Python Basics

Week 1 of Python For LM

Today in Python For LM

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- Brief Review
- The Data Model
- String Formatting
- File I/O
- Modules
- Virtual Environments

Brief Review

Brief Review

- Interactive interpreter
- Comments
- Variables and types
- Numbers and Booleans
- Strings and lists
- Console I/O
- Control Flow
- Loops
- Functions
- Assignment Expressions

Interactive Interpreter

Python is interpreted, and we can get direct access to its interpreter…

Run Python code in real-time.

```
psarin$
```

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Run Python code in real-time.

```
psarin$ python3
Python 3.8.0 (v3.8.0:fa919fdf25, Oct 14 2019, 10:23:27)
[Clang 6.0 (clang-600.0.57)] on darwin
Type "help", "copyright", "credits" or "license" for more
information.
>>>
```

Comments

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lecturers = [
    'Abdallah' # imma let you finish, but...
    ...
]
```

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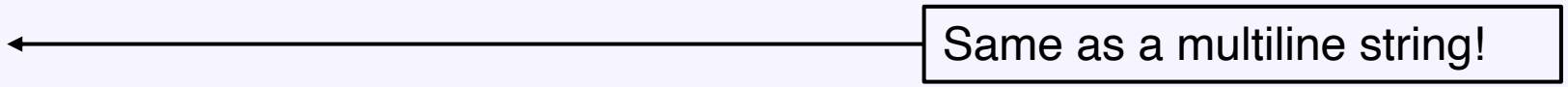
In Python, they start with an octothorpe (pound sign).

```
# Is this thing on?
lecturers = [
    'Abdallah' # imma let you finish, but...
    ...
]
"""
It's turtles
all
the
way
down.
"""
```



Variables and Types (so far…)

Python is *dynamically typed*. Variables don't have a type, but objects do!

```
abdallah= 22
type(abdallah) # => int
```

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Python is *dynamically typed*. Variables don't have a type, but objects do!

```
abdallah= 22
type(abdallah) # => int

abdallah= 'Lecturer, Tunisian'
type(abdallah) # => str
```

Numbers and Booleans

Python has three numeric types: `int`, `float`, and `complex`.

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5     # => 5 (int)
5.0   # => 5.0 (float)
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8_675_309 # => 8675309
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3 + 2    # => 5
3 * 2    # => 6
3 ** 2   # => 9
13 / 4   # => 3.25
```

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3 + 2    # => 5
3 * 2    # => 6
3 ** 2   # => 9
13 / 4   # => 3.25

(3**2 + 4**2) ** (1/2) # => 5.0
```

Always a float when the exponent is a float.

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True and False    # => False
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2 + 3 != 5         # => False
1 < 2 < 3          # => True (1 < 2 and 2 < 3)
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(True + 1) * 5
# => 10 (please, please, please don't do this)
```
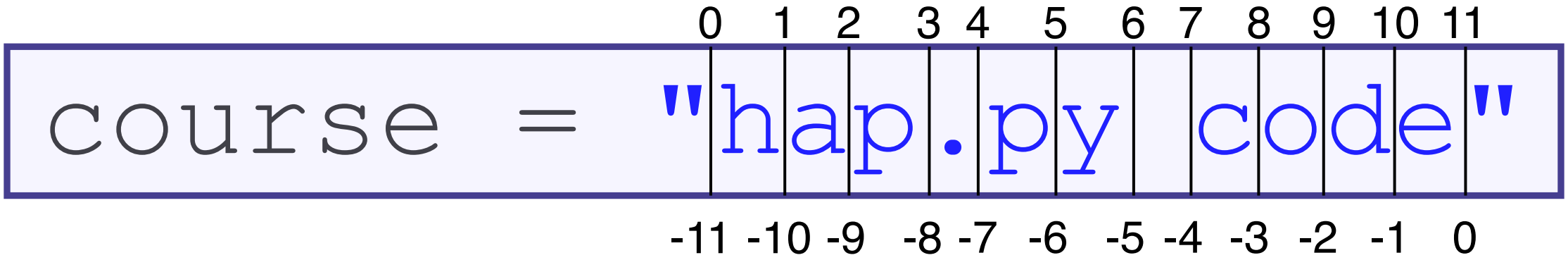

Strings and Lists



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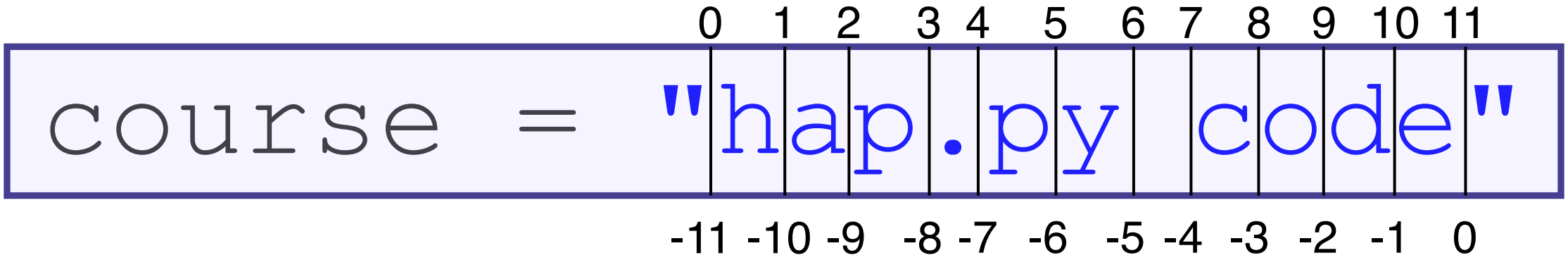
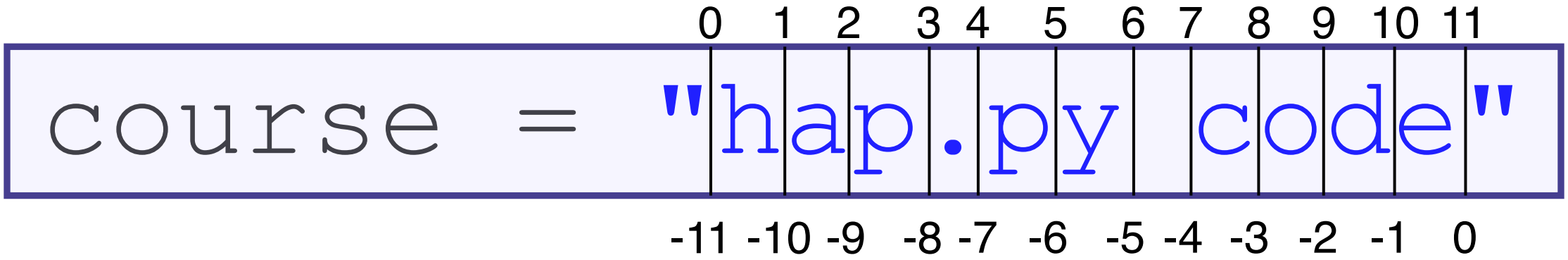



```
course[start:stop:step]
```

Inclusive

Not Inclusive

Strings and Lists

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course[2]          # => 'p'
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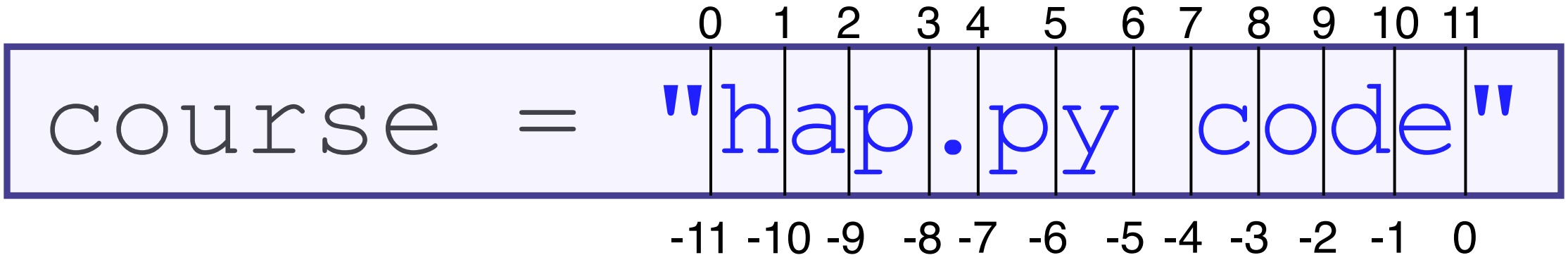


