CSE 4304-Data Structures Lab.
Winter 2024-25
Batch: CSE23
Date: 19 November 2025
Target Group: All groups
Topic: Stacks

Instructions:

- Task naming format: fullID_T01L01_2A.c/cpp
- If you find any issues in the problem description/test cases, comment in the Google Classroom.
- If you find any tricky test cases that I didn't include but that others might forget to handle, please comment! I'll be happy to add them.
- Use appropriate comments in your code. This will help you recall the solution in the future easily.
- The obtained marks will vary based on the efficiency of the solution.
- Do not use <bits/stdc++.h> library.
- Modified sections will be marked with BLUE color.
- You are allowed to use the STL stack unless it's specifically mentioned to use manual functions.

Group	**Tasks**
1A/1B/2A/2B	1 6 7 10
Assignments:	2 4 5 8 12 13 15
Additional Assignments for bonus marks:	9 11 14 (submit with the assignment)

Task 1: Implementing the basic operations of a Stack

A stack is a linear data structure that follows the Last In First Out (LIFO) principle. The last item to be inserted is the first one to be deleted. For example, you have a stack of trays on a table. The tray at the top of the stack is the first item to be moved if you require a tray from that stack.

The Insertion and Deletion of an element from the stack slightly differ from the traditional operation. We define the corresponding operations as **Push()** and **Pop()** from the stack.

- The first line contains *N,* representing the size of the stack. The lines contain the 'function IDs' and the required parameter (if applicable).
- Function ID 1, 2, 3, 4, 5, and 6 correspond to push(), pop,() isEmpty(), isFull() (assume the max size of Stack=5), size(), and top().
- The return type of isEmpty() and isFull() is Boolean. Stop taking input once given -1.
- After each push/pop operation, print the status of the stack.

Input	**Output**	**Explanation**
5		
3	True	Stack is empty
2	Underflow	Empty stack, can't pop
1 10	10	Pushed 10
1 20	10 20	Pushed 20
5	2	Stack has 2 items
1 30	10 20 30	Pushed 30
6	30	Top of stack has 30
2	10 20	Popped item
1 40	10 20 40	Pushed 40
1 50	10 20 40 50	Pushed 50
4	False	The stack isn't full yet
1 60	10 20 40 50 60	Pushed 60
4	True	Stack full
5	5	Stach has 5 items
1 60	Overflow	Stack full, can't push
5	5	Stach has 5 items
2	10 20 40 50	Item popped
6	50	Top of stack has 50
-1		Break

Note:
You have to **implement** the stack operation functions **by yourself** for this task. Do **not** use the STL stack here.

Task 1.1 (assignment): C++ offers a header file called **<stack>,** which has different stack operations implemented as library functions. Follow this (https://www.geeksforgeeks.org/stack-in-cpp-stl/) and try to understand the usage of each function. Finally, implement **Task 1** using those STL library functions (assignment).

Task 2: Parsing HTML code with Stacks

HTML stands for Hyper Text Markup Language· HTML is the standard markup language for creating Web pages· It describes the structure of a Web page using different **‘tags’**. Each tag has two portions - ‘opening’ and ‘closing’ with the notations‘ <tagName>’ and ‘</tagName>, respectively.

Given a snippet of HTML code, your task is to check whether the tags are properly nested or not.
Cases:

- ‘No error’: If all the tags are properly given.
- ‘Error at line ##’: If any error is detected.

Input	**Output**	**Comment**
8 <html> <head> <title> title of webpage </title> </head> <body> This is a paragraph </body> </html> -1	No error	After code traversal, the stack was empty
8 <html> <head> <title> title of webpage </head> </title> <body> This is a paragraph </body> </html> -1	Error at Line 3	The closing tag </head> was found, but the top of the stack doesn't contain the corresponding opening tag
7 <html> <head> <title> </title> </head> <body> An unordered HTML list This is a paragraph -1	Error at line 7	Code traversal is finished, but the stack isn’t empty. Interesting !!
9 <html> <head> <title> title of webpage </head> </title>	Error at line 9	Closing tag </html> found, but the stack is empty

