The Pragmatic Programmers

Python Brain Teasers

Exercise Your Mind

Miki Tebeka

edited by Margaret Eldridge

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Exercise Your Mind

by Miki Tebeka

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Thanks for your continued support,

Andy Hunt
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To the Python community, I'm proud to call myself a member.

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Early Praise for *Python Brain Teasers*

Miki Tebeka's brain teasers are a delightful and challenging collection of puzzles that will amuse novice Python developers and challenge experienced developers to think carefully about their mental model of Python execution.

Beyond amusement, the kind of thinking Miki urges on readers is genuinely important for all of us who have puzzled for far too long (and far too often) over some small snippet of code, written in our real codebases, that just "has to" do one thing, but actually does another.

→Dr. David Mertz
Partner and Senior Trainer, KDM Training

Miki is a world-class Python and Go expert and a hands-on professional. This publication is another evidence that he comes from the field and that he can articulate not only the practical benefits and their practice but also the thought and the meta thinking behind them.

→Shlomo Yona
Founder and Chief Scientist, mathematic.ai

I think even the seasoned Pythonista has a lot to learn from *Python Brain Teasers* by @tebeka.

→David Bordeynik

Software Architect, NVIDIA

I strongly recommended this book to every Python programmer I know.

→Mafinar Khan

Pythonista. Dartisan. Alchemist.

Acknowledgments

I'm grateful for anyone who helped me write this book. Every contribution, from finding bugs to fixing grammar to letting me work in peace, was super helpful.

Here is a list of people who helped; my apologies to anyone I forgot:

- David Bordeynik for his comments and suggestions
- Elad Eyal for his comments
- Iddo Berger for his comments and suggestions
- Raymond Hettinger for lifelong Python education
- Shmuel Amar for his comments
- Yaki Tebeka for his comments
- Yehuda Lavy for his comments

Preface

The Python programming language is a simple one, but like all other languages it has its quirks. This book uses these quirks as a teaching opportunity. By understanding the gaps in your knowledge, you'll become better at what you do.

There's a lot of research showing that people who make mistakes during the learning process learn better than people who don't. If you use this approach when fixing bugs, you'll find you enjoy bug hunting more and become a better developer after each bug you fix.

These teasers will help you avoid mistakes. Some of the teasers are from my own experience shipping bugs to production, and some are from others doing the same.

Teasers are fun! We geeks love to solve puzzles. You can also use these teasers to impress your coworkers, have knowledge competitions, and become better together.

Many of these brain teasers are from quizzes I gave at conferences and meetups. I've found that people highly enjoy them and they tend to liven the room.

At the beginning of each chapter, I'll show you a short Python program and will ask you to guess the output. The following are the possible answers:

- Syntax error
- Exception
- Hang
- Some output (e.g., `[1 2 3]`)

Python Version

I'm using Python version 3.8.2 to run the code. The output *might* change in future versions.

Before moving on to the answer and the explanation, go ahead and guess the output. After guessing the output, I encourage you to run the code and see the output yourself; only then proceed to read the solution and the explanation. I've been teaching programming for many years and found this course of action to be highly effective.

About the Author

Miki Tebeka has a B.Sc. in computer science from Ben Gurion University. He also studied there toward an M.Sc. in computational linguistics.

Miki has a passion for teaching and mentoring. He teaches many workshops on various technical subjects all over the world and has mentored many young developers on their way to success. Miki is involved in open source, has several projects of his own, and has contributed to several more, including the Python project. He has been using Python for more than twenty-three years.

Miki wrote *Pandas Brain Teasers*, *Go Brain Teasers*, and *Forging Python* and is a LinkedIn Learning author and an organizer of Go Israel Meetup, GopherCon Israel, and PyData Israel Conference.

About the Code

You can find the brain teasers code at https://pragprog.com/titles/d-pybrain/python-brain-teasers/.

I've tried to keep the code as short as possible and remove anything that is not related to the teaser. This is *not* how you'll normally write code.

About You

I assume you know Python at some level and have experience programming with it. This book is not for learning how to program in Python. If you don't know Python, I'm afraid these brain teasers are not for you.

I recommend learning Python first (it's also fun). There are many resources online. Google is your friend.

One More Thing

As you work through the puzzles in this book, it might help to picture yourself as Nancy Drew, Sherlock Holmes, or any other of your favorite detectives trying to solve a murder mystery in which *you* are the murderer. Think of it like this:

> *Debugging is like being a detective in a crime movie where you're also the murderer.*
>
> *— Filipe Fortes*

With this mindset, I have found that things are easier to understand, and the work is more enjoyable. So, with that in mind, have fun guessing the brain teasers in this book—perhaps you might even learn a new trick or two.

If you'd like to learn more, please send an email to mailto:info@353-solutions.com, and we'll tailor a hands-on workshop to meet your needs. There's also a comprehensive offering of hands-on workshops at http://www.353solutions.com.

Stay curious, and keep hacking!

Miki Tebeka, March 2020

Foreword by Raymond Hettinger

In my Python conference talks, I frequently check in with the audience to ask, “Have you learned something new?” Getting a “yes” over and over again fills everyone with delight and tells us that our time is being well-spent. Miki’s collection of brain teasers will give you that immediate gratification, once per puzzle. Expect to have a lot fun with his stream of “aha!” moments.

Miki and I have worked together three times: once in a trading company, once at a web services company, and again as Python trainers. Working with him always gives you that “I learned something new” experience.

As trainers, we’ve found that a key skill is the ability to read code and to know, really know, what it does. With Miki’s well-chosen examples, you can rapidly learn this essential skill. He gives you an interesting code fragment, asks you to make a prediction, and then gently explains the outcome. As icing on the cake, he also provides links to authoritative references to deepen your knowledge.

Python is not a difficult language, but there is much more to it than meets the eye. It is easy to assume you know the language well when you really don't. The Dunning-Kruger effect is pervasive in the Python world. Miki's brain teasers will help you quickly discover what you don't know, and his explanations will fill in the missing knowledge to build your expertise.

Here's an example that I've asked during interviews: What does this code do?

```
for i in range(10):
    print(i)
    i = 5
print(i)
```

The answer quickly reveals whether someone understands iterators and scoping in Python. Miki's book is full of such gems.

Hope you enjoy the ride,
Raymond Hettinger
Python Core Developer with a PSF Distinguished Service Award

Part 1
Python Brain Teasers

Puzzle 1	Ready Player One

player.py

```
class Player:
    # Number of players in the Game
    count = 0

    def __init__(self, name):
        self.name = name
        self.count += 1


p1 = Player('Parzival')
print(Player.count)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: **0**

When you write `self.count`, you're doing an attribute lookup. The attribute you're looking for, in this case, is `count`.

Getting an attribute in Python is a complex operation. Almost every Python object stores its attributes in a `dict` called `__dict__`. Python will first try to find the attribute in the instance dictionary, then in the instance's class (`__class__`) dictionary, and then up the inheritance hierarchy (`__mro__`). Finally, if the attribute you're looking for is not found, Python will raise an `AttributeError`.

Attribute Lookup

Python's attribute lookup is actually more complex than the previous explanation. Some objects such as C extensions and classes with `__slots__` don't have a `__dict__` and there are also descriptors, the `__getattribute__` special methods, and other special cases.

Here's possible code for this algorithm, which is implemented in Python by the built-in `getattr`:

```
def get_attr(obj, name):
    """Emulate built in getattr"""
    if name in obj.__dict__:
```

```
        print(f'found {name} in obj')
        return obj.__dict__[name]

    if name in obj.__class__.__dict__:
        print(f'found {name} in class')
        return obj.__class__.__dict__[name]

    for cls in obj.__class__.__mro__:
        if name in cls.__dict__:
            print(f'found {name} in {cls.__name__}')
            return cls.__dict__[name]

    raise AttributeError(name)
```

What happens when you do `self.count += 1` in the teaser? Python will translate it to `self.count = self.count + 1`. Then it'll use `getattr(self, count)` and will get the `count` defined in `Player` with the value of `0`. Once Python has the value of `self.count + 1` = `1` on the right-hand side of the assignment (`=`), it'll call `setattr(self, count, 1)`. `setattr` will create a new entry in `self.__dict__` that will *shadow* the `count` in `Player`.

Lastly, you print `Player.count`, which is still `0`. If you print `p1.count` you will get `1`.

Further Reading

Class Instances

http://docs.python.org/3/reference/datamodel.html#index-49

Special Attributes

http://docs.python.org/3/library/stdtypes.html#special-attributes

Python's Class Development Toolkit (Video by Raymond Hettinger)

http://youtube.com/watch?v=HTLu2DFOdTg

Customizing Module Attribute Access

http://docs.python.org/3/reference/datamodel.html#customizing-module-attribute-access

Variable Shadowing on Wikipedia

http://en.wikipedia.org/wiki/Variable_shadowing

`getattr` *Documentation*

http://docs.python.org/3/library/functions.html#getattr

Puzzle 2	A Slice of π

pi.py

```
π = 355 / 113
print(π)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `3.1415929203539825`

There are two surprising things here: one is that `π` is a valid identifier, and the second is that `355 / 113` computes to a `float`.