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Not Inclusive

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course[2]       # => 'p'
course[:4]      # => 'hap.'
course[5:]      # => 'y code'
```

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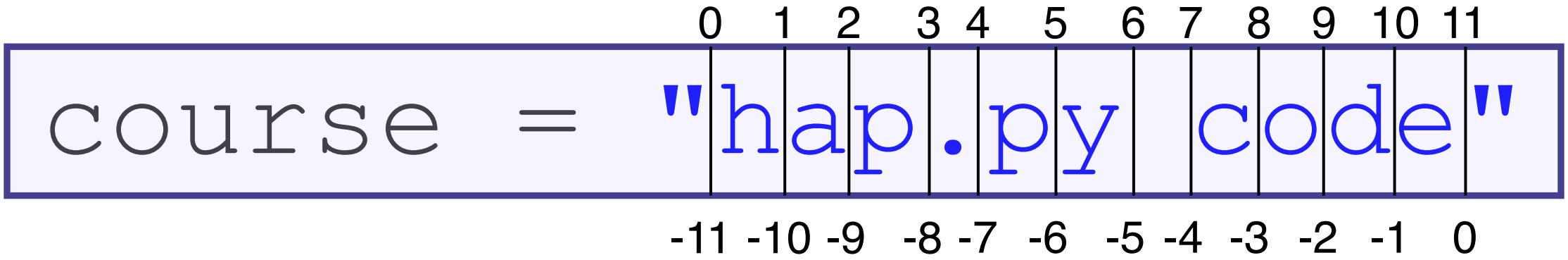


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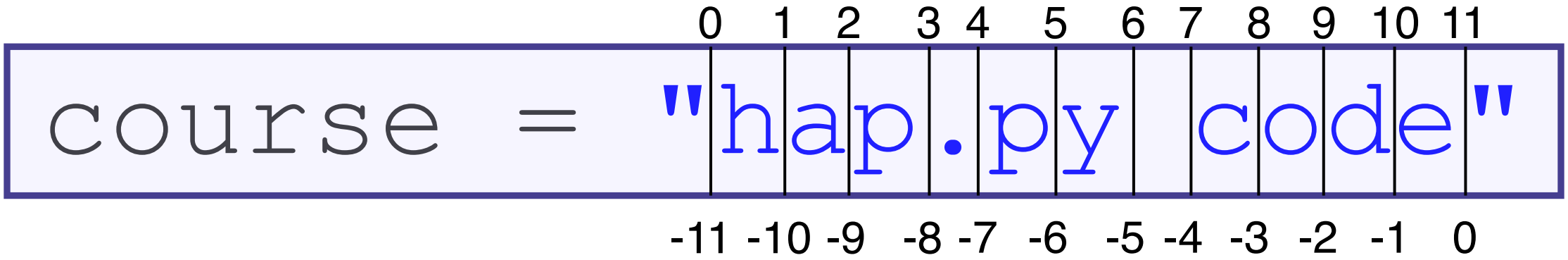
Strings and Lists

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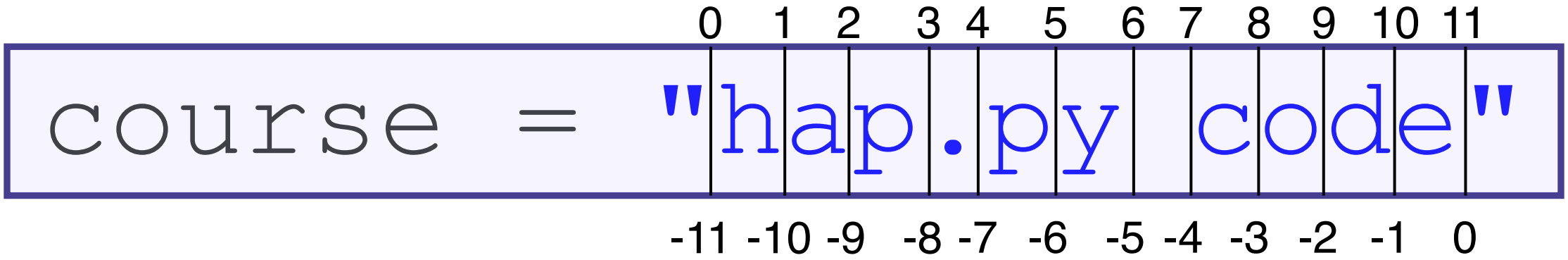


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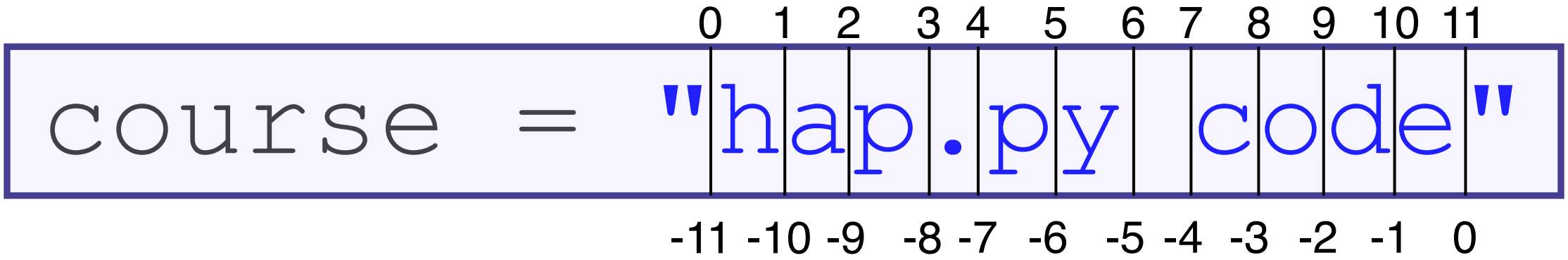


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course[::-1]     # => 'edoc yp.pah'
```

Console I/O

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`input` prompts for input from the terminal

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    print("It's not done yet!")
```

If it's `False`, Python checks `elif` statements sequentially

```
elif = else + if
```

Control Flow

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if time_in_oven == required_time :
    print("Take it out of the oven!")
elif time_in_oven < required_time:
    print("It's not done yet!")
else:
    print("Uhhh... Hate to break it to you...")
```

If it's `False`, Python checks `elif` statements sequentially

`elif = else + if`

Otherwise, Python executes the else statement

Control Flow, Addendum

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Solution!

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Solution!

```
while True:
```

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Solution!

```
while True:
    try:
        n = int(input('How many unicorns would you like? '))
        break
    except ValueError:
        print("Invalid input. Try again...")
```

Control Flow, Addendum

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try:
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Control Flow, Addendum

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Catch multiple exceptions

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except:
    handle_wildcard()
```

Bind a name to the exception

Catch multiple exceptions

Wildcard catches everything

Good Python:
Don’t be a Pokémon Trainer!

Control Flow, Addendum

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while True:
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"I'll just catch 'em all!"

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"I'll just catch 'em all!"

Uh oh! We can't use Control-C to exit!

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Translation: Errors are really lightweight and easy to raise! Use them to handle control flow.

- Just open a file instead of checking first that it exists!
- Just pop an element; don't check that the list is nonempty.

Raise an error with

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Raise an error with `raise SomeError`

Helps prevent race conditions but can often be a source of bugs if you forget to handle all potential exceptions.

Try to remove `filename`. If that fails, deal with the error

```
try:
    os.remove(filename)
except FileNotFoundError:
    pass
```

Loops

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For loops are over some collection of items…

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```

…which can be a range object, producing C++/Java-like loops.

