu 16.04, Debian 8, or another version of Debian Linux installed. You'll also need a sudo non-root user, which you can set up by following one of the tutorials below:

- [Initial Server Setup with Ubuntu 16.04](#)
- [Initial Server Setup with Debian 8](#)

If you're not already familiar with a terminal environment, you may find the article "[An Introduction to the Linux Terminal](#)" useful for becoming better oriented with the terminal.

## Step 1 — Setting Up Python 3

Ubuntu 16.04, Debian 8, and other versions of Debian Linux ship with both Python 3 and Python 2 pre-installed. To make sure that our versions are up-to-date, let's update and upgrade the system with `apt-get`:

```
sudo apt-get update
sudo apt-get -y upgrade
```

The `-y` flag will confirm that we are agreeing for all items to be installed, but depending on your version of Linux, you may need to confirm additional prompts as your system updates and upgrades.

Once the process is complete, we can check the version of Python 3 that is installed in the system by typing:

```
python3 -V
```

You'll receive output in the terminal window that will let you know the version number. The version number may vary depending on whether you are on Ubuntu 16.04, Debian 8, or another version of Linux, but it will look similar to this:

### Output

```
Python 3.5.2
```

To manage software packages for Python, let's install pip:

```
sudo apt-get install -y python3-pip
```

A tool for use with Python, pip installs and manages programming packages we may want to use in our development projects. You can install Python packages by typing:

```
pip3 install package_name
```

Here, **package\_name** can refer to any Python package or library, such as Django for web development or NumPy for scientific computing. So if you would like to install NumPy, you can do so with the command `pip3 install numpy`.

There are a few more packages and development tools to install to ensure that we have a robust set-up for our programming environment:

```
sudo apt-get install build-essential libssl-dev  
libffi-dev python3-dev
```

Once Python is set up, and pip and other tools are installed, we can set up a virtual environment for our development projects.

## Step 2 — Setting Up a Virtual Environment

Virtual environments enable you to have an isolated space on your server for Python projects, ensuring that each of your projects can have its own set of dependencies that won't disrupt any of your other projects.



Setting up a programming environment provides us with greater control over our Python projects and over how different versions of packages are handled. This is especially important when working with third-party packages.

You can set up as many Python programming environments as you want. Each environment is basically a directory or folder on your server that has a few scripts in it to make it act as an environment.

We need to first install the `venv` module, part of the standard Python 3 library, so that we can invoke the `pyvenv` command which will create virtual environments for us. Let's install `venv` by typing:

```
sudo apt-get install -y python3-venv
```

With this installed, we are ready to create environments. Let's choose which directory we would like to put our Python programming environments in, or we can create a new directory with `mkdir`, as in:

```
mkdir environments  
cd environments
```

Once you are in the directory where you would like the environments to live, you can create an environment by running the following command:

```
pyvenv my_env
```

Essentially, `pyvenv` sets up a new directory that contains a few items which we can view with the `ls` command:

```
ls my_env
```

### Output

```
bin include lib lib64 pyvenv.cfg share
```

Together, these files work to make sure that your projects are isolated from the broader context of your local machine, so that system files and project files don't mix. This is good practice for version control and to ensure that each of your projects has access to the particular packages that it needs. Python Wheels, a built-package format for Python that can speed up your software production by reducing the number of times you need to compile, will be in the Ubuntu 16.04 `share` directory but in Debian 8 it will be in each of the `lib` directories as there is no `share` directory.

To use this environment, you need to activate it, which you can do by typing the following command that calls the activate script:

```
source my_env/bin/activate
```

Your prompt will now be prefixed with the name of your environment, in this case it is called **my\_env**. Depending on what version of Debian Linux you are running, your prefix may look somewhat different, but the name of your environment in parentheses should be the first thing you see on your line:

```
(my_env) sammy@ubuntu:~/environments$
```

This prefix lets us know that the environment **my\_env** is currently active, meaning that when we create programs here they will use only this particular environment's settings and packages.

Note: Within the virtual environment, you can use the command `python` instead of `python3`, and `pip` instead of `pip3` if you would prefer. If you use Python 3 on your machine outside of an environment, you will need to use the `python3` and `pip3` commands exclusively.

After following these steps, your virtual environment is ready to use.

### Step 3 — Creating a Simple Program

Now that we have our virtual environment set up, let's create a simple "Hello, World!" program. This will make sure that our environment is working and gives us the opportunity to become more familiar with Python if we aren't already.

To do this, we'll open up a command-line text editor such as `nano` and create a new file:

```
(my_env) sammy@ubuntu:~/environments$ nano hello.py
```

Once the text file opens up in the terminal window we'll type out our program:

```
print("Hello, World!")
```

Exit `nano` by typing the `control` and `x` keys, and when prompted to save the file press `y`.

Once you exit out of `nano` and return to your shell, let's run the program:

```
(my_env) sammy@ubuntu:~/environments$ python hello.py
```

The `hello.py` program that you just created should cause your terminal to produce the following output:

#### **Output**

```
Hello, World!
```

To leave the environment, simply type the command `deactivate` and you will return to your original directory.

## **Conclusion**

Congratulations! At this point you have a Python 3 programming environment set up on your Debian Linux server and you can now begin a coding project!

To set up Python 3 on another computer, follow the [local programming environment guides](#) for [Ubuntu 16.04](#), [Debian 8](#), [Windows 10](#), or [macOS](#).

With your server set up for software development, you can continue to learn more about coding in Python by following “[Understanding Data Types in Python 3](#)” and “[How To Use Variables in Python 3](#)”.

# How To Write Your First Python 3 Program

The “Hello, World!” program is a classic and time-honored tradition in computer programming. Serving as a simple and complete first program for beginners, as well as a good program to test systems and programming environments, “Hello, World!” illustrates the basic syntax of programming languages.

This tutorial will walk you through writing a “Hello, World” program in Python 3.

## Prerequisites

You should have [Python 3 installed](#) as well as a local programming environment set up on your computer.

If you don’t have one set up, you can use one of the installation and setup guides below that is appropriate for your operating system:

- [Ubuntu 16.04 or Debian 8](#)
- [CentOS 7](#)
- [Mac OS X](#)
- [Windows 10](#)

## Writing the “Hello, World!” Program

To write the “Hello, World!” program, let’s open up a command-line text editor such as nano and create a new file:

```
nano hello.py
```

Once the text file opens up in the terminal window we'll type out our program:

**hello.py**

```
print("Hello, World!")
```

Let's break down the different components of the code.

`print()` is a function that tells the computer to perform an action. We know it is a function because it uses parentheses. `print()` tells Python to display or output whatever we put in the parentheses. By default, this will output to the current terminal window.

Some functions, like the `print()` function, are built-in functions included in Python by default. These built-in functions are always available for us to use in programs that we create. We can also [define our own functions](#) that we construct ourselves through other elements.

Inside the parentheses of the `print()` function is a sequence of characters — `Hello, World!` — that is enclosed in quotation marks. Any characters that are inside of quotation marks are called a [string](#).

Once we are done writing our program, we can exit nano by typing the `control` and `x` keys, and when prompted to save the file press `y`.

Once you exit out of nano you'll return to your shell.

## Running the “Hello, World!” Program

With our “Hello, World!” program written, we are ready to run the program. We'll use the `python3` command along with the name of our program file. Let's run the program:

```
python3 hello.py
```

The `hello.py` program that you just created will cause your terminal to produce the following output:

#### Output

```
Hello, World!
```

Let's go over what the program did in more detail.

Python executed the line `print("Hello, World!")` by calling the `print()` function. The string value of `Hello, World!` was passed to the function.

In this example, the string `Hello, World!` is also called an argument since it is a value that is passed to a function.

The quotes that are on either side of `Hello, World!` were not printed to the screen because they are used to tell Python that they contain a string. The quotation marks delineate where the string begins and ends.

Since the program ran, you can now confirm that Python 3 is properly installed and that the program is syntactically correct.

## Conclusion

Congratulations! You have written the “Hello, World!” program in Python 3.

From here, you can continue to work with the `print()` function by writing your own strings to display, and can also create new program files.

Keep learning about programming in Python by reading our full tutorial series [How To Code in Python 3](#).

# How To Work with the Python Interactive Console

The Python interactive console (also called the Python interpreter or Python shell) provides programmers with a quick way to execute commands and try out or test code without creating a file.

Providing access to all of Python's built-in functions and any installed modules, command history, and auto-completion, the interactive console offers the opportunity to explore Python and the ability to paste code into programming files when you are ready.

This tutorial will go over how to work with the Python interactive console and leverage it as a programming tool.

## Entering the Interactive Console

The Python interactive console can be accessed from any local computer or server with Python installed.

The command you generally will want to use to enter into the Python interactive console for your default version of Python is:

```
python
```

If you have set up a [programming environment](#), you can launch the environment and access the version of Python and modules you have installed in that environment by first entering into that environment:

```
cd environments
```



```
. my_env/bin/activate
```

Then typing the `python` command:

```
(my_env) sammy@ubuntu:~/environments$ python
```

In this case, the default version of Python is Python 3.5.2, which is displayed in the output once we enter the command, along with the relevant copyright notice and some commands you can type for extra information:

#### **Output**

```
Python 3.5.2 (default, Nov 17 2016, 17:05:23)
[GCC 5.4.0 20160609] on linux
Type "help", "copyright", "credits" or "license" for
more information.
>>>
```

The primary prompt for the next command is three greater-than signs (`>>>`):

```
>>>
```

You can target specific versions of Python by appending the version number to your command, with no spaces:

```
python2.7
```

**Output**

```
Python 2.7.12 (default, Nov 19 2016, 06:48:10)
[GCC 5.4.0 20160609] on linux2
Type "help", "copyright", "credits" or "license" for
more information.
>>>
```

Here, we received the output that Python 2.7.12 will be used. If this is our default version of Python 2, we could also have entered into this interactive console with the command `python2`.

Alternatively, we can call the default Python 3 version with the following command:

```
python3
```

**Output**

```
Python 3.5.2 (default, Nov 17 2016, 17:05:23)
[GCC 5.4.0 20160609] on linux
Type "help", "copyright", "credits" or "license" for
more information.
>>>
```

We could have also called the above interactive console with the command `python3.5`.

With the Python interactive console running, we can move onto working with the shell environment for Python.

## Working with the Python Interactive Console

The Python interactive interpreter accepts Python syntax, which you place following the `>>>` prefix.

We can, for example, assign values to [variables](#):

```
>>> birth_year = 1868
```

Once we have assigned the integer value of 1868 to the variable `birth_year`, we will press return and receive a new line with the three greater-than signs as a prefix:

```
>>> birth_year = 1868
```

We can continue to assign variables and then [perform math with operators](#) to get calculations returned:

```
>>> birth_year = 1868
>>> death_year = 1921
>>> age_at_death = death_year - birth_year
>>> print(age_at_death)
53
>>>
```

As we would with a script in a file, we assigned variables, subtracted one variable from the other, and asked the console to print the variable that represents the difference.

Just like in any form of Python, you can also use the interactive console as a calculator:

```
>>> 203 / 20
10.15
>>>
```

Here, we divided the integer 203 by 20 and were returned the quotient of 10.15.

## Multiple Lines

When we are writing Python code that will cover multiple lines, the interpreter will use the secondary prompt for continuation lines, three dots (...).

To break out of these continuation lines, you will need to press ENTER twice.

We can see what this looks like in the following code that assigns two variables and then uses a [conditional statement](#) to determine what to print out to the console:

```
>>> sammy = 'Sammy'
>>> shark = 'Shark'
>>> if len(sammy) > len(shark):
...     print('Sammy codes in Java.')
... else:
...     print('Sammy codes in Python.')
...
Sammy codes in Python.
>>>
```

In this case the lengths of the two [strings](#) are equal, so the `else` statement prints. Note that you will need to keep Python indenting convention of four whitespaces, otherwise you will receive an error:

```
>>> if len(sammy) > len(shark):
...   print('Sammy codes in Java.')
      File "<stdin>", line 2
        print('Sammy codes in Java.')
        ^
IndentationError: expected an indented block
>>>
```

You can not only experiment with code across multiple lines in the Python console, you can also import modules.

## Importing Modules

The Python interpreter provides a quick way for you to check to see if modules are available in a specific programming environment. You can do this by using the `import` statement:

```
>>> import matplotlib
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ImportError: No module named 'matplotlib'
```

In the case above, the module [matplotlib](#) was not available within the current programming environment.

In order to install it, we'll need to leave the interactive interpreter and install with pip as usual:

```
(my_env) sammy@ubuntu:~/environments$ pip install  
matplotlib
```

### Output

```
Collecting matplotlib
```

```
  Downloading matplotlib-2.0.2-cp35-cp35m-  
manylinux1_x86_64.whl (14.6MB)
```

```
...
```

```
Installing collected packages: pyparsing, cyclcr,  
python-dateutil, numpy, pytz, matplotlib
```

```
Successfully installed cyclcr-0.10.0 matplotlib-2.0.2  
numpy-1.13.0 pyparsing-2.2.0 python-dateutil-2.6.0  
pytz-2017.2
```

Once the matplotlib module along with its dependencies are successfully installed, you can go back into the interactive interpreter:

```
(my_env) sammy@ubuntu:~/environments$ python
```

```
>>> import matplotlib
```

At this point you will receive no error message and can use the installed module either within the shell or within a file.

## Leaving the Python Interactive Console

There are two main ways to leave the Python interactive console, either with a keyboard shortcut or a Python function.

The keyboard shortcut `CTRL + D` in \*nix-based systems or `CTRL + Z` then the `CTRL` key in Windows systems will interrupt your console and return you to your original terminal environment:

```
...
>>> age_at_death = death_year - birth_year
>>> print(age_at_death)
53
>>>
sammy@ubuntu:~/environments$
```

Alternatively, the Python function `quit()` will quit out of the interactive console and also bring you back to the original terminal environment that you were previously in:

```
>>> octopus = 'Ollie'
>>> quit()
sammy@PythonUbuntu:~/environments$
```

When you use the function `quit()`, it will show up in your history file, but the keyboard shortcut `CTRL + D` will not be recorded:

**File: /home/sammy/.python\_history**

```
...
age_at_death = death_year - birth_year
print(age_at_death)
```

```
octopus = 'Ollie'  
quit()
```

Quitting the Python interpreter can be done either way, depending on what makes sense for your workflow and your history needs.

## Accessing History

One of the useful things about the Python interactive console is that all of your commands are logged to the `.python_history` file in \*nix-based systems, which you can look at in a text editor like nano, for instance:

```
nano ~/.python_history
```

Once opened with a text editor, your Python history file will look something like this, with your own Python command history:

**File: /home/sammy/.python\_history**

```
import pygame  
quit()  
if 10 > 5:  
    print("hello, world")  
else:  
    print("nope")  
sammy = 'Sammy'  
shark = 'Shark'  
...
```



Once you are done with your file, you can press CTRL + X to leave nano.

By keeping track of all of your Python history, you can go back to previous commands and experiments, and copy and paste or modify that code for use in Python programming files or in a [Jupyter Notebook](#).

## Conclusion

The Python interactive console provides a space to experiment with Python code. You can use it as a tool for testing, working out logic, and more.

For use with debugging Python programming files, you can use the Python `code` module to open up an interactive interpreter within a file, which you can read about in our guide [How To Debug Python with an Interactive Console](#).

# How To Write Comments

Comments are lines that exist in computer programs that are ignored by compilers and interpreters. Including comments in programs makes code more readable for humans as it provides some information or explanation about what each part of a program is doing.

Depending on the purpose of your program, comments can serve as notes to yourself or reminders, or they can be written with the intention of other programmers being able to understand what your code is doing.

In general, it is a good idea to write comments while you are writing or updating a program as it is easy to forget your thought process later on, and comments written later may be less useful in the long term.

## Comment Syntax

Comments in Python begin with a hash mark (#) and whitespace character and continue to the end of the line.

Generally, comments will look something like this:

```
# This is a comment
```

Because comments do not execute, when you run a program you will not see any indication of the comment there. Comments are in the source code for humans to read, not for computers to execute.

In a “Hello, World!” program, a comment may look like this:

**hello.py**

```
# Print "Hello, World!" to console
print("Hello, World!")
```

In a [for loop](#) that iterates over a [list](#), comments may look like this:

#### **sharks.py**

```
# Define sharks variable as a list of strings
sharks = ['hammerhead', 'great white', 'dogfish',
          'frilled', 'bullhead', 'requiem']

# For loop that iterates over sharks list and prints
each string item
for shark in sharks:
    print(shark)
```

Comments should be made at the same indent as the code it is commenting. That is, a [function definition](#) with no indent would have a comment with no indent, and each indent level following would have comments that are aligned with the code it is commenting.

For example, here is how the `again()` function from the [How To Make a Simple Calculator Program in Python 3 tutorial](#) is commented, with comments following each indent level of the code:

#### **calculator.py**

```
...
# Define again() function to ask user if they want to
use the calculator again
def again():
```

```
# Take input from user
calc_again = input(''
Do you want to calculate again?
Please type Y for YES or N for NO.
''')

# If user types Y, run the calculate() function
if calc_again == 'Y':
    calculate()

# If user types N, say good-bye to the user and
end the program
elif calc_again == 'N':
    print('See you later.')

# If user types another key, run the function
again
else:
    again()
```

Comments are made to help programmers, whether it is the original programmer or someone else using or collaborating on the project. If comments cannot be properly maintained and updated along with the code base, it is better to not include a comment rather than write a comment that contradicts or will contradict the code.

When commenting code, you should be looking to answer the why behind the code as opposed to the what or how. Unless the code is

particularly tricky, looking at the code can generally tell what the code is doing or how it is doing it.

## Block Comments

Block comments can be used to explain more complicated code or code that you don't expect the reader to be familiar with. These longer-form comments apply to some or all of the code that follows, and are also indented at the same level as the code.

In block comments, each line begins with the hash mark and a single space. If you need to use more than one paragraph, they should be separated by a line that contains a single hash mark.

Here is an example of a block comment that defines what is happening in the `main()` function defined below:

```
# The main function will parse arguments via the
# parser variable.  These
# arguments will be defined by the user on the
# console.  This will pass
# the word argument the user wants to parse along with
# the filename the
# user wants to use, and also provide help text if the
# user does not
# correctly pass the arguments.
```

```
def main():
    parser = argparse.ArgumentParser()
    parser.add_argument(
        "word",
```

```
        help="the word to be searched for in the text
file."
    )
    parser.add_argument(
        "filename",
        help="the path to the text file to be searched
through"
    )
    ...
```

Block comments are typically used when operations are less straightforward and are therefore demanding of a thorough explanation. You should try to avoid over-commenting the code and should tend to trust other programmers to understand Python unless you are writing for a particular audience.

## Inline Comments

Inline comments occur on the same line of a statement, following the code itself. Like other comments, they begin with a hash mark and a single whitespace character.

Generally, inline comments look like this:

```
[code]  # Inline comment about the code
```

Inline comments should be used sparingly, but can be effective for explaining tricky or non-obvious parts of code. They can also be useful if you think you may not remember a line of the code you are writing in the

future, or if you are collaborating with someone who you know may not be familiar with all aspects of the code.

For example, if you don't use a lot of [math](#) in your Python programs, you or your collaborators may not know that the following creates a complex number, so you may want to include an inline comment about that:

```
z = 2.5 + 3j # Create a complex number
```

Inline comments can also be used to explain the reason behind doing something, or some extra information, as in:

```
x = 8 # Initialize x with an arbitrary number
```

Comments that are made in line should be used only when necessary and when they can provide helpful guidance for the person reading the program.

## Commenting Out Code for Testing

In addition to using comments as a way to document code, the hash mark can also be used to comment out code that you don't want to execute while you are testing or debugging a program you are currently creating. That is, when you experience errors after implementing new lines of code, you may want to comment a few of them out to see if you can troubleshoot the precise issue.

Using the hash mark can also allow you to try alternatives while you're determining how to set up your code. For example, you may be deciding between using a [while loop](#) or a `for` loop in a Python game, and can

comment out one or the other while testing and determining which one may be best:

**guess.py**

```
import random

number = random.randint(1, 25)

# number_of_guesses = 0

for i in range(5):
    # while number_of_guesses < 5:
        print('Guess a number between 1 and 25:')
        guess = input()
        guess = int(guess)

        # number_of_guesses = number_of_guesses + 1

        if guess < number:
            print('Your guess is too low')

        if guess > number:
            print('Your guess is too high')

        if guess == number:
            break

if guess == number:
```



```
    print('You guessed the number!')

else:
    print('You did not guess the number. The number
was ' + str(number))

<figure class="code">
```

Commenting out code with the hash mark can allow you to try out different programming methods as well as help you find the source of an error through systematically commenting out and running parts of a program.

## Conclusion

Using comments within your Python programs helps to make your programs more readable for humans, including your future self. Including appropriate comments that are relevant and useful can make it easier for others to collaborate with you on programming projects and make the value of your code more obvious.

From here, you may want to read about Python's [Docstrings in PEP 257](#) to provide you with more resources to properly document your Python projects.

# Understanding Data Types

In Python, like in all programming languages, data types are used to classify one particular type of data. This is important because the specific data type you use will determine what values you can assign to it and what you can do to it (including what operations you can perform on it).

In this tutorial, we will go over the important data types native to Python. This is not an exhaustive investigation of data types, but will help you become familiar with what options you have available to you in Python.

## Background

One way to think about data types is to consider the different types of data that we use in the real world. An example of data in the real world are numbers: we may use whole numbers (0, 1, 2, ...), integers (... , -1, 0, 1, ...), and irrational numbers ( $\pi$ ), for example.

Usually, in math, we can combine numbers from different types, and get some kind of an answer. We may want to add 5 to  $\pi$ , for example:

$$5 + \pi$$

We can either keep the equation as the answer to account for the irrational number, or round  $\pi$  to a number with a brief number of decimal places, and then add the numbers together:

$$5 + \pi = 5 + 3.14 = 8.14$$

But, if we start to try to evaluate numbers with another data type, such as words, things start to make less sense. How would we solve for the following equation?

```
sky + 8
```

For computers, each data type can be thought of as being quite different, like words and numbers, so we will have to be careful about how we use them to assign values and how we manipulate them through operations.

## Numbers

Any [number](#) you enter in Python will be interpreted as a number; you are not required to declare what kind of data type you are entering. Python will consider any number written without decimals as an integer (as in 138) and any number written with decimals as a float (as in 138.0).

## Integers

Like in [math](#), integers in computer programming are whole numbers that can be positive, negative, or 0 (... , -1, 0, 1, ...). An integer can also be known as an `int`. As with other programming languages, you should not use commas in numbers of four digits or more, so when you write 1,000 in your program, write it as 1000.

We can print out an integer in a simple way like this:

```
print(-25)
```

**Output**

-25

Or, we can declare a variable, which in this case is essentially a symbol of the number we are using or manipulating, like so:

```
my_int = -25  
print(my_int)
```

**Output**

-25

We can do math with integers in Python, too:

```
int_ans = 116 - 68  
print(int_ans)
```

**Output**

48

Integers can be used in many ways within Python programs, and as you continue to learn more about the language you will have a lot of opportunities to work with integers and understand more about this data type.

**Floating-Point Numbers**

A floating-point number or a float is a real number, meaning that it can be either a rational or an irrational number. Because of this, floating-point

numbers can be numbers that can contain a fractional part, such as `9.0` or `-116.42`. Simply speaking, for the purposes of thinking of a `float` in a Python program, it is a number that contains a decimal point.

Like we did with the integer, we can print out a floating-point number in a simple way like this:

```
print(17.3)
```

**Output**

```
17.3
```

We can also declare a variable that stands in for a float, like so:

```
my_flt = 17.3  
print(my_flt)
```

**Output**

```
17.3
```

And, just like with integers, we can do math with floats in Python, too:

```
flt_ans = 564.0 + 365.24  
print(flt_ans)
```

**Output**

```
929.24
```

With integers and floating-point numbers, it is important to keep in mind that  $3 \neq 3.0$ , as 3 refers to an integer while 3.0 refers to a float.

## Booleans

The [Boolean](#) data type can be one of two values, either True or False. Booleans are used to represent the truth values that are associated with the logic branch of mathematics, which informs algorithms in computer science.

Whenever you see the data type Boolean, it will start with a capitalized B because it is named for the mathematician George Boole. The values True and False will also always be with a capital T and F respectively, as they are special values in Python.

Many operations in math give us answers that evaluate to either True or False:

- greater than
  - $500 > 100$  True
  - $1 > 5$  False
- less than
  - $200 < 400$  True
  - $4 < 2$  False
- equal
  - $5 = 5$  True
  - $500 = 400$  False

Like with numbers, we can store a Boolean value in a variable:

```
my_bool = 5 > 8
```

We can then print the Boolean value with a call to the `print()` function:

```
print(my_bool)
```

Since 5 is not greater than 8, we will receive the following output:

**Ouput**

```
False
```

As you write more programs in Python, you will become more familiar with how Booleans work and how different functions and operations evaluating to either True or False can change the course of the program.

## Strings

A string is a sequence of one or more characters (letters, numbers, symbols) that can be either a constant or a variable. Strings exist within either single quotes `'` or double quotes `"` in Python, so to create a string, enclose a sequence of characters in quotes:

```
'This is a string in single quotes.'
```

```
"This is a string in double quotes."
```

You can choose to use either single quotes or double quotes, but whichever you decide on you should be consistent within a program.

The simple program “[Hello, World!](#)” demonstrates how a string can be used in computer programming, as the characters that make up the phrase `Hello, World!` are a string.

```
print("Hello, World!")
```

As with other data types, we can store strings in variables:

```
hw = "Hello, World!"
```

And print out the string by calling the variable:

```
print(hw)
```

#### **Output**

```
Hello, World!
```

Like numbers, there are many operations that we can perform on strings within our programs in order to manipulate them to achieve the results we are seeking. Strings are important for communicating information to the user, and for the user to communicate information back to the program.

## **Lists**

A [list](#) is a mutable, or changeable, ordered sequence of elements. Each element or value that is inside of a list is called an item. Just as strings are



defined as characters between quotes, lists are defined by having values between square brackets [ ].

A list of integers looks like this:

```
[-3, -2, -1, 0, 1, 2, 3]
```

A list of floats looks like this:

```
[3.14, 9.23, 111.11, 312.12, 1.05]
```

A list of strings:

```
['shark', 'cuttlefish', 'squid', 'mantis shrimp']
```

If we define our string list as `sea_creatures`:

```
sea_creatures = ['shark', 'cuttlefish', 'squid',  
'mantis shrimp']
```

We can print them out by calling the variable:

```
print(sea_creatures)
```

And we see that the output looks exactly like the list that we created:

**Output**

```
['shark', 'cuttlefish', 'squid', 'mantis shrimp']
```

Lists are a very flexible data type because they are mutable in that they can have values added, removed, and changed. There is a data type that is similar to lists but that can't be changed, and that is called a tuple.

## Tuples

A [tuple](#) is used for grouping data. It is an immutable, or unchangeable, ordered sequence of elements.

Tuples are very similar to lists, but they use parentheses ( ) instead of square brackets and because they are immutable their values cannot be modified.

A tuple looks like this:

```
('blue coral', 'staghorn coral', 'pillar coral')
```

We can store a tuple in a variable and print it out:

```
coral = ('blue coral', 'staghorn coral', 'pillar  
coral')  
print(coral)
```

### Output

```
('blue coral', 'staghorn coral', 'pillar coral')
```

Like in the other data types, Python prints out the tuple just as we had typed it, with parentheses containing a sequence of values.

## Dictionaries

The [dictionary](#) is Python's built-in mapping type. This means that dictionaries map keys to values and these key-value pairs are a useful way to store data in Python. A dictionary is constructed with curly braces on either side { }.

Typically used to hold data that are related, such as the information contained in an ID, a dictionary looks like this:

```
{'name': 'Sammy', 'animal': 'shark', 'color': 'blue',  
'location': 'ocean'}
```

You will notice that in addition to the curly braces, there are also colons throughout the dictionary. The words to the left of the colons are the keys. Keys can be made up of any immutable data type. The keys in the dictionary above are: 'name', 'animal', 'color', 'location'.

The words to the right of the colons are the values. Values can be comprised of any data type. The values in the dictionary above are: 'Sammy', 'shark', 'blue', 'ocean'.

Like the other data types, let's store the dictionary inside a variable, and print it out:

```
sammy = {'name': 'Sammy', 'animal': 'shark', 'color':  
'blue', 'location': 'ocean'}  
print(sammy)
```

#### **Ouput**

```
{'color': 'blue', 'animal': 'shark', 'name': 'Sammy',  
'location': 'ocean'}
```

If we want to isolate Sammy's color, we can do so by calling `sammy['color']`. Let's print that out:

```
print(sammy['color'])
```

#### **Output**

```
blue
```

As dictionaries offer key-value pairs for storing data, they can be important elements in your Python program.

## **Conclusion**

At this point, you should have a better understanding of some of the major data types that are available for you to use in Python. Each of these data types will become important as you develop programming projects in the Python language.

You can learn about each of the data types above in more detail by reading the following specific tutorials: - [Numbers](#) - [Booleans](#) - [Strings](#) - [Lists](#) - [Tuples](#) - [Dictionaries](#)

Once you have a solid grasp of data types available to you in Python, you can learn how to [convert data types](#).

# An Introduction to Working with Strings

A string is a sequence of one or more characters (letters, numbers, symbols) that can be either a constant or a variable. Made up of Unicode, strings are immutable sequences, meaning they are unchanging.

Because text is such a common form of data that we use in everyday life, the string data type is a very important building block of programming.

This Python tutorial will go over how to create and print strings, how to concatenate and replicate strings, and how to store strings in variables.

## Creating and Printing Strings

Strings exist within either single quotes ' or double quotes " in Python, so to create a string, enclose a sequence of characters in one or the other:

```
'This is a string in single quotes.'
```

```
"This is a string in double quotes."
```

You can choose to use either single quotes or double quotes, but whichever you decide on you should be consistent within a program.

We can print out strings by simply calling the `print()` function:

```
print("Let's print out this string.")
```

## Output

Let's print out this string.

With an understanding of how strings are formatted in Python, let's take a look at how we can work with and manipulate strings in programs.

## String Concatenation

Concatenation means joining strings together end-to-end to create a new string. To concatenate strings, we use the + operator. Keep in mind that when we work with [numbers, + will be an operator for addition](#), but when used with strings it is a joining operator.

Let's combine the strings "Sammy" and "Shark" together with concatenation through a `print()` statement:

```
print("Sammy" + "Shark")
```

### Output

SammyShark

If we would like a whitespace between the two strings, we can simply include the whitespace within a string, like after the word "Sammy":

```
print("Sammy " + "Shark")
```

### Output

Sammy Shark

Be sure not to use the + operator between two different data types. We can't concatenate strings and integers together, for instance. So, if we try to write:

```
print("Sammy" + 27)
```

We will receive the following error:

#### Output

```
TypeError: Can't convert 'int' object to str  
implicitly
```

If we wanted to create the string "Sammy27", we could do so by putting the number 27 in quotes ("27") so that it is no longer an integer but is instead a string. [Converting numbers to strings](#) for concatenation can be useful when dealing with zip codes or phone numbers, for example, as we don't want to perform addition between a country code and an area code, but we do want them to stay together.

When we combine two or more strings through concatenation we are creating a new string that we can use throughout our program.

## String Replication

There may be times when you need to use Python to automate tasks, and one way you may do this is through repeating a string several times. You can do so with the \* operator. Like the + operator, [the \\* operator has a different use when used with numbers](#), where it is the operator for multiplication. When used with one string and one integer, \* is the string

replication operator, repeating a single string however many times you would like through the integer you provide.

Let's print out "Sammy" 9 times without typing out "Sammy" 9 times with the \* operator:

```
print("Sammy" * 9)
```

### Output

```
SammySammySammySammySammySammySammySammySammy
```

With string replication, we can repeat the single string value the amount of times equivalent to the integer value.

## Storing Strings in Variables

[Variables](#) are symbols that you can use to store data in a program. You can think of them as an empty box that you fill with some data or value. Strings are data, so we can use them to fill up a variable. Declaring strings as variables can make it easier for us to work with strings throughout our Python programs.

To store a string inside a variable, we simply need to assign a variable to a string. In this case let's declare `my_str` as our variable:

```
my_str = "Sammy likes declaring strings."
```

Now that we have the variable `my_str` set to that particular string, we can print the variable like so:

```
print(my_str)
```



And we will receive the following output:

#### **Output**

```
Sammy likes declaring strings.
```

By using variables to stand in for strings, we do not have to retype a string each time we want to use it, making it simpler for us to work with and manipulate strings within our programs.

#### **Conclusion**

This tutorial went over the basics of working with the string data type in the Python 3 programming language. Creating and printing strings, concatenating and replicating strings, and storing strings in variables will provide you with the fundamentals to use strings in your Python 3 programs.

Continue learning more about strings by taking a look at the following tutorials: - [How To Format Text in Python 3](#) - [An Introduction to String Functions](#) - [How To Index and Slice Strings](#) - [How To Use String Formatters](#)

# How To Format Text

As strings are often made up of written text, there are many instances when we may want to have greater control over how strings look to make them more readable for humans through punctuation, line breaks, and indentation.

In this tutorial, we'll go over some of the ways we can work with Python strings to make sure that all output text is formatted correctly.

## String Literals

Let's first differentiate between a string literal and a string value. A string literal is what we see in the source code of a computer program, including the quotation marks. A string value is what we see when we call the `print()` function and run the program.

In the "Hello, World!" program, the string literal is `"Hello, World!"` while the string value is `Hello, World!` without the quotation marks. The string value is what we see as the output in a terminal window when we run a Python program.

But some string values may need to include quotation marks, like when we are quoting a source. Because string literals and string values are not equivalent, it is often necessary to add additional formatting to string literals to ensure that string values are displayed the way in which we intend.

## Quotes and Apostrophes

Because we can use single quotes or double quotes within Python, it is simple to embed quotes within a string by using double quotes within a string enclosed by single quotes:

```
'Sammy says, "Hello!"'
```

Or, to use a possessive apostrophe in a string enclosed by double quotes:

```
"Sammy's balloon is red."
```

In the way we combine single and double quotes, we can control the display of quotation marks and apostrophes within our strings.

## Multiple Lines

Printing strings on multiple lines can make text more readable to humans. With multiple lines, strings can be grouped into clean and orderly text, formatted as a letter, or used to maintain the linebreaks of a poem or song lyrics.

To create strings that span multiple lines, triple single quotes `'''` or triple double quotes `"""` are used to enclose the string.

```
'''
```

```
This string is on  
multiple lines  
within three single  
quotes on either side.
```

```
'''
```

```
"""
```

```
This string is on  
multiple lines  
within three double  
quotes on either side.
```

```
"""
```

With triple quotes, you can print strings on multiple lines to make text, especially lengthy text, easier to read.

## Escape Characters

Another way to format strings is to use an escape character. Escape characters all start with the backslash key ( \ ) combined with another character within a string to format the given string a certain way.

Here is a list of several of the common escape characters:

| ESCAPE CHARACTER | HOW IT FORMATS                  |
|------------------|---------------------------------|
| \n               | New line in a multi-line string |
| \\               | Backslash                       |
| '                | Apostrophe or single quote      |
| "                | Double quote                    |

| Line break | Tab (horizontal indentation)

Let's use an escape character to add the quotation marks to the example on quotation marks above, but this time we'll use double quotes:

```
print("Sammy says, \"Hello!\")
```

#### **Output**

```
Sammy says, "Hello!"
```

By using the escape character `\"` we are able to use double quotes to enclose a string that includes text quoted between double quotes.

Similarly, we can use the escape character `\'` to add an apostrophe in a string that is enclosed in single quotes:

```
print('Sammy\'s balloon is red.')
```

#### **Output**

```
Sammy's balloon is red.
```

Because we are now using the escape character we can have an apostrophe within a string that uses single quotes.

When we use triple quotes like we did above, we will see that there is a space at the top and bottom when we print the string. We can remove those spaces by using the `\` escape key at the top of our string and again at the end of the string while keeping the text within the program very readable.

```
"""\  
This multi-line string  
has no space at the  
top or the bottom  
when it prints.\
```

"""

Similarly, we can use the escape character to break lines without hitting the enter or return key:

```
print("This string  
spans multiple  
lines.")
```

#### **Output**

```
This string  
spans multiple  
lines.
```

We can combine escape characters, too. Let's print a multi-line string and include tab spacing for an itemized list, for example:

```
print("1.   Shark  
2.   Shrimp  
10.  Squid")
```

#### **Output**

```
1.   Shark  
2.   Shrimp  
10.  Squid
```

The horizontal indentation provided with the ` ` escape character ensures alignment within the second column in the example above,

making the output extremely readable for humans.

Though the escape character works well for short string literals, it is important to ensure that source code is also readable to humans. In the case of lengthy strings, the triple quote approach to multi-line strings is often preferable.

Escape characters are used to add additional formatting to strings that may be difficult or impossible to achieve. Without escape characters, how would you construct the string `Sammy says, "The balloon's color is red."`?

## Raw Strings

What if we don't want special formatting within our strings? For example, we may need to compare or evaluate strings of computer code that use the backslash on purpose, so we won't want Python to use it as an escape character.

A raw string tells Python to ignore all formatting within a string, including escape characters.

We create a raw string by putting an `r` in front of the string, right before the beginning quotation mark:

```
print(r"Sammy says,\"The balloon's color is red.\")
```

### Output

```
Sammy says,\"The balloon's color is red.\"
```

By constructing a raw string by using `r` in front of a given string, we can retain backslashes and other characters that are used as escape characters.

## Conclusion

This tutorial went over several ways to format text in Python 3 through working with strings. By using techniques such as escape characters or raw strings, we are able to ensure that the strings of our program are rendered correctly on-screen so that the end user is able to easily read all of the output text.

Continue learning more about strings by taking a look at the following tutorials: - [An Introduction to String Functions](#) - [How To Index and Slice Strings](#) - [How To Use String Formatters](#)



# An Introduction to String Functions

Python has several built-in functions associated with the [string data type](#). These functions let us easily modify and manipulate strings. We can think of functions as being actions that we perform on elements of our code. Built-in functions are those that are defined in the Python programming language and are readily available for us to use.

In this tutorial, we'll go over several different functions that we can use to work with strings in Python 3.

## Making Strings Upper and Lower Case

The functions `str.upper()` and `str.lower()` will return a string with all the letters of an original string converted to upper- or lower-case letters. Because strings are immutable data types, the returned string will be a new string. Any characters in the string that are not letters will not be changed.

Let's convert the string `Sammy Shark` to be all upper case:

```
ss = "Sammy Shark"
print(ss.upper())
```

**Output**

```
SAMMY SHARK
```

Now, let's convert the string to be all lower case:

```
print(ss.lower())
```

### Output

```
sammy shark
```

The `str.upper()` and `str.lower()` functions make it easier to evaluate and compare strings by making case consistent throughout. That way if a user writes their name all lower case, we can still determine whether their name is in our database by checking it against an all upper-case version, for example.

