LEC 04

CSE 122

Stacks & Queues

BEFORE WE START

Talk to your neighbors:

Best place for boba on the Ave? near campus?

Music: Suave – Luis Miguel

Instructor Elba Garza

TAs

Abigail	Ambika	Arthur	Atharva
Autumn	Ayush	Chaafen	Chloë
Claire	Colin	Elizabeth	Helena
Jacob	Jasmine	Jaylyn	Kavya
Kevin	Kyle	Marcus	Megana
Mia	Poojitha	Rishi	Rohini
Rucha	Saivi	Shananda	Shivani
Shreya	Smriti	Steven	Zane

Questions during Class?

Raise hand or send here

sli.do #cse122

Lecture Outline

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

Announcements

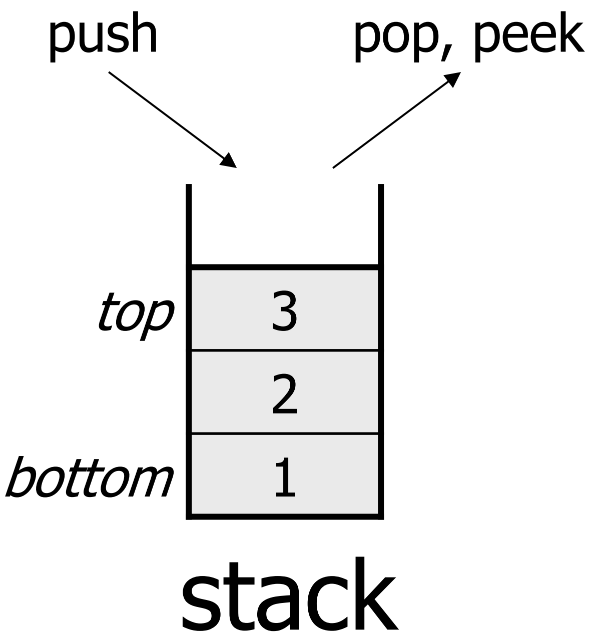
- Quizzes
  - Feedback released in a couple weeks
  - Okay if it didn't go exactly as wanted 🥺
- Creative Project (C0) due tomorrow
- Feedback from P0 will be posted soon
- Resubmission logistics on Ed; R0 opens Friday
  - Eligible assignment(s): P0
- Programming Assignment 1 will be released Friday
  - Due next Thursday, October 17th
- Final Exam: Tuesday, December 12^{th} 12:30 – 2:30 PM (KNE 120/KNE 110)

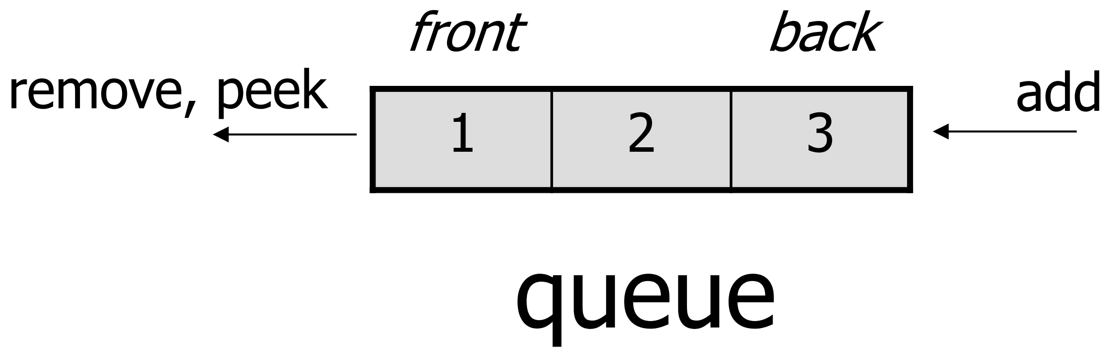
Lecture Outline

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

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





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 and its operations
  - **Stack:** retrieves elements in reverse order as added.
    Operations: push, pop, peek, …
  - **Queue:** retrieves elements in same order as added.
    Operations: add, remove, peek, …

Wait, ADT? Interfaces?