Let's start with `π` (the Greek letter pi). Python 3 changed the default encoding for source files to UTF-8 and allows Unicode identifiers.

This can be fun to write, but in practice it'll make your coworkers' lives harder. I can easily type `π` in the Vim editor that I use; however, most

editors and IDEs will require more effort.

One area where I've found that Unicode identifiers are helpful is when translating mathematical formulas to code. Apart from that, stick to plain old ASCII.

Now for `355 / 113`. Python 3 does the right mathematical division. If you try this code in Python 2, you'll get `3` since Python 2 shows more of its C origins. If you want integer division to return an `int` in Python 3, use the `//` operator (e.g., `355 // 113`). This is handy when calculating indices, which must be whole numbers.

Further Reading

Identifiers and Keywords in the Python Reference
http://docs.python.org/3/reference/lexical_analysis.html#identifiers

PEP 3120: Using UTF-8 as the Default Source Encoding
http://python.org/dev/peps/pep-3120/

PEP 263: Defining Python Source Code Encodings
http://python.org/dev/peps/pep-0263/

Vim Editor
http://vim.org

Puzzle 3	When in Kraków

city.py

```
city = 'Kraków'
print(len(city))
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: 7

Unicode

If you're reading this book in electronic format, don't copy and paste the code from the book; you'll probably get a different answer due to Unicode translation issues. Use the book source code. See the *About the Code* section on where to find it.

If you count the number of characters in `Kraków`, it'll come out to 6. So why 7? The reason is ... history.

In the beginning, computers were developed in English-speaking countries—the UK and the US. When early developers wanted to encode text in computers that only understand bits, they came out with the following scheme. Use a `byte` (8 bits) to represent a character. For example, `a` is 97 (`01100001`), `b` is 98, and so on. One byte is enough for the English alphabet, containing twenty-six lowercase letters, twenty-six uppercase letters, and ten digits. There is even some space left for other special characters (e.g., 9 for tab). This encoding is called ASCII. (To be precise, ASCII uses only 7 bits, and LATIN-1 extends it to 8 bits.)

After a while, other countries started to use computers and they wanted to write using their native languages. ASCII wasn't good enough; a single byte can't hold all the numbers needed to represent letters in different languages. This led to several different encoding schemes; the most common is UTF-8.

Some of the characters in UTF-8 are control characters. In this case we have the character `o` at position 4, and after it a control character saying "add an umlaut to the previous character." This is why the length of the string is 7.

In Python 3 you have `str`, which is an immutable sequence of Unicode code points, and `bytes`, which is an immutable sequence of bytes. At the edges of your program when you get `bytes`, convert it to a `str` using the `decode` method. When you send data, use the `str.encode` method to convert it to bytes. Internally, use `str` in your code.

Further Reading

Unicode HOWTO
http://docs.python.org/3/howto/unicode.html

Unicode and You
http://betterexplained.com/articles/unicode/

Unicode on Wikipedia
http://en.wikipedia.org/wiki/Unicode

"Pragmatic Unicode, or, How Do I Stop the Pain?" (Video)
http://youtube.com/watch?v=sgHbC6udIqc

ASCII on Wikipedia
http://en.wikipedia.org/wiki/ASCII

UTF-8 on Wikipedia
http://en.wikipedia.org/wiki/UTF-8

`bytes.decode` in the Python Documentation

http://docs.python.org/3/library/stdtypes.html#bytes.decode

str.encode in the Python Documentation

http://docs.python.org/3/library/stdtypes.html#str.encode

Puzzle 4	A Task to Do

tasks.py

```
from heapq import heappush, heappop

tasks = []
heappush(tasks, (30, 'work out'))
heappush(tasks, (10, 'wake up'))
heappush(tasks, (20, 0xCAFFE))
heappush(tasks, (20, 'feed cat'))
heappush(tasks, (40, 'write book'))

while tasks:
    _, payload = heappop(tasks)
    print(payload)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise a `TypeError` exception.

The built-in `heapq` module implements min-heap over lists.

It's common to use a heap for a priority queue. Pushing and deleting from the heap are `log(N)` operations, and the first item in the heap (e.g., `tasks[0]`) is always the smallest.

To compare items in the heap, `heapq` uses the comparison defined in the object's type (using the `<` operator, which maps to the specific type's `__lt__` special method). The objects in the `tasks` heap are tuples. Python orders tuples, and lists, in a lexicographical order, very much like books are ordered in the library. Lexicographical order compares the first two items, then the second two, and so on. Finally, if all of the items are equal, the longer tuple is considered bigger.

In line 11, you pop the first item from `tasks`, which is `(10, 'wake up')`. After this item is removed from the heap, `heapq` will move the smallest item to the top of the heap. There are two candidates `(20, 'feed cat')` and `(20, 0xCAFFE)`; since the first items in these tuples are equal, Python will try to compare the second items.

l33t Code

l33t Code

`0xCAFFE` is a hexadecimal (base 16) number. Writing "English" this way is called "leet" (or "l33t").

Comparing `'feed cat'` (a `str`) with `0xCAFFE` (an `int`) will raise an exception.

Further Reading

`heapq` Module
http://docs.python.org/3/library/heapq.html

Heap Data Structure on Wikipedia
http://en.wikipedia.org/wiki/Heap_(data_structure)

Lexicographical Order on Wikipedia
http://en.wikipedia.org/wiki/Lexicographical_order

Tuples and Sequences
http://docs.python.org/3/tutorial/datastructures.html#tuples-and-sequences

Puzzle 5	Send It to the Printer

printer.py

```
from threading import Thread
from time import sleep


def printer():
    for i in range(3):
        print(i, end=' ')
        sleep(0.1)


thr = Thread(target=printer, daemon=True)
thr.start()
print()  # Add newline
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `0`

Output

Due to the unpredictable nature of threads, this code might not print anything.

In line 11, you start a daemon thread.

The Python documentation says

> *The entire Python program exits when no alive non-daemon threads are left.*

Since after the `print()` line there are no more non-daemon threads running, the process will exit. `printer` will manage to print the first number (`0`) and then the program will exit, taking down the thread with it.

If you see that your Python program finished working but seems to be "stuck," it's usually a sign there's a non-daemon thread running loose somewhere.

If you *do* want to wait for a thread to terminate, you can use the thread's **join** method.

printer_join.py

```
from threading import Thread
from time import sleep


def printer():
    for i in range(3):
        print(i, end=' ')
        sleep(0.1)


thr = Thread(target=printer, daemon=True)
thr.start()
thr.join()
print()  # Add newline
```

Further Reading

Threading Module

http://docs.python.org/3/library/threading.html

Thread.join *Documentation*

http://docs.python.org/3/library/threading.html#threading.Thread-.join

Puzzle 6	Spam, Spam, Spam

email.py

```
from email.message import EmailMessage

msg = EmailMessage()
msg['From'] = 'prince@palace.ng'
msg['To'] = 'Scrooge McDuck <scoorge@disney.com>'
msg.set_content('''\
Dear Sir.

I'm a Nigerian prince who came into some misfortune.
...
''')
print(msg)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise a `ModuleNotFoundError` exception.

