Introduction to Python
Topics

Christopher Barker

UW Continuing Education

October 15, 2013

Table of Contents

Review of Previous Class

- .
- .
- .

Lightning Talks

Lightning talks today:

Nate Flagg

Duane Wright

Jo-Anne Antoun

Josh Rakita

Homework review

Homework Questions?

My Solution

topic

Some Stuff

```
sample code
```

Sequences

Sequences are ordered collections of objects

They can be indexed, sliced, iterated over,...

They have a length: `len(sequence)`

Common sequences (Remember Duck Typing?):

- strings
- tuples
- lists

Indexing

square brackets for indexing: []

Indexing starts at zero

```
In [98]: s = "this is a string"

In [99]: s[0]
Out[99]: 't'

In [100]: s[5]
Out[100]: 'i'
```

Indexing

Negative indexes count from the end

```
In [105]: s = "this is a string"

In [106]: s[-1]
Out[106]: 'g'

In [107]: s[-6]
Out[107]: 's'
```

Slices

Slicing: Pulling a range out of a sequence

`sequence[start:finish]`

`indexes for which:`

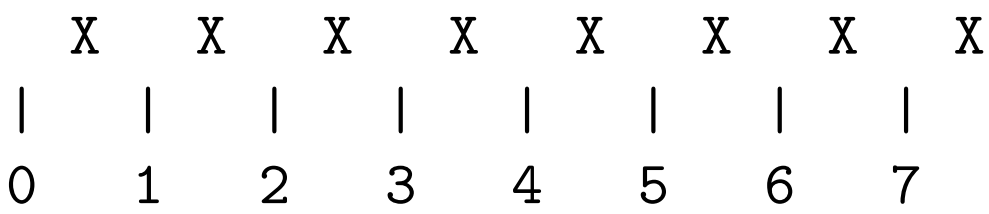
`start <= i < finish`

Slices

```
In [121]: s = "a bunch of words"
In [122]: s[2]
Out[122]: 'b'

In [123]: s[6]
Out[123]: 'h'

In [124]: s[2:6]
Out[124]: 'bunc'

In [125]: s[2:7]
Out[125]: 'bunch'
```

Slices

the indexes point to the spaces between the items



Slices

Slicing satisfies nifty properties:

```
len( seq[a:b] ) == b - a
```

```
seq[a:b] + seq[b:c] == seq
```

Slicing vs. Indexing

Indexing returns a single element

```
In [86]: l
Out[86]: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

In [87]: type(l)
Out[87]: list

In [88]: l[3]
Out[88]: 3

In [89]: type( l[3] )
Out[89]: int
```

Slicing vs. Indexing

Unless it's a string:

```
In [75]: s = "a string"

In [76]: s[3]
Out[76]: 't'

In [77]: type(s[3])
Out[77]: str
```

There is no single character type

Slicing vs. Indexing

Slicing returns a sequence:

```
In [68]: l
Out[68]: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

In [69]: l[2:4]
Out[69]: [2, 3]
```

Even if it's one element long

```
In [70]: l[2:3]
Out[70]: [2]

In [71]: type(l[2:3])
Out[71]: list
```

Slicing vs. Indexing

Indexing out of range produces an error

```
In [129]: s = "a bunch of words"
In [130]: s[17]
----> 1 s[17]
IndexError: string index out of range
```

Slicing just gives you what's there

```
In [131]: s[10:20]
Out[131]: ' words'

In [132]: s[20:30]
Out[132]: ''
```

(demo)

Multiplying and slicing

from CodingBat: Warmup-1 – front3

```
def front3(str):
  if len(str) < 3:
    return str+str+str
  else:
    return str[:3]+str[:3]+str[:3]
```

or

```
def front3(str):
    return str[:3] * 3
```

Slicing

from CodingBat: Warmup-1 – missing_char

```
def missing_char(str, n):
  front = str[0:n]
  l = len(str)-1
  back = str[n+1:l+1]
  return front + back

def missing_char(str, n):
    return str[:n] + str[n+1:]
```

