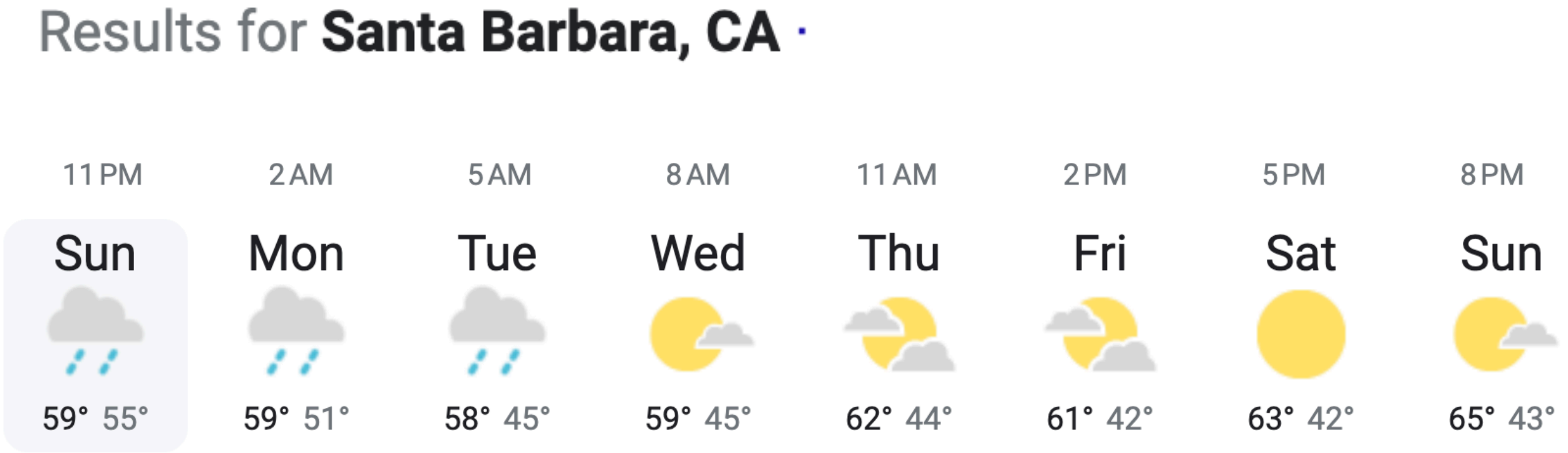
STACKS

Problem Solving with Computers-II

Announcements

- Midterm next week, May 8 (Thursday)!
  - Closed book, closed notes
  - Practice problems available in Canvas
  - All topics covered so far including this week's lectures
  - Data structures covered: Linked lists, BST, stacks and queues
  - Labs 1 - 4 and pa01
  - Leetcode problem sets 1- 3



https://leetcode.com/problems/daily-temperatures/

stack<int> s

Empty stack

Operations: **push()** **pop()** **top()**

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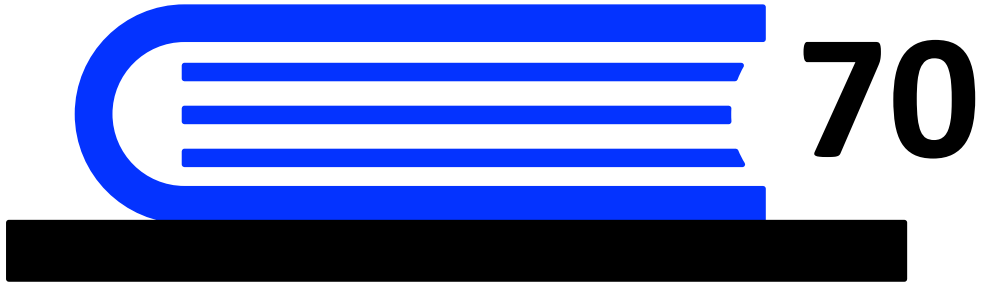
s.push(70)