When Python looks for a module to import (e.g., `email`), it'll go over the directories in `sys.path` and try to find a module matching the name. The first value in `sys.path` is `''` (the empty string). `''` stands for the current directory, and in the current directory you have the teaser file `email.py`. Python will load this `email.py` instead of the one in the standard library and will not find the `message` submodule in it.

The lesson here: don't use module names already taken by the standard library. ☺

Python's import mechanism is pretty complex. Apart from `.py` files, it can import the following:

- Built-in modules (e.g., `sys` is "baked" into Python)
- Directories with `__init__.py` file in them
- Shared libraries (`.so`, `.dll`, `.dyld` …)
- `.pyc` byte-compiled files (found in `__pycache__` directory)
- And more

You can also add import hooks to import from other locations. There's a built-in hook to import from zip files and you can see `python38.zip` in `sys.path`.

To allow distributions to customize the import path, Python looks for `site.py` and loads it when it starts. You can run `python -m site` to view the import path.

If you'd like more freedom with package names, you can use relative imports. If you have a file called `email.py` in your package, it *can* import the system `email`. Inside your package you can use `from .email import send_email` to import the `send_email` from your package.

Further Reading

Import System
http://docs.python.org/3/reference/import.html

`importlib` Module
http://docs.python.org/3/library/importlib.html

"Modules and Packages: Live and Let Die!" Video by David Beazley
http://youtube.com/watch?v=0oTh1CXRaQ0

Monty Python "Spam Song"
http://youtube.com/watch?v=mBcY3W5WgNU

Relative Imports in the Python Documentation

http://docs.python.org/3/reference/import.html#package-relative-imports

Puzzle 7	User! Identify Yourself

user.py

```
next_uid = 1



class User:
    def __init__(self, name):
        global next_uid

        self.name = name
        self.__id = next_uid
        next_uid += 1



u = User('daffy')
print(f'name={u.name}, id={u.__id}')
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise an `AttributeError` exception.

Python does not have `private` and `protected` attributes like other languages (we joke that Python is a language for consenting adults).

By convention, if you prefix your attributes (or variables) with `_` (called *underscore*), they are considered an implementation detail. You can still access them, but the author doesn't consider them part of the public API and might rename or remove them in the next version.

Say you choose to use `_id` in `User`. Now all the subclasses of `User` can't use their own `_id` attribute because they might run over the `_id` the methods in `User` use. The solution Python provides is called *name mangling*.

Let's have a look at the `u`'s attributes.

```
>>> print(vars(u))  # Also print(u.__dict__)
{'name': 'daffy', '_User__id': 0}
```

`__id` was transformed into `_User__id`. Inside a `User` method, you can use `__id` and it'll work. But from "outside," including subclasses, this attribute is `_User__id`.

This approach frees the set of names classes can use for nonpublic attributes and methods. You can pick a name, add __ before it, and ensure no subclass will overrun it.

If someone really wants, they can still `print(u._User__id)` and it'll work. However, they are intentionally doing something risky.

Name mangling is not something unique to Python. It's also used in C, Java, and other languages. See the following links for more information.

Further Reading

Private Variables on the Python Documentation
http://docs.python.org/3/tutorial/classes.html#private-variables

Name Mangling on Wikipedia
http://en.wikipedia.org/wiki/Name_mangling

"Python's Class Development Toolkit" Video by Raymond Hettinger
http://youtube.com/watch?v=HTLu2DFOdTg

Puzzle 8	sorted? reversed?

sorted.py

```
nums = [4, 1, 3, 2]
rev = reversed(nums)
print(sorted(rev) == sorted(rev))
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `False`

The built-in `reversed` function returns an iterator.

Python's iterators can do two things:

- Return the next item (by using a `for loop` or calling the built-in `next` function)

- Signal there are no more items by raising `StopIteration` (we say the iterator is exhausted)

The first call to `sorted(rev)` consumes everything from the iterator. When you call `sorted(rev)` the second time, the iterator will immediately raise `StopIteration` and `sorted` will assume an empty iterator.

The result of the first `sorted(rev)` is `[1, 2, 3, 4]`, and the result of the second `sorted(rev)` is `[]` (the empty list). This is why the comparison returns `False`.

Further Reading

`reversed` Documentation
http://docs.python.org/3/library/functions.html#reversed

Iterator on "Functional Programming HOWTO"
http://docs.python.org/3/howto/functional.html#functional-howto-iterators

Iterator on the Python Wiki
http://wiki.python.org/moin/Iterator

"Generator Tricks for System Programmers" by David Beazley
http://dabeaz.com/generators/

"Generators: The Final Frontier" Video by David Beazley

http://youtube.com/watch?v=D1twn9kLmYg

itertools Module Code Examples

http://docs.python.org/3/library/itertools.html

next *Documentation*

http://docs.python.org/3/library/functions.html#next

Puzzle 9	A Simple Math

mul.py

```
print(1.1 * 1.1)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `1.2100000000000002`

You might have expected `1.21`, which is the right mathematical answer.

Some new developers, when seeing this or similar output, come to the message boards and say, “We found a bug in Python!” The usual answer is, “Read the fine manual” (or RTFM for short).

> *Floating point is sort of like quantum physics: the closer you look, the messier it gets.*

— *Grant Edwards*

The basic idea behind this issue is that floating points sacrifice accuracy for speed (i.e., cheat). Don't be shocked. It's a trade-off we do a lot in computer science.

The result you see conforms with the floating-point specification. If you run the same code in C, Java, Go … you will see the same output.

See the links in the next section if you're interested in understanding more about how floating points work. The main thing you need to remember is that they are not accurate; and accuracy worsens as the number gets bigger.

One implication is that when testing involves floating points, you need to check for *roughly equal* and decide what is an acceptable threshold. The built-in `unittest` module has an `assertAlmostEqual` method for these cases. In the scientific Python world, `numpy` offers a versatile `allclose` function.

Floating points have several other oddities. For example, there's a special `nan` value (short for *not a number*). `nan` does not equal any number, *including itself*.

```
>>> float('nan') == float('nan')
```

```
False
```

To check that a value is `nan`, you need to use a special function such as `math.isnan`.

If you need better accuracy, look into the `decimal` module, which provides correctly rounded decimal floating-point arithmetic.

Further Reading

"Floating-Point Arithmetic: Issues and Limitations" in the Python Documentation
http://docs.python.org/3/tutorial/floatingpoint.html

floating point zine by Julia Evans
http://twitter.com/b0rk/status/986424989648936960

What Every Computer Scientist Should Know About Floating-Point Arithmetic
http://docs.oracle.com/cd/E19957-01/806-3568/ncg_goldberg.html

IEEE 754 on Wikipedia
http://en.wikipedia.org/wiki/IEEE_754

Built-in `decimal` Module
http://docs.python.org/3/library/decimal.html

assertAlmostEqual Documentation

http://docs.python.org/3/library/unittest.html#unittest.TestCase.assertAlmostEqual

numpy's allclose

http://docs.scipy.org/doc/numpy/reference/generated/numpy.allclose.html

Puzzle 10	Will It Fit?

assign.py

```
a = [1, 2, 3, 4]
a[1:2] = [10, 20, 30]
print(a)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `[1, 10, 20, 30, 3, 4]`

Python's slicing operator is half open ([) in math), meaning you'll get from the first index up to but not including the last index. `a[1:2]` is in size `1`, yet we assign a list of size 3 to it.

The assignment documentation is a bit hard to read (see below if you're interested). Here's an excerpt (my clipping and emphasis):

> *If the target is a slicing: … Finally, the sequence object is asked to replace the slice with the items of the assigned sequence. The length of the slice may be different from the length of the assigned sequence …*

In short, when you write `a[1:2] = [10, 20, 30]` it's like writing `a = a[:1] + [10, 20, 30] + a[2:]`.

