

LEC 06

CSE 122

Stacks & Queues

BEFORE WE START

*Talk to your neighbors:
Best place for boba on the Ave? near
campus?*

Music: [122 24sp Lecture Tunes](#) 

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TAs:	Ayush	Kyle	Colin	Chaafen
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	Chloe	Atharva	Saivi	Ambika
	Ailsa	Rucha	Shivani	Elizabeth
	Jasmine	Megana	Kavya	Aishah
	Lucas	Eesha	Steven	Minh
	Logan	Zane	Ken	Katharine


Questions during Class?

Raise hand or send here

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Lecture Outline

- **Announcements** 
- Review: ADTs, Stacks & Queues
- Queue Manipulation
- Stack Manipulation
 - Problem Solving

Announcements

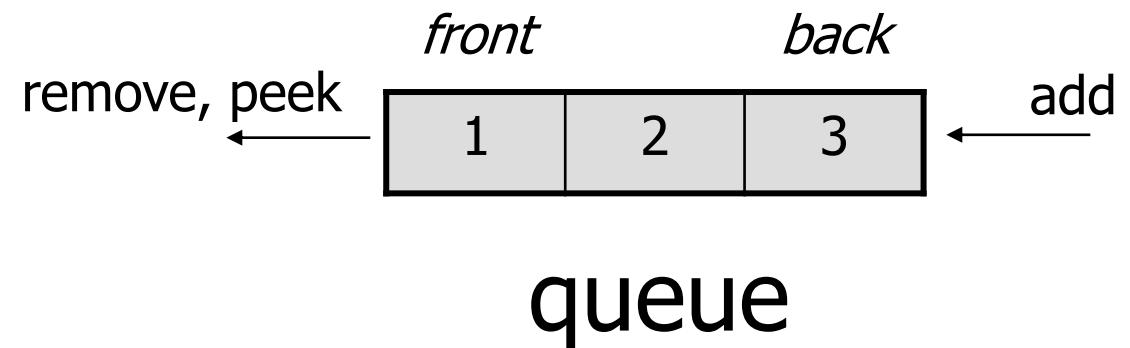
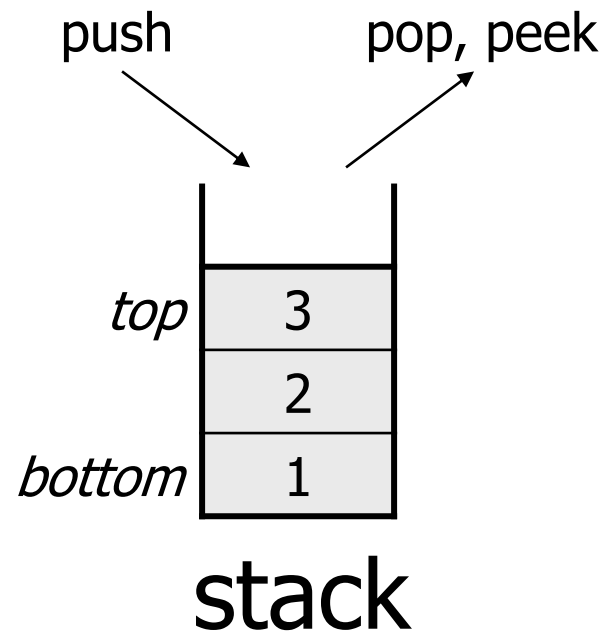
- Quizzes
 - Quiz 0 was yesterday
 - Feedback released sometime before Quiz 1 (May 7)
 - *Metacognition*: How did it go? Was your studying and preparation effective?
- Creative Project 1 is due tomorrow by 11:59pm PT
- Programming Assignment 1 releasing on Friday
 - Focus on Stacks & Queues
 - Due Thursday, April 25 by 11:59pm PT
- Resub 0 closed yesterday (Tuesday), but Resub 1 will open tomorrow!
 - P0, C0 eligible for R1
- Friday – Guest lecture by *Ido*!
- Viewing feedback in Ed...