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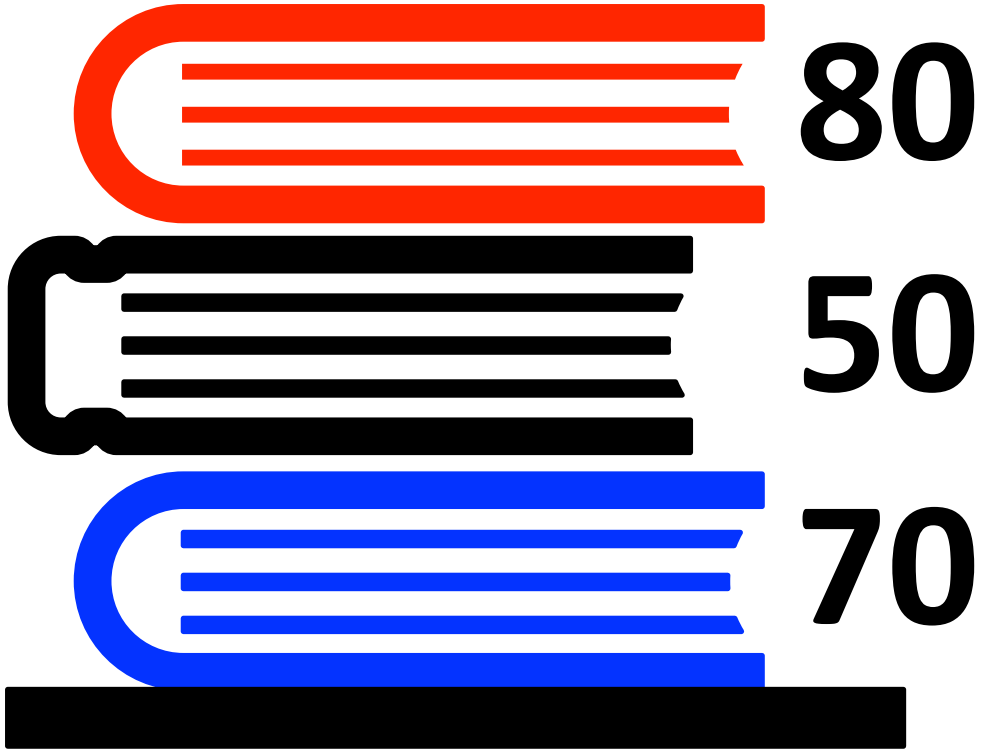
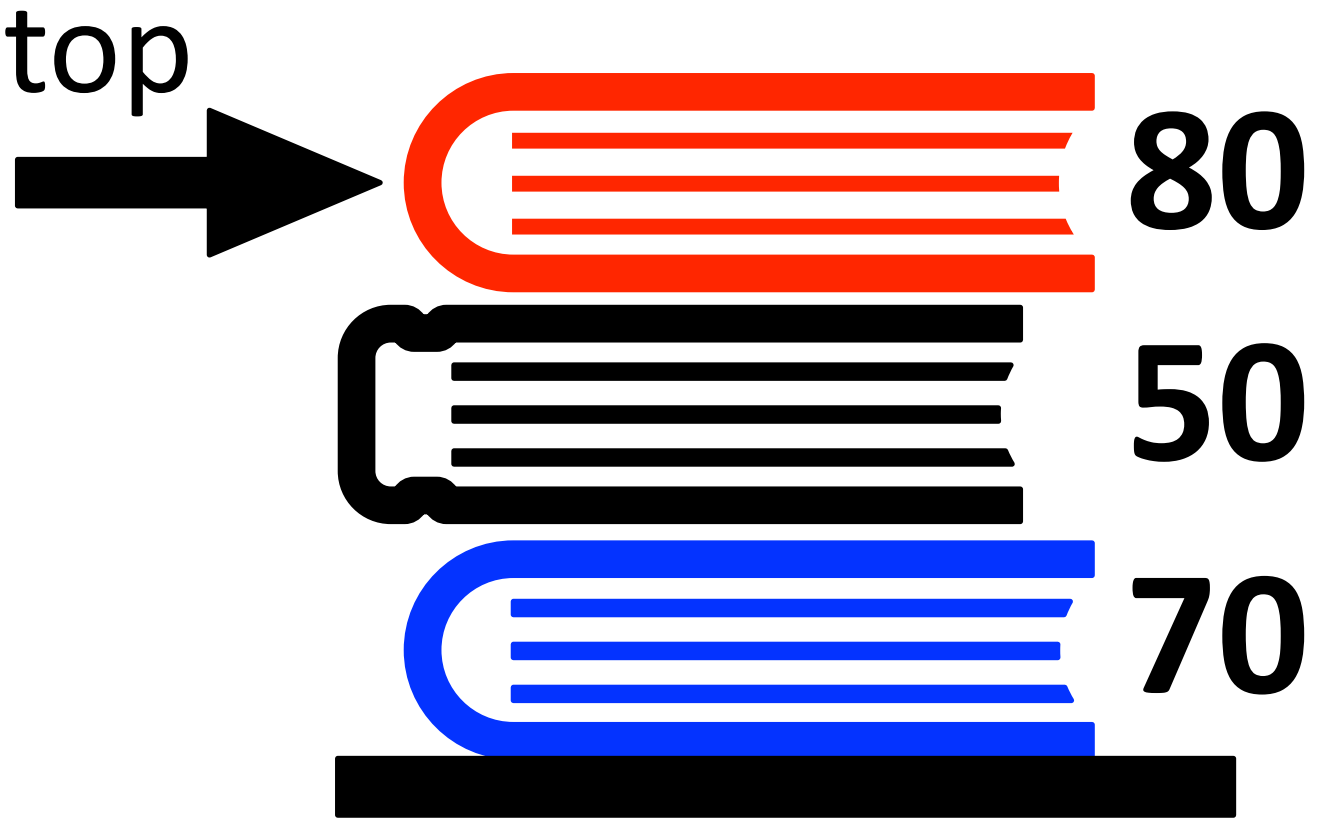


