Data Structures in Python
Chapter 3

1. **Stack Concept and ADT**
2. Stack Example - Matching
3. Stack Example - Postfix
4. Queue
5. Deque & Profiling
6. Circular Queue
7. Linked list
8. Unordered List
9. Ordered List and Iterator

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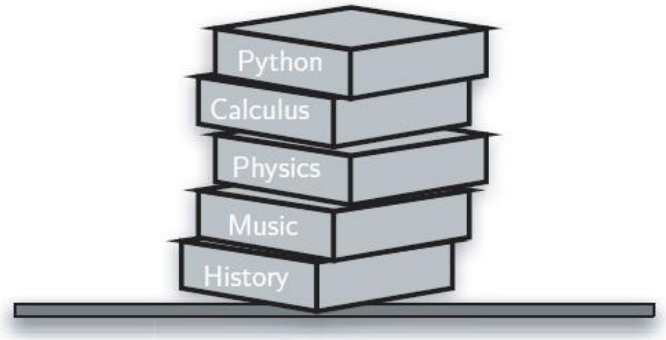
Software Design Principles - Modularity

- Agenda
  - Introduction
  - The Stack Abstract Data Type (ADT)
  - Two implementations of Stack

- Reference:
  - Textbook: Problem Solving with Algorithms and Data Structures
    - Chapter 3: Basic Data Structures



Introduction - Linear Structures

- Linear structures are data collections whose items are ordered depending on how they are added or removed from the structure.
- Once an item is added, it stays in that position relative to the other elements that came before and came after it.
- Linear structures can be thought of as having two **ends, top** and **bottom**, (or front and end or front and back).
- What distinguishes one linear structure from another is the way in which items are added and removed, in particular the location where these additions and removals occur, e.g., add only to one end, add to both, etc.

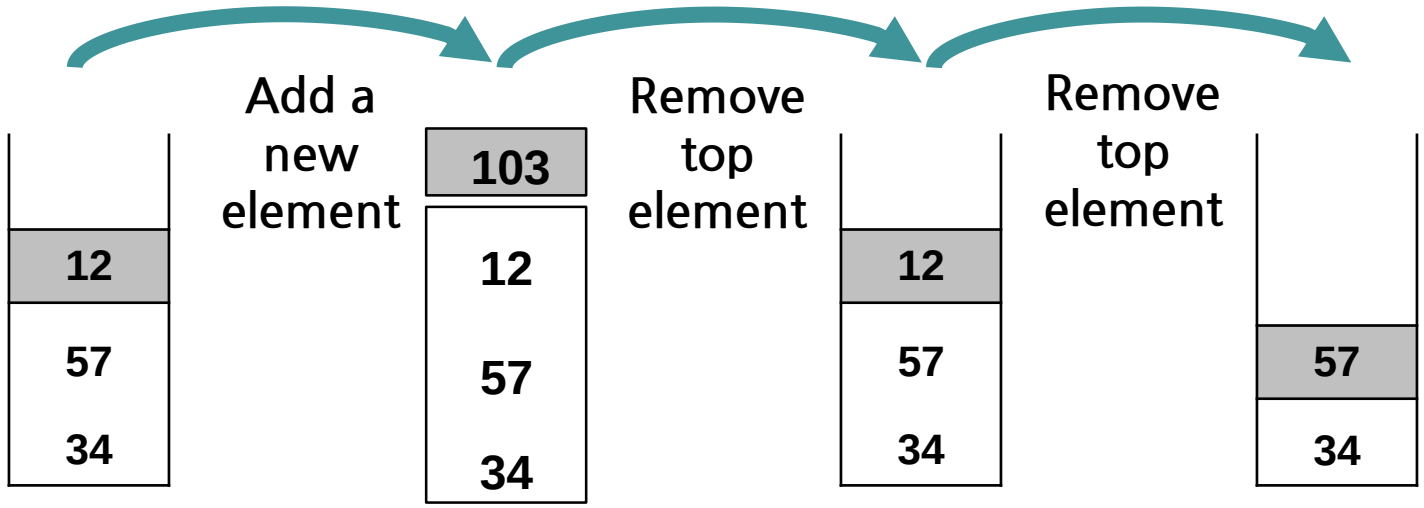
Introduction - What is a Stack?