```
for i in range(start, stop, step):
    use_number(i)
```

Functions

```
def is_prime(n):
    for i in range(2, n):
        if n % i == 0:
            return False
    return True
```

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The `def` keyword defines functions

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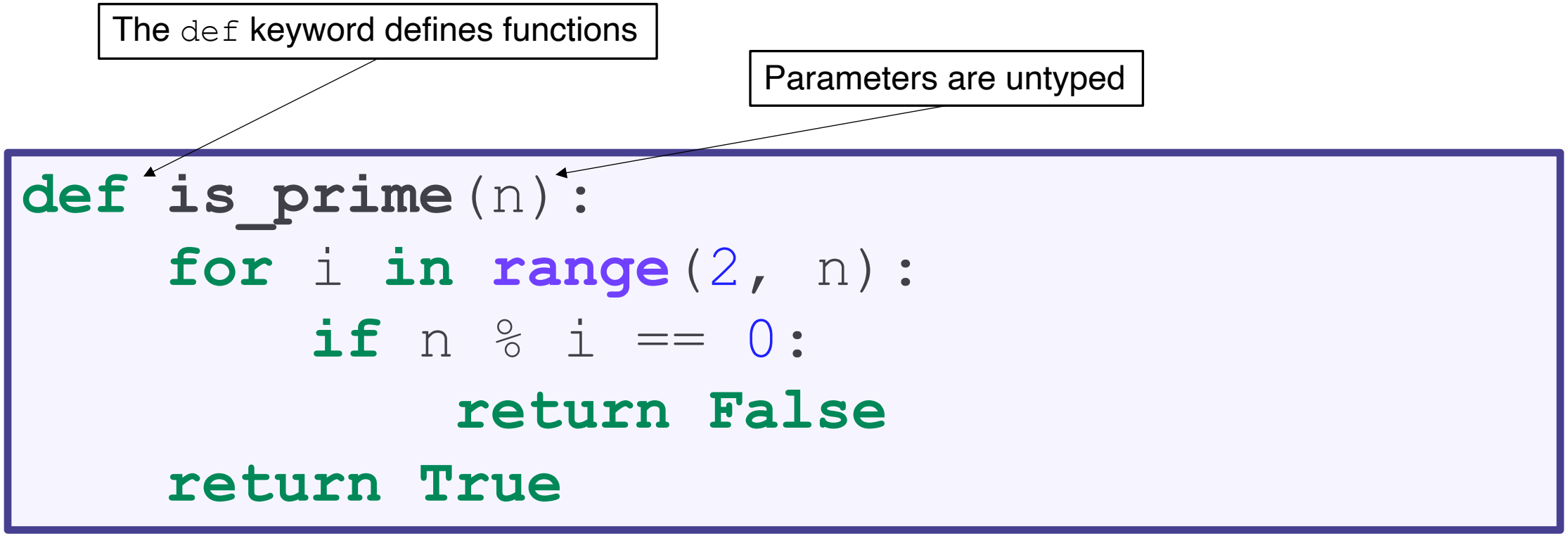
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All functions return something, even if it's `None`

Assignment Expressions

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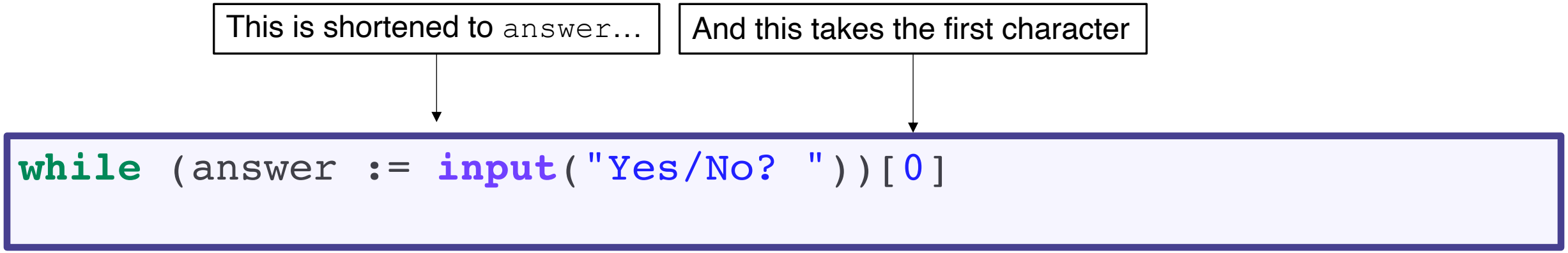

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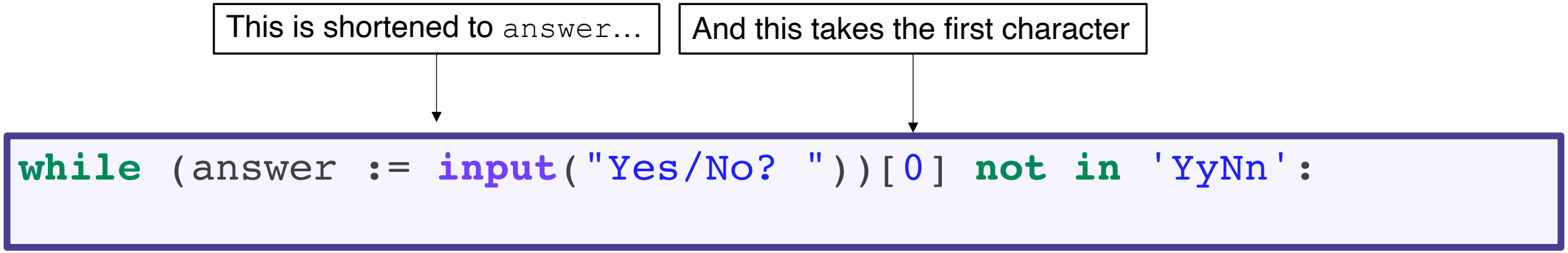

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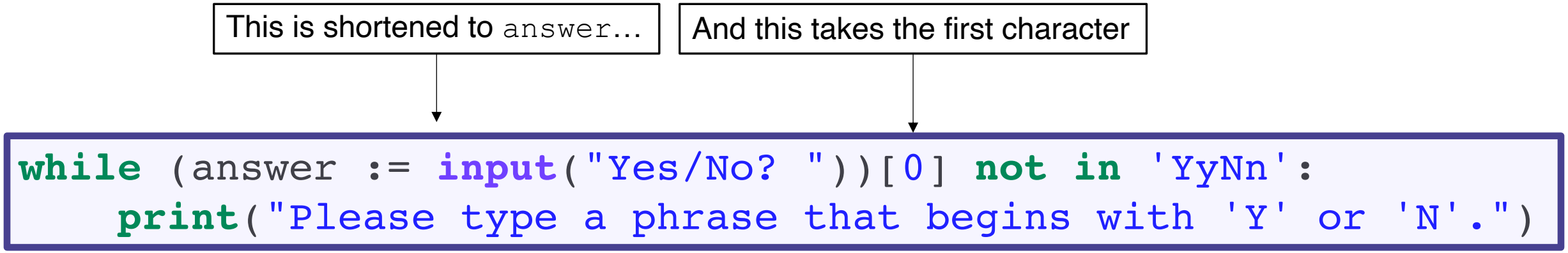

Assignment Expressions

Because of the execution order, you can do operations on the assignment variable without storing them!

This is shortened to `answer`...

And this takes the first character

```
while (answer := input("Yes/No? "))[0] not in 'YyNn':
    print("Please type a phrase that begins with 'Y' or 'N'.")
```

This is shortened to `answer`...

```
while (answer := input("Enter a palindrome: "))
```

Assignment Expressions

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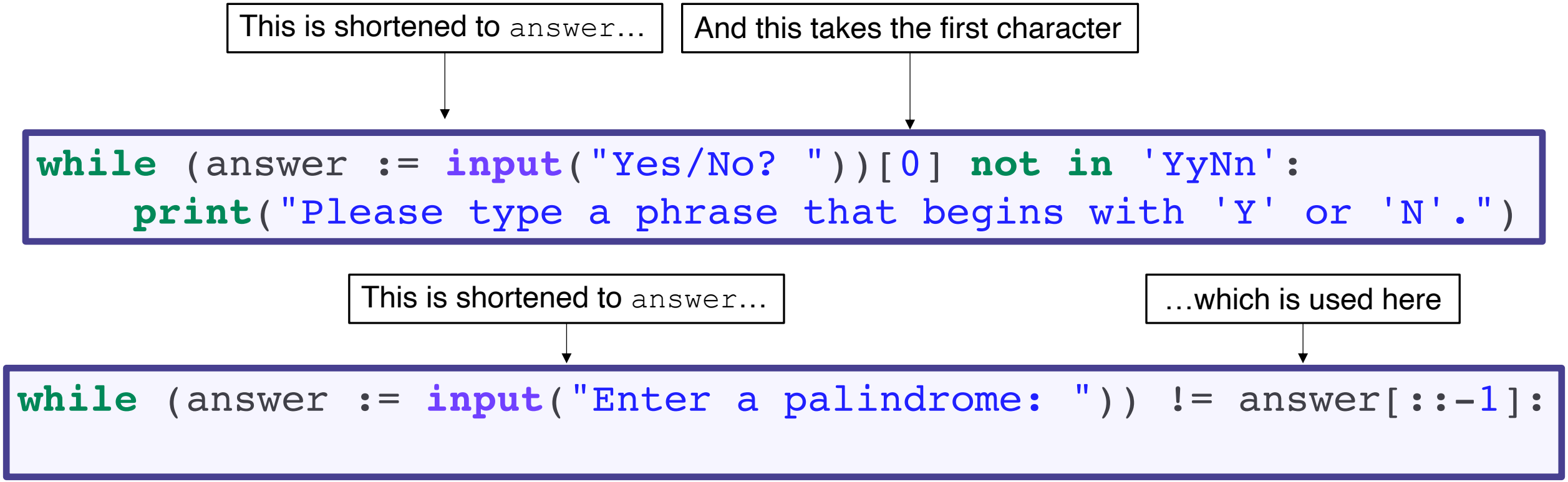

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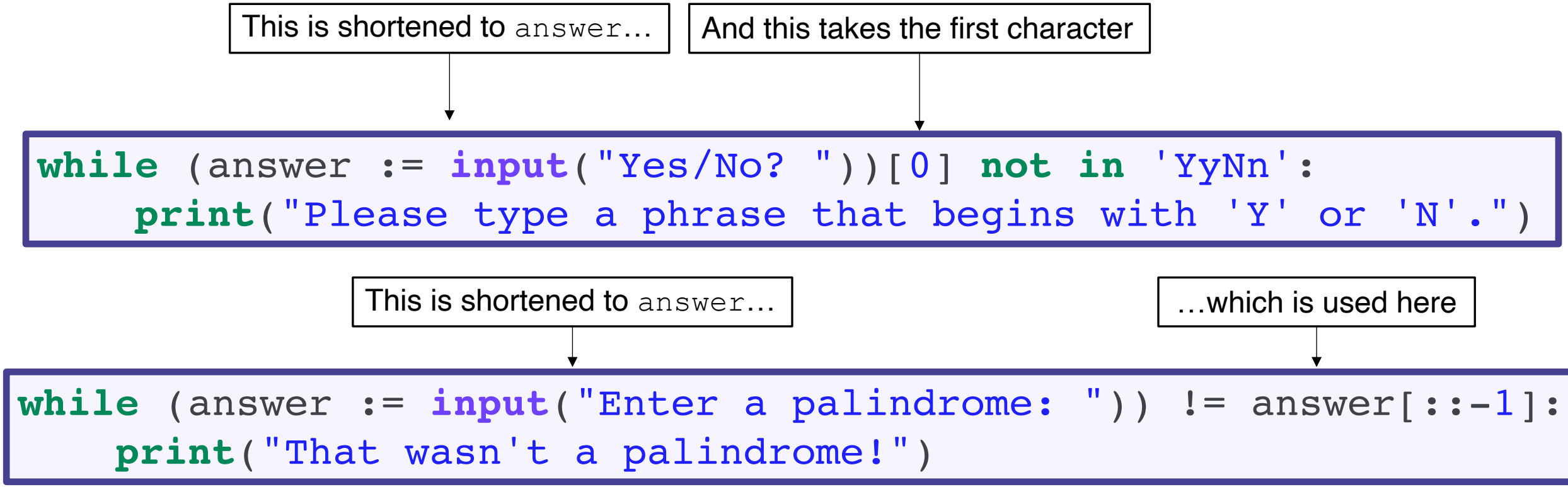

Time for New Stuff!

More on Crazy Cool Python Basics!

The Data Model

Objects

Everything is an object!

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```
isinstance(4, object)                    # => True
```

