SEQUENCES AND CONTAINERS

COMPUTER SCIENCE MENTORS 61A

September 26–September 30, 2022

1 Sequences

Sequences are ordered data structures that have length and support element selection. Here are some common types of sequences you'll be dealing with in this class:

- Lists: `[1, [2], 'a', lambda x: 5]`
- Tuples: `(1, (2,), 'a', lambda x: 5)`
- Strings: `'Hello World!'`

While each type of sequence is different, they all share a common interface for manipulating and accessing their data:

- **Item selection**: Use square brackets to select an element at an index:

  `(3, 1, 2)[0]` → `"3"`, `"Hello"[-1]` → `"o"`

- **Length**: The built-in **`len`** function returns the length of a sequence:

  `len``((1,2))` → `2`

- **Concatenation**: Sequences can be concatenated with the + operator, which returns a *new* sequence:

  `[1, 2] + [3,4]` → `[1,2,3,4]`

- **Membership**: The **`in`** operator tests for sequence membership:

  `1` **`in`** `(1, 2, 3)` → `True`, `5` **`not in`** `(1, 2, 3)` → `True`, `"apple"` **`in`** `"snapple"` → `True`

- **Looping**: Sequences can be looped through with **`for`** loops:

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```
>>> for x in [1, 2, 3]:
...     print(x)
1
2
3
```

- **Aggregation**: Common built-in functions—including **`sum`**, **`min`**, and **`max`**—can take sequences and aggregate them into a single value:

  `max``((3, 4, 5))` → `5`

- **Slicing**: Slicing is a way to create a copy of all or part of a sequence. The general syntax for slicing a sequence `seq` is as follows:

  `seq[<start index>:<end index>:<step size>]`

  This evaluates to a new sequence that includes every element starting at `<start index>` and up to and *excluding* `<end index>` in `seq`, taking steps of size `<step size>`.

  If we do not supply `<start index>` or `<end index>`, it will start at the beginning of the sequence and include every element up to and including the end of the sequence.

  ```
  >>> lst = [1, 2, 3, 4, 5]
  >>> lst[2:]
  [3, 4, 5]
  >>> lst[:3]
  [1, 2, 3]
  >>> lst[::-1]
  [5, 4, 3, 2, 1]
  >>> lst[1::2]
  [2, 4]
  ```

List comprehensions, which only apply to lists, are a concise and powerful method to create a new list from another sequence. The syntax for a list comprehension is

`[<expression>` **`for`** `<element>` **`in`** `<sequence>` **`if`** `<condition>]`

We could equivalently write the following:

```
lst = []
for <element> in <sequence>:
    if <condition>:
        lst = lst + [<expression>]
```

The **if** <condition> filter statement is optional. The following list comprehension doubles each odd element of [1, 2, 3, 4]:

```
>>> [i * 2 for i in [1, 2, 3, 4] if i % 2 != 0]
[2, 6]
```

Equivalent in **for** loop syntax:

```
lst = []
for i in [1, 2, 3, 4]:
    if i % 2 != 0:
        lst = lst + [i * 2]
```

1. What would Python display? Draw box-and-pointer diagrams for the following:

```
>>> a = [1, 2, 3]
>>> a


>>> a[2]


>>> a[-1]


>>> b = a
>>> a = a + [4, [5, 6]]
>>> a


>>> b


>>> c = a
>>> a = [4, 5]
>>> a


>>> c
```

```
>>> d = c[3:5]
>>> c[3] = 9
>>> d


>>> c[4][0] = 7
>>> d


>>> c[4] = 10
>>> d


>>> c
```

2. Draw the environment diagram that results from running the code below.