Slicing

you can skip items, too

```
In [289]: string = "a fairly long string"

In [290]: string[0:15]
Out[290]: 'a fairly long s'

In [291]: string[0:15:2]
Out[291]: 'afil ogs'

In [292]: string[0:15:3]
Out[292]: 'aallg'
```

Command Line Input

`input` evaluates the input:

```
In [265]: val = input("a message> ")
a message> 4.5
In [266]: type(val)
Out[266]: float
```

`raw_input` gives you the plain string:

```
In [265]: val = input("a message> ")
a message> 4.5
In [266]: type(val)
Out[266]: float
```

(demo)

LAB

`def count_them(letter):`

- prompts the user to input a letter
- counts the number of times the given letter is input
- prompts the user for another letter
- continues until the user inputs "x"
- returns the count of the letter input

`def count_letter_in_string(string, letter):`

- counts the number of instances of the letter in the string
- ends when a period is encountered
- if no period is encountered – prints "hey, there was no period!"

LAB

Write some functions that:

- return a string with the first and last characters exchanged.
- return a string with every other character removed
- return a string with the first and last 4 characters removed, and every other char in between
- return a string reversed (just with slicing)
- return a string with the middle, then last, then first third in a new order

Lists

Lists Literals

```
>>> []
[]
>>> list()
[]
>>> [1, 2, 3]
[1, 2, 3]
>>> [1, 3.14, "abc"]
[1, 3.14, 'abc']
```

List Indexing

Indexing just like all sequences

```
>>> food = ['spam', 'eggs', 'ham']
>>> food[2]
'ham'
>>> food[0]
'spam'
>>> food[42]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: list index out of range
```

List Mutability

Lists are mutable

```
>>> food = ['spam', 'eggs', 'ham']
>>> food[1] = 'raspberries'
>>> food
['spam', 'raspberries', 'ham']
```

List Elements

Each element is a value, and can be in multiple lists and have multiple names (or no name)

```
>>> name = 'Brian'
 >>> a = [1, 2, name]
 >>> b = [3, 4, name]
 >>> name
 'Brian'
 >>> a
 [1, 2, 'Brian']
 >>> b
 [3, 4, 'Brian']
 >>> a[2]
 'Brian'
 >>> b[2]
```

List Methods

.append(), .insert()

```
>>> food = ['spam', 'eggs', 'ham']
>>> food.append('sushi')
>>> food
['spam', 'eggs', 'ham', 'sushi']
>>> food.insert(0, 'carrots')
>>> food
['carrots', 'spam', 'eggs', 'ham', 'sushi']
```

List Methods

.extend()

```
>>> food = ['spam', 'eggs', 'ham']
>>> food.extend(['fish', 'chips'])
>>> food
['spam', 'eggs', 'ham', 'fish', 'chips']
```

could be any sequence:

```
>>>  food
>>>  ['spam', 'eggs', 'ham']
>>>  silverware = ('fork', 'knife', 'spoon') # a tuple
>>>  food.extend(silverware)
>>>  food
>>>  ['spam', 'eggs', 'ham', 'fork', 'knife', 'spoon']
```

List Methods

pop(), remove()

```
In [203]: food = ['spam', 'eggs', 'ham', 'toast']
In [204]: food.pop()
Out[204]: 'toast'
In [205]: food.pop(0)
Out[205]: 'spam'
In [206]: food
Out[206]: ['eggs', 'ham']
In [207]: food.remove('ham')
In [208]: food
Out[208]: ['eggs']
```

List Constructor

`list()` accepts any sequence and returns a list of that sequence

```
>>> word = 'Python '
>>> chars = []
>>> for char in word:
...     chars.append(char)
>>> chars
['P', 'y', 't', 'h', 'o', 'n', ' ']
>>> list(word)
['P', 'y', 't', 'h', 'o', 'n', ' ']
```

String to List to String

If you need to change individual letters... you can do this, but usually `somestring.replace()` will be enough

```
In [216]: name = 'Chris'
In [217]: lname = list(name)
In [218]: lname[0:2] = 'K'
In [219]: name = ''.join(lname)
In [220]: name
Out[220]: 'Kris'
```

