FS12

Week 02
Python Basics II

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Python Collections I

- In the previous lecture you have learned basic Python data types:
  - numeric: integers, float, complex;
  - logical (yes/no, true/false): boolean;
  - strings.
- These data types are sufficient for solving small programming tasks like your homework for previous week. However, sometimes you need to do much more complex stuff. For example, remember multiple numbers or strings, provided by user.

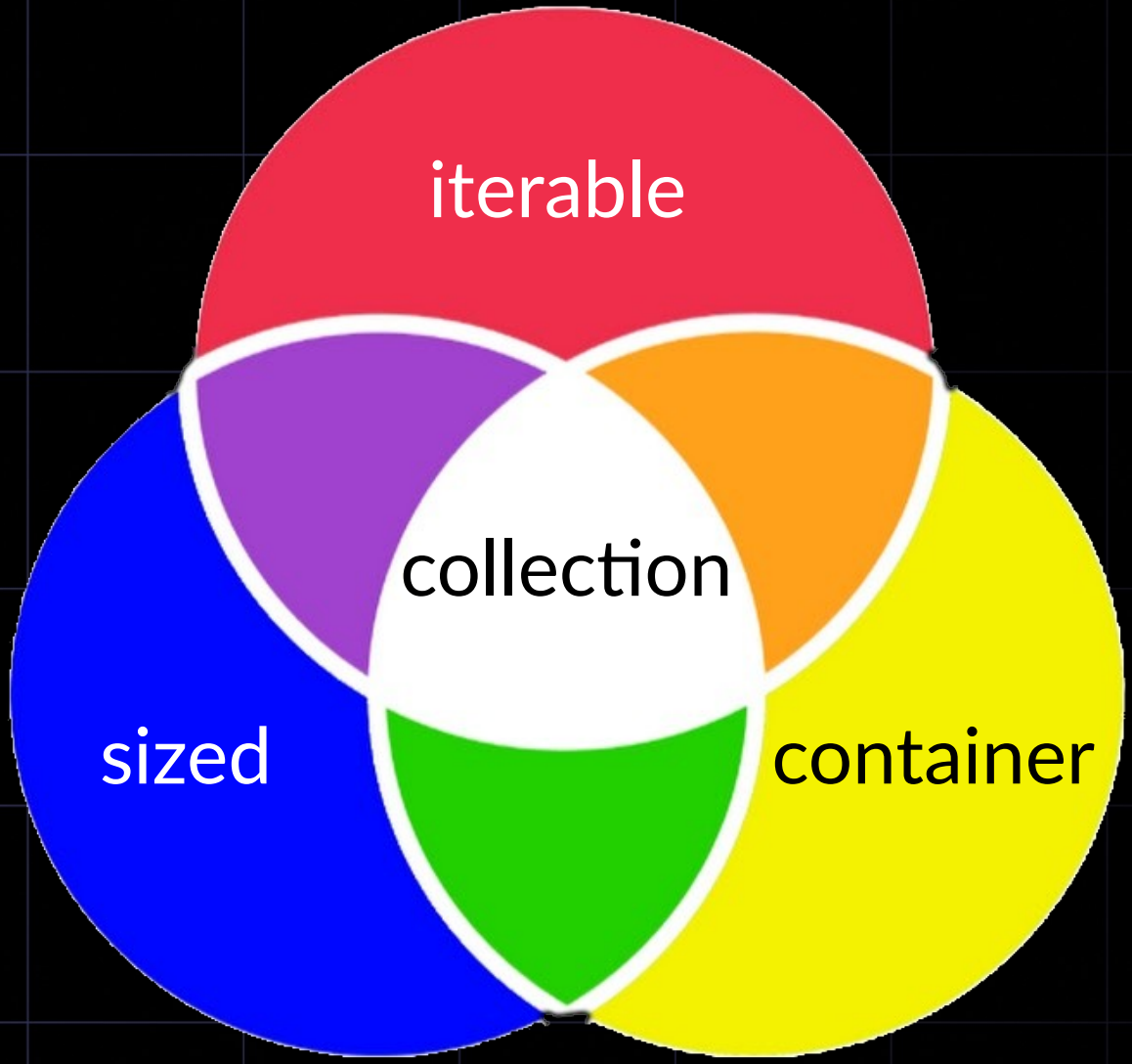
Python Collections II

- Python **Collections** can help us with it!
- Let's try to answer the question: what is collection?
- hm…
- hm-hm…
- hm-hm-hm…
- Well, from the naming we can assume, that collection is something, that collects elements.
- Good answer, but not enough.