Operations: **push()** pop() top()

```
stack<int> s
s.push(70)
s.push(50)
s.push(80)
```

s.top() returns 80



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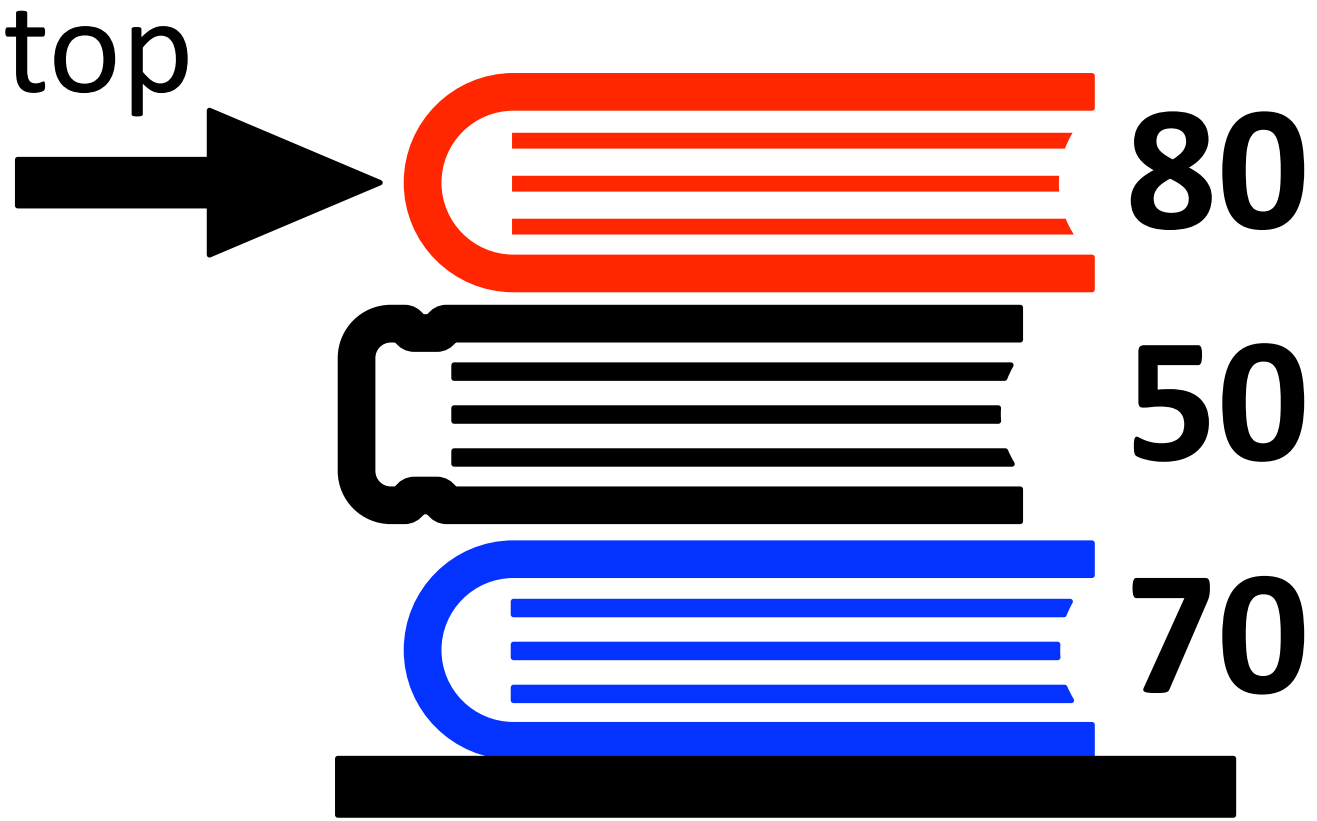