- A stack is an ordered collection of items where the addition of new items and the removal of existing items always takes place at the same end, referred to as the top of the stack.
  - i.e., add at **top**, remove from **top**
- Last-in, first-out (LIFO) property
  - The **last** item placed on the stack will be the **first** item removed.
- Example:
  - A stack of dishes in a cafeteria

Introduction - Stack Example

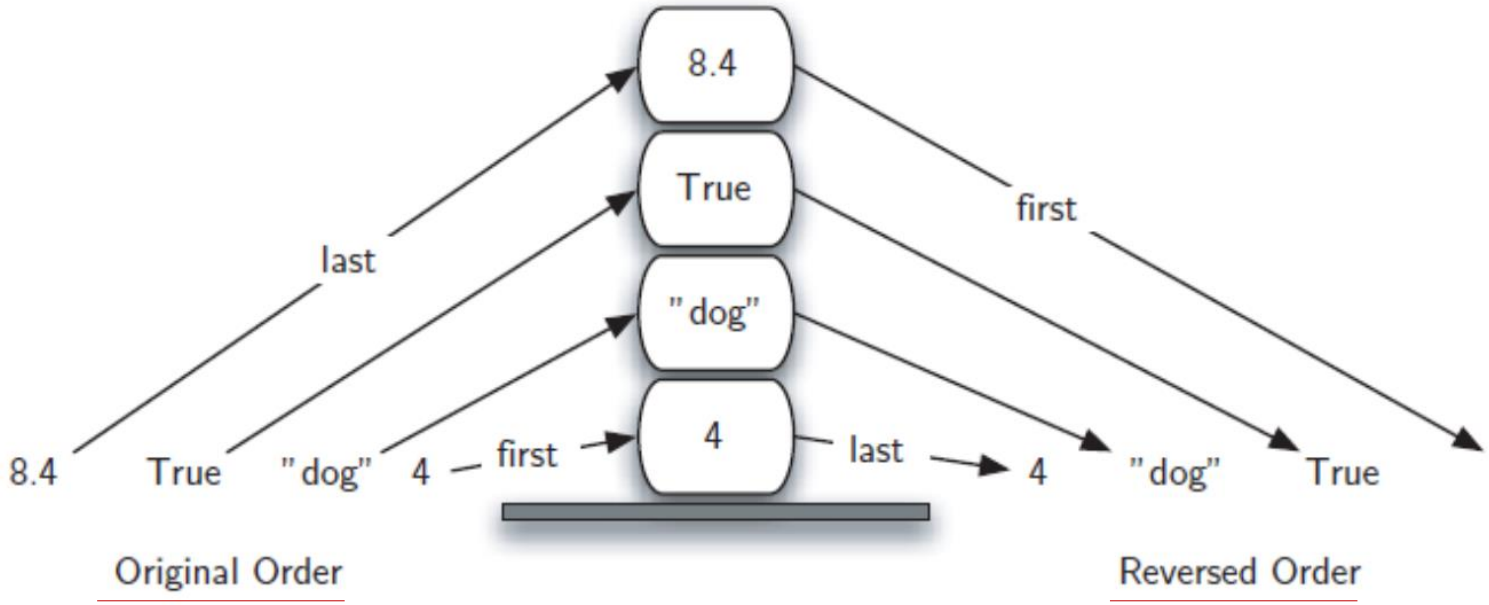
- Add only to the **top** of a Stack
- Remove only from the **top** of the Stack
  - Note: The last item placed on the stack will be the first item removed

Last In - First Out (LIFO)



Introduction - Orders

- The base of the stack contains the oldest item, the one which has been there the longest.
- For a stack, the order in which items are removed is exactly the reverse of the order that they were placed.