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```

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```

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isinstance(str, object)                  # => True
isinstance(object, object)               # => True
```

Objects have identity, type, and value
Variables are un-typed (dynamically typed)

Objects have identity

Objects have identity

When objects are created, they're given an identity, which never changes.

- In CPython (an implementation of Python), the identity of an object is the *actual* memory address of the object.

Objects have identity

When Python creates an object for us, the object is given a permanent numerical identity.

- In CPython (an implementation of Python), the identity of an object is the *actual* memory address of the object.

The id function returns the object's "identity."

```
id(41)  # => 4421836688 (e.g.)
```

Objects have type

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The type determines what can be done to an object (e.g., does it have a length?)

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```
type("unicorn")  # => str
type(1)          # => int
type(3.0)        # => float
```

Objects have type

The type determines what can be done to an object (e.g., does it have a length?)

```
type("unicorn")  # => str
type(1)          # => int
type(3.0)        # => float
```

Types are also objects!

```
isinstance(type('unicorn'), object) # => True
```

Objects have value

Objects have value

Objects contain pointers to their underlying data blob.

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Objects contain pointers to their underlying data blob.

This overhead means that even small things take up a lot of space!

```
(41).__sizeof__() # => 28 (bytes)
```

Variables

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Variables are references to objects (little more than a pointer).

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y = "Hello!"
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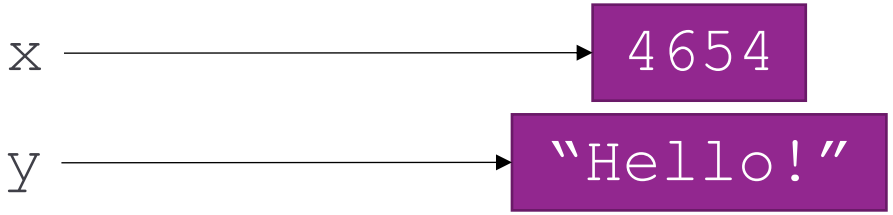

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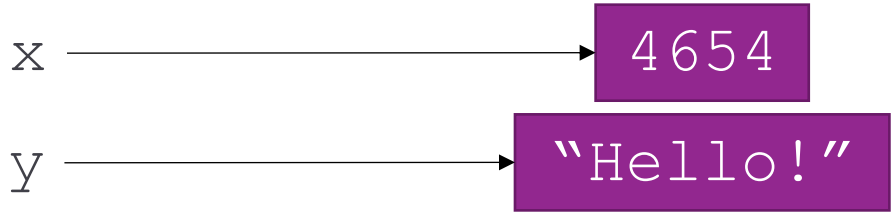

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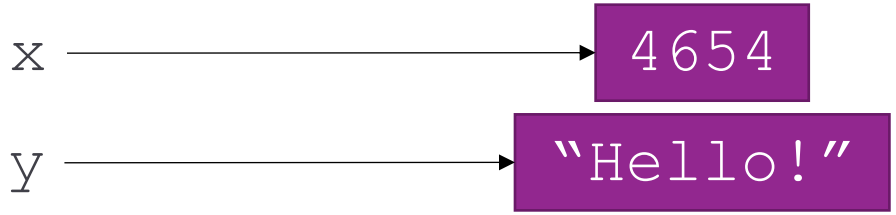

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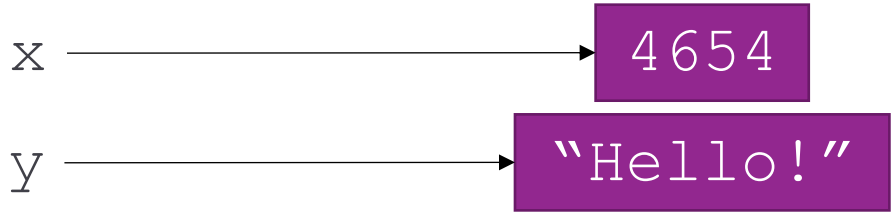

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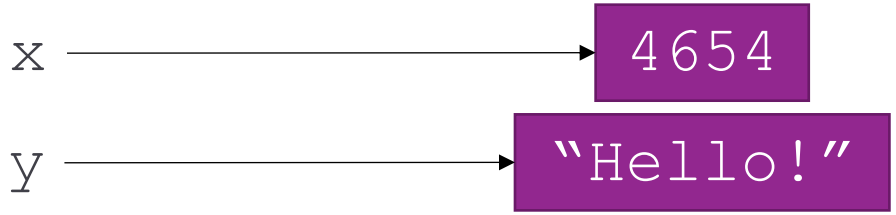

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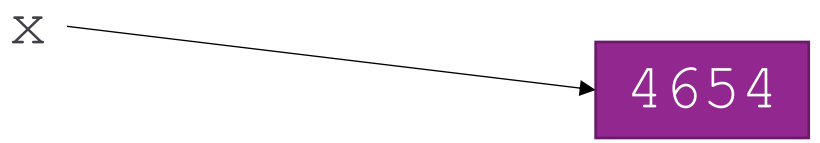

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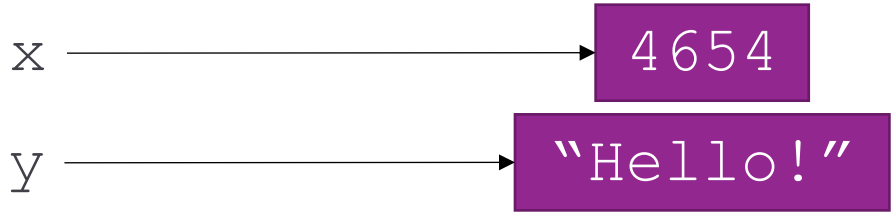

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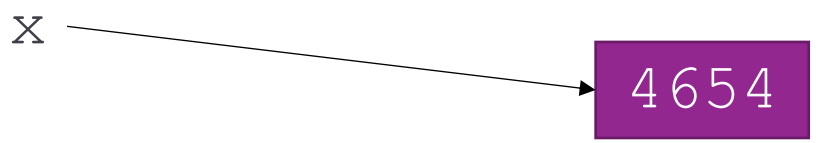

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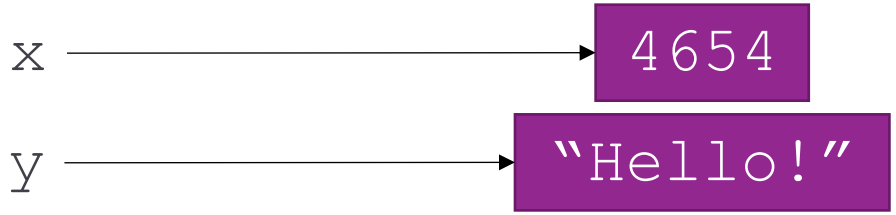

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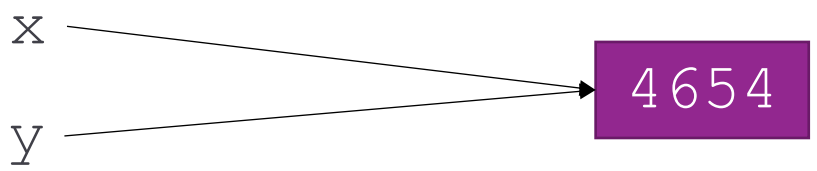

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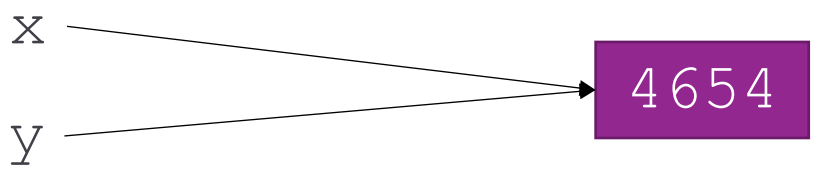

Variables

Remember “Namespaces are one honking great idea!”?