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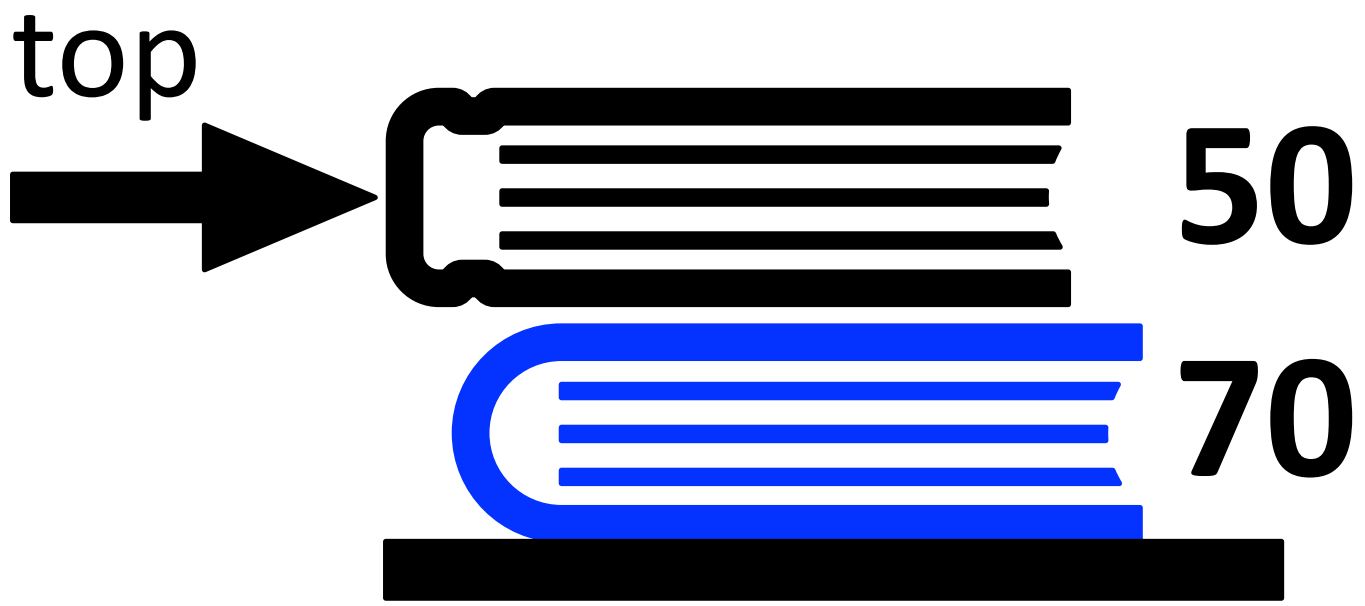