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- **Review: Stacks & Queues** ◀
- Queue Manipulation
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(PCM) Stacks & Queues

- PCM focused on these new data structures!
- Some collections are constrained, only use optimized (but limited) operations
 - **Stack:** retrieves elements in reverse order as added
 - **Queue:** retrieves elements in same order as added



(PCM) Abstract Data Types

- **Abstract Data Type (ADT):** A specification of a collection of data and the operations that can be performed on it.
 - Describes *what* a collection does, not *how* it does it (not implementation!)
 - Think of it as an *idea* of a data type
- We don't know exactly how a stack or queue is implemented, and we don't need to.
 - Only need to understand high-level idea of what a collection does
 - **Stack:** retrieves elements in reverse order as added.
 - **Queue:** retrieves elements in same order as added.

Wait, ADT? Interfaces?

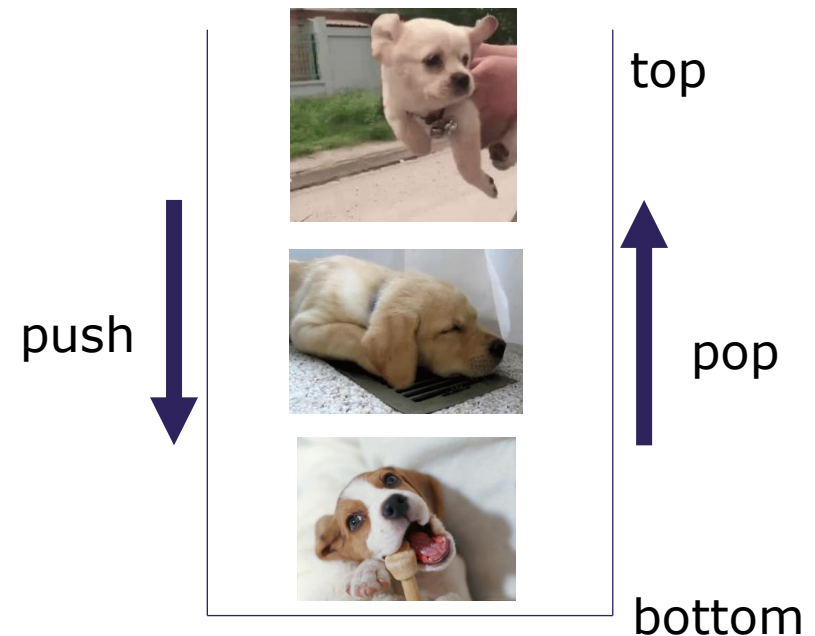
- **Abstract Data Type (ADT):** A *description of the idea* of a data structure including what operations are available on it and how those operations should behave. For example, the English explanation of what a list should be.
- **Interface:** Java construct that lets programmers *specify what methods a class should have*. For example the `List` interface in java.
- **Implementation:** *Concrete code* that meets the specified interface. For example, the `ArrayList` and `LinkedList` classes that implement the `List` interface.

(PCM) Stacks

- **Stack:** A collection based on the principle of adding elements and retrieving them in the **opposite** order.
 - Last-In, First-Out ("LIFO")
 - Elements are stored in order of insertion.
 - We do not think of them as having indexes.
 - Client can only add/remove/examine the last element added (the "top")

Basic **Stack** operations:

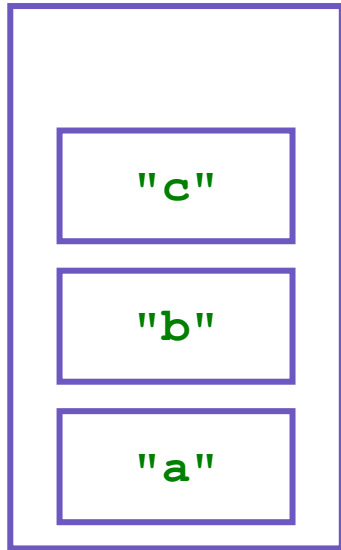
- **push:** Add an element to the top
- **pop:** Remove the top element
- **peek:** Examine the top element