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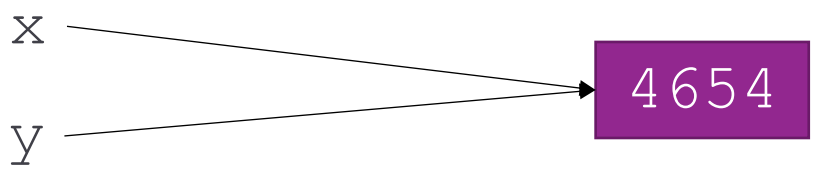

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A Python namespace maintains information about variables and their associations. (Kind of like “scope” in other languages)

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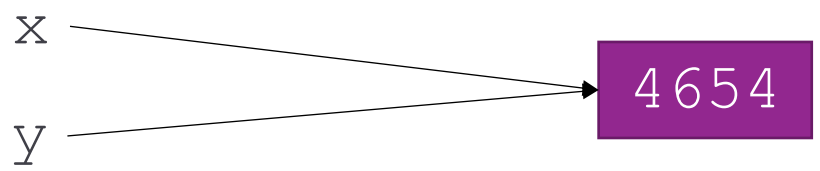

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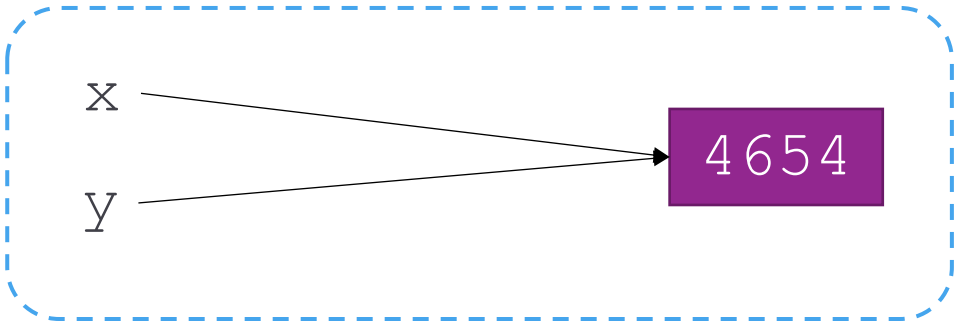


A namespace tracks associations between variables and objects

Variables

Remember “Namespaces are one honking great idea!”?

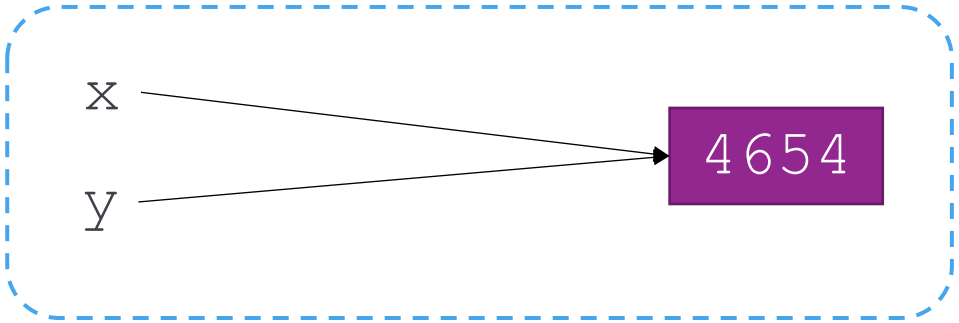
A Python namespace maintains information about variables and their associations. (Kind of like “scope” in other languages)

The namespace is implemented using a dict, and there are several: local, global, module, and more!

`locals()`, `globals()`, etc.

We’ll learn more about dicts next week!

```
x = 4654
y = x
```



A namespace tracks associations between variables and objects

Another piece of Python Philosophy:
Duck Typing

When I see a bird that walks like a duck and swims like a duck and quacks like a duck, I call that bird a duck.

James Whitcomb Riley

Duck Typing

```
def compute(a, b, c):
    return (a + b) * c
```

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compute(4, 1, 3)          # => 15
```

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def compute(a, b, c):
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compute([1], [2, 3], 2) # => [1, 2, 3, 1, 2, 3]
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compute('1', 'olo', 4)    # => 'lolololololololo'
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Write code that does not look at an object's type to determine if it has the right interface.

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Instead, the method or attribute is simply called or used.

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```

Write code that does not look at an object's type to determine if it has the right interface.

Instead, the method or attribute is simply called or used.

All that matters is that `compute`'s arguments support `+` and `*`

Duck Typing

If you can `walk`, `swim`, and `quack`, then you're a `Duck`

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Promotes interface-style generic programming.

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Promotes interface-style generic programming.

We'll see more later – stay tuned!

Aside: `is` vs. `==`

`is` vs. `==`

We've seen == for equality testing

```
1 == 1.0
```

`is` vs. `==`

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but we know these are different… they're different *objects.*

```
type(1) != type(1.0)
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int != float
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The `is` operator checks *identity* instead of *equality.*

```
1 is not 1.0
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`a is not b`
is syntactic sugar for
`not (a is b)`

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`a is not b`
is syntactic sugar for
`not (a is b)`

When comparing `None` against other singletons, always use `is None` instead of `== None`.

Identity Crisis

```
x = "cs41 rocks!"
y = "cs41 "
y += "rocks!"
```

Identity Crisis

```
x = "cs41 rocks!"
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x == y # => True
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id(x)  # => 4512586800
id(y)  # => 4512586672
```

Identity Crisis

```
x = "cs41 rocks!"
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x == y # => True
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[1, 2, 3] is [1, 2, 3] # => ???
```

Identity Crisis

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x = "cs41 rocks!"
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x == y # => True
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[1, 2, 3] is [1, 2, 3] # => False
```
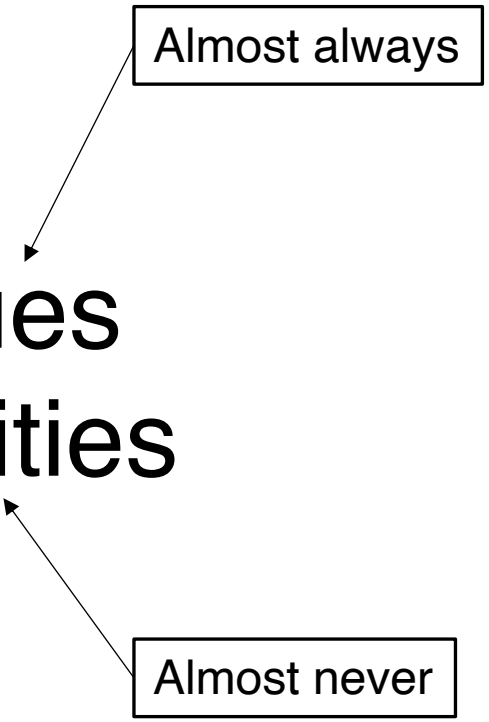

Use `==` when comparing values
Use `is` when comparing identities

Use `==` when comparing values

Use `is` when comparing identities



Strings, Revisited

Special Characters

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print('doesn\'t') # => doesn't
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print('"Yes," he said.')    # => "Yes," he said.
print("\"Yes,\" he said.") # => "Yes," he said.
```

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print('"It isn\'t," she said.') # => "It isn't," she said.
```

Just choose the easiest delimiter to work with!

Useful String Methods

```
greeting = "Hello! Love, unicorn.  "
```

Useful String Methods

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greeting = "Hello! Love, unicorn.  "

greeting[4]           # => 'o'
'corn' in greeting    # => True
len(greeting)         # => 23
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Useful String Methods

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greeting.find('lo')                  # => 3 (-1 if not found)
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greeting.startswith('Hell')          # => True
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greeting.endswith(' ')               # => True
greeting.isalpha()                   # => False
```

Useful String Methods

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Useful String Methods

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greeting = "Hello! Love, unicorn.  "

greeting.lower()          # => 'hello! love, unicorn.'
greeting.title()          # => 'Hello! Love, Unicorn.'
greeting.upper()          # => 'HELLO! LOVE, UNICORN.'
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greeting.strip('.nrH ') # => 'ello! Love, unico'
```

Lists <—> Strings

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```
list('Hair toss!')
# => ['H', 'a', 'i', 'r', ' ', 't', 'o', 's', 's', '!']
```

Lists <—> Strings

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# `.split` partitions by a delimiter...
'ham cheese bacon'.split()
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# ...which can be specified, but defaults to whitespace
'3-14-2015'.split(sep='-')
# => ['3', '14', '2015']
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# ...which can be specified, but defaults to whitespace
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# `.join` creates a string from a list of strings
', '.join(['Zheng', 'Antonio', 'Sam'])
# => 'Zheng, Antonio, Sam'
```

