Dictionaries + More Lists

Class outline:

- Dictionaries
- List diagrams
- Slicing
- Built-ins for iterables
- Recursive exercises

Dictionaries

Dictionaries

A `dict` is a mapping of key-value pairs

```
states = {
        "CA": "California",
        "DE": "Delaware",
        "NY": "New York",
        "TX": "Texas",
        "WY": "Wyoming"
}
```

Dictionaries support similar operations as lists/strings:

```
>>> len(states)
```

```
>>> "CA" in states
```

```
>>> "ZZ" in states
```

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```
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```

```
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Dictionary access

```
words = {
        "más": "more",
        "otro": "other",
        "agua": "water"
}
```

Ways to access a value by key:

```
>>> words["otro"]
```

```
>>> first_word = "agua"
>>> words[first_word]
```

```
>>> words["pavo"]
```

```
>>> words.get("pavo", "")
```

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>>> words["pavo"]
KeyError: pavo
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>>> words.get("pavo", "")
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```
>>> words["pavo"]
KeyError: pavo
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```
>>> words.get("pavo", "")
''
```

Dictionary rules

- All keys in a dictionary are distinct (there can only be one value per key)
- A key **cannot** be a list or dictionary (or any other mutable type)
- The values can be any type, however!

```
spiders = {
  "smeringopus": {
          "name": "Pale Daddy Long-leg",
          "length": 7
  },
  "holocnemus pluchei": {
          "name": "Marbled cellar spider",
          "length": (5, 7)
  }
}
```

Dictionary iteration

```
insects = {"spiders": 8, "centipedes": 100, "bees": 6}
for name in insects:
    print(insects[name])
```

What will be the order of items?

Dictionary iteration

```
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for name in insects:
    print(insects[name])
```

What will be the order of items?

```
8 100 6
```

Keys are iterated over in the order they are first added.

Dictionary comprehensions

General syntax:

```
{key: value for <name> in <iter exp>}
```

Example:

```
{x: x*x for x in range(3,6)}
```

Exercise: Prune

```
def prune(d, keys):
    """Return a copy of D which only contains key/value pairs
    whose keys are also in KEYS.
    >>> prune({"a": 1, "b": 2, "c": 3, "d": 4}, ["a", "b", "c"])
    {'a': 1, 'b': 2, 'c': 3}
    """
```

Exercise: Prune (Solution)

```
def prune(d, keys):
    """Return a copy of D which only contains key/value pairs
    whose keys are also in KEYS.
    >>> prune({"a": 1, "b": 2, "c": 3, "d": 4}, ["a", "b", "c"])
    {'a': 1, 'b': 2, 'c': 3}
    """
    return {k: d[k] for k in keys}
```

Exercise: Index

```
def index(keys, values, match):
    """Return a dictionary from keys k to a list of values v for which
    match(k, v) is a true value.

    >>> index([7, 9, 11], range(30, 50), lambda k, v: v % k == 0)
    {7: [35, 42, 49], 9: [36, 45], 11: [33, 44]}
    """
```

Exercise: Index (solution)

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    >>> index([7, 9, 11], range(30, 50), lambda k, v: v % k == 0)
    {7: [35, 42, 49], 9: [36, 45], 11: [33, 44]}
    """
    return {k: [v for v in values if match(k, v)] for k in keys}
```

Nested data

Many useful way to combine lists and dicts:

Lists of lists	`[ [1, 2], [3, 4] ]`
Dicts of dicts	`{"name": "Brazilian Breads", "location": {"lat": 37.8, "lng": -122}}`
Dicts of lists	`{"heights": [89, 97], "ages": [6, 8]}`
Lists of dicts	`[{"title": "Ponyo", "year": 2009}, {"title": "Totoro", "year": 1993}]`

Slicing

Slicing syntax

Slicing a list creates a new list with a subsequence of the original list.

```
letters = ["A", "B", "C", "D", "E", "F"]
        #   0    1    2    3    4    5

sublist1 = letters[1:]
sublist2 = letters[1:4]
```

Slicing also works for strings.

