# Scripting in Python



Python scripting is available from OpenSim 3.2, onward. Starting with 4.0, OpenSim is distributed as 64-bit only, so you must use 64-bit Python. If you are using 4.0, you need Python 2.7.x. If you are using 4.1 or 4.2, you need Python 3.7.x.

***Python version 3.8 is not supported for OpenSim version 4.2 or earlier; please use Python version 3.7 or earlier. Python version 3.8 is supported for OpenSim version 4.3+.***



## Introduction to Python

Python is a widely used general purpose programming language. Python is free and open source, with a large user community that encourages sharing and user contributions. The Python language is very flexible, supporting object-oriented and procedural styles of computing. The Python design philosophy also emphasizes code readability which makes sharing and using code easier than with some other languages.

Those from scientific and engineering backgrounds who are new to Python should check out the following resources to help get started with the language:

- Python wikipedia
- python.org
- Python vs Matlab
- Google Python classes
- Python style guide (PEP8)
- Structuring a Python project

## Note on Python 2 vs Python 3

- The Python package that comes with the OpenSim GUI distribution up to version 4.0 will only work with Python 2.7.x. OpenSim version 4.1 distribution upgrades to support Python version 3.7. If you want a different python version, you must build the OpenSim API (opensim-core) from scratch and set the CMake variable OPENSIM_PYTHON_VERSION to the desired version (2 or 3). In all text below that refers to Python version 2.7 (for versions 4.0 and earlier) the same applies to Python version 3 for version 4.1 and later. Starting with version 4.4, only Python version 3 is supported/maintained.

## Setting up your Python scripting environment

### Windows

There are a couple options for setting up Python on your Windows machine. You will need the main Python package, as well as NumPy and SciPy. Alternatively, there are applications such as Anaconda that bundle all the required packages. You can also just set-up Python and the associated packages manually. We have tested both methods, but currently advise you to use Anaconda. ***Make sure that you get 64-bit Python***.

| Package Name | Downloads | Costs/licensing |
|---|---|---|
| Continuum Anaconda | Anaconda Application | Basic package is free to download and use, contains Python and other dependent packages. Cleanly installs into a single directory on your machine. Make sure to pick version consistent with your OpenSim distribution (Python 2.7 for OpenSim version 4.0 or earlier, Python 3.7 for OpenSim 4.1). |

| | | |
|---|---|---|
| Python 2.7 | Python.org<br>Numpy<br>SciPy | Free to use and download. |
| Python 3.7 | Python | Free to use and download. |

## Special instructions for Python 3.8+ on Windows:

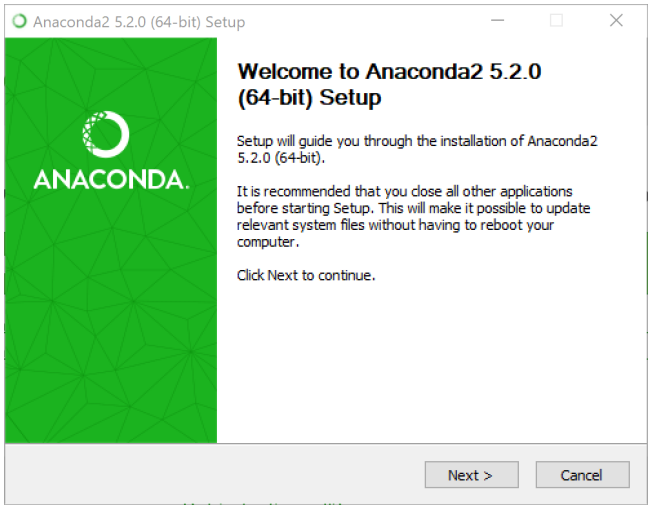
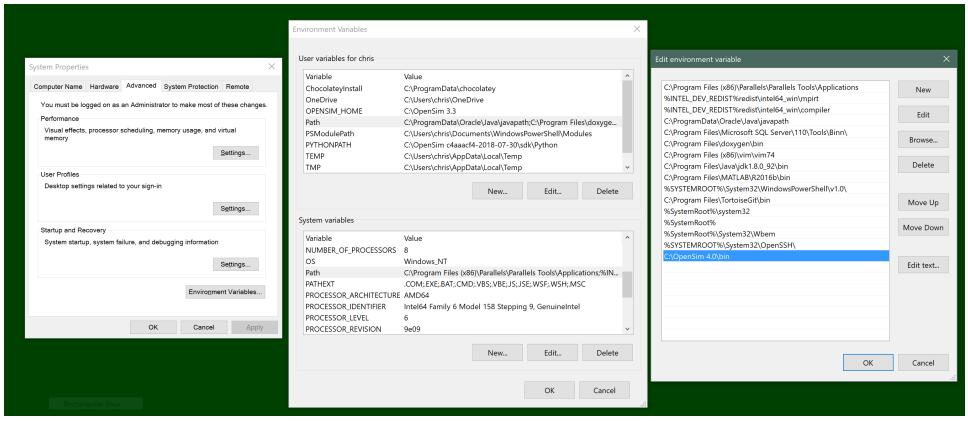
Starting at version 3.8, Python changed how dll's are located on windows, in particular PATH is not used any more, instead every environment should set the path to locate the dlls using this snippet