String Formatting

String Formatting

```
# Curly braces are placeholders
'{} {}'.format('beautiful', 'unicorn') # => 'beautiful unicorn'
```

String Formatting

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'{} {}'.format('beautiful', 'unicorn') # => 'beautiful unicorn'

# Provide values by position or placeholder
'{0} can be {1} {0}, even in summer!'.format('snowmen', 'frozen')
# => 'snowmen can be frozen snowmen, even in summer!'
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String Formatting

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'{} {}'.format('beautiful', 'unicorn') # => 'beautiful unicorn'

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'{0} can be {1} {0}, even in summer!'.format('snowmen', 'frozen')
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'{name} loves {food}'.format(name='Michael', food='applesauce')
# => 'Michael loves applesauce' (he does)
```

String Formatting

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# Curly braces are placeholders
'{} {}'.format('beautiful', 'unicorn') # => 'beautiful unicorn'

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# => 'snowmen can be frozen snowmen, even in summer!'

'{name} loves {food}'.format(name='Michael', food='applesauce')
# => 'Michael loves applesauce' (he does)

# Values are converted to strings
'{} squared is {}'.format(5, 5**2) # => '5 squared is 25'
```

String Formatting

String Formatting

```
# You can use C-style specifiers too!
"{:06.2f}".format(3.14159) # => '003.14'
```

String Formatting

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'{:10}'.format('left') # => 'left      '
'{:*^12}'.format('1LMX') # => '****1LMX****'
```

String Formatting

```
# You can use C-style specifiers too!
"{:06.2f}".format(3.14159) # => '003.14'

# Padding can be specified as well.
'{:10}'.format('left') # => 'left      '
'{:*^12}'.format('1LMX') # => '****1LMX****'

# You can even look up values!
captains = ['Kirk', 'Picard']
"{caps[0]} > {caps[1]}".format(caps=captains)
```

(Other Options for) String Formatting

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```
# String concatenation with +
"I am " + str(age) + " years old."
```

(Other Options for) String Formatting

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"I am " + str(age) + " years old."

# Formatted string literals (only on Python 3.6+)
f"I am {age} years old."
f"{', '.join(['Zheng', 'Antonio', 'Sam'])} are awesome!"
```

(Other Options for) String Formatting

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# String concatenation with +
"I am " + str(age) + " years old."

# Formatted string literals (only on Python 3.6+)
f"I am {age} years old."
f"{', '.join(['Zheng', 'Antonio', 'Sam'])} are awesome!"
```

`.format` is generally the safest, fastest option

Break for “Half”time!

Announcements

Onwards and Upwards!

Week 1 of Python For LM

Today in Python For LM

- Brief Review
- The Data Model
- String Formatting
- File I/O
- Modules
- Virtual Environments

Week 1 of Pyhton For LM

Today in Python For LM

- Brief Review
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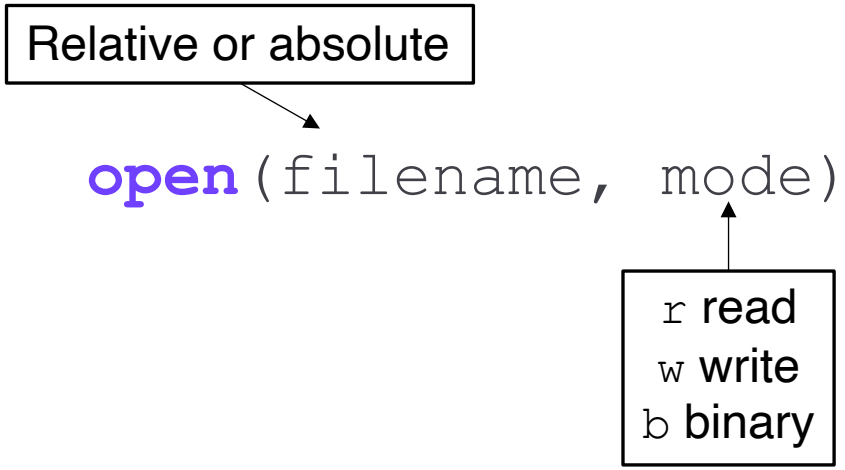
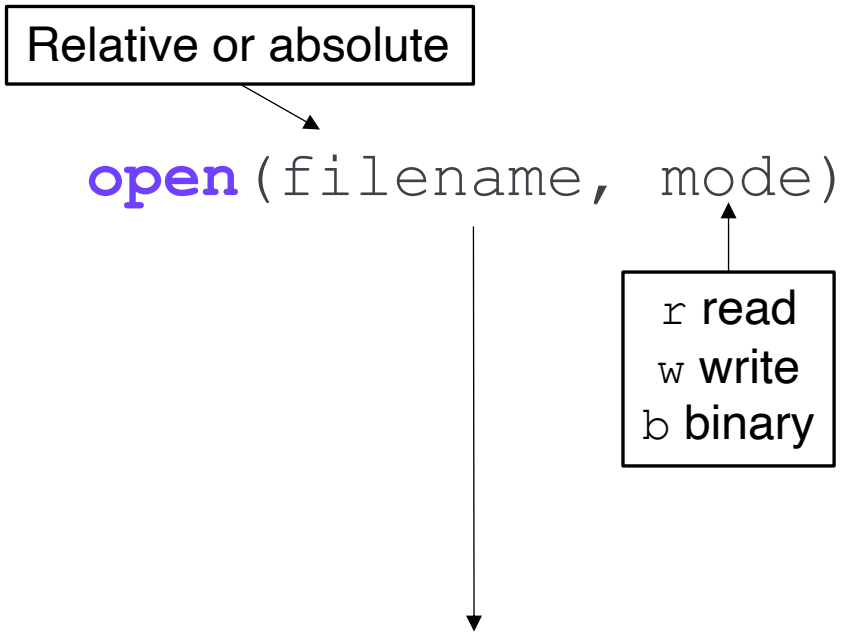
- Virtual Environments