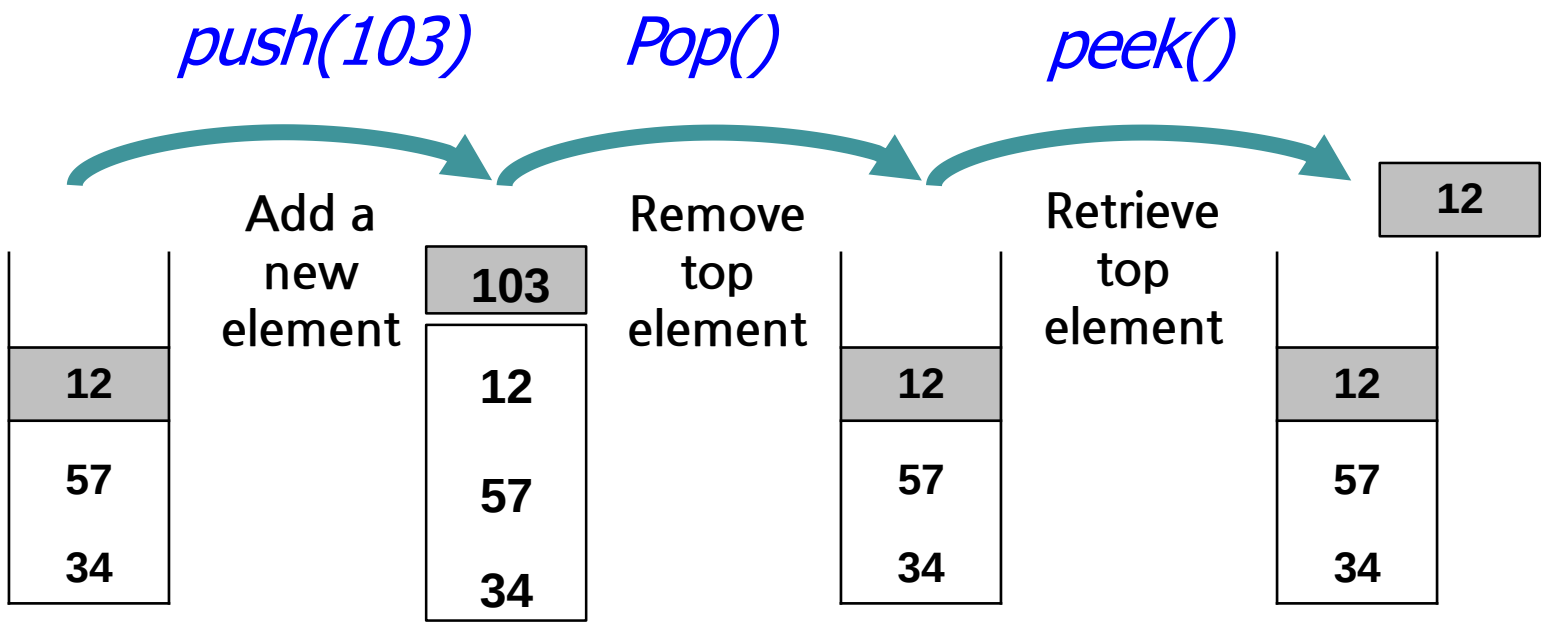
The reversal property of stacks

Introduction - ADT Stack Operations

- What are the operations which can be used with a **Stack Abstract Data**?
  - Create an **empty** stack.
  - Determine whether a stack is empty.
    - is_empty()
  - Count the number of items in the stack.
    - size
  - Add a new item to the stack.
    - push
  - Remove from the stack the item that was added most recently.
    - pop
  - Retrieve from the stack the item that was added most recently.
    - peek

Introduction - ADT Stack Operations

- What are the operations which can be used with a Stack Abstract Data?



The Stack Abstract Data Type

- Stack() creates a new stack that is empty.
  - It needs no parameters and returns an empty stack.
- push(item) adds a new item to the top of the stack.
  - It needs the item and returns nothing.
  - The stack is modified.
- pop() removes the top item from the stack.
  - It needs no parameters and returns the item.
  - The stack is modified.

Stack(), push(item) and **pop()** are critical operations in order to manipulate the elements of the stack

The Stack Abstract Data Type

- peek() returns the top item from the stack but does not remove it.
  - It needs no parameters.
  - The stack is not modified.
- is_empty() tests to see whether the stack is empty.
  - It needs no parameters and returns a Boolean value.
  - The stack is not modified.
- size() returns the number of items on the stack.
  - It needs no parameters and returns an integer.
  - The stack is not modified

peek(), is_empty() and **size()** are useful to allow the users to retrieve the properties of the stack but they are not necessary.

The Stack Abstract Data Type - Exercise 1

- What is the output of the following code snippet?

Code	Stack Implementation	Output

`s = Stack()`
`print(s.is_empty())`
`s.push(5)`
`print(s.peek())`
`s.pop()`
`s.push(8.5)`
`print(s.size())`
`s.push('cat')`
`print(s.peek())`
`s.pop()`
`print(s.size())`
	`s =`
	`s =`
	`s =`
	`s =`
	`s =`
	`s =`
	`s =`
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The Stack Abstract Data Type - Exercise 1

- What is the output of the following code snippet?