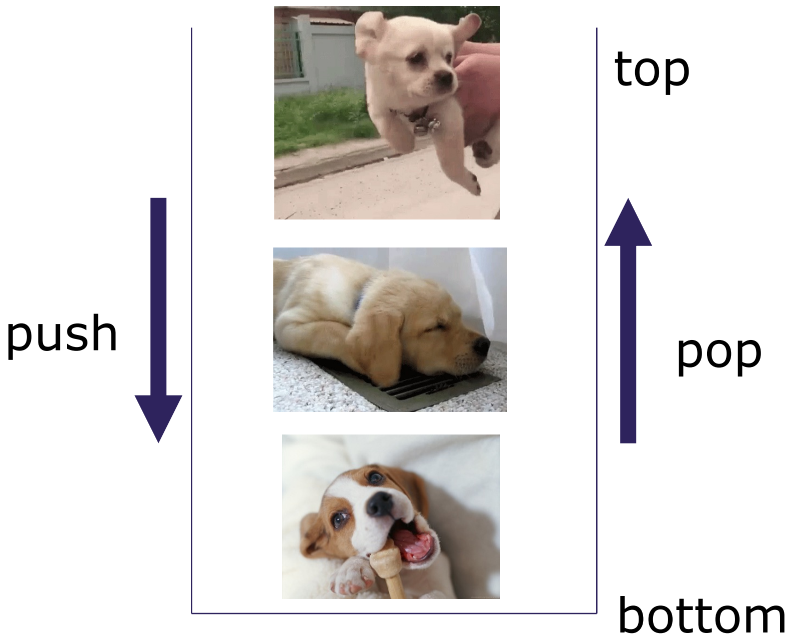
- **Abstract Data Type (ADT)**: A *description of the idea* of a data structure including what operations are available on it and how those operations should behave. For example, the English explanation of what a list should be.
- **Interface**: Java construct that lets programmers *specify what methods 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.

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:

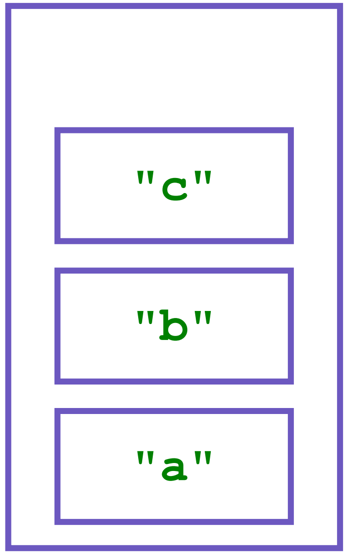
- **push**: Add an element to the top
- **pop**: Remove the top element
- **peek**: Examine the top element



Stacks in Computer Science

- Programming languages and compilers:
  - method calls are placed onto a stack (*call*↔*push, return* ↔ *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

Programming with Stacks



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

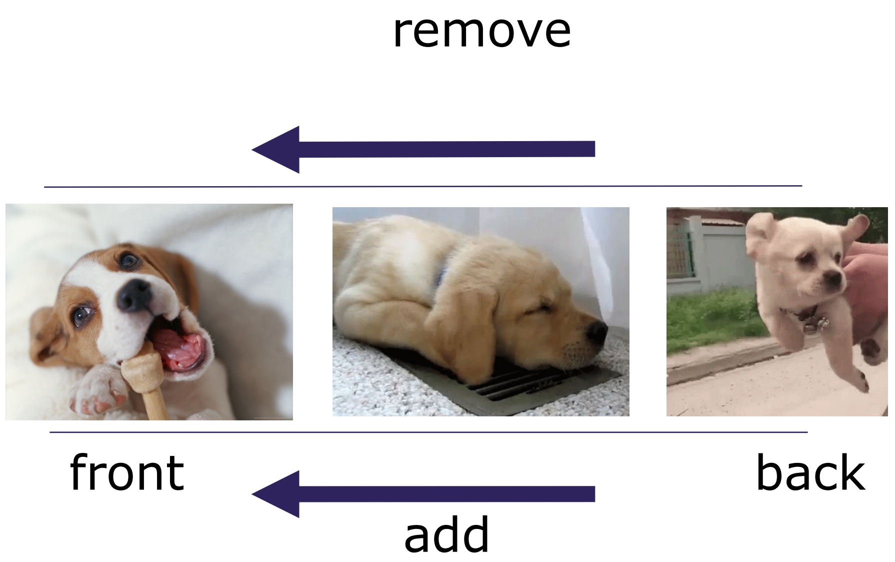
```
Stack<String> s = new Stack<String>();
s.push("a");
s.push("b");
s.push("c");
System.out.println(s.pop());
```

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

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.