File I/O

```
open(filename, mode)
```


Relative or absolute
open(filename, mode)
r read
w write
b binary


Relative or absolute
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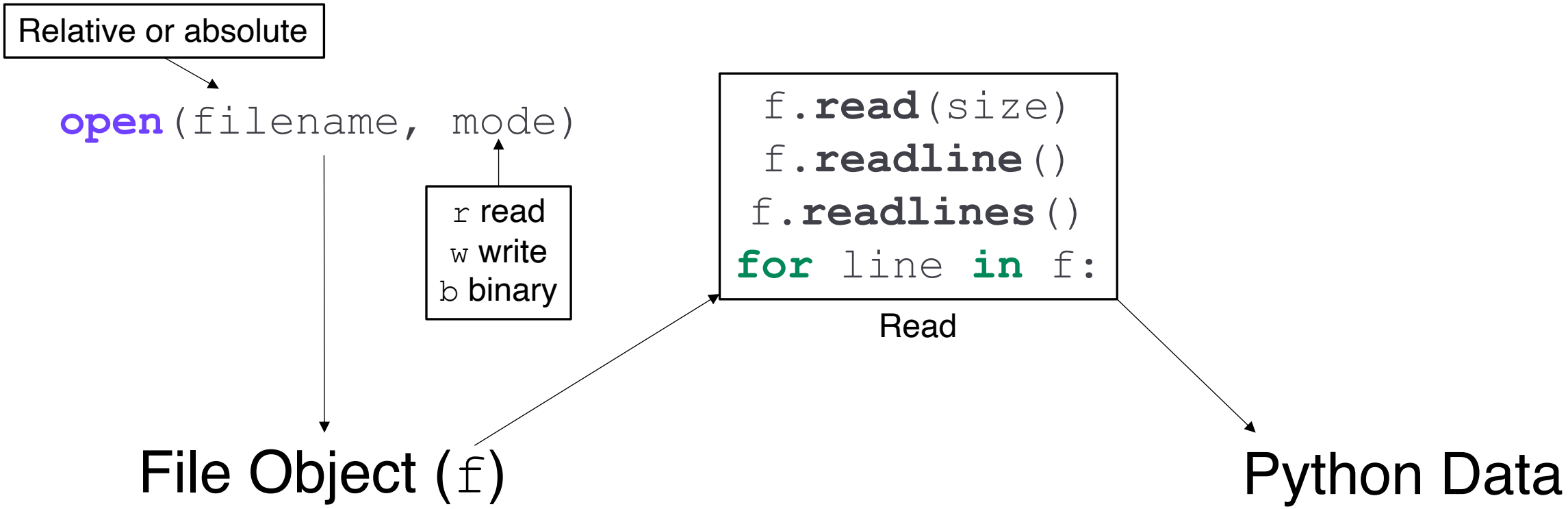
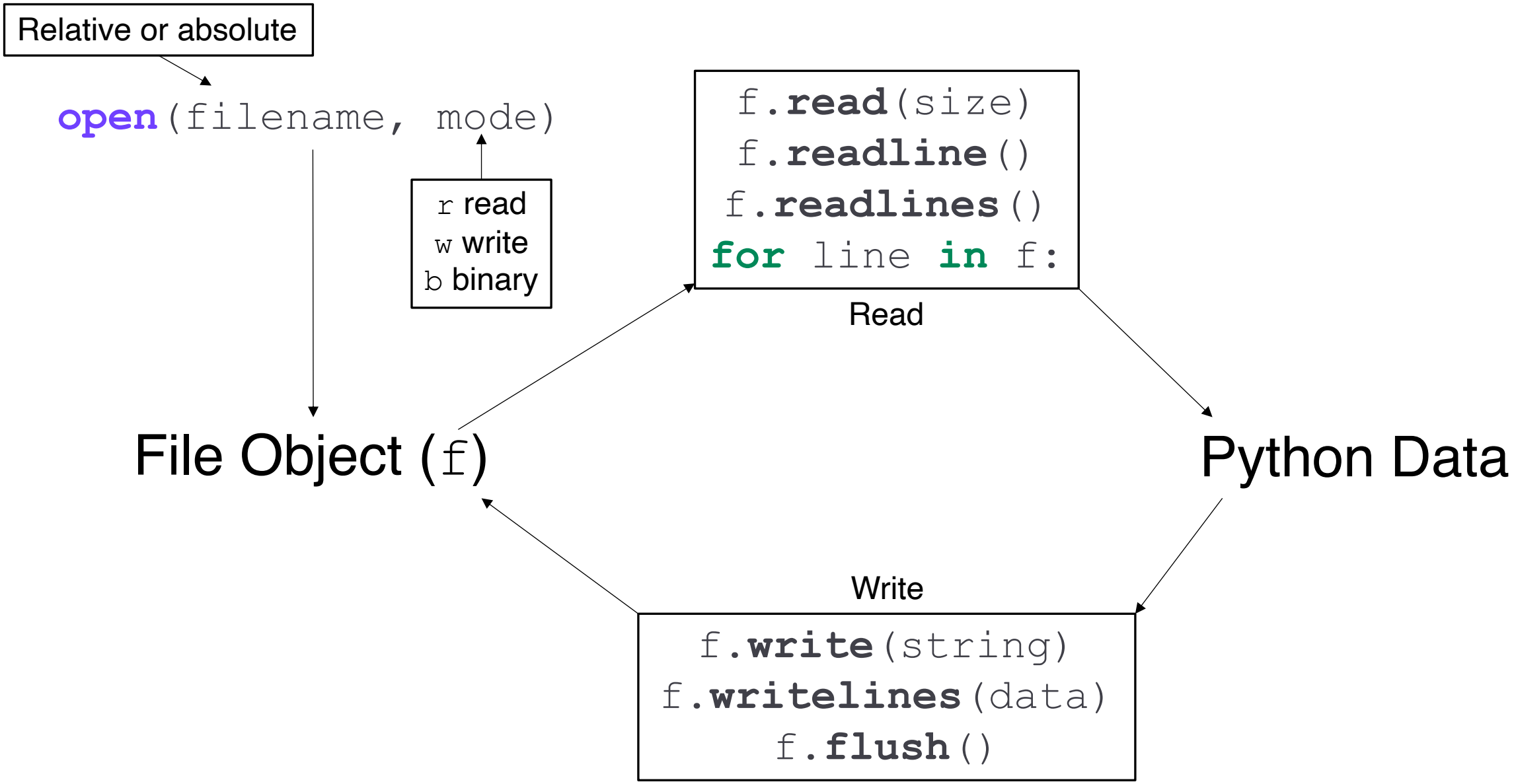
File Object (f)


Relative or absolute
open(filename, mode)
r read
w write
b binary
f.read(size)
f.readline()
f.readlines()
for line in f:
Read
File Object (f)
Python Data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f.read(size)
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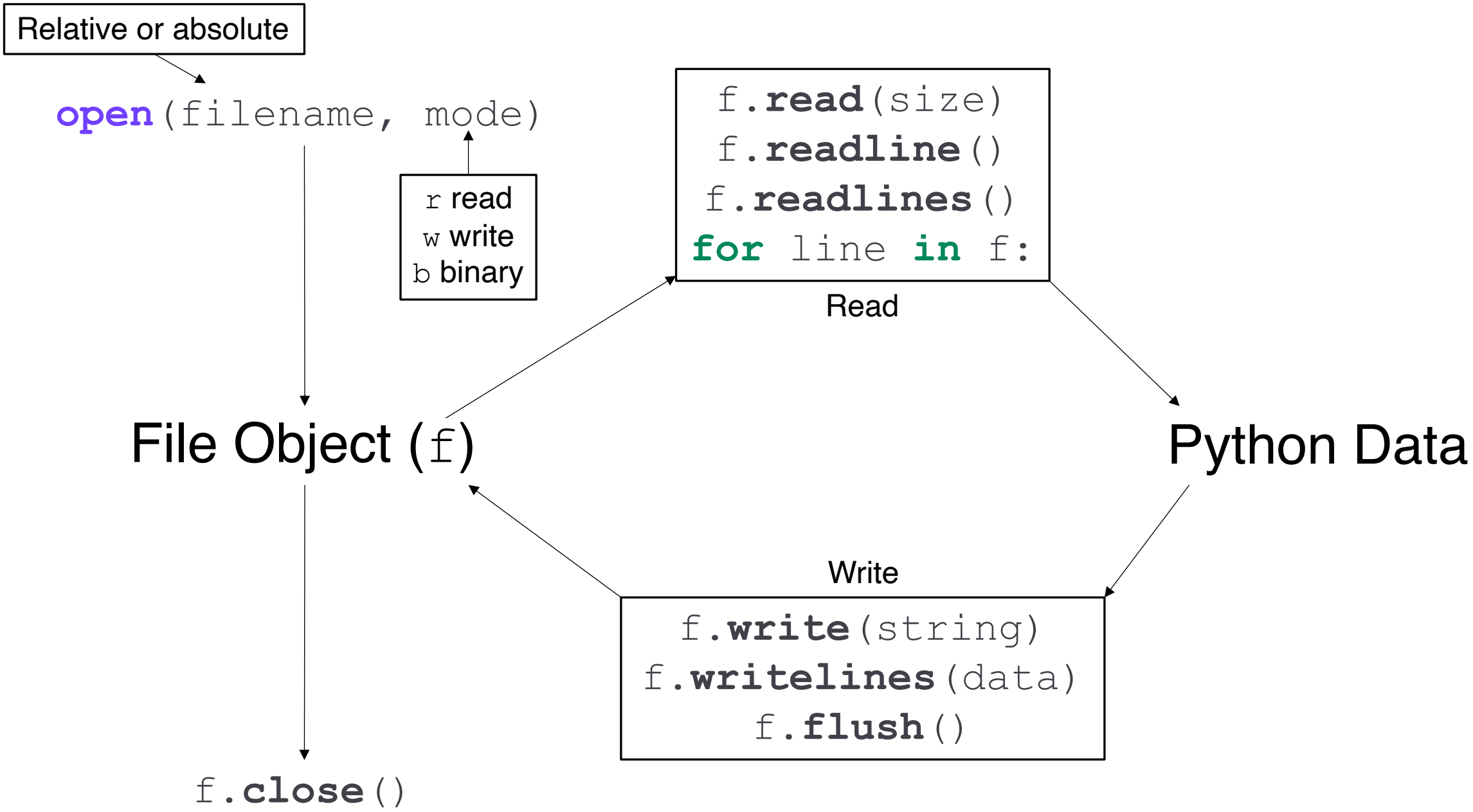
Read
File Object (f)
Python Data
Write
f.write(string)
f.writelines(data)
f.flush()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A Motivating Example

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```
f = open('knights.txt')
```

```
Lancelot 6 0
Galahad 7 12
Geraint 3 1
Mordred 0 0
```

knights.txt

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Galahad 7 12
Geraint 3 1
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knights.txt

A Motivating Example

```
f = open('knights.txt')
for line in f:
    data = line.split()

    name = data[0]
    wins = int(data[1])
    losses = int(data[2])
```

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Galahad 7 12
Geraint 3 1
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```

knights.txt

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f = open('knights.txt')
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    losses = int(data[2])

    win_percent = 100 * wins / (wins + losses)
```

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Lancelot 6 0
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knights.txt

Something goes wrong…

A Motivating Example

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f = open("file.txt", "r")
print(1 / 0) # Crash!
f.close() # Never executes!
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We never close the file! That's bad!

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with open('file.txt', 'r') as f:
    content = f.read()
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We never close the file! That's bad!

```
with open('file.txt', 'r') as f:
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```

`with expr as var` ensures that `expr` will be "entered" and "exited" regardless of the code block execution

Be responsible:
Use context management to prevent sad unicorns!

```
with open('file.txt', 'r') as f:
```

Modules

So far: The Interactive Interpreter

```
psarin$ python3
Python 3.8.0 (v3.8.0:fa919fdf25, Oct 14 2019, 10:23:27)
[Clang 6.0 (clang-600.0.57)] on darwin
Type "help", "copyright", "credits" or "license" for more
information.
>>>
```

So far: The Interactive Interpreter

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Problem: Code is temporary!

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information.
>>>
```

Problem: Code is temporary!
Solution: Write the code in a file!