Building up strings in a list

```
In [221]: msg = []

In [222]: msg.append('The first line of a message')

In [223]: msg.append('The second line of a message')

In [224]: msg.append('And one more line')

In [225]: print '\n'.join(msg)
The first line of a message
The second line of a message
And one more line
```

List Slicing

Slicing makes a copy

```
In [227]: food = ['spam', 'eggs', 'ham', 'sushi']

In [228]: some_food = food[1:3]

In [229]: some_food[1] = 'bacon'

In [230]: food
Out[230]: ['spam', 'eggs', 'ham', 'sushi']

In [231]: some_food
Out[231]: ['eggs', 'bacon']
```

List Slicing

Easy way to copy a whole list

```
In [232]: food
Out[232]: ['spam', 'eggs', 'ham', 'sushi']

In [233]: food2 = food[:]

In [234]: food is food2
Out[234]: False
```

but the copy is "shallow":

http://docs.python.org/library/copy.html

List Slicing

"Shallow" copy

```
In [249]: food = ['spam', ['eggs', 'ham']]
In [251]: food_copy = food[:]
In [252]: food[1].pop()
Out[252]: 'ham'
In [253]: food
Out[253]: ['spam', ['eggs']]
In [256]: food.pop(0)
Out[256]: 'spam'
In [257]: food
Out[257]: [['eggs']]
In [258]: food_copy
Out[258]: ['spam', ['eggs']]
```

Name Binding

Assigning to a name does not copy:

```
>>> food = ['spam', 'eggs', 'ham', 'sushi']
>>> food_again = food
>>> food_copy = food[:]
>>> food.remove('sushi')
>>> food
['spam', 'eggs', 'ham']
>>> food_again
['spam', 'eggs', 'ham']
>>> food_copy
['spam', 'eggs', 'ham', 'sushi']
```

List Iterating

Iterating over a list

```
>>> food = ['spam', 'eggs', 'ham', 'sushi']
>>> for x in food:
...     print x
...
spam
eggs
ham
sushi
```

Processing Lists

A common pattern

```
filtered = []
for x in somelist:
    if should_be_included(x):
        filtered.append(x)
del(somelist)  # maybe
```

you don't want to be deleting items from the list while iterating...

Mutating Lists

if you're going to change the list, iterate over a copy for safety

```
>>> food = ['spam', 'eggs', 'ham', 'sushi']
>>> for x in food[:]:
    ...    # change the list somehow
    ...
```

insidious bugs otherwise

operators vs methods

What's the difference?

```
>>> food = ['spam', 'eggs', 'ham']
>>> more = ['fish', 'chips']
>>> food = food + more
>>> food
['spam', 'eggs', 'ham', 'fish', 'chips']

>>> food = ['spam', 'eggs', 'ham']
>>> more = ['fish', 'chips']
>>> food.extend(more)
>>> food
['spam', 'eggs', 'ham', 'fish', 'chips']
```

(the operator makes a new list...)

in

```
>>> food = ['spam', 'eggs', 'ham']
>>> 'eggs' in food
True
>>> 'chicken feet' in food
False
```

reverse()

```
>>> food = ['spam', 'eggs', 'ham']
>>> food.reverse()
>>> food
['ham', 'eggs', 'spam']
```

sort()

```
>>> food = ['spam', 'eggs', 'ham', 'sushi']
>>> food.sort()
>>> food
['eggs', 'ham', 'spam', 'sushi']
```

note:

```
>>> food = ['spam', 'eggs', 'ham', 'sushi']
>>> result = food.sort()
>>> print result
None
```

Sorting

How should this sort?

```
>>> s
[[2, 'a'], [1, 'b'], [1, 'c'], [1, 'a'], [2, 'c']]
```

Sorting

How should this sort?

```
>>> s
[[2, 'a'], [1, 'b'], [1, 'c'], [1, 'a'], [2, 'c']]

>>> s.sort()
>>> s
[[1, 'a'], [1, 'b'], [1, 'c'], [2, 'a'], [2, 'c']]
```

Sorting

You can specify your own compare function:

```
In [279]: s = [[2, 'a'], [1, 'b'], [1, 'c'], [1, 'a'], [2,
In [281]: def comp(s1,s2):
   .....:     if s1[1] > s2[1]: return 1
   .....:     elif s1[1]<s2[1]: return -1
   .....:     else:
   .....:         if s1[0] > s2[0]: return 1
   .....:         elif s1[0] < s2[0]: return -1
   .....:     return 0
In [282]: s.sort(comp)
In [283]: s
Out[283]: [[1, 'a'], [2, 'a'], [1, 'b'], [1, 'c'], [2, 'c']
```

Sorting

Mixed types can be sorted.