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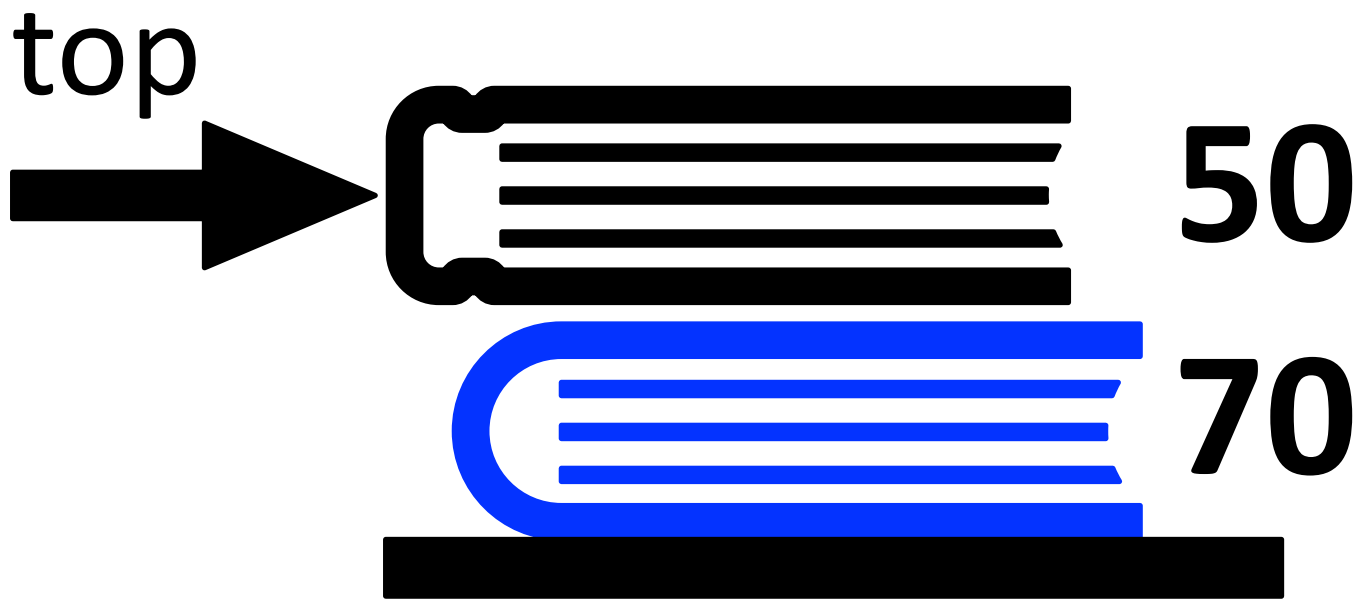
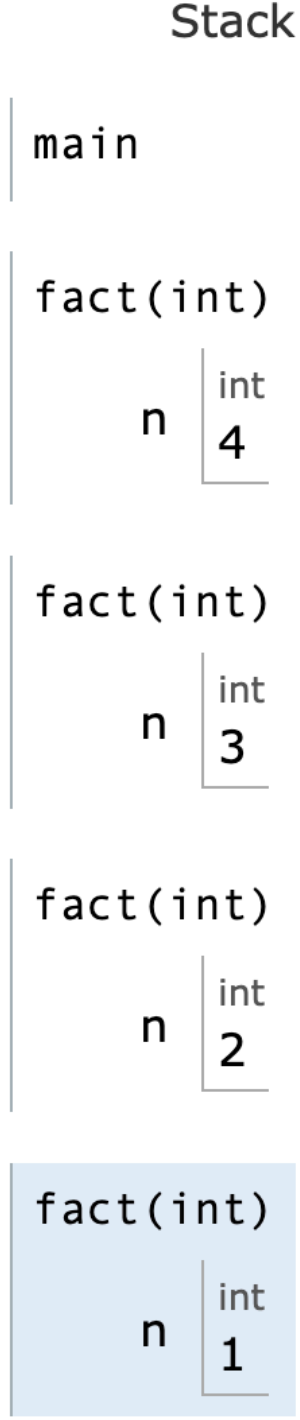


The Last value In is the First value Out (LIFO)

```
1  #include <iostream>
2  using namespace std;
3
4  int fact(int n){
5    if(n <= 1) return 1;
6    return n * fact(n - 1);
7  }
8
9  int main() {
10   cout<< fact(4) << endl;
11   return 0;
12 }
```

The call stack:

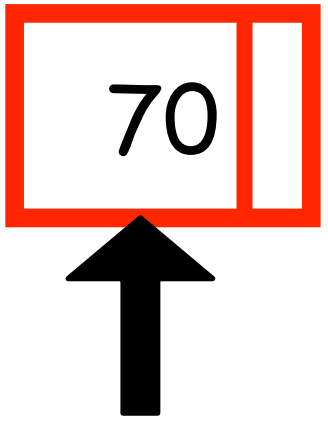


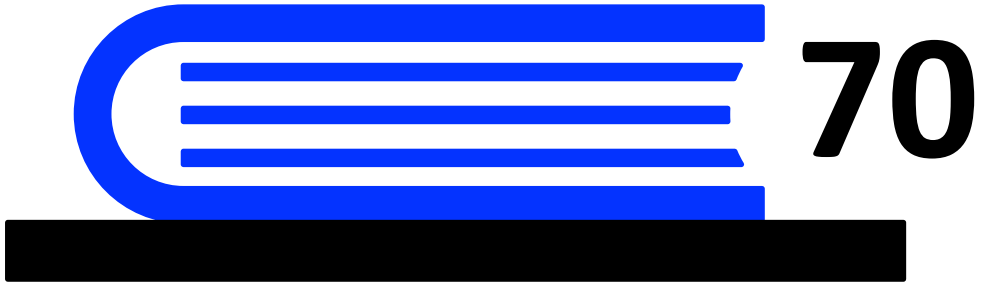
The Last value In is the First value Out (LIFO)