## Boolean Methods

Python has some string methods that will evaluate to a [Boolean value](#). These methods are useful when we are creating forms for users to fill in, for example. If we are asking for a post code we will only want to accept a numeric string, but when we are asking for a name, we will only want to accept an alphabetic string.

There are a number of string methods that will return Boolean values:

| METHOD                       | TRUE IF                                                         |
|------------------------------|-----------------------------------------------------------------|
| <code>str.isalnum()</code>   | String consists of only alphanumeric characters<br>(no symbols) |
| <code>str.isalpha()</code>   | String consists of only alphabetic characters (no<br>symbols)   |
| <code>str.islower()</code>   | String's alphabetic characters are all lower case               |
| <code>str.isnumeric()</code> | String consists of only numeric characters                      |

|                            |                                                   |
|----------------------------|---------------------------------------------------|
| <code>str.isspace()</code> | String consists of only whitespace characters     |
| <code>str.istitle()</code> | String is in title case                           |
| <code>str.isupper()</code> | String's alphabetic characters are all upper case |

Let's look at a couple of these in action:

```
number = "5"
letters = "abcdef"

print(number.isnumeric())
print(letters.isnumeric())
```

#### **Output**

```
True
False
```

Using the `str.isnumeric()` method on the string `5` returns a value of `True`, while using the same method on the string `abcdef` returns a value of `False`.

Similarly, we can query whether a string's alphabetic characters are in title case, upper case, or lower case. Let's create a few strings:

```
movie = "2001: A SAMMY ODYSSEY"
book = "A Thousand Splendid Sharks"
poem = "sammy lived in a pretty how town"
```

Now let's try the Boolean methods that check for case:

```
print(movie.islower())  
print(movie.isupper())
```

```
print(book.istitle())  
print(book.isupper())
```

```
print(poem.istitle())  
print(poem.islower())
```

Now we can run these small programs and see the output:

**Output of movie string**

False

True

**Output of book string**

True

False

**Output of poem string**

False

True

Checking whether characters are lower case, upper case, or title case, can help us to sort our data appropriately, as well as provide us with the opportunity to standardize data we collect by checking and then modifying strings as needed.

Boolean string methods are useful when we want to check whether something a user enters fits within given parameters.

## Determining String Length

The string method `len()` returns the number of characters in a string. This method is useful for when you need to enforce minimum or maximum password lengths, for example, or to truncate larger strings to be within certain limits for use as abbreviations.

To demonstrate this method, we'll find the length of a sentence-long string:

```
open_source = "Sammy contributes to open source."  
print(len(open_source))
```

### Output

```
33
```

We set the variable `open_source` equal to the string "Sammy contributes to open source." and then we passed that variable to the `len()` method with `len(open_source)`. We then passed the method into the `print()` method so that we could see the output on the screen from our program.

Keep in mind that any character bound by single or double quotation marks — including letters, numbers, whitespace characters, and symbols — will be counted by the `len()` method.

## `join()`, `split()`, and `replace()` Methods

The `str.join()`, `str.split()`, and `str.replace()` methods are a few additional ways to manipulate strings in Python.

The `str.join()` method will concatenate two strings, but in a way that passes one string through another.

Let's create a string:

```
balloon = "Sammy has a balloon."
```

Now, let's use the `str.join()` method to add whitespace to that string, which we can do like so:

```
" ".join(balloon)
```

If we print this out:

```
print(" ".join(balloon))
```

We will see that in the new string that is returned there is added space throughout the first string:

**Output**

```
S a m m y   h a s   a   b a l l o o n .
```

We can also use the `str.join()` method to return a string that is a reversal from the original string:

```
print("".join(reversed(balloon)))
```

**Ouput**

```
.noollab a sah ymmaS
```

We did not want to add any part of another string to the first string, so we kept the quotation marks touching with no space in between.

The `str.join()` method is also useful to combine a list of strings into a new single string.

Let's create a comma-separated string from a list of strings:

```
print(", ".join(["sharks", "crustaceans", "plankton"]))
```

**Ouput**

```
sharks, crustaceans, plankton
```

If we want to add a comma and a space between string values in our new string, we can simply rewrite our expression with a whitespace after the comma:  `", ".join(["sharks", "crustaceans", "plankton"])`.

Just as we can join strings together, we can also split strings up. To do this, we will use the `str.split()` method:

```
print(balloon.split())
```

**Ouput**

```
['Sammy', 'has', 'a', 'balloon.']
```

The `str.split()` method returns a list of strings that are separated by whitespace if no other parameter is given.

We can also use `str.split()` to remove certain parts of an original string. For example, let's remove the letter a from the string:

```
print(balloon.split("a"))
```

#### **Ouput**

```
['S', 'mmy h', 's ', ' b', 'lloon.']
```

Now the letter a has been removed and the strings have been separated where each instance of the letter a had been, with whitespace retained.

The `str.replace()` method can take an original string and return an updated string with some replacement.

Let's say that the balloon that Sammy had is lost. Since Sammy no longer has this balloon, we will change the substring "has" from the original string balloon to "had" in a new string:

```
print(balloon.replace("has", "had"))
```

Within the parentheses, the first substring is what we want to be replaced, and the second substring is what we are replacing that first substring with. Our output will look like this:

#### **Ouput**

```
Sammy had a balloon.
```

Using the string methods `str.join()`, `str.split()`, and `str.replace()` will provide you with greater control to manipulate



strings in Python.

## Conclusion

This tutorial went through some of the common built-in methods for the string data type that you can use to work with and manipulate strings in your Python programs.

You can learn more about other data types in “[Understanding Data Types](#),” read more about strings in “[An Introduction to Working with Strings](#),” and learn about changing the way strings look in “[How To Format Text in Python 3](#).”

# How To Index and Slice Strings

The Python string data type is a sequence made up of one or more individual characters that could consist of letters, numbers, whitespace characters, or symbols. Because a string is a sequence, it can be accessed in the same ways that other sequence-based data types are, through indexing and slicing.

This tutorial will guide you through accessing strings through indexing, slicing them through their character sequences, and go over some counting and character location methods.

## How Strings are Indexed

Like the [list data type](#) that has items that correspond to an index number, each of a string's characters also correspond to an index number, starting with the index number 0.

For the string `Sammy Shark!` the index breakdown looks like this:

|       |   |   |   |   |   |   |   |   |   |    |    |
|-------|---|---|---|---|---|---|---|---|---|----|----|
| S     | A | M | M | Y |   | S | H | A | R | K  | !  |
| <hr/> |   |   |   |   |   |   |   |   |   |    |    |
| 0     | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

As you can see, the first `S` starts at index 0, and the string ends at index 11 with the `!` symbol.

We also notice that the whitespace character between `Sammy` and `Shark` also corresponds with its own index number. In this case, the index number associated with the whitespace is 5.

The exclamation point (`!`) also has an index number associated with it. Any other symbol or punctuation mark, such as `*#&.;?,` is also a

character and would be associated with its own index number.

The fact that each character in a Python string has a corresponding index number allows us to access and manipulate strings in the same ways we can with other sequential data types.

## Accessing Characters by Positive Index Number

By referencing index numbers, we can isolate one of the characters in a string. We do this by putting the index numbers in square brackets. Let's declare a string, print it, and call the index number in square brackets:

```
ss = "Sammy Shark!"  
print(ss[4])
```

### Output

y

When we refer to a particular index number of a string, Python returns the character that is in that position. Since the letter y is at index number 4 of the string `ss = "Sammy Shark!"`, when we `print ss[4]` we receive y as the output.

Index numbers allow us to access specific characters within a string.

## Accessing Characters by Negative Index Number

If we have a long string and we want to pinpoint an item towards the end, we can also count backwards from the end of the string, starting at the index number -1.

For the same string `Sammy Shark!` the negative index breakdown looks like this:

|       |     |     |    |    |    |    |    |    |    |    |    |
|-------|-----|-----|----|----|----|----|----|----|----|----|----|
| S     | A   | M   | M  | Y  |    | S  | H  | A  | R  | K  | !  |
| <hr/> |     |     |    |    |    |    |    |    |    |    |    |
| -12   | -11 | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 |

By using negative index numbers, we can print out the character `r`, by referring to its position at the -3 index, like so:

```
print(ss[-3])
```

**Output**

```
r
```

Using negative index numbers can be advantageous for isolating a single character towards the end of a long string.

## Slicing Strings

We can also call out a range of characters from the string. Say we would like to just print the word `Shark`. We can do so by creating a slice, which is a sequence of characters within an original string. With slices, we can call multiple character values by creating a range of index numbers separated by a colon `[x:y]`:

```
print(ss[6:11])
```

**Output**

```
Shark
```

When constructing a slice, as in `[6:11]`, the first index number is where the slice starts (inclusive), and the second index number is where the slice ends (exclusive), which is why in our example above the range has to be the index number that would occur just after the string ends.

When slicing strings, we are creating a substring, which is essentially a string that exists within another string. When we call `ss[6:11]`, we are calling the substring `Shark` that exists within the string `Sammy Shark!`.

If we want to include either end of a string, we can omit one of the numbers in the `string[n:n]` syntax. For example, if we want to print the first word of string `ss` — “Sammy” — we can do so by typing:

```
print(ss[:5])
```

**Output**

```
Sammy
```

We did this by omitting the index number before the colon in the slice syntax, and only including the index number after the colon, which refers to the end of the substring.

To print a substring that starts in the middle of a string and prints to the end, we can do so by including only the index number before the colon, like so:

```
print(ss[7:])
```

**Output**

```
hark!
```

By including only the index number before the colon and leaving the second index number out of the syntax, the substring will go from the character of the index number called to the end of the string.

You can also use negative index numbers to slice a string. As we went through before, negative index numbers of a string start at -1, and count down from there until we reach the beginning of the string. When using negative index numbers, we'll start with the lower number first as it occurs earlier in the string.

Let's use two negative index numbers to slice the string `ss`:

```
print(ss[-4:-1])
```

**Output**

```
ark
```

The substring "ark" is printed from the string "Sammy Shark!" because the character "a" occurs at the -4 index number position, and the character "k" occurs just before the -1 index number position.

## Specifying Stride while Slicing Strings

String slicing can accept a third parameter in addition to two index numbers. The third parameter specifies the stride, which refers to how many characters to move forward after the first character is retrieved from the string. So far, we have omitted the stride parameter, and Python defaults to the stride of 1, so that every character between two index numbers is retrieved.

Let's look again at the example above that prints out the substring "Shark":

```
print(ss[6:11])
```

**Output**

Shark

We can obtain the same results by including a third parameter with a stride of 1:

```
print(ss[6:11:1])
```

**Output**

Shark

So, a stride of 1 will take in every character between two index numbers of a slice. If we omit the stride parameter then Python will default with 1.

If, instead, we increase the stride, we will see that characters are skipped:

```
print(ss[0:12:2])
```

**Output**

SmySak

Specifying the stride of 2 as the last parameter in the Python syntax `ss[0:12:2]` skips every other character. Let's look at the characters that are printed in red:

**Sammy Shark!**

Note that the whitespace character at index number 5 is also skipped with a stride of 2 specified.

If we use a larger number for our stride parameter, we will have a significantly smaller substring:

```
print(ss[0:12:4])
```

**Output**

Sya

Specifying the stride of 4 as the last parameter in the Python syntax `ss[0:12:4]` prints only every fourth character. Again, let's look at the characters that are printed in red:

**Sammy Shark!**

In this example the whitespace character is skipped as well.

Since we are printing the whole string we can omit the two index numbers and keep the two colons within the syntax to achieve the same result:

```
print(ss[::4])
```

**Output**

Sya

Omitting the two index numbers and retaining colons will keep the whole string within range, while adding a final parameter for stride will specify the number of characters to skip.



Additionally, you can indicate a negative numeric value for the stride, which we can use to print the original string in reverse order if we set the stride to -1:

```
print(ss[::-1])
```

#### Output

```
!krahS ymmaS
```

The two colons without specified parameter will include all the characters from the original string, a stride of 1 will include every character without skipping, and negating that stride will reverse the order of the characters.

Let's do this again but with a stride of -2:

```
print(ss[::-2])
```

#### Output

```
!rh ma
```

In this example, `ss[::-2]`, we are dealing with the entirety of the original string as no index numbers are included in the parameters, and reversing the string through the negative stride. Additionally, by having a stride of -2 we are skipping every other letter of the reversed string:

```
!krahS[whitespace]ymmaS
```

The whitespace character is printed in this example.

By specifying the third parameter of the Python slice syntax, you are indicating the stride of the substring that you are pulling from the

original string.

## Counting Methods

While we are thinking about the relevant index numbers that correspond to characters within strings, it is worth going through some of the methods that count strings or return index numbers. This can be useful for limiting the number of characters we would like to accept within a user-input form, or comparing strings. Like other sequential data types, strings can be counted through several methods.

We'll first look at the `len()` method which can get the length of any data type that is a sequence, whether ordered or unordered, including strings, lists, [tuples](#), and [dictionaries](#).

Let's print the length of the string `ss`:

```
print(len(ss))
```

### Output

```
12
```

The length of the string "Sammy Shark!" is 12 characters long, including the whitespace character and the exclamation point symbol.

Instead of using a variable, we can also pass a string right into the `len()` method:

```
print(len("Let's print the length of this string."))
```

### Output

```
38
```

The `len()` method counts the total number of characters within a string.

If we want to count the number of times either one particular character or a sequence of characters shows up in a string, we can do so with the `str.count()` method. Let's work with our string `ss = "Sammy Shark!"` and count the number of times the character "a" appears:

```
print(ss.count("a"))
```

**Output**

2

We can search for another character:

```
print(ss.count("s"))
```

**Output**

0

Though the letter "S" is in the string, it is important to keep in mind that each character is case-sensitive. If we want to search for all the letters in a string regardless of case, we can use the `str.lower()` method to convert the string to all lower-case first. You can read more about this method in "[An Introduction to String Methods in Python 3](#)."

Let's try `str.count()` with a sequence of characters:

```
likes = "Sammy likes to swim in the ocean, likes to  
spin up servers, and likes to smile."
```

```
print(likes.count("likes"))
```

**Output**

3

In the string `likes`, the character sequence that is equivalent to “likes” occurs 3 times in the original string.

We can also find at what position a character or character sequence occurs in a string. We can do this with the `str.find()` method, and it will return the position of the character based on index number.

We can check to see where the first “m” occurs in the string `ss`:

```
print(ss.find("m"))
```

**Ouput**

2

The first character “m” occurs at the index position of 2 in the string “Sammy Shark!” We can review the index number positions of the string `ss` [above](#).

Let’s check to see where the first “likes” character sequence occurs in the string `likes`:

```
print(likes.find("likes"))
```

**Ouput**

6

The first instance of the character sequence “likes” begins at index number position 6, which is where the character `l` of the sequence `likes` is positioned.

What if we want to see where the second sequence of “likes” begins? We can do that by passing a second parameter to the `str.find()` method that will start at a particular index number. So, instead of starting at the beginning of the string, let’s start after the index number 9:

```
print(likes.find("likes", 9))
```

**Output**

34

In this second example that begins at the index number of 9, the first occurrence of the character sequence “likes” begins at index number 34.

Additionally, we can specify an end to the range as a third parameter. Like slicing, we can do so by counting backwards using a negative index number:

```
print(likes.find("likes", 40, -6))
```

**Output**

64

This last example searches for the position of the sequence “likes” between the index numbers of 40 and -6. Since the final parameter entered is a negative number it will be counting from the end of the original string.

The string methods of `len()`, `str.count()`, and `str.find()` can be used to determine length, counts of characters or character sequences, and index positions of characters or character sequences within strings.

## Conclusion

Being able to call specific index numbers of strings, or a particular slice of a string gives us greater flexibility when working with this data type. Because strings, like lists and tuples, are a sequence-based data type, it can be accessed through indexing and slicing.

You can read more about [formatting strings](#) and [string methods](#) to continue learning about strings.

# How To Convert Data Types

In Python, [data types](#) are used to classify one particular type of data, determining the values that you can assign to the type and the operations you can perform on it. When programming, there are times we need to convert values between types in order to manipulate values in a different way. For example, we may need to concatenate numeric values with strings, or represent decimal places in numbers that were initialized as integer values.

This tutorial will guide you through converting numbers, strings, tuples and lists, as well as provide examples to help familiarize yourself with different use cases.

## Converting Number Types

In Python, there are two [number data types](#): [integers](#) and [floating-point numbers](#) or floats. Sometimes you are working on someone else's code and will need to convert an integer to a float or vice versa, or you may find that you have been using an integer when what you really need is a float. Python has built-in methods to allow you to easily convert integers to floats and floats to integers.

### Converting Integers to Floats

Python's method `float()` will convert integers to floats. To use this function, add an integer inside of the parentheses:

```
float(57)
```

In this case, 57 will be converted to 57.0.

You can also use this with a variable. Let's declare `f` as equal to 57, and then print out the new float:

```
f = 57
print(float(f))
```

**Output**

```
57.0
```

By using the `float()` function, we can convert integers to floats.

## Converting Floats to Integers

Python also has a built-in function to convert floats to integers: `int()`.

The `int()` function works similarly to the `float()` function: you can add a floating-point number inside of the parentheses to convert it to an integer:

```
int(390.8)
```

In this case, 390.8 will be converted to 390.

You can also use this with variables. Let's declare `b` as equal to 125.0, and `c` as equal to 390.8, then print out the new floats:

```
b = 125.0
c = 390.8

print(int(b))
```



```
print(int(c))
```

#### Output

```
125  
390
```

When converting floats to integers with the `int()` function, Python cuts off the decimal and remaining numbers of a float to create an integer. Even though we may want to round 390.8 up to 391, Python will not do this through the `int()` function.

### Numbers Converted Through Division

In Python 3, relevant quotients are converted from integers to floats when doing [division](#) though they are not in [Python 2](#). That is, when you divide 5 by 2, in Python 3 you will get a float for an answer (2.5):

```
a = 5 / 2  
print(a)
```

#### Output

```
2.5
```

In Python 2, since you were dealing with two integers, you would receive an integer back as your answer, instead:  $5 / 2 = 2$ . Read [“Python 2 vs Python 3: Practical Considerations”](#) for more information about the differences between Python 2 and Python 3.

### Converting with Strings

A [string](#) is a sequence of one or more characters (letters, numbers, symbols). Strings are a common form of data in computer programs, and we may need to convert strings to numbers or numbers to strings fairly often, especially when we are taking in user-generated data.

## Converting Numbers to Strings

We can convert numbers to strings through using the `str()` method. We'll pass either a number or a variable into the parentheses of the method and then that numeric value will be converted into a string value.

Let's first look at converting integers. To convert the integer 12 to a string value, you can pass 12 into the `str()` method:

```
str(12)
```

When running `str(12)` in the Python interactive shell with the `python` command in a terminal window, you'll receive the following output:

**Output**

```
'12'
```

The quotes around the number 12 signify that the number is no longer an integer but is now a string value.

With variables we can begin to see how practical it can be to convert integers to strings. Let's say we want to keep track of a user's daily programming progress and are inputting how many lines of code they

write at a time. We would like to show this feedback to the user and will be printing out string and integer values at the same time:

```
user = "Sammy"
lines = 50

print("Congratulations, " + user + "! You just wrote "
+ lines + " lines of code.")
```

When we run this code, we receive the following error:

#### **Output**

```
TypeError: Can't convert 'int' object to str
implicitly
```

We're not able to concatenate strings and integers in Python, so we'll have to convert the variable `lines` to be a string value:

```
user = "Sammy"
lines = 50

print("Congratulations, " + user + "! You just wrote "
+ str(lines) + " lines of code.")
```

Now, when we run the code, we receive the following output that congratulates our user on their progress:

#### **Output**

Congratulations, Sammy! You just wrote 50 lines of code.

If we are looking to convert a float to a string rather than an integer to a string, we follow the same steps and format. When we pass a float into the `str()` method, a string value of the float will be returned. We can use either the float value itself or a variable:

```
print(str(421.034))
```

```
f = 5524.53  
print(str(f))
```

#### **Output**

```
421.034  
5524.53
```

We can test to make sure it's right by concatenating with a string:

```
f = 5524.53  
print("Sammy has " + str(f) + " points.")
```

#### **Output**

```
Sammy has 5524.53 points.
```

We can be sure our float was properly converted to a string because the concatenation was performed without error.

## Converting Strings to Numbers

Strings can be converted to numbers by using the `int()` and `float()` methods.

If your string does not have decimal places, you'll most likely want to convert it to an integer by using the `int()` method.

Let's use the example of the user Sammy keeping track of lines of code written each day. We may want to manipulate those values with math to provide more interesting feedback for the user, but those values are currently stored in strings:

```
lines_yesterday = "50"
lines_today = "108"

lines_more = lines_today - lines_yesterday

print(lines_more)
```

### Output

```
TypeError: unsupported operand type(s) for -: 'str'
and 'str'
```

Because the two numeric values were stored in strings, we received an error. The operand `-` for subtraction is not a valid operand for two string values.

Let's modify the code to include the `int()` method that will convert the strings to integers, and allow us to do math with values these that were originally strings.

```
lines_yesterday = "50"
lines_today = "108"

lines_more = int(lines_today) - int(lines_yesterday)

print(lines_more)
```

#### **Output**

58

The variable `lines_more` is automatically an integer, and it is equal to the numeric value of 58 in this example.

We can also convert the numbers in the example above to float values by using the `float()` method in place of the `int()` method. Instead of receiving the output of 58, we'll receive the output of 58.0, a float.

The user Sammy is earning points in decimal values

```
total_points = "5524.53"
new_points = "45.30"

new_total_points = total_points + new_points

print(new_total_points)
```

#### **Output**

5524.5345.30

In this case, using the `+` operand with two strings is a valid operation, but it is concatenating two strings rather than adding two numeric values together. So, our output looks unusual since it just places the two values next to each other.

We'll want to convert these strings to floats prior to performing any math with the `float()` method:

```
total_points = "5524.53"
new_points = "45.30"

new_total_points = float(total_points) +
float(new_points)

print(new_total_points)
```

#### **Output**

```
5569.83
```

Now that we have converted the two strings to floats, we receive the anticipated result that adds `45.30` to `5524.53`.

If we try to convert a string value with decimal places to an integer, we'll receive an error:

```
f = "54.23"
print(int(f))
```

#### **Output**

```
ValueError: invalid literal for int() with base 10:
```

'54.23'

If we pass a decimal value in a string to the `int()` method we'll receive an error because it will not convert to an integer.

Converting strings to numbers enables us to quickly modify the data type we are working with so that we can perform operations on numeric values that were originally cast as strings.

## Converting to Tuples and Lists

You can use the methods `list()` and `tuple()` to convert the values passed to them into the list and tuple data type respectively. In Python: - a [list](#) is a mutable ordered sequence of elements that is contained within square brackets `[ ]`. - a [tuple](#) is an immutable ordered sequence of elements contained within parentheses `( )`.

### Converting to Tuples

Let's start with converting a list to a tuple. Converting a list to a tuple, because it's an immutable data type, can allow substantial optimization to the programs that we create. When we use the method `tuple()` it will return the tuple version of the value passed to it.

```
print(tuple(['pull request', 'open source',  
'repository', 'branch']))
```

### Output

```
('pull request', 'open source', 'repository',  
'branch')
```



We see that a tuple is printed out in the output, as the items are now contained within parentheses rather than square brackets.

Let's use `tuple()` with a variable that represents a list:

```
sea_creatures = ['shark', 'cuttlefish', 'squid',  
'mantis shrimp']  
print(tuple(sea_creatures))
```

**Output**

```
('shark', 'cuttlefish', 'squid', 'mantis shrimp')
```

Again, we see that the list value is changed to a tuple value, indicated by the parentheses. We can convert any iterable type to a tuple, including strings:

```
print(tuple('Sammy'))
```

**Output**

```
('S', 'a', 'm', 'm', 'y')
```

Because we can iterate through strings, we can convert them to tuples with the `tuple()` method. With data types that are not iterable, however, like integers and floats, we will receive a type error:

```
print(tuple(5000))
```

**Output**

```
TypeError: 'int' object is not iterable
```

While it is possible to convert the integer to a string and then convert to a tuple, as in `tuple(str(5000))`, it is best to opt for readable code over complicated conversions.

## Converting to Lists

Converting values, especially tuples, to lists can be useful when you need to have a mutable version of that value.

We'll use the `list()` method to convert the following tuple to a list. Because the syntax for creating a list uses parentheses, be sure to include the parentheses of the `list()` method, and in this case the `print()` method as well:

```
print(list(('blue coral', 'staghorn coral', 'pillar coral')))
```

### Output

```
['blue coral', 'staghorn coral', 'pillar coral']
```

The square brackets signal that a list has been returned from the original tuple value that was passed through the `list()` method.

To make the code more readable, we can remove one of the pairs of parentheses by using a variable:

```
coral = ('blue coral', 'staghorn coral', 'pillar coral')
list(coral)
```

If we print `list(coral)` we would receive the same output as above.

Just like tuples, strings can be converted to lists:

```
print(list('shark'))
```

**Output**

```
['s', 'h', 'a', 'r', 'k']
```

Here the string 'shark' was converted to a list, providing a mutable version of the original value.

## Conclusion

This Python tutorial demonstrated how to convert several of the important native data types to other data types, primarily through built-in methods. Being able to convert data types in Python provides you with extra flexibility when writing your programs.

# How To Use Variables

Variables are an important programming concept to master. They are essentially symbols that stand in for a value you're using in a program.

This tutorial will cover some variable basics and how to best use them within the Python 3 programs you create.

## Understanding Variables

In technical terms, a variable is assigning a storage location to a value that is tied to a symbolic name or identifier. The variable name is used to reference that stored value within a computer program.

You can think of a variable as a label that has a name on it, which you tie onto a value:



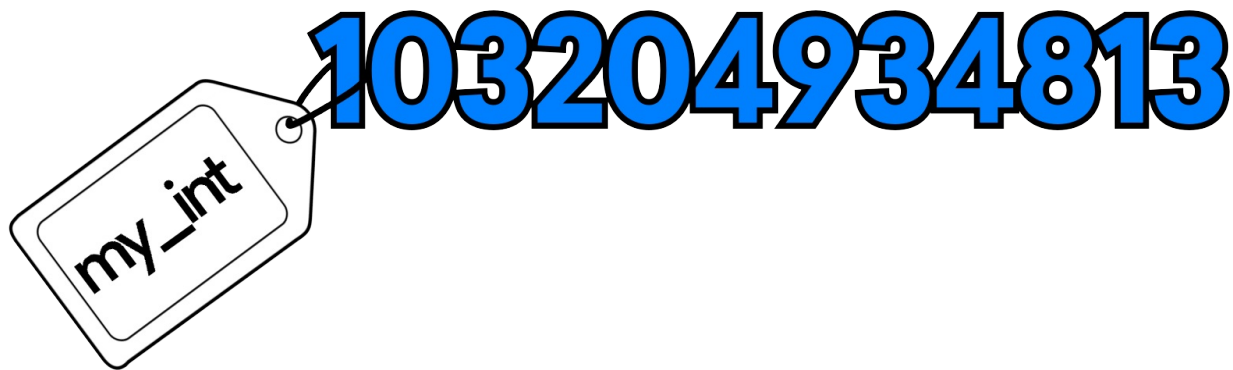
### Variables in Python

Let's say we have an integer, 103204934813, and we want to store it in a variable rather than continuously retype the long number over and

over again. Instead, let's use something that's easy to remember like the variable `my_int`:

```
my_int = 103204934813
```

If we think of it like a label that is tied to the value, it will look something like this:



#### Python Variable Example

The label has the variable name `my_int` written on it, and is tied to the integer value `103204934813`.

The phrase `my_int = 103204934813` is an assignment statement, which consists of a few parts:

- the variable name (`my_int`)
- the assignment operator, also known as the equal sign (`=`)
- the value that is being tied to the variable name (`103204934813`)

Together, those three parts make up the statement that sets the variable `my_int` equal to the value of the integer `103204934813`.

As soon as we set a variable equal to a value, we initialize or create that variable. Once we have done that, we are set to use the variable instead of the value. In Python, variables do not need explicit declaration prior to use like some programming languages; you can start using the variable right away.

As soon as we set `my_int` equal to the value of 103204934813, we can use `my_int` in the place of the integer, so let's print it out:

```
print(my_int)
```

**Output**

```
103204934813
```

Using variables, we can quickly and easily do [math](#). With `my_int = 1040`, let's subtract the integer value 813:

```
print(my_int - 813)
```

**Output**

```
103204934000
```

In this example, Python does the math for us, subtracting 813 from the variable `my_int` to return the sum 103204934000.

Speaking of math, variables can be set equal to the result of a math equation. Let's add two numbers together and store the value of the sum into the variable `x`:

```
x = 76 + 145
```

The above example may look like something you're already familiar with: algebra. In algebra, letters and other symbols are used to represent numbers and quantities within formulas and equations, just like how variables are symbolic names that represent the value of a data type. For correct Python syntax, you'll need to make sure that your variable is on the left side of any equations.

Let's go ahead and print `x`:

```
print(x)
```

#### **Output**

221

Python returned the value 221 because the variable `x` was set equal to the sum of 76 and 145.

Variables can represent any data type, not just integers:

```
my_string = 'Hello, World!'
myflt = 45.06
my_bool = 5 > 9 #A Boolean value will return either
True or False
my_list = ['item_1', 'item_2', 'item_3', 'item_4']
my_tuple = ('one', 'two', 'three')
my_dict = {'letter': 'g', 'number': 'seven', 'symbol':
'&'}
```

If you print any of the above variables, Python will return what that variable is equivalent to. For example, let's work with the assignment

statement for the [list data type](#) above:

```
my_list = ['item_1', 'item_2', 'item_3', 'item_4']  
print(my_list)
```

### Output

```
['item_1', 'item_2', 'item_3', 'item_4']
```

We passed the list value of `['item_1', 'item_2', 'item_3', 'item_4']` to the variable `my_list`, and then used the `print()` function to print out that value by calling `my_list`.

Variables work by carving out a little area of memory within your computer which accepts specified values that are then associated with that space.

## Naming Variables: Rules and Style

The naming of variables is quite flexible, but there are some rules you need to keep in mind:

- Variable names must only be one word (as in no spaces)
- Variable names must be made up of only letters, numbers, and underscore (`_`)
- Variable names cannot begin with a number

Following the rules above, let's look at both valid and invalid variable names:

| VALID | INVALID | WHY INVALID |
|-------|---------|-------------|
| <hr/> |         |             |



|                          |                          |                                              |
|--------------------------|--------------------------|----------------------------------------------|
| <code>my_int</code>      | <code>my-int</code>      | Hyphens are not permitted                    |
| <code>int4</code>        | <code>4int</code>        | Cannot begin with a number                   |
| <code>MY_INT</code>      | <code>\$MY_INT</code>    | Cannot use symbols other than <code>_</code> |
| <code>another_int</code> | <code>another int</code> | Cannot be more than one word                 |

Something else to keep in mind when naming variables, is that they are case-sensitive, meaning that `my_int`, `MY_INT`, `My_Int`, and `mY_iNt` are all completely different variables. You should avoid using similar variable names within a program to ensure that both you and your current and future collaborators can keep your variables straight.

Finally, some notes about style. Conventionally speaking, when naming variables it is customary to begin them with a lower-case letter and to use underscores when separating words. Beginning with an upper-case letter is not invalid, and some people may prefer camelCase or mixed upper- and lower-case letters when writing their variables, but these are less conventional choices.

| CONVENTIONAL<br>STYLE        | UNCONVENTIONAL<br>STYLE    | WHY UNCONVENTIONAL                       |
|------------------------------|----------------------------|------------------------------------------|
| <code>my_int</code>          | <code>myInt</code>         | camelCase not conventional               |
| <code>int4</code>            | <code>Int4</code>          | Upper-case first letter not conventional |
| <code>my_first_string</code> | <code>myFirstString</code> | camelCase not conventional               |

The most important style choice you can make is to be consistent. If you begin working on an existing project that has been using camelCase

for its variable names, then it is best to continue using the existing style.

[PEP 8](#) is the official Python code style guide and it addresses many of the stylistic questions you may have about Python. In general, readability and consistency are favored over other stylistic concerns.

## Reassigning Variables

As the word variable implies, Python variables can be readily changed. This means that you can connect a different value with a previously assigned variable very easily through simple reassignment.

Being able to reassign is useful because throughout the course of a program, you may need to accept user-generated values into already initialized variables, or may have to change the assignment to something you previously defined.

Knowing that you can readily and easily reassign a variable can also be useful in situations where you may be working on a large program that was begun by someone else and you are not clear yet on what has already been defined.

Let's assign `x` first as an integer, and then reassign it as a [string](#):

```
#Assign x to be an integer
x = 76
print(x)
```

```
#Reassign x to be a string
x = "Sammy"
print(x)
```

**Output**

76

Sammy

The example above shows that we can first assign the variable `x` and assign it with the value of an integer, and then reassign the variable `x` assigning it this time with the value of a string.

If we rewrote the program this way:

```
x = 76
x = "Sammy"
print(x)
```

We would only receive the second assigned value as the output since that was the most recent assignment:

**Output**

Sammy

Reassigning variables can be useful in some cases, but you will want to be aware of the readability of your code and work to make your program as clear as possible.

## Multiple Assignment

With Python, you can assign one single value to several variables at the same time. This lets you initialize several variables at once, which you can reassign later in the program yourself, or through user input.

Through multiple assignment, you can set the variables `x`, `y`, and `z` to the value of the integer 0:

```
x = y = z = 0
print(x)
print(y)
print(z)
```

**Output**

```
0
0
0
```

In this example, all three of the variables (`x`, `y`, and `z`) are assigned to the same memory location. They are each equal to the value of 0.

Python also allows you to assign several values to several variables within the same line. Each of these values can be of a different data type:

```
j, k, l = "shark", 2.05, 15
print(j)
print(k)
print(l)
```

**Output**

```
shark
2.05
15
```

In the example above, the variable `j` was assigned to the string `"shark"`, the variable `k` was assigned to the float `2.05`, and the variable `l` was assigned to the integer `15`.

This approach to assigning multiple variables to multiple values in one line can keep your lines of code down, but make sure you are not compromising readability for fewer lines of code.

## Global and Local Variables

When using variables within a program, it is important to keep variable scope in mind. A variable's scope refers to the particular places it is accessible within the code of a given program. This is to say that not all variables are accessible from all parts of a given program — some variables will be global and some will be local.

Global variables exist outside of [functions](#). Local variables exist within functions.

Let's take a look at global and local variables in action:

```
#Create a global variable, outside of a function
glb_var = "global"

#Define a function
def var_function():
    lcl_var = "local" #Create a local variable, inside
    function
    print(lcl_var)

#Call function to print local variable
var_function()

#Print global variable outside function
print(glb_var)
```

**Output**

```
local
global
```

The above program assigns the global variable `glb_var` outside of any function, then defines the function `var_function()`. Inside of the function a local variable called `lcl_var` is assigned and then printed out. The program ends by calling the `var_function()` and then printing the `glb_var`.

Because `glb_var` is a global variable, we can refer to it in `var_function()`. Let's modify the small program above to do that:

```
glb_var = "global"

def var_function():
    lcl_var = "local"
    print(lcl_var)
    print(glb_var) #Print glb_var within function

var_function()
print(glb_var)
```

**Output**

```
local
global
global
```

We now have the global variable `glb_var` printed out twice, because it is printed both by the function and outside of the function.

What if we try to call the local variable outside of the function?

```
glb_var = "global"

def var_function():
    lcl_var = "local"
    print(lcl_var)

print(lcl_var)
```

#### **Output**

```
NameError: name 'lcl_var' is not defined
```

We cannot use a local variable outside of the function it is assigned in. If we try to do so, we'll receive a `NameError` in return.

Let's look at another example where we use the same variable name for a global variable and a local variable:

```
num1 = 5 #Global variable

def my_function():
    num1 = 10 #Use the same variable name num1
    num2 = 7 #Assign local variable

    print(num1) #Print local variable num1
    print(num2) #Print local variable num2
```

```
#Call my_function()
my_function()

#Print global variable num1
print(num1)
```

### **Output**

```
10
7
5
```

Because the local variable of `num1` is assigned locally within a function, when we call that function we see `num1` as equal to the local value of 10. When we print out the global value of `num1` after calling `my_function()`, we see that the global variable `num1` is still equal to the value of 5.

It is possible to assign global variables within a function by using Python's `global` statement:

```
def new_shark():
    #Assign variable as global
    global shark
    shark = "Sammy"

#Call new_shark() function
new_shark()
```



```
#Print global variable shark  
print(shark)
```

Even though the variable `shark` was assigned locally within the `new_shark()` function, it is accessible outside of the function because of the `global` statement used before the assignment of the variable within the function. Due to that `global` statement, when we call `print(shark)` outside of the function we don't receive an error. Though you can assign a global variable within a function, you likely will not need to do this often, and should err on the side of readable code.

Something else to keep in mind is that if you reference a variable within a function, without also assigning it a value, that variable is implicitly global. In order to have a local variable, you must assign a value to it within the body of the function.

When working with variables, it is important to decide whether it is more appropriate to use a global or local variable. Usually it is best to keep variables local, but when you are using the same variable throughout several functions, you may want to initialize a global variable. If you are working with the variable only within one function or one [class](#), you'll probably want to use a local variable instead.

## Conclusion

This tutorial went through some of the common use cases of variables within Python 3. Variables are an important building block of programming, serving as symbols that stand in for the value of a [data type](#) you are using in a program.

# How To Use String Formatters

Python's `str.format()` method of the [string](#) class allows you to do [variable](#) substitutions and value formatting. This lets you [concatenate](#) elements together within a string through positional formatting.

This tutorial will guide you through some of the common uses of formatters in Python, which can help make your code and program more readable and user friendly.

## Using Formatters

Formatters work by putting in one or more replacement fields or placeholders — defined by a pair of curly braces `{ }` — into a string and calling the `str.format()` method. You'll pass into the method the value you want to concatenate with the string. This value will be passed through in the same place that your placeholder is positioned when you run the program.

Let's print out a string that uses a formatter:

```
print("Sammy has {} balloons.".format(5))
```

### Output

```
Sammy has 5 balloons.
```

In the example above, we constructed a string with a pair of curly braces as a placeholder:

```
"Sammy has {} balloons."
```

We then added the `str.format()` method and passed the value of the integer 5 to that method. This places the value of 5 into the string where the curly braces were:

```
Sammy has 5 balloons.
```

We can also assign a variable to be equal to the value of a string that has formatter placeholders:

```
open_string = "Sammy loves {}."  
print(open_string.format("open source"))
```

#### **Output**

```
Sammy loves open source.
```

In this second example, we concatenated the string "open source" with the larger string, replacing the curly braces in the original string.

