

# Implement a stack using an array

May 3, 2020

## 1 Implement a stack using an array

In this notebook, we'll look at one way to implement a stack. First, check out the walkthrough for an overview, and then you'll get some practice implementing it for yourself.

Walkthrough

Below we'll go through the implementation step by step. Each step has a walkthrough and also a solution. We recommend that you first watch the walkthrough, and then try to write the code on your own.

When you first try to remember and write out the code for yourself, this effort helps you understand and remember the ideas better. At the same time, it's normal to get stuck and need a refresher—so don't hesitate to use the *Show Solution* buttons when you need them.

### 1.1 Functionality

Our goal will be to implement a `Stack` class that has the following behaviors:

1. `push` - adds an item to the top of the stack
2. `pop` - removes an item from the top of the stack (and returns the value of that item)
3. `size` - returns the size of the stack
4. `top` - returns the value of the item at the top of stack (without removing that item)
5. `is_empty` - returns `True` if the stack is empty and `False` otherwise

### 1.2 1. Create and initialize the `Stack` class

First, have a look at the walkthrough:

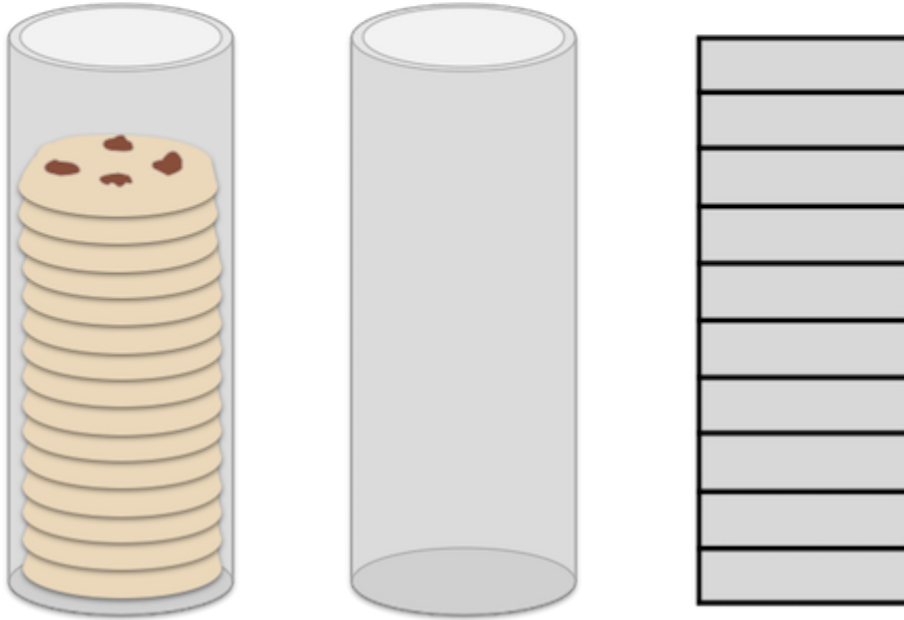
Walkthrough

In [ ]:

In the cell below: \* Define a class named `Stack` and add the `__init__` method \* Initialize the `arr` attribute with an array containing 10 elements, like this: `[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]` \* Initialize the `next_index` attribute \* Initialize the `num_elements` attribute

In [13]:

Let's check that the array is being initialized correctly. We can create a `Stack` object and access the `arr` attribute, and we should see our ten-element array:



Arrays and stacks.

```
In [3]: foo = Stack()
        print(foo.arr)
        print("Pass" if foo.arr == [0, 0, 0, 0, 0, 0, 0, 0, 0, 0] else "Fail")
```

```
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
```

```
Pass
```

Hide Solution

```
In [ ]: class Stack:

        def __init__(self, initial_size = 10):
            self.arr = [0 for _ in range(initial_size)]
            self.next_index = 0
            self.num_elements = 0
```

### 1.3 2. Add the push method

Next, we need to define our push method, so that we have a way of adding elements to the top of the stack.