"objects of different types always compare unequal, and are ordered consistently but arbitrarily."

`http://docs.python.org/reference/expressions.html#not-in`

Searching

Finding or Counting items

```
In [288]: l = [3,1,7,5,4,3]

In [289]: l.index(5)
Out[289]: 3

In [290]: l.count(3)
Out[290]: 2
```

List Performance

- indexing is fast and constant time: O(1)
- x in s proportional to n: O(n)
- visiting all is proportional to n: O(n)
- operating on the end of list is fast and constant time: O(1)
  append(), pop()
- operating on the front (or middle) of the list depends on n: O(n)
  pop(0), insert(0, v)
  But, reversing is fast. Also, collections.deque

`http://wiki.python.org/moin/TimeComplexity`

Lists vs. Tuples

List or Tuples

If it needs to mutable: list

If it needs to be immutable: tuple
(dict key, safety when passing to a function)

Otherwise ... taste and convention

List vs Tuple

Convention:

Lists are Collections (homogeneous):

– contain values of the same type
– simplifies iterating, sorting, etc

tuples are mixed types:

– Group multiple values into one logical thing – Kind of like simple C structs.

List vs Tuple

- Do the same operation to each element?
- Small collection of values which make a single logical item?
- To document that these values won't change?
- Build it iteratively?
- Transform, filter, etc?

List vs Tuple

- Do the same operation to each element? **list**
- Small collection of values which make a single logical item? **tuple**
- To document that these values won't change? **tuple**
- Build it iteratively? **list**
- Transform, filter, etc? **list**

List Docs

The list docs:

`http://docs.python.org/library/stdtypes.html#mutable-sequence-types`

(actually any mutable sequence....)

tuples and commas..

Tuples don't NEED parentheses...

```
In [161]: t = (1,2,3)
In [162]: t
Out[162]: (1, 2, 3)

In [163]: t = 1,2,3
In [164]: t
Out[164]: (1, 2, 3)

In [165]: type(t)
Out[165]: tuple
```

tuples and commas..

Tuples do need commas...

```
In [156]: t = ( 3 )

In [157]: type(t)
Out[157]: int

In [158]: t = (3,)
In [159]: t
Out[159]: (3,)

In [160]: type(t)
Out[160]: tuple
```

LAB

List Lab

`week-03/code/list_lab.rst`

for loops

looping through sequences

```
for x in sequence:
    do_something_with_x
```

for loops

```
In [170]: for x in "a string":
   .....:         print x
   .....:
a

s
t
r
i
n
g
```

range

looping a known number of times..

```
In [171]: for i in range(5):
    .....:     print i
    .....:
0
1
2
3
4
```

(you don't need to do anything with i...

range

`range` defined similarly to indexing

```
In [183]: range(4)
Out[183]: [0, 1, 2, 3]

In [184]: range(2,4)
Out[184]: [2, 3]

In [185]: range(2,10,2)
Out[185]: [2, 4, 6, 8]
```

indexing?

Python only loops through a sequence – not like C, Javascript, etc...

```
for(var i=0; i<arr.length; i++) {
    var value = arr[i];
    alert(i =") "+value);
}
```

indexing?

Use range?

```
In [193]: letters = "Python"

In [194]: for i in range(len(letters)):
   .....:     print letters[i]
   .....:
P
y
t
h
o
n
```

indexing?