Python Collections III

- To find the best definition for Collections let's discuss three base Python objects concepts first:
  - Being **Container** – object's ability to answer the question "if it contains something or not?".
  - Being **Iterable** – ability to loop through all object's elements.
  - Being **Sized** – object's ability to answer the question "how many elements does it contain?".
  - **Collection** is something that is **Container**, **Iterable** & **Sized**.

Python Collections IV



Container I

- Being **Container** – object's ability to answer the question "if it contains something or not?".
- All collections are containers, however not all containers are collections (!!!).
- Example: $(a,b)=\{X \in \mathbb{R} | a<x<b\}$:
  - This mathematical interval is a **Container**, because it can if number lies in it.
  - It is NOT **Iterable**, because it contains infinite number of elements and you can not choose step.
  - It is not **Sized** for similar reason.

Container II

```
from collections.abc import Container
from dataclasses import dataclass


@dataclass
class Interval(Container):
    a: float
    b: float

    def __contains__(self, x):
        return self.a < x < self.b

interval = Interval(0, 1)
print(interval) > Interval(a=0, b=1)
```

```
for x in (0.5, 0.7, 1.2):
    c = x in interval
    print(f"{x}: {c}")
> 0.5: True\n 0.7: True\n
1.2: False

for x in interval:
    print(x)
> TypeError: 'Interval'
object is not iterable

len(interval) > TypeError:
object of type 'Interval'
has no len()
```

Iterable I

- Being **Iterable** – ability to loop through all object's elements.
- All collections are Iterable, however not all Iterables are collections (!!!)
- Example: generator (special object, which return new values each time it is being called):
  - Generator is iterable, because you can loop through its generated new values.
  - It is NOT a **Container**: it does not store elements.
  - It is NOT **Sized**, because their "size" depends on external conditions.

Iterable II

```
def generator(n):
    yield from range(n)

for i in generator(10):
    print(i, end=" ")
> 0 1 2 3 4 5 6 7 8 9
len(generator(10)) > TypeError: object
of type 'generator' has no len()
g = generator(10)
print(0 in g) > True
print(0 in g) > False
```

Sized I

- Being **Sized** – object's ability to answer the question "how many elements does it contain?".
- All collections are Sized, however not all Sized are collections (!!!)
- Example: line segment in N-dim space:
  - It is a **Container**: it can say does point belong to it or not.
  - It is **Sized**, because its size can be calculated as distance between its two main points.
  - It is not **Iterable**, because it contains infinite number of elements.

Sized II

```
@dataclass
class Interval(Container):
    a: float
    b: float

    def __contains__(self, x):
        return self.a < x < self.b

    # TODO
```

Python Collections V

- Python Collections can be divided in two big groups: **Sequences** and **Mappings**.
- However, there are also sets, etc.
- Collection is a **Sequence** if all its elements are ordered → so then can be indexed by their serial number (e.g. array indexing).
- Collection is a **Mapping** if it provides a way to map (translate) one elements to another elements. For example strings into integers. From this point of view **Sequence** is a **Mapping** from integers (its indexes) to some data type.

Sequences I

- There are following sequential basic data types in Python:
  - list – changeable elements sequence;
  - tuple – UNchangeable elements sequence;
  - range – generated sequence of elements;
  - string – Python strings;
  - bytearray – changeable bytes sequence;
  - bytes – UNchangeable bytes sequence.

Sequences II

- All sequences support indexing operations:
  - `s[i]` - gets i'th element of sequence s (starting from 0 (!!!));
  - `s[i:j]` - gets subsequence of elements from i'th to j'th (including i'th and excluding j'th);
  - `s[i:j:k]` - gets subsequence of elements from i'th to j'th with step k (including i'th and excluding j'th);
  - You can skip beginning or (and) starting indexes. Their default values are `0` and `len(s)-1`

Sequences II

- Python allows to index sequences not only from `0` and `len(s)-1`. You can use negative values too. For example, `s[-1]` returns the last element of sequence, `s[-5]`.

Sequences III

- All sequences support following operations on them:
  -

Base Collections Types: List I

What we should do for collect multiply elements in memory? There are good data structure – array. You can imagine pill box:

But arr[illegible]nd option – to increase size. In Python (dynamic) array is represented by a `list()` or `[]`.