<body> This is a paragraph </body> </html> </html> -1		
9 <html> <head> <title> </title> </head> <body> An unordered HTML list This is a paragraph </body> </html> -1	Error at line 6	The closing tag </h3> was found, but the top of the stack doesn't contain the corresponding opening tag
9 <html> <head> <title> </title> </head> <body> An unordered HTML list This is a paragraph </body> </html> -1	Error at line 7	The closing tag was found, but the top of the stack doesn't contain the corresponding opening tag
8 <html> <head> <title> </title> </head> An unordered HTML list This is a paragraph </body> </html> -1	Error at line 7	The closing tag </body> was found, but the top of the stack doesn’t match

Note:

- You just have to return the **occurrence of the first error** detected by your solution.
- For the last test case, there are some opening tags for which no closing tags were found, although the entire code was checked. So we assume that there is an error in the last line.
- For simplicity, we’ve omitted the tags like
 for which no closing tags are defined.
- **You can use STL <stack> for this task.**

Task 4: Next Greater Element

Given a set of numbers, your task is to print the ***Next Greater Element (NGE)*** for every element. The NGE for an element ***x*** is the first greater element on the right side of ***x*** in the array. Element for which no NGE exists, consider the NGE-value as -1.

Examples:

- For an array, the last element always has NGE as -1.
- For an array sorted in descending order, every element has NGE as -1
- For the input array (4, 5, 2, 25) the NGE for each element is (5, 25, 25, -1).
- For the input array (13, 7, 6, 12) the NGE for each element is (-1, 12, 12, -1}

We can solve this using two simple nested loops! The outer loop picks the elements one by one and the inner loop looks for the first greater element for element picked by the outer loop. If a greater element is found then that element is printed as the NGE, otherwise, -1 is printed.
But this approach has the worst-case Time complexity is $O(n^2)$. (worst case occurs when the elements are in descending order. It will lead us to look for all the elements.)

We can improve the time complexity to **O(n)** using stacks! Your task is to propose an algorithm to find the NGE of every element using stack in O(n) time.

Input:
Each test case can consist of a different number of integers. Every test case will end with a -1 indicating the end of a particular test case (-1 will not be considered as part of the input.)

Output:
Find the NGE of every element using a stack with O(n) worst-case time complexity.

Input	**Output**
4 5 2 25 -1	5 25 25 -1
13 7 6 12 -1	-1 12 12 -1
11 13 21 3 20 -1	13 21 -1 20 -1
12 17 1 5 0 2 2 7 18 25 20 12 5 1 2 -1	17 18 5 7 2 7 7 18 25 -1 -1 -1 -1 2 -1
10 20 30 40 50 -1	20 30 40 50 -1
50 40 30 20 10 -1	-1 -1 -1 -1 -1

Task 5: Reverse string with Stack

Write a program that will take **N** strings as input and print the reverse of them. There are many ways to solve this problem. However, today we want you to solve this problem using **Stack**.
Input will be the number of test cases (**N**) followed by N strings.

Sample Input	**Sample Output**
3 IUT data mozzarella	TUI atad allerazzom

Task 6: Checking parentheses in Mathematical Expressions

Write a program that takes a mathematical expression as input and checks whether it is properly parenthesized or not.

The first line of input will take an integer **N** signifying the number of test cases. The next lines will be **N** mathematical expressions. Each input expression may contain any single-digit number (0~9), operators (+ - x /) and any parenthesis ( )/[ ]/{ }.

The output will be Yes/No, representing whether it is properly parenthesized.

Sample Input	**Sample Output**
10 [5 + (2 x 5) - (7 / 2)] [1 + { 3 x (2 / 3)] } [(1 + 1)] [(1 + 1]) [( )] { } { [( ) ( )] ( ) } ((([5 + (2 x 5) - (7 / 2) 5 + (2 x 5) - (7 / 2)] ( ))) ((( ))	 Yes No Yes No Yes No No No No No

Note: You may need to use fflush(stdin) if you face a problem taking input.

Task 7: Evaluating postfix notation

Write a program to take an expression represented using **postfix notation** as input and evaluate the expression using a stack.

Input expression may contain addition (+), subtraction (-), multiplication (*), and division (/) operators and numbers between (0~9).

Sample Input	**Sample Output**
2 345*+6- 225+*1+5-52**	 17 100

Note: You can use STL <stack> for this task.

Task 8: Parentheses checking in a Code

Write a program that will take a block of code consisting of N lines as input and return if there is any error in the code or not. Consider the ()[]{} symbols as valid parenthesis.