Stacks in Computer Science

- Programming languages and compilers:
 - method calls are placed onto a stack (*call* \leftrightarrow *push*, *return* \leftrightarrow *pop*)
 - compilers use stacks to evaluate expressions
- Matching up related pairs of things:
 - find out whether a string is a palindrome
 - examine a file to see if its braces { } match
 - convert "infix" expressions to pre/postfix
- Sophisticated algorithms:
 - searching through a maze with "backtracking"
 - many programs use an "undo stack" of previous operations

(PCM) Programming with Stacks



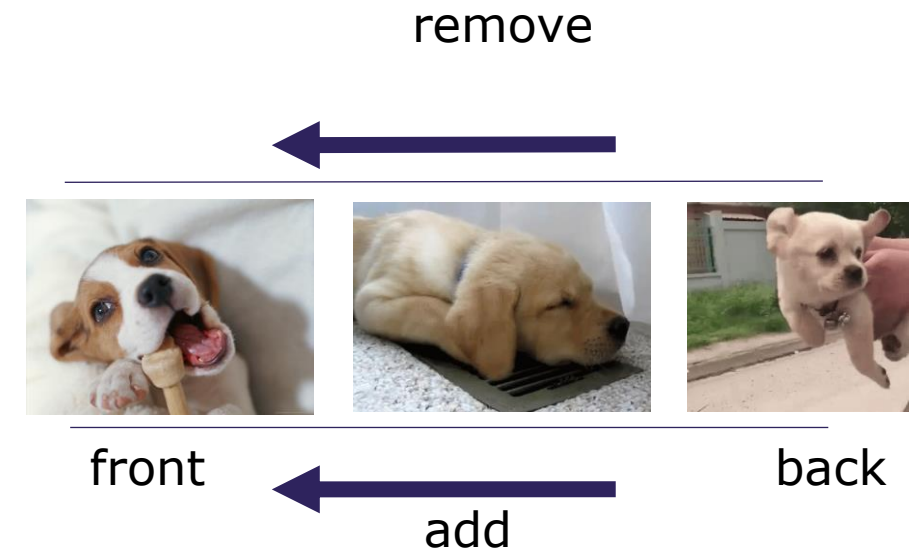
<code>Stack<E>()</code>	constructs a new stack with elements of type E
<code>push(value)</code>	places given value on top of stack
<code>pop()</code>	removes top value from stack and returns it; throws <code>EmptyStackException</code> if stack is empty
<code>peek()</code>	returns top value from stack without removing it; throws <code>EmptyStackException</code> if stack is empty
<code>size()</code>	returns number of elements in stack
<code>isEmpty()</code>	returns <code>true</code> if stack has no elements

```
Stack<String> s = new Stack<String>();  
s.push("a");  
s.push("b");  
s.push("c");  
  
System.out.println(s.pop());
```

- Stack has other methods that we will ask you not to use 🤪

(PCM) Queue

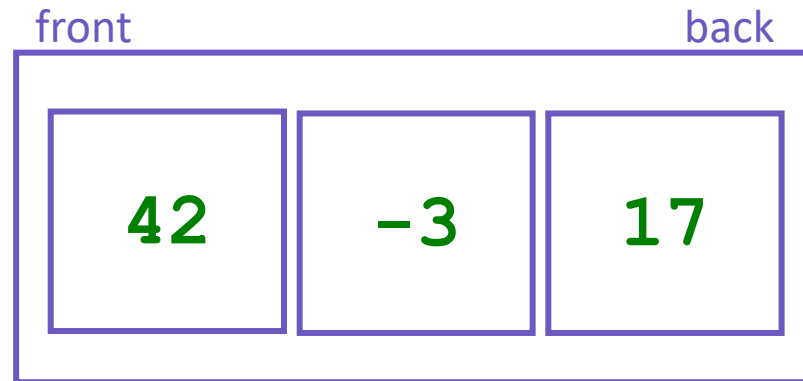
- **Queue:** Retrieves elements **in the order** they were added.
 - First-In, First-Out ("FIFO")
 - Elements are stored in order of insertion but don't have indexes.
 - Client can only add to the end of the queue, and can only examine/remove the front of the queue.
- Basic Queue operations:
 - **add** (enqueue): Add an element to the back.
 - **remove** (dequeue): Remove the front element.
 - **peek**: Examine the front element.