Base Collections Types: List II

- Empty list creation

  `>>> lst1 = []`

  `>>> lst1 = list()`

- Non empty list creation

  `>>> lst2 = [6, 7, 8, 9, 10, 11]`

  `>>> lst2 = list(collection),` where collection is iterable;

- Add element to list
- `>>> lst2.append(4)` # inplace method

Base Collections Types: List II

- Get element

```
>>> lst2[1] # 7
```

- Get multiple elements: list[start: stop: step]

```
>>> lst2[2:6:2] # [8, 10]
>>> lst2[0:len(lst2):2] # [7, 9, 11]
>>> lst2[::-1] # [11, 10, 9, 8, 7, 6]
>>> lst2[:3] # [6, 7, 8]
>>> lst2[3:] # [9, 10, 11]
```

lst2[0:len(lst2):2] <=> lst2[::2]

Base Collections Types: List III

- len(tuple) – return length of list;
- list.extend(iterable) – add other collection to list, inplace method;
- list.insert(i, x) – insert an item x at a position x;
- list.copy() - return a shallow copy of the list;
- list.index(x) – retrun pos x in list, if existence;
- list.sort(key, reverse) – sorting list inplace by key and reverse order;
- sorted(list) – return sorted list;
- And more...

Base Collections Types: Tuple I

- Empty tuple creation

```
>>> tpl = ()
>>> tpl1 = tuple()
```

- Non empty tuple creation

```
>>> tpl2 = (1, )
>>> tpl2 = (1, 2, 3)
>>> tpl2 = tuple(collection)
```

where collection is iterable;

- Add element to tuple

Nothing can be added to tuple!!!

Base Collections Types: Tuple II

- len(tuple) – return length of list;
- tuple.index(x) – return pos x in list, if existence;

  …

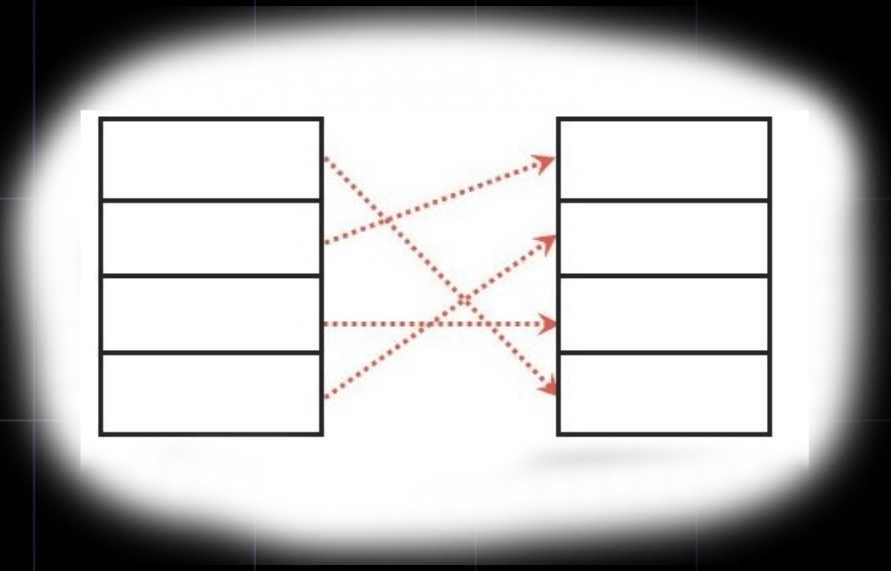
  But tuple is faster than list!

- Element access similar to lists: see slide 4

Mappings

Base Collections Types: Dict I

- Dict is a data structure for collecting keys and values, where access to value is by key.
  Keys should be unique!!! For example we can use people like a key and their pills like a value.