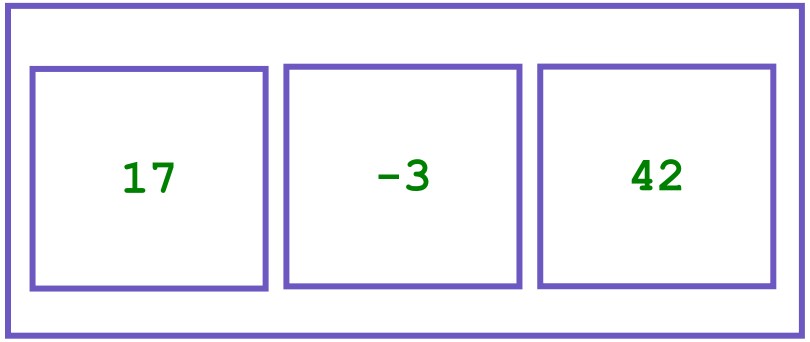
Queues in Computer Science

- 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)
  - Me at Microsoft Café after class when I forget my lunch

Programming with Queues



`add(`**`value`**`)`	places given value at back of queue
`remove()`	removes value from front of queue and returns it; throws a `NoSuchElementException` if queue is empty
`peek()`	returns front value from queue without removing it; returns `null` if queue is empty
`size()`	returns number of elements in queue
`isEmpty()`	returns `true` 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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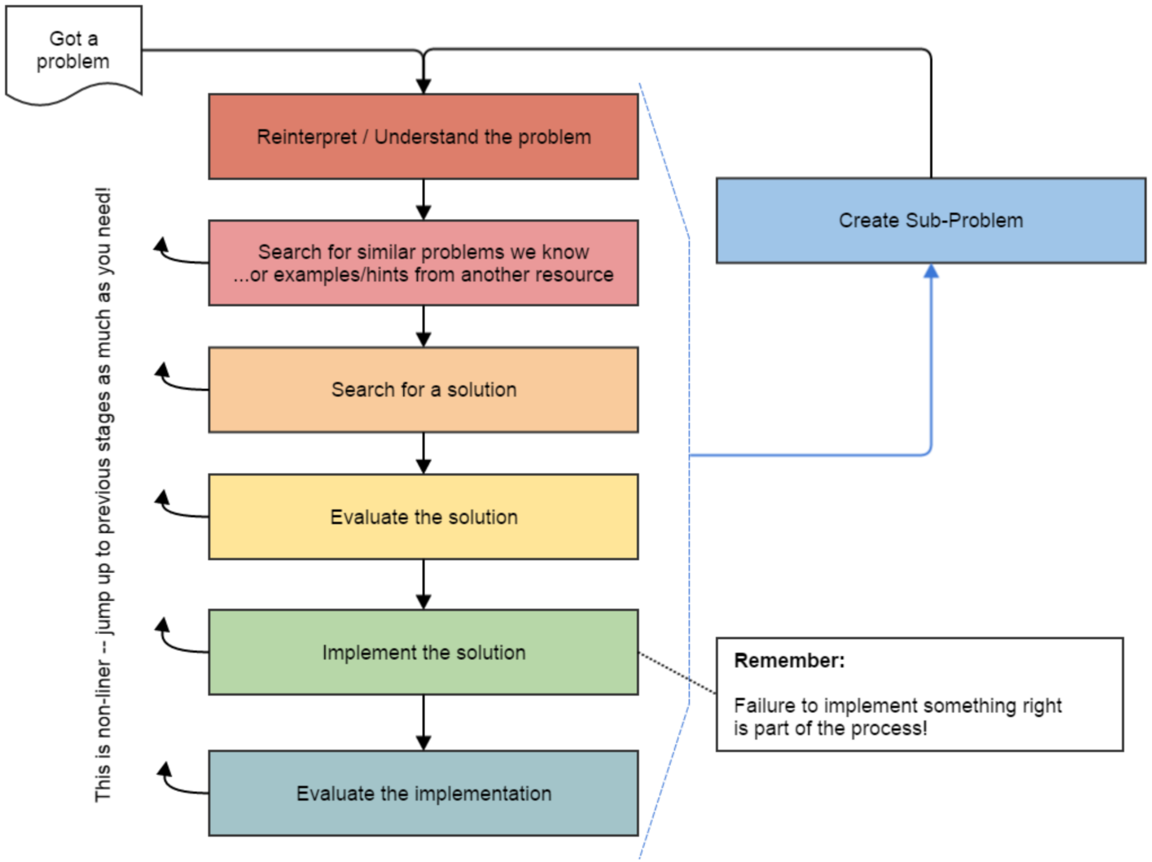
Problem Solving

- 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 → Queue and Queue → Stack
  - We give you helper methods for this on problems
- Reverse a Stack with a S→Q + Q→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