Further Reading

Assignment Statements on the Python Reference
http://docs.python.org/3/reference/simple_stmts.html#assignment-statements

Informal Introduction to Python
http://docs.python.org/3/tutorial/introduction.html

Slice Type
http://docs.python.org/3/library/functions.html#slice

Python's List Type
http://docs.python.org/3/tutorial/datastructures.html#more-on-lists

Puzzle 11	Click the Button

buttons.py

```
1: display = []
2: buttons = []
3: for n in range(10):
4:     # A button is a function called when user clicks on it
5:     buttons.append(lambda: display.append(n))
6:
7: btn = buttons[3]
8: btn()
9: print(display)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `[9]`

You probably expected `[3]` since each lambda appends its `n` to `display`.

However, the `n` that each lambda uses is the same `n` defined in line 3. This type of variable binding is known as a *closure*.

You have two options to fix this bug. The first, and my preference, is to have a `make_button(n)` function.

buttons_make.py

```
display = []
buttons = []



def make_button(n):
    return lambda: display.append(n)



for n in range(10):
    # A button is a function called when user clicks on it
    buttons.append(make_button(n))

btn = buttons[3]
btn()
print(display)
```

The second solution is to use the fact that default function arguments are evaluated once at function creation.

buttons_default.py

```
display = []
buttons = []
for n in range(10):
    # A button is a function called when user clicks on it
    buttons.append(lambda n=n: display.append(n))  # <1>

btn = buttons[3]
btn()
print(display)
```

The `n=n` defines a function parameter that shadows the `n` from the outer scope.

Further Reading

PEP 227: Statically Nested Scopes
http://python.org/dev/peps/pep-0227/

PEP 3104: Access to Names in Outer Scopes
http://python.org/dev/peps/pep-3104/

Closure on Wikipedia
http://en.wikipedia.org/wiki/Closure_(computer_programming)

Variable Shadowing on Wikipedia

http://en.wikipedia.org/wiki/Variable_shadowing

Puzzle 12	Attention Seeker

seeker.py

```
1: class Seeker:
2:     def __getattribute__(self, name):
3:         if name not in self.__dict__:
4:             return '<not found>'
5:         return self.__dict__[name]
6:
7:
8: s = Seeker()
9: print(s.id)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise a `RecursionError` exception.

When you write `s.id`, Python does an attribute lookup (see puzzle 1, Puzzle 1, *Ready Player One*). Python defines several hooks to bypass the usual attribute lookup algorithm. The two main options are `__getattr__` and `__getattribute__`.

Other Options

There are several other ways to modify attribute access such as `staticmethod`, `classmethod`, properties, descriptors, and more.

`__getattr__` is called when the regular attribute lookup fails, and it's usually the one you should use. `__getattribute__` bypasses the attribute lookup and gives you full control.

> *With great power comes great responsibility.*
>
> *— Uncle Ben*

Since `__getattribute__` bypasses the attribute lookup, the code `self.__dict__` in line 3 will call `__getattribute__` again, and you descend into infinite recursion. Python has a guard against infinite recursions. Once the call stack size is more than `sys.getrecursionlimit()` a `RecursionError` will be raised. That is what you see in this teaser.

You can increase the recursion limit with `sys.setrecursionlimt`. Unless you have a really good reason, don't do that.

Dictionaries in Python provide a similar hook to `__getattr__` called `__missing__`. You can implement `collections.defaultdict` and the like with `__missing__`.

Further Reading

Class Instances
http://docs.python.org/3/reference/datamodel.html#index-49

"Customizing Attribute Access" on the Python Reference
http://docs.python.org/3/reference/datamodel.html#customizing-attribute-access

"Descriptor HowTo Guide" on the Python Documentation
http://docs.python.org/3/howto/descriptor.html

`__getattr__` *Documentation*
http://docs.python.org/3/reference/datamodel.html#object.__getattr__

`__getattribute__` *Documentation*
http://docs.python.org/3/reference/datamodel.html#object.__getattribute__)

__missing__ Documentation

http://docs.python.org/3/reference/datamodel.html#object.__missing__

collections.defaultdict Documentation

http://docs.python.org/3/library/collections.html#collections.defaultdict

Puzzle 13	Identity Crisis

identity.py

```
a, b = 12, 3
x = a * b
y = b * a
print(x is y)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `True`

A Python variable is a name pointing to a Python object. When you have two variables (such as `x` and `y`), you can ask two questions:

Equality

Are the objects these variables point to equal? (the `==` operator)

Identity

Do these two variables point to the same object? (the `is` operator)

Since you did two separate calculations for `x` and `y`, you'd expect them to be equal but not identical. In general, you'd be right. Change the value of `b` to `333` and re-run; you will see `False` as the output.

The reason you're seeing `True` is due to an implementation detail. Since the small numbers are used a lot, Python is *interning* them.

Here's what the documentation says:

> *The current implementation keeps an array of integer objects for all integers between -5 and 256; when you create an int in that range you actually just get back a reference to the existing object.*

Meaning there's only one copy of the number `1` in a Python program. Every calculation that results in `1` returns the same object.

Further Reading

`PyLong_FromLong` *Documentation*

http://docs.python.org/3/c-api/long.html#c.PyLong_FromLong

String Interning on Wikipedia

http://en.wikipedia.org/wiki/String_interning

Flyweight Pattern on Wikipedia

http://en.wikipedia.org/wiki/Flyweight_pattern

Puzzle 14	The Great Divide

div.py

```
def div(a, b):
    return a / b


if div(1, 2) > 0 or div(1, 0) > 0:
    print('OK')
else:
    print('oopsie')
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `OK`

You probably expected this code to raise `ZeroDivisionErro` due to `div(1, 0)`.

If you call `div(1, 0)` by itself, you will see the exception. Yet the logic operators in Python, `and` and `or`, are short-circuit operators.

Here's what the documentation says on `and`:

> *This is a short-circuit operator, so it only evaluates the second argument if the first one is false.*

In contrast, all arguments to a function call are evaluated before calling the function. This means you can't write your own `my_and` function that will behave like the built-in `and`.

You can use this to your advantage. Say you'd like to load the current user from the database (slow operation) only if the user is not in the session.

```
user = session.get('user') or load_current_user()
```

`load_current_user()` will be called only if `session.get('user')` returns `None` (which is `False` in Python).

If you write

```
user = session.get('user', load_current_user())
```

then `load_current_user()` will be called *every time*, even if the user is in the session.

Further Reading

"Boolean Operations—and, or, not" in the Python Documentation
http://docs.python.org/3/library/stdtypes.html#boolean-operations-and-or-not

Short-Circuit Evaluation on Wikipedia
http://en.wikipedia.org/wiki/Short-circuit_evaluation

Puzzle 15	Where's Waldo?

waldo.py

```
name = 'Waldo'
text = 'Can you find where Wally is?'

if text.find(name):
    print('Found Waldo')
else:
    print('Cannot find Waldo')
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: **Found Waldo**

The **str.find** documentation says

Return -1 if sub is not found.

We have two Boolean values in Python: `True` and `False`. They weren't always there; they were added in Python 2.3.

How can you do logical operations without `True` and `False`? There are *rules*! Everything is `True` except

- 0 numbers: `0`, `0.0`, `0+0j`, …
- Empty collections: `[]`, `{}`, `''`, …
- `None`
- `False`

You can test the truth value of a Python object using the built-in `bool` function.

Going back to the teaser, `text.find(name)` returns `-1`, and the Boolean value of `-1` is `True`.

If you want to check whether a string contains another, use the `in` operator:

```
if name in text:
    print('Found Waldo')
else:
    print('Cannot find Waldo')
```

This will print `Cannot find Waldo`.

If you want to define a Boolean logic for your object, implement the `__bool__` special method.

Further Reading

`str.find` Documentation
http://docs.python.org/3/library/stdtypes.html#str.find

PEP 285: Adding a bool Type
http://python.org/dev/peps/pep-0285/

"Truth Value Testing" in the Python Documentation
http://docs.python.org/3/library/stdtypes.html#truth-value-testing

`__bool__` Documentation
http://docs.python.org/3/reference/datamodel.html#object.__bool__

Puzzle 16	Call Me Maybe

metrics.py

```
from functools import wraps



def metrics(fn):
    ncalls = 0
    name = fn.__name__

    @wraps(fn)
    def wrapper(*args, **kw):
        ncalls += 1
        print(f'{name} called {ncalls} times')

    return wrapper



@metrics
def inc(n):
    return n + 1
```

```
inc(3)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise an `UnboundLocalError` exception.