Formatters in Python allow you to use curly braces as placeholders for values that you'll pass through with the `str.format()` method.

## **Using Formatters with Multiple Placeholders**

You can use multiple pairs of curly braces when using formatters. If we'd like to add another variable substitution to the sentence above, we can do so by adding a second pair of curly braces and passing a second value into the method:

```
new_open_string = "Sammy loves {} {}."
#2 {} placeholders
print(new_open_string.format("open-source",
"software"))    #Pass 2 strings into method, separated
by a comma
```

### **Output**

Sammy loves open-source software.

To add another substitution, we added a second pair of curly braces into the original string. Then, we passed two strings into the `str.format()` method, separating them by a comma.

Following the same syntax, we can add additional substitutions:

```
sammy_string = "Sammy loves {} {}, and has {} {}."
#4 {} placeholders
print(sammy_string.format("open-source", "software",
5, "balloons"))    #Pass 4 strings into method
```

### **Output**

Sammy loves open-source software, and has 5 balloons.

In `sammy_string` we added 4 pairs of curly braces as placeholders for variable substitution. We then passed 4 values into the `str.format()` method, mixing string and integer data types. Each of these values are separated by a comma.

## **Reordering Formatters with Positional and Keyword Arguments**

When we leave curly braces empty without any parameters, Python will replace the values passed through the `str.format()` method in order. As we have seen, so far, a formatter construction with two empty curly braces with two values passed through will look like this:

```
print("Sammy the {} has a pet {}".format("shark",  
"pilot fish"))
```

### Output

```
Sammy the shark has a pet pilot fish!
```

The first pair of curly braces is substituted with the string value of "shark", and the second pair is substituted with the string value of "pilot fish".

The values that exist within the method look like this:

```
("shark", "pilot fish")
```

They are essentially the [tuple data type](#) and each individual value contained in the tuple can be called by its index number, which starts with the index number 0.

We can pass these index numbers into the curly braces that serve as the placeholders in the original string:

```
print("Sammy the {0} has a pet {1}".format("shark",  
"pilot fish"))
```

In the above example, the output will be what we get without passing index numbers into the braces as we are calling the values in the tuple in order:

**Output**

```
Sammy the shark has a pet pilot fish!
```

But, if we reverse the index numbers with the parameters of the placeholders we can reverse the values being passed into the string:

```
print("Sammy the {1} has a pet {0}!".format("shark",  
      "pilot fish"))
```

**Output**

```
Sammy the pilot fish has a pet shark!
```

If you call an index number of 2 in a tuple that has values at index positions 0 and 1, then you are calling on a value that is out of range. When you call an index number that is out of range, you'll receive an error message:

```
print("Sammy the {2} has a pet {1}!".format("shark",  
      "pilot fish"))
```

**Output**

```
IndexError: tuple index out of range
```

The error message we see refers to the tuple only having values at index numbers 0 and 1, therefore placing index number 2 out of range.

Let's add a few more placeholders and a few more values to pass to them, so we can understand how we can reorder formatters a little better. First, here is a new string with four placeholders:

```
print("Sammy is a {}, {}, and {} {}!".format("happy",  
"smiling", "blue", "shark"))
```

#### **Output**

```
Sammy is a happy, smiling and blue shark!
```

Without parameters, the values that are passed into the `str.format()` method are concatenated into the string in order.

The string values contained in the tuple correspond to the following index numbers:

|         |           |        |         |
|---------|-----------|--------|---------|
| "HAPPY" | "SMILING" | "BLUE" | "SHARK" |
| <hr/>   |           |        |         |
| 0       | 1         | 2      | 3       |

Let's use the index numbers of the values to change the order that they appear in the string:

```
print("Sammy is a {3}, {2}, and {1}  
{0}!".format("happy", "smiling", "blue", "shark"))
```

#### **Output**

```
Sammy is a shark, blue, and smiling happy!
```

Since we started with index number 3, we called the last value of "shark" first. The other index numbers included as parameters change the order of how the words appear within the original string.

In addition to positional arguments, we can also introduce keyword arguments that are called by their keyword name:

```
print("Sammy the {0} {1} a {pr}.".format("shark",  
"made", pr = "pull request"))
```

#### **Output**

```
Sammy the shark made a pull request.
```

This example shows the use of a keyword argument being used with positional arguments. We can fill in the keyword argument `pr` alongside positional arguments, and can move these arguments around to change the resulting string:

```
print("Sammy the {pr} {1} a {0}.".format("shark",  
"made", pr = "pull request"))
```

#### **Output**

```
Sammy the pull request made a shark.
```

Positional and keyword arguments used with string formatters give us more control over manipulating our original strings through reordering.

## **Specifying Type**



We can include more parameters within the curly braces of our syntax. We'll use the format code syntax `{field_name:conversion}`, where `field_name` specifies the index number of the argument to the `str.format()` method that we went through in the [reordering section](#), and `conversion` refers to the conversion code of the data type that you're using with the formatter.

The conversion type refers to the single-character type code that Python uses. The codes that we'll be using here are `s` for string, `d` to display decimal integers (10-base), and `f` which we'll use to display floats with decimal places. You can read more about the [Format-Specification Mini-Language](#) through Python 3's official documentation.

Let's look at an example where we have an integer passed through the method, but want to display it as a float by adding the `f` conversion type argument:

```
print("Sammy ate {0:f} percent of a {1}!".format(75,
"pizza"))
```

#### Output

```
Sammy ate 75.000000 percent of a pizza!
```

We used the syntax of `{field_name:conversion}` for the first curly brace replacement field to output a float. The second curly braces only uses the first parameter `{field_name}`.

In the example above, there are a lot of numbers displaying after the decimal point, but you can limit those. When you are specifying `f` for float values, you can additionally specify the precision of that value by

including a full stop . followed by the number of digits after the decimal you would like to include.

If Sammy ate 75.765367% of the pizza, but we don't need to have a high level of accuracy, we can limit the places after the decimal to 3 by adding .3 before the conversion type f:

```
print("Sammy ate {0:.3f} percent of a  
pizza!".format(75.765367))
```

#### **Output**

```
Sammy ate 75.765 percent of a pizza!
```

If we just want one decimal place, we can rewrite the string and method like so:

```
print("Sammy ate {0:.1f} percent of a  
pizza!".format(75.765367))
```

#### **Output**

```
Sammy ate 75.8 percent of a pizza!
```

Note that modifying precision will cause the number to be rounded.

Although we display a number with no decimal places as a float, if we try to change the float to an integer by using the d conversion type, we will receive an error:

```
print("Sammy ate {0:d} percent of a  
pizza!".format(75.765367))
```

### Output

```
ValueError: Unknown format code 'd' for object of type 'float'
```

If you would like no decimal places to be shown, you can write your formatter like so:

```
print("Sammy ate {0:.0f} percent of a  
pizza!".format(75.765367))
```

### Output

```
Sammy ate 75 percent of a pizza!
```

This will not [convert your float to an integer](#), but instead limit the number of places shown after the decimal point.

## Padding Variable Substitutions

Because the placeholders are replacement fields, you can pad or create space around an element by increasing field size through additional parameters. This can be useful when we need to organize a lot of data visually.

We can add a number to indicate field size (in terms of characters) after the colon : in the curly braces of our syntax:

```
print("Sammy has {0:4} red {1:16}!".format(5,  
"balloons"))
```

### Output

```
Sammy has      5 red balloons      !
```

In the example above, we gave the number 5 a character field size of 4, and the string balloons a character field size of 16 (because it is a long string).

As we see, by default strings are left-justified within the field, and numbers are right-justified. You can modify this by placing an alignment code just following the colon. < will left-align the text in a field, ^ will center the text in the field, and > will right-align it.

Let's left-align the number and center the string:

```
print("Sammy has {0:<4} red {1:^16}!".format(5,
"balloons"))
```

#### **Output**

```
Sammy has 5      red      balloons      !
```

Now we see that 5 is left-aligned, providing space in the field before red, and balloons is centered in its field with space to the left and right of it.

By default, when we make a field larger with formatters, Python will fill the field with whitespace characters. We can modify that to be a different character by specifying the character we want it to be directly following the colon:

```
print("{:*^20s}".format("Sammy"))
```

#### **Output**

```
*****Sammy*****
```

We are accepting the string being passed to `str.format()` in the index position of 0 since we did not specify otherwise, including the colon, and specifying that we will use `*` instead of space to fill up the field. We're centering the string with `^`, specifying that the field is 20 characters in size, and also indicating that we are working with a string conversion type by including `s`.

We can combine these parameters with other parameters we've used before:

```
print("Sammy ate {0:5.0f} percent of a  
pizza!".format(75.765367))
```

### Output

```
Sammy ate      76 percent of a pizza!
```

In the parameters within the curly braces, we specified the index field number of the float and included the colon, indicated the size of the field number and included the full stop, wrote in the number of places after the decimal place, and then specified the conversion type of `f`.

## Using Variables

So far, we have passed integers, floats, and strings into the `str.format()` method, but we can also pass variables through the method. This works just like any other variable.

```
nBalloons = 8
```

```
print("Sammy has {} balloons  
today!".format(nBalloons))
```

#### **Output**

```
Sammy has 8 balloons today!
```

We can use variables for both the original string and what is passed into the method :

```
sammy = "Sammy has {} balloons today!"  
nBalloons = 8  
print(sammy.format(nBalloons))
```

#### **Output**

```
Sammy has 8 balloons today!
```

Variables can be easily substituted for each part of our formatter syntax construction. This makes it easier to work with when we are taking in user-generated input and assigning those values to variables.

## Using Formatters to Organize Data

Formatters can be seen in their best light when they are being used to organize a lot of data in a visual way. If we are showing databases to users, using formatters to increase field size and modify alignment can make your output more readable.

Let's look at a typical [for loop](#) in Python that will print out  $i$ ,  $i*i$ , and  $i*i*i$  in the range from 3 to 12:

```
for i in range(3,13):  
    print(i, i*i, i*i*i)
```

### **Output**

```
3 9 27  
4 16 64  
5 25 125  
6 36 216  
7 49 343  
8 64 512  
9 81 729  
10 100 1000  
11 121 1331  
12 144 1728
```

While the output is organized in a way, the numbers overflow into each other's columns, making the bottom of the output less readable. If you are working with a bigger data set with many small and big numbers, this can pose a problem.

Let's use formatters to give more space to these numbers:

```
for i in range(3,13):  
    print("{:3d} {:4d} {:5d}".format(i, i*i, i*i*i))
```

Here, in our curly braces, we didn't add the field name for index number and started with the colon, followed by the number for the field size, and a d conversion type since we're working with integers. In this example, we accommodated for the size of each expected output, giving

2 extra character spaces for each, depending on the maximum possible number size, so our output looks like this:

**Output**

|    |     |      |
|----|-----|------|
| 3  | 9   | 27   |
| 4  | 16  | 64   |
| 5  | 25  | 125  |
| 6  | 36  | 216  |
| 7  | 49  | 343  |
| 8  | 64  | 512  |
| 9  | 81  | 729  |
| 10 | 100 | 1000 |
| 11 | 121 | 1331 |
| 12 | 144 | 1728 |

We can specify a consistent field size number in order to have even columns, making sure that we accommodate the larger numbers:

```
for i in range(3,13):  
    print("{:6d} {:6d} {:6d}".format(i, i*i, i*i*i))
```

**Output**

|   |    |     |
|---|----|-----|
| 3 | 9  | 27  |
| 4 | 16 | 64  |
| 5 | 25 | 125 |
| 6 | 36 | 216 |
| 7 | 49 | 343 |
| 8 | 64 | 512 |



|    |     |      |
|----|-----|------|
| 9  | 81  | 729  |
| 10 | 100 | 1000 |
| 11 | 121 | 1331 |
| 12 | 144 | 1728 |

We can also manipulate the alignment of the columns by adding `<`, `^`, and `>` for text alignment, change `d` to `f` to add decimal places, change field name index numbers, and more to ensure that we are displaying the data as we would like.

## Conclusion

Using formatters for variable substitution can be effective way to concatenate strings and organize values and data. Formatters represent a simple but non-descriptive way for passing variable substitutions into a string, and are useful for making sure output is readable and user friendly.

# How To Do Math with Operators

Numbers are extremely common in programming. They are used to represent things like screen size dimensions, geographic locations, money and points, the amount of time that passes in a video, positions of game avatars, and colors through assigning numeric codes.

Being able to effectively perform mathematical operations in programming is an important skill to develop because of how frequently you'll be working with numbers. Though a high-level understanding of mathematics can certainly help you become a better programmer, it is not a prerequisite. If you don't have a background in mathematics, try to think of math as a tool to accomplish what you would like to achieve, and as a way to improve your logical thinking.

We'll be working with two of Python's most used numeric data types, integers and floats:

- [Integers](#) are whole numbers that can be positive, negative, or 0 (... , -1, 0, 1, ...).
- [Floats](#) are real numbers, they contain a decimal point (as in 9.0 or -2.25).

This tutorial will go over operators that can be used with number data types in Python.

## Operators

An operator is a symbol or function that indicates an operation. For example, in math the plus sign or + is the operator that indicates

addition.

In Python, we will see some familiar operators that are brought over from math, but other operators we will use are specific to computer programming.

Here is a quick reference table of math-related operators in Python. We'll be covering all of the following operations in this tutorial.

| OPERATION                           | WHAT IT RETURNS                                                   |
|-------------------------------------|-------------------------------------------------------------------|
| <a href="#"><code>x + y</code></a>  | Sum of <code>x</code> and <code>y</code>                          |
| <a href="#"><code>x - y</code></a>  | Difference of <code>x</code> and <code>y</code>                   |
| <a href="#"><code>-x</code></a>     | Changed sign of <code>x</code>                                    |
| <a href="#"><code>+x</code></a>     | Identity of <code>x</code>                                        |
| <a href="#"><code>x * y</code></a>  | Product of <code>x</code> and <code>y</code>                      |
| <a href="#"><code>x / y</code></a>  | Quotient of <code>x</code> and <code>y</code>                     |
| <a href="#"><code>x // y</code></a> | Quotient from floor division of <code>x</code> and <code>y</code> |
| <a href="#"><code>x % y</code></a>  | Remainder of <code>x / y</code>                                   |
| <a href="#"><code>x ** y</code></a> | <code>x</code> to the <code>y</code> power                        |

We'll also be covering [compound assignment operators](#), including `+=` and `*=`, that combine an arithmetic operator with the `=` operator.

## Addition and Subtraction

In Python, addition and subtraction operators perform just as they do in mathematics. In fact, you can use the Python programming language as a calculator.

Let's look at some examples, starting with integers:

```
print(1 + 5)
```

**Output**

6

Instead of passing integers directly into the `print` statement, we can initialize variables to stand for integer values:

```
a = 88  
b = 103
```

```
print(a + b)
```

**Output**

191

Because integers can be both positive and negative numbers (and 0 too), we can add a negative number with a positive number:

```
c = -36  
d = 25
```

```
print(c + d)
```

**Output**

-11

Addition will behave similarly with floats:

```
e = 5.5  
f = 2.5  
  
print(e + f)
```

**Output**

```
8.0
```

Because we added two floats together, Python returned a float value with a decimal place.

The syntax for subtraction is the same as for addition, except you'll change your operator from the plus sign (+) to the minus sign (-):

```
g = 75.67  
h = 32  
  
print(g - h)
```

**Output**

```
43.67
```

Here, we subtracted an integer from a float. Python will return a float if at least one of the numbers involved in an equation is a float.

## Unary Arithmetic Operations

A unary mathematical expression consists of only one component or element, and in Python the plus and minus signs can be used as a single element paired with a value to return the value's identity (+), or change the sign of the value (-).

Though not commonly used, the plus sign indicates the identity of the value. We can use the plus sign with positive values:

```
i = 3.3  
print(+i)
```

**Output**

3.3

When we use the plus sign with a negative value, it will also return the identity of that value, and in this case it would be a negative value:

```
j = -19  
print(+j)
```

**Output**

-19

With a negative value the plus sign returns the same negative value.

The minus sign, alternatively, changes the sign of a value. So, when we pass a positive value we'll find that the minus sign before the value will return a negative value:

```
i = 3.3
```

```
print(-i)
```

**Output**

```
-3.3
```

Alternatively, when we use the minus sign unary operator with a negative value, a positive value will be returned:

```
j = -19  
print(-j)
```

**Output**

```
19
```

The unary arithmetic operations indicated by the plus sign and minus sign will return either the value's identity in the case of `+i`, or the opposite sign of the value as in `-i`.

## Multiplication and Division

Like addition and subtraction, multiplication and division will look very similar to how they do in mathematics. The sign we'll use in Python for multiplication is `*` and the sign we'll use for division is `/`.

Here's an example of doing multiplication in Python with two float values:

```
k = 100.1  
l = 10.1
```

```
print(k * l)
```

**Output**

```
1011.00999999999999
```

When you divide in Python 3, your quotient will always be returned as a float, even if you use two integers:

```
m = 80
```

```
n = 5
```

```
print(m / n)
```

**Output**

```
16.0
```

This is one of the [major changes between Python 2 and Python 3](#). Python 3's approach provides a fractional answer so that when you use / to divide 11 by 2 the quotient of 5.5 will be returned. In Python 2 the quotient returned for the expression 11 / 2 is 5.

Python 2's / operator performs floor division, where for the quotient  $x$  the number returned is the largest integer less than or equal to  $x$ . If you run the above example of `print(80 / 5)` with Python 2 instead of Python 3, you'll receive 16 as the output without the decimal place.

In Python 3, you can use // to perform floor division. The expression `100 // 40` will return the value of 2. Floor division is useful when you need a quotient to be in whole numbers.



## Modulo

The `%` operator is the modulo, which returns the remainder rather than the quotient after division. This is useful for finding numbers that are multiples of the same number, for example.

Let's look at the modulo in action:

```
o = 85
```

```
p = 15
```

```
print(o % p)
```

### Output

```
10
```

To break this down, 85 divided by 15 returns the quotient of 5 with a remainder of 10. The value 10 is what is returned here because the modulo operator returns the remainder of a division expression.

If we use two floats with the modulo, a float value will be returned for the remainder:

```
q = 36.0
```

```
r = 6.0
```

```
print(o % p)
```

### Output

```
0.0
```

In the case of 36.0 divided by 6.0, there is no remainder, so the value of 0.0 is returned.

## Power

The `**` operator in Python is used to raise the number on the left to the power of the exponent of the right. That is, in the expression `5 ** 3`, 5 is being raised to the 3rd power. In mathematics, we often see this expression rendered as  $5^3$ , and what is really going on is 5 is being multiplied by itself 3 times. In Python, we would get the same result of 125 by running either `5 ** 3` or `5 * 5 * 5`.

Let's look at an example with variables:

```
s = 52.25
```

```
t = 7
```

```
print(s ** t)
```

```
1063173305051.292
```

Raising the float 52.25 to the power of 7 through the `**` operator results in a large float value returned.

## Operator Precedence

In Python, as in mathematics, we need to keep in mind that operators will be evaluated in order of precedence, not from left to right or right to left.

If we look at the following expression:

```
u = 10 + 10 * 5
```

We may read it left to right, but remember that multiplication will be done first, so if we call `print(u)`, we will receive the following value:

**Output**

```
60
```

This is because `10 * 5` evaluates to 50, and then we add 10 to return 60 as the final result.

If instead we would like to add the value 10 to 10, then multiply that sum by 5, we can use parentheses just like we would in math:

```
u = (10 + 10) * 5  
print(u)
```

**Output**

```
100
```

One way to remember the order of operation is through the acronym PEMDAS:

| ORDER | LETTER | STANDS FOR     |
|-------|--------|----------------|
| 1     | P      | Parentheses    |
| 2     | E      | Exponent       |
| 3     | M      | Multiplication |
| 4     | D      | Division       |

|   |   |             |
|---|---|-------------|
| 5 | A | Addition    |
| 6 | S | Subtraction |

You may be familiar with another acronym for the order of operations, such as BEDMAS or BODMAS. Whatever acronym works best for you, try to keep it in mind when performing math operations in Python so that the results that you expect are returned.

## Assignment Operators

The most common assignment operator is one you have already used: the equals sign `=`. The `=` assignment operator assigns the value on the right to a variable on the left. For example, `v = 23` assigns the value of the integer 23 to the variable `v`.

When programming, it is common to use compound assignment operators that perform an operation on a variable's value and then assign the resulting new value to that variable. These compound operators combine an arithmetic operator with the `=` operator, so for addition we'll combine `+` with `=` to get the compound operator `+=`. Let's see what that looks like:

```
w = 5
w += 1
print(w)
```

### Output

6

First, we set the variable `w` equal to the value of 5, then we used the `+=` compound assignment operator to add the right number to the value of the left variable and then assign the result to `w`.

Compound assignment operators are used frequently in the case of [for loops](#), which you'll use when you want to repeat a process several times:

```
for x in range (0, 7):  
    x *= 2  
    print(x)
```

#### **Output**

```
0  
2  
4  
6  
8  
10  
12
```

With the for loop, we were able to automate the process of the `*=` operator that multiplied the variable `w` by the number 2 and then assigned the result in the variable `w` for the next iteration of the for loop.

Python has a compound assignment operator for each of the arithmetic operators discussed in this tutorial:

```
y += 1          # add then assign value
```

```
y -= 1          # subtract then assign value
```

```
y *= 2          # multiply then assign value

y /= 3          # divide then assign value

y // = 5        # floor divide then assign value

y **= 2         # increase to the power of then assign
value

y %= 3          # return remainder then assign value
```

Compound assignment operators can be useful when things need to be incrementally increased or decreased, or when you need to automate certain processes in your program.

## Conclusion

This tutorial covered many of the operators you'll use with the integer and float numeric data types. If you would like to keep reading about numbers in Python, you can continue onto [Built-in Python 3 Functions for Working with Numbers](#).

To learn more about other data types, take a look at [Understanding Data Types in Python 3](#), and learn about how to convert data types by reading [How To Convert Data Types in Python 3](#).

# Built-in Python 3 Functions for Working with Numbers

Python 3 comes with many built-in functions that you can readily use in any program that you're working on. Some functions enable you to [convert data types](#), and others are specific to a certain type, like [strings](#).

This tutorial will go through a few of the built-in functions that can be used with numeric data types in Python 3. We'll go over the following functions: - `abs()` for absolute value - `divmod()` to find a quotient and remainder simultaneously - `pow()` to raise a number to a certain power - `round()` to round a number to a certain decimal point - `sum()` to calculate the sum of the items in an iterable data type

Becoming familiar with these methods can give you more flexibility when programming so that you can make informed decisions when deciding what operators and functions to use. We'll go through some of these functions with examples throughout this tutorial.

## Absolute Value

The built-in function `abs()` will return the absolute value of a number that you pass to it. In mathematics, absolute value refers to the distance that a number is on the number line from 0. Absolute value does not take into consideration which direction from zero the number lies, meaning that negative numbers will be represented with positive numbers.

To give some examples, the absolute value of 15 is 15, the absolute value of -74 is 74, and the absolute value of 0 is 0.

Absolute value is an important concept for calculus and real analysis, but it also makes sense when we think about everyday situations like

distance travelled. For example, if we are trying to get somewhere that is 58 miles away but we travel 93 miles instead, we overshoot our original destination. If we want to calculate now how many miles left to travel to get to the intended destination, we'll end up with a negative number, but we can't travel negative miles.

Let's use `abs()` to solve this problem:

#### **destination\_miles.py**

```
miles_from_origin = 58  # Miles destination is from
origin
miles_travelled = 93    # Miles travelled from origin
to destination (too many)

# Calculate how many miles destination is from current
location:
miles_to_go = miles_from_origin - miles_travelled

print(miles_to_go)      # Print how many miles left (a
negative number)
print(abs(miles_to_go)) # Use absolute value to
account for negative number
```

#### **Output**

-35

35

In the output, we see that if we don't use the `abs()` function, in this instance we have a negative number, -35. Though we may be in a



position where `miles_travelled` is less than `miles_from_origin`, including the `abs()` function takes the possibility of a negative number into account.

With a negative number, `abs()` will return a positive number as absolute values are always positive numbers or zero.

Let's go through using `abs()` with a positive number and zero:

```
print(abs(89.9))  
print(abs(0))
```

#### **Output**

```
89.9  
0
```

We're most likely to use `abs()` with a variable that may be positive or negative in an instance when we are looking only for a positive number. To account for a negative input or result, we'll use `abs()` to modify what is returned to be a positive number.

## **Finding the Quotient and Remainder in One Function**

Because both floor division (which returns a quotient), and modulo division (which returns a remainder), are closely related, it can be useful to use a function that combines both operations at once.

The Python built-in function `divmod()` combines the two, returning first the quotient that comes from floor division, then the remainder.

Because `divmod()` will be working with two numbers, we need to pass two numbers to it.

```
divmod(a,b)
```

With this function we are basically performing the following:

```
a // b  
a & b
```

Let's say we have written a book that is 80,000 words long. With our publisher, we have the option of either 300 or 250 words per page, and we'd like to get a sense of how many pages we would have in each case. With `divmod()` we can see immediately how many pages we would have, and how many words would be spilled over onto an additional page.

**words\_per\_page.py**

```
words = 80000          # How many words in our book  
per_page_A = 300       # Option A, 300 words per page  
per_page_B = 250       # Option B, 25- words per page  
  
print(divmod(words,per_page_A)) # Calculate Option A  
print(divmod(words,per_page_B)) # Calculate Option B
```

**Output**

```
(266, 200)  
(320, 0)
```

In Option A, we will have 266 pages filled with words and 200 words left over ( $\frac{2}{3}$  of a page) for a total of 267 pages, and in Option B we'll have

an even 320-page book. If we want to be environmentally-conscious, we can choose Option A, but if we want to look more impressive with a bigger-sized book we may choose Option B.

Because the function `divmod()` can take both integers and floats, let's also go through an example that uses floats:

```
a = 985.5
b = 115.25

print(divmod(a,b))
```

**Output**

```
(8.0, 63.5)
```

In this example, `8.0` is the floor quotient of `985.5` divided by `115.25`, and `63.5` is the remainder.

Keep in mind that you can use the floor division operator `//` and the modulo operator `%` to verify what `divmod()` did:

```
print(a//b)
print(a%b)
```

**Output**

```
8.0
63.5
```

When using the `divmod()` function in Python, we get both the whole number of times the division occurs and the remainder returned.

## Power

In Python, you can use [the operator](#) `**` to raise a number by an exponent, or you can use the built-in function `pow()` which takes in two numbers.

To see how the `pow()` function works, let's say we are doing research on bacteria and want to see how many bacteria we'll have at the end of the day if we start with 1. The particular bacteria we're working with doubles each hour, so we'll be calculating 2 (doubling) to the power of the total number of hours (24 in our case).

**bacteria.py**

```
hours = 24
total_bacteria = pow(2, hours)

print(total_bacteria)
```

**Output**

```
16777216
```

We passed two integers to the `pow()` function and determined that by the end of this 24-hour period, we'll have over 16 million bacteria.

In mathematics, if we want to calculate 3 to the power of 3, it is generally written like this:

$$3^3$$

The computation that we are completing is  $3 \times 3 \times 3$ , which is equal to 27.

To calculate  $3^3$  in Python, we would type out `pow(3, 3)`.

The function `pow()` will take both integers and floats, and provides an alternative to using the `**` operator when you intend to raise numbers to a certain power.

## Rounding Numbers

Being able to quickly and readily round numbers becomes important when working with floats that have a lot of decimal places. The built-in Python function `round()` takes in two numbers, one to be rounded, and one that specifies the number of decimal places to include.

We'll use the function to take a float with more than 10 decimal places and use the `round()` function to reduce decimal places to 4:

```
i = 17.34989436516001
print(round(i,4))
```

### Output

```
17.3499
```

In the example above, the float `17.34989436516001` is rounded to `17.3499` because we have specified that the number of decimal places should be limited to 4.

Note also that the `round()` function rounds numbers up, so instead of providing `17.3498` as the output, it has provided `17.3499` because the number following the decimal number 8 is the number 9. Any number that is followed by the number 5 or greater will be rounded up to the next whole number.

Let's break down the syntax for `round()`:

`round(number to round, number of decimal places)`

In everyday life, rounding numbers happens often, especially when working with money; we can't split up a penny evenly among several friends.

Let's go through an example of a simple program that can calculate a tip. Here we'll provide figures, but we could rewrite the program to bring in user-provided numbers instead. In this example, 3 friends went to a restaurant who want to split a bill of \$87.93 evenly, along with adding a 20% tip.

**bill\_split.py**

```
bill = 87.93                # Total bill
tip = 0.2                   # 20% tip
split = 3                   # Number of people
splitting the bill

total = bill + (bill * tip) # Calculate the total bill

each_pay = total / split    # Calculate what each
person pays

print(each_pay)             # What each person pays
before rounded

print(round(each_pay,2))     # Round the number — we
can't split pennies
```

## Output

```
35.1720000000000004
```

```
35.17
```

In this program, we ask first for output of the number after we calculate the total bill plus tip divided by 3, which evaluates to a number with a lot of decimal places: `35.1720000000000004`. Since this number doesn't make sense as a monetary figure, we use the `round()` function and limit the decimal places to 2, so that we can provide an output that the 3 friends can actually work with: `35.17`.

If you would prefer to round to a number with only 0 as a decimal value, you can do so by using 0 as the second parameter in the `round()` function:

```
round(345.9874590348545304636, 0)
```

This would evaluate to `346.0`.

You can also pass integers into `round()` without receiving an error, in case you receive user input in the form of an integer rather than a float. When an integer is passed as the first parameter, an integer will be returned.

## Calculating a Sum

The `sum()` function is used for calculating sums of numeric compound data types, including [lists](#), [tuples](#), and [dictionaries](#).

We can pass a list to the `sum()` function to add all the items in the list together in order from left to right:

```
some_floats = [1.1, 2.2, 3.3, 4.4, 5.5, 6.6, 7.7, 8.8,
9.9]
print(sum(some_floats))
```

### **Output**

49.5

This will work similarly with tuples and dictionaries:

```
print(sum((8,16,64,512)))    # Calculate sum of numbers
in tuple
print(sum({-10: 'x', -20: 'y', -30: 'z'}))  #
Calculate sum of numbers in dictionary
```

### **Output**

```
600 # Sum of numbers in tuple
-60 # Sum of numbers in dictionary
```

The `sum()` function can take up to 2 arguments, so you can add an additional number in integer or float form to add to the numbers that make up the argument in the first position:

```
some_floats = [1.1, 2.2, 3.3, 4.4, 5.5, 6.6, 7.7, 8.8,
9.9]

print(sum(some_floats, 0.5))
print(sum({-10: 'x', -20: 'y', -30: 'z'},60))
```



## Output

50.0

0

When you don't include a second argument, the `sum()` function defaults to adding 0 to the iterable compound data type.

## Conclusion

This tutorial covered some built-in methods that you can use with numeric data types in the Python programming language.

To learn more about working with numbers, you can read "[How To Do Math in Python 3 with Operators](#)", and to learn more about lists, take a look at "[Understanding Lists in Python 3](#)."

# Understanding Boolean Logic

The Boolean data type can be one of two values, either `True` or `False`. We use Booleans in programming to make comparisons and to control the flow of the program.

Booleans represent the truth values that are associated with the logic branch of mathematics, which informs algorithms in computer science. Named for the mathematician George Boole, the word Boolean always begins with a capitalized B. The values `True` and `False` will also always be with a capital T and F respectively, as they are special values in Python.

In this tutorial, we'll go over the basics you'll need to understand how Booleans work, including Boolean comparison and logical operators, and truth tables.

## Comparison Operators

In programming, comparison operators are used to compare values and evaluate down to a single Boolean value of either `True` or `False`.

The table below shows Boolean comparison operators.

| OPERATOR          | WHAT IT MEANS |
|-------------------|---------------|
| <code>==</code>   | Equal to      |
| <code>!=</code>   | Not equal to  |
| <code>&lt;</code> | Less than     |
| <code>&gt;</code> | Greater than  |

`<=`      Less than or equal to

`>=`      Greater than or equal to

To understand how these operators work, let's assign two integers to two variables in a Python program:

```
x = 5
y = 8
```

We know that in this example, since `x` has the value of 5, it is less than `y` which has the value of 8.

Using those two variables and their associated values, let's go through the operators from the table above. In our program, we'll ask Python to print out whether each comparison operator evaluates to either `True` or `False`. To help us and other humans better understand this output, we'll have Python also print a [string](#) to show us what it's evaluating.

```
x = 5
y = 8

print("x == y:", x == y)
print("x != y:", x != y)
print("x < y:", x < y)
print("x > y:", x > y)
print("x <= y:", x <= y)
print("x >= y:", x >= y)
```

**Output**

```
x == y: False
x != y: True
x < y: True
x > y: False
x <= y: True
x >= y: False
```

Following mathematical logic, in each of the expressions above, Python has evaluated:

- Is 5 (x) equal to 8 (y)? False
- Is 5 not equal to 8? True
- Is 5 less than 8? True
- Is 5 greater than 8? False
- Is 5 less than or equal to 8? True
- Is 5 not less than or equal to 8? False

Although we used integers here, we could substitute them with float values.

Strings can also be used with Boolean operators. They are case-sensitive unless you employ an additional [string method](#).

We can look at how strings are compared in practice:

```
Sammy = "Sammy"
sammy = "sammy"

print("Sammy == sammy: ", Sammy == sammy)
```

### Output

```
Sammy == sammy: False
```

The string "Sammy" above is not equal to the string "sammy", because they are not exactly the same; one starts with an upper-case S and the other with a lower-case s. But, if we add another variable that is assigned the value of "Sammy", then they will evaluate to equal:

```
Sammy = "Sammy"
sammy = "sammy"
also_Sammy = "Sammy"

print("Sammy == sammy: ", Sammy == sammy)
print("Sammy == also_Sammy", Sammy == also_Sammy)
```

### Output

```
Sammy == sammy: False
Sammy == also_Sammy: True
```

You can also use the other comparison operators including > and < to compare two strings. Python will compare these strings lexicographically using the ASCII values of the characters.

We can also evaluate Boolean values with comparison operators:

```
t = True
f = False

print("t != f: ", t != f)
```

## Output

```
t != f: True
```

The above code block evaluated that `True` is not equal to `False`.

Note the difference between the two operators `=` and `==`.

```
x = y    # Sets x equal to y
x == y   # Evaluates whether x is equal to y
```

The first, `=` is the assignment operator, which will set one value equal to another. The second, `==` is a comparison operator which will evaluate whether two values are equal.

## Logical Operators

There are three logical operators that are used to compare values. They evaluate expressions down to Boolean values, returning either `True` or `False`. These operators are `and`, `or`, and `not` and are defined in the table below.

| OPERATOR         | WHAT IT MEANS                | WHAT IT LOOKS LIKE   |
|------------------|------------------------------|----------------------|
| <code>and</code> | True if both are true        | <code>x and y</code> |
| <code>or</code>  | True if at least one is true | <code>x or y</code>  |
| <code>not</code> | True only if false           | <code>not x</code>   |

Logical operators are typically used to evaluate whether two or more expressions are true or not true. For example, they can be used to determine if the grade is passing and that the student is registered in the

course, and if both cases are true then the student will be assigned a grade in the system. Another example would be to determine whether a user is a valid active customer of an online shop based on whether they have store credit or have made a purchase in the past 6 months.

To understand how logical operators work, let's evaluate three expressions:

```
print((9 > 7) and (2 < 4)) # Both original
expressions are True
print((8 == 8) or (6 != 6)) # One original expression
is True
print(not(3 <= 1))          # The original expression
is False
```

### Output

```
True
True
True
```

In the first case, `print((9 > 7) and (2 < 4))`, both `9 > 7` and `2 < 4` needed to evaluate to True since the `and` operator was being used.

In the second case, `print((8 == 8) or (6 != 6))`, since `8 == 8` evaluated to True, it did not make a difference that `6 != 6` evaluates to False because the `or` operator was used. If we had used the `and` operator, this would evaluate to False.

In the third case, `print(not(3 <= 1))`, the `not` operator negates the False value that `3 <= 1` returns.

Let's substitute floats for integers and aim for False evaluations:

```
print((-0.2 > 1.4) and (0.8 < 3.1)) # One original
expression is False
print((7.5 == 8.9) or (9.2 != 9.2)) # Both original
expressions are False
print(not(-5.7 <= 0.3))                # The original
expression is True
```

In the example above, `- and` must have at least one `False` expression evaluate to `False`, `- or` must have both expressions evaluate to `False`, `- not` must have its inner expression be `True` for the new expression to evaluate to `False`.

If the results above seem unclear to you, we'll go through some [truth tables](#) below to get you up to speed.

You can also write compound statements using `and`, `or`, and `not`:

```
not((-0.2 > 1.4) and ((0.8 < 3.1) or (0.1 == 0.1)))
```

Let's look at the inner-most expression first: `(0.8 < 3.1) or (0.1 == 0.1)`. This expression evaluates to `True` because both mathematical statements are `True`.

Now, we can take the returned value `True` and combine it with the next inner expression: `(-0.2 > 1.4) and (True)`. This example returns `False` because the mathematical statement `-0.2 > 1.4` is `False`, and `(False) and (True)` returns `False`.

Finally, we have the outer expression: `not(False)`, which evaluates to `True`, so the final returned value if we print this statement out is:

**Output**



True

The logical operators `and`, `or`, and `not` evaluate expressions and return Boolean values.

## Truth Tables

There is a lot to learn about the logic branch of mathematics, but we can selectively learn some of it to improve our algorithmic thinking when programming.

Below are truth tables for the comparison operator `==`, and each of the logic operators `and`, `or`, and `not`. While you may be able to reason them out, it can also be helpful to work to memorize them as that can make your programming decision-making process quicker.

### **`==` Truth Table**

| X     | == | Y     | RETURNS |
|-------|----|-------|---------|
| True  | == | True  | True    |
| True  | == | False | False   |
| False | == | True  | False   |
| False | == | False | True    |

### **AND Truth Table**

| X    | AND | Y     | RETURNS |
|------|-----|-------|---------|
| True | and | True  | True    |
| True | and | False | False   |

False and True False

False and False False

## OR Truth Table

| X     | OR | Y     | RETURNS |
|-------|----|-------|---------|
| True  | or | True  | True    |
| True  | or | False | True    |
| False | or | True  | True    |
| False | or | False | False   |

## NOT Truth Table

| NOT | X     | RETURNS |
|-----|-------|---------|
| not | True  | False   |
| not | False | True    |

Truth tables are common mathematical tables used in logic, and are useful to memorize or keep in mind when constructing algorithms (instructions) in computer programming.

## Using Boolean Operators for Flow Control

To control the stream and outcomes of a program in the form of flow control statements, we can use a condition followed by a clause.