Queues in Computer Science


- Operating systems:
 - queue of print jobs to send to the printer
 - queue of programs / processes to be run
 - queue of network data packets to send
- Programming:
 - modeling a line of customers or clients
 - storing a queue of computations to be performed in order
- Real world examples:
 - people on an escalator or waiting in a line
 - cars at a gas station (or on an assembly line)

(PCM) Programming with Queues



<code>add (value)</code>	places given value at back of queue
<code>remove ()</code>	removes value from front of queue and returns it; throws a <code>NoSuchElementException</code> if queue is empty
<code>peek ()</code>	returns front value from queue without removing it; returns <code>null</code> if queue is empty
<code>size ()</code>	returns number of elements in queue
<code>isEmpty ()</code>	returns <code>true</code> if queue has no elements


```
Queue<Integer> q = new LinkedList<Integer> ();  
q.add(42);  
q.add(-3);  
q.add(17);  
  
System.out.println(q.remove());
```

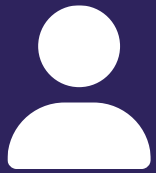
 **IMPORTANT:** When constructing a queue you must use a new `LinkedList` object instead of a new `Queue` object. (More on that with Interfaces.)

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- **Queue Manipulation** ◀
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Practice : Think

[sli.do](#)[#cse122](#)

What does this method return?

```
// numbers: bottom [1, 2, 3, 4, 5] top
public static int sum(Stack<Integer> numbers) {
    int total = 0;
    for (int i = 0; i < numbers.size(); i++) {
        int number = numbers.pop();
        total += number;
        numbers.push(number);
    }

    return total;
}
```

A) 0

B) 5

C) 12

D) 15

E) 25

F) Error /
Exception



Practice : Pair

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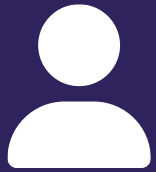
#cse122

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Practice : Think

[sli.do](#)[#cse122](#)