Implement using vector or linked list

Empty stack

Stack Abstract Data Type





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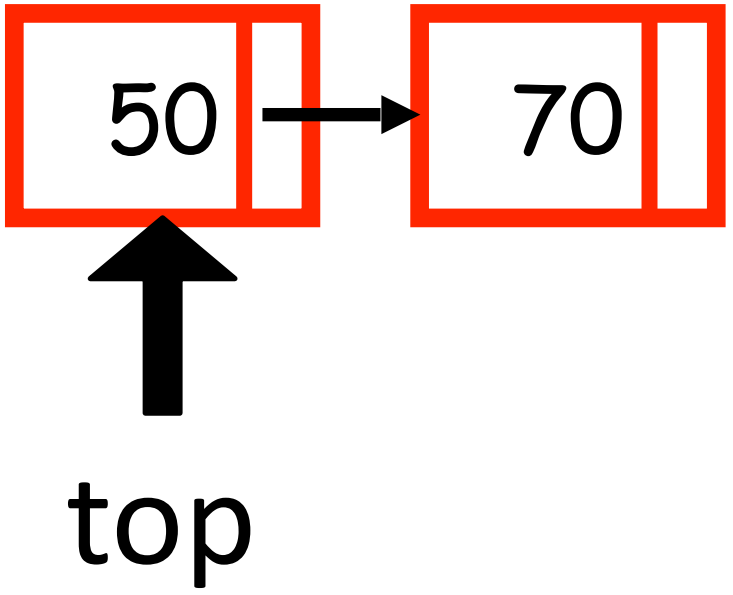

