10 awesome features of Python that you can't use because you refuse to upgrade to Python 3

There is also a pdf version of these slides

10 awesome features of Python that you can't use because you refuse to upgrade to Python 3

or

Turning it up to 13!

Prelude

- Last month (March) APUG: only three people use Python 3 (including me)
- Lots of new features of Python 3.
- Some have been backported to Python 2.7. (like dictionary/set comprehensions or set literals, `__future__.print_function`)
- But there's more than that.
- New features that you *can't* use unless you are in Python 3.
- New syntax. New interpreter behavior. Standard library fixes.
- And it's more than bytes/unicode...

Feature 1: Advanced unpacking

- You can already do this:

```
>>> a, b = range(2)
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- Now you can do this:

```
>>> a, b, *rest = range(10)
>>> a
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>>> b
1
>>> rest
[2, 3, 4, 5, 6, 7, 8, 9]
```

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[2, 3, 4, 5, 6, 7, 8, 9]
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- `*rest` can go anywhere:

```
>>> a, *rest, b = range(10)
>>> a
0
>>> b
9
>>> rest
[1, 2, 3, 4, 5, 6, 7, 8]
```

```
>>> *rest, b = range(10)
>>> rest
[0, 1, 2, 3, 4, 5, 6, 7, 8]
>>> b
9
```

Feature 1: Advanced unpacking

Get the first and last lines of a file

```
>>> with open("using_python_to_profit") as f:
...     first, *_, last = f.readlines()
>>> first
'Step 1: Use Python 3\n'
>>> last
'Step 10: Profit!\n'
```

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```

Refactor your functions

```
def f(a, b, *args):
    stuff
```

```
def f(*args):
    a, b, *args = args
    stuff
```

Feature 2: Keyword only arguments

```
def f(a, b, *args, option=True):
    ...
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```
def f(a, b, *args, option=True):
    ...
```

- `option` comes *after* `*args`.
- The only way to access it is to explicitly call `f(a, b, option=True)`
- You can write just a `*` if you don't want to collect `*args`.

  ```
  def f(a, b, *, option=True):
      ...
  ```

Feature 2: Keyword only arguments

- No more, "Oops, I accidentally passed too many arguments to the function, and one of them was swallowed by a keyword argument".

```
def sum(a, b, biteme=False):
    if biteme:
        shutil.rmtree('/')
    else:
        return a + b
```

```
>>> sum(1, 2)
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def sum(a, b, *, biteme=False):
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```
>>> sum(1, 2, 3)
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
TypeError: sum() takes 2 positional arguments but 3 were given
```

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Traceback (most recent call last):
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Feature 2: Keyword only arguments

- Or, "I reordered the keyword arguments of a function, but something was implicitly passing in arguments expecting the order"
- Example:

```
def maxall(iterable, key=None):
    """
    A list of all max items from the iterable
    """
    key = key or (lambda x: x)
    m = max(iterable, key=key)
    return [i for i in iterable if key(i) == key(m)]
```

```
>>> maxall(['a', 'ab', 'bc'], len)
['ab', 'bc']
```

Feature 2: Keyword only arguments

- The `max` builtin supports `max(a, b, c)`. We should allow that too.

```
def maxall(*args, key=None):
    """
    A list of all max items from the iterable
    """
    if len(args) == 1:
        iterable = args[0]
    else:
        iterable = args
    key = key or (lambda x: x)
    m = max(iterable, key=key)
    return [i for i in iterable if key(i) == key(m)]
```

- We just broke any code that passed in the key as a second argument without using the keyword.

```
>>> maxall(['a', 'ab', 'ac'], len)
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
File "<stdin>", line 10, in maxall
TypeError: unorderable types: builtin_function_or_method() > list()
```

- (Actually in Python 2 it would just return `['a', 'ab', 'ac']`, see feature 6).
- By the way, `max` shows that this is already possible in Python 2, but only if you write your function in C.
- Obviously, we should have used `maxall(iterable, *, key=None)` to begin with.

Feature 2: Keyword only arguments

- You can make your APIs "future change proof".
- Stupid example:

```
def extendto(value, shorter, longer):
    """
    Extend list `shorter` to the length of list `longer` with `value`
    """
    if len(shorter) > len(longer):
        raise ValueError('The `shorter` list is longer than the `longer` list')
    shorter.extend([value]*(len(longer) - len(shorter)))
```

```
>>> a = [1, 2]
>>> b = [1, 2, 3, 4, 5]
>>> extendto(10, a, b)
>>> a
[1, 2, 10, 10, 10]
```

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>>> extendto(10, a, b)
>>> a
[1, 2, 10, 10, 10]
```

- Hmm, maybe it makes more sense for `longer` to come before `shorter`...
- Too bad, you'll break the code.