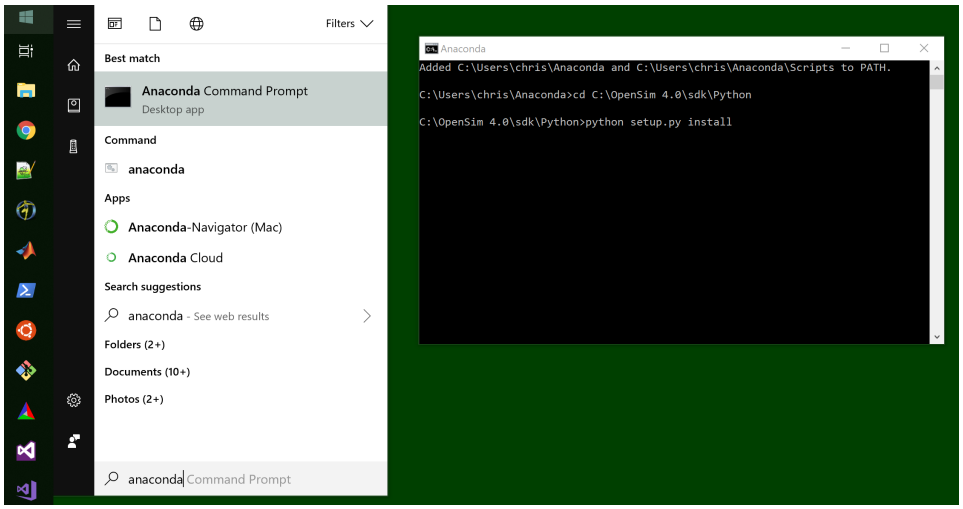
```
>>> import os
>>> os.add_dll_directory("C:/OpenSim 4.2/bin")
```

This works for versions 4.2 and earlier, however for version 4.3+ you need to change directory to the sdk/Python folder under the install folder then invoke the following 2 commands in the Command Prompt or PowerShell:

```
C:/> python setup_win_python38.py
C:/> python -m pip install .
```

### Installing Anaconda and the "opensim" Python package

| | |
|---|---|
|  | **Download and Install Anaconda**<br><br>Visit the Anaconda website and download Anaconda for the appropriate Python version (64-bit). You can try using the following direct download link, though it may be outdated: Anaconda2-5.2.0-Windows-x86_64.exe |
|  | **Insert OpenSim into the System Path**<br><br>Edit your Path environment variable to include <OPENSIM_INSTALL_DIRECTORY>\bin is in system variables Path, where OPENSIM_INSTALL_DIRECTORY is the directory where you installed the current version of OpenSim (e.g. C:\OpenSim 4.0). Delete any other OpenSim Path entries. For instructions, see https://www.java.com/en/download/help/path.xml |




**Run the Setup File from Command Line**

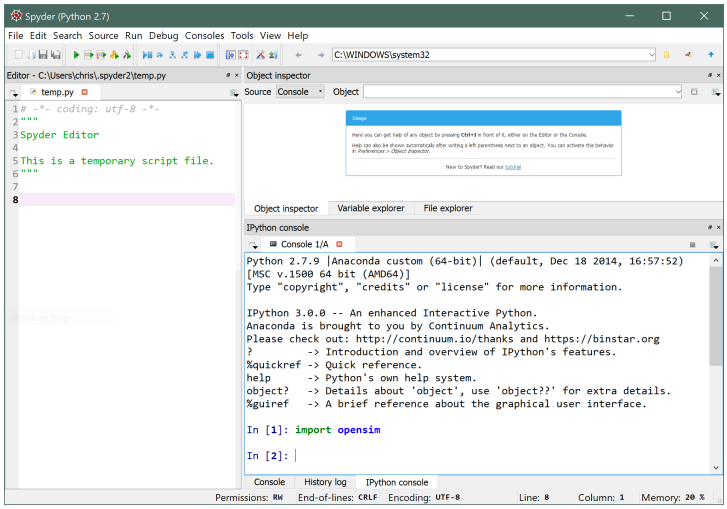
Open an Anaconda Command Prompt (type *anaconda* into the Windows Start menu). Navigate to the OpenSim Installation folder and find the subfolder *sdk* which contains the script *setup.py*.

```
cd C:\OpenSim 4.0
\sdk\Python
```

Run the python script by typing:

```
python setup.py
install
```

This will copy the required files and folders into the Anaconda directory.