A condition evaluates down to a Boolean value of True or False, presenting a point where a decision is made in the program. That is, a

condition would tell us if something evaluates to True or False.

The clause is the block of code that follows the condition and dictates the outcome of the program. That is, it is the do this part of the construction “If x is True, then do this.”

The code block below shows an example of comparison operators working in tandem with [conditional statements](#) to control the flow of a Python program:

```
if grade >= 65:                # Condition
    print("Passing grade")      # Clause

else:
    print("Failing grade")
```

This program will evaluate whether each student’s grade is passing or failing. In the case of a student with a grade of 83, the first statement will evaluate to True, and the print statement of Passing grade will be triggered. In the case of a student with a grade of 59, the first statement will evaluate to False, so the program will move on to execute the print statement tied to the else expression: Failing grade.

Because every single object in Python can be evaluated to True or False, the [PEP 8 Style Guide](#) recommends against comparing a value to True or False because it is less readable and will frequently return an unexpected Boolean. That is, you should avoid using `if sammy == True:` in your programs. Instead, compare sammy to another non-Boolean value that will return a Boolean.

Boolean operators present conditions that can be used to decide the eventual outcome of a program through flow control statements.

## Conclusion

This tutorial went through comparison and logical operators belonging to the Boolean type, as well as truth tables and using Booleans for program flow control.

You can learn more about other data types in our “[Understanding Data Types](#)” tutorial, and can read about conditional statements in our “[How To Write Conditional Statements](#)” tutorial.

# Understanding Lists

A list is a data structure in Python that is a mutable, or changeable, ordered sequence of elements. Each element or value that is inside of a list is called an item. Just as [strings](#) are defined as characters between quotes, lists are defined by having values between square brackets [ ].

Lists are great to use when you want to work with many related values. They enable you to keep data together that belongs together, condense your code, and perform the same methods and operations on multiple values at once.

When thinking about Python lists and other data structures that are types of collections, it is useful to consider all the different collections you have on your computer: your assortment of files, your song playlists, your browser bookmarks, your emails, the collection of videos you can access on a streaming service, and more.

To get started, let's create a list that contains items of the string data type:

```
sea_creatures = ['shark', 'cuttlefish', 'squid',  
'mantis shrimp', 'anemone']
```

When we print out the list, the output looks exactly like the list we created:

```
print(sea_creatures)
```

**Output**

```
['shark', 'cuttlefish', 'squid', 'mantis shrimp',  
'anemone']
```

As an ordered sequence of elements, each item in a list can be called individually, through indexing. Lists are a compound data type made up of smaller parts, and are very flexible because they can have values added, removed, and changed. When you need to store a lot of values or iterate over values, and you want to be able to readily modify those values, you'll likely want to work with list data types.

In this tutorial, we'll go through some of the ways that we can work with lists in Python.

## Indexing Lists

Each item in a list corresponds to an index number, which is an integer value, starting with the index number 0.

For the list `sea_creatures`, the index breakdown looks like this:

|         |              |         |                 |           |
|---------|--------------|---------|-----------------|-----------|
| 'SHARK' | 'CUTTLEFISH' | 'SQUID' | 'MANTIS SHRIMP' | 'ANEMONE' |
| 0       | 1            | 2       | 3               | 4         |

The first item, the string `'shark'` starts at index 0, and the list ends at index 4 with the item `'anemone'`.

Because each item in a Python list has a corresponding index number, we're able to access and manipulate lists in the same ways we can with other sequential data types.

Now we can call a discrete item of the list by referring to its index number:

```
print(sea_creatures[1])
```

**Output**

```
cuttlefish
```

The index numbers for this list range from 0-4, as shown in the table above. So to call any of the items individually, we would refer to the index numbers like this:

```
sea_creatures[0] = 'shark'  
sea_creatures[1] = 'cuttlefish'  
sea_creatures[2] = 'squid'  
sea_creatures[3] = 'mantis shrimp'  
sea_creatures[4] = 'anemone'
```

If we call the list `sea_creatures` with an index number of any that is greater than 4, it will be out of range as it will not be valid:

```
print(sea_creatures[18])
```

**Output**

```
IndexError: list index out of range
```

In addition to positive index numbers, we can also access items from the list with a negative index number, by counting backwards from the end of the list, starting at -1. This is especially useful if we have a long list and we want to pinpoint an item towards the end of a list.

For the same list `sea_creatures`, the negative index breakdown looks like this:

|         |              |         |                 |           |
|---------|--------------|---------|-----------------|-----------|
| 'SHARK' | 'CUTTLEFISH' | 'SQUID' | 'MANTIS SHRIMP' | 'ANEMONE' |
| -5      | -4           | -3      | -2              | -1        |

So, if we would like to print out the item `'squid'` by using its negative index number, we can do so like this:

```
print(sea_creatures[-3])
```

**Output**

```
squid
```

We can concatenate string items in a list with other strings using the `+` operator:

```
print('Sammy is a ' + sea_creatures[0])
```

**Output**

```
Sammy is a shark
```

We were able to concatenate the string item at index number 0 with the string `'Sammy is a '`. We can also use the `+` operator to [concatenate 2 or more lists together](#).

With index numbers that correspond to items within a list, we're able to access each item of a list discretely and work with those items.



## Modifying Items in Lists

We can use indexing to change items within the list, by setting an index number equal to a different value. This gives us greater control over lists as we are able to modify and update the items that they contain.

If we want to change the string value of the item at index 1 from 'cuttlefish' to 'octopus', we can do so like this:

```
sea_creatures[1] = 'octopus'
```

Now when we print `sea_creatures`, the list will be different:

```
print(sea_creatures)
```

### Output

```
['shark', 'octopus', 'squid', 'mantis shrimp',  
'anemone']
```

We can also change the value of an item by using a negative index number instead:

```
sea_creatures[-3] = 'blobfish'  
print(sea_creatures)
```

### Output

```
['shark', 'octopus', 'blobfish', 'mantis shrimp',  
'anemone']
```

Now 'blobfish' has replaced 'squid' at the negative index number of -3 (which corresponds to the positive index number of 2).

Being able to modify items in lists gives us the ability to change and update lists in an efficient way.

## Slicing Lists

We can also call out a few items from the list. Let's say we would like to just print the middle items of `sea_creatures`, we can do so by creating a slice. With slices, we can call multiple values by creating a range of index numbers separated by a colon `[x:y]`:

```
print(sea_creatures[1:4])
```

### Output

```
['octopus', 'blobfish', 'mantis shrimp']
```

When creating a slice, as in `[1:4]`, the first index number is where the slice starts (inclusive), and the second index number is where the slice ends (exclusive), which is why in our example above the items at position, 1, 2, and 3 are the items that print out.

If we want to include either end of the list, we can omit one of the numbers in the `list[x:y]` syntax. For example, if we want to print the first 3 items of the list `sea_creatures` — which would be 'shark', 'octopus', 'blobfish' — we can do so by typing:

```
print(sea_creatures[:3])
```

### Output

```
['shark', 'octopus', 'blobfish']
```

This printed the beginning of the list, stopping right before index 3.

To include all the items at the end of a list, we would reverse the syntax:

```
print(sea_creatures[2:])
```

**Output**

```
['blobfish', 'mantis shrimp', 'anemone']
```

We can also use negative index numbers when slicing lists, just like with positive index numbers:

```
print(sea_creatures[-4:-2])  
print(sea_creatures[-3:])
```

**Output**

```
['octopus', 'blobfish']  
['blobfish', 'mantis shrimp', 'anemone']
```

One last parameter that we can use with slicing is called stride, which refers to how many items to move forward after the first item is retrieved from the list. So far, we have omitted the stride parameter, and Python defaults to the stride of 1, so that every item between two index numbers is retrieved.

The syntax for this construction is `list[x:y:z]`, with `z` referring to stride. Let's make a larger list, then slice it, and give the stride a value of

2:

```
numbers = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]

print(numbers[1:11:2])
```

#### Output

```
[1, 3, 5, 7, 9]
```

Our construction `numbers[1:11:2]` prints the values between index numbers inclusive of 1 and exclusive of 11, then the stride value of 2 tells the program to print out only every other item.

We can omit the first two parameters and use stride alone as a parameter with the syntax `list[:z]`:

```
print(numbers[::3])
```

#### Output

```
[0, 3, 6, 9, 12]
```

By printing out the list `numbers` with the stride set to 3, only every third item is printed:

```
0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
```

Slicing lists with both positive and negative index numbers and indicating stride provides us with the control to manipulate lists and receive the output we're trying to achieve.

## Modifying Lists with Operators

Operators can be used to make modifications to lists. We'll look at using the + and \* operators and their compound forms += and \*+=.

The + operator can be used to concatenate two or more lists together:

```
sea_creatures = ['shark', 'octopus', 'blobfish',  
'mantis shrimp', 'anemone']  
oceans = ['Pacific', 'Atlantic', 'Indian', 'Southern',  
'Arctic']  
  
print(sea_creatures + oceans)
```

#### **Output**

```
['shark', 'octopus', 'blobfish', 'mantis shrimp',  
'anemone', 'Pacific', 'Atlantic', 'Indian',  
'Southern', 'Arctic']
```

Because the + operator can concatenate, it can be used to add an item (or several) in list form to the end of another list. Remember to place the item in square brackets:

```
sea_creatures = sea_creatures + ['yeti crab']  
print (sea_creatures)
```

#### **Output**

```
['shark', 'octopus', 'blobfish', 'mantis shrimp',  
'anemone', 'yeti crab']
```

The `*` operator can be used to multiply lists. Perhaps you need to make copies of all the files in a directory onto a server, or share a playlist with friends — in these cases you would need to multiply collections of data.

Let's multiply the `sea_creatures` list by 2 and the `oceans` list by 3:

```
print(sea_creatures * 2)
print(oceans * 3)
```

#### Output

```
['shark', 'octopus', 'blobfish', 'mantis shrimp',
'anemone', 'yeti crab', 'shark', 'octopus',
'blobfish', 'mantis shrimp', 'anemone', 'yeti crab']
['Pacific', 'Atlantic', 'Indian', 'Southern',
'Arctic', 'Pacific', 'Atlantic', 'Indian', 'Southern',
'Arctic', 'Pacific', 'Atlantic', 'Indian', 'Southern',
'Arctic']
```

By using the `*` operator we can replicate our lists by the number of times we specify.

We can also use compound forms of the `+` and `*` operators with the assignment operator `=`. The `+=` and `*=` compound operators can be used to populate lists in a quick and automated way. You can use these operators to fill in lists with placeholders that you can modify at a later time with user-provided input, for example.

Let's add an item in list form to the list `sea_creatures`. This item will act as a placeholder, and we'd like to add this placeholder item several times. To do this, we'll use the `+=` operator with a [for loop](#).

```
for x in range(1,4):
    sea_creatures += ['fish']
    print(sea_creatures)
```

#### **Output**

```
['shark', 'octopus', 'blobfish', 'mantis shrimp',
'anemone', 'yeti crab', 'fish']
['shark', 'octopus', 'blobfish', 'mantis shrimp',
'anemone', 'yeti crab', 'fish', 'fish']
['shark', 'octopus', 'blobfish', 'mantis shrimp',
'anemone', 'yeti crab', 'fish', 'fish', 'fish']
```

For each iteration of the for loop, an extra list item of 'fish' is added to the original list sea\_creatures.

The \*= operator behaves in a similar way:

```
sharks = ['shark']

for x in range(1,4):
    sharks *= 2
    print(sharks)
```

#### **Output**

```
['shark', 'shark']
['shark', 'shark', 'shark', 'shark']
['shark', 'shark', 'shark', 'shark', 'shark', 'shark',
'shark', 'shark']
```

The operators `+` and `*` can be used to concatenate lists and multiply lists. The compound operators `+=` and `*=` can concatenate lists and multiply lists and pass the new identity to the original list.

## Removing an Item from a List

Items can be removed from lists by using the `del` statement. This will delete the value at the index number you specify within a list.

From the `sea_creatures` list, let's remove the item `'octopus'`. This item is located at the index position of 1. To remove the item, we'll use the `del` statement then call the list variable and the index number of that item:

```
sea_creatures = ['shark', 'octopus', 'blobfish',  
'mantis shrimp', 'anemone', 'yeti crab']  
  
del sea_creatures[1]  
print(sea_creatures)
```

### Output

```
['shark', 'blobfish', 'mantis shrimp', 'anemone',  
'yeti crab']
```

Now the item at index position 1, the string `'octopus'`, is no longer in our list `sea_creatures`.

We can also specify a range with the `del` statement. Say we wanted to remove not only the item `'octopus'`, but also `'blobfish'` and `'mantis shrimp'` as well. We can call a range in `sea_creatures` with the `del` statement to accomplish this:



```
sea_creatures = ['shark', 'octopus', 'blobfish',  
'mantis shrimp', 'anemone', 'yeti crab']
```

```
del sea_creatures[1:4]  
print(sea_creatures)
```

### Output

```
['shark', 'anemone', 'yeti crab']
```

By using a range with the `del` statement, we were able to remove the items between the index number of 1 (inclusive), and the index number of 4 (exclusive), leaving us with a list of 3 items following the removal of 3 items.

The `del` statement allows us to remove specific items from the list data type.

## Constructing a List with List Items

Lists can be defined with items that are made up of lists, with each bracketed list enclosed inside the larger brackets of the parent list:

```
sea_names = [['shark', 'octopus', 'squid', 'mantis  
shrimp'], ['Sammy', 'Jesse', 'Drew', 'Jamie']]
```

These lists within lists are called nested lists.

To access an item within this list, we will have to use multiple indices:

```
print(sea_names[1][0])  
print(sea_names[0][0])
```

## Output

```
Sammy  
shark
```

The first list, since it is equal to an item, will have the index number of 0, which will be the first number in the construction, and the second list will have the index number of 1. Within each inner nested list there will be separate index numbers, which we will call in the second index number:

```
sea_names[0][0] = 'shark'  
sea_names[0][1] = 'octopus'  
sea_names[0][2] = 'squid'  
sea_names[0][3] = 'mantis shrimp'  
  
sea_names[1][0] = 'Sammy'  
sea_names[1][1] = 'Jesse'  
sea_names[1][2] = 'Drew'  
sea_names[1][3] = 'Jamie'
```

When working with lists of lists, it is important to keep in mind that you'll need to refer to more than one index number in order to access specific items within the relevant nested list.

## Conclusion

The list data type is a flexible data type that can be modified throughout the course of your program. This tutorial covered the basic features of lists, including indexing, slicing, modifying, and concatenating lists.

From here, you can find out more about working with lists in Python by reading “[How To Use List Methods](#),” and about [list comprehensions](#) to create lists based on existing lists. To learn more about data types in general you can read our “[Understanding Data Types](#)” tutorial.

# How To Use List Methods

Python 3 has a number of built-in data structures, including lists. Data structures provide us with a way to organize and store data, and we can use built-in methods to retrieve or manipulate that data.

To get the most out of this tutorial, you should have some familiarity with the list data type, its syntax, and how it is indexed. You can review lists by reading the tutorial [Understanding Lists in Python 3](#).

Here, we'll go through the built-in methods that you can use to work with lists. We'll add items to and remove items from lists, extend lists, reverse and sort lists, and more.

It is important to keep in mind that lists are mutable — or changeable — data types. Unlike [strings](#), which are immutable, whenever you use a method on a list you will be affecting the list itself and not a copy of the list.

For this tutorial, we'll be working primarily with a list comprised of an inventory of various fish that we need to modify as fish are added to or removed from a municipal aquarium.

## `list.append()`

The method `list.append(x)` will add an item (`x`) to the end of a list. We'll start with a list of our fish that are dispersed throughout the aquarium.

```
fish = ['barracuda', 'cod', 'devil ray', 'eel']
```

This list is comprised of 4 string items, and their index numbers range from 'barracuda' at 0 to 'eel' at index 3.

We just got a new fish into the aquarium today, and we would like to add that fish to our list. We'll pass the string of our new fish type, 'flounder' into the `list.append()` method, and then print out our modified list to confirm that the item was added.

```
fish.append('flounder')
print(fish)
```

#### **Output**

```
['barracuda', 'cod', 'devil ray', 'eel', 'flounder']
```

Now, we have a list of 5 string items that ends with the item we passed to the `.append()` function.

#### **list.insert()**

The `list.insert(i, x)` method takes two arguments, with `i` being the index position you would like to add an item to, and `x` being the item itself.

Our aquarium acquired another new fish, an anchovy. You may have noticed that so far the list `fish` is in alphabetical order. Because of this, we don't want to just add the string 'anchovy' to the end of `fish` with the `list.append()` function. Instead, we'll use `list.insert()` to add 'anchovy' to the beginning of this list at index position 0:

```
fish.insert(0, 'anchovy')
print(fish)
```

### Output

```
['anchovy', 'barracuda', 'cod', 'devil ray', 'eel',  
'flounder']
```

In this case, we added the string item to the front of the list. Each of the successive items will now be at a new index number as they have all moved down. Therefore, 'barracuda' will be at index 1, 'cod' will be at index 2, and 'flounder' — the last item — will be at index 5.

If, at this point, we are bringing a damselfish to the aquarium and we wanted to maintain alphabetical order based on the list above, we would put the item at index 3: `fish.insert(3, 'damselfish')`.

### `list.extend()`

If we want to combine more than one list, we can use the `list.extend(L)` method, which takes in a second list as its argument.

Our aquarium is welcoming four new fish from another aquarium that is closing. We have these fish together in the list `more_fish`:

```
more_fish = ['goby', 'herring', 'ide', 'kissing gourami']
```

We'll now add the items from the list `more_fish` to the list `fish` and print the list to ensure that the second list was incorporated:

```
fish.extend(more_fish)  
print(fish)
```

### Output

```
['anchovy', 'barracuda', 'cod', 'devil ray', 'eel',
```

```
'flounder', 'goby', 'herring', 'ide', 'kissing  
gourami']
```

At this point, the list `fish` is comprised of 10 items.

## `list.remove()`

When we need to remove an item from a list, we'll use the `list.remove(x)` method which removes the first item in a list whose value is equivalent to `x`.

A group of local research scientists have come to visit the aquarium. They are doing research on the kissing gourami species of fish. They have requested for us to loan our kissing gourami to them, so we'd like to remove the 'kissing gourami' item from the list to reflect this change:

```
fish.remove('kissing gourami')  
print(fish)
```

### Output

```
['anchovy', 'barracuda', 'cod', 'devil ray', 'eel',  
'flounder', 'goby', 'herring', 'ide']
```

Following the use of the `list.remove()` method, our list no longer has the 'kissing gourami' item.

If you pass an item in for `x` in `list.remove()` that does not exist in the list, you'll receive the following error:

### Output

```
ValueError: list.remove(x): x not in list
```

Keep in mind that `list.remove()` will only remove the first instance of the item you pass to it, so if we had two kissing gouramis at our aquarium and we only loaned one to the scientists, we could use the same construction of `fish.remove('kissing gourami')` and still have the second kissing gourami on our list.

## `list.pop()`

We can use the `list.pop([i])` method to return the item at the given index position from the list and then remove that item. The square brackets around the `i` for index tell us that this parameter is optional, so if we don't specify an index (as in `fish.pop()`), the last item will be returned and removed.

Our devil ray has gotten too large for our aquarium, and thankfully an aquarium a few towns over can accommodate the ray's needs. We'll use `.pop()` and specify the index number (3) of the string item 'devil ray' to remove the item from our list, and through returning it we'll confirm that we are removing the correct item.

```
print(fish.pop(3))
print(fish)
```

## Output

```
devil ray
['anchovy', 'barracuda', 'cod', 'eel', 'flounder',
'goby', 'herring', 'ide']
```



By using the `.pop()` method we were able to return and remove 'devil ray' from the list `fish`.

If we were to pass no parameters to this method and perform `fish.pop()`, the last item 'ide' would be returned and then removed from the list.

## `list.index()`

When lists start to get long, it becomes more difficult for us to count out our items to determine at what index position a certain value is located. We can use `list.index(x)`, where `x` is equivalent to an item value, to return the index in the list where that item is located. If there is more than one item with value `x`, this method will return the first index location.

```
print(fish)
print(fish.index('herring'))
```

### Output

```
['anchovy', 'barracuda', 'cod', 'eel', 'flounder',
'goby', 'herring', 'ide']
6
```

Although the list `fish` is not very long, we're still able to determine the index position of the item 'herring' without counting. The index of each item is very important to know so that we are able to manipulate lists effectively.

We'll receive an error if we specify a value with `.index()` and no such value exists in the given list: `ValueError: 'x' is not in list`.

## `list.copy()`

When we are working with a list and may want to manipulate it in multiple ways while still having the original list available to us unchanged, we can use `list.copy()` to make a copy of the list.

We'll pass the value returned from `fish.copy()` to the variable `fish_2`, and then print out the value of `fish_2` to ensure that it is a list with the same items as `fish`.

```
fish_2 = fish.copy()
print(fish_2)
```

### **Output**

```
['anchovy', 'barracuda', 'cod', 'eel', 'flounder',
'goby', 'herring', 'ide']
```

At this point, both `fish` and `fish_2` are equivalent lists.

## `list.reverse()`

We can reverse the order of items in a list by using the `list.reverse()` method. Perhaps it is more convenient for us to use reverse alphabetical order rather than traditional alphabetical order. In that case, we need to use the `.reverse()` method with the `fish` list to have the list be reversed in place.

```
fish.reverse()
print(fish)
```

### Output

```
['ide', 'herring', 'goby', 'flounder', 'eel', 'cod',  
'barracuda', 'anchovy']
```

After using the `.reverse()` method, our list begins with the item 'ide', which was at the end of our list, and ends with 'anchovy', which was at the beginning of the list.

### `list.count()`

The `list.count(x)` method will return the number of times the value `x` occurs within a specified list. We may want to use this method when we have a long list with a lot of matching values. If we had a larger aquarium, for example, and we had an item for each and every neon tetra that we had, we could use `.count()` to determine the total number of neon tetras we have at any given time.

We'll use our current list to count the number of times the item 'goby' appears:

```
print(fish.count('goby'))
```

### Output

```
1
```

Because the string 'goby' appears only one time, the number 1 is returned when we use the `.count()` method.

Let's also use this method with an integer list. Our aquarium is committed to providing great care for each and every fish, so we are keeping track of how old each of our fish are so we can ensure that their

diets meet fish's needs based on their ages. This second list, `fish_ages` corresponds to the type of fish from our other list, `fish`.

Because 1-year-old fish have special dietary needs, we're going to count how many 1-year-old fish we have:

```
fish_ages = [1,2,4,3,2,1,1,2]
print(fish_ages.count(1))
```

**Output**

3

The integer 1 occurs in the list `fish_ages` 3 times, so when we use the `.count()` method, the number 3 is returned.

## **list.sort()**

We can use the `list.sort()` method to sort the items in a list.

Just like `list.count()`, `list.sort()` can make it more apparent how many of a certain integer value we have, and it can also put an unsorted list of numbers into numeric order.

Let's use the integer list, `fish_ages` to see the `.sort()` method in action:

```
fish_ages.sort()
print(fish_ages)
```

**Output**

[1, 1, 1, 2, 2, 2, 3, 4]

By using `.sort()` with `fish_ages`, the integer values are returned in order. In practice, since these ages correspond to specific fish, you would likely want to make a copy of the original list prior to sorting it.

## `list.clear()`

When we're done with a list, we can remove all values contained in it by using the `list.clear()` method.

The local government has decided to take over our aquarium, making it a public space for the people in our city to enjoy. Since we're no longer working on the aquarium ourselves, we no longer need to keep an inventory of the fish, so let's clear the `fish` list:

```
fish.clear()
print(fish)
```

### Output

```
[]
```

We receive square brackets as our output after using the `.clear()` function on `fish`, letting us know that the list is now clear of all items.

## Conclusion

As a mutable, or changeable, ordered sequence of elements, lists are very flexible data structures in Python. List methods enable us to work with lists in a sophisticated manner. We can combine methods with [other ways to modify lists](#) in order to have a full range of tools to use lists effectively in our programs. From here, you can read about [list comprehensions](#) to create lists based on existing lists.

# Understanding List Comprehensions

List comprehensions offer a succinct way to create [lists](#) based on existing lists. When using list comprehensions, lists can be built by leveraging any [iterable](#), including [strings](#) and [tuples](#).

Syntactically, list comprehensions consist of an iterable containing an expression followed by a `for` clause. This can be followed by additional `for` or `if` clauses, so familiarity with [for loops](#) and [conditional statements](#) will help you understand list comprehensions better.

List comprehensions provide an alternative syntax to creating lists and other sequential [data types](#). While other methods of iteration, such as `for` loops, can also be used to create lists, list comprehensions may be preferred because they can limit the number of lines used in your program.

## List Comprehensions

In Python, list comprehensions are constructed like so:

```
list_variable = [x for x in iterable]
```

A list, or other iterable, is assigned to a variable. Additional variables that stand for items within the iterable are constructed around a `for` clause. The `in` keyword is used as it is in `for` loops, to iterate over the iterable.

Let's look at an example that creates a list based on a string:

```
shark_letters = [letter for letter in 'shark']  
print(shark_letters)
```

Here, the new list is assigned to the variable `shark_letters`, and `letter` is used to stand in for the items contained in the iterable string `'shark'`.

For us to confirm what the new list `shark_letters` looks like, we call for it to `print()` and receive the following output:

#### **Output**

```
['s', 'h', 'a', 'r', 'k']
```

The list we created with the list comprehension is comprised of the items in the string `'shark'`, that is, one string for each letter.

List comprehensions can be rewritten as `for` loops, though not every `for` loop is able to be rewritten as a list comprehension.

Using our list comprehension that created the `shark_letters` list above, let's rewrite it as a `for` loop. This may help us better understand how the list comprehension works.

```
shark_letters = []  
  
for letter in 'shark':  
    shark_letters.append(letter)  
  
print(shark_letters)
```

When creating a list with a `for` loop, the variable assigned to the list needs to be initialized with an empty list, as it is in the first line of our code block. The `for` loop then iterates over the item, using the variable `letter` in the iterable string `'shark'`. Within the `for` loop, each item within the string is [added to the list with the `list.append\(x\)` method](#).

Rewriting the list comprehension as a `for` loop provides us with the same output:

#### Output

```
['s', 'h', 'a', 'r', 'k']
```

List comprehensions can be rewritten as `for` loops, and some `for` loops can be rewritten to be list comprehensions to make code more succinct.

## Using Conditionals with List Comprehensions

List comprehensions can utilize conditional statements to modify existing lists or other sequential data types when creating new lists.

Let's look at an example of an `if` statement used in a list comprehension:

```
fish_tuple = ('blowfish', 'clownfish', 'catfish',  
'octopus')
```

```
fish_list = [fish for fish in fish_tuple if fish !=  
'octopus']  
print(fish_list)
```



The list comprehension uses the tuple `fish_tuple` as the basis for the new list called `fish_list`. The keywords of `for` and `in` are used, as they were in the [section above](#), and now an `if` statement is added. The `if` statement says to only add those items that are not equivalent to the string `'octopus'`, so the new list only takes in items from the tuple that do not match `'octopus'`.

When we run this, we'll see that `fish_list` contains the same string items as `fish_tuple` except for the fact that the string `'octopus'` has been omitted:

#### Output

```
['blowfish', 'clownfish', 'catfish']
```

Our new list therefore has every item of the original tuple except for the string that is excluded by the conditional statement.

We'll create another example that uses [mathematical operators](#), [integers](#), and the [range\(\) sequence type](#).

```
number_list = [x ** 2 for x in range(10) if x % 2 == 0]
print(number_list)
```

The list that is being created, `number_list`, will be populated with the squared values of each item in the range from 0-9 if the item's value is divisible by 2. The output is as follows:

#### Output

```
[0, 4, 16, 36, 64]
```

To break down what the list comprehension is doing a little more, let's think about what would be printed out if we were just calling `x for x in range(10)`. Our small program and output would then look like this:

```
number_list = [x for x in range(10)]
print(number_list)
```

**Output**

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Now, let's add the conditional statement:

```
number_list = [x for x in range(10) if x % 2 == 0]
print(number_list)
```

**Output**

```
[0, 2, 4, 6, 8]
```

The `if` statement has limited the items in the final list to only include those items that are divisible by 2, omitting all of the odd numbers.

Finally, we can add the operator to have each `x` squared:

```
number_list = [x ** 2 for x in range(10) if x % 2 == 0]
print(number_list)
```

So each of the numbers in the previous list of `[0, 2, 4, 6, 8]` are now squared:

**Output**

```
[0, 4, 16, 36, 64]
```

You can also replicate [nested if statements](#) with a list comprehension:

```
number_list = [x for x in range(100) if x % 3 == 0 if
x % 5 == 0]
print(number_list)
```

Here, the list comprehension will first check to see if the number `x` is divisible by 3, and then check to see if `x` is divisible by 5. If `x` satisfies both requirements it will print, and the output is:

**Output**

```
[0, 15, 30, 45, 60, 75, 90]
```

Conditional `if` statements can be used to control which items from an existing sequence are included in the creation of a new list.

## Nested Loops in a List Comprehension

[Nested loops](#) can be used to perform multiple iterations in our programs.

This time, we'll look at an existing nested `for` loop construction and work our way towards a list comprehension.

Our code will create a new list that iterates over 2 lists and performs mathematical operations based on them. Here is our nested `for` loop

code block:

```
my_list = []

for x in [20, 40, 60]:
    for y in [2, 4, 6]:
        my_list.append(x * y)

print(my_list)
```

When we run this code, we receive the following output:

**Output**

```
[40, 80, 120, 80, 160, 240, 120, 240, 360]
```

This code is multiplying the items in the first list by the items in the second list over each iteration.

To transform this into a list comprehension, we will condense each of the lines of code into one line, beginning with the `x * y` operation. This will be followed by the outer `for` loop, then the inner `for` loop. We'll add a `print()` statement below our list comprehension to confirm that the new list matches the list we created with our nested `for` loop block above:

```
my_list = [x * y for x in [20, 40, 60] for y in [2, 4, 6]]
print(my_list)
```

## Output

```
[40, 80, 120, 80, 160, 240, 120, 240, 360]
```

Our list comprehension takes the nested `for` loops and flattens them into one line of code while still creating the exact same list to assign to the `my_list` variable.

List comprehensions provide us with a succinct way of making lists, enabling us to distill several lines of code into a single line. However, it is worth keeping in mind that the readability of our code should always take precedence, so when a list comprehension line becomes too long or unwieldy, it may be best to break it out into loops.

## Conclusion

List comprehensions allow us to transform one list or other sequence into a new list. They provide a concise syntax for completing this task, limiting our lines of code.

List comprehensions follow the mathematical form of set-builder notation or set comprehension, so they may be particularly intuitive to programmers with a mathematical background.

Though list comprehensions can make our code more succinct, it is important to ensure that our final code is as readable as possible, so very long single lines of code should be avoided to ensure that our code is user friendly.

# Understanding Tuples

A tuple in Python looks like this:

```
coral = ('blue coral', 'staghorn coral', 'pillar  
coral', 'elkhorn coral')
```

A tuple is a data structure that is an immutable, or unchangeable, ordered sequence of elements. Because tuples are immutable, their values cannot be modified.

Tuples are used for grouping data. Each element or value that is inside of a tuple is called an item.

Tuples have values between parentheses ( ) separated by commas ,. Empty tuples will appear as `coral = ()`, but tuples with even one value must use a comma as in `coral = ('blue coral',)`.

If we `print()` the tuple above, we'll receive the following output, with the tuple still typed by parentheses:

```
print(coral)
```

## Output

```
('blue coral', 'staghorn coral', 'pillar coral',  
'elkhorn coral')
```

When thinking about Python tuples and other data structures that are types of collections, it is useful to consider all the different collections you have on your computer: your assortment of files, your song playlists,

your browser bookmarks, your emails, the collection of videos you can access on a streaming service, and more.

Tuples are similar to [lists](#), but their values can't be modified. Because of this, when you use tuples in your code, you are conveying to others that you don't intend for there to be changes to that sequence of values. Additionally, because the values do not change, your code can be optimized through the use of tuples in Python, as the code will be slightly faster for tuples than for lists.

## Indexing Tuples

As an ordered sequence of elements, each item in a tuple can be called individually, through indexing.

Each item corresponds to an index number, which is an integer value, starting with the index number 0.

For the `coral` tuple, the index breakdown looks like this:

|              |                  |                |                 |
|--------------|------------------|----------------|-----------------|
| 'BLUE CORAL' | 'STAGHORN CORAL' | 'PILLAR CORAL' | 'ELKHORN CORAL' |
| 0            | 1                | 2              | 3               |

The first item, the string `'blue coral'` starts at index 0, and the list ends at index 4 with the item `'elkhorn coral'`.

Because each item in a Python tuple has a corresponding index number, we're able to access items.

Now we can call a discrete item of the tuple by referring to its index number:

```
print(coral[2])
```

### Output

```
pillar coral
```

The index numbers for this tuple range from 0-3, as shown in the table above. So to call any of the items individually, we would refer to the index numbers like this:

```
coral[0] = 'blue coral'  
coral[1] = 'staghorn coral'  
coral[2] = 'pillar coral'  
coral[3] = 'elkhorn coral'
```

If we call the tuple `coral` with an index number of any that is greater than 3, it will be out of range as it will not be valid:

```
print(coral[22])
```

### Output

```
IndexError: tuple index out of range
```

In addition to positive index numbers, we can also access items from the tuple with a negative index number, by counting backwards from the end of the tuple, starting at -1. This is especially useful if we have a long tuple and we want to pinpoint an item towards the end of a tuple.

For the same tuple `coral`, the negative index breakdown looks like this:

```
'BLUE CORAL' 'STAGHORN CORAL' 'PILLAR CORAL' 'ELKHORN CORAL'
```



-4

-3

-2

-1

So, if we would like to print out the item 'blue coral' by using its negative index number, we can do so like this:

```
print(coral[-4])
```

**Output**

```
blue coral
```

We can concatenate string items in a tuple with other strings using the + operator:

```
print('This reef is made up of ' + coral[1])
```

**Output**

```
This reef is made up of staghorn coral
```

We were able to concatenate the string item at index number 0 with the string 'This reef is made up of '. We can also use the + operator to [concatenate 2 or more tuples together](#).

With index numbers that correspond to items within a tuple, we're able to access each item of a tuple discretely.

## Slicing Tuples

We can use indexing to call out a few items from the tuple. Slices allow us to call multiple values by creating a range of index numbers separated by a colon [x:y].

Let's say we would like to just print the middle items of `coral`, we can do so by creating a slice.

```
print(coral[1:3])
```

#### **Output**

```
('staghorn coral', 'pillar coral')
```

When creating a slice, as in `[1:3]`, the first index number is where the slice starts (inclusive), and the second index number is where the slice ends (exclusive), which is why in our example above the items at position, 1 and 2 are the items that print out.

If we want to include either end of the list, we can omit one of the numbers in the `tuple[x:y]` syntax. For example, if we want to print the first 3 items of the tuple `coral` — which would be `'blue coral'`, `'staghorn coral'`, `'pillar coral'` — we can do so by typing:

```
print(coral[:3])
```

#### **Output**

```
('blue coral', 'staghorn coral', 'pillar coral')
```

This printed the beginning of the tuple, stopping right before index 3.

To include all the items at the end of a tuple, we would reverse the syntax:

```
print(coral[1:])
```

**Output**

```
('staghorn coral', 'pillar coral', 'elkhorn coral')
```

We can also use negative index numbers when slicing tuples, just like with positive index numbers:

```
print(coral[-3:-1])  
print(coral[-2:])
```

**Output**

```
('staghorn coral', 'pillar coral')  
('pillar coral', 'elkhorn coral')
```

One last parameter that we can use with slicing is called stride, which refers to how many items to move forward after the first item is retrieved from the tuple.

So far, we have omitted the stride parameter, and Python defaults to the stride of 1, so that every item between two index numbers is retrieved.

The syntax for this construction is `tuple[x:y:z]`, with `z` referring to stride. Let's make a larger list, then slice it, and give the stride a value of 2:

```
numbers = (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12)  
  
print(numbers[1:11:2])
```

**Output**

```
(1, 3, 5, 7, 9)
```

Our construction `numbers[1:11:2]` prints the values between index numbers inclusive of 1 and exclusive of 11, then the stride value of 2 tells the program to print out only every other item.

We can omit the first two parameters and use stride alone as a parameter with the syntax `tuple[::z]`:

```
print(numbers[::3])
```

#### Output

```
(0, 3, 6, 9, 12)
```

By printing out the tuple `numbers` with the stride set to 3, only every third item is printed:

```
0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
```

Slicing tuples with both positive and negative index numbers and indicating stride provides us with the control to receive the output we're trying to achieve.

## Concatenating and Multiplying Tuples

[Operators](#) can be used to concatenate or multiply tuples. Concatenation is done with the `+` operator, and multiplication is done with the `*` operator.

The `+` operator can be used to concatenate two or more tuples together. We can assign the values of two existing tuples to a new tuple:

```
coral = ('blue coral', 'staghorn coral', 'pillar
```

```
coral', 'elkhorn coral')
kelp = ('wakame', 'alaria', 'deep-sea tangle',
'macrocystis')

coral_kelp = (coral + kelp)

print(coral_kelp)
```

### Output

```
('blue coral', 'staghorn coral', 'pillar coral',
'elkhorn coral', 'wakame', 'alaria', 'deep-sea
tangle', 'macrocystis')
```

Because the `+` operator can concatenate, it can be used to combine tuples to form a new tuple, though it cannot modify an existing tuple.

The `*` operator can be used to multiply tuples. Perhaps you need to make copies of all the files in a directory onto a server or share a playlist with friends — in these cases you would need to multiply collections of data.

Let's multiply the `coral` tuple by 2 and the `kelp` tuple by 3, and assign those to new tuples:

```
multiplied_coral = coral * 2
multiplied_kelp = kelp * 3

print(multiplied_coral)
print(multiplied_kelp)
```

## Output

```
('blue coral', 'staghorn coral', 'pillar coral',  
'elkhorn coral', 'blue coral', 'staghorn coral',  
'pillar coral', 'elkhorn coral')  
( 'wakame', 'alaria', 'deep-sea tangle', 'macrocystis',  
'wakame', 'alaria', 'deep-sea tangle', 'macrocystis',  
'wakame', 'alaria', 'deep-sea tangle', 'macrocystis')
```

By using the `*` operator we can replicate our tuples by the number of times we specify, creating new tuples based on the original data sequence.

Existing tuples can be concatenated or multiplied to form new tuples through using the `+` and `*` operators.

## Tuple Functions

There are a few built-in functions that you can use to work with tuples. Let's look at a few of them.

### **len()**

Like with strings and lists, we can calculate the length of a tuple by using `len()`, where we pass the tuple as a parameter, as in:

```
len(coral)
```

This function is useful for when you need to enforce minimum or maximum collection lengths, for example, or to compare sequenced data.