More Pythonic – for loops through sequences

```
In [196]: for l in letters:
   .....:     print l
   .....:
P
y
t
h
o
n
```

Never index in normal cases

enumerate

If you need an index – enumerate

```
In [197]: for i, l in enumerate(letters):
   .....:     print i, l
   .....:
0 P
1 y
2 t
3 h
4 o
5 n
```

multiple sequences – zip

If you need to loop though parallel sequences – `zip`

```
In [200]: first_names = ['Fred', 'Mary', 'Jane']

In [201]: last_names = ['Baker', 'Jones', 'Miller']

In [203]: for first, last in zip(first_names, last_names):
   .....:     print first, last
   .....:
Fred Baker
Mary Jones
Jane Miller
```

xrange

`range` creates the whole list

`xrange` is a generator – creates it as it's needed –

a good idea for large numbers

```
In [207]: for i in xrange(3):
   .....:     print i
0
1
2
```

(Python 3 – `range == xrange`)

for

`for` does NOT create a name space:

```
In [172]: x = 10

In [173]: for x in range(3):
   .....:     pass
   .....:

In [174]: x
Out[174]: 2
```

while

`while` is for when you don't know how many loops you need

Continues to execute the body until condition is not `True`

```
while a_condition:
    some_code
    in_the_body
```

while

`while` is more general than `for` – you can always express for as while, but not always vice-versa.

`while` is more error-prone – requires some care to terminate

loop body must make progress, so condition can become `False`

potential error: infinite loops

while vs. for

```
letters = 'Python'
i=0
while i < len(letters):
    print letters[i]
    i += 1
```

vs.

```
letters = 'Python'
for c in letters:
    print c
```

while

Shortcut: recall – 0 or empty sequence is `False`

break

break ends a loop early

```
x = 0
while True:
    print x
    if x > 3:
        break
    x = x + 1
In [216]: run for_while.py
0
1
2
3
4
```

break

same way with a `for` loop

```
name = "Chris Barker"
for c in name:
    print c,
    if c == "B":
        break
print "I'm done"
```

```
C h r i s   B
I'm done
```

continue

`continue` skips to the start of the loop again

```
print "continue in a for loop"
name = "Chris Barker"
for c in name:
    if c == "B":
        continue
    print c,
print "\nI'm done"
```

```
continue in a for loop
C h r i s   a r k e r
I'm done
```

continue

`continue` works for a `while` loop too.

```
print "continue in a while loop"
x = 6
while x > 0:
    x = x-1
    if x%2:
        continue
    print x,
print "\nI'm done"
```

```
continue in a while loop
4 2 0
I'm done
```

else again

`else` block run if the loop finished naturally – no `break`

```
print "else in a for loop"
x = 5
for i in range(5):
    print i
    if i == x:
        break
else:
    print "else block run"
```

Dictionary

Python calls it a `dict`

Other languages call it:

- dictionary
- associative array
- map
- hash table
- hash
- key-value pair

Dictionary Constructors

```
>>> {'key1': 3, 'key2': 5}
{'key1': 3, 'key2': 5}

>>> dict([('key1', 3),('key2', 5)])
{'key1': 3, 'key2': 5}

>>> dict(key1=3, key2= 5)
{'key1': 3, 'key2': 5}

>>> d = {}
>>> d['key1'] = 3
>>> d['key2'] = 5
>>> d
{'key1': 3, 'key2': 5}
```

Dictionary Indexing

```
>>> d = {'name': 'Brian', 'score': 42}
>>> d['score']
42
>>> d = {1: 'one', 0: 'zero'}
>>> d[0]
'zero'
>>> d['non-existing key']
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'non-existing key'
```

Dictionary Indexing

Keys can be any immutable:

- numbers
- string
- tuples

```
In [325]: d[3] = 'string'
In [326]: d[3.14] = 'pi'
In [327]: d['pi'] = 3.14
In [328]: d[ (1,2,3) ] = 'a tuple key'
In [329]: d[ [1,2,3] ] = 'a list key'
   TypeError: unhashable type: 'list'
```

Actually – any "hashable" type.

Dictionary Indexing

hash functions convert arbitrarily large data to a small proxy (usually int)

always return the same proxy for the same input

MD5, SHA, etc

Dictionary Indexing

Dictionaries hash the key to an integer proxy and use it to find the key and value

Key lookup is efficient because the hash function leads directly to a bucket with a very few keys (often just one)

Dictionary Indexing

What would happen if the proxy changed after storing a key?