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- In Python 3, you can use

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def extendto(value, *, shorter=None, longer=None):
    """
    Extend list `shorter` to the length of list `longer` with `value`
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    if shorter is None or longer is None:
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- Now, `a` and `b` *have* to be passed in as `extendto(10, shorter=a, longer=b)`.

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- Now, `a` and `b` *have* to be passed in as `extendto(10, shorter=a, longer=b)`.
- Or if you prefer, `extendto(10, longer=b, shorter=a)`.

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- So you can just use `os.stat(file, follow_symlinks=False)` instead of `os.lstat`.
- In case that sounds more verbose, it lets you do

```
s = os.stat(file, follow_symlinks=some_condition)
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instead of

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if some_condition:
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  ```

- But `os.stat(file, some_condition)` doesn't work.
- Keeps you from thinking it's a two-argument function.

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- In Python 2, you have to use `**kwargs` and do the handling yourself.
- Lots of ugly `option = kwargs.pop(True)` at the top of your functions.
- No longer self documenting.
- If you somehow are writing for a Python 3 only codebase, I highly recommend making all your keyword arguments keyword only, especially keyword arguments that represent "options".

Feature 3: Chained exceptions

- **Situation:** you catch an exception with `except`, do something, and then raise a different exception.

```
def mycopy(source, dest):
    try:
        shutil.copy2(source, dest)
    except OSError: # We don't have permissions. More on this later
        raise NotImplementedError("automatic sudo injection")
```

- **Problem:** You lose the original traceback

```
>>> mycopy('noway', 'noway2')
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Traceback (most recent call last):
File "<stdin>", line 1, in <module>
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```

- What happened with the `OSError`?

Feature 3: Chained exceptions

- Python 3 shows you the whole chain of exceptions:

```
mycopy('noway', 'noway2')
Traceback (most recent call last):
File "<stdin>", line 3, in mycopy
File "/Users/aaronmeurer/anaconda3/lib/python3.3/shutil.py", line 243, in copy2
  copyfile(src, dst, follow_symlinks=follow_symlinks)
File "/Users/aaronmeurer/anaconda3/lib/python3.3/shutil.py", line 109, in copyfile
  with open(src, 'rb') as fsrc:
PermissionError: [Errno 13] Permission denied: 'noway'

During handling of the above exception, another exception occurred:

Traceback (most recent call last):
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File "<stdin>", line 5, in mycopy
NotImplementedError: automatic sudo injection
```

- You can also do this manually using `raise from`

```
raise exception from e
```

```
>>> raise NotImplementedError from OSError
OSError

The above exception was the direct cause of the following exception:

Traceback (most recent call last):
File "<stdin>", line 1, in <module>
NotImplementedError
```

Feature 4: Fine grained `OSError` subclasses

- The code I just showed you is wrong.
- It catches `OSError` and assumes it is a permission error.
- But `OSError` can be a lot of things (file not found, is a directory, is not a directory, broken pipe, ...)
- You really have to do

```
import errno
def mycopy(source, dest):
    try:
        shutil.copy2(source, dest)
    except OSError as e:
        if e.errno in [errno.EPERM, errno.EACCES]:
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        else:
            raise
```

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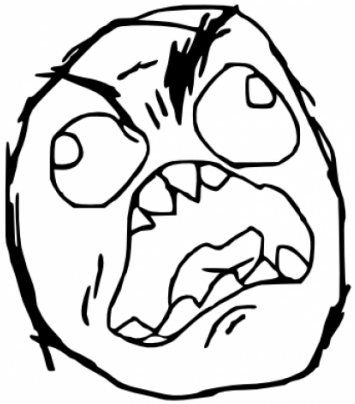

Feature 4: Fine grained `OSError` subclasses

- Python 3 fixes this by adding a ton of new exceptions.
- You can just do

```
def mycopy(source, dest):
    try:
        shutil.copy2(source, dest)
    except PermissionError:
        raise NotImplementedError("automatic sudo injection")
```

- (Don't worry, `PermissionError` subclasses from `OSError` and still has `.errno`. Old code will still work).