Base Collections Types: Dict II

- Empty dict creation

```
>>> d1 = dict()
>>> d1 = {}
```

- Non empty tuple creation

```
>>> d2 = {“a”: 1, “b”: 2, “c”: 3}
>>> d2 = dict(a=1, b=2, c=3)
>>> d2 = dict(list(tuple))
```

- Add element to set

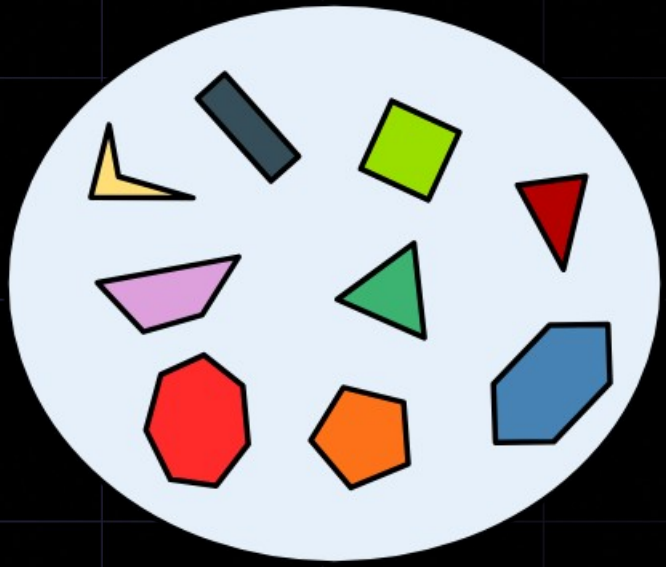
```
>>> d2[“d”] = 4
>>> d2.update({“e”: 5}) # inplace method
```

Base Collections Types: Dict III

- len(dict) – return amount of keys;
- dict.keys() – returns a list of a dict's keys;
- dict.values() - returns a list of all the values in the dict;
- dict.items() – returns a list of a tuple for each key value pair;
- dict.setdefault(key, value) - returns the value of the specified key.
- And more...

Base Collections Types: Set I

- Set is a set from math. Set is a collection of a unique elements. You can add elements to set like a list. In Python set is represented by a `set()` or `{}`.



Base Collections Types: Set II

- Empty set creation

```
>>> s1 = set()
```

- Non empty set creation

```
>>> s2 = {1, 2, 3}
>>> s2 = set(collection)
```

  where collection is iterable;

- Add element to set

```
>>> s2.add(4) # inplace method
>>> s2.add(1) # collection is not change
```

Base Collections Types: Set III

- len(set) – return length of list;
- set.discard(x) – remove the specified item;
- set.intersection(set1) – returns a set, that is the intersection of two or more sets;
- set.copy() - returns a copy of the set;
- set.symmetric_difference(x) –returns a set with the symmetric differences of two sets;
- set.issubset(set1) – check, is set1 subset of set;
- And more...

Base Collections Types: Set III

- Also we apply logical operators to sets;
- | - or, & - and, `-` - difference, ^ - xor;

```
>>> x1 = {1, 3}
>>> x2 = {2, 3, 4}
>>> x1 & x2 # {3}
>>> x1 | x2 # {1, 2, 3 ,4}
>>> x1 – x2 # {1}
>>> x1 ^ x2 # {1, 2, 4}
```

Type casting

- You can create mapping list → tuple, set → list etc:

```
>>> list((1, 2, 3)) # [1, 2, 3]
>>> list({1, 2, 3}) # [1, 2, 3]
>>> tuple([1, 2, 3]) # (1, 2, 3)
>>> tuple({1, 2, 3}) # (1, 2, 3)
>>> set([1, 2, 3]) # {1, 2, 3}
>>> set((1, 2, 3)) # {1, 2, 3}
```

Base Types: immutable or mutable

Mutable

- list
- dict, set
- user defined

Immutable

- int, float, bool
- str, bytes
- tuple, frozenset

Some Python's Feature

- In Python you can create list, tuple, set and dict of elements of different types:

```
>>> tpl = (1, "a", True, (76, ), [99])
>>> lst = [1, "a", True, (76, ), [99]]
>> > s = {1, "a", True, (76, )}
>>> d = {1: "1", "2": 2, }
```

BUT you can't use mutable types like a key in dict and elements in set!!!