There will be three types of messages:

- ‘No Error’: If the code is compiled successfully.
- ‘Improper parenthesis’: If the code has the necessary number of parentheses but the wrong ones.
- ‘Missing parentheses’” If there is any shortage of parenthesis.

Input	**Output**

5
int main(){
  int x=5, arr[10];
  if(x == 5) return True;
  Else return false;
}
	No Errors.

5
int main(){{
  int x=5, arr[10];
  if(x == 5) return True;
  Else return false;
}
	Error

5
int main(){
  int x=5, arr[10];
  if(x == 5) return True;
  Else return false;
}}
	Error

5
int main(){
  int x=5, arr[10);
  if(x == 5) return True;
  Else return false;
}
	Error

8
for (i=0; i<10;i++){
  printf(“Hello %d”, i);
  if(i%2 == 0){
  print(“even”);
  else{
  print(“odd”);
  }
}
	Error

9 for (i=0; i<10;i++)	Error

printf(“Hello %d”, i);
if(i%2 == 0){
print(“even”);
}
else{
print(“odd”);
}
}	

Note: Use **cin.ignore**() after taking the number of line (sometimes the newline after N gets taken as part of input.

Limitation:

We have omitted some cases like,

```
for (i=0; i<10;i++)
  printf(“Hello %d”, i);
  if(i%2 == 0){
    print(“even”);
  else{
    print(“odd”);
  }
}
```

Where the closing curly brace at line-7 is a bit ambiguous. If we follow the trivial procedure, program will think that it is the closing bracket for the if condition and give no error. It is true in a sense. We are limited here with the ability to just check the number of parenthesis and not the correctness of the code. We can’t also check that there is no parenthesis provided for the ‘for loop’.

Task 9: Remove All Adjacent Duplicates In String

(optional - for bonus marks)

You are given a string *S* consisting of lowercase English letters. A duplicate removal consists of choosing two **adjacent** and **equal** letters and removing them. We repeatedly make duplicate removals on *S* until we no longer can.

Given the string, your task is to return the final string after all such duplicate removals have been made. (It can be proven that the answer is unique).

Input	**Output**	**Explanation**
abbaca	ca	‘abbaca’ we could remove ‘bb’ since the letters are adjacent and equal. The result of this move is that the string is ‘aaca’, of which only ‘aa’ has to be removed, so the final string is ‘ca’.
abbaac	ac	
abbbaaa	aba	
aaabaabaaa	Null	
cxyyyxccc	cxyxc	
geeksforgeeg	gksfor	
datastructure	datastructure	
caaabbbaacdddd	cabc	

Note: This problem can be solved in multiple ways. For this lab, we want you to use a stack to solve this.

Task 10: STPAR - Street Parade

For sure, the love mobiles will roll again on this summer's street parade. Each year, the organizers decide on a fixed order for the decorated trucks. Experience taught them to keep free a side street to be able to bring the trucks into order.
The side street is so narrow that two cars can't pass each other. Thus, the love mobile that enters the side street last must necessarily leave the side street first. Because the trucks and the ravers move up close, a truck cannot drive back and re-enter the side street or the approach street.
You are given the order in which the love mobiles arrive. Write a program that decides if the love mobiles can be brought into the order that the organizers want them to be.

Input
There are several test cases. The first line of each test case contains a single number **n**, the number of love mobiles. The second line contains the numbers ***1 to n*** in an arbitrary order. All the numbers are separated by single spaces. These numbers indicate the order in which the trucks arrive on the approach street. No more than 1000 love mobiles participate in the street parade.

Output
For each test case your program has to output a line containing a single word "yes" if the love mobiles can be re-ordered with the help of the side street, and a single word "no" in the opposite case.

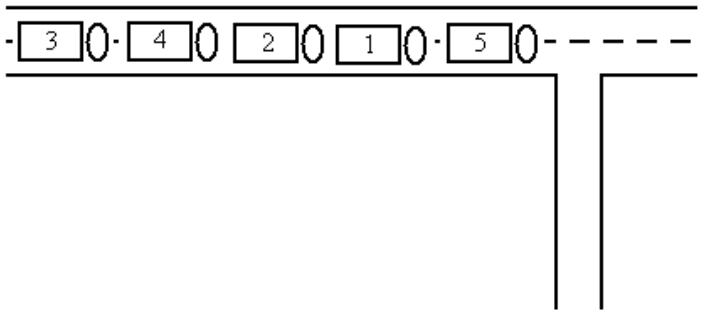
Input	**Output**
5 5 1 2 4 3	Yes
5 5 3 1 2 4	Yes
5 5 4 3 2 1	Yes
5 1 2 4 3 5	Yes
5 1 2 5 3 4	Yes
5 4 5 1 2 3	No
5 1 4 3 5 2	No
5 4 1 2 3 5	Yes