When you have a variable (name) in Python (say, `cart = ['lamp']`), you can do two operations:

Mutate
Change the object the variable is pointing to (e.g., `cart.append('mug')`)

Rebind
Have the variable point to another object (e.g., `cart = ['carrots']`)

When you mutate, the variable can be in any scope. However, when you rebind a variable, you need to be in the same scope as the variable.

What are these *scopes*? It's where the name you're using currently is defined. Let's see an example:

```
scale = 1.1


def make_mul(n):
    def mul(val):
        out = val * n * scale
        return out
    return mul


mul7 = make_mul(7)
print(mul7(3))  # 23.1
```

- `val` is local scope, `n` is enclosing scope, `scale` is global scope.
- `out` is from local scope.

When Python sees a name (e.g., `ncalls`), it looks for it in `LEGB` order:

- Local
- Enclosing (closure)
- Global
- Builtin

Builtin refers to the `builtins` module.

Abusing the builtins Module

If you want to define something that can be accessed from *any* module, you can stick it in `builtins`. Don't do that. ☺

Since integers are immutable in Python, the `+=` operator rebinds the variable on the left side of it to a new integer object. Since `ncalls` is from the enclosing scope, you can't rebind it without being more specific.

Python 2 has the `global` keyword for rebinding global variables, and Python 3 added the `nonlocal` keyword for rebinding enclosing variables. You can use `nonlocal` in this teaser.

metrics_nl.py

```
from functools import wraps



def metrics(fn):
    ncalls = 0
    name = fn.__name__
```

```
    @wraps(fn)
    def wrapper(*args, **kw):
        nonlocal ncalls
        ncalls += 1
        print(f'{name} called {ncalls} times')

    return wrapper


@metrics
def inc(n):
    return n + 1


inc(3)
```

If you're in Python 2, you do the following trick (called *boxing*).

metrics_box.py

```
1: from functools import wraps
 -
 -
 - def metrics(fn):
5:     ncalls = [0]
```

```
    name = fn.__name__

    @wraps(fn)
    def wrapper(*args, **kw):
        ncalls[0] += 1
        print(f'{name} called {ncalls[0]} times')

    return wrapper


@metrics
def inc(n):
    return n + 1

inc(3)
```

Now, in line 10, you're not rebinding `ncalls`; you're mutating it and that is OK.

Further Reading

Assignment Statements in the Python Documentation
http://docs.python.org/3/reference/simple_stmts.html#assignment-statements

PEP 227: Statically Nested Scopes
http://python.org/dev/peps/pep-0227/

Nonlocal Statement in the Python Documentation
http://docs.python.org/3/reference/simple_stmts.html#nonlocal

Global Statement in the Python Documentation
http://docs.python.org/3/reference/simple_stmts.html#global

"What Are the Rules for Local and Global Variables in Python?" in the Python FAQ
http://docs.python.org/3/faq/programming.html#what-are-the-rules-for-local-and-global-variables-in-python

"Why Am I Getting an UnboundLocalError When the Variable Has a Value?" in the Python FAQ
http://docs.python.org/3/faq/programming.html#why-am-i-getting-an-unboundlocalerror-when-the-variable-has-a-value

builtins Module
http://docs.python.org/3/library/builtins.html#module-builtins

Puzzle 17	Endgame

avengers.py

```
1: avengers = ['Bruce', 'Carol', 'Natasha', 'Tony']
2: idx = 3
3: avengers[idx], idx = 'Peter', 2
4: print(avengers)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `['Bruce', 'Carol', 'Natasha', 'Peter']`

You're doing multiple assignments, also known as *unpacking*. In line 3, Python will first evaluate the right side of the `=` from left to right and then assign to the left side, again from left to right.

In the line `avengers[idx], idx = 'Peter', 2`, Python first evaluates `avengers[idx] = 'Peter`. Since `idx` is still 3 here, the fourth item on the list,

`Tony`, is being replaced. Then Python will evaluate `idx = 2`.

This is confusing and considered bad practice. Don't do it.

Further Reading

PEP 3132: Extended Iterable Unpacking
http://python.org/dev/peps/pep-3132/

PEP 448: Additional Unpacking Generalizations
http://python.org/dev/peps/pep-0448/

Evaluation Order in the Python Reference
http://docs.python.org/3/reference/expressions.html#evaluation-order

Puzzle 18	Round and Round We Go

round.py

```
print(round(1.5), round(2.5))
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `2 2`

Rounding seems easy. `round(1.1)` evaluates to `1`. `round(1.8)` evaluates to `2`. The question is, how do you round the `.5` numbers? Should you round up? Down? Turns out, there are a lot of ways to do it.

Python 3 uses *bankers' rounding*. Odd numbers are rounded up; even numbers are rounded down. The reasoning behind this method is that if you round a list of numbers, assuming there's roughly the same number of odd and even numbers, the error (rounding) will cancel each other.

Python 2 uses a different method called *round away from zero*. If you run this teaser in Python 2, you'll see `(2.0, 3.0)` as the output.

Further Reading

Rounding on Wikipedia
http://en.wikipedia.org/wiki/Rounding

Built-in round Documentation
http://docs.python.org/3/library/functions.html#round

Floating-Point Arithmetic: Issues and Limitations in the Python Tutorial
http://docs.python.org/3/tutorial/floatingpoint.html#tut-fp-issues

Puzzle 19	TF (Without IDF)

word_freq.py

```
import re
from collections import defaultdict


def word_freq(text, freqs=defaultdict(int)):
    """Calculate word frequency in text. freqs are previous frequencies"""
    for word in [w.lower() for w in re.findall(r'\w+', text)]:
        freqs[word] += 1
    return freqs


freqs1 = word_freq('Duck season. Duck!')
freqs2 = word_freq('Rabbit season. Rabbit!')
print(freqs1)
print(freqs2)
```

Guess the Output

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print:

```
defaultdict(<class 'int'>, {'duck': 2, 'season': 2, 'rabbit': 2})
defaultdict(<class 'int'>, {'duck': 2, 'season': 2, 'rabbit': 2})
```

One of the solutions to the Puzzle 11, *Click the Button* puzzle is using the fact that default arguments to a function are evaluated once when the function is defined. Here you see the dark side of this aspect.

Mutable default arguments are considered bad practice, and linters such as `flake8` or `pylint` will mark line 5 in this teaser code as an error.

The solution is to use `None` as the default value and in the function itself to create the mutable default.

word_freq_none.py

```
import re
```

```
from collections import defaultdict



def word_freq(text, freqs=None):
    """Calculate word frequency in text. freqs are previous
frequencies"""
    freqs = defaultdict(int) if freqs is None else freqs
    for word in [w.lower() for w in re.findall(r'\w+', text)]:
        freqs[word] += 1
    return freqs



freqs1 = word_freq('Duck season. Duck!')
freqs2 = word_freq('Rabbit season. Rabbit!')
print(freqs1)
print(freqs2)
```

Further Reading

flake8 Linter

http://flake8.pycqa.org

pylint Linter

http://pylint.org

Default Argument Values in the Python Tutorial

http://docs.python.org/3/tutorial/controlflow.html#default-argument-values

Common Gotchas in the "Hitchhiker's Guide to Python"

http://docs.python-guide.org/writing/gotchas/

tf-idf on Wikipedia

http://en.wikipedia.org/wiki/Tf%E2%80%93idf

Puzzle 20	A Divided Time

timer.py

```
class timer:
    def __init__(self, name):
        self.name = name

    def __enter__(self):
        ...

    def __exit__(self, exc_type, exc_value, traceback):
        result = 'OK' if exc_type is None else 'ERROR'
        print(f'{self.name} - {result}')
        return True


with timer('div'):
    1 / 0
```

Guess the Output

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `div - ERROR`

You might have expected to see a `ZeroDivisionError` exception.

`timer` is a context manager. A context manager is used with the `with` statement and is usually for managing resources. For example, `with open('input.txt')` will make sure that the file is closed after the code inside the context manager is done, even if the code inside the `with` raised an exception.