Feature 5: Everything is an iterator

- This is the hardest one to sell.
- Iterators exist in Python 2 as well.
- But you have to use them. Don't write `range` or `zip` or `dict.values` or ....

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- If you do...

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```
def naivesum(N):
    """
    Naively sum the first N integers
    """
    A = 0
    for i in range(N + 1):
        A += i
    return A
```

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In [3]: timeit naivesum(1000000)
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```
In [5]: timeit naivesum(100000000)
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Feature 5: Everything is an iterator

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- Instead write some variant (`xrange`, `itertools.izip`, `dict.itervalues`, ...).
- Inconsistent API anyone?

Feature 5: Everything is an iterator

- In Python 3, `range`, `zip`, `map`, `dict.values`, etc. are all iterators.
- If you want a list, just wrap the result with `list`.
- Explicit is better than implicit.
- Harder to write code that accidentally uses too much memory, because the input was bigger than you expected.

Feature 6: No more comparison of everything to everything

- In Python 2, you can do

```
>>> max(['one', 2]) # One *is* the loneliest number
'one'
```

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```
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'one'
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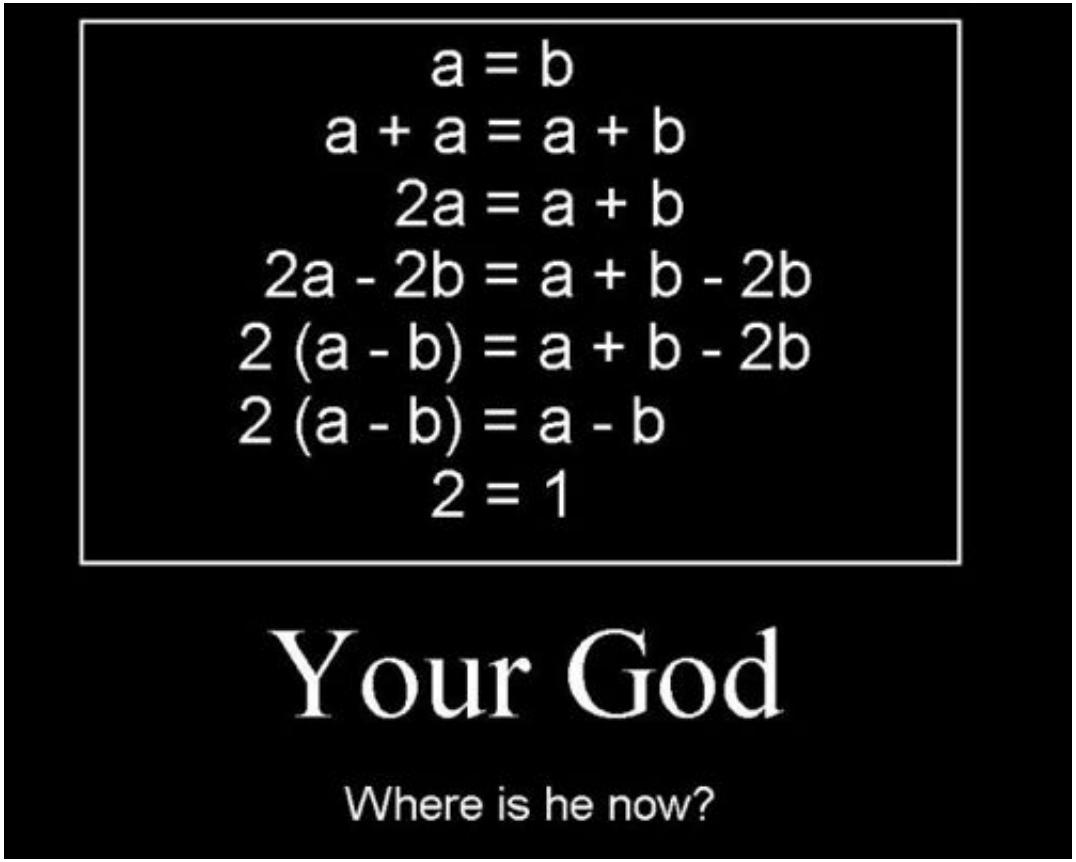
- Hurray. I just disproved math!



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- It's because in Python 2, you can < compare anything to anything.

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>>> 'abc' > 123
True
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False
```