```
compound_word = "cortaúñas"

word1 = compound_word[:5]
word2 = compound_word[5:]
```

Negatives indices and steps can also be specified.

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```

Negatives indices and steps can also be specified.

Copying whole lists

Slicing a whole list copies a list:

```
listA = [2, 3]
listB = listA

listC = listA[:]
listA[0] = 4
listB[1] = 5
```

`list()` creates a new list containing existing elements from any iterable:

```
listA = [2, 3]
listB = listA

listC = list(listA)
listA[0] = 4
listB[1] = 5
```

 Try both in PythonTutor.

Python3 provides more ways in the copy module.

Built-in functions for iterables

Functions that process iterables

The following built-in functions work for lists, strings, dicts, and any other **iterable** data type.

Function	Description
`sum(iterable, start)`	Returns the sum of values in `iterable`, initializing sum to `start`
`all(iterable)`	Return `True` if all elements of `iterable` are true (or if `iterable` is empty)
`any(iterable)`	Return `True` if any element of `iterable` is true. Return `False` if `iterable` is empty.
`max(iterable, key=None)`	Return the max value in `iterable`
`min(iterable, key=None)`	Return the min value in `iterable`

Examples with sum/any/all

```
sum([73, 89, 74, 95], 0)  # 331
```

```
all([True, True, True, True])
any([False, False, False, True])

all([x < 5 for x in range(5)])

perfect_square = lambda x: x == round(x ** 0.5) ** 2
any([perfect_square(x) for x in range(50, 60)])
```

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Examples with max/min

```
max([73, 89, 74, 95])          # 95
max(["C+", "B+", "C", "A"])
max(range(10))
```

Examples with max/min

```
max([73, 89, 74, 95])          # 95
max(["C+", "B+", "C", "A"])    # C+
max(range(10))
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max([73, 89, 74, 95])          # 95
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A key function can decide how to compare each value:

```
coords = [ [37, -144], [-22, -115], [56, -163] ]
max(coords, key=lambda coord: coord[0])
min(coords, key=lambda coord: coord[0])
```

```
gymnasts = [ ["Brittany", 9.15, 9.4, 9.3, 9.2],
    ["Lea", 9, 8.8, 9.1, 9.5],
    ["Maya", 9.2, 8.7, 9.2, 8.8] ]
min(gymnasts, key=lambda scores: min(scores[1:]))
max(gymnasts, key=lambda scores: sum(scores[1:], 0))
```

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max(gymnasts, key=lambda scores: sum(scores[1:], 0)) # ["Brittany",
```

Recursion exercises

Helper functions

If a recursive function needs to keep track of more state than the arguments of the original function, you may need a helper function.

```
def fUnKyCaSe(text):
    """
    >>> fUnKyCaSe("wats up")
    'wAtS Up'
    """

    def toggle_case(letter, should_up_case):
      return letter.upper() if should_up_case else letter.lower()

    def up_down(text, should_up_case):
      if len(text) == 1:
        return toggle_case(text, should_up_case)
      else:
        return toggle_case(text[0], should_up_case) + \
               up_down(text[1:], not should_up_case)

    return up_down(text, False)
```

Recursively sum a list

Let's code this up recursively:

```
def sum_nums(nums):
    """Returns the sum of the numbers in NUMS.
    >>> sum_nums([6, 24, 1984])
    2014
    >>> sum_nums([-32, 0, 32])
    0
    """
```

Docstrings typically would not specify whether an approach was recursive or iterative, since that is an implementation detail.

However, we'll make it clear in assignments and exam questions.

Recursively sum a list (solution)

```
def sum_nums(nums):
    """Returns the sum of the numbers in NUMS.
    >>> sum_nums([6, 24, 1984])
    2014
    >>> sum_nums([-32, 0, 32])
    0
    """
    if nums == []:
        return 0
    else:
        return nums[0] + sum_nums( nums[1:] )
```

When recursively processing lists, the base case is often the empty list and the recursive case is often all-but-the-first items.

Recursively reversing a string