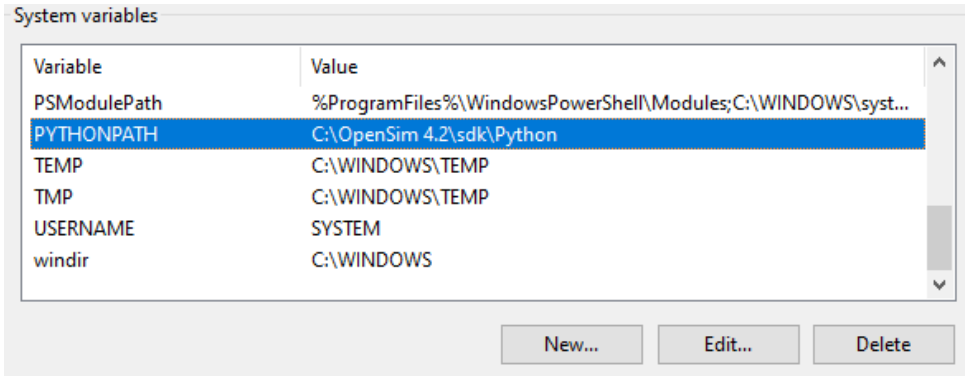

**Test Installation**

Start the Spyder integrated development environment, installed by Anaconda, by typing *spyder* into the Windows Start menu. Run the following in the interpreter that appears within Spyder:

```
import opensim
```

If there is no error, then the installation worked.

## Add a folder to PYTHONPATH variable (needed for OpenSim 4.2)




**Insert OpenSim Python directory into PYTHONPATH**

Edit your PYTHONPATH environment variable to include <OPENSIM_INSTALL_DIRECTORY>\sdk\Python is in system variable PYTHONPATH, where OPENSIM_INSTALL_DIRECTORY is the directory where you installed the current version of OpenSim (e.g. C:\OpenSim 4.0). Delete any other OpenSim Path entries. If PYTHONPATH doesn't exit, you can add the variable using the "New..." button. For instructions, see https://www.java.com/en/download/help/path.xml

### Having trouble?

If you are having trouble with getting python wrapping to work on Windows, the issue is almost certainly one of the following:

1. You are trying to use 32-bit Python with 64-bit OpenSim libraries. If you are using 64-bit OpenSim libraries, make sure to use 64-bit python.
2. OpenSim's DLLs are not on your PATH. In a command window, you could achieve this with a command like "set PATH=C:\OpenSim 4.0 \bin;%PATH%"

## Step-by-step instructions when using Anaconda with OpenSim 4.3+

1. If paths to previous OpenSim versions exist on your PYTHONPATH environment variable, remove them. (If you used OpenSim 4.2 with Python, this step is likely necessary.)
2. Download Anaconda.
3. Download the Anaconda environment file (conda_env.yml) and place it directory of your choice; perhaps **<RESOURCES_DIR>\Code\Python**. This environment includes the following packages:
    a. Python 3.8
    b. NumPy 1.20.2
    c. Matplotlib
    d. Spyder (Python IDE)
4. Open the Anaconda Prompt.
5. Before proceeding, you may need to initialize conda for shell interaction by running

    ```
    C:\> conda init <shell-name>
    ```

    where <shell-name> is one of the following: cmd.exe (Windows default) or powershell.
6. Navigate to the location of the Anaconda environment file. For example, if using cmd.exe:

    ```
    C:\> cd "C:\Users\<profile>\Documents\OpenSim\4.3\Code\Python"
    ```

7. Create the environment from the file:

    ```
    C:\> conda env create -f conda_env.yml
    ```

8. Deactivate any existing environments and activate the OpenSim scripting environment. The prefix "opensim_scripting" should now appear in the Anaconda Prompt.