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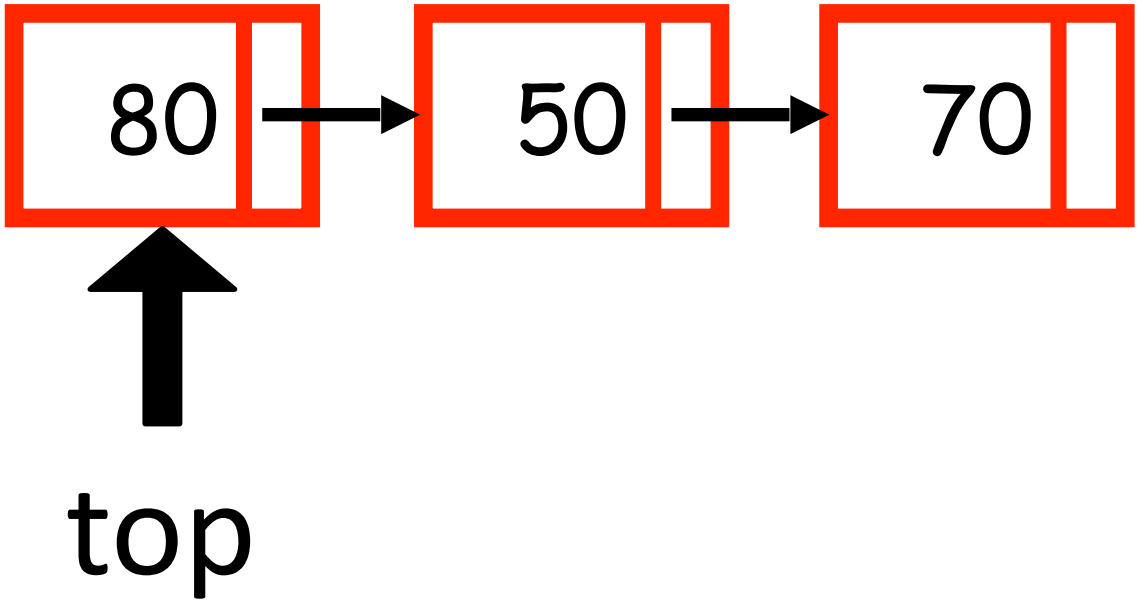
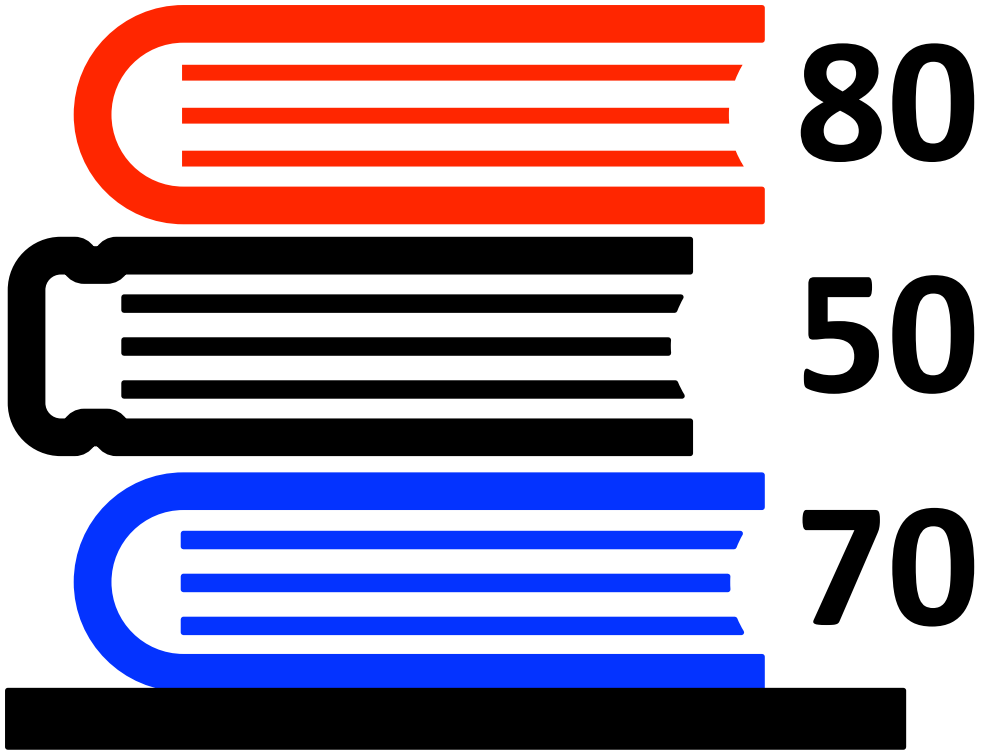
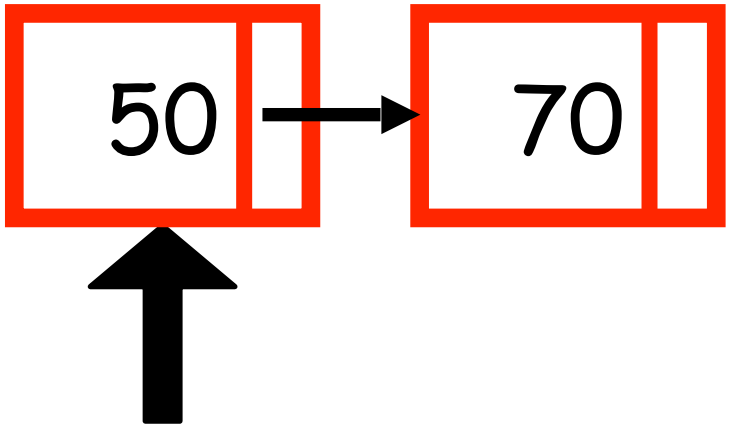




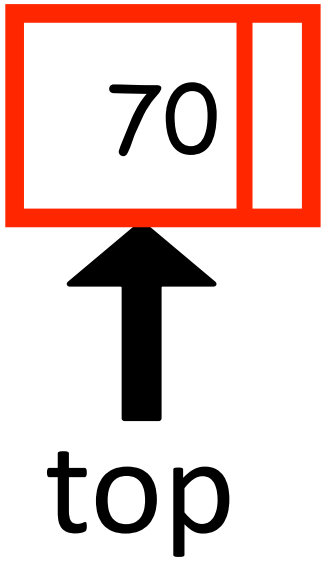
s.push(80)