What does this method return?

```
// numbers: bottom [1, 2, 3, 4, 5] top
public static int sum(Stack<Integer> numbers) {
    Queue<Integer> q = new LinkedList<>();

    int total = 0;
    for (int i = 0; i < numbers.size(); i++) {
        int number = numbers.pop();
        total += number;
        q.add(number);
    }

    return total;
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#cse122

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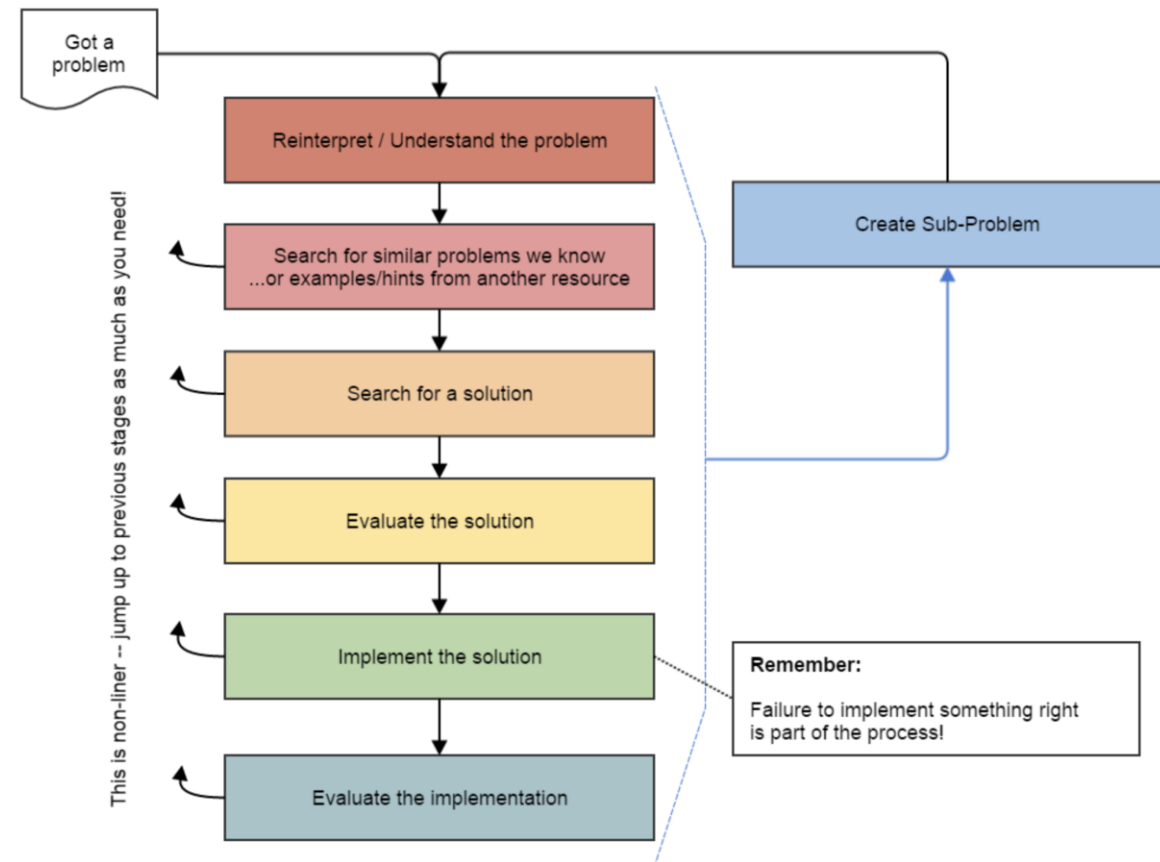
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 - **Problem Solving** 

Problem Solving

- On their own, Stacks & Queues are quite simple with practice (few methods, simple model)
- Some of the problems we ask are complex *because* the tools you have to solve them are restrictive
 - sum(Stack) is hard with a Queue as the auxiliary structure
- We challenge you on purpose here to practice **problem solving**



Source: Oleson, Ko (2016) - Programming, Problem Solving, and Self-Awareness: Effects of Explicit Guidance

Common Problem-Solving Strategies

- **Analogy** – Is this similar to a problem you've seen?
 - `sum(Stack)` is probably a lot like `sum(Queue)`, start there!
- **Brainstorming** – Consider steps to solve problem before writing code
 - Try to do an example “by hand” → outline steps
- **Solve Sub-Problems** – Is there a smaller part of the problem to solve?
 - Move to queue first
- **Debugging** – Does your solution behave correctly on the example input.
 - Test on input from specification
 - Test edge cases (“What if the Stack is empty?”)
- **Iterative Development** – Can we start by solving a different problem that is easier?
 - Just looping over a queue and printing elements

Common Stack & Queue Patterns

- Stack \rightarrow Queue and Queue \rightarrow Stack
 - We give you helper methods for this on problems
- Reverse a Stack with a $S \rightarrow Q + Q \rightarrow S$
- “Cycling” a queue: Inspect each element by repeatedly removing and adding to back `size` times
 - Careful: Watch your loop bounds when queue’s size changes
- A “splitting” loop that moves some values to the Stack and others to the Queue