```
def reverse(s):
    """Returns a string with the letters of S
    in the inverse order.
    >>> reverse('ward')
    'draw'
    """
```

Breaking it down into subproblems:

```
reverse("ward") =
reverse("ard") =
reverse("rd") =
reverse("d") =
```

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Breaking it down into subproblems:

```
reverse("ward") = reverse("ard") + "w"
reverse("ard") = reverse("rd") + "a"
reverse("rd") = reverse("d") + "r"
reverse("d") =
```

Recursively reversing a string

```
def reverse(s):
    """Returns a string with the letters of S
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Breaking it down into subproblems:

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reverse("ward") = reverse("ard") + "w"
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reverse("rd") = reverse("d") + "r"
reverse("d") = "d"
```
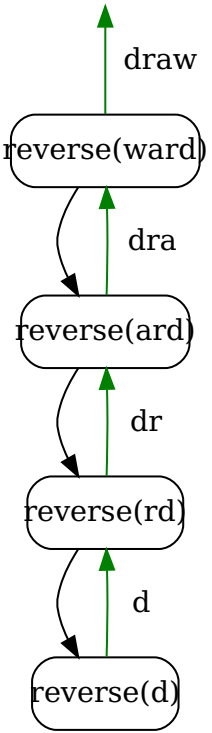

Recursively reversing a string (solution)

```
def reverse(s):
    """Returns a string with the letters of S
    in the inverse order.
    >>> reverse('ward')
    'draw'
    """
    if len(s) == 1:
        return s
    else:
        return reverse(s[1:]) + s[0]
```

When recursively processing strings, the base case is typically an empty string or single-character string, and the recursive case is often all-but-the-first characters.

Recursively reversing a string (visual)



Exercise: Reversing a number

```
def reverse(n):
    """Returns N with the digits reversed.
    >>> reverse_digits(123)
    321
    """
```

See walkthrough video here

Recursion on different data types

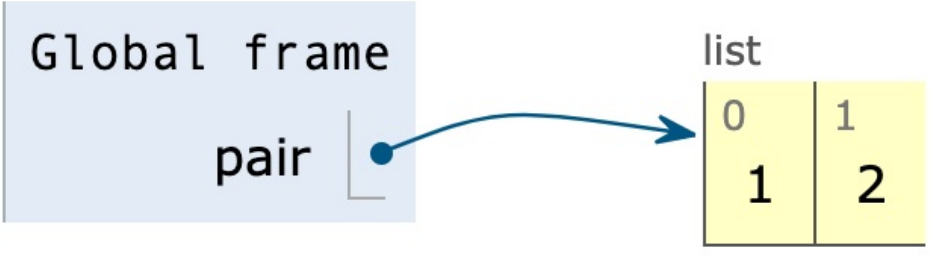
Data type	Base case condition	Current item	Recursive case argument
Numbers	`== 0` `== 1`	`n`	`n - 1`
Numbers (Digits)	`== 0` `< 10`	`n % 10`	`n // 10`
Lists	`== []` `len(L) == 0`	`L[0]` `L[-1]`	`L[1:]` `L[:-1]`
Strings	`== ''` `len(S) == 1`	`S[0]`	`S[1:]` `S[:-1]`

List diagrams

Lists in environment diagrams

Lists are represented as a row of index-labeled adjacent boxes, one per element.

```
pair = [1, 2]
```

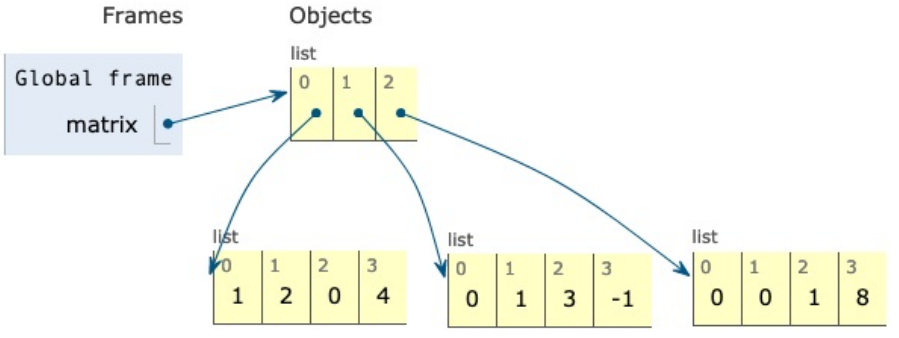


Try in PythonTutor.

Nested lists in environment diagrams

Each box either contains a primitive value or points to a compound value.