In Files

hello.py

In Files

hello.py

```
#!/usr/bin/env python3
"""Ask the user's name and greet them."""

def greet(name):
    print("Hey, {}! I'm Python.".format(name))

def main():
    name = input("What is your name? ")
    greet(name)

if __name__ == '__main__':
    main()
```

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Shebang specifies executables and options

In Files

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Shebang specifies executables and options

`__name__` is set to `'__main__'` if the file is executed as a script

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Running Scripts

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```
psarin$ python3 my_script.py
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Running Scripts

```
psarin$ python3 my_script.py
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psarin$ python3 hello.py
What is your name?
```

Running Scripts

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What is your name? Unicorn
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Running Scripts

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Hey Unicorn! I'm Python.

psarin$
```

Running Scripts: Interactive Mode

```
psarin$ python3 -i hello.py
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Running Scripts: Interactive Mode

```
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What is your name? Unicorn
Hey Unicorn! I'm Python.
>>>
```

Super useful for debugging!

We'll see more ways to debug… Stay tuned!

Running Scripts: Interactive Mode

```
psarin$ python3 -i hello.py
What is your name? Unicorn
Hey Unicorn! I'm Python.
>>> greet('Michael')
Hey Michael! I'm Python.
>>>
```

Super useful for debugging!

We'll see more ways to debug… Stay tuned!

Running Scripts as Executables

```
psarin$ chmod +x hello.py
```

The shebang line specifies how the script should be run, when it's called as an executable

Running Scripts as Executables

```
psarin$ chmod +x hello.py
psarin$ ./hello.py
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psarin$
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Using Modules

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# Import a module.
import math
math.sqrt(16) # => 4.0
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import why_did_anyone_name_a_module_this_long as short_module

# *Any* python file (including those you write) is a module.
from my_file import my_fn, my_variable
```

Virtual Environments

What is a virtual environment?

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A local, isolated Python environment.

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- Can run an isolated interpreter environment…
- …install third party libraries…
- …and write/run scripts.

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But… why?

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But… why?

- Imagine one application uses SuperCoolLibrary v1 but another uses SuperCoolLibrary v2.

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- Imagine one application uses SuperCoolLibrary v1 but another uses SuperCoolLibrary v2.
- We'll use Python 3, but many computers default to Python 2.7.

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- …and write/run scripts.

But… why?

- Imagine one application uses SuperCoolLibrary v1 but another uses SuperCoolLibrary v2.
- We'll use Python 3, but many computers default to Python 2.7.
- Solution: Create an isolated sandbox for this course.

An Analogy: Building a Unicorn Shelter

Unicorn World

Default Toolshed

Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
Rusted Nails

We want to build a unicorn shelter, but we don't want to use the default tools!

An Analogy: Building a Unicorn Shelter

Unicorn World

Default Toolshed

Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
Rusted Nails

My Unicorn Shelter

Wood? Rotten
Nails? Rusted
Shingles? Not magical!

We want to build a unicorn shelter, but we don't want to use the default tools!

An Analogy: Building a Unicorn Shelter

Unicorn World

Default Toolshed

Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
Rusted Nails

Solution 1: Get new tools and keep them in my shelter, **where I'm working**

An Analogy: Building a Unicorn Shelter

Unicorn World

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Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
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My Unicorn Shelter

New Wood
Magical Shingles
Good Hammer
Shiny Nails

Solution 1: Get new tools and keep them in my shelter, **where I'm working**

An Analogy: Building a Unicorn Shelter

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Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
Rusted Nails

My Unicorn Shelter

New Wood
Magical Shingles
Good Hammer
Shiny Nails

But, what if we want to build a new unicorn shelter? We need some way to **share the new tools**

Solution 1: Get new tools and keep them in my shelter, **where I'm working**

An Analogy: Building a Unicorn Shelter

Unicorn World

Default Toolshed

Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
Rusted Nails

My Unicorn Shelter

Using tools from
Parth's Toolshed

Parth's Toolshed

New Wood
Magical Shingles
Good Hammer
Shiny Nails

Solution 2: Put the tools in a **toolshed**

An Analogy: Building a Unicorn Shelter

Unicorn World

Default Toolshed

Rotten Wood
Un-magical Shingles (the magic wore off)
Broken Hammer
Rusted Nails

My Unicorn Shelter

Using tools from
Parth's Toolshed

Another Unicorn Shelter

Using tools from
Parth's Toolshed

Parth's Toolshed

New Wood
Magical Shingles
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Solution 2: Put the tools in a **toolshed**

Virtual Environments: Unicorn Shelters in Practice

Your Computer

System Installation

Packages installed on your global version of Python.

Virtual Environments: Unicorn Shelters in Practice

Your Computer

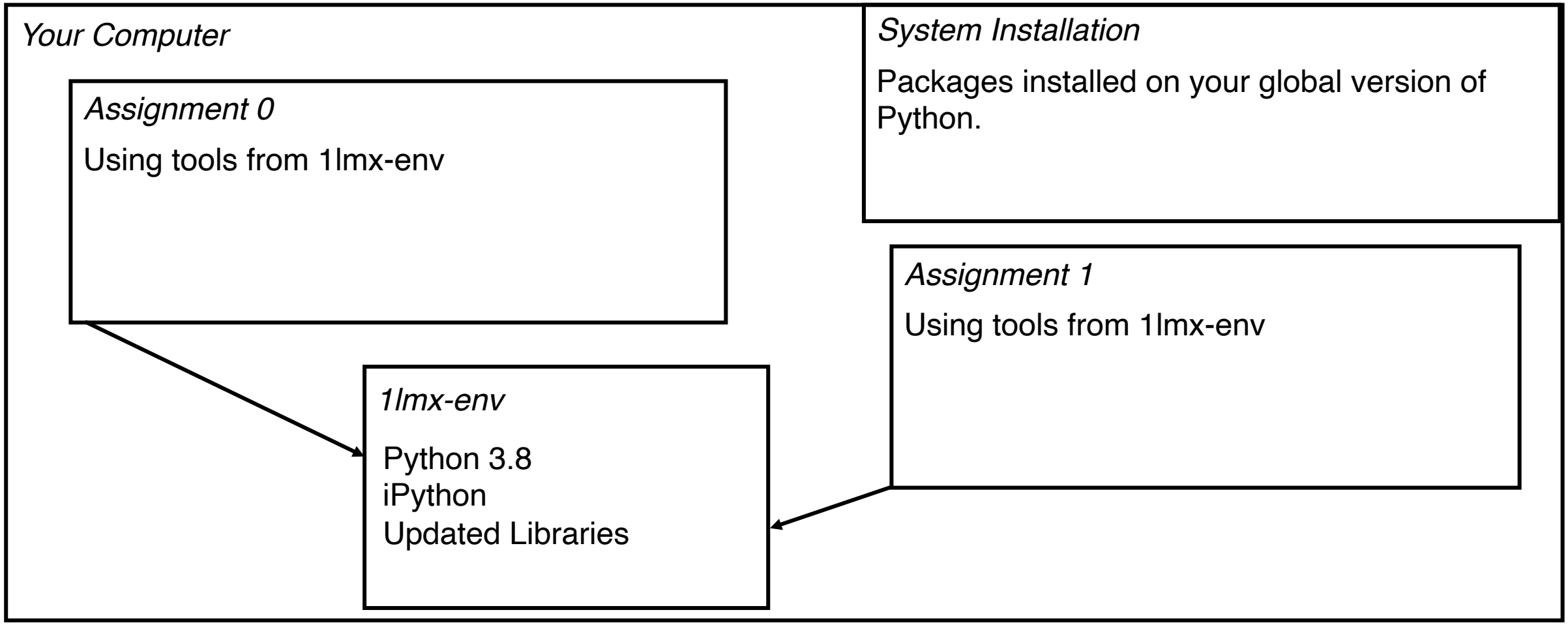
System Installation

Packages installed on your global version of Python.

1lmx-env

Python 3.8
iPython
Updated Libraries

Virtual Environments: Unicorn Shelters in Practice



Virtual Environments: Unicorn Shelters in Practice

Your Computer

Assignment 0

Using tools from 1lmx-env

System Installation

Packages installed on your global version of Python.

Assignment 1

Using tools from 1lmx-env

1lmx-env

Python 3.8
iPython
Updated Libraries

Unicorn, watching you code

How do I get new tools?

How do I get new tools?

Use `pip`! It's the preferred package manager.

```
pip install numpy
```

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```
pip install numpy
```

When you can, use pip instead of:

`conda` – less flexible, less supported

`pipenv` — newer, less stable

`python setup.py install` — building from source (longer, riskier)

High Level: Setting up the Toolshed

1. Install Python 3.8 or ++
2. Create a *virtual environment* that uses Python 3.8
   (and learn how to activate/deactivate the virtual environment)
3. Install and upgrade packages in the virtual environment

Optional: Use `virtualenvwrapper` for managed environments.

Detailed instructions online!

Next Time

Transition

Moving from Python *basics and syntax* to *tools and tricks*.

Week 2: Data Structures

Week 3: Functions

Week 4: Functional Programming

Week 5: Python & the Web