If we print out the length for our tuples `kelp` and `numbers`, we'll receive the following output:

```
print(len(kelp))  
print(len(numbers))
```

### Output

```
4  
13
```

We receive the above output because the tuple `kelp` has 4 items:

```
kelp = ('wakame', 'alaria', 'deep-sea tangle',  
        'macrocystis')
```

And the tuple `numbers` has 13 items:

```
numbers = (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12)
```

Although these examples have relatively few items, the `len()` function provides us with the opportunity to see how many items are in large tuples.

### **max() and min()**

When we work with tuples composed of numeric items, (including [integers](#) and [floats](#)) we can use the `max()` and `min()` functions to find the highest and lowest values contained in the respective tuple.

These functions allow us to find out information about quantitative data, such as test scores, temperatures, prices, etc.

Let's look at a tuple comprised of floats:

```
more_numbers = (11.13, 34.87, 95.59, 82.49, 42.73,  
11.12, 95.57)
```

To get the `max()`, we would pass the tuple into the function, as in `max(more_numbers)`. We'll combine this with the `print()` function so that we can output our results:

```
print(max(more_numbers))
```

**Output**

```
95.59
```

The `max()` function returned the highest value in our tuple.

Similarly, we can use the `min()` function:

```
print(min(more_numbers))
```

**Output**

```
11.12
```

Here, the smallest float was found in the tuple and printed out.

Just like with the `len()` function, the `max()` and `min()` functions can be very useful when working with tuples that contain many values.

## How Tuples Differ from Lists

The primary way in which tuples are different from lists is that they cannot be modified. This means that items cannot be added to or removed from tuples, and items cannot be replaced within tuples.



You can, however, [concatenate](#) 2 or more tuples to form a new tuple.

Let's consider our coral tuple:

```
coral = ('blue coral', 'staghorn coral', 'pillar  
coral', 'elkhorn coral')
```

Say we want to replace the item 'blue coral' with a different item called 'black coral'. If we try to change that output the same way we do with a list, by typing:

```
coral[0] = 'black coral'
```

We will receive an error as our output:

#### **Output**

```
TypeError: 'tuple' object does not support item  
assignment
```

This is because tuples cannot be modified.

If we create a tuple and decide what we really need is a list, we can convert it to a list. To convert a tuple to a list, we can do so with `list()`:

```
list(coral)
```

And now, our coral data type will be a list:

```
coral = ['blue coral', 'staghorn coral', 'pillar  
coral']
```

We can see that the tuple was converted to a list because the parentheses changed to square brackets.

Likewise, we can convert lists to tuples with `tuple()`.

You can learn more about data type conversion by reading “[How To Convert Data Types in Python 3](#).”

## Conclusion

The tuple data type is a sequenced [data type](#) that cannot be modified, offering optimization to your programs by being a somewhat faster type than lists for Python to process. When others collaborate with you on your code, your use of tuples will convey to them that you don’t intend for those sequences of values to be modified.

This tutorial covered the basic features of tuples, including indexing, slicing and concatenating tuples, and showing built-in functions that are available.

# Understanding Dictionaries

The dictionary is Python's built-in mapping type. Dictionaries map keys to values and these key-value pairs provide a useful way to store data in Python.

Typically used to hold data that are related, such as the information contained in an ID or a user profile, dictionaries are constructed with curly braces on either side { }.

A dictionary looks like this:

```
sammy = {'username': 'sammy-shark', 'online': True,
'followers': 987}
```

In addition to the curly braces, there are also colons (:) throughout the dictionary.

The words to the left of the colons are the keys. Keys can be made up of any immutable data type. The keys in the dictionary above are: - 'username' - 'online' - 'followers'

Each of the keys in the above example are [string](#) values.

The words to the right of the colons are the values. Values can be comprised of any data type. The values in the dictionary above are: - 'sammy-shark' - True - 987

Each of these values is either a string, [Boolean](#), or [integer](#).

Let's print out the dictionary sammy:

```
print(sammy)
```

### Output

```
{'username': 'sammy-shark', 'followers': 987,  
'online': True}
```

Looking at the output, you may notice that the order of the key-value pairs has shifted. That is because the dictionary data type is unordered. In this regard, dictionaries are unlike [lists](#) or [tuples](#) that preserve order and can be indexed. Whenever you print out a dictionary, the order will be arbitrary, but the key-value pairs will remain intact, enabling us to access data based on their relational meaning.

## Accessing Dictionary Elements

Because the dictionary data structure is unordered, we cannot call its values by an index number, as we can with lists and tuples. We can, however, call its values by referencing the related keys.

### Accessing Data Items with Keys

Because dictionaries offer key-value pairs for storing data, they can be important elements in your Python program.

If we want to isolate Sammy's username, we can do so by calling `sammy['username']`. Let's print that out:

```
print(sammy['username'])
```

### Output

```
sammy-shark
```

Dictionaries behave like a database in that instead of calling an integer to get a particular index value as you would with a list, you assign a value to a key and can call that key to get its related value.

By invoking the key 'username' we receive the value of that key, which is 'sammy-shark'.

The remaining values in the sammy dictionary can similarly be called using the same format:

```
sammy['followers']  
# Returns 987
```

```
sammy['online']  
# Returns True
```

By making use of dictionaries' key-value pairs, we can reference keys to retrieve values.

## Using Functions to Access Elements

In addition to using keys to access values, we can also work with some built-in functions: - `dict.keys()` isolates keys - `dict.values()` isolates values - `dict.items()` returns items in a list format of (key, value) tuple pairs

To return the keys, we would use the `dict.keys()` function. In our example, that would use the variable name and be `sammy.keys()`. Let's pass that to a `print()` function and look at the output:

```
print(sammy.keys())
```

### Output

```
dict_keys(['followers', 'username', 'online'])
```

We receive output that places the keys within an iterable view object of the `dict_keys` class. The keys are then printed within a list format.

This function can be used to query across dictionaries. For example, we can take a look at the common keys shared between two dictionary data structures:

```
sammy = {'username': 'sammy-shark', 'online': True,
         'followers': 987}
jesse = {'username': 'JOctopus', 'online': False,
         'points': 723}

for common_key in sammy.keys() & jesse.keys():
    print(sammy[common_key], jesse[common_key])
```

The dictionary `sammy` and the dictionary `jesse` are each a user profile dictionary.

Their profiles have different keys, however, because Sammy has a social profile with associated followers, and Jesse has a gaming profile with associated points. The 2 keys they have in common are `username` and `online` status, which we can find when we run this small program:

### Output

```
sammy-shark JOctopus
True False
```

We could certainly improve on the program to make the output more user-readable, but this illustrates that `dict.keys()` can be used to check across various dictionaries to see what they share in common or not. This is especially useful for large dictionaries.

Similarly, we can use the `dict.values()` function to query the values in the `sammy` dictionary, which would be constructed as `sammy.values()`. Let's print those out:

```
sammy = {'username': 'sammy-shark', 'online': True,
'followers': 987}

print(sammy.values())
```

#### **Output**

```
dict_values([True, 'sammy-shark', 987])
```

Both the methods `keys()` and `values()` return unsorted lists of the keys and values present in the `sammy` dictionary with the view objects of `dict_keys` and `dict_values` respectively.

If we are interested in all of the items in a dictionary, we can access them with the `items()` function:

```
print(sammy.items())
```

#### **Output**

```
dict_items([('online', True), ('username', 'sammy-
shark'), ('followers', 987)])
```

The returned format of this is a list made up of (key, value) tuple pairs with the `dict_items` view object.

We can iterate over the returned list format with a `for` loop. For example, we can print out each of the keys and values of a given dictionary, and then make it more human-readable by adding a string:

```
for key, value in sammy.items():  
    print(key, 'is the key for the value', value)
```

### **Output**

```
online is the key for the value True  
followers is the key for the value 987  
username is the key for the value sammy-shark
```

The `for` loop above iterated over the items within the `sammy` dictionary and printed out the keys and values line by line, with information to make it easier to understand by humans.

We can use built-in functions to access items, values, and keys from dictionary data structures.

## **Modifying Dictionaries**

Dictionaries are a mutable data structure, so you are able to modify them. In this section, we'll go over adding and deleting dictionary elements.

### **Adding and Changing Dictionary Elements**

Without using a function, you can add key-value pairs to dictionaries by using the following syntax:



```
dict[key] = value
```

We'll look at how this works in practice by adding a key-value pair to a dictionary called `username`s:

```
username = {'Sammy': 'sammy-shark', 'Jamie':  
'mantisshrimp54'}
```

```
username['Drew'] = 'squidly'
```

```
print(username)
```

#### Output

```
{'Drew': 'squidly', 'Sammy': 'sammy-shark', 'Jamie':  
'mantisshrimp54'}
```

We see now that the dictionary has been updated with the `'Drew': 'squidly'` key-value pair. Because dictionaries are unordered, this pair can occur anywhere in the dictionary. If we use the `username` dictionary later in our program file, it will include the additional key-value pair.

Additionally, this syntax can be used for modifying the value assigned to a key. In this case, we'll reference an existing key and pass a different value to it.

Let's consider a dictionary `drew` that is one of the users on a given network. We'll say that this user got a bump in followers today, so we need to update the integer value passed to the `'followers'` key. We'll use the `print()` function to check that the dictionary was modified.

```
drew = {'username': 'squidly', 'online': True,  
        'followers': 305}
```

```
drew['followers'] = 342
```

```
print(drew)
```

### **Output**

```
{'username': 'squidly', 'followers': 342, 'online':  
True}
```

In the output, we see that the number of followers jumped from the integer value of 305 to 342.

We can use this method for adding key-value pairs to dictionaries with user-input. Let's write a quick program, `usernames.py` that runs on the command line and allows input from the user to add more names and associated usernames:

### **usernames.py**

```
# Define original dictionary  
usernames = {'Sammy': 'sammy-shark', 'Jamie':  
             'mantisshrimp54'}
```

```
# Set up while loop to iterate  
while True:
```

```
    # Request user to enter a name  
    print('Enter a name:')
```

```
# Assign to name variable
name = input()

# Check whether name is in the dictionary and
print feedback
if name in usernames:
    print(usernames[name] + ' is the username of '
+ name)

# If the name is not in the dictionary...
else:

    # Provide feedback
    print('I don\'t have ' + name + '\\'s username,
what is it?')

# Take in a new username for the associated
name
username = input()

# Assign username value to name key
usernames[name] = username

# Print feedback that the data was updated
print('Data updated.')
```

Let's run the program on the command line:

```
python usernames.py
```

When we run the program we'll get something like the following output:

#### Output

```
Enter a name:
```

```
Sammy
```

```
sammy-shark is the username of Sammy
```

```
Enter a name:
```

```
Jesse
```

```
I don't have Jesse's username, what is it?
```

```
JOctopus
```

```
Data updated.
```

```
Enter a name:
```

When we are done testing the program, we can press CTRL + C to escape the program. You can set up a trigger to quit the program (such as typing the letter q) with a [conditional statement](#) to improve the code.

This shows how you can modify dictionaries interactively. With this particular program, as soon as you exit the program with CTRL + C you'll lose all your data unless you implement a way to [handle reading and writing files](#).

We can also add and modify dictionaries by using the `dict.update()` function. This varies from the `append()` [function](#) available in lists.

In the `jesse` dictionary below, let's add the key 'followers' and give it an integer value with `jesse.update()`. Following that, let's

`print()` the updated dictionary.

```
jesse = {'username': 'JOctopus', 'online': False,  
        'points': 723}
```

```
jesse.update({'followers': 481})
```

```
print(jesse)
```

### **Output**

```
{'followers': 481, 'username': 'JOctopus', 'points':  
723, 'online': False}
```

From the output, we can see that we successfully added the `'followers': 481` key-value pair to the dictionary `jesse`.

We can also use the `dict.update()` method to modify an existing key-value pair by replacing a given value for a specific key.

Let's change the online status of Sammy from `True` to `False` in the `sammy` dictionary:

```
sammy = {'username': 'sammy-shark', 'online': True,  
        'followers': 987}
```

```
sammy.update({'online': False})
```

```
print(sammy)
```

### **Output**

```
{'username': 'sammy-shark', 'followers': 987,  
'online': False}
```

The line `sammy.update({'online': False})` references the existing key `'online'` and modifies its Boolean value from `True` to `False`. When we call to `print()` the dictionary, we see the update take place in the output.

To add items to dictionaries or modify values, we can use either the `dict[key] = value` syntax or the function `dict.update()`.

## Deleting Dictionary Elements

Just as you can add key-value pairs and change values within the dictionary data type, you can also delete items within a dictionary.

To remove a key-value pair from a dictionary, we'll use the following syntax:

```
del dict[key]
```

Let's take the `jesse` dictionary that represents one of the users. We'll say that Jesse is no longer using the online platform for playing games, so we'll remove the item associated with the `'points'` key. Then, we'll print the dictionary out to confirm that the item was deleted:

```
jesse = {'username': 'JOctopus', 'online': False,  
'points': 723, 'followers': 481}
```

```
del jesse['points']
```

```
print(jesse)
```

### Output

```
{'online': False, 'username': 'JOctopus', 'followers':  
481}
```

The line `del jesse['points']` removes the key-value pair `'points': 723` from the `jesse` dictionary.

If we would like to clear a dictionary of all of its values, we can do so with the `dict.clear()` function. This will keep a given dictionary in case we need to use it later in the program, but it will no longer contain any items.

Let's remove all the items within the `jesse` dictionary:

```
jesse = {'username': 'JOctopus', 'online': False,  
'points': 723, 'followers': 481}
```

```
jesse.clear()
```

```
print(jesse)
```

### Output

```
{}
```

The output shows that we now have an empty dictionary devoid of key-value pairs.

If we no longer need a specific dictionary, we can use `del` to get rid of it entirely:

```
del jesse
```

```
print(jesse)
```

When we run a call to `print()` after deleting the `jesse` dictionary, we'll receive the following error:

#### Output

```
...  
NameError: name 'jesse' is not defined
```

Because dictionaries are mutable data types, they can be added to, modified, and have items removed and cleared.

## Conclusion

This tutorial went through the dictionary data structure in Python. Dictionaries are made up of key-value pairs and provide a way to store data without relying on indexing. This allows us to retrieve values based on their meaning and relation to other data types.

From here, you can learn more about other data types in our [“Understanding Data Types”](#) tutorial.

You can see the dictionary data type used in programming projects such as [web scraping with Scrapy](#).



# How To Import Modules

The Python programming language comes with a variety of [built-in functions](#). Among these are several common functions, including: - `print()` which prints expressions out - `abs()` which returns the absolute value of a number - `int()` which converts another data type to an integer - `len()` which returns the length of a sequence or collection

These built-in functions, however, are limited, and we can make use of modules to make more sophisticated programs.

Modules are Python `.py` files that consist of Python code. Any Python file can be referenced as a module. A Python file called `hello.py` has the module name of `hello` that can be imported into other Python files or used on the Python command line interpreter. You can learn about creating your own modules by reading [How To Write Modules in Python 3](#).

Modules can [define functions](#), [classes](#), and [variables](#) that you can reference in other Python `.py` files or via the Python command line interpreter.

In Python, modules are accessed by using the `import` statement. When you do this, you execute the code of the module, keeping the scopes of the definitions so that your current file(s) can make use of these.

When Python imports a module called `hello` for example, the interpreter will first search for a built-in module called `hello`. If a built-in module is not found, the Python interpreter will then search for a file named `hello.py` in a list of directories that it receives from the `sys.path` variable.

This tutorial will walk you through checking for and installing modules, importing modules, and aliasing modules.

## Checking For and Installing Modules

There are a number of modules that are built into the [Python Standard Library](#), which contains many modules that provide access to system functionality or provide standardized solutions. The Python Standard Library is part of every Python installation.

To check that these Python modules are ready to go, enter into your [local Python 3 programming environment](#) or [server-based programming environment](#) and start the Python interpreter in your command line like so:

```
(my_env) sammy@ubuntu:~/environments$ python
```

From within the interpreter you can run the `import` statement to make sure that the given module is ready to be called, as in:

```
>>> import math
```

Since `math` is a built-in module, your interpreter should complete the task with no feedback, returning to the prompt. This means you don't need to do anything to start using the `math` module.

Let's run the `import` statement with a module that you may not have installed, like the 2D plotting library `matplotlib`:

```
>>> import matplotlib
```

If `matplotlib` is not installed, you'll receive an error like this:

#### Output

```
ImportError: No module named 'matplotlib'
```

You can deactivate the Python interpreter with `CTRL + D` and then install `matplotlib` with `pip`.

Next, we can use `pip` to install the `matplotlib` module:

```
(my_env) sammy@ubuntu:~/environments$ pip install  
matplotlib
```

Once it is installed, you can import `matplotlib` in the Python interpreter using `import matplotlib`, and it will complete without error.

## Importing Modules

To make use of the functions in a module, you'll need to import the module with an `import` statement.

An `import` statement is made up of the `import` keyword along with the name of the module.

In a Python file, this will be declared at the top of the code, under any shebang lines or general comments.

So, in the Python program file `my_rand_int.py` we would import the `random` module to generate random numbers in this manner:

```
my_rand_int.py  
import random
```

When we import a module, we are making it available to us in our current program as a separate namespace. This means that we will have to refer to the function in dot notation, as in `[module].[function]`.

In practice, with the example of the `random` module, this may look like a function such as: - `random.randint()` which calls the function to return a random integer, or - `random.randrange()` which calls the function to return a random element from a specified range.

Let's create a [for loop](#) to show how we will call a function of the `random` module within our `my_rand_int.py` program:

```
my_rand_int.py
```

```
import random

for i in range(10):
    print(random.randint(1, 25))
```

This small program first imports the `random` module on the first line, then moves into a `for` loop which will be working with 10 elements. Within the loop, the program will print a random integer within the range of 1 through 25 (inclusive). The integers 1 and 25 are passed to `random.randint()` as its parameters.

When we run the program with `python my_rand_int.py`, we'll receive 10 random integers as output. Because these are random you'll likely get different integers each time you run the program, but they'll look something like this:

**Output**

6  
9  
1  
14  
3  
22  
10  
1  
15  
9

The integers should never go below 1 or above 25.

If you would like to use functions from more than one module, you can do so by adding multiple `import` statements:

```
my_rand_int.py  
import random  
import math
```

You may see programs that import multiple modules with commas separating them — as in `import random, math` — but this is not consistent with the [PEP 8 Style Guide](#).

To make use of our additional module, we can add the constant `pi` from `math` to our program, and decrease the number of random integers printed out:

```
my_rand_int.py  
import random
```

```
import math

for i in range(5):
    print(random.randint(1, 25))

print(math.pi)
```

Now, when we run our program, we'll receive output that looks like this, with an approximation of pi as our last line of output:

#### **Output**

```
18
10
7
13
10
3.141592653589793
```

The `import` statement allows you to import one or more modules into your Python program, letting you make use of the definitions constructed in those modules.

#### **Using `from ... import`**

To refer to items from a module within your program's namespace, you can use the `from ... import` statement. When you import modules this way, you can refer to the functions by name rather than through dot notation

In this construction, you can specify which definitions to reference directly.

In other programs, you may see the `import` statement take in references to everything defined within the module by using an asterisk (\*) as a wildcard, but this is discouraged by [PEP 8](#).

Let's first look at importing one specific function, `randint()` from the `random` module:

```
my_rand_int.py
from random import randint
```

Here, we first call the `from` keyword, then `random` for the module. Next, we use the `import` keyword and call the specific function we would like to use.

Now, when we implement this function within our program, we will no longer write the function in dot notation as `random.randint()` but instead will just write `randint()`:

```
my_rand_int.py
from random import randint

for i in range(10):
    print(randint(1, 25))
```

When you run the program, you'll receive output similar to what we received earlier.

Using the `from ... import` construction allows us to reference the defined elements of a module within our program's namespace, letting us avoid dot notation.

## Aliasing Modules

It is possible to modify the names of modules and their functions within Python by using the `as` keyword.

You may want to change a name because you have already used the same name for something else in your program, another module you have imported also uses that name, or you may want to abbreviate a longer name that you are using a lot.

The construction of this statement looks like this:

```
import [module] as [another_name]
```

Let's modify the name of the `math` module in our `my_math.py` program file. We'll change the module name of `math` to `m` in order to abbreviate it. Our modified program will look like this:

**my\_math.py**

```
import math as m
```

```
print(m.pi)
```

```
print(m.e)
```

Within the program, we now refer to the `pi` constant as `m.pi` rather than `math.pi`.



For some modules, it is commonplace to use aliases. The [matplotlib.pyplot module's official documentation](#) calls for use of `plt` as an alias:

```
import matplotlib.pyplot as plt
```

This allows programmers to append the shorter word `plt` to any of the functions available within the module, as in `plt.show()`. You can see this alias import statement in use within our “[How to Plot Data in Python 3 Using matplotlib tutorial](#).”

## Conclusion

When we import modules we're able to call functions that are not built into Python. Some modules are installed as part of Python, and some we will install through `pip`.

Making use of modules allows us to make our programs more robust and powerful as we're leveraging existing code. We can also [create our own modules](#) for ourselves and for other programmers to use in future programs.

# How To Write Modules

Python modules are `.py` files that consist of Python code. Any Python file can be referenced as a module.

Some modules are available through the [Python Standard Library](#) and are therefore installed with your Python installation. Others can be [installed](#) with Python's package manager `pip`. Additionally, you can create your own Python modules since modules are comprised of Python `.py` files.

This tutorial will guide you through writing Python modules for use within other programming files.

## Writing and Importing Modules

Writing a module is just like writing any other Python file. Modules can contain definitions of functions, classes, and variables that can then be utilized in other Python programs.

From our Python 3 [local programming environment](#) or [server-based programming environment](#), let's start by creating a file `hello.py` that we'll later import into another file.

To begin, we'll [create a function](#) that prints `Hello, World!`:

**hello.py**

```
# Define a function
def world():
    print("Hello, World!")
```

If we run the program on the command line with `python hello.py` nothing will happen since we have not told the program to do anything.

Let's create a second file in the same directory called `main_program.py` so that we can [import the module](#) we just created, and then call the function. This file needs to be in the same directory so that Python knows where to find the module since it's not a built-in module.

**main\_program.py**

```
# Import hello module
import hello
```

```
# Call function
hello.world()
```

Because we are [importing a module](#), we need to call the function by referencing the module name in dot notation.

We could instead import the module as `from hello import world` and call the function directly as `world()`. You can learn more about this method by reading [how to using from ... import when importing modules](#).

Now, we can run the program on the command line:

```
python main_program.py
```

When we do, we'll receive the following output:

## Output

Hello, World!

To see how we can use [variables](#) in a module, let's add a variable definition in our `hello.py` file:

### **hello.py**

```
# Define a function
def world():
    print("Hello, World!")

# Define a variable
shark = "Sammy"
```

Next, we'll call the variable in a `print()` function within our `main_program.py` file:

### **main\_program.py**

```
# Import hello module
import hello

# Call function
hello.world()

# Print variable
print(hello.shark)
```

Once we run the program again, we'll receive the following output:

#### **Output**

```
Hello, World!  
Sammy
```

Finally, let's also [define a class](#) in the `hello.py` file. We'll create the class `Octopus` with `name` and `color` attributes and a function that will print out the attributes when called.

#### **hello.py**

```
# Define a function  
def world():  
    print("Hello, World!")  
  
# Define a variable  
shark = "Sammy"  
  
# Define a class  
class Octopus:  
    def __init__(self, name, color):  
        self.color = color  
        self.name = name  
  
    def tell_me_about_the_octopus(self):  
        print("This octopus is " + self.color + ".")  
        print(self.name + " is the octopus's name.")
```

We'll now add the class to the end of our `main_program.py` file:

**main\_program.py**

```
# Import hello module
import hello

# Call function
hello.world()

# Print variable
print(hello.shark)

# Call class
jesse = hello.Octopus("Jesse", "orange")
jesse.tell_me_about_the_octopus()
```

Once we have called the `Octopus` class with `hello.Octopus()`, we can access the functions and attributes of the class within the `main_program.py` file's namespace. This lets us write `jesse.tell_me_about_the_octopus()` on the last line without invoking `hello`. We could also, for example, call one of the class's attributes such as `jesse.color` without referencing the name of the `hello` module.

When we run the program, we'll receive the following output:

**Output**

Hello, World!

Sammy

This octopus is orange.

Jesse is the octopus's name.

It is important to keep in mind that though modules are often definitions, they can also implement code. To see how this works, let's rewrite our `hello.py` file so that it implements the `world()` function:

**hello.py**

```
# Define a function
def world():
    print("Hello, World!")

# Call function within module
world()
```

We have also deleted the other definitions in the file.

Now, in our `main_program.py` file, we'll delete every line except for the import statement:

**main\_program.py**

```
# Import hello module
import hello
```

When we run `main_program.py` we'll receive the following output:

**Output**

Hello, World!

This is because the `hello` module implemented the `world()` function which is then passed to `main_program.py` and executes when `main_program.py` runs.

A module is a Python program file composed of definitions or code that you can leverage in other Python program files.

## Accessing Modules from Another Directory

Modules may be useful for more than one programming project, and in that case it makes less sense to keep a module in a particular directory that's tied to a specific project.

If you want to use a Python module from a location other than the same directory where your main program is, you have a few options.

### Appending Paths

One option is to invoke the path of the module via the programming files that use that module. This should be considered more of a temporary solution that can be done during the development process as it does not make the module available system-wide.

To append the path of a module to another programming file, you'll start by importing the `sys` module alongside any other modules you wish to use in your main program file.

The `sys` module is part of the Python Standard Library and provides system-specific parameters and functions that you can use in your program to set the path of the module you wish to implement.

For example, let's say we moved the `hello.py` file and it is now on the path `/usr/sammy/` while the `main_program.py` file is in another directory.



In our `main_program.py` file, we can still import the `hello` module by importing the `sys` module and then appending `/usr/sammy/` to the path that Python checks for files.

```
main_program.py
import sys
sys.path.append('/usr/sammy/')

import hello
...
```

As long as you correctly set the path for the `hello.py` file, you'll be able to run the `main_program.py` file without any errors and receive the same output as above when `hello.py` was in the same directory.

## **Adding the Module to the Python Path**

A second option that you have is to add the module to the path where Python checks for modules and packages. This is a more permanent solution that makes the module available environment-wide or system-wide, making this method more portable.

To find out what path Python checks, run the Python interpreter from your programming environment:

```
python
```

Next, import the `sys` module:

```
>>> import sys
```

Then have Python print out the system path:

```
>>> print(sys.path)
```

Here, you'll receive some output with at least one system path. If you're in a programming environment, you may receive several. You'll want to look for the one that is in the environment you're currently using, but you may also want to add the module to your main system Python path. What you're looking for will be similar to this:

#### Output

```
'/usr/sammy/my_env/lib/python3.5/site-packages'
```

Now you can move your `hello.py` file into that directory. Once that is complete, you can import the `hello` module as usual:

```
main_program.py
import hello
...
```

When you run your program, it should complete without error.

Modifying the path of your module can ensure that you can access the module regardless of what directory you are in. This is useful especially if you have more than one project referencing a particular module.

## Conclusion

Writing a Python module is the same as writing any other Python `.py` file. This tutorial covered how to write definitions within a module, make

use of those definitions within another Python programming file, and went over options of where to keep the module in order to access it.

You can learn more about installing and importing modules by reading [How To Import Modules in Python 3](#).

# How To Write Conditional Statements

Conditional statements are part of every programming language. With conditional statements, we can have code that sometimes runs and at other times does not run, depending on the conditions of the program at that time.

When we fully execute each statement of a program, moving from the top to the bottom with each line executed in order, we are not asking the program to evaluate specific conditions. By using conditional statements, programs can determine whether certain conditions are being met and then be told what to do next.

Let's look at some examples where we would use conditional statements:

- If the student receives over 65% on her test, report that her grade passes; if not, report that her grade fails
- If he has money in his account, calculate interest; if he doesn't, charge a penalty fee
- If they buy 10 oranges or more, calculate a discount of 5%; if they buy fewer, then don't

Through evaluating conditions and assigning code to run based on whether or not those conditions are met, we are writing conditional code.

This tutorial will take you through writing conditional statements in the Python programming language.

## If statement

We will start with the `if` statement, which will evaluate whether a statement is true or false, and run code only in the case that the statement is true.

In a plain text editor, open a file and write the following code:

```
grade = 70

if grade >= 65:
    print("Passing grade")
```

With this code, we have the variable `grade` and are giving it the integer value of 70. We are then using the `if` statement to evaluate whether or not the variable `grade` is greater than or equal ( `>=` ) to 65. If it does meet this condition, we are telling the program to print out the [string](#) `Passing grade`.

Save the program as `grade.py` and run it in a [local programming environment from a terminal window](#) with the command `python grade.py`.

In this case, the grade of 70 does meet the condition of being greater than or equal to 65, so you will receive the following output once you run the program:

#### **Output**

```
Passing grade
```

Let's now change the result of this program by changing the value of the `grade` variable to 60:

**grade.py**

```
grade = 60

if grade >= 65:
    print("Passing grade")
```

When we save and run this code, we will receive no output because the condition was not met and we did not tell the program to execute another statement.

To give one more example, let us calculate whether a bank account balance is below 0. Let's create a file called `account.py` and write the following program:

**account.py**

```
balance = -5

if balance < 0:
    print("Balance is below 0, add funds now or you
will be charged a penalty.")
```

When we run the program with `python account.py`, we'll receive the following output:

**Output**

```
Balance is below 0, add funds now or you will be
charged a penalty.
```

In the program we initialized the variable `balance` with the value of `-5`, which is less than `0`. Since the balance met the condition of the `if` statement (`balance < 0`), once we save and run the code, we will receive the string output. Again, if we change the balance to `0` or a positive number, we will receive no output.

## Else Statement

It is likely that we will want the program to do something even when an `if` statement evaluates to false. In our grade example, we will want output whether the grade is passing or failing.

To do this, we will add an `else` statement to the grade condition above that is constructed like this:

**grade.py**

```
grade = 60

if grade >= 65:
    print("Passing grade")

else:
    print("Failing grade")
```

Since the grade variable above has the value of `60`, the `if` statement evaluates as false, so the program will not print out `Passing grade`. The `else` statement that follows tells the program to do something anyway.

When we save and run the program, we'll receive the following output:

## Output

Failing grade

If we then rewrite the program to give the grade a value of 65 or higher, we will instead receive the output `Passing grade`.

To add an `else` statement to the bank account example, we rewrite the code like this:

`account.py`

```
balance = 522
```

```
if balance < 0:
```

```
    print("Balance is below 0, add funds now or you  
will be charged a penalty.")
```

```
else:
```

```
    print("Your balance is 0 or above.")
```

## Output

Your balance is 0 or above.

Here, we changed the `balance` variable value to a positive number so that the `else` statement will print. To get the first `if` statement to print, we can rewrite the value to a negative number.

By combining an `if` statement with an `else` statement, you are constructing a two-part conditional statement that will tell the computer to execute certain code whether or not the `if` condition is met.



## Else if statement

So far, we have presented a Boolean option for conditional statements, with each `if` statement evaluating to either true or false. In many cases, we will want a program that evaluates more than two possible outcomes. For this, we will use an else if statement, which is written in Python as `elif`. The `elif` or else if statement looks like the `if` statement and will evaluate another condition.

In the bank account program, we may want to have three discrete outputs for three different situations:

- The balance is below 0
- The balance is equal to 0
- The balance is above 0

The `elif` statement will be placed between the `if` statement and the `else` statement as follows:

**account.py**

```
. . .  
if balance < 0:  
    print("Balance is below 0, add funds now or you  
will be charged a penalty.")  
  
elif balance == 0:  
    print("Balance is equal to 0, add funds soon.")  
  
else:  
    print("Your balance is 0 or above.")
```

Now, there are three possible outputs that can occur once we run the program: - If the variable `balance` is equal to 0 we will receive the output from the `elif` statement (Balance is equal to 0, add funds soon.) - If the variable `balance` is set to a positive number, we will receive the output from the `else` statement (Your balance is 0 or above.). - If the variable `balance` is set to a negative number, the output will be the string from the `if` statement (Balance is below 0, add funds now or you will be charged a penalty).

What if we want to have more than three possibilities, though? We can do this by writing more than one `elif` statement into our code.

In the `grade.py` program, let's rewrite the code so that there are a few letter grades corresponding to ranges of numerical grades:

- 90 or above is equivalent to an A grade
- 80-89 is equivalent to a B grade
- 70-79 is equivalent to a C grade
- 65-69 is equivalent to a D grade
- 64 or below is equivalent to an F grade

To run this code, we will need one `if` statement, three `elif` statements, and an `else` statement that will handle all failing cases.

Let's rewrite the code from the example above to have strings that print out each of the letter grades. We can keep our `else` statement the same.

`grade.py`

```
. . .  
if grade >= 90:
```

```
    print("A grade")

elif grade >=80:
    print("B grade")

elif grade >=70:
    print("C grade")

elif grade >= 65:
    print("D grade")

else:
    print("Failing grade")
```

Since `elif` statements will evaluate in order, we can keep our statements pretty basic. This program is completing the following steps:

1. If the grade is greater than 90, the program will print A grade, if the grade is less than 90, the program will continue to the next statement...
2. If the grade is greater than or equal to 80, the program will print B grade, if the grade is 79 or less, the program will continue to the next statement...
3. If the grade is greater than or equal to 70, the program will print C grade, if the grade is 69 or less, the program will continue to the next statement...
4. If the grade is greater than or equal to 65, the program will print D grade, if the grade is 64 or less, the program will continue to the

next statement...

5. The program will print `Failing` grade because all of the above conditions were not met.

## Nested If Statements

Once you are feeling comfortable with the `if`, `elif`, and `else` statements, you can move on to nested conditional statements. We can use nested `if` statements for situations where we want to check for a secondary condition if the first condition executes as true. For this, we can have an `if-else` statement inside of another `if-else` statement. Let's look at the syntax of a nested `if` statement:

```
if statement1:                                #outer if statement
    print("true")

    if nested_statement:                      #nested if statement
        print("yes")

    else:                                     #nested else statement
        print("no")

else:                                         #outer else statement
    print("false")
```

A few possible outputs can result from this code:

- If `statement1` evaluates to true, the program will then evaluate whether the `nested_statement` also evaluates to true. If both



```

        elif nested_statement2:           #first nested elif
            print("maybe")

        else:                             #first nested else
            print("no")

elif statement2:                         #outer elif
    print("hello galaxy")

    if nested_statement3:                 #second nested if
        print("yes")

    elif nested_statement4:               #second nested elif
        print("maybe")

    else:                                 #second nested else
        print("no")

else:                                     #outer else
    statement("hello universe")

```

In the above code, there is a nested `if` statement inside each `if` statement in addition to the `elif` statement. This will allow for more options within each condition.

Let's look at an example of nested `if` statements with our `grade.py` program. We can check for whether a grade is passing first (greater than or equal to 65%), then evaluate which letter grade the numerical grade should be equivalent to. If the grade is not passing, though, we do not

need to run through the letter grades, and instead can have the program report that the grade is failing. Our modified code with the nested `if` statement will look like this:

**grade.py**

```
. . .  
if grade >= 65:  
    print("Passing grade of:")  
  
    if grade >= 90:  
        print("A")  
  
    elif grade >=80:  
        print("B")  
  
    elif grade >=70:  
        print("C")  
  
    elif grade >= 65:  
        print("D")  
  
else:  
    print("Failing grade")
```

If we run the code with the variable `grade` set to the integer value 92, the first condition is met, and the program will print out `Passing grade of:`. Next, it will check to see if the grade is greater than or equal to 90, and since this condition is also met, it will print out `A`.

If we run the code with the `grade` variable set to 60, then the first condition is not met, so the program will skip the nested `if` statements and move down to the `else` statement, with the program printing out `Failing grade`.

We can of course add even more options to this, and use a second layer of nested `if` statements. Perhaps we will want to evaluate for grades of `A+`, `A` and `A-` separately. We can do so by first checking if the grade is passing, then checking to see if the grade is 90 or above, then checking to see if the grade is over 96 for an `A+` for instance:

**grade.py**

```
. . .  
if grade >= 65:  
    print("Passing grade of:")  
  
    if grade >= 90:  
        if grade > 96:  
            print("A+")  
  
        elif grade > 93 and grade <= 96:  
            print("A")  
  
        elif grade >= 90:  
            print("A-")  
  
. . .
```

In the code above, for a `grade` variable set to 96, the program will run the following:



1. Check if the grade is greater than or equal to 65 (true)
2. Print out `Passing grade of:`
3. Check if the grade is greater than or equal to 90 (true)
4. Check if the grade is greater than 96 (false)
5. Check if the grade is greater than 93 and also less than or equal to 96 (true)
6. Print A
7. Leave these nested conditional statements and continue with remaining code

The output of the program for a grade of 96 therefore looks like this:

#### Output

```
Passing grade of:
```

```
A
```

Nested `if` statements can provide the opportunity to add several specific levels of conditions to your code.

## Conclusion

By using conditional statements like the `if` statement, you will have greater control over what your program executes. Conditional statements tell the program to evaluate whether a certain condition is being met. If the condition is met it will execute specific code, but if it is not met the program will continue to move down to other code.

To continue practicing conditional statements, try using different [operators](#), combining operators with `and` or `or`, and using conditional statements alongside [loops](#). You can also go through our tutorial on [How](#)

[To Make a Simple Calculator Program](#) to gain more familiarity with conditional statements.

# How To Construct While Loops

Computer programs are great to use for automating and repeating tasks so that we don't have to. One way to repeat similar tasks is through using loops. We'll be covering Python's while loop in this tutorial.

A `while` loop implements the repeated execution of code based on a given [Boolean](#) condition. The code that is in a `while` block will execute as long as the `while` statement evaluates to `True`.

You can think of the `while` loop as a repeating [conditional statement](#). After an `if` statement, the program continues to execute code, but in a `while` loop, the program jumps back to the start of the `while` statement until the condition is `False`.

As opposed to [for loops](#) that execute a certain number of times, `while` loops are conditionally based, so you don't need to know how many times to repeat the code going in.

## While Loop

In Python, `while` loops are constructed like so:

```
while [a condition is True]:  
    [do something]
```

The something that is being done will continue to be executed until the condition that is being assessed is no longer true.

Let's create a small program that executes a `while` loop. In this program, we'll ask for the user to input a password. While going through

this loop, there are two possible outcomes:

- If the password is correct, the `while` loop will exit.
- If the password is not correct, the `while` loop will continue to execute.

We'll create a file called `password.py` in our text editor of choice, and begin by initializing the variable `password` as an empty [string](#):

```
password.py  
password = ''
```

The empty string will be used to take in input from the user within the `while` loop.