Walkthrough

```
In [ ]:
```

Now give it a try for yourself. Here's are the key things to include: \* The method will need to have a parameter for the value that you want to push \* Remember that `next_index` will have the index for where the value should be added \* Once you've added the value, you'll want to increment both `next_index` and `num_elements`

```
In [170]: class Stack:

    def __init__(self, initial_size = 10):
        self.arr = [0 for _ in range(initial_size)]
        self.next_index = 0
        self.num_elements = 0

    # TODO Add the push method
```

Let's test it by creating a stack object and pushing an item onto the stack:

```
In [174]: foo = Stack()
          foo.push("Test!")
          print(foo.arr)
          print("Pass" if foo.arr[0] == "Test!" else "Fail")

['Test!', 0, 0, 0, 0, 0, 0, 0, 0, 0]
Pass
```

Hide Solution

```
In [ ]: class Stack:

    def __init__(self, initial_size = 10):
        self.arr = [0 for _ in range(initial_size)]
        self.next_index = 0
        self.num_elements = 0

    def push(self, data):
        self.arr[self.next_index] = data
        self.next_index += 1
        self.num_elements += 1
```

## 1.4 3. Handle full capacity

Great, the push method seems to be working fine! But we know that it's not done yet. If we keep pushing items onto the stack, eventually we will run out of room in the array. Currently, that will cause an `Index out of range` error. In order to avoid a stack overflow, we need to check the capacity of the array before pushing an item to the stack. And if the array is full, we need to increase the array size before pushing the new element.

Walkthrough

```
In [ ]:
```

First, define the `_handle_stack_capacity_full` method: \* Define an `old_arr` variable and assign it the current (full) array \* Create a new (larger) array and assign it to `arr`. \* Iterate over the values in the old array and copy them to the new array.

Then, in the `push` method: \* Add a conditional to check if the array is full; if it is, call the `_handle_stack_capacity_full`

```
In [33]: class Stack:
```

```
    def __init__(self, initial_size = 10):
        self.arr = [0 for _ in range(initial_size)]
        self.next_index = 0
        self.num_elements = 0

    def push(self, data):
        # TODO: Add a conditional to check for full capacity

        self.arr[self.next_index] = data
        self.next_index += 1
        self.num_elements += 1

    # TODO: Add the _handle_stack_capacity_full method
```

We can test this by pushing items onto the stack until we exceed the original capacity. Let's try it and see if we get an error, or if the array size gets increased like we want it to.

```
In [28]: foo = Stack()
        foo.push(1)
        foo.push(2)
        foo.push(3)
        foo.push(4)
        foo.push(5)
        foo.push(6)
        foo.push(7)
        foo.push(8)
        foo.push(9)
        foo.push(10) # The array is now at capacity!
        foo.push(11) # This one should cause the array to increase in size
        print(foo.arr) # Let's see what the array looks like now!
        print("Pass" if len(foo.arr) == 20 else "Fail") # If we successfully doubled the array
```

Out of space! Increasing array capacity ...

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 0, 0, 0, 0, 0, 0, 0, 0]
```

Pass

Hide Solution

```
In [ ]: class Stack:
```

```

def __init__(self, initial_size = 10):
    self.arr = [0 for _ in range(initial_size)]
    self.next_index = 0
    self.num_elements = 0

def push(self, data):
    if self.next_index == len(self.arr):
        print("Out of space! Increasing array capacity ...")
        self._handle_stack_capacity_full()

    self.arr[self.next_index] = data
    self.next_index += 1
    self.num_elements += 1

def _handle_stack_capacity_full(self):
    old_arr = self.arr

    self.arr = [0 for _ in range( 2* len(old_arr))]
    for index, element in enumerate(old_arr):
        self.arr[index] = element

```

## 1.5 4. Add the size and is\_empty methods

Next, we need to add a couple of simple methods: \* Add a size method that returns the current size of the stack \* Add an is\_empty method that returns True if the stack is empty and False otherwise

(This one is pretty straightforward, so there's no walkthrough—but there's still solution code below if you should need it.)

In [30]: `class Stack:`