6 5 2 1 4 3 6	Yes
6 5 2 1 6 4 3	No
5 2 1 5 3 4	Yes
5 1 2 4 5 3	No

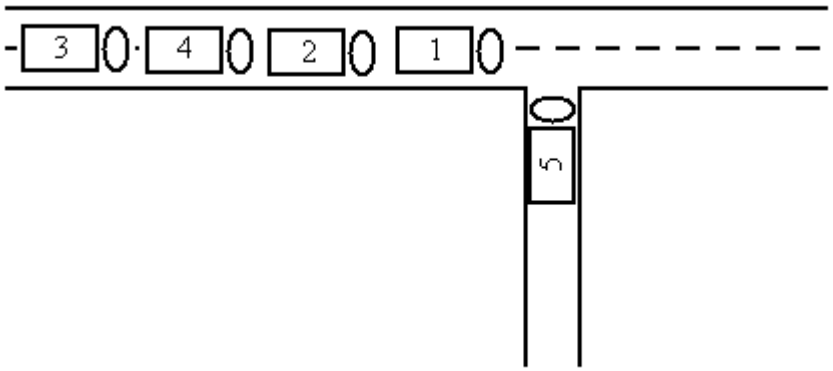
(Check the illustration for test case-1)

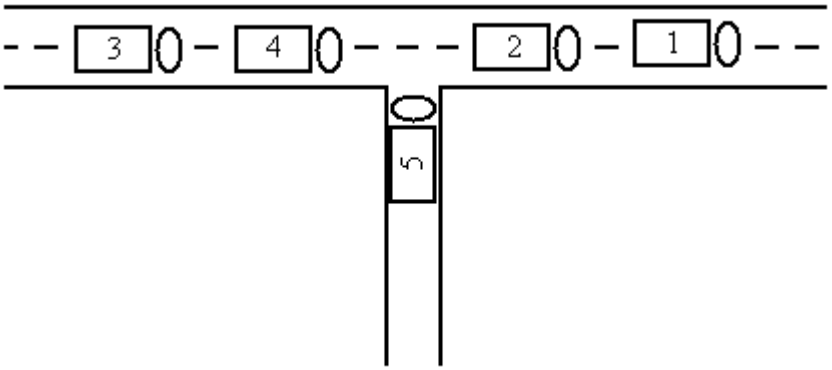
Illustration (for first test case):

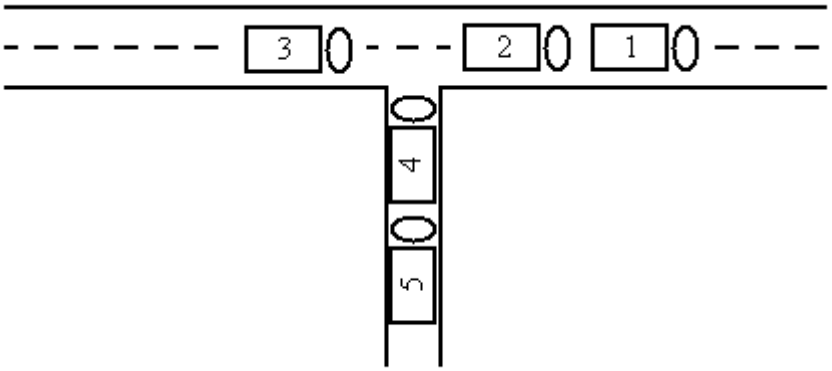
The sample input reflects the following situation:

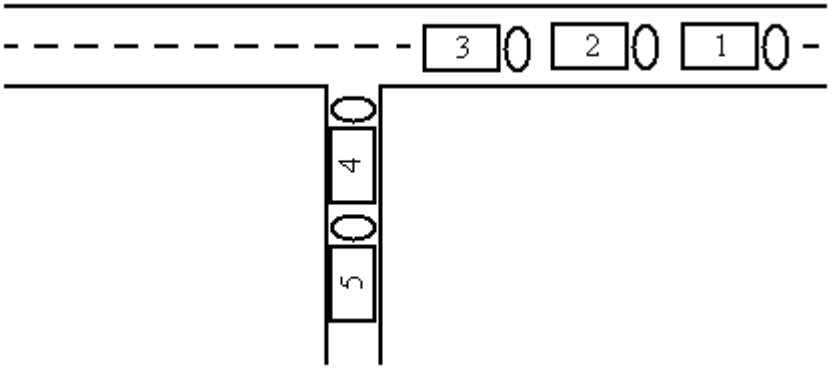


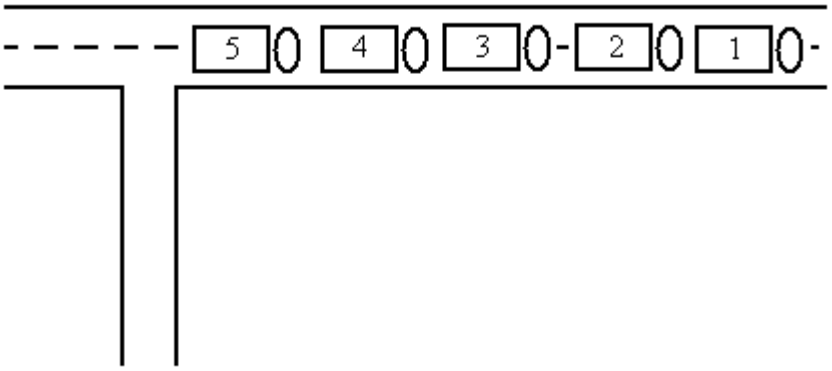
The five trucks can be re-ordered in the following way:




3
4
2
1
5


3
2
1
4
5


3
2
1
4
5


5
4
3
2
1

Task 11 – Colorful Shuttlecocks

(optional -- for bonus marks)

Problem Statement

In order to play badminton with your friends, you bought a cylindrical container full of n Yonex Aerosensa-50 shuttlecocks. The shuttlecocks are numbered from top to bottom, i.e., the topmost shuttlecock is labeled with index 1, and the shuttlecock at the very bottom is labeled with the index n. The shuttlecocks have their own colors – the i-th shuttlecock has the color a_i.

You will be given q queries. For each of the j-th query t_j , you should –

- find the highest shuttlecock in the container with color t_j, i.e., the shuttlecock with the minimum index;
- print the position of the shuttlecock you found;
- take the shuttlecock and place it at the topmost position in the container.

Input

The first line contains two integers n and q – the number of shuttlecocks in the container and the number of queries.

The second line contains n integers a_1, a_2, ..., a_n – the colors of the shuttlecocks.

The third line contains q integers t_1, t_2 ..., t_q – the query colors.

It's guaranteed that queries ask only for colors that are present within the shuttlecock container.

Output

Print q integers – the answers for each query.

Sample Test Case(s)

Input

```
7 5
2 1 1 4 3 3 1
3 2 1 1 4
```

Output

```
5 2 3 1 5
```

Task 12 – Playing with Pringles

Problem Statement

One of the most popular brands of potato chips, *Pringles*, is known for its chips which have a distinctive saddle-shaped appearance. Suppose, you have n such potato chips, where n is an even number.

Each chip can be represented as a Left Parenthesis Shape '(' or a Right Parenthesis Shape ')'. As a perfectionist, you want to arrange the chips in a ***Perfect Sequence***.

A perfect sequence has the following properties –

- "()" is a perfect sequence of parenthesis.
- if S is a perfect sequence, then '(' + S + ')' is also a perfect sequence.
- if S_1 and S_2 are both perfect sequences, S_1 + S_2 is also a perfect sequence.

According to the properties, "(())", "()()", and "((()))" are perfect sequences, but ")(", "())(()", and "((" are not.

You decide to arrange the chips using minimum moves. Each move is defined as the act of moving exactly one chip from any position to either the start or the end of the sequence.

You are given the parenthesis sequence that the Pringles container had when you open it. Find how many moves you need to make it a perfect sequence of parenthesis.

Input

The first line contains one integer t – the number of test cases. Then t cases follow.

The first line of each case contains one even number n – the number of chips.

The second line of each case contains a string s consisting of an equal number of left and right parenthesis shapes – the sequence that the can of Pringles initially had.

Output

For each test case, print the minimum number of moves you need.