Now, we'll construct the `while` statement along with its condition:

```
password.py  
password = ''  
  
while password != 'password':
```

Here, the `while` is followed by the variable `password`. We are looking to see if the variable `password` is set to the string `password` (based on the user input later), but you can choose whichever string you'd like.

This means that if the user inputs the string `password`, then the loop will stop and the program will continue to execute any code outside of the loop. However, if the string that the user inputs is not equal to the string `password`, the loop will continue.

Next, we'll add the block of code that does something within the `while` loop:

**password.py**

```
password = ''

while password != 'password':
    print('What is the password?')
    password = input()
```

Inside of the `while` loop, the program runs a `print` statement that prompts for the password. Then the variable `password` is set to the user's input with the `input()` function.

The program will check to see if the variable `password` is assigned to the string `password`, and if it is, the `while` loop will end. Let's give the program another line of code for when that happens:

**password.py**

```
password = ''

while password != 'password':
    print('What is the password?')
    password = input()

print('Yes, the password is ' + password + '. You may enter.')
```

The last `print()` statement is outside of the `while` loop, so when the user enters `password` as the password, they will see the final `print` statement outside of the loop.

However, if the user never enters the word `password`, they will never get to the last `print()` statement and will be stuck in an infinite loop.

An infinite loop occurs when a program keeps executing within one loop, never leaving it. To exit out of infinite loops on the command line, press `CTRL + C`.

Save the program and run it:

```
python password.py
```

You'll be prompted for a password, and then may test it with various possible inputs. Here is sample output from the program:

#### **Output**

```
What is the password?
```

```
hello
```

```
What is the password?
```

```
sammy
```

```
What is the password?
```

```
PASSWORD
```

```
What is the password?
```

```
password
```

```
Yes, the password is password. You may enter.
```

Keep in mind that strings are case sensitive unless you also use a [string function](#) to convert the string to all lower-case (for example) before

checking.

## Example Program with While Loop

Now that we understand the general premise of a `while` loop, let's create a command-line guessing game that uses a `while` loop effectively. To best understand how this program works, you should also read about [using conditional statements](#) and [converting data types](#).

First, we'll create a file called `guess.py` in our text editor of choice. We want the computer to come up with random numbers for the user to guess, so we'll [import](#) the `random` module with an `import` statement. If you're unfamiliar with this package, you can learn more about [generating random numbers from the Python docs](#).

**guess.py**

```
import random
```

Next, we'll assign a random integer to the variable `number`, and keep it in the range of 1 through 25 (inclusive), in the hope that it does not make the game too difficult.

**guess.py**

```
import random
```

```
number = random.randint(1, 25)
```

At this point, we can get into our `while` loop, first initializing a variable and then creating the loop.

guess.py

```
import random

number = random.randint(1, 25)

number_of_guesses = 0

while number_of_guesses < 5:
    print('Guess a number between 1 and 25:')

    guess = input()
    guess = int(guess)

    number_of_guesses = number_of_guesses + 1

    if guess == number:
        break
```

We've initialized the variable `number_of_guesses` at 0, so that we increase it with each iteration of our loop so that we don't have an infinite loop. Then we added the `while` statement so that the `number_of_guesses` is limited to 5 total. After the fifth guess, the user will return to the command line, and for now, if the user enters something other than an integer, they'll receive an error.

Within the loop, we added a `print()` statement to prompt the user to enter a number, which we took in with the `input()` function and set to the `guess` variable. Then, we converted `guess` from a string to an integer.



Before the loop is over, we also want to increase the `number_of_guesses` variable by 1 so that we can iterate through the loop 5 times.

Finally, we write a conditional `if` statement to see if the `guess` that the user made is equivalent to the `number` that the computer generated, and if so we use a [break statement](#) to come out of the loop.

The program is fully functioning, and we can run it with the following command:

```
python guess.py
```

Though it works, right now the user never knows if their guess is correct and they can guess the full 5 times without ever knowing if they got it right. Sample output of the current program looks like this:

#### **Output**

```
Guess a number between 1 and 25:
11
Guess a number between 1 and 25:
19
Guess a number between 1 and 25:
22
Guess a number between 1 and 25:
3
Guess a number between 1 and 25:
8
```

Let's add some conditional statements outside of the loop so that the user is given feedback as to whether they correctly guess the number or not. These will go at the end of our current file.

**guess.py**

```
import random

number = random.randint(1, 25)

number_of_guesses = 0

while number_of_guesses < 5:
    print('Guess a number between 1 and 25:')
    guess = input()
    guess = int(guess)

    number_of_guesses = number_of_guesses + 1

    if guess == number:
        break

if guess == number:
    print('You guessed the number in ' +
str(number_of_guesses) + ' tries!')

else:
    print('You did not guess the number. The number
was ' + str(number))
```

At this point, the program will tell the user if they got the number right or wrong, which may not happen until the end of the loop when the user is out of guesses.

To give the user a little help along the way, let's add a few more conditional statements into the `while` loop. These can tell the user whether their number was too low or too high, so that they can be more likely to guess the correct number. We'll add these before our `if guess == number` line

**guess.py**

```
import random

number = random.randint(1, 25)

number_of_guesses = 0

while number_of_guesses < 5:
    print('Guess a number between 1 and 25:')
    guess = input()
    guess = int(guess)

    number_of_guesses = number_of_guesses + 1

    if guess < number:
        print('Your guess is too low')

    if guess > number:
        print('Your guess is too high')
```

```
    if guess == number:
        break

if guess == number:
    print('You guessed the number in ' +
str(number_of_guesses) + ' tries!')

else:
    print('You did not guess the number. The number
was ' + str(number))
```

When we run the program again with `python guess.py`, we see that the user gets more guided assistance in their guessing. So, if the randomly-generated number is 12 and the user guesses 18, they will be told that their guess is too high, and they can adjust their next guess accordingly.

There is more that can be done to improve the code, including error handling for when the user does not input an integer, but in this example we see a `while` loop at work in a short command-line program.

## Conclusion

This tutorial went over how `while` loops work in Python and how to construct them. While loops continue to loop through a block of code provided that the condition set in the `while` statement is `True`.

From here, you can continue to learn about looping by reading tutorials on [for loops](#) and [break, continue, and pass statements](#).

# How To Construct For Loops

Using loops in computer programming allows us to automate and repeat similar tasks multiple times. In this tutorial, we'll be covering Python's for loop.

A for loop implements the repeated execution of code based on a loop counter or loop variable. This means that for loops are used most often when the number of iterations is known before entering the loop, unlike [while loops](#) which are conditionally based.

## For Loops

In Python, for loops are constructed like so:

```
for [iterating variable] in [sequence]:  
    [do something]
```

The something that is being done will be executed until the sequence is over.

Let's look at a for loop that iterates through a range of values:

```
for i in range(0,5):  
    print(i)
```

When we run this program, the output looks like this:

## Output

0  
1  
2  
3  
4

This `for` loop sets up `i` as its iterating variable, and the sequence exists in the range of 0 to 5.

Then within the loop we print out one integer per loop iteration. Keep in mind that in programming we tend to begin at index 0, so that is why although 5 numbers are printed out, they range from 0-4.

You'll commonly see and use `for` loops when a program needs to repeat a block of code a number of times.

## For Loops using `range()`

One of Python's built-in immutable sequence types is `range()`. In loops, `range()` is used to control how many times the loop will be repeated.

When working with `range()`, you can pass between 1 and 3 integer arguments to it:

- `start` states the integer value at which the sequence begins, if this is not included then `start` begins at 0
- `stop` is always required and is the integer that is counted up to but not included
- `step` sets how much to increase (or decrease in the case of negative numbers) the next iteration, if this is omitted then `step` defaults to 1

We'll look at some examples of passing different arguments to `range()`.

First, let's only pass the `stop` argument, so that our sequence set up is `range(stop)`:

```
for i in range(6):  
    print(i)
```

In the program above, the `stop` argument is 6, so the code will iterate from 0-6 (exclusive of 6):

#### **Output**

```
0  
1  
2  
3  
4  
5
```

Next, we'll look at `range(start, stop)`, with values passed for when the iteration should start and for when it should stop:

```
for i in range(20,25):  
    print(i)
```

Here, the range goes from 20 (inclusive) to 25 (exclusive), so the output looks like this:

### Output

```
20
21
22
23
24
```

The `step` argument of `range()` is similar to [specifying stride while slicing strings](#) in that it can be used to skip values within the sequence.

With all three arguments, `step` comes in the final position: `range(start, stop, step)`. First, let's use a `step` with a positive value:

```
for i in range(0,15,3):
    print(i)
```

In this case, the `for` loop is set up so that the numbers from 0 to 15 print out, but at a `step` of 3, so that only every third number is printed, like so:

### Output

```
0
3
6
9
12
```



We can also use a negative value for our `step` argument to iterate backwards, but we'll have to adjust our `start` and `stop` arguments accordingly:

```
for i in range(100,0,-10):  
    print(i)
```

Here, 100 is the `start` value, 0 is the `stop` value, and -10 is the range, so the loop begins at 100 and ends at 0, decreasing by 10 with each iteration. We can see this occur in the output:

#### **Output**

```
100  
90  
80  
70  
60  
50  
40  
30  
20  
10
```

When programming in Python, `for` loops often make use of the `range()` sequence type as its parameters for iteration.

## **For Loops using Sequential Data Types**

[Lists](#) and other data sequence types can also be leveraged as iteration parameters in `for` loops. Rather than iterating through a `range()`, you can define a list and iterate through that list.

We'll assign a list to a variable, and then iterate through the list:

```
sharks = ['hammerhead', 'great white', 'dogfish',  
'frilled', 'bullhead', 'requiem']  
  
for shark in sharks:  
    print(shark)
```

In this case, we are printing out each item in the list. Though we used the variable `shark`, we could have called the variable any other [valid variable name](#) and we would get the same output:

#### **Output**

```
hammerhead  
great white  
dogfish  
frilled  
bullhead  
requiem
```

The output above shows that the `for` loop iterated through the list, and printed each item from the list per line.

Lists and other sequence-based [data types](#) like [strings](#) and [tuples](#) are common to use with loops because they are iterable. You can combine these data types with `range()` to add items to a list, for example:

```
sharks = ['hammerhead', 'great white', 'dogfish',  
'frilled', 'bullhead', 'requiem']  
  
for item in range(len(sharks)):  
    sharks.append('shark')  
  
print(sharks)
```

#### **Output**

```
['hammerhead', 'great white', 'dogfish', 'frilled',  
'bullhead', 'requiem', 'shark', 'shark', 'shark',  
'shark', 'shark', 'shark']
```

Here, we have added a placeholder string of 'shark' for each item of the length of the sharks list.

You can also use a for loop to construct a list from scratch:

```
integers = []  
  
for i in range(10):  
    integers.append(i)  
  
print(integers)
```

In this example, the list `integers` is initialized empty, but the `for` loop populates the list like so:

#### **Output**

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Similarly, we can iterate through strings:

```
sammy = 'Sammy'

for letter in sammy:
    print(letter)
```

### Output

```
S
a
m
m
y
```

Iterating through [tuples](#) is done in the same format as iterating through lists or strings above.

When iterating through a [dictionary](#), it's important to keep the key : value structure in mind to ensure that you are calling the correct element of the dictionary. Here is an example that calls both the key and the value:

```
sammy_shark = {'name': 'Sammy', 'animal': 'shark',
               'color': 'blue', 'location': 'ocean'}

for key in sammy_shark:
    print(key + ': ' + sammy_shark[key])
```

## Output

```
name: Sammy  
animal: shark  
location: ocean  
color: blue
```

When using dictionaries with `for` loops, the iterating variable corresponds to the keys of the dictionary, and `dictionary_variable[iterating_variable]` corresponds to the values. In the case above, the iterating variable `key` was used to stand for key, and `sammy_shark[key]` was used to stand for the values.

Loops are often used to iterate and manipulate sequential data types.

## Nested For Loops

Loops can be nested in Python, as they can with other programming languages.

A nested loop is a loop that occurs within another loop, structurally similar to [nested if statements](#). These are constructed like so:

```
for [first iterating variable] in [outer loop]: #  
Outer loop  
    [do something] # Optional  
    for [second iterating variable] in [nested loop]:  
# Nested loop  
    [do something]
```

The program first encounters the outer loop, executing its first iteration. This first iteration triggers the inner, nested loop, which then

runs to completion. Then the program returns back to the top of the outer loop, completing the second iteration and again triggering the nested loop. Again, the nested loop runs to completion, and the program returns back to the top of the outer loop until the sequence is complete or a [break](#) or other statement disrupts the process.

Let's implement a nested `for` loop so we can take a closer look. In this example, the outer loop will iterate through a list of integers called `num_list`, and the inner loop will iterate through a list of strings called `alpha_list`.

```
num_list = [1, 2, 3]
alpha_list = ['a', 'b', 'c']

for number in num_list:
    print(number)
    for letter in alpha_list:
        print(letter)
```

When we run this program, we'll receive the following output:

#### **Output**

```
1
a
b
c
2
a
b
```

```
c
3
a
b
c
```

The output illustrates that the program completes the first iteration of the outer loop by printing 1, which then triggers completion of the inner loop, printing a, b, c consecutively. Once the inner loop has completed, the program returns to the top of the outer loop, prints 2, then again prints the inner loop in its entirety (a, b, c), etc.

Nested `for` loops can be useful for iterating through items within lists composed of lists. In a list composed of lists, if we employ just one `for` loop, the program will output each internal list as an item:

```
list_of_lists = [['hammerhead', 'great white',
'dogfish'],[0, 1, 2],[9.9, 8.8, 7.7]]

for list in list_of_lists:
    print(list)
```

#### **Output**

```
['hammerhead', 'great white', 'dogfish']
[0, 1, 2]
[9.9, 8.8, 7.7]
```

In order to access each individual item of the internal lists, we'll implement a nested `for` loop:

```
list_of_lists = [['hammerhead', 'great white',  
'dogfish'], [0, 1, 2], [9.9, 8.8, 7.7]]  
  
for list in list_of_lists:  
    for item in list:  
        print(item)
```

### Output

```
hammerhead  
great white  
dogfish  
0  
1  
2  
9.9  
8.8  
7.7
```

When we utilize a nested `for` loop we are able to iterate over the individual items contained in the lists.

We can see nested `for` loops working in use in a working program in our tutorial on the [Natural Language Processing Toolkit \(NLTK\)](#).

### Conclusion

This tutorial went over how `for` loops work in Python and how to construct them. For loops continue to loop through a block of code provided a certain number of times.



From here, you can continue to learn about looping by reading tutorials on [while loops](#) and [break, continue, and pass statements](#).

To work with `for` loops in projects, follow along with the following tutorials: - [How To Create a Twitterbot with Python 3 and the Tweepy Library](#) - [How To Work with Language Data in Python 3 using the Natural Language Toolkit NLTK](#) - [How To Graph Word Frequency Using matplotlib with Python 3](#)

# How To Use Break, Continue, and Pass Statements when Working with Loops

Using [for loops](#) and [while loops](#) in Python allow you to automate and repeat tasks in an efficient manner.

But sometimes, an external factor may influence the way your program runs. When this occurs, you may want your program to exit a loop completely, skip part of a loop before continuing, or ignore that external factor. You can do these actions with `break`, `continue`, and `pass` statements.

## Break Statement

In Python, the `break` statement provides you with the opportunity to exit out of a loop when an external condition is triggered. You'll put the `break` statement within the block of code under your loop statement, usually after a [conditional if statement](#).

Let's look at an example that uses the `break` statement in a `for` loop:

```
number = 0

for number in range(10):
    number = number + 1

    if number == 5:
        break      # break here
```

```
print('Number is ' + str(number))

print('Out of loop')
```

In this small program, the variable `number` is initialized at 0. Then a `for` statement constructs the loop as long as the variable `number` is less than 10.

Within the `for` loop, the number increases incrementally by 1 with each pass because of the line `number = number + 1`.

Then, there is an `if` statement that presents the condition that if the variable `number` is equivalent to the integer 5, then the loop will break.

Within the loop is also a `print()` statement that will execute with each iteration of the `for` loop until the loop breaks, since it is after the `break` statement.

To see when we are out of the loop, we have included a final `print()` statement outside of the `for` loop.

When we run this code, our output will be the following:

#### **Output**

```
Number is 1
Number is 2
Number is 3
Number is 4
Out of loop
```

This shows that once the integer `number` is evaluated as equivalent to 5, the loop breaks, as the program is told to do so with the `break` statement.

The `break` statement causes a program to break out of a loop.

## Continue Statement

The `continue` statement gives you the option to skip over the part of a loop where an external condition is triggered, but to go on to complete the rest of the loop. That is, the current iteration of the loop will be disrupted, but the program will return to the top of the loop.

The `continue` statement will be within the block of code under the loop statement, usually after a conditional `if` statement.

Using the same `for` loop program as in the [Break Statement](#) section above, we'll use a `continue` statement rather than a `break` statement:

```
number = 0

for number in range(10):
    number = number + 1

    if number == 5:
        continue    # continue here

    print('Number is ' + str(number))

print('Out of loop')
```

The difference in using the `continue` statement rather than a `break` statement is that our code will continue despite the disruption when the variable `number` is evaluated as equivalent to 5. Let's look at our output:

## Output

```
Number is 1
Number is 2
Number is 3
Number is 4
Number is 6
Number is 7
Number is 8
Number is 9
Number is 10
Out of loop
```

Here we see that the line `Number is 5` never occurs in the output, but the loop continues after that point to print lines for the numbers 6-10 before leaving the loop.

You can use the `continue` statement to avoid deeply nested conditional code, or to optimize a loop by eliminating frequently occurring cases that you would like to reject.

The `continue` statement causes a program to skip certain factors that come up within a loop, but then continue through the rest of the loop.

## Pass Statement

When an external condition is triggered, the `pass` statement allows you to handle the condition without the loop being impacted in any way; all of the code will continue to be read unless a `break` or other statement occurs.

As with the other statements, the `pass` statement will be within the block of code under the loop statement, typically after a conditional `if`

statement.

Using the same code block as above, let's replace the `break` or `continue` statement with a `pass` statement:

```
number = 0

for number in range(10):
    number = number + 1

    if number == 5:
        pass      # pass here

    print('Number is ' + str(number))

print('Out of loop')
```

The `pass` statement occurring after the `if` conditional statement is telling the program to continue to run the loop and ignore the fact that the variable `number` evaluates as equivalent to 5 during one of its iterations.

We'll run the program and take a look at the output:

#### **Output**

```
Number is 1
Number is 2
Number is 3
Number is 4
Number is 5
```

```
Number is 6  
Number is 7  
Number is 8  
Number is 9  
Number is 10  
Out of loop
```

By using the `pass` statement in this program, we notice that the program runs exactly as it would if there were no conditional statement in the program. The `pass` statement tells the program to disregard that condition and continue to run the program as usual.

The `pass` statement can create minimal classes, or act as a placeholder when working on new code and thinking on an algorithmic level before hammering out details.

## Conclusion

The `break`, `continue`, and `pass` statements in Python will allow you to use `for` loops and `while` loops more effectively in your code.

You can see `break` and `pass` statements in action in our tutorial “[How To Create a Twitterbot with Python 3 and the Tweepy Library](#).”

# How To Define Functions

A function is a block of instructions that performs an action and, once defined, can be reused. Functions make code more modular, allowing you to use the same code over and over again.

Python has a number of built-in functions that you may be familiar with, including:

- `print()` which will print an object to the terminal
- `int()` which will convert a string or number data type to an integer data type
- `len()` which returns the length of an object

Function names include parentheses and may include parameters.

In this tutorial, we'll go over how to define your own functions to use in your coding projects.

## Defining a Function

Let's start with turning the classic ["Hello, World!" program](#) into a function.

We'll create a new text file in our text editor of choice, and call the program `hello.py`. Then, we'll define the function.

A function is defined by using the `def` keyword, followed by a name of your choosing, followed by a set of parentheses which hold any parameters the function will take (they can be empty), and ending with a colon.

In this case, we'll define a function named `hello()`:



**hello.py**

```
def hello():
```

This sets up the initial statement for creating a function.

From here, we'll add a second line with a 4-space indent to provide the instructions for what the function does. In this case, we'll be printing Hello, World! to the console:

**hello.py**

```
def hello():  
    print("Hello, World!")
```

<figure class="code">

Our function is now fully defined, but if we run the program at this point, nothing will happen since we didn't call the function.

So, outside of our defined function block, let's call the function with hello():

**hello.py**

```
def hello():  
    print("Hello, World!")
```

```
hello()
```

<figure class="code">

Now, let's run the program:

```
python hello.py
```

You should receive the following output:

#### **Output**

```
Hello, World!
```

Functions can be more complicated than the `hello()` function we defined above. For example, we can use [for loops](#), [conditional statements](#), and more within our function block.

For example, the function defined below utilizes a conditional statement to check if the input for the `name` variable contains a vowel, then uses a `for` loop to iterate over the letters in the `name` string.

#### **names.py**

```
# Define function names()
def names():
    # Set up name variable with input
    name = str(input('Enter your name: '))
    # Check whether name has a vowel
    if set('aeiou').intersection(name.lower()):
        print('Your name contains a vowel.')
    else:
        print('Your name does not contain a vowel.')

    # Iterate over name
    for letter in name:
        print(letter)
```

```
# Call the function
names()
```

```
<figure class="code">
```

The `names()` function we defined above sets up a conditional statement and a `for` loop, showing how code can be organized within a function definition. However, depending on what we intend with our program and how we want to set up our code, we may want to define the conditional statement and the `for` loop as two separate functions.

Defining functions within a program makes our code modular and reusable so that we can call the same functions without rewriting them.

## Working with Parameters

So far we have looked at functions with empty parentheses that do not take arguments, but we can define parameters in function definitions within their parentheses.

A parameter is a named entity in a function definition, specifying an argument that the function can accept.

Let's create a small program that takes in parameters `x`, `y`, and `z`. We'll create a function that adds the parameters together in different configurations. The sums of these will be printed by the function. Then we'll call the function and pass numbers into the function.

**add\_numbers.py**

```
def add_numbers(x, y, z):
    a = x + y
```

```
b = x + z
c = y + z
print(a, b, c)
```

```
add_numbers(1, 2, 3)
```

```
<figure class="code">
```

We passed the number 1 in for the `x` parameter, 2 in for the `y` parameter, and 3 in for the `z` parameter. These values correspond with each parameter in the order they are given.

The program is essentially doing the following math based on the values we passed to the parameters:

```
a = 1 + 2
b = 1 + 3
c = 2 + 3
```

The function also prints `a`, `b`, and `c`, and based on the math above we would expect `a` to be equal to 3, `b` to be 4, and `c` to be 5. Let's run the program:

```
python add_numbers.py
```

### **Output**

```
3 4 5
```

When we pass 1, 2, and 3 as parameters to the `add_numbers()` function, we receive the expected output.

Parameters are arguments that are typically defined as variables within function definitions. They can be assigned values when you run the method, passing the arguments into the function.

## Keyword Arguments

In addition to calling parameters in order, you can use keyword arguments in a function call, in which the caller identifies the arguments by the parameter name.

When you use keyword arguments, you can use parameters out of order because the Python interpreter will use the keywords provided to match the values to the parameters.

Let's create a function that will show us profile information for a user. We'll pass parameters to it in the form of `username` (intended as a string), and `followers` (intended as an integer).

### **profile.py**

```
# Define function with parameters
def profile_info(username, followers):
    print("Username: " + username)
    print("Followers: " + str(followers))
```

<figure class="code">

Within the function definition statement, `username` and `followers` are contained in the parentheses of the `profile_info()` function. The

block of the function prints out information about the user as strings, making use of the two parameters.

Now, we can call the function and assign parameters to it:

**profile.py**

```
def profile_info(username, followers):  
    print("Username: " + username)  
    print("Followers: " + str(followers))  
  
# Call function with parameters assigned as above  
profile_info("sammyshark", 945)  
  
# Call function with keyword arguments  
profile_info(username="AlexAnglerfish", followers=342)
```

<figure class="code">

In the first function call, we have filled in the information with a username of sammyshark and followers being 945, in the second function call we used keyword arguments, assigning values to the argument variables.

Let's run the program:

```
python profile.py
```

**Output**

```
Username: sammyshark  
Followers: 945
```

```
Username: AlexAnglerfish  
Followers: 342
```

The output shows us the usernames and numbers of followers for both users.

This also permits us to modify the order of the parameters, as in this example of the same program with a different call:

**profile.py**

```
def profile_info(username, followers):  
    print("Username: " + username)  
    print("Followers: " + str(followers))  
  
# Change order of parameters  
profile_info(followers=820, username="cameron-  
catfish")
```

<figure class="code">

When we run the program again with the `python profile.py` command, we'll receive the following output:

**Output**

```
Username: cameron-catfish  
Followers: 820
```

Because the function definition maintains the same order of `print()` statements, if we use keyword arguments, it does not matter which order

we pass them into the function call.

## Default Argument Values

We can also provide default values for one or both of the parameters. Let's create a default value for the `followers` parameter with a value of 1:

**profile.py**

```
def profile_info(username, followers=1):  
    print("Username: " + username)  
    print("Followers: " + str(followers))
```

Now, we can run the function with only the `username` function assigned, and the number of followers will automatically default to 1. We can also still change the number of followers if we would like.

**profile.py**

```
def profile_info(username, followers=1):  
    print("Username: " + username)  
    print("Followers: " + str(followers))
```

```
profile_info(username="JOctopus")  
profile_info(username="sammyshark", followers=945)
```

When we run the program with the `python profile.py` command, we'll receive the following output:

**Output**



Username: JOctopus

Followers: 1

Username: sammyshark

Followers: 945

Providing default parameters with values can let us skip defining values for each argument that already has a default.

## Returning a Value

You can pass a parameter value into a function, and a function can also produce a value.

A function can produce a value with the `return` statement, which will exit a function and optionally pass an expression back to the caller. If you use a `return` statement with no arguments, the function will return `None`.

So far, we have used the `print()` statement instead of the `return` statement in our functions. Let's create a program that instead of printing will return a variable.

In a new text file called `square.py`, we'll create a program that squares the parameter `x` and returns the variable `y`. We issue a call to print the `result` variable, which is formed by running the `square()` function with 3 passed into it.

**square.py**

```
def square(x):  
    y = x ** 2  
    return y
```

```
result = square(3)
print(result)
```

<figure class="code">

We can run the program and see the output:

```
python square.py
```

**Output**

9

The integer 9 is returned as output, which is what we would expect by asking Python to find the square of 3.

To further understand how the `return` statement works, we can comment out the `return` statement in the program:

**square.py**

```
def square(x):
    y = x ** 2
    # return y
```

```
result = square(3)
print(result)
```

<figure class="code">

Now, let's run the program again:

```
python square.py
```

### Output

None

Without using the `return` statement here, the program cannot return a value so the value defaults to `None`.

As another example, in the `add_numbers.py` program above, we could swap out the `print()` statement for a `return` statement.

### `add_numbers.py`

```
def add_numbers(x, y, z):  
    a = x + y  
    b = x + z  
    c = y + z  
    return a, b, c  
  
sums = add_numbers(1, 2, 3)  
print(sums)
```

<figure class="code">

Outside of the function, we set the variable `sums` equal to the result of the function taking in 1, 2, and 3 as we did above. Then we called a `print` of the `sums` variable.

Let's run the program again now that it has the `return` statement:

```
python add_numbers.py
```

## Output

(3, 4, 5)

We receive the same numbers 3, 4, and 5 as output that we received previously by using the `print()` statement in the function. This time it is delivered as a [tuple](#) because the `return` statement's [expression list](#) has at least one comma.

Functions exit immediately when they hit a `return` statement, whether or not they're returning a value.

### `return_loop.py`

```
def loop_five():
    for x in range(0, 25):
        print(x)
        if x == 5:
            # Stop function at x == 5
            return
    print("This line will not execute.")

loop_five()
```

<figure class="code">

Using the `return` statement within the `for` loop ends the function, so the line that is outside of the loop will not run. If, instead, we had used a [break statement](#), only the loop would have exited at that time, and the last `print()` line would run.

The `return` statement exits a function, and may return a value when issued with a parameter.

## Using `main()` as a Function

Although in Python you can call the function at the bottom of your program and it will run (as we have done in the examples above), many programming languages (like C++ and Java) require a `main` function in order to execute. Including a `main()` function, though not required, can structure our Python programs in a logical way that puts the most important components of the program into one function. It can also make our programs easier for non-Python programmers to read.

We'll start with adding a `main()` function to the `hello.py` program above. We'll keep our `hello()` function, and then define a `main()` function:

**hello.py**

```
def hello():  
    print("Hello, World!")
```

```
def main():
```

Within the `main()` function, let's include a `print()` statement to let us know that we're in the `main()` function. Additionally, let's call the `hello()` function within the `main()` function:

**hello.py**

```
def hello():  
    print("Hello, World!")
```

```
def main():  
    print("This is the main function")  
    hello()
```

Finally, at the bottom of the program we'll call the `main()` function:

**hello.py**

```
def hello():  
    print("Hello, World!")  
  
def main():  
    print("This is the main function.")  
    hello()  
  
main()
```

<figure class="code">

At this point, we can run our program:

```
python hello.py
```

We'll receive the following output:

**Output**

```
This is the main function.
```

```
Hello, World!
```

Because we called the `hello()` function within `main()` and then only called `main()` to run, the `Hello, World!` text printed only once, after the string that told us we were in the main function.

Next we're going to be working with multiple functions, so it is worth reviewing the variable scope of [global and local variables](#). If you define a variable within a function block, you'll only be able to use that variable within that function. If you would like to use variables across functions it may be better to declare a global variable.

In Python, `'__main__'` is the name of the scope where top-level code will execute. When a program is run from standard input, a script, or from an interactive prompt, its `__name__` is set equal to `'__main__'`.

Because of this, there is a convention to use the following construction:

```
if __name__ == '__main__':  
    # Code to run when this is the main program here
```

This lets program files be used either: - as the main program and run what follows the `if` statement - as a module and not run what follows the `if` statement.

Any code that is not contained within this statement will be executed upon running. If you're using your program file as a module, the code that is not in this statement will also execute upon its import while running the secondary file.

Let's expand on our `names.py` program above, and create a new file called `more_names.py`. In this program we'll declare a global variable

and modify our original `names()` function so that the instructions are in two discrete functions.

The first function, `has_vowel()` will check to see if the name string contains a vowel.

The second function `print_letters()` will print each letter of the name string.

**more\_names.py**

```
# Declare global variable name for use in all
functions
name = str(input('Enter your name: '))

# Define function to check if name contains a vowel
def has_vowel():
    if set('aeiou').intersection(name.lower()):
        print('Your name contains a vowel.')
    else:
        print('Your name does not contain a vowel.')

# Iterate over letters in name string
def print_letters():
    for letter in name:
        print(letter)
```

With this set up, let's define the `main()` function which will contain a call to both the `has_vowel()` and the `print_letters()` functions.



**more\_names.py**

```
# Declare global variable name for use in all
functions
name = str(input('Enter your name: '))

# Define function to check if name contains a vowel
def has_vowel():
    if set('aeiou').intersection(name.lower()):
        print('Your name contains a vowel.')
    else:
        print('Your name does not contain a vowel.')

# Iterate over letters in name string
def print_letters():
    for letter in name:
        print(letter)

# Define main method that calls other functions
def main():
    has_vowel()
    print_letters()
```

Finally, we'll add the `if __name__ == '__main__':` construction at the bottom of the file. For our purposes, since we have put all the

functions we would like to do in the `main()` function, we'll call the `main()` function following this `if` statement.

**more\_names.py**

```
# Declare global variable name for use in all
functions
name = str(input('Enter your name: '))

# Define function to check if name contains a vowel
def has_vowel():
    if set('aeiou').intersection(name.lower()):
        print('Your name contains a vowel.')
    else:
        print('Your name does not contain a vowel.')

# Iterate over letters in name string
def print_letters():
    for letter in name:
        print(letter)

# Define main method that calls other functions
def main():
    has_vowel()
    print_letters()
```

```
# Execute main() function
if __name__ == '__main__':
    main()
```

<figure class="code">

We can now run the program:

```
python more_names.py
```

The program will show the same output as the `names.py` program, but here the code is more organized and can be used in a modular way without modification.

If you did not want to declare a `main()` function, you alternatively could have ended the program like this:

**more\_names.py**

```
...
if __name__ == '__main__':
    has_vowel()
    print_letters()
```

Using `main()` as a function and the `if __name__ == '__main__':` statement can organize your code in a logical way, making it more readable and modular.

## Conclusion

Functions are code blocks of instructions that perform actions within a program, helping to make our code reusable and modular.

To learn more about how to make your code more modular, you can read our guide on [How To Write Modules in Python 3](#).

# How To Use `*args` and `**kwargs`

In [function definitions](#), [parameters](#) are named entities that specify an argument that a given function can accept.

When programming, you may not be aware of all the possible use cases of your code, and may want to offer more options for future programmers working with the module, or for users interacting with the code. We can pass a variable number of arguments to a function by using `*args` and `**kwargs` in our code.

## Understanding `*args`

In Python, the single-asterisk form of `*args` can be used as a parameter to send a non-keyworded variable-length argument list to functions. It is worth noting that the asterisk (`*`) is the important element here, as the word `args` is the established conventional idiom, though it is not enforced by the language.

Let's look at a typical function that uses two arguments:

**lets\_multiply.py**

```
def multiply(x, y):  
    print (x * y)
```

In the code above, we built the function with `x` and `y` as arguments, and then when we call the function, we need to use numbers to correspond with `x` and `y`. In this case, we will pass the integer 5 in for `x` and the integer 4 in for `y`:

**lets\_multiply.py**

```
def multiply(x, y):  
    print (x * y)
```

**multiply(5, 4)**

Now, we can run the above code:

```
python lets_multiply.py
```

We'll receive the following output, showing that the integers 5 and 4 were multiplied as per the `multiply(x, y)` function:

**Output**

20

What if, later on, we decide that we would like to multiply three numbers rather than just two? If we try to add an additional number to the function, as shown below, we'll receive an error.

**lets\_multiply.py**

```
def multiply(x, y):  
    print (x * y)
```

**multiply(5, 4, 3)**

**Output**

`TypeError: multiply() takes 2 positional arguments but`

3 were given

So, if you suspect that you may need to use more arguments later on, you can make use of `*args` as your parameter instead.

We can essentially create the same function and code that we showed in the first example, by removing `x` and `y` as function parameters, and instead replacing them with `*args`:

**lets\_multiply.py**

```
def multiply(*args):  
    z = 1  
    for num in args:  
        z *= num  
    print(z)  
  
multiply(4, 5)  
multiply(10, 9)  
multiply(2, 3, 4)  
multiply(3, 5, 10, 6)
```

When we run this code, we'll receive the product for each of these function calls:

**Output**

20  
90  
24  
900

Because we used `*args` to send a variable-length argument list to our function, we were able to pass in as many arguments as we wished into the function calls.

With `*args` you can create more flexible code that accepts a varied amount of non-keyworded arguments within your function.

## Understanding `**kwargs`

The double asterisk form of `**kwargs` is used to pass a keyworded, variable-length argument [dictionary](#) to a function. Again, the two asterisks (`**`) are the important element here, as the word `kwargs` is conventionally used, though not enforced by the language.

Like `*args`, `**kwargs` can take however many arguments you would like to supply to it. However, `**kwargs` differs from `*args` in that you will need to assign keywords.

First, let's simply print out the `**kwargs` arguments that we pass to a function. We'll create a short function to do this:

`print_kwargs.py`

```
def print_kwargs(**kwargs):  
    print(kwargs)
```

Next, we'll call the function with some keyworded arguments passed into the function:

`print_kwargs.py`

```
def print_kwargs(**kwargs):  
    print(kwargs)
```



```
print_kwargs(kwargs_1="Shark", kwargs_2=4.5,  
kwargs_3=True)
```

Let's run the program above and look at the output:

```
python print_kwargs.py
```

#### Output

```
{'kwargs_3': True, 'kwargs_2': 4.5, 'kwargs_1':  
'Shark'}
```

Because the dictionary data type is unordered, we received the key-value pairs in a random order, but it is important to note that a dictionary called `**kwargs` is created and we can work with it just like we can work with other dictionaries.

Let's create another short program to show how we can make use of `**kwargs`. Here we'll create a function to greet a dictionary of names. First, we'll start with a dictionary of two names:

#### `print_values.py`

```
def print_values(**kwargs):  
    for key, value in kwargs.items():  
        print("The value of {} is {}".format(key,  
value))  
  
print_values(my_name="Sammy", your_name="Casey")
```

We can now run the program and look at the output:

```
python print_values.py
```

### Output

```
The value of your_name is Casey
```

```
The value of my_name is Sammy
```

Again, because dictionaries are unordered, your output may be with the name Casey first or with the name Sammy first.

Let's now pass additional arguments to the function to show that `**kwargs` will accept however many arguments you would like to include:

### `print_values.py`

```
def print_values(**kwargs):  
    for key, value in kwargs.items():  
        print("The value of {} is {}".format(key,  
value))
```

```
print_values(  
    name_1="Alex",  
    name_2="Gray",  
    name_3="Harper",  
    name_4="Phoenix",  
    name_5="Remy",  
    name_6="Val"  
)
```

When we run the program at this point, we'll receive the following output, which is again unordered:

#### **Output**

```
The value of name_2 is Gray
The value of name_6 is Val
The value of name_4 is Phoenix
The value of name_5 is Remy
The value of name_3 is Harper
The value of name_1 is Alex
```

Using `**kwargs` provides us with flexibility to use keyword arguments in our program. When we use `**kwargs` as a parameter, we don't need to know how many arguments we would eventually like to pass to a function.

## **Ordering Arguments**

When ordering arguments within a function or function call, arguments need to occur in a particular order:

1. Formal positional arguments
2. `*args`
3. Keyword arguments
4. `**kwargs`

In practice, when working with explicit positional parameters along with `*args` and `**kwargs`, your function would look like this:

```
def example(arg_1, arg_2, *args, **kwargs):  
    ...
```

And, when working with positional parameters along with named keyword parameters in addition to `*args` and `**kwargs`, your function would look like this:

```
def example2(arg_1, arg_2, *args, kw_1="shark",  
kw_2="blobfish", **kwargs):  
    ...
```

It is important to keep the order of arguments in mind when creating functions so that you do not receive a syntax error in your Python code.

## Using `*args` and `**kwargs` in Function Calls

We can also use `*args` and `**kwargs` to pass arguments into functions. First, let's look at an example with `*args`.

**some\_args.py**

```
def some_args(arg_1, arg_2, arg_3):  
    print("arg_1:", arg_1)  
    print("arg_2:", arg_2)  
    print("arg_3:", arg_3)  
  
args = ("Sammy", "Casey", "Alex")  
some_args(*args)
```

In the function above, there are three parameters defined as `arg_1`, `arg_2`, and `arg_3`. The function will print out each of these arguments. We then create a variable that is set to an iterable (in this case, a [tuple](#)), and can pass that variable into the function with the asterisk syntax.