There are several types in the Python standard library that can be used with a `with` statement:

- A `file` will be closed.
- A `socket` will be closed.
- A `threading.Lock` will be released.

There's one resource you don't need to explicitly manage: the memory. Python has a garbage collector that manages the memory for you.

All other resources need to be managed manually. For example, if you forget to close a file, you will reach the operating system limit on the number of open files. Your server will start failing after a while with `too many open files` errors.

Some database packages also support `with` statements but with different semantics. If there's no error, they will issue a `COMMIT`; otherwise, they will issue a `ROLLBACK`.

You can implement context managers either by writing a class with `__enter__` and `__exit__` methods (like we do in the teaser) or by using the `contextlib.contextmanager` decorator.

The `__exit__` method is called when the code inside the `with` statement is done, and its arguments will be `None` if there was no exception. If `__exit__` returns a `False` value, the exception will propagate; otherwise, the exception is suppressed.

Most `__exit__` methods don't return a value, which in Python means it returns `None`, whose Boolean value is `False`.

In the teaser, `__exit__` returns `True`, suppressing the `ZeroDivisionError`.

Oh, and the ... in line 6 is called *ellipsis*; it's valid Python.

Further Reading

Context Manager Types in the Python Documentation
http://docs.python.org/3/library/stdtypes.html#typecontextmanager

PEP 343: The "with" Statement
http://python.org/dev/peps/pep-0343/

contextlib Module
http://docs.python.org/3/library/contextlib.html

Commit on Wikipedia
http://en.wikipedia.org/wiki/Commit_(data_management)

Rollback on Wikipedia
http://en.wikipedia.org/wiki/Rollback_(data_management)

Ellipsis on the Python Documentation
http://docs.python.org/3/library/constants.html#Ellipsis

Puzzle 21	Tell Me the Future

future.py

```
from datetime import datetime


date = datetime(10_000, 1, 1)
print(f'The party started on {date:%B, %d %Y} and lasted a 10 days'
)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise a `ValueError`.

Computers and time have a complicated relationship. There are day-light saving time, leap years, time zones, and more details to work out.

Computers store time as the number of seconds that elapsed since January 1, 1970, GMT, known as Unix or epoch time. This means that in 2038, time will overflow on 32-bit machines. Ouch!

Python has two libraries to work with time:

- The good old `time` module
- The new and shiny `datetime` module

This teaser uses `datetime`, which is written mostly in C and has a fixed amount of space for storing time information. This means there's a maximal and minimal value to `datetime`.

```
>>> from datetime import datetime
>>> print(datetime.min, datetime.max)
0001-01-01 00:00:00 9999-12-31 23:59:59.999999
```

The value provided in the teaser is bigger than the maximal value for `datetime`, hence, the `ValueError` exception.

Further Reading

`time` Module Documentation

http://docs.python.org/3/library/time.html

`datetime` Module Documentation

http://docs.python.org/3/library/datetime.html

Falsehoods Programmers Believe About Time
http://infiniteundo.com/post/25326999628/falsehoods-programmers-believe-about-time

Unix Time on Wikipedia
http://en.wikipedia.org/wiki/Unix_time

Year 2038 Problem on Wikipedia
http://en.wikipedia.org/wiki/Year_2038_problem

Puzzle 22	Loop de Loop

loop.py

```
for n in range(5):
    print(n, end=' ')
    n = 5
print()
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `0 1 2 3 4`

Python's `for` loop is a "for each." Iteration in Python involves two types:

Iterable

The object we're iterating over (e.g., `str`, `list`, `dict` …)

Iterator

Does the actual iteration; can *only* fetch the next item and signal it's done (i.e., exhausted) by raising a `StopIteration`

Here's what the `for` loop looks like under the hood.

loop_internal.py

```
iterable = range(5)  # range is the iterable
iterator = iter(iterable)  # extract iterator from iterable
while True:
    try:
        n = next(iterator)
        # Code inside "for" loop
        print(n, end=' ')
        n = 5  # Will be overridden by line 5 in next iteration
    except StopIteration:  # iterator signaled it's exhausted
        break
print()  # Code after "for" loop
```

From this code, it's clear why `n = 5` will not stop the `for` loop.

You can create iterators for your own type by creating a class that implements two methods: `__next__` and `__iter__`. Your iterable type should implement `__iter__` that returns the iterator.

Or … you can choose the easier path and implement a generator.

Further Reading

__next__ Documentation

http://docs.python.org/3/library/stdtypes.html#iterator.__next__

__iter__ Documentation

http://docs.python.org/3/library/stdtypes.html#iterator.__iter__

Iterator Types in the Python Documentation

http://docs.python.org/3/library/stdtypes.html#iterator-types

Generators on the Python Wiki

http://wiki.python.org/moin/Generators

"Generator Tricks for System Programmers" by David Beazley

http://dabeaz.com/generators/

itertools Module Code Examples

http://docs.python.org/3/library/itertools.html

Puzzle 23	Path to Nowhere

winpath.py

```
path = 'c:\path\to\nowhere'
print(path)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print:

```
c:\path o
owhere
```

The `\` in Python strings is used as an escape sequence to write special characters. `\t` translates to the `tab` character, and `\n` translates to the newline character.

There are several other ways you can escape special characters in strings.

escape.py

```
s1 = '\x61'  # \x - 2 digits
print(s1)  # a

s2 = '\u2122'  # \u - 4 digits (8482 in hex)
print(s2)  # ™

s3 = '\U00002122'  # \U - 8 digits
print(s3)  # ™

s4 = '\N{trade mark sign}'
print(s4)  # ™
```

What if you want a \ inside your string? You can escape it with another \.

```
path = 'c:\\path\\to\\nowhere'
```

The easier approach is to use a *raw* string. Here's what the documentation says:

> *Both string and bytes literals may optionally be prefixed with a letter 'r' or 'R'; such strings are called raw strings and treat*

backslashes as literal characters.

In this case

```
path = r'c:\path\to\nowhere'
```

The two most common use cases for raw strings are Windows paths (when you cut and paste from Explorer) and when defining regular expressions that have special characters that start with `\` (e.g., `\s` for white space).

Further Reading

String and Bytes Literals in the Python Reference
http://docs.python.org/3/reference/lexical_analysis.html#string-and-bytes-literals

Find Fun Unicode Characters in the Unicode Table
http://unicode-table.com/en/

Regular Expression Syntax in the Python Documentation
http://docs.python.org/3/library/re.html#regular-expression-syntax

Puzzle 24	12 Angry Men

jury.py

```
from concurrent.futures import ProcessPoolExecutor
from itertools import repeat

guilty = 0


def juror():
    global guilty

    guilty += 1


with ProcessPoolExecutor() as pool:
    for _ in repeat(None, 12):
        pool.submit(juror)

print(guilty)
```

Guess the Output

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `0`

Both threads and processes are concurrent units of work. The main difference is that threads share the same memory space and processes don't.

This means that if you have a global variable (e.g., `guilty`), all threads in the same process will be able to access and modify it. Whereas in processes, you will need to communicate the data between the processes in some way (e.g., a socket).

This teaser uses a `ProcessPoolExecutor`, meaning the code is executed in a different process. Every `juror` changes its own copy of `guilty`.

Threads allow faster access to shared data, but they are more dangerous. None of the built-in types in Python (e.g., `list`, `dict`, …) are thread safe. If you change (i.e., mutate) a `list` from two threads at the

same time, the behavior is undefined. You'll need to use `threading.Lock` to guard that only one thread changes the list at a time.

Making all built-in types thread-safe will make them much slower, and most of the Python code out there still runs in a single thread. This is why the built-in types will not be thread-safe in the near (or far) future.

When should you use threads and when processes? The rule of thumb is that if you have CPU-bound code, you should use processes, and if you have an I/O-bound code you should use threads.

Before moving to threads or processes, remember that there's a limit on how much parallelization will help you and that it's much harder to write such code than sequential code.

Further Reading

`concurrent.futures` Module
http://docs.python.org/3/library/concurrent.futures.html

Amdahl's Law on Wikipedia
http://en.wikipedia.org/wiki/Amdahl%27s_law

I/O-bound on Wikipedia
http://en.wikipedia.org/wiki/I/O_bound

CPU-bound on Wikipedia

http://en.wikipedia.org/wiki/CPU-bound

Lock in the Python Documentation

http://docs.python.org/3/library/threading.html#lock-objects

"Using repeat Over range" by Raymond Hettinger

http://twitter.com/raymondh/status/114452718334137548?lang=en

Puzzle 25	Look at the Pretty Colors

colors.py

```
colors = [
    'red',
    'green'
    'blue'
]

print(colors)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `['red', 'greenblue']`

Python's use of white space is pretty unique in programming languages. Some people don't like it. I personally find it makes the code more readable.