Code

```
s = Stack()
print(s.is_empty())
s.push(5)
print(s.peek())
s.pop()
s.push(8.5)
print(s.size())
s.push('cat')
print(s.peek())
s.pop()
print(s.size())
```

Stack Implementation

```
s = []
s = []
s = [5]
s = [5]
s = []
s = [8.5]
s = [8.5]
s = [8.5, 'cat']
s = [8.5, 'cat']
s = [8.5]
s = [8.5]
```

Output

```

True

5
5

1

cat
cat
1
```

The Stack Abstract Data Type - Exercise 2

- What is the output of the following code snippet?

Code

```
s = Stack()
print(s.is_empty())
s.push(4)
print(s.peek())
s.push(8.4)
print(s.size())
s.push('dog')
print(s.peek())
print(s.size())
```

Stack Implementation

```
s =
s =
s =
s =
s =
s =
s =
s =
s =
```

Output

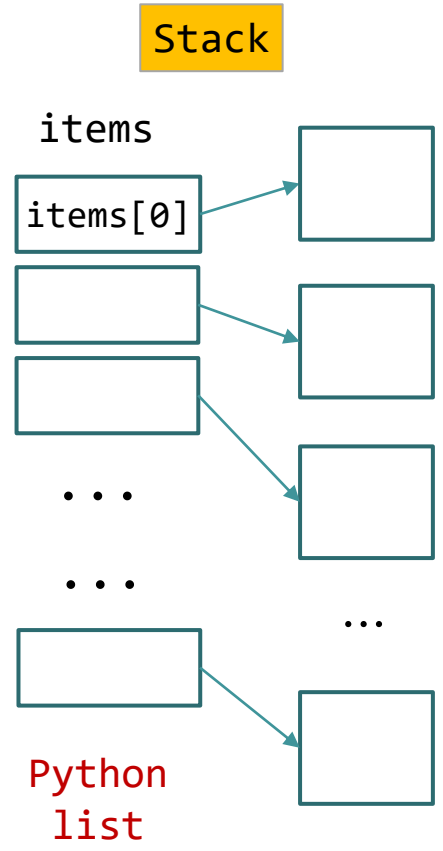
The Stack Implementation - The Stack In Python

- We use a python **List** data structure to implement the stack.
  - Remember:
    The addition of new items and the removal of existing items always takes place at the same end, referred to as the top of the stack.

```
class Stack:
    def __init__(self):
        self.items = []

    def is_empty(self):
        return self.items == []

    def size(self):
        return len(self.items)
    ...
```



The Stack Implementation - The Stack In Python

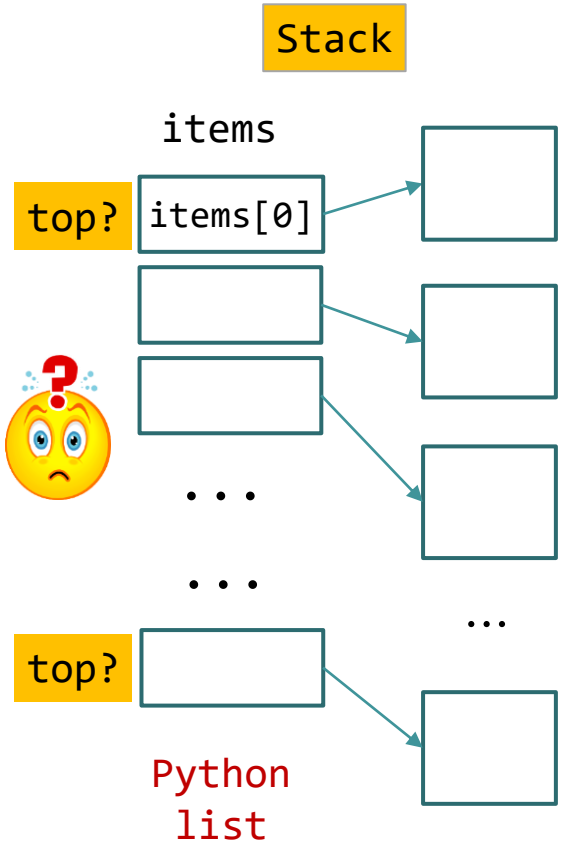
- We use a python List data structure to implement the stack
  - Question:
    - Which “end” of the Python list is better for our Stack implementation?

```
class Stack:
    def __init__(self):
        self.items = []

    def is_empty(self):
        return self.items == []

    def size(self):
        return len(self.items)

    ...
```