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- It's because in Python 2, you can < compare anything to anything.

```
>>> 'abc' > 123
True
>>> None > all
False
```

- In Python 3, you can't do this:

```
>>> 'one' > 2
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
TypeError: unorderable types: str() > int()
```

- This avoids subtle bugs, e.g., from not coercing all types from int to str or visa versa.
- Especially when you use > implicitly, like with `max` or `sorted`.
- In Python 2:

```
>>> sorted(['1', 2, '3'])
[2, '1', '3']
```

Feature 7: yield from

- Pretty great if you use generators
- Instead of writing

  ```
  for i in gen():
      yield i
  ```

  Just write

  ```
  yield from gen()
  ```

- Easily refactor generators into subgenerators.

Feature 7: yield from

- Makes it easier to turn everything into a generator. See "Feature 5: Everything is an iterator" above for why you should do this.
- Instead of accumulating a list, just `yield` or `yield from`.
- **Bad**

```
def dup(n):
    A = []
    for i in range(n):
        A.extend([i, i])
    return A
```

Good

```
def dup(n):
    for i in range(n):
        yield i
        yield i
```

Better

```
def dup(n):
    for i in range(n):
        yield from [i, i]
```

Feature 7: yield from

In case you don't know, generators are awesome because:

- Only one value is computed at a time. Low memory impact (see `range` example above).
- Can break in the middle. Don't have to compute everything just to find out you needed none of it. Compute just what you need. If you often *don't* need it all, you can gain a lot of performance here.
- If you need a list (e.g., for slicing), just call `list()` on the generator.
- Function state is "saved" between yields.
- This leads to interesting possibilities, à la coroutines...

Feature 8: asyncio

- Uses new coroutine features and saved state of generators to do asynchronous IO.

```
# Taken from Guido's slides from “Tulip: Async I/O for Python 3” by Guido
# van Rossum, at LinkedIn, Mountain View, Jan 23, 2014
@coroutine
def fetch(host, port):
    r,w = yield from open_connection(host,port)
    w.write(b'GET /HTTP/1.0\r\n\r\n ')
    while (yield from r.readline()).decode('latin-1').strip():
        pass
    body=yield from r.read()
    return body

@coroutine
def start():
    data = yield from fetch('python.org', 80)
    print(data.decode('utf-8'))
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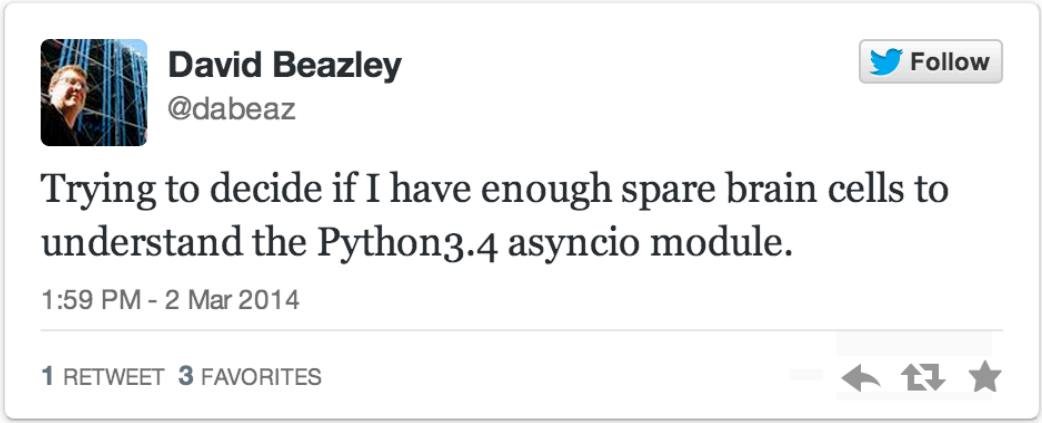
- It's OK, though. Even David Beazley had a hard time with it:



Feature 9: Standard library additions

`faulthandler`

- Display (limited) tracebacks, even when Python dies the hard way.
- Won't work with `kill -9`, but does work with, e.g., segfaults.