The Python documentation says

> *A logical line is constructed from one or more physical lines by following the explicit or implicit line joining rules.*

And a bit later

> *Expressions in parentheses, square brackets, or curly braces can be split over more than one physical line without using backslashes.*

Which means

- `'a' 'b'` is not valid.
- `('a', 'b')` is a tuple (`'a', 'b'` is also a tuple).
- `('a' 'b')` is the string `'ab'`.

In the teaser, there is a `,` missing between `'green'` and `'blue'`. Python will join them together as `'greenblue'`.

This is why you should have a *dangling comma* when you write expressions like `colors`:

```
colors = [
    'red',
    'green',
    'blue',  # ← A dangling comma
```

```
]
```

Not only will it save you from bugs, in code reviews, if you add another color, there will be only one line change. Sadly, not every language or format allows dangling commas. I'm looking at you JSON and SQL.

black

You can use the **black** code formatter with your IDE. It will format your code and add dangling commas.

You can use this *implicit line joining* to make your code clearer. Here's an example from the **matplotlib** documentation:

Turn

```
plot(x, y, color='green', marker='o', linestyle='dashed', linewidth=2, markersize=12)
```

into

```
plot(
        x, y,
```

```
        color='green',
        marker='o', markersize=12,
        linestyle='dashed', linewidth=2,
)
```

You can even surround your code with () and do *method chaining*:

```
(
        df[df['passenger_count'] > 1]  # rides with more than 1
        ['tpep_pickup_datetime'].dt.hour  # extract hour
        .value_counts()  # count hours
        .sort_index()  # sort by hour
        .plot.bar(rot=45, title='11am rides')  # plot with 45° axis
labels
)
```

Further Reading

Line Structure in the Python Reference
http://docs.python.org/3/reference/lexical_analysis.html#line-structure

When to Use Trailing Commas in the "Style Guide for Python" (aka PEP 8)
http://python.org/dev/peps/pep-0008/#id29

Tuple Syntax on the Python Wiki

http://wiki.python.org/moin/TupleSyntax

“That Trailing Comma” by Dave Cheney

http://dave.cheney.net/2014/10/04/that-trailing-comma

Matplotlib Documentation

http://matplotlib.org

Black Code Formatter

http://black.readthedocs.io

Puzzle 26	Let's Vote

vote.py

```
import re

text = 'The vote was 65 in favour, 43 against and 21 abstentions'
match = re.search(r'(\d+).*(\d+).*(\d+)', text)
print(match.group(1), match.group(2), match.group(3))
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `65 2 1`

You might have expected to see `65 43 21`. The reason for this output is that the `.*` regular expression is *greedy*, which means it will match as much as it can. Here's what happened:

- The first `.*(\d+)` will match `65`.

- The `.*` after it will match `in favour, 43 against and`.
- The next `.*(\d+)` will match `2`.
- The `.*` after it will match the empty string since `*` means *zero or more*.
- The final `.*(\d+)` will match `1`.

To make `.*` nongreedy, add `?` at the end. The following will work as expected:

```
match = re.search(r'(\d+).*?(\d+).*?(\d+)', text)
```

You can use sites such as http://www.pyregex.com/ to test your regular expressions.

Further Reading

`re` Module
http://docs.python.org/3/library/re.html

"Regular Expression HOWTO" in the Python Documentation
http://docs.python.org/3/howto/regex.html

Puzzle 27	An Inside Job

inside.py

```
def add_n(items, n):
    items += range(n)



items = [1]
add_n(items, 3)
print(items)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: **[1, 0, 1, 2]**

In the Puzzle 16, *Call Me Maybe* puzzle, we talked about rebinding versus mutation. And most of the time, **items += range(n)** is translated to **items = items + range(n)**, which is rebinding.

There is a special optimization for `+=` in some cases. Here's what the documentation says (my emphasis):

> *An augmented assignment expression like x += 1 can be rewritten as x = x + 1 to achieve a similar, but not exactly equal, effect. In the augmented version, x is only evaluated once. Also, when possible, the actual operation is performed in place, meaning that rather than creating a new object and assigning that to the target, the old object is modified instead.*

A type defines how the `+` operator behaves with the `__add__` special method and can define `__iadd__` as a special case for `+=`. The documentation says

> *These methods are called to implement the augmented arithmetic assignments (`+=, -=, =, @=, /=, //=, %=, *=, <<=, >>=, &=, ^=, |=`). These methods should attempt to do the operation in place (modifying self) and return the result (which could be, but does not have to be, self). If a specific method is not defined, the augmented assignment falls back to the normal methods.*

The built-in `list` object defines `__iadd__`, which calls the `extend` method.

What will happen if you change the code inside `add_n` to `items = items + range(n)`? You will get an exception: `TypeError: can only concatenate list (not "range") to list`.

In Python 3 the built-in `range` function returns a `range` object. Even though it *looks* like a `list` (`len`, `[]`, and friends will work), you can't add it to a `list`.

If you want the rebinding code to work, you'll need to write `items = items + list(range(n))` and then the output will be `[1]`.

As a general rule, try not to mutate the object passed to your functions. This style of programming is called *functional* programming. Functional code is easier to test and reason about. Give it a try. It's fun.

Further Reading

Functional Programming on Wikipedia
http://en.wikipedia.org/wiki/Functional_programming

Built-in `range` Documentation
http://docs.python.org/3/library/functions.html#func-range

"Augmented Assignment Statements" in the Python Reference
http://docs.python.org/3/reference/simple_stmts.html#augmented-assignment-statements

"Functional Programming HOWTO" in the Python Documentation
http://docs.python.org/3/howto/functional.html

__iadd__ Documentation

http://docs.python.org/3/reference/datamodel.html#object.__iadd__

"More on Lists" in the Python Documentation

http://docs.python.org/3/tutorial/datastructures.html#more-on-lists

Puzzle 28	Here Kitty Kitty

cat.py

```
pali = 'Was it a cat I saw?'
print(pali[::-1])
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `?was I tac a ti saW`

Palindrome

“Was it a cat I saw?” is a palindrome. A palindrome can be read the same backward and forward.
And no, Officer Ripley, it wasn’t a cat you saw. ☺

This is the best way to reverse a string in Python:

`pali[::-1]` is a string slice. Slices have `start`, `stop`, and `step`, each of them optional. `start` to `stop` is a *half-open* range, meaning you'll get from the first index up to but not including the last. Additionally, if you specify a negative `stop`, it'll be an offset from the end.

Let's see some examples:

```
>>> 'Python'[1:4]  # start & stop
'yth'
>>> 'Python'[1:]  # only start
'ython'
>>> 'Python'[:4]  # only stop
'Pyth'
>>> 'Python'[1:-1] # start & negative stop
'ytho'
>>> 'Python'[::2]  # only step
'Pto'
```

In general, the `step` must match the direction of `stop - start`. For example, `'Python'[4:2]` will return the empty string, which is what you'll expect in this teaser. `::-1` is a special case and will work in reverse.

If you really want to have fun with slices, check out the scientific Python packages such as numpy and pandas that take slicing to another level.[1]

Further Reading

Slicings in the Python Reference

http://docs.python.org/3/reference/expressions.html#slicings

String Slicing in the Python Tutorial

http://docs.python.org/3/tutorial/introduction.html#strings

slice Class

http://docs.python.org/3/library/functions.html#slice

"Extended Slices" in Python 2.3 "What's New"

http://docs.python.org/3/whatsnew/2.3.html#extended-slices

Scientific Python Documentation

http://docs.scipy.org/doc/numpy/reference/arrays.indexing.html

Puzzle 29	Not My Type

add.py

```
def add(a: int, b: int) -> int:
    return a + b



val = add('1', '2')
print(val)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will print: `12`

Python 3 added support for type hints. But as the name suggests, they are only hints and are not enforced by the Python interpreter. The only thing Python does with these hints (sometimes called *anno-*

tations) is to add them to the function object as the `__annotations__` attribute.

```
>>> add.__annotations__
{'a': int, 'b': int, 'return': int}
```

Over time, type annotation became more powerful. You can annotate variables (e.g., `answer: int = 42`) and attributes. There's a dedicated `typing` module and more.