Sample Test Case(s)

Input

```
2
8
())()()(
10
)))((((())
```

Output

```
1
3
```

Task 13 – Regular Parenthesis Sequence

Problem Statement

A bracket sequence is considered regular if it can be transformed into a valid arithmetic expression by adding the characters “+” and “1” at appropriate positions within the sequence. For example, sequences “(())()”, “()”, and “((()))” are regular, while “)(”, “((”, and “((()))(” are not.

Johnny found a bracket sequence and wanted to extract a regular bracket sequence by removing certain brackets. What’s the maximum length of the resulting regular bracket sequence?

Input

Input consists of a single line with non-empty string s of ‘(’ and ‘)’ characters.

Output

Output the maximum possible length of a regular bracket sequence.

Sample Test Case(s)

Input

```
(()))(
```

Output

4

Input

```
(((()))
```

Output

6

Task 14 – Largest Rectangle in a Bar Graph

(Optional - for bonus marks)

A bar graph is a geometric shape formed by a series of rectangles placed along a shared baseline.
These rectangles have uniform widths but can vary in their individual heights. For instance, consider the illustration on the left side of Figure-1, which depicts a histogram comprising rectangles with heights of 2, 1, 4, 5, 1, 3, and 3 units, respectively, where each rectangle's width is equivalent to 1 unit.

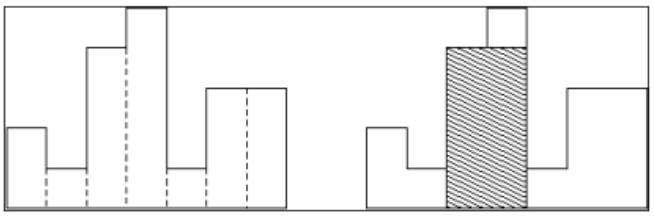


Figure 1: An example bar chart with its largest rectangle.

Calculate the area of the largest rectangle in a bar graph that is aligned at the common base line, too. The illustration on the right side of Figure-1 shows the largest aligned rectangle for the depicted bar graph.

Input

The input contains several test cases. Each test case describes a bar graph and starts with an integer n, denoting the number of rectangles it is composed of. Then follow n integers h_1, ..., h_n. These numbers denote the heights of the rectangles of the bar graph in left-to-right order. The width of each rectangle is 1. **A zero follows the input for the last test case.**

Output

For each test case output on a single line the area of the largest rectangle in the specified bar graph. Remember that this rectangle must be aligned at the common base line.

Sample Test Case(s)

Input	**Output**
7 2 1 4 5 1 3 3 **4 1000 1000 1000 1000** **3 2 1 2** **8 2 1 2 0 3 2 2 3** **1 0** **0**	**8** **4000** **3** **8** **0**

Task 15: Implementing the basic operations of Stack

Stacks is a linear data structure that follows the Last In First Out (LIFO) principle. The last item to be inserted is the first one to be deleted. For example, you have a stack of trays on a table. The tray at the top of the stack is the first item to be moved if you require a tray from that stack.

The Insertion and Deletion of an element from the stack slightly differ from the traditional operation. We define the corresponding operations as push() and pop() from the stack.

The **first line** contains ***N*** representing the **size** of the stack. The following lines contain instructions to be executed in a stack sequentially. There might be two types of instructions –

1) “ + x ” : which means x needs to be pushed into the stack.
2) “ – “ : which means the topmost stack element needs to be popped.

Implement the stack functions isFull(), isEmpty(), push(), pop(), top(), size() by **yourself** (you can’t use stack from STL for this task) and print the stack status as shown in sample output. Stop taking input once given ‘/’.

Input	**Output**
3	
+ 10	Size : 1 Stack elements : 10 Top Element : 10 isFull : False isEmpty : False
+ 7	Size : 2 Stack elements : 10 7 Top Element : 7 isFull : False isEmpty : False
+ 12	Size : 3 Stack elements : 10 7 12 Top Element : 12 isFull : True isEmpty : False
+ 15	Overflow !!! Size : 3 Stack elements : 10 7 12 Top Element : 12 isFull : True isEmpty : False

-	Size : 2 Stack elements : 10 7 Top Element : 7 isFull : False isEmpty : False
-	Size : 1 Stack elements : 10 Top Element : 10 isFull : False isEmpty : False
-	Size : 0 Stack elements : Top Element : 0 isFull : False isEmpty : True
/	