```
def reverse(lst):
    if len(lst) <= 1:
        return lst
    return reverse(lst[1:]) + [lst[0]]

lst = [1, [2, 3], 4]
rev = reverse(lst)
```

3. Write a list comprehension that accomplishes each of the following tasks.

   (a) Square all the elements of a given list, `lst`.

   (b) Compute the dot product of two lists `lst1` and `lst2`. *Hint*: The dot product is defined as lst1$[0] \cdot$ lst2$[0]$ + lst1$[1] \cdot$ lst2$[1] + \ldots +$ lst1$[n] \cdot$ lst2$[n]$. The Python **`zip`** function may be useful here.

   (c) Return a list of lists such that `a = [[0], [0, 1], [0, 1, 2], [0, 1, 2, 3], [0, 1, 2, 3, 4]]`.

   (d) Return the same list as above, except now excluding every instance of the number 2: `b = [[0], [0, 1], [0, 1], [0, 1, 3], [0, 1, 3, 4]])`.

4. Write a function `duplicate_list`, which takes in a list of positive integers and returns a new list with each element `x` in the original list duplicated `x` times.

```
def duplicate_list(lst):
    """
    >>> duplicate_list([1, 2, 3])
    [1, 2, 2, 3, 3, 3]
    >>> duplicate_list([5])
    [5, 5, 5, 5, 5]
    """
    _____________________________________

    for _____________________________:

        for _____________________________:

            ___________________________________________

    _____________________________________
```

2 Dictionaries

Dictionaries are another useful Python data structure that store a collection of items. However, instead of assigning each item a numerical index, each **value** in a dictionary is mapped to by some **key**.

Dictionaries are denoted with curly braces and use much of the syntax—including item selection with square brackets, membership testing with **`in`**, and length checking with **`len`**—is the same as that of sequences. Consider the following "Big" example:

```
>>> big_game_wins = {"Cal": 48, "Stanford": 65}
>>> big_game_wins
{"Cal": 48, "Stanford": 65}
>>> big_game_wins["Stanford"]
65
>>> big_game_wins["Cal"]
48
>>> big_game_wins["Cal"] += 1
>>> big_game_wins["Cal"]
49


>>> list(big_game_wins.keys())
["Cal", "Stanford"]
>>> list(big_game_wins.values())
[49, 65]

>>> "Cal" in big_game_wins
True
>>> "Tie" in big_game_wins
False
>>> 65 in big_game_wins
False


>>> big_game_wins["Tie"]
KeyError: Tie
>>> big_game_wins["Tie"] = 11
>>> big_game_wins["Tie"]
11
```

1. Complete the function `snapshot`, which takes a single-argument function `f` and a list `inputs` and returns a "snapshot" of `f` on `inputs`. A "snapshot" is a dictionary where the keys are the provided `inputs` and the values are the corresponding outputs of `f` on each input.

```
def snapshot(f, inputs):
    """
    >>> snapshot(lambda x: x**2, [1, 2, 3])
    {1: 1, 2: 4, 3: 9}
    """

    snap = ____________________________________________

    ____________________________________________:

        ____________________________________________

    return snap
```

2. A *digraph* is any pair of immediately adjacent letters; for example, "otto" contains three digraphs: "ot", "tt", and "to". Write a function `count_digraphs`, which takes a piece of `text` and a list of letters `alphabet` and analyzes the frequency of diagraphs in `text`. Specifically, `count_digraphs` returns a dictionary whose keys are the valid digraphs of `text` and whose values are the number of times each digraph occurred. (A digraph is valid if it is formed out of letters from the specified `alphabet`.)

```
def count_digraphs(text, alphabet):
    """
    >>> count_digraphs("otto", ['o', 't'])
    {'ot': 1, 'tt': 1, 'to': 1}
    >>> count_digraphs("otto", ['t'])
    {'tt': 1}
    >>> count_digraphs("6161 6", ['6', '1'])
    {'61': 2, '16': 1}
    """

    freq = {}

    _____________________________________________________________:

        if _____________________________________________________:

            digraph = _____________________________________

            _____________________________________________________

                _____________________________________________________

            _____________________________________________________

                _____________________________________________________

    return freq
```