```
matrix = [ [1, 2, 0, 4], [0, 1, 3, -1], [0, 0, 1, 8] ]
```

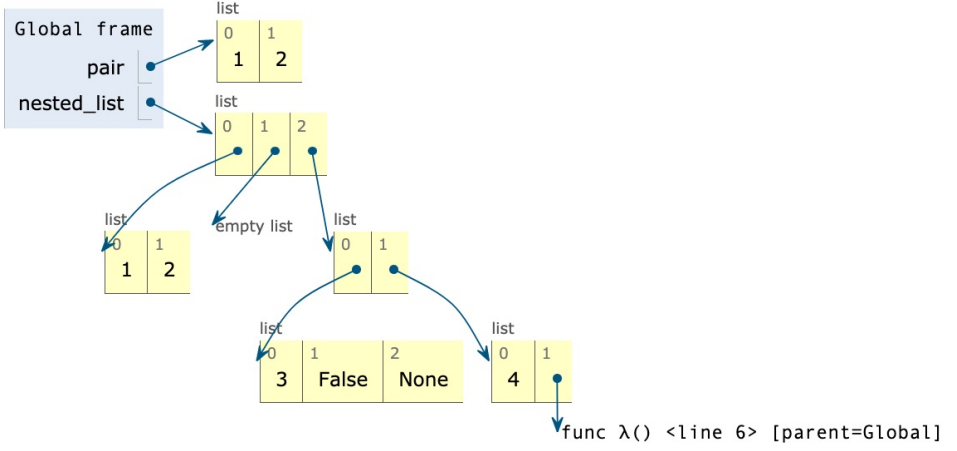


View in PythonTutor

Nested lists in environment diagrams

A very nested list:

```
worst_list = [ [1, 2],
               [],
               [ [3, False, None], [4, lambda: 5]]]
```

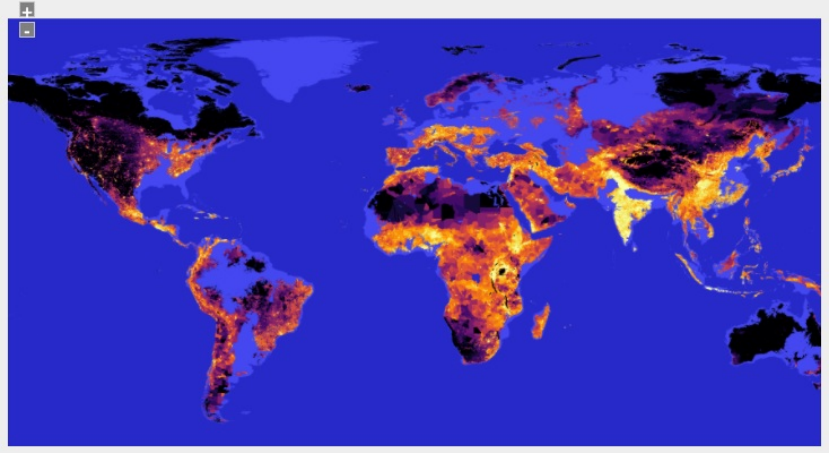


View in PythonTutor

Python Project of The Day!

Sea Level Rise

Sea Level Rise, by Douwe Osinga: Visualize sea levels and population density on interactive maps.



Technologies used: Python (notebook) with PIL/numpy/Rasterio, HTML/CSS/JS with PanZoom
(Github repository)