```
import faulthandler
faulthandler.enable()

def killme():
    # Taken from http://nbviewer.ipython.org/github/ipython/ipython/blob/1.x/examples/notebooks/Part%2
    import sys
    from ctypes import CDLL
    # This will crash a Linux or Mac system; equivalent calls can be made on
    # Windows
    dll = 'dylib' if sys.platform == 'darwin' else 'so.6'
    libc = CDLL("libc.%s" % dll)
    libc.time(-1)  # BOOM!!

killme()
```

```
$python test.py
Fatal Python error: Segmentation fault

Current thread 0x00007fff781b6310:
File "test.py", line 11 in killme
File "test.py", line 13 in <module>
Segmentation fault: 11
```

- Or `kill -6` (`SIGABRT`)
- Can also enable with `python -X faulthandler`

Feature 9: Standard library additions

`ipaddress`

- Exactly that. IP addresses.

```
>>> ipaddress.ip_address('192.168.0.1')
IPv4Address('192.168.0.1')
>>> ipaddress.ip_address('2001:db8::')
IPv6Address('2001:db8::')
```

- Just another thing you don't want to roll yourself.

Feature 9: Standard library additions

`functools.lru_cache`

- A LRU cache decorator for your functions.
- From docs.

```
@lru_cache(maxsize=32)
def get_pep(num):
    'Retrieve text of a Python Enhancement Proposal'
    resource = 'http://www.python.org/dev/peps/pep-%04d/' % num
    try:
        with urllib.request.urlopen(resource) as s:
            return s.read()
    except urllib.error.HTTPError:
        return 'Not Found'

>>> for n in 8, 290, 308, 320, 8, 218, 320, 279, 289, 320, 9991:
...     pep = get_pep(n)
...     print(n, len(pep))

>>> get_pep.cache_info()
CacheInfo(hits=3, misses=8, maxsize=32, currsize=8)
```

Feature 9: Standard library additions

`enum`

- Finally, an enumerated type in the standard library.
- Python 3.4 only.

```
>>> from enum import Enum
>>> class Color(Enum):
...     red = 1
...     green = 2
...     blue = 3
...
```

- Uses some magic that is only possible in Python 3 (due to metaclass changes):

```
>>> class Shape(Enum):
...     square = 2
...     square = 3
...
Traceback (most recent call last):
...
TypeError: Attempted to reuse key: 'square'
```

Feature 10: Fun

Unicode variable names

```
>>> résumé = "knows Python"
>>> π = math.pi
```

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- Sorry, letter-like characters only.
- 🍺 = "beer" does not work.

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Function annotations

```
def f(a: stuff, b: stuff = 2) -> result:
    ...
```

- Annotations can be arbitrary Python objects.
- Python doesn't do anything with the annotations other than put them in an __annotations__ dictionary.

```
>>> def f(x: int) -> float:
...     pass
...
>>> f.__annotations__
{'return': <class 'float'>, 'x': <class 'int'>}
```

- But it leaves open the possibility for library authors to do fun things.
- Example, IPython 2.0 widgets.
- Run IPython notebook (in Python 3) from IPython git checkout and open http://127.0.0.1:8888/notebooks/examples/Interactive%20Widgets/Image%20Processing.ipynb

Feature 11: Unicode and bytes

- In Python 2, `str` acts like bytes of data.
- There is also `unicode` type to represent Unicode strings.

Feature 11: Unicode and bytes

- In Python 2, `str` acts like bytes of data.
- There is also `unicode` type to represent Unicode strings.
- In Python 3, `str` is a *string*.
- `bytes` are bytes.
- There is no `unicode`. `str` strings are Unicode.

Feature 12: Matrix Multiplication

In Python 3.5, you are able to replace