    ```
    (base) C:\> conda deactivate
    C:\> conda activate opensim_scripting
    (opensim_scripting) C:\>
    ```

9. Navigate to folder **sdk\Python** in the OpenSim 4.3 installation; perhaps **C:\OpenSim 4.3\sdk\Python**.
10. First, run the following script:

    ```
    (opensim_scripting) C:\> python setup_win_python38.py
    ```

11. Install OpenSim by running

    ```
    (opensim_scripting) C:\> python -m pip install .
    ```

12. Once installation completes, test the configuration by checking the timestamp from running

    ```
    (opensim_scripting) C:\> python
    >>> import opensim as osim
    >>> osim.GetVersionAndDate()
    >>> quit()
    ```

    in the Anaconda Prompt. Test that the visualizer is working by running the following

    ```
    (opensim_scripting) C:\> cd "C:\Users\<PROFILE_NAME_HERE>\Documents\OpenSim\4.3\Code\Python\Moco"
    (opensim_scripting) C:\> python exampleSlidingMass.py
    ```

You should see a visualizer window appear with a sliding mass animation. Hit ESC twice to close the window. If you get an error about loading DLL failure check that PATH has been updated correctly before relaunching the shell.

13. Scripting can be performed by using a text editor and running the scripts from the Anaconda Prompt via "python <script_name>.py". However, if you prefer using an interactive development environment (IDE) similar to Matlab, we've included the Spyder IDE in the Anaconda environment. Launch Spyder by simply running

```
(opensim_scripting) C:\> spyder
```

## Mac

macOS comes with some version of Python, but you may also want to obtain Python through Homebrew or the Anaconda Python distribution. Note that the Python package that comes with the OpenSim GUI distribution was built to use the Python that comes with macOS, and it will not work with Homebrew's Python or with Anaconda Python; in the latter cases, you must compile OpenSim from the source code.

Navigate to the location of the **opensim** python package within the OpenSim installation. If you are using OpenSim's GUI distribution, this location is likely /Applications/OpenSim 4.x/sdk/Python. If you built OpenSim from source, this location is likely <OPENSIM_INSTALL_DIR>/lib/python2.7/site-packages (or OPENSIM_INSTALL_DIR>/lib/python3.7/site-packages if using Python 3). Perform the following (modifying the path below if necessary):

```
$ cd /Applications/OpenSim 4.0/sdk/Python
$ sudo python setup.py install
```

The OpenSim libraries must be on your DYLD_LIBRARY_PATH:

```
$ export DYLD_LIBRARY_PATH=$DYLD_LIBRARY_PATH:<OPENSIM_INSTALL_DIR>/lib
```

***Needed for OpenSim 4.2: You must also add OpenSim's python folder to PYTHONPATH, also by adding the following to the `~/.bashrc` file:***

```
export PYTHONPATH=<OPENSIM_INSTALL_DIR>/sdk/Python:$PYTHONPATH
```

You can place the above `export` commands in your `~/.bash_profile` file so that they are set whenever you open up a new terminal.

You should be ready to use the Python wrapping now. Try the following from any directory:

```
$ python
...
>>> import opensim
>>> m = opensim.Model()
```

## Step-by-step instructions when using Anaconda with OpenSim 4.3+

1. If paths to previous OpenSim versions exist on your PYTHONPATH environment variable, remove them. (If you used OpenSim 4.2 with Python, this step is likely necessary.)
2. Download Anaconda.
3. Download the Anaconda environment file (conda_env.yml) and place it directory of your choice; perhaps **<RESOURCES_DIR>/Code /Python**. This environment includes the following packages:
    a. Python 3.8
    b. NumPy 1.20.2
    c. Matplotlib
    d. Spyder (Python IDE)
4. Open the terminal.
5. Before proceeding, you may need to initialize conda for shell interaction by running

```
$ conda init <shell-name>
```

    where <shell-name> is one of the following: bash (macOS default), fish, zsh, tcsh, or xonsh.
6. Navigate to the location of the Anaconda environment file:

```
$ cd /Users/<profile>/Documents/OpenSim/4.3/Code/Python
```

7. Create the environment from the file:

```
$ conda env create -f conda_env.yml
```

8. Deactivate any existing environments and activate the OpenSim scripting environment. The prefix "opensim_scripting" should now appear in the terminal (it may appear on the right side of the screen).

```
(base) $ conda deactivate
$ conda activate opensim_scripting
(opensim_scripting) $
```

9. Navigate to folder **sdk/Python** in the OpenSim 4.3 installation; perhaps **/Applications/OpenSim 4.3**.
10. Install OpenSim by running

```
(opensim_scripting) $ python -m pip install .
```