You might wonder why type annotation is so popular. Here are some reasons:

Correctness
There are external tools such as `mypy` that will check type correctness. Some teams have `mypy` as part of the test suite.

Documentation
Seeing a definition like `def current_user(session: dict) → User:`, you know what the input and output types are.

Tooling
Once a tool knows the type of objects, it can be smarter. Most IDEs (such as PyCharm) use type annotation to help with completion.

Code

Once you have annotations, you can write modules such as `dataclasses`.

Back to our teaser. You add `'a'` and `'b'`, which are of type `str`. The `+` operator, defined by `__add__`, in `str` does concatenation, for example, `'a' + 'b'` → `'ab'`.

Further Reading

PEP-3107: Function Annotations

http://python.org/dev/peps/pep-3107/

`typing` Module

http://docs.python.org/3/library/typing.html

`dataclasses` Module for Easy Creation of Classes

http://docs.python.org/3/library/dataclasses.html

PEP 483: The Theory of Type Hints

http://python.org/dev/peps/pep-0483/

PEP 484: Type Hints

http://python.org/dev/peps/pep-0484/

`mypy` Type Checker (which works even for Python 2 code)

http://mypy-lang.org

Puzzle 30	Highly Valued

eval.py

```
a = eval('a = 7')
val = eval('a * 3')
print(val)
```

Guess the Output

Try to guess what the output is before moving to the next page.

This code will raise a `SyntaxError` exception.

The `eval` built-in function takes a Python expression as a string and returns its value.

We tend to split the code into two categories:

Expressions

An expression is something that has a value (e.g., `5 / 7`, `1 < 3`).

Statements

A statement is an operation that does not have a value, mostly with side effects (e.g., `a = 3`, `import csv`).

Some languages only have expressions, and then `a = 3` will have some value (usually `3`). In Python we have both expressions and statements.

The built-in `eval` function only works with expressions, and the parameter we're passing (`a = 3`) is a statement.

If you want to evaluate statements, you'll need to use the built-in `exec` function. `exec` returns `None`, so how can you get the new variable from `exec`? It'll just show up:

```
>>> exec('answer = 42')
>>> answer
42
```

By default, `exec` will change the global symbol. You can also pass it a `locals` dictionary to work with if you don't want to contaminate the global namespace.

```
  >>> env = {}
①>>> exec('answer = 42', None, env)
  >>> env
```

```
{'answer': 42}
②>>> answer
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'answer' is not defined
```

① `None` argument is for the global symbol table and defaults to `globals`
`answer` not found in the global symbol table

② `eval` gives you a lot of power but can be very dangerous. If you `eval` (or `exec`) a random string from a user, bad things can happen. Modules such as the built-in `pickle` and the external `PyYaml` use `exec` under the hood. In short, follow Agent Mulder's advice and "trust no one."

Further Reading

`eval` Documentation
http://docs.python.org/3/library/functions.html#eval

`exec` Documentation
http://docs.python.org/3/library/functions.html#exec

`globals` Documentation
http://docs.python.org/3/library/functions.html#globals

"Expressions" in the Python Documentation

http://docs.python.org/3/reference/expressions.html#expressions

“Simple Statements” in the Python Documentation

http://docs.python.org/3/reference/simple_stmts.html

Expression on Wikipedia

http://en.wikipedia.org/wiki/Expression_(computer_science)

Statement on Wikipedia

http://en.wikipedia.org/wiki/Statement_(computer_science)

Possible Use for ***eval*** *and* ***exec***

http://github.com/tebeka/ingress

PyYAML ***yaml.load(input)*** *Deprecation*

http://github.com/yaml/pyyaml/wiki/PyYAML-yaml.load(input)-Deprecation

Warning in pickle Documentation

http://docs.python.org/3/library/pickle.html#restricting-globals

XKCD’s Exploits of a Mom

http://xkcd.com/327/

Agent Mulder

http://en.wikipedia.org/wiki/Fox_Mulder

FOOTNOTES

[1] http://numpy.org and http://pandas.pydata.org

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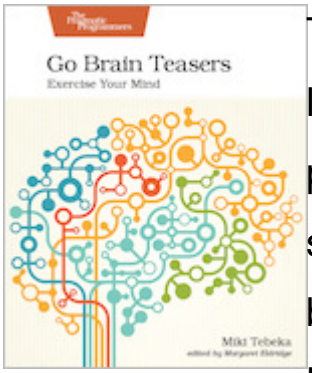

This book contains 25 short programs that will challenge your understanding of Go. Like any big project, the Go developers had to make some design decisions that at times seem surprising. This book uses those quirks as a teaching opportunity. By understanding the gaps in your knowledge, you'll become better at what you do. Some of the teasers are from the author's experience shipping bugs to production, and some from others doing the same. Teasers and puzzles are fun, and learning how to solve them can teach you to avoid programming mistakes and maybe even impress your colleagues and future employers.

Miki Tebeka

(78 pages) ISBN: 9781680508994 $18.95

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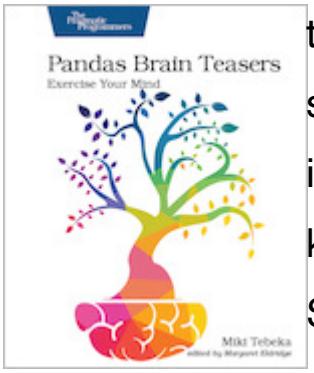

to make some design decisions that at times seem surprising. This book uses those quirks as a teaching opportunity. By understanding the gaps in your knowledge, you'll become better at what you do. Some of the teasers are from the author's experience shipping bugs to production, and some from others doing the same. Teasers and puzzles are fun, and learning how to solve them can teach you to avoid programming mistakes and maybe even impress your colleagues and future employers.

Miki Tebeka

(77 pages) ISBN: 9781680509014 $18.95

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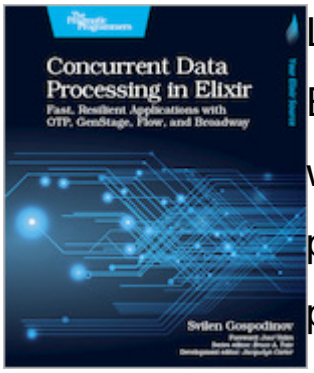

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these questions, start building highly concurrent applications in no time, and write code that's not only fast, but also resilient to errors and easy to scale.

Svilen Gospodinov

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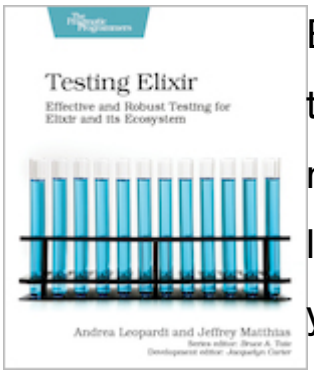

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Andrea Leopardi and Jeffrey Matthias

(262 pages) ISBN: 9781680507829 $45.95

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David Muller

(140 pages) ISBN: 9781680508239 $26.95

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Ken Kousen

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Dmitri Sotnikov and Scot Brown

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Herbert Wolverson

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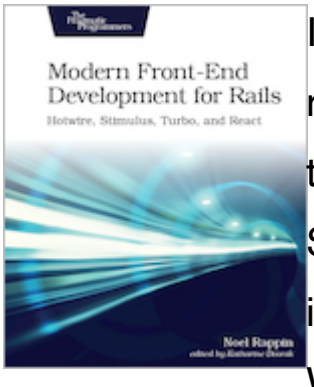

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