Container's iterators

```
>>> lst = [1, 3, 2]
>>> dct = {1: 11, 2: 22}
```

Operator `in`:

- `>>> 1 in lst` # True
- `>>> 1 in dct` # True
- `>>> "3" not in "456"` # True

Iteration:

- `>>> for val in lst: pass`
- `>>> for key, val in dct.items(): pass`

tuple and set similarly

Comprehension

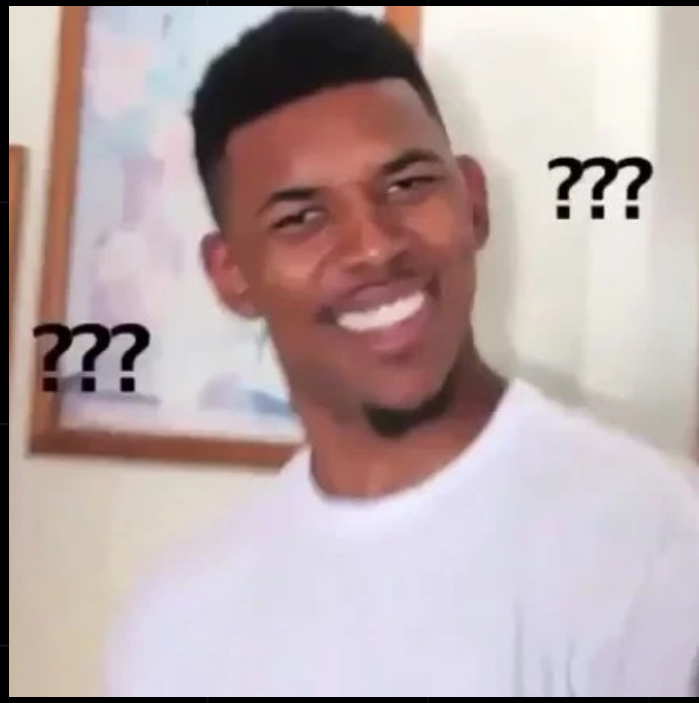
Comprehension is a syntax sugar for fast collections building

```
>>> lst = [n ** 2 for n in range(10) if n % 2]
# [1, 9, 25, 49, 81]

>>> s = {ch for ch in "abcabcbca"}
# {'a', 'c', 'b'}

>>> d = {n: n**2 for n in range(10) if n % 2}
# {1: 1, 3: 9, 5: 25, 7: 49, 9: 81}

>>> gen = (n ** 2 for n in range(10) if n % 2)
# it's not a tuple!!!
```

Type hint’s I

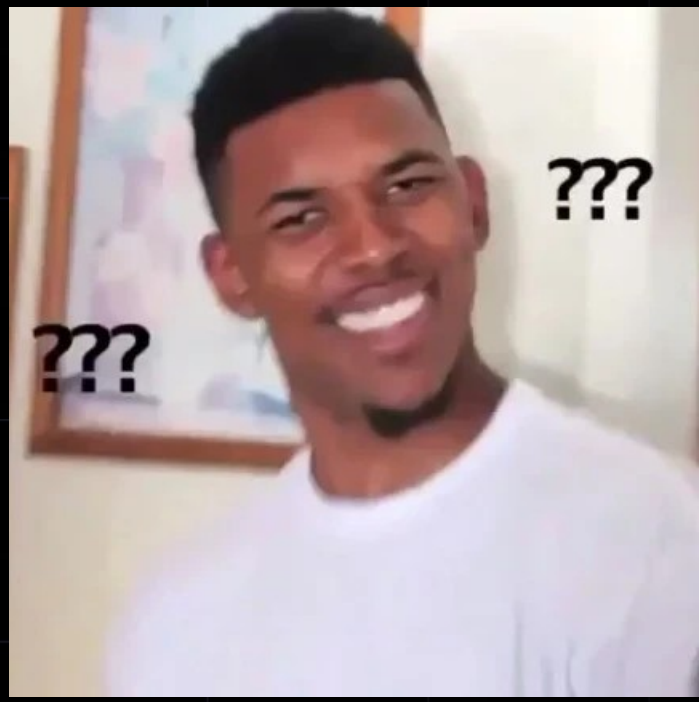
For what??? Python is a dynamic PL...

- Identifying errors, when you write code;
- readability, comprehensibility, maintainability for code;
- IDE hints;
- It’s a good style
- VERY useful for LONG time development;



Type hint’s II

- int, float, str, bool;
- list, tuple, dict, set;
- from typing import *
- NamedTuple, NamedDict



Type hint's Example I

```
def add(x: float, y: float) → float:
        return x + y
```

Type hint's Example I

```
def get_keys(
        x: dict,
        is_sort: bool,
) → list:
        keys = x.keys()
        return sorted(keys) if is_sort else keys
```

Bad practice

```
from typing import Mapping, List
def get_keys(
        x: Mapping[str, int],
        is_sort: bool,
) → List[str]:
        keys = x.keys()
        return sorted(keys) if is_sort else keys
```

Best practice