When we run the program with the `python some_args.py` command, we'll receive the following output:

#### Output

```
arg_1: Sammy  
arg_2: Casey  
arg_3: Alex
```

We can also modify the program above to an iterable [list data type](#) with a different variable name. Let's also combine the `*args` syntax with a [named parameter](#):

#### `some_args.py`

```
def some_args(arg_1, arg_2, arg_3):  
    print("arg_1:", arg_1)  
    print("arg_2:", arg_2)  
    print("arg_3:", arg_3)  
  
my_list = [2, 3]  
some_args(1, *my_list)
```

If we run the program above, it will produce the following output:

#### Output

```
arg_1: 1
arg_2: 2
arg_3: 3
```

Similarly, the keyworded `**kwargs` arguments can be used to call a function. We will set up a variable equal to a dictionary with 3 key-value pairs (we'll use `kwargs` here, but it can be called whatever you want), and pass it to a function with 3 arguments:

**some\_kwargs.py**

```
def some_kwargs(kwarg_1, kwarg_2, kwarg_3):
    print("kwarg_1:", kwarg_1)
    print("kwarg_2:", kwarg_2)
    print("kwarg_3:", kwarg_3)

kwargs = {"kwarg_1": "Val", "kwarg_2": "Harper",
"kwarg_3": "Remy"}
some_kwargs(**kwargs)
```

Let's run the program above with the `python some_kwargs.py` command:

### **Output**

```
kwarg_1: Val
kwarg_2: Harper
kwarg_3: Remy
```

When calling a function, you can use `*args` and `**kwargs` to pass arguments.

## Conclusion

We can use the special syntax of `*args` and `**kwargs` within a function definition in order to pass a variable number of arguments to the function.

Creating functions that accept `*args` and `**kwargs` are best used in situations where you expect that the number of inputs within the argument list will remain relatively small. The use of `*args` and `**kwargs` is primarily to provide readability and convenience, but should be done with care.

# How To Construct Classes and Define Objects

Python is an object-oriented programming language. Object-oriented programming (OOP) focuses on creating reusable patterns of code, in contrast to procedural programming, which focuses on explicit sequenced instructions. When working on complex programs in particular, object-oriented programming lets you reuse code and write code that is more readable, which in turn makes it more maintainable.

One of the most important concepts in object-oriented programming is the distinction between classes and objects, which are defined as follows:

- Class — A blueprint created by a programmer for an object. This defines a set of attributes that will characterize any object that is instantiated from this class.
- Object — An instance of a class. This is the realized version of the class, where the class is manifested in the program.

These are used to create patterns (in the case of classes) and then make use of the patterns (in the case of objects).

In this tutorial, we'll go through creating classes, instantiating objects, initializing attributes with the constructor method, and working with more than one object of the same class.

## Classes

Classes are like a blueprint or a prototype that you can define to use to create objects.



We define classes by using the `class` keyword, similar to how we [define functions](#) by using the `def` keyword.

Let's define a class called `Shark` that has two functions associated with it, one for swimming and one for being awesome:

**shark.py**

```
class Shark:
    def swim(self):
        print("The shark is swimming.")

    def be_awesome(self):
        print("The shark is being awesome.")
```

Because these functions are indented under the class `Shark`, they are called methods. Methods are a special kind of function that are defined within a class.

The argument to these functions is the word `self`, which is a reference to objects that are made based on this class. To reference instances (or objects) of the class, `self` will always be the first parameter, but it need not be the only one.

Defining this class did not create any `Shark` objects, only the pattern for a `Shark` object that we can define later. That is, if you run the program above at this stage nothing will be returned.

Creating the `Shark` class above provided us with a blueprint for an object.

## Objects

An object is an instance of a class. We can take the `Shark` class defined above, and use it to create an object or instance of it.

We'll make a `Shark` object called `sammy`:

```
sammy = Shark()
```

Here, we initialized the object `sammy` as an instance of the class by setting it equal to `Shark()`.

Now, let's use the two methods with the `Shark` object `sammy`:

```
sammy = Shark()  
sammy.swim()  
sammy.be_awesome()
```

The `Shark` object `sammy` is using the two methods `swim()` and `be_awesome()`. We called these using the dot operator (`.`), which is used to reference an attribute of the object. In this case, the attribute is a method and it's called with parentheses, like how you would also call with a function.

Because the keyword `self` was a parameter of the methods as defined in the `Shark` class, the `sammy` object gets passed to the methods. The `self` parameter ensures that the methods have a way of referring to object attributes.

When we call the methods, however, nothing is passed inside the parentheses, the object `sammy` is being automatically passed with the dot operator.

Let's add the object within the context of a program:

**shark.py**

```
class Shark:
    def swim(self):
        print("The shark is swimming.")

    def be_awesome(self):
        print("The shark is being awesome.")

def main():
    sammy = Shark()
    sammy.swim()
    sammy.be_awesome()

if __name__ == "__main__":
    main()
```

<figure class="code">

Let's run the program to see what it does:

```
python shark.py
```

### **Output**

The shark is swimming.

The shark is being awesome.

The object `sammy` calls the two methods in the `main()` function of the program, causing those methods to run.

## The Constructor Method

The constructor method is used to initialize data. It is run as soon as an object of a class is instantiated. Also known as the `__init__` method, it will be the first definition of a class and looks like this:

```
class Shark:
    def __init__(self):
        print("This is the constructor method.")
```

If you added the above `__init__` method to the `Shark` class in the program above, the program would output the following without your modifying anything within the `sammy` instantiation:

### Output

```
This is the constructor method.
The shark is swimming.
The shark is being awesome.
```

This is because the constructor method is automatically initialized. You should use this method to carry out any initializing you would like to do with your class objects.

Instead of using the constructor method above, let's create one that uses a `name` variable that we can use to assign names to objects. We'll pass `name` as a parameter and set `self.name` equal to `name`:

**shark.py**

```
class Shark:
    def __init__(self, name):
        self.name = name
```

Next, we can modify the strings in our functions to reference the names, as below:

**shark.py**

```
class Shark:
    def __init__(self, name):
        self.name = name

    def swim(self):
        # Reference the name
        print(self.name + " is swimming.")

    def be_awesome(self):
        # Reference the name
        print(self.name + " is being awesome.")
```

Finally, we can set the name of the Shark object sammy as equal to "Sammy" by passing it as a parameter of the Shark class:

**shark.py**

```
class Shark:
    def __init__(self, name):
        self.name = name
```

```
def swim(self):
    print(self.name + " is swimming.")

def be_awesome(self):
    print(self.name + " is being awesome.")

def main():
    # Set name of Shark object
    sammy = Shark("Sammy")
    sammy.swim()
    sammy.be_awesome()

if __name__ == "__main__":
    main()
```

<figure class="code">

We can run the program now:

```
python shark.py
```

### **Output**

Sammy is swimming.

Sammy is being awesome.

We see that the name we passed to the object is being printed out. We defined the `__init__` method with the parameter `name` (along with the `self` keyword) and defined a variable within the method.

Because the constructor method is automatically initialized, we do not need to explicitly call it, only pass the arguments in the parentheses following the class name when we create a new instance of the class.

If we wanted to add another parameter, such as `age`, we could do so by also passing it to the `__init__` method:

```
class Shark:
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

Then, when we create our object `sammy`, we can pass Sammy's age in our statement:

```
sammy = Shark("Sammy", 5)
```

To make use of `age`, we would need to also create a method in the class that calls for it.

Constructor methods allow us to initialize certain attributes of an object.

## Working with More Than One Object

Classes are useful because they allow us to create many similar objects based on the same blueprint.

To get a sense for how this works, let's add another Shark object to our program:

**shark.py**

```
class Shark:
    def __init__(self, name):
        self.name = name

    def swim(self):
        print(self.name + " is swimming.")

    def be_awesome(self):
        print(self.name + " is being awesome.")

def main():
    sammy = Shark("Sammy")
    sammy.be_awesome()
    stevie = Shark("Stevie")
    stevie.swim()

if __name__ == "__main__":
    main()
```

<figure class="code">

We have created a second Shark object called `stevie` and passed the name "Stevie" to it. In this example, we used the `be_awesome()` method with `sammy` and the `swim()` method with `stevie`.



Let's run the program:

```
python shark.py
```

### **Output**

```
Sammy is being awesome.
```

```
Stevie is swimming.
```

The output shows that we are using two different objects, the `sammy` object and the `stevie` object, both of the `Shark` class.

Classes make it possible to create more than one object following the same pattern without creating each one from scratch.

### **Conclusion**

This tutorial went through creating classes, instantiating objects, initializing attributes with the constructor method, and working with more than one object of the same class.

Object-oriented programming is an important concept to understand because it makes code recycling more straightforward, as objects created for one program can be used in another. Object-oriented programs also make for better program design since complex programs are difficult to write and require careful planning, and this in turn makes it less work to maintain the program over time.

# Understanding Class and Instance Variables

[Object-oriented programming](#) allows for [variables](#) to be used at the class level or the instance level. Variables are essentially symbols that stand in for a value you're using in a program.

At the class level, variables are referred to as class variables, whereas variables at the instance level are called instance variables.

When we expect variables are going to be consistent across instances, or when we would like to initialize a variable, we can define that variable at the class level. When we anticipate the variables will change significantly across instances, we can define them at the instance level.

One of the principles of software development is the DRY principle, which stands for don't repeat yourself. This principle is geared towards limiting repetition within code, and object-oriented programming adheres to the DRY principle as it reduces redundancy.

This tutorial will demonstrate the use of both class and instance variables in object-oriented programming within Python.

## Class Variables

Class variables are defined within the [class construction](#). Because they are owned by the class itself, class variables are shared by all instances of the class. They therefore will generally have the same value for every instance unless you are using the class variable to initialize a variable.

Defined outside of all the methods, class variables are, by convention, typically placed right below the class header and before the [constructor method](#) and other methods.

A class variable alone looks like this:

```
class Shark:
    animal_type = "fish"
```

Here, the variable `animal_type` is assigned the value `"fish"`.

We can create an instance of the `Shark` class (we'll call it `new_shark`) and print the variable by using dot notation:

**shark.py**

```
class Shark:
    animal_type = "fish"

new_shark = Shark()
print(new_shark.animal_type)
```

Let's run the program:

```
python shark.py
```

**Output**

```
fish
```

Our program returns the value of the variable.

Let's add a few more class variables and print them out:

**shark.py**

```
class Shark:
```

```
    animal_type = "fish"
    location = "ocean"
    followers = 5

new_shark = Shark()
print(new_shark.animal_type)
print(new_shark.location)
print(new_shark.followers)
```

Just like with any other variable, class variables can consist of any [data type](#) available to us in Python. In this program we have strings and an integer. Let's run the program again with the `python shark.py` command and see the output:

#### **Output**

```
fish
ocean
5
```

The instance of `new_shark` is able to access all the class variables and print them out when we run the program.

Class variables allow us to define variables upon constructing the class. These variables and their associated values are then accessible to each instance of the class.

## **Instance Variables**

Instance variables are owned by instances of the class. This means that for each object or instance of a class, the instance variables are different.

Unlike class variables, instance variables are defined within methods.

In the Shark class example below, name and age are instance variables:

```
class Shark:
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

When we create a Shark object, we will have to define these variables, which are passed as parameters within the constructor method or another method.

```
class Shark:
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

```
new_shark = Shark("Sammy", 5)
```

As with class variables, we can similarly call to print instance variables:

**shark.py**

```
class Shark:
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

```
new_shark = Shark("Sammy", 5)
print(new_shark.name)
print(new_shark.age)
```

When we run the program above with `python shark.py`, we'll receive the following output:

#### **Output**

```
Sammy
5
```

The output we receive is made up of the values of the variables that we initialized for the object instance of `new_shark`.

Let's create another object of the `Shark` class called `stevie`:

#### **shark.py**

```
class Shark:
    def __init__(self, name, age):
        self.name = name
        self.age = age
```

```
new_shark = Shark("Sammy", 5)
print(new_shark.name)
print(new_shark.age)
```

```
stevie = Shark("Stevie", 8)
print(stevie.name)
```

```
print(stevie.age)
```

The `stevie` object, like the `new_shark` object passes the parameters specific for that instance of the `Shark` class to assign values to the instance variables.

Instance variables, owned by objects of the class, allow for each object or instance to have different values assigned to those variables.

## Working with Class and Instance Variables Together

Class variables and instance variables will often be utilized at the same time, so let's look at an example of this using the `Shark` class we created. The comments in the program outline each step of the process.

`shark.py`

```
class Shark:

    # Class variables
    animal_type = "fish"
    location = "ocean"

    # Constructor method with instance variables name
    and age
    def __init__(self, name, age):
        self.name = name
        self.age = age

    # Method with instance variable followers
    def set_followers(self, followers):
```

```
        print("This user has " + str(followers) + "
followers")
```

```
def main():
```

```
    # First object, set up instance variables of
constructor method
```

```
    sammy = Shark("Sammy", 5)
```

```
    # Print out instance variable name
```

```
    print(sammy.name)
```

```
    # Print out class variable location
```

```
    print(sammy.location)
```

```
    # Second object
```

```
    stevie = Shark("Stevie", 8)
```

```
    # Print out instance variable name
```

```
    print(stevie.name)
```

```
    # Use set_followers method and pass followers
instance variable
```

```
    stevie.set_followers(77)
```

```
    # Print out class variable animal_type
```

```
    print(stevie.animal_type)
```



```
if __name__ == "__main__":  
    main()
```

<figure class="code">

When we run the program with `python shark.py`, we'll receive the following output:

#### **Output**

```
Sammy  
ocean  
Stevie  
This user has 77 followers  
fish
```

Here, we have made use of both class and instance variables in two objects of the `Shark` class, `sammy` and `stevie`.

## **Conclusion**

In object-oriented programming, variables at the class level are referred to as class variables, whereas variables at the object level are called instance variables.

This differentiation allows us to use class variables to initialize objects with a specific value assigned to variables, and use different variables for each object with instance variables.

Making use of class- and instance-specific variables can ensure that our code adheres to the DRY principle to reduce repetition within code.

# Understanding Inheritance

Object-oriented programming creates reusable patterns of code to curtail redundancy in development projects. One way that object-oriented programming achieves recyclable code is through inheritance, when one subclass can leverage code from another base class.

This tutorial will go through some of the major aspects of inheritance in Python, including how parent classes and child classes work, how to override methods and attributes, how to use the `super()` function, and how to make use of multiple inheritance.

## What Is Inheritance?

Inheritance is when a class uses code constructed within another class. If we think of inheritance in terms of biology, we can think of a child inheriting certain traits from their parent. That is, a child can inherit a parent's height or eye color. Children also may share the same last name with their parents.

Classes called child classes or subclasses inherit methods and variables from parent classes or base classes.

We can think of a parent class called `Parent` that has [class variables](#) for `last_name`, `height`, and `eye_color` that the child class `Child` will inherit from the `Parent`.

Because the `Child` subclass is inheriting from the `Parent` base class, the `Child` class can reuse the code of `Parent`, allowing the programmer to use fewer lines of code and decrease redundancy.

## Parent Classes

Parent or base classes create a pattern out of which child or subclasses can be based on. Parent classes allow us to create child classes through inheritance without having to write the same code over again each time. Any class can be made into a parent class, so they are each fully functional classes in their own right, rather than just templates.

Let's say we have a general `Bank_account` parent class that has `Personal_account` and `Business_account` child classes. Many of the methods between personal and business accounts will be similar, such as methods to withdraw and deposit money, so those can belong to the parent class of `Bank_account`. The `Business_account` subclass would have methods specific to it, including perhaps a way to collect business records and forms, as well as an `employee_identification_number` variable.

Similarly, an `Animal` class may have `eating()` and `sleeping()` methods, and a `Snake` subclass may include its own specific `hissing()` and `slithering()` methods.

Let's create a `Fish` parent class that we will later use to construct types of fish as its subclasses. Each of these fish will have first names and last names in addition to characteristics.

We'll create a new file called `fish.py` and start with the [`\_\_init\_\_\(\)` constructor method](#), which we'll populate with `first_name` and `last_name` class variables for each `Fish` object or subclass.

**fish.py**

```
class Fish:
    def __init__(self, first_name, last_name="Fish"):
        self.first_name = first_name
        self.last_name = last_name
```

We have initialized our `last_name` variable with the string "Fish" because we know that most fish will have this as their last name.

Let's also add some other methods:

**fish.py**

```
class Fish:
    def __init__(self, first_name, last_name="Fish"):
        self.first_name = first_name
        self.last_name = last_name

    def swim(self):
        print("The fish is swimming.")

    def swim_backwards(self):
        print("The fish can swim backwards.")
```

We have added the methods `swim()` and `swim_backwards()` to the `Fish` class, so that every subclass will also be able to make use of these methods.

Since most of the fish we'll be creating are considered to be [bony fish](#) (as in they have a skeleton made out of bone) rather than [cartilaginous fish](#) (as in they have a skeleton made out of cartilage), we can add a few more attributes to the `__init__()` method:

**fish.py**

```
class Fish:
    def __init__(self, first_name, last_name="Fish",
                 skeleton="bone", eyelids=False):
```

```
self.first_name = first_name
self.last_name = last_name
self.skeleton = skeleton
self.eyelids = eyelids

def swim(self):
    print("The fish is swimming.")

def swim_backwards(self):
    print("The fish can swim backwards.")
```

Building a parent class follows the same methodology as building any other class, except we are thinking about what methods the child classes will be able to make use of once we create those.

## Child Classes

Child or subclasses are classes that will inherit from the parent class. That means that each child class will be able to make use of the methods and variables of the parent class.

For example, a `Goldfish` child class that subclasses the `Fish` class will be able to make use of the `swim()` method declared in `Fish` without needing to declare it.

We can think of each child class as being a class of the parent class. That is, if we have a child class called `Rhombus` and a parent class called `Parallelogram`, we can say that a `Rhombus` is a `Parallelogram`, just as a `Goldfish` is a `Fish`.

The first line of a child class looks a little different than non-child classes as you must pass the parent class into the child class as a

parameter:

```
class Trout(Fish):
```

The `Trout` class is a child of the `Fish` class. We know this because of the inclusion of the word `Fish` in parentheses.

With child classes, we can choose to add more methods, override existing parent methods, or simply accept the default parent methods with the `pass` keyword, which we'll do in this case:

**fish.py**

```
...  
class Trout(Fish):  
    pass
```

We can now create a `Trout` object without having to define any additional methods.

**fish.py**

```
...  
class Trout(Fish):  
    pass  
  
terry = Trout("Terry")  
print(terry.first_name + " " + terry.last_name)  
print(terry.skeleton)  
print(terry.eyelids)  
terry.swim()
```

```
terry.swim_backwards()
```

We have created a `Trout` object `terry` that makes use of each of the methods of the `Fish` class even though we did not define those methods in the `Trout` child class. We only needed to pass the value of "Terry" to the `first_name` variable because all of the other variables were initialized.

When we run the program, we'll receive the following output:

#### **Output**

```
Terry Fish
bone
False
The fish is swimming.
The fish can swim backwards.
```

Next, let's create another child class that includes its own method. We'll call this class `Clownfish`, and its special method will permit it to live with sea anemone:

#### **fish.py**

```
...
class Clownfish(Fish):

    def live_with_anemone(self):
        print("The clownfish is coexisting with sea
anemone.")
```

Next, let's create a `Clownfish` object to see how this works:

**fish.py**

```
...
casey = Clownfish("Casey")
print(casey.first_name + " " + casey.last_name)
casey.swim()
casey.live_with_anemone()
```

When we run the program, we'll receive the following output:

**Output**

```
Casey Fish
The fish is swimming.
The clownfish is coexisting with sea anemone.
```

The output shows that the `Clownfish` object `casey` is able to use the `Fish` methods `__init__()` and `swim()` as well as its child class method of `live_with_anemone()`.

If we try to use the `live_with_anemone()` method in a `Trout` object, we'll receive an error:

**Output**

```
terry.live_with_anemone()
AttributeError: 'Trout' object has no attribute
'live_with_anemone'
```



This is because the method `live_with_anemone()` belongs only to the `Clownfish` child class, and not the `Fish` parent class.

Child classes inherit the methods of the parent class it belongs to, so each child class can make use of those methods within programs.

## Overriding Parent Methods

So far, we have looked at the child class `Trout` that made use of the `pass` keyword to inherit all of the parent class `Fish` behaviors, and another child class `Clownfish` that inherited all of the parent class behaviors and also created its own unique method that is specific to the child class. Sometimes, however, we will want to make use of some of the parent class behaviors but not all of them. When we change parent class methods we override them.

When constructing parent and child classes, it is important to keep program design in mind so that overriding does not produce unnecessary or redundant code.

We'll create a `Shark` child class of the `Fish` parent class. Because we created the `Fish` class with the idea that we would be creating primarily bony fish, we'll have to make adjustments for the `Shark` class that is instead a cartilaginous fish. In terms of program design, if we had more than one non-bony fish, we would most likely want to make separate classes for each of these two types of fish.

Sharks, unlike bony fish, have skeletons made of cartilage instead of bone. They also have eyelids and are unable to swim backwards. Sharks can, however, maneuver themselves backwards by sinking.

In light of this, we'll be overriding the `__init__()` constructor method and the `swim_backwards()` method. We don't need to modify

the `swim()` method since sharks are fish that can swim. Let's take a look at this child class:

**fish.py**

```
...  
class Shark(Fish):  
    def __init__(self, first_name, last_name="Shark",  
                  skeleton="cartilage", eyelids=True):  
        self.first_name = first_name  
        self.last_name = last_name  
        self.skeleton = skeleton  
        self.eyelids = eyelids  
  
    def swim_backwards(self):  
        print("The shark cannot swim backwards, but  
can sink backwards.")
```

We have overridden the initialized parameters in the `__init__()` method, so that the `last_name` variable is now set equal to the string "Shark", the `skeleton` variable is now set equal to the string "cartilage", and the `eyelids` variable is now set to the Boolean value `True`. Each instance of the class can also override these parameters.

The method `swim_backwards()` now prints a different string than the one in the `Fish` parent class because sharks are not able to swim backwards in the way that bony fish can.

We can now create an instance of the `Shark` child class, which will still make use of the `swim()` method of the `Fish` parent class:

**fish.py**

```
...
sammy = Shark("Sammy")
print(sammy.first_name + " " + sammy.last_name)
sammy.swim()
sammy.swim_backwards()
print(sammy.eyelids)
print(sammy.skeleton)
```

When we run this code, we'll receive the following output:

### **Output**

```
Sammy Shark
The fish is swimming.
The shark cannot swim backwards, but can sink
backwards.
True
cartilage
```

The Shark child class successfully overrode the `__init__()` and `swim_backwards()` methods of the Fish parent class, while also inheriting the `swim()` method of the parent class.

When there will be a limited number of child classes that are more unique than others, overriding parent class methods can prove to be useful.

### **The `super()` Function**

With the `super()` function, you can gain access to inherited methods that have been overwritten in a class object.

When we use the `super()` function, we are calling a parent method into a child method to make use of it. For example, we may want to override one aspect of the parent method with certain functionality, but then call the rest of the original parent method to finish the method.

In a program that grades students, we may want to have a child class for `Weighted_grade` that inherits from the `Grade` parent class. In the child class `Weighted_grade`, we may want to override a `calculate_grade()` method of the parent class in order to include functionality to calculate a weighted grade, but still keep the rest of the functionality of the original class. By invoking the `super()` function we would be able to achieve this.

The `super()` function is most commonly used within the `__init__()` method because that is where you will most likely need to add some uniqueness to the child class and then complete initialization from the parent.

To see how this works, let's modify our `Trout` child class. Since trout are typically freshwater fish, let's add a `water` variable to the `__init__()` method and set it equal to the string `"freshwater"`, but then maintain the rest of the parent class's variables and parameters:

**fish.py**

```
...  
class Trout(Fish):  
    def __init__(self, water = "freshwater"):  
        self.water = water  
        super().__init__(self)
```

...

We have overridden the `__init__()` method in the `Trout` child class, providing a different implementation of the `__init__()` that is already defined by its parent class `Fish`. Within the `__init__()` method of our `Trout` class we have explicitly invoked the `__init__()` method of the `Fish` class.

Because we have overridden the method, we no longer need to pass `first_name` in as a parameter to `Trout`, and if we did pass in a parameter, we would reset `freshwater` instead. We will therefore initialize the `first_name` by calling the variable in our object instance.

Now we can invoke the initialized variables of the parent class and also make use of the unique child variable. Let's use this in an instance of `Trout`:

**fish.py**

```
...
terry = Trout()

# Initialize first name
terry.first_name = "Terry"

# Use parent __init__() through super()
print(terry.first_name + " " + terry.last_name)
print(terry.eyelids)

# Use child __init__() override
print(terry.water)
```

```
# Use parent swim() method
terry.swim()
```

### **Output**

```
Terry Fish
False
freshwater
The fish is swimming.
```

The output shows that the object `terry` of the `Trout` child class is able to make use of both the child-specific `__init__()` variable `water` while also being able to call the `Fish` parent `__init__()` variables of `first_name`, `last_name`, and `eyelids`.

The built-in Python function `super()` allows us to utilize parent class methods even when overriding certain aspects of those methods in our child classes.

## **Multiple Inheritance**

Multiple inheritance is when a class can inherit attributes and methods from more than one parent class. This can allow programs to reduce redundancy, but it can also introduce a certain amount of complexity as well as ambiguity, so it should be done with thought to overall program design.

To show how multiple inheritance works, let's create a `Coral_reef` child class that inherits from a `Coral` class and a `Sea_anemone` class. We can create a method in each and then use the `pass` keyword in the `Coral_reef` child class:

**coral\_reef.py**

```
class Coral:

    def community(self):
        print("Coral lives in a community.")

class Anemone:

    def protect_clownfish(self):
        print("The anemone is protecting the
clownfish.")

class CoralReef(Coral, Anemone):
    pass
```

The `Coral` class has a method called `community()` that prints one line, and the `Anemone` class has a method called `protect_clownfish()` that prints another line. Then we call both classes into the inheritance [tuple](#). This means that `Coral` is inheriting from two parent classes.

Let's now instantiate a `Coral` object:

**coral\_reef.py**

```
...
great_barrier = CoralReef()
great_barrier.community()
```

```
great_barrier.protect_clownfish()
```

The object `great_barrier` is set as a `CoralReef` object, and can use the methods in both parent classes. When we run the program, we'll see the following output:

### Output

```
Coral lives in a community.  
The anemone is protecting the clownfish.
```

The output shows that methods from both parent classes were effectively used in the child class.

Multiple inheritance allows us to use the code from more than one parent class in a child class. If the same method is defined in multiple parent methods, the child class will use the method of the first parent declared in its tuple list.

Though it can be used effectively, multiple inheritance should be done with care so that our programs do not become ambiguous and difficult for other programmers to understand.

### Conclusion

This tutorial went through constructing parent classes and child classes, overriding parent methods and attributes within child classes, using the `super()` function, and allowing for child classes to inherit from multiple parent classes.

Inheritance in object-oriented coding can allow for adherence to the DRY (don't repeat yourself) principle of software development, allowing for more to be done with less code and repetition. Inheritance also



compels programmers to think about how they are designing the programs they are creating to ensure that code is effective and clear.

# How To Apply Polymorphism to Classes

Polymorphism is the ability to leverage the same interface for different underlying forms such as [data types](#) or [classes](#). This permits [functions](#) to use entities of different types at different times.

For object-oriented programming in Python, this means that a particular object belonging to a particular class can be used in the same way as if it were a different object belonging to a different class.

Polymorphism allows for flexibility and loose coupling so that code can be extended and easily maintained over time.

This tutorial will go through applying polymorphism to classes in Python.

## What Is Polymorphism?

Polymorphism is an important feature of class definition in Python that is utilized when you have commonly named methods across classes or subclasses. This allows functions to use objects of any of these polymorphic classes without needing to be aware of distinctions across the classes.

Polymorphism can be carried out through [inheritance](#), with subclasses making use of base class methods or overriding them.

Python's duck typing, a special case of dynamic typing, uses techniques characteristic of polymorphism, including [late binding](#) and [dynamic dispatch](#). The term "duck typing" is derived from a quote of writer James Whitcomb Riley: "When I see a bird that walks like a duck and swims like a duck and quacks like a duck, I call that bird a duck."

Appropriated by Italian computer engineer Alex Martelli in a message to the comp.lang.python newsgroup, the use of duck typing is concerned with establishing the suitability of an object for a specific purpose. When using normal typing this suitability is determined by the type of an object alone, but with duck typing the presence of methods and properties are used to determine suitability rather than the actual type of the object in question. That is to say, you check whether the object quacks like a duck and walks like a duck rather than asking whether the object is a duck.

When several classes or subclasses have the same method names, but different implementations for these same methods, the classes are polymorphic because they are using a single interface to use with entities of different types. A function will be able to evaluate these polymorphic methods without knowing which classes are invoked.

## Creating Polymorphic Classes

To make use of polymorphism, we're going to create two distinct classes to use with two distinct objects. Each of these distinct classes need to have an interface that is in common so that they can be used polymorphically, so we will give them methods that are distinct but that have the same name.

We'll create a `Shark` class and a `Clownfish` class, each of which will define methods for `swim()`, `swim_backwards()`, and `skeleton()`.

**polymorphic\_fish.py**

```
class Shark():
    def swim(self):
        print("The shark is swimming.")
```

```

    def swim_backwards(self):
        print("The shark cannot swim backwards, but
can sink backwards.")

    def skeleton(self):
        print("The shark's skeleton is made of
cartilage.")

class Clownfish():
    def swim(self):
        print("The clownfish is swimming.")

    def swim_backwards(self):
        print("The clownfish can swim backwards.")

    def skeleton(self):
        print("The clownfish's skeleton is made of
bone.")

```

In the code above, both the Shark and Clownfish class have three methods with the same name in common. However, each of the functionalities of these methods differ for each class.

Let's instantiate these classes into two objects:

**polymorphic\_fish.py**

```

...
sammy = Shark()

```

```
sammy.skeleton()
```

```
casey = Clownfish()  
casey.skeleton()
```

When we run the program with the `python polymorphic_fish.py` command, we can see that each object behaves as expected:

### Output

```
The shark's skeleton is made of cartilage.  
The clownfish's skeleton is made of bone.
```

Now that we have two objects that make use of a common interface, we can use the two objects in the same way regardless of their individual types.

## Polymorphism with Class Methods

To show how Python can use each of these different class types in the same way, we can first create a [for loop](#) that iterates through a [tuple](#) of objects. Then we can call the methods without being concerned about which class type each object is. We will only assume that these methods actually exist in each class.

**polymorphic\_fish.py**

```
...  
sammy = Shark()
```

```
casey = Clownfish()

for fish in (sammy, casey):
    fish.swim()
    fish.swim_backwards()
    fish.skeleton()
```

We have two objects, sammy of the Shark class, and casey of the Clownfish class. Our for loop iterates through these objects, calling the swim(), swim\_backwards(), and skeleton() methods on each.

When we run the program, the output will be as follows:

#### **Output**

```
The shark is swimming.
The shark cannot swim backwards, but can sink
backwards.
The shark's skeleton is made of cartilage.
The clownfish is swimming.
The clownfish can swim backwards.
The clownfish's skeleton is made of bone.
```

The for loop iterated first through the sammy instantiation of the Shark class, then the casey object of the Clownfish class, so we see the methods related to the Shark class first, then the Clownfish class.

This shows that Python is using these methods in a way without knowing or caring exactly what class type each of these objects is. That is, using these methods in a polymorphic way.

## Polymorphism with a Function

We can also create a function that can take any object, allowing for polymorphism.

Let's create a function called `in_the_pacific()` which takes in an object we can call `fish`. Though we are using the name `fish`, any instantiated object will be able to be called into this function:

**polymorphic\_fish.py**

...

```
def in_the_pacific(fish):
```

Next, we'll give the function something to do that uses the `fish` object we passed to it. In this case we'll call the `swim()` methods, each of which is defined in the two classes `Shark` and `Clownfish`:

**polymorphic\_fish.py**

...

```
def in_the_pacific(fish):  
    fish.swim()
```

Next, we'll create instantiations of both the `Shark` and `Clownfish` classes if we don't have them already. With those, we can call their action using the same `in_the_pacific()` function:

**polymorphic\_fish.py**

...

```
def in_the_pacific(fish):
```

```
fish.swim()

sammy = Shark()

casey = Clownfish()

in_the_pacific(sammy)
in_the_pacific(casey)
```

When we run the program, the output will be as follows:

### **Output**

```
The shark is swimming.
The clownfish is swimming.
```

Even though we passed a random object (`fish`) into the `in_the_pacific()` function when defining it, we were still able to use it effectively for instantiations of the `Shark` and `Clownfish` classes. The `casey` object called the `swim()` method defined in the `Clownfish` class, and the `sammy` object called the `swim()` method defined in the `Shark` class.

### **Conclusion**

By allowing different objects to leverage functions and methods in similar ways through polymorphism, making use of this Python feature provides greater flexibility and extendability of your object-oriented code.



# How To Use the Python Debugger

In software development, debugging is the process of looking for and then resolving issues that prevent the software from running correctly.

The Python debugger provides a debugging environment for Python programs. It supports setting conditional breakpoints, stepping through the source code one line at a time, stack inspection, and more.

## Working Interactively with the Python Debugger

The Python debugger comes as part of the standard Python distribution as a module called `pdb`. The debugger is also extensible, and is defined as the class `Pdb`. You can read the [official documentation of `pdb`](#) to learn more.

We'll begin by working with a short program that has two global [variables](#), a [function](#) that creates a nested [loop](#), and the `if __name__ == '__main__':` construction that will call the `nested_loop()` function.

**looping.py**

```
num_list = [500, 600, 700]
alpha_list = ['x', 'y', 'z']
```

```
def nested_loop():
    for number in num_list:
        print(number)
```

```
        for letter in alpha_list:
            print(letter)

if __name__ == '__main__':
    nested_loop()
```

We can now run this program through the Python debugger by using the following command:

```
python -m pdb looping.py
```

The `-m` command-line flag will import any Python module for you and run it as a script. In this case we are importing and running the `pdb` module, which we pass into the command as shown above.

Upon running this command, you'll receive the following output:

#### Output

```
> /Users/sammy/looping.py(1)<module>()
-> num_list = [500, 600, 700]
(Pdb)
```

In the output, the first line contains the current module name (as indicated with `<module>`) with a directory path, and the printed line number that follows (in this case it's 1, but if there is a comment or other non-executable line it could be a higher number). The second line shows the current line of source code that is executed here, as `pdb` provides an interactive console for debugging. You can use the command `help` to learn its commands, and `help command` to learn more about a specific

command. Note that the `pdb` console is different than the Python interactive shell.

The Python debugger will automatically start over when it reaches the end of your program. Whenever you want to leave the `pdb` console, type the command `quit` or `exit`. If you would like to explicitly restart a program at any place within the program, you can do so with the command `run`.

## Using the Debugger to Move through a Program

When working with programs in the Python debugger, you're likely to use the `list`, `step`, and `next` commands to move through your code. We'll go over these commands in this section.

Within the shell, we can type the command `list` in order to get context around the current line. From the first line of the program `looping.py` that we displayed above — `num_list = [500, 600, 700]` — that will look like this:

```
(Pdb) list
1  -> num_list = [500, 600, 700]
2      alpha_list = ['x', 'y', 'z']
3
4
5      def nested_loop():
6          for number in num_list:
7              print(number)
8              for letter in alpha_list:
9                  print(letter)
10
```

```
11      if __name__ == '__main__':  
(Pdb)
```

The current line is indicated with the characters `->`, which in our case is the first line of the program file.

Since this is a relatively short program, we receive nearly all of the program back with the `list` command. Without providing arguments, the `list` command provides 11 lines around the current line, but you can also specify which lines to include, like so:

```
(Pdb) list 3, 7  
3  
4  
5      def nested_loop():  
6          for number in num_list:  
7              print(number)  
(Pdb)
```

Here, we requested that the lines 3-7 be displayed by using the command `list 3, 7`.

To move through the program line by line, we can use `step` or `next`:

```
(Pdb) step  
> /Users/sammy/looping.py(2)<module>()  
-> alpha_list = ['x', 'y', 'z']  
(Pdb)  
  
(Pdb) next
```

```
> /Users/sammy/looping.py(2)<module>()
-> alpha_list = ['x', 'y', 'z']
(Pdb)
```

The difference between `step` and `next` is that `step` will stop within a called function, while `next` executes called functions to only stop at the next line of the current function. We can see this difference when we work with the function.

The `step` command will iterate through the loops once it gets to the running of the function, showing exactly what the loop is doing, as it will first print a number with `print(number)` then go through to print the letters with `print(letter)`, return to the number, etc:

```
(Pdb) step
> /Users/sammy/looping.py(5)<module>()
-> def nested_loop():
(Pdb) step
> /Users/sammy/looping.py(11)<module>()
-> if __name__ == '__main__':
(Pdb) step
> /Users/sammy/looping.py(12)<module>()
-> nested_loop()
(Pdb) step
--Call--
> /Users/sammy/looping.py(5)nested_loop()
-> def nested_loop():
(Pdb) step
> /Users/sammy/looping.py(6)nested_loop()
```

```
-> for number in num_list:
(Pdb) step
> /Users/sammy/looping.py(7)nested_loop()
-> print(number)
(Pdb) step
500
> /Users/sammy/looping.py(8)nested_loop()
-> for letter in alpha_list:
(Pdb) step
> /Users/sammy/looping.py(9)nested_loop()
-> print(letter)
(Pdb) step
x
> /Users/sammy/looping.py(8)nested_loop()
-> for letter in alpha_list:
(Pdb) step
> /Users/sammy/looping.py(9)nested_loop()
-> print(letter)
(Pdb) step
y
> /Users/sammy/looping.py(8)nested_loop()
-> for letter in alpha_list:
(Pdb)
```

The next command, instead, will execute the entire function without showing the step-by-step process. Let's quit the current session with the `exit` command and then begin the debugger again:

```
python -m pdb looping.py
```

Now we can work with the next command:

```
(Pdb) next
> /Users/sammy/looping.py(5)<module>()
-> def nested_loop():
(Pdb) next
> /Users/sammy/looping.py(11)<module>()
-> if __name__ == '__main__':
(Pdb) next
> /Users/sammy/looping.py(12)<module>()
-> nested_loop()
(Pdb) next
500
x
y
z
600
x
y
z
700
x
y
z
--Return--
> /Users/sammy/looping.py(12)<module>()->None
```

```
-> nested_loop()  
(Pdb)
```

While going through your code, you may want to examine the value passed to a variable, which you can do with the `pp` command, which will pretty-print the value of the expression using the [pprint module](#):

```
(Pdb) pp num_list  
[500, 600, 700]  
(Pdb)
```

Most commands in `pdb` have shorter aliases. For `step` that short form is `s`, and for `next` it is `n`. The `help` command will list available aliases. You can also call the last command you called by pressing the `ENTER` key at the prompt.