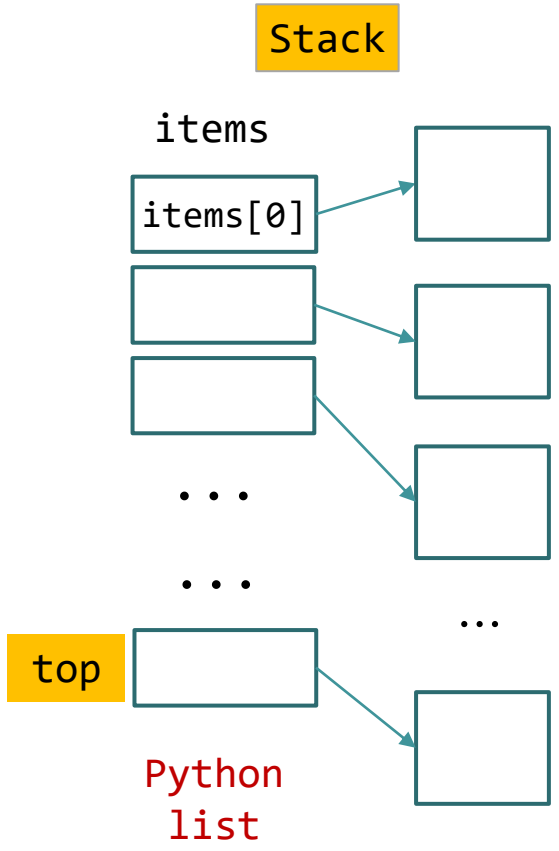


The Stack Implementation - The Stack In Python

- We use a python List data structure to implement the stack
  - Question:
    - Which “end” of the Python list is better for our Stack implementation?
  - Version 1: Big-O?
    - push() and pop(): O(1)
    - search(): O(n)

```
class Stack:
    ...
    def push(self, item):
        self.items.append(item)

    def pop(self):
        return self.items.pop()
    ...
```



The Stack Implementation - The Stack In Python

- We use a python List data structure to implement the stack
  - Question:
    - Which “end” of the Python list is better for our Stack implementation?

  - Version 1: Big-O?
    - push() and pop(): O(1)
    - search(): O(n)

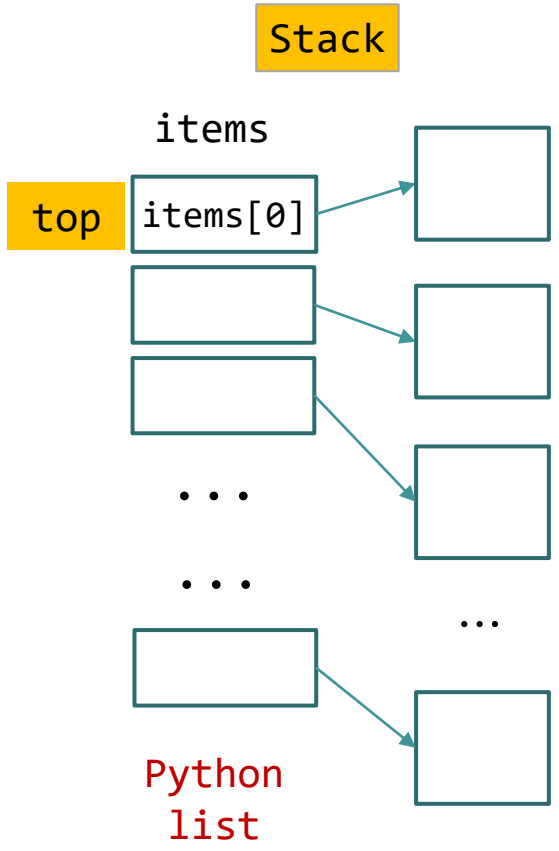
  - Version 2: Big-O?
    - push() and pop(): **O(n)**
    - search(): **O(n)**

```
class Stack:
    ...
    def push(self, item):
        self.items.append(item)

    def pop(self):
        return self.items.pop()
    ...
```

```
class Stack:
    ...
    def push(self, item):
        self.items.insert(0, item)

    def pop(self):
        return self.item.pop(0)
    ...
```



Summary

- Last-in, first-out data structure (push, pop)
- Access is at one point (top of the stack)
- Python lists support simple implementations of stacks