Hashability requires immutability

Dictionary Indexing

Key lookup is very efficient

Same average time regardless of size

also... Python name look-ups are implemented with dict:
— its highly optimized

Dictionary Indexing

key to value
lookup is one way

value to key
requires visiting the whole dict

if you need to check dict values often, create another dict or set (up to you to keep them in sync)

Dictionary Ordering (not)

dictionaries have no defined order

```
In [352]: d = {'one':1, 'two':2, 'three':3}

In [353]: d
Out[353]: {'one': 1, 'three': 3, 'two': 2}

In [354]: d.keys()
Out[354]: ['three', 'two', 'one']
```

Dictionary Iterating

`for` iterates the keys

```
>>> d = {'name': 'Brian', 'score': 42}
>>> for x in d:
...     print x
...
score name
```

note the different order...

dict keys and values

```
>>> d.keys()
['score', 'name']

>>> d.values()
[42, 'Brian']

>>> d.items()
[('score', 42), ('name', 'Brian')]
```

dict keys and values

iterating on everything

```
>>> d = {'name': 'Brian', 'score': 42}
>>> for k, v in d.items():
...     print "%s: %s" % (k, v)
...
score: 42
name: Brian
```

Dictionary Performance

- indexing is fast and constant time: O(1)
- x in s cpnstant time: O(1)
- visiting all is proportional to n: O(n)
- inserting is constant time: O(1)
- deleting is constant time: O(1)

`http://wiki.python.org/moin/TimeComplexity`

Dict Comprehensions

You can do it with dicts, too:

```
new_dict = { key:value for variable in a_sequence}
```

same as for loop:

```
new_dict = {}
for key in a_list:
    new_dict[key] = value
```

Dict Comprehensions

Example

```
In [340]: { i: "this_%i"%i for i in range(5) }
Out[340]: {0: 'this_0', 1: 'this_1', 2: 'this_2',
           3: 'this_3', 4: 'this_4'}
```

(not as useful with the dict() constructor...)

Switch ?

How do you spell switch/case in Python?

Put the values to switch on in the keys:

Functions to call in values:

demo: sample code (`switch_case.py`)

Sets

`set` is an unordered collection of distinct values

Essentially a dict with only keys

Set Constructors

```
>>> set()
set([])
>>> set([1, 2, 3])
set([1, 2, 3])
# as of 2.7
>>> {1, 2, 3}
set([1, 2, 3])
>>> s = set()
>>> s.update([1, 2, 3])
>>> s
set([1, 2, 3])
```

Set Properties

Set members must be hashable

Like dictionary keys – and for same reason (efficient lookup)

No indexing (unordered)

```
>>> s[1]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'set' object does not support indexing
```

Set Methods

```
>> s = set([1])
>>> s.pop() # an arbitrary member
1
>>> s.pop()
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'pop from an empty set'

>>> s = set([1, 2, 3])
>>> s.remove(2)
>>> s.remove(2)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 2
```

Set Methods

```
s.isdisjoint(other)

s.issubset(other)

s.union(other, ...)

s.intersection(other, ...)

s.difference(other, ...)

s.symmetric_difference( other, ...)
```

Frozen Set

Also `frozenset`

immutable – for use as a key in a dict
(or another set...)

```
>>> fs = frozenset((3,8,5))
>>> fs.add(9)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'frozenset' object has no attribute 'add'
```

LAB

Some lab excercises

Lightning Talk

Lightning Talks:

person 1

person 2

Homework

Recommended Reading:

- some stuff

Do:

- Some things

Homework

Recommended Reading:

- Read Think Python: 9, 14
- extra: string methods: `http://docs.python.org/library/stdtypes.html#string-methods`
- extra: unicode: `http://www.joelonsoftware.com/articles/Unicode.html`

Do:

- Six more CodingBat exercises.
- LPTHW: for extra practice with the concepts – some of:

strings: ex5, ex6, ex7, ex8, ex9, ex10
raw_input(), sys.argv: ex12, ex13, ex14 (needed for files)
files: ex15, ex16, ex17