```
>>> a = np.array([[1, 0], [0, 1]])
>>> b = np.array([[4, 1], [2, 2]])
>>> np.dot(a, b)
array([[4, 1],
       [2, 2]])
```

with

```
>>> a = np.array([[1, 0], [0, 1]])
>>> b = np.array([[4, 1], [2, 2]])
>>> a @ b
array([[4, 1],
       [2, 2]])
```

- Any object can override `__matmul__` to use `@`.

Feature 13: Pathlib

- In Python 2, path handling is verbose

```
import os

directory = "/etc"
filepath = os.path.join(directory, "test_file.txt")

if os.path.exists(filepath):
    stuff
```

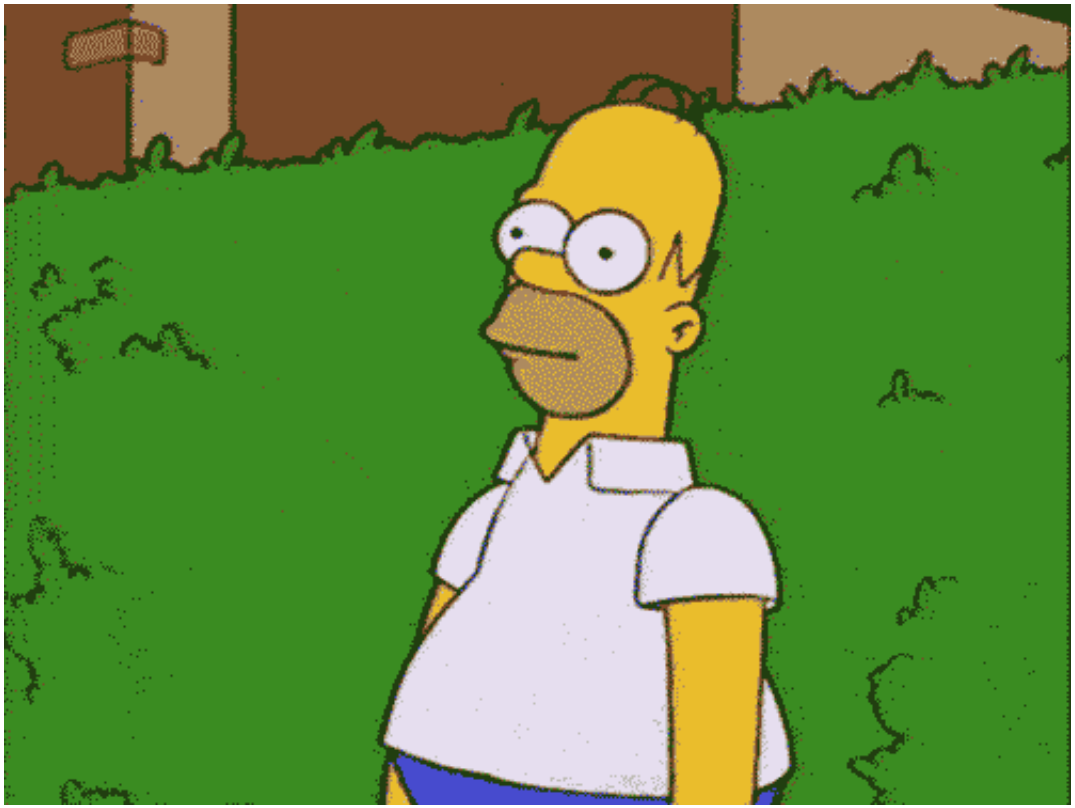
- In Python 3, it is much more simpler

```
from pathlib import Path

directory = Path("/etc")
filepath = directory / "test_file.txt"

if filepath.exists():
    stuff
```

Discuss



Slides were made with http://remarkjs.com/

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Source for slides can be found at https://github.com/asmeurer/python3-presentation.

I am Aaron Meurer (@asmeurer).

I gave this presentation on April 9, 2014 at APUG. If you are in Austin, TX and you enjoy Python, you should come to APUG!

This presentation was updated by Jules David (@galactics) on march 2016, to include some changes brought by Python 3.5.