11. You may need to update the DYLD_LIBRARY_PATH to include the OpenSim and Simbody libraries:

```
(opensim_scripting) $ export DYLD_LIBRARY_PATH="$DYLD_LIBRARY_PATH:<YOUR_INSTALL_DIRECTORY_HERE>
/sdk/lib"
(opensim_scripting) $ export DYLD_LIBRARY_PATH="$DYLD_LIBRARY_PATH:<YOUR_INSTALL_DIRECTORY_HERE>
/sdk/Simbody/lib"
```

12. Once installation completes, test the configuration by checking the timestamp from running

```
(opensim_scripting) $ python
>>> import opensim as osim
>>> osim.GetVersionAndDate()
>>> quit()
```

in the terminal. Test that the visualizer is working by running the following

```
(opensim_scripting) $ cd "/Users/<PROFILE_NAME_HERE>/Documents/OpenSim/4.3/Code/Python/Moco"
(opensim_scripting) $ python exampleSlidingMass.py
```

You should see a visualizer window appear with a sliding mass animation. Hit ESC twice to close the window. If you get an error about loading DLL failure check that PATH has been updated correctly before relaunching the shell.

13. Scripting can be performed by using a text editor and running the scripts from the Anaconda Prompt via "python <script_name>.py". However, if you prefer using an interactive development environment (IDE) similar to Matlab, we've included the Spyder IDE in the Anaconda environment. Launch Spyder by simply running

```
(opensim_scripting) $ spyder
```

## Ubuntu

We assume that you will use Python through the terminal. Open a new terminal window.

```
$ sudo apt-get install python-setuptools
```

Navigate to the sdk/python folder in your OpenSim installation. Assuming that OpenSim is installed into directory OPENSIM_INSTALL_DIR, perform the following:

```
$ cd <OPENSIM_INSTALL_DIR>/lib/python3.7/site-packages
$ sudo python setup.py install
```

The OpenSim libraries must be on your LD_LIBRARY_PATH:

```
$ export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:<OPENSIM_INSTALL_DIR>/lib
```

You can place the above `export` commands in your `~/.bashrc` file so that they are set whenever you open up a new terminal.

***Needed for OpenSim 4.2: You must also add OpenSim's python folder to PYTHONPATH, also by adding the following to the `~/.bashrc` file:***

```
export PYTHONPATH=<OPENSIM_INSTALL_DIR>/sdk/Python:$PYTHONPATH
```

You should be ready to use the Python wrapping now. Try the following from any directory:

```
$ python
...
>>> import opensim
>>> m = opensim.Model()
```

## Available Example Scripts

Scripts can are located in the OpenSim distribution in the sdk/Scripts/Python folder.

| Script Name | Description |
|---|---|
| build_simple_arm_model.py | This script generates a simple arm model, runs a simulation, and visualizes the results. |
| wiring_inputs_and_outputs_with_TableReporter.py | This script shows how to write model outputs (the position of a body) to a data file. |

## Pythonic extensions of the OpenSim API

We have add some pythonic aspects to our Python interface. All examples assume that you have already imported the **opensim** package ("import opensim").

### Initializing a Vector from a Python list

```
v = opensim.Vector([6, 7, 8, 9])
rv = opensim.RowVector([1, 2, 5])
```

### Accessing elements of VecX and Vector using brackets

```
v = opensim.Vec3(1, 2, 3)
v[0] = 1.5 + v[1]
w = opensim.Vector(5, 1.5)
w[0] = 3 * w[1]
```

### Printing the contents of a VecX or Vector

```
>>> v = opensim.Vec3(1, 2, 3)
>>> print v
~[1,2,3]
```

### Getting the length of a VecX or Vector

You can use the built-in python function len() on VecX (e.g., Vec3) and Vector:

```
w = opensim.Vector(5)
if len(w) < 5:
    raise Exception()
```

### Iterate over elements of any Set

There are two iterators: one that treats the Set like a python list, and another that treats the Set like a python dict:

```
model = opensim.Model("my_model.osim")
for force in model.getForceSet():
    print(force.getName())
for name, muscle in model.getMuscles():
    print(name, muscle.get_max_isometric_force())
```

**Iterate over all bodies in a model (even bodies not in the model's BodySet)**

```
model = opensim.Model("my_model.osim")
for body in model.getBodyList():
    print(body.getName())
```

Next: Developer's Guide

Previous: Scripting with Matlab

Home: Scripting and Development