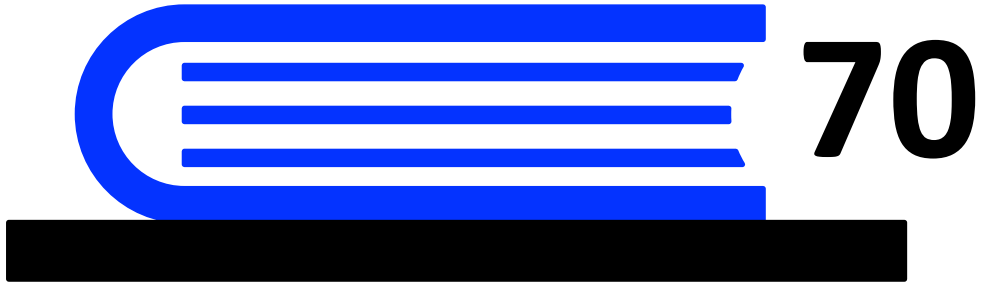
Stack Abstract Data Type



s.pop()

Stack Abstract Data Type





s.pop()

Stack Abstract Data Type

Why implement a stack at all?
After all a stack is a vector or linked list with a
reduced set of operations

Stack has only three operations: **push()** **pop()** **top()**

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After all a stack is a vector or linked list with a **reduced set of operations**

A stack is useful for keeping track of history information where computation only depends on the most recent information !!

Stack has only three operations: **push()** **pop()** **top()**

Stacks and Santa Barbara Weather Puzzle

A stack manages keys using the principle of Last in First Out (LIFO) via four operations, each O(1): 1. push(value) 2. pop() 3. top() 4. empty()

A stack is useful for keeping track of history information where computation only depends on the most recent information !!

Objective: Analyze the complexity of a naive solution for the Daily Temperatures problem by determining its complexity. Next, optimize using a stack-based solution. Explore time and space complexity tradeoff.

Problem: Given an array of daily temperatures, return an array `answer` where `answer[i]` is the number of days after day `i` until a *warmer* temperature occurs, or 0 if none exists. Use Santa Barbara's forecast:

Day:	0	1	2	3	4	5	6	7
Temp:	59	59	58	59	62	61	63	65

Part 1: Naive Solution - Turn the problem's definition into an algorithm.

Approach: Check all future days until a warmer one is found.

Ans: `[ ____, ____, ____, ____, ____, ____, ____, ____ ]`

Leetcode (medium) daily temperatures:
https://leetcode.com/problems/daily-temperatures/

Fill in the blanks to complete pseudocode:

```
Unset
  Initialize answer = [0] * n
   For each day i from n-1 down to 0:
       For each day j from i+1 to n-1:
           If temperatures[j] _____ temperatures[i]:
               answer[i] = _________
               break
   return answer
```

Part 2: Complexity Analysis of Naive Solution

1. How many comparisons did you make to get the answer for day 0 for the given input? _____
2. Write an 8-day temperature input vector that incurs the worst-case running time

   [____, ____, ____, ____, ____, ____, ____, ____]

   - Total comparisons for worst-case input:
   - Why worst?
3. Find the worst-case time and space complexity expressed in Big-O

Part 4: Stack-Based Solution

The refined solution takes O(n) for Day 0 (answer[0] = 4). Can we make it O(1) by tracking useful temperatures?

If we parse the temperatures from right to left, every day we encounter could be a potential answer (for some preceding day) — **remember potential answers in a stack!**

Complete the table to compute the answer for each day, traversing the input vector right to left and updating the stack after each iteration.

Input: temperature on each day:

Temp	**59**	**59**	**58**	**59**	**62**	**61**	**63**	**65**
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Output: Num days until a warmer day:

Num days								
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Show the state of the stack after the temperature for each day is processed!

Stack	**D0**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
Top								
Bottom								

1. Complete the code to capture the stack-based solution from the previous page as the input vector is traversed right to left:

```
#include <vector>
#include <stack>
std::vector<int> dailyTemperatures(std::vector<int>& temperatures) {
       int n = temperatures.size();
       std::vector<int> answer(n, 0);
       std::stack<int> stack;
       for (int i = n - 1; i >= 0; --i) {









        }
        return answer;
    }
```

2. What is the time and space complexity of this solution?

Next steps:

- Attempt a different solution to this problem, traversing the input vector left to right.
- Discuss your solutions with the course staff in office hours