## Breakpoints

You typically will be working with larger programs than the example above, so you'll likely be wanting to look at particular functions or lines rather than going through an entire program. By using the `break` command to set breakpoints, you'll run the program up until the specified breakpoint.

When you insert a breakpoint, the debugger assigns a number to it. The numbers assigned to breakpoints are successive integers that begin with the number 1, which you can refer to when working with breakpoints.

Breakpoints can be placed at certain line numbers by following the syntax of `<program_file>:<line_number>` as shown below:



```
(Pdb) break looping.py:5
```

```
Breakpoint 1 at /Users/sammy/looping.py:5
```

```
(Pdb)
```

Type `clear` and then `y` to remove all current breakpoints. You can then place a breakpoint where a function is defined:

```
(Pdb) break looping.nested_loop
```

```
Breakpoint 1 at /Users/sammy/looping.py:5
```

```
(Pdb)
```

To remove current breakpoints, type `clear` and then `y`. You can also set up a condition:

```
(Pdb) break looping.py:7, number > 500
```

```
Breakpoint 1 at /Users/sammy/looping.py:7
```

```
(Pdb)
```

Now, if we issue the `continue` command, the program will break when the `number x` is evaluated to being greater than 500 (that is, when it is set equal to 600 in the second iteration of the outer loop):

```
(Pdb) continue
```

```
500
```

```
x
```

```
y
```

```
z
```

```
> /Users/sammy/looping.py(7)nested_loop()
```

```
-> print(number)
(Pdb)
```

To see a list of breakpoints that are currently set to run, use the command `break` without any arguments. You'll receive information about the particularities of the breakpoint(s) you've set:

```
(Pdb) break
Num Type          Disp Enb   Where
1  breakpoint    keep yes   at
/Users/sammy/looping.py:7
    stop only if number > 500
    breakpoint already hit 2 times
(Pdb)
```

We can also disable a breakpoint with the command `disable` and the number of the breakpoint. In this session, we add another breakpoint and then disable the first one:

```
(Pdb) break looping.py:11
Breakpoint 2 at /Users/sammy/looping.py:11
(Pdb) disable 1
Disabled breakpoint 1 at /Users/sammy/looping.py:7
(Pdb) break
Num Type          Disp Enb   Where
1  breakpoint    keep no   at
/Users/sammy/looping.py:7
    stop only if number > 500
```

```
breakpoint already hit 2 times
2 breakpoint keep yes at
/Users/sammy/looping.py:11
(Pdb)
```

To enable a breakpoint, use the `enable` command, and to remove a breakpoint entirely, use the `clear` command:

```
(Pdb) enable 1
Enabled breakpoint 1 at /Users/sammy/looping.py:7
(Pdb) clear 2
Deleted breakpoint 2 at /Users/sammy/looping.py:11
(Pdb)
```

Breakpoints in `pdb` provide you with a lot of control. Some additional functionalities include ignoring breakpoints during the current iteration of the program with the `ignore` command (as in `ignore 1`), triggering actions to occur at a breakpoint with the `commands` command (as in `command 1`), and creating temporary breakpoints that are automatically cleared the first time program execution hits the point with the command `tbreak` (for a temporary break at line 3, for example, you could type `tbreak 3`).

## Integrating `pdb` into Programs

You can trigger a debugging session by importing the `pdb` module and adding the `pdb` function `pdb.set_trace()` above the line where you would like the session to begin.

In our sample program above, we'll add the `import` statement and the function where we would like to enter into the debugger. For our example, let's add it before the nested loop.

```
# Import pdb module
import pdb

num_list = [500, 600, 700]
alpha_list = ['x', 'y', 'z']

def nested_loop():
    for number in num_list:
        print(number)

        # Trigger debugger at this line
        pdb.set_trace()
        for letter in alpha_list:
            print(letter)

if __name__ == '__main__':
    nested_loop()
```

By adding the debugger into your code you do not need to launch your program in a special way or remember to set breakpoints.

Importing the `pdb` module and running the `pdb.set_trace()` function lets you begin your program as usual and run the debugger through its execution.

## Modifying Program Execution Flow

The Python debugger lets you change the flow of your program at runtime with the `jump` command. This lets you skip forward to prevent some code from running, or can let you go backwards to run the code again.

We'll be working with a small program that creates a list of the letters contained in the string `sammy = "sammy"`:

**letter\_list.py**

```
def print_sammy():
    sammy_list = []
    sammy = "sammy"
    for letter in sammy:
        sammy_list.append(letter)
    print(sammy_list)

if __name__ == "__main__":
    print_sammy()
```

If we run the program as usual with the `python letter_list.py` command, we'll receive the following output:

**Output**

```
['s']
['s', 'a']
['s', 'a', 'm']
['s', 'a', 'm', 'm']
```

```
['s', 'a', 'm', 'm', 'y']
```

With the Python debugger, let's show how we can change the execution by first jumping ahead after the first cycle. When we do this, we'll notice that there is a disruption of the [for loop](#):

```
python -m pdb letter_list.py
```

```
> /Users/sammy/letter_list.py(1)<module>()
```

```
-> def print_sammy():
```

```
(Pdb) list
```

```
1  -> def print_sammy():
```

```
2      sammy_list = []
```

```
3      sammy = "sammy"
```

```
4      for letter in sammy:
```

```
5          sammy_list.append(letter)
```

```
6          print(sammy_list)
```

```
7
```

```
8      if __name__ == "__main__":
```

```
9          print_sammy()
```

```
10
```

```
11
```

```
(Pdb) break 5
```

```
Breakpoint 1 at /Users/sammy/letter_list.py:5
```

```
(Pdb) continue
```

```
> /Users/sammy/letter_list.py(5)print_sammy()
```

```
-> sammy_list.append(letter)
```

```
(Pdb) pp letter
```

```
's'
(Pdb) continue
['s']
> /Users/sammy/letter_list.py(5)print_sammy()
-> sammy_list.append(letter)
(Pdb) jump 6
> /Users/sammy/letter_list.py(6)print_sammy()
-> print(sammy_list)
(Pdb) pp letter
'a'
(Pdb) disable 1
Disabled breakpoint 1 at /Users/sammy/letter_list.py:5
(Pdb) continue
['s']
['s', 'm']
['s', 'm', 'm']
['s', 'm', 'm', 'y']
```

The above debugging session puts a break at line 5 to prevent code from continuing, then continues through code (along with pretty-printing some values of `letter` to show what is happening). Next, we use the `jump` command to skip to line 6. At this point, the variable `letter` is set equal to the string `'a'`, but we jump the code that adds that to the list `sammy_list`. We then disable the breakpoint to proceed with the execution as usual with the `continue` command, so `'a'` is never appended to `sammy_list`.

Next, we can quit this first session and restart the debugger to jump back within the program to re-run a statement that has already been

executed. This time, we'll run the first iteration of the for loop again in the debugger:

```
> /Users/sammy/letter_list.py(1)<module>()
-> def print_sammy():
(Pdb) list
1  -> def print_sammy():
2      sammy_list = []
3      sammy = "sammy"
4      for letter in sammy:
5          sammy_list.append(letter)
6          print(sammy_list)
7
8      if __name__ == "__main__":
9          print_sammy()
10
11
(Pdb) break 6
Breakpoint 1 at /Users/sammy/letter_list.py:6
(Pdb) continue
> /Users/sammy/letter_list.py(6)print_sammy()
-> print(sammy_list)
(Pdb) pp letter
's'
(Pdb) jump 5
> /Users/sammy/letter_list.py(5)print_sammy()
-> sammy_list.append(letter)
(Pdb) continue
```



```
> /Users/sammy/letter_list.py(6)print_sammy()
-> print(sammy_list)
(Pdb) pp letter
's'
(Pdb) disable 1
Disabled breakpoint 1 at /Users/sammy/letter_list.py:6
(Pdb) continue
['s', 's']
['s', 's', 'a']
['s', 's', 'a', 'm']
['s', 's', 'a', 'm', 'm']
['s', 's', 'a', 'm', 'm', 'y']
```

In the debugging session above, we added a break at line 6, and then jumped back to line 5 after continuing. We pretty-printed along the way to show that the string 's' was being appended to the list `sammy_list` twice. We then disabled the break at line 6 and continued running the program. The output shows two values of 's' appended to `sammy_list`.

Some jumps are prevented by the debugger, especially when jumping in and out of certain flow control statements that are undefined. For example, you cannot jump into functions before arguments are defined, and you cannot jump into the middle of a `try:except` statement. You also cannot jump out of a `finally` block.

The `jump` statement with the Python debugger allows you to change the execution flow while debugging a program to see whether flow control can be modified to different purposes or to better understand what issues are arising in your code.

## Table of Common `pdb` Commands

Here is a table of useful `pdb` commands along with their short forms to keep in mind while working with the Python debugger.

| COMMAND               | SHORT FORM                          | WHAT IT DOES                                                                         |
|-----------------------|-------------------------------------|--------------------------------------------------------------------------------------|
| <code>args</code>     | <code>a</code>                      | Print the argument list of the current function                                      |
| <code>break</code>    | <code>b</code>                      | Creates a breakpoint (requires parameters) in the program execution                  |
| <code>continue</code> | <code>c</code> or <code>cont</code> | Continues program execution                                                          |
| <code>help</code>     | <code>h</code>                      | Provides list of commands or help for a specified command                            |
| <code>jump</code>     | <code>j</code>                      | Set the next line to be executed                                                     |
| <code>list</code>     | <code>l</code>                      | Print the source code around the current line                                        |
| <code>next</code>     | <code>n</code>                      | Continue execution until the next line in the current function is reached or returns |
| <code>step</code>     | <code>s</code>                      | Execute the current line, stopping at first possible occasion                        |
| <code>pp</code>       | <code>pp</code>                     | Pretty-prints the value of the expression                                            |

|              |   |                                                          |
|--------------|---|----------------------------------------------------------|
| quit or exit | q | Aborts the program                                       |
| return       | r | Continue execution until the<br>current function returns |

You can read more about the commands and working with the debugger from the [Python debugger documentation](#).

## Conclusion

Debugging is an important step of any software development project. The Python debugger `pdb` implements an interactive debugging environment that you can use with any of your programs written in Python.

With features that let you pause your program, look at what values your variables are set to, and go through program execution in a discrete step-by-step manner, you can more fully understand what your program is doing and find bugs that exist in the logic or troubleshoot known issues.

# How To Debug Python with an Interactive Console

Debugging is a part of the software development process where programmers look for and then resolve issues that prevent the software from running correctly.

A useful and quick tool for debugging is the Python [code module](#) because it can be used to emulate the interactive interpreter. The module also provides the opportunity for you to experiment with code that you write in Python.

## Understanding the `code` Module

Rather than step through code with a debugger, you can [add the code module](#) to your Python program to instruct the program to stop execution and enter into the interactive mode in order to examine how your code is working. The `code` module is part of the Python standard library.

This is useful because you are able to leverage an interpreter without sacrificing the complexity and permanence that programming files can provide. Through using the `code` module you can avoid using `print()` statements throughout your code as a form of debugging, which can become unwieldy over time.

To make use of the module as a method for debugging, you can use the `interact()` function of the module, which stops execution of the program at the point at which it is called, and provides you with an

interactive console so that you can examine the current state of your program.

The function with its possible parameters are as follows:

```
code.interact(banner=None, readfunc=None, local=None,
exitmsg=None)
```

This function runs a read-eval-print loop, and creates an object instance of the [InteractiveConsole class](#), which emulates the behavior of the interactive Python interpreter.

The optional parameters are as follows: - banner can be set to a [string](#), so that you can flag where the interpreter launches - readfunc can be used as the [InteractiveConsole.raw\\_input\(\) method](#) - local will set the default namespace for the interpreter loop - exitmsg can be set to a string to note where the interpreter ends

With the local parameter, you can use, for example: - local=locals() for a local namespace - local=globals() for a global namespace - local=dict(globals(), \*\*locals()) to use both the global namespace and the present local namespace

Note that the exitmsg parameter is new for Python 3.6, so if you are using an older version of Python, update it or leave off the exitmsg parameter.

You can place the interact() function wherever you would like in your program to launch the interactive interpreter in the code.

## Working with the code Module

Let's look at this in the context of a bank account balances program called balances.py. We'll set the local parameter to locals() to set the

namespace to local.

**balances.py**

```
# Import code module
import code
```

```
bal_a = 2324
bal_b = 0
bal_c = 409
bal_d = -2
```

```
account_balances = [bal_a, bal_b, bal_c, bal_d]
```

```
def display_bal():
    for balance in account_balances:
        if balance < 0:
            print("Account balance of {} is below 0;
add funds now."
                .format(balance))

        elif balance == 0:
            print("Account balance of {} is equal to
0; add funds soon."
                .format(balance))

        else:
            print("Account balance of {} is above
```

```
0.".format(balance))
```

```
# Use interact() function to start the interpreter  
with local namespace  
code.interact(local=locals())
```

```
display_bal()
```

We used the function `code.interact()` with the `local=locals()` parameter to use the local namespace as the default within the interpreter loop.

Let's run the program above, using the `python3` command if we're not in a virtual environment, or the `python` command if we are:

```
python balances.py
```

Once we run the program, we'll receive the following output initially:

```
Python 3.5.2 (default, Nov 17 2016, 17:05:23)  
[GCC 5.4.0 20160609] on linux  
Type "help", "copyright", "credits" or "license" for  
more information.  
(InteractiveConsole)  
>>>
```

Your cursor will be placed at the end of the `>>>` line, just like it would be in the Python interactive shell.

From here, you can issue calls to print variables, functions, etc.:

```
>>> print(bal_c)
409
>>> print(account_balances)
[2324, 0, 409, -2]
>>> print(display_bal())
Account balance of 2324 is 0 or above.
Account balance of 0 is equal to 0, add funds soon.
Account balance of 409 is 0 or above.
Account balance of -2 is below 0, add funds now.
None
>>> print(display_bal)
<function display_bal at 0x104b80f28>
>>>
```

We see that, by using the local namespace, we are able to print the variables and invoke the function. The final `print()` call shows the location of the function `display_bal` within computer memory.

Once you are satisfied with what you have been able to examine from working with the interpreter, you can press `CTRL + D` for \*nix-based systems, or `CTRL + Z` for Windows-based systems to leave the console and continue with the execution of the program.

If you would like to leave the console without running the remainder of the program, you can do so by typing `quit()` and the program will be aborted.

To leverage the `banner` and `exitmsg` parameters, we can do so as follows:

**balances.py**



```
...  
# Use interact() function to start the interpreter  
code.interact(banner="Start", local=locals(),  
exitmsg="End")  
  
display_bal()
```

When we run the program, we'll receive the following output when we run the program:

```
Start  
>>>
```

Using the `banner` parameter can allow you to set multiple points within your code and give you the ability to identify them. For example, you can have a banner that prints "In for-loop" with an `exitmsg` that prints "Out of for-loop", so you can tell exactly where you are in the code.

From here, we can use the interpreter as usual. Once we type `CTRL + D` to exit the interpreter, we'll receive the exit message and the function will run:

```
End  
Account balance of 2324 is 0 or above.  
Account balance of 0 is equal to 0, add funds soon.  
Account balance of 409 is 0 or above.  
Account balance of -2 is below 0, add funds now.
```

The program has now fully run following the interactive session.

Once you are done using the `code` module to debug your code, you should remove the `code` functions and import statement so that your program will run as usual. The `code` module provides a utility, so once you are done it is important to clean up after yourself.

## Conclusion

Using the `code` module to launch an interactive console can allow you to look at what the code is doing on a granular level to understand its behavior and make changes as needed. To read more about it, you can read the [official documentation of the `code` module](#).

To learn more about other methods you can use to debug your Python code, read our tutorial on [how to use the Python debugger `pdb`](#), and our tutorial on [how to use logging](#).

# How To Use Logging

The `logging` module is part of the standard Python library and provides tracking for events that occur while software runs. You can add logging calls to your code to indicate what events have happened.

The `logging` module allows for both diagnostic logging that records events related to an application's operation, as well as audit logging which records the events of a user's transactions for analysis. It is especially used to record events to a file.

## Why Use the `logging` Module

The `logging` module keeps a record of the events that occur within a program, making it possible to see output related to any of the events that occur throughout the runtime of a piece of software.

You may be more familiar with checking that events are occurring by using the `print()` statement throughout your code. The `print()` statement does provide a basic way to go about debugging your code to resolve issues. While embedding `print()` statements throughout your code can track the execution flow and the current state of your program, this solution proves to be less maintainable than using the `logging` module for a few reasons:

- It becomes difficult to distinguish between debugging output and normal program output because the two are mixed
- When using `print()` statements dispersed throughout code, there is no easy way to disable the ones that provide debugging output

- It becomes difficult to remove all the `print()` statements when you are done with debugging
- There is no log record that contains readily available diagnostic information

It is a good idea to get in the habit of using the `logging` module in your code as this is more suitable for applications that grow beyond simple Python scripts and provides a sustainable approach to debugging.

Because logs can show you behavior and errors over time, they also can give you a better overall picture of what is going on in your application development process.

## Printing Debug Messages to Console

If you are used to using the `print()` statement to see what is occurring in a program, you may be used to seeing a program that [defines a class](#) and instantiates objects that looks something like this:

**pizza.py**

```
class Pizza():
    def __init__(self, name, price):
        self.name = name
        self.price = price
        print("Pizza created: {}
        (${})".format(self.name, self.price))

    def make(self, quantity=1):
        print("Made {} {} pizza(s)".format(quantity,
        self.name))
```

```
def eat(self, quantity=1):  
    print("Ate {} pizza(s)".format(quantity,  
self.name))  
  
pizza_01 = Pizza("artichoke", 15)  
pizza_01.make()  
pizza_01.eat()  
  
pizza_02 = Pizza("margherita", 12)  
pizza_02.make(2)  
pizza_02.eat()
```

The code above has an `__init__` method to define the name and price of an object of the `Pizza` class. It then has two methods, one called `make()` for making pizzas, and one called `eat()` for eating pizzas. These two methods take in the parameter of `quantity`, which is initialized at 1.

Now let's run the program:

```
python pizza.py
```

We'll receive the following output:

#### **Output**

```
Pizza created: artichoke ($15)  
Made 1 artichoke pizza(s)  
Ate 1 pizza(s)
```

```
Pizza created: margherita ($12)
Made 2 margherita pizza(s)
Ate 1 pizza(s)
```

While the `print()` statement allows us to see that the code is working, we can use the logging module to do this instead.

Let's remove or comment out the `print()` statements throughout the code, and add `import logging` to the top of the file:

**pizza.py**

```
import logging
```

```
class Pizza():
    def __init__(self, name, value):
        self.name = name
        self.value = value
    ...
```

The logging module has a [default level](#) of WARNING, which is a level above DEBUG. Since we're going to use the logging module for debugging in this example, we need to modify the configuration so that the level of `logging.DEBUG` will return information to the console for us. We can do that by adding the following line below the [import statement](#):

**pizza.py**

```
import logging
```

```
logging.basicConfig(level=logging.DEBUG)
```

```
class Pizza():  
    ...
```

This level of `logging.DEBUG` refers to a constant integer value that we reference in the code above to set a threshold. The level of `DEBUG` is 10.

Now, we will replace all of the `print()` statements with `logging.debug()` statements instead. Unlike `logging.DEBUG` which is a constant, `logging.debug()` is a method of the `logging` module. When working with this method, we can make use of the same [string](#) passed to `print()`, as shown below.

**pizza.py**

```
import logging
```

```
logging.basicConfig(level=logging.DEBUG)
```

```
class Pizza():  
    def __init__(self, name, price):  
        self.name = name  
        self.price = price  
        logging.debug("Pizza created: {}  
(${})".format(self.name, self.price))
```

```
def make(self, quantity=1):
    logging.debug("Made {} {}
pizza(s)".format(quantity, self.name))

def eat(self, quantity=1):
    logging.debug("Ate {}
pizza(s)".format(quantity, self.name))

pizza_01 = Pizza("artichoke", 15)
pizza_01.make()
pizza_01.eat()

pizza_02 = Pizza("margherita", 12)
pizza_02.make(2)
pizza_02.eat()
```

At this point, when we run the program with the `python pizza.py` command, we'll receive this output:

### Output

```
DEBUG:root:Pizza created: artichoke ($15)
DEBUG:root:Made 1 artichoke pizza(s)
DEBUG:root:Ate 1 pizza(s)
DEBUG:root:Pizza created: margherita ($12)
DEBUG:root:Made 2 margherita pizza(s)
DEBUG:root:Ate 1 pizza(s)
```



The log messages have the severity level `DEBUG` as well as the word `root` embedded in them, which refers to the level of your Python module. The `logging` module can be used with a hierarchy of loggers that have different names, so that you can use a different logger for each of your modules.

For example, you can set loggers equal to different loggers that have different names and different output:

```
logger1 = logging.getLogger("module_1")
logger2 = logging.getLogger("module_2")

logger1.debug("Module 1 debugger")
logger2.debug("Module 2 debugger")
```

#### **Output**

```
DEBUG:module_1:Module 1 debugger
DEBUG:module_2:Module 2 debugger
```

Now that we have an understanding of how to use the `logging` module to print messages to the console, let's move on to using the `logging` module to print messages out to a file.

## **Logging Messages to a File**

The primary purpose of the `logging` module is to log messages to a file rather than to a console. Keeping a file of messages provides you with data over time that you can consult and quantify so that you can see what changes need to be made to your code.

To start logging to a file, we can modify the `logging.basicConfig()` method to include a `filename` parameter. In this case, let's call the filename `test.log`:

**pizza.py**

```
import logging

logging.basicConfig(filename="test.log",
                    level=logging.DEBUG)

class Pizza():
    def __init__(self, name, price):
        self.name = name
        self.price = price
        logging.debug("Pizza created: {}
(${})".format(self.name, self.price))

    def make(self, quantity=1):
        logging.debug("Made {} {}
pizza(s)".format(quantity, self.name))

    def eat(self, quantity=1):
        logging.debug("Ate {}
pizza(s)".format(quantity, self.name))

pizza_01 = Pizza("artichoke", 15)
pizza_01.make()
```

```
pizza_01.eat()
```

```
pizza_02 = Pizza("margherita", 12)
pizza_02.make(2)
pizza_02.eat()
```

The code above is the same as it was in the previous section, except that now we added the filename for the log to print to. Once we run the code with the `python pizza.py` command, we should have a new file in our directory called `test.log`.

Let's open the `test.log` file with `nano` (or the text editor of your choice):

```
nano test.log
```

When the file opens, we'll see the following:

**test.log**

```
DEBUG:root:Pizza created: artichoke ($15)
DEBUG:root:Made 1 artichoke pizza(s)
DEBUG:root:Ate 1 pizza(s)
DEBUG:root:Pizza created: margherita ($12)
DEBUG:root:Made 2 margherita pizza(s)
DEBUG:root:Ate 1 pizza(s)
```

This is similar to the console output that we encountered in the previous section, except now it is in the `test.log` file.

Let's close the file with CTRL + x and move back into the `pizza.py` file so that we can modify the code.

We'll keep much of the code the same, but modify the parameters in the two `pizza` instances, `pizza_01` and `pizza_02`:

**pizza.py**

```
import logging
```

```
logging.basicConfig(filename="test.log",  
level=logging.DEBUG)
```

```
class Pizza():  
    def __init__(self, name, price):  
        self.name = name  
        self.price = price  
        logging.debug("Pizza created: {}  
(${})".format(self.name, self.price))
```

```
    def make(self, quantity=1):  
        logging.debug("Made {} {}  
pizza(s)".format(quantity, self.name))
```

```
    def eat(self, quantity=1):  
        logging.debug("Ate {}  
pizza(s)".format(quantity, self.name))
```

```
# Modify the parameters of the pizza_01 object
```

```
pizza_01 = Pizza("Sicilian", 18)
pizza_01.make(5)
pizza_01.eat(4)

# Modify the parameters of the pizza_02 object
pizza_02 = Pizza("quattro formaggi", 16)
pizza_02.make(2)
pizza_02.eat(2)
```

With these changes, let's run the program again with the `python pizza.py` command.

Once the program has run, we can open our `test.log` file again with `nano`:

```
nano test.log
```

When we look at the file, we'll see that several new lines were added, and that the previous lines from the last time that the program ran were retained:

**test.log**

```
DEBUG:root:Pizza created: artichoke ($15)
DEBUG:root:Made 1 artichoke pizza(s)
DEBUG:root:Ate 1 pizza(s)
DEBUG:root:Pizza created: margherita ($12)
DEBUG:root:Made 2 margherita pizza(s)
DEBUG:root:Ate 1 pizza(s)
DEBUG:root:Pizza created: Sicilian ($18)
```

```
DEBUG:root:Made 5 Sicilian pizza(s)
DEBUG:root:Ate 4 pizza(s)
DEBUG:root:Pizza created: quattro formaggi ($16)
DEBUG:root:Made 2 quattro formaggi pizza(s)
DEBUG:root:Ate 2 pizza(s)
```

While this information is certainly useful, we can make the log more informative by adding additional [LogRecord attributes](#). Primarily, we would like to add a human-readable time stamp that tells us when the LogRecord was created.

We can add that attribute to a parameter called `format`, referencing it as shown in the table with the string `%(asctime)s`. Additionally, to keep the `DEBUG` level name, we'll need to include the string `%(levelname)s` and to keep the string message that we ask the logger to print out we'll include `%(message)s`. Each of these attributes will be separated by a colon, as shown in the code added below.

**pizza.py**

```
import logging

logging.basicConfig(
    filename="test.log",
    level=logging.DEBUG,
    format="%(asctime)s: %(levelname)s: %(message)s"
)

class Pizza():
```

```

    def __init__(self, name, price):
        self.name = name
        self.price = price
        logging.debug("Pizza created: {}
(${})".format(self.name, self.price))

    def make(self, quantity=1):
        logging.debug("Made {} {}
pizza(s)".format(quantity, self.name))

    def eat(self, quantity=1):
        logging.debug("Ate {}
pizza(s)".format(quantity, self.name))

pizza_01 = Pizza("Sicilian", 18)
pizza_01.make(5)
pizza_01.eat(4)

pizza_02 = Pizza("quattro formaggi", 16)
pizza_02.make(2)
pizza_02.eat(2)

```

When we run the code above with the added attributes with the `python pizza.py` command, we'll get new lines added to our `test.log` file that include the human-readable time stamp in addition to the level name of `DEBUG` and the associated messages that are passed into the logger as strings.

## Output

```
DEBUG:root:Pizza created: Sicilian ($18)
DEBUG:root:Made 5 Sicilian pizza(s)
DEBUG:root:Ate 4 pizza(s)
DEBUG:root:Pizza created: quattro formaggi ($16)
DEBUG:root:Made 2 quattro formaggi pizza(s)
DEBUG:root:Ate 2 pizza(s)
2017-05-01 16:28:54,593:DEBUG:Pizza created: Sicilian
($18)
2017-05-01 16:28:54,593:DEBUG:Made 5 Sicilian pizza(s)
2017-05-01 16:28:54,593:DEBUG:Ate 4 pizza(s)
2017-05-01 16:28:54,593:DEBUG:Pizza created: quattro
formaggi ($16)
2017-05-01 16:28:54,593:DEBUG:Made 2 quattro formaggi
pizza(s)
2017-05-01 16:28:54,593:DEBUG:Ate 2 pizza(s)
```

Depending on your needs, you may want to make use of additional [LogRecord attributes](#) in your code in order to make your program files' logs relevant to you.

Logging debugging and other messages into separate files provides you with a holistic understanding of your Python program over time, giving you the opportunity to troubleshoot and modify your code in a manner that is informed by the historical work put into the program, as well as the events and transactions that occur.

## Table of Logging Levels



As a developer, you can ascribe a level of importance to the event that is captured in the logger by adding a severity level. The severity levels are shown in the table below.

Logging levels are technically integers (a constant), and they are all in increments of 10, starting with `NOTSET` which initializes the logger at the numeric value of 0.

You can also define your own levels relative to the predefined levels. If you define a level with the same numeric value, you will overwrite the name associated with that value.

The table below shows the various level names, their numeric value, what function you can use to call the level, and what that level is used for.

| LEVEL    | NUMERIC VALUE | FUNCTION                        | USED TO                                                             |
|----------|---------------|---------------------------------|---------------------------------------------------------------------|
| CRITICAL | 50            | <code>logging.critical()</code> | Show a serious error, the program may be unable to continue running |
| ERROR    | 40            | <code>logging.error()</code>    | Show a more serious problem                                         |
| WARNING  | 30            | <code>logging.warning()</code>  | Indicate something unexpected happened, or could happen             |
| INFO     | 20            | <code>logging.info()</code>     | Confirm that things are working as expected                         |

DEBUG

10

`logging.debug()`

Diagnose problems,  
show detailed  
information

The `logging` module sets the default level at `WARNING`, so `WARNING`, `ERROR`, and `CRITICAL` will all be logged by default. In the example above, we modified the configuration to include the `DEBUG` level with the following code:

```
logging.basicConfig(level=logging.DEBUG)
```

You can read more about the commands and working with the debugger from the [official logging documentation](#).

## Conclusion

Debugging is an important step of any software development project. The `logging` module is part of the standard Python library, provides tracking for events that occur while software runs, and can output these events to a separate log file to allow you to keep track of what occurs while your code runs. This provides you with the opportunity to debug your code based on understanding the various events that occur from running your program over time.

# How To Port Python 2 Code to Python 3

Python was developed in the late 1980s and first published in 1991. With a name inspired by the British comedy group Monty Python, Python was conceived as a successor to the imperative general-purpose ABC programming language. In its first iteration, Python already included exception handling, [functions](#), and [classes with inheritance](#).

This tutorial will guide you through best practices and considerations to make when migrating code from Python 2 to Python 3 and whether you should maintain code that is compatible with both versions.

## Background

Python 2 was published in 2000, signalling a more transparent and inclusive language development process. It included many more programmatic features and added more features throughout its development.

Python 3 is regarded as the future of Python and is the version of the language that is currently in development. Released in late 2008, Python 3 addressed and amended intrinsic design flaws. However, Python 3 adoption has been slow due to the language not being backwards compatible with Python 2.

Python 2.7 was published in 2010 as the last of the 2.x releases. The intention behind Python 2.7 was to make it easier for Python 2.x users to port features over to Python 3 by providing some measure of compatibility between the two.

You can learn more about Python versions and choosing which to use by reading our tutorial “[Python 2 vs Python 3: Practical Considerations](#).”

## Start with Python 2.7

To move to Python 3, or to support Python 2 and Python 3 simultaneously, you should ensure that your Python 2 code is completely Python 2.7 compatible.

Many developers have already been working exclusively with Python 2.7 code, but it is important to confirm that anything that is only supported by earlier versions is working properly with Python 2.7 and is consistent with Python 2.7 style.

Making sure that your code is in Python 2.7 is especially important because it is the only version of Python 2 that is still being maintained and receiving bugfixes. If you are working on an earlier version of Python 2, you will have to work around issues you encounter with code that is no longer supported and is no longer receiving bugfixes.

Additionally, some tools that make it easier for you to port code, such as the [Pylint](#) package that looks for programming errors, is not supported by versions of Python that are earlier than 2.7.

It is important to keep in mind that though Python 2.7 is currently still being supported and maintained, it will eventually meet its end of life. [PEP 373](#) details the Python 2.7 release schedule and, at the time of writing, marks its sunset date as 2020.

## Test Coverage

Creating test cases can be an important part of the work done to migrate Python 2 to Python 3 code. If you are maintaining more than one version

of Python, you should also ensure that your test suite has good coverage overall to ensure that each version is still working as expected.

As part of your testing, you can add interactive Python cases to the docstrings of all of your functions, methods, classes, and modules and then use the built-in [doctest module](#) to verify that they work as shown.

Alongside doctest, you can use the [coverage.py package](#) to track unit test coverages. This tool will monitor your program and note which parts of the code have been executed and which parts could have been executed but were not. `coverage.py` can print out reports to the command line or provide HTML output. It is typically used to measure the effectiveness of tests, showing you what parts of the code are being exercised by testing and which are not.

Keep in mind that you are not aiming for 100% test coverage — you want to make sure that you cover any code that is confusing or unusual. For best practices, you should aim for 80% coverage.

## Learn About Differences Between Python 2 and Python 3

Learning about the differences between Python 2 and Python 3 will ensure that you are able to leverage the new features that are available, or will be available, in Python 3.

Our guide on “[Python 2 vs Python 3](#)” goes over some of the [key differences](#) between the two versions, and you can review the [official Python documentation](#) for more detail.

When getting started with porting and migration, there are several syntax changes that you can implement now.

**print**

The `print` statement of Python 2 has changed to a `print()` function in Python 3.

| PYTHON 2                           | PYTHON 3                            |
|------------------------------------|-------------------------------------|
| <hr/>                              |                                     |
| <code>print "Hello, World!"</code> | <code>print("Hello, World!")</code> |

## **exec**

The `exec` statement of Python 2 has changed to a function that allows explicit locals and globals in Python 3.

| PYTHON 2                                    | PYTHON 3                                 |
|---------------------------------------------|------------------------------------------|
| <hr/>                                       |                                          |
| <code>exec code</code>                      | <code>exec(code)</code>                  |
| <code>exec code in globals</code>           | <code>exec(code, globals)</code>         |
| <code>exec code in (globals, locals)</code> | <code>exec(code, globals, locals)</code> |

## **/ and //**

Python 2 does floor division with the `/` [operator](#), Python 3 introduced `//` for floor division.

| PYTHON 2                | PYTHON 3                 |
|-------------------------|--------------------------|
| <hr/>                   |                          |
| <code>5 / 2 = 2</code>  | <code>5 / 2 = 2.5</code> |
| <code>5 // 2 = 2</code> |                          |

To make use of these operators in Python 2, [import](#) division from the `__future__` module:

```
from __future__ import division
```

Read more about [division with integers](#).

## **raise**

In Python 3, raising exceptions with arguments requires parentheses, and [strings](#) cannot be used as exceptions.

| PYTHON 2                                        | PYTHON 3                                                       |
|-------------------------------------------------|----------------------------------------------------------------|
| <pre>raise Exception, args</pre>                | <pre>raise Exception</pre>                                     |
| <pre>raise Exception(args)</pre>                |                                                                |
| <pre>raise Exception, args,<br/>traceback</pre> | <pre>raise<br/>Exception(args).with_traceback(traceback)</pre> |
| <pre>raise "Error"</pre>                        | <pre>raise Exception("Error")</pre>                            |

## **except**

In Python 2 it was difficult to list multiple exceptions, but that has changed in Python 3.

Note that `as` is used explicitly with `except` in Python 3

| PYTHON 2                                                        | PYTHON 3                                       |
|-----------------------------------------------------------------|------------------------------------------------|
| <pre>except Exception, variable:</pre>                          | <pre>except AnException as<br/>variable:</pre> |
| <pre>except (OneException, TwoException) as<br/>variable:</pre> |                                                |

## def

In Python 2, functions can take in sequences like [tuples](#) or [lists](#). In Python 3, this unpacking has been removed.

### PYTHON 2

### PYTHON 3

---

```
def function(arg1, (x, y)): def function(arg1, x_y): x, y = x_y
```

## expr

The backtick syntax of Python 2 no longer exists. Use `repr()` or `str.format()` in Python 3.

### PYTHON 2

### PYTHON 3

---

```
x = `355/113` x = repr(355/113):
```

## String Formatting

String formatting syntax has changed from Python 2 to Python 3.

### PYTHON 2

### PYTHON 3

---

```
"%d %s" % (i, s)
```

```
"{} {}".format(i, s)
```

```
"%d/%d=%f" % (355, 113, 355/113)
```

```
"{:d}/{:d}={:f}".format(355, 113, 355/113)
```

Learn [How To Use String Formatters in Python 3](#).

## class

There is no need to state `object` in Python 3.

Python 2



```
class MyClass(object):  
    pass
```

## Python 3

```
class MyClass:  
    pass
```

In Python 3, metaclasses are set with the `metaclass` keyword.

## Python 2

```
class MyClass:  
    __metaclass__ = MyMeta
```

```
class MyClass(MyBase):  
    __metaclass__ = MyMeta
```

## Python 3

```
class MyClass(metaclass=type):  
    pass
```

```
class MyClass(MyBase, metaclass=MyMeta):  
    pass
```

## Update Code

There are two main tools you can use to automatically update your code to Python 3 while keeping it compatible with Python 2: [future](#) and [modernize](#). Each of these tools behaves somewhat differently: `future` works to make Python 3 idioms and best practices exist in Python 2, while `modernize` aims for a Python 2/3 subset of Python that uses the Python [six module](#) to improve compatibility.

Using these tools to handle the details of rewriting the code can help you identify and correct potential problems and ambiguities.

You can run the tool over your unittest suite to visually inspect and verify the code, and ensure that the automatic revisions made are accurate. Once the tests pass, you can transform your code.

From here, you will likely need to do some manual revision, especially targeting the [changes between Python 2 and 3 noted in the section above](#).

Leveraging `future`, you should consider adding this `import` statement to each of your Python 2.7 modules:

```
from __future__ import print_function, division,  
absolute_imports, unicode_literals
```

While this will also lead to rewrites, it will ensure that your Python 2 code aligns with Python 3 syntax.

Finally, you can use the [pylint package](#) to identify any other potential issues in the code. This package contains hundreds of individual rules that cover a broad spectrum of problems that may occur, including [PEP 8 style guide](#) rules, as well as usage errors.

You may find that there are some constructs in your code that could potentially confuse `pylint` and tools used for automatic migration. If

you can't simplify these constructs, you'll need to employ thorough unittest cases.

## Continuous Integration

If you're going to maintain your code for multiple versions of Python, you'll need to remain vigilant about running and re-running your unittest suite through continuous integration (rather than manually) as often as possible on the code as you develop it.

If you make use of the [six package](#) as part of your Python 2 and 3 compatibility maintenance, you'll need to use multiple environments for your testing.

One environment management tool you may consider using is the [tox package](#), as it will check your package installs with different Python versions, run tests in each of your environments, and act as a frontend to Continuous Integration servers.

## Conclusion

It is important to keep in mind that as more developer and community attention focuses on Python 3, the language will become more refined and in-line with the evolving needs of programmers, and less support will be given to Python 2.7. If you decide to maintain versions of your code base for both Python 2 and Python 3, you may have increasing difficulty with the former as it will receive fewer bugfixes over time.

It is worthwhile to look at projects that ported Python 2 to Python 3, including case studies such as [Porting chardet to Python 3](#).