```

def __init__(self, initial_size = 10):
    self.arr = [0 for _ in range(initial_size)]
    self.next_index = 0
    self.num_elements = 0

def push(self, data):
    if self.next_index == len(self.arr):
        print("Out of space! Increasing array capacity ...")
        self._handle_stack_capacity_full()

    self.arr[self.next_index] = data
    self.next_index += 1
    self.num_elements += 1

# TODO: Add the size method

# TODO: Add the is_empty method

```

```

def _handle_stack_capacity_full(self):
    old_arr = self.arr

    self.arr = [0 for _ in range( 2* len(old_arr))]
    for index, value in enumerate(old_arr):
        self.arr[index] = value

```

Let's test the new methods:

```

In [36]: foo = Stack()
         print(foo.size()) # Should return 0
         print(foo.is_empty()) # Should return True
         foo.push("Test") # Let's push an item onto the stack and check again
         print(foo.size()) # Should return 1
         print(foo.is_empty()) # Should return False

```

```

0
True
1
False

```

Hide Solution

```

In [ ]: class Stack:

        def __init__(self, initial_size = 10):
            self.arr = [0 for _ in range(initial_size)]
            self.next_index = 0
            self.num_elements = 0

        def push(self, data):
            if self.next_index == len(self.arr):
                print("Out of space! Increasing array capacity ...")
                self._handle_stack_capacity_full()

            self.arr[self.next_index] = data
            self.next_index += 1
            self.num_elements += 1

        def size(self):
            return self.num_elements

        def is_empty(self):
            return self.num_elements == 0

        def _handle_stack_capacity_full(self):
            old_arr = self.arr

```

```

self.arr = [0 for _ in range( 2* len(old_arr))]
for index, element in enumerate(old_arr):
    self.arr[index] = element

```

## 1.6 5. Add the pop method

The last thing we need to do is add the pop method.

Walkthrough

In [ ]:

The method needs to: \* Check if the stack is empty and, if it is, return None \* Decrement next\_index and num\_elements \* Return the item that is being "popped"

In [37]: `class Stack:`

```

def __init__(self, initial_size = 10):
    self.arr = [0 for _ in range(initial_size)]
    self.next_index = 0
    self.num_elements = 0

def push(self, data):
    if self.next_index == len(self.arr):
        print("Out of space! Increasing array capacity ...")
        self._handle_stack_capacity_full()

    self.arr[self.next_index] = data
    self.next_index += 1
    self.num_elements += 1

# TODO: Add the pop method

def size(self):
    return self.num_elements

def is_empty(self):
    return self.num_elements == 0

def _handle_stack_capacity_full(self):
    old_arr = self.arr

    self.arr = [0 for _ in range( 2* len(old_arr))]
    for index, value in enumerate(old_arr):
        self.arr[index] = value

```

Let's test the pop method:

```
In [45]: foo = Stack()
foo.push("Test") # We first have to push an item so that we'll have something to pop
print(foo.pop()) # Should return the popped item, which is "Test"
print(foo.pop()) # Should return None, since there's nothing left in the stack
```

Test

None

Hide Solution

```
In [ ]: class Stack:

    def __init__(self, initial_size = 10):
        self.arr = [0 for _ in range(initial_size)]
        self.next_index = 0
        self.num_elements = 0

    def push(self, data):
        if self.next_index == len(self.arr):
            print("Out of space! Increasing array capacity ...")
            self._handle_stack_capacity_full()

        self.arr[self.next_index] = data
        self.next_index += 1
        self.num_elements += 1

    def pop(self):
        if self.is_empty():
            self.next_index = 0
            return None
        self.next_index -= 1
        self.num_elements -= 1
        return self.arr[self.next_index]

    def size(self):
        return self.num_elements

    def is_empty(self):
        return self.num_elements == 0

    def _handle_stack_capacity_full(self):
        old_arr = self.arr

        self.arr = [0 for _ in range( 2* len(old_arr))]
        for index, element in enumerate(old_arr):
            self.arr[index] = element
```

Done!