LEC 04

CSE 122

Stacks & Queues

Questions during Class?

Raise hand or send here

sli.do #cse-122

BEFORE WE START

Talk to your neighbors:
What are your favorite/least favorite classes at UW so far?

Music: [Hunter/Miya's Playlist]

Instructor: Hunter Schafer / Miya Natsuhara

TAs: Ajay, Andrew, Anson, Anthony, Audrey, Chloe, Colton, Connor, Elizabeth, Evelyn, Gaurav, Hilal, Hitesh, Jake, Jin, Joe, Joe, Karen, Kyler, Leon, Melissa, Noa, Parker, Poojitha, Samuel, Sara, Simon, Sravani, Tan, Vivek

Lecture Outline

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

Announcements

- Quizzes
  - Feedback released next week
  - Okay if it didn't go exactly as wanted, retakes and more quizzes
  - Information about retakes will be posted after feedback
- Creative Project (C0) due tomorrow
- Feedback from A0 will be posted before C0 is due
- Programming Assignment 1 will be released Friday
  - It will be due next Thursday (Oct 20)
- Only "new" logistics for a while are resubmissions and retakes

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- **Review: Stacks & Queues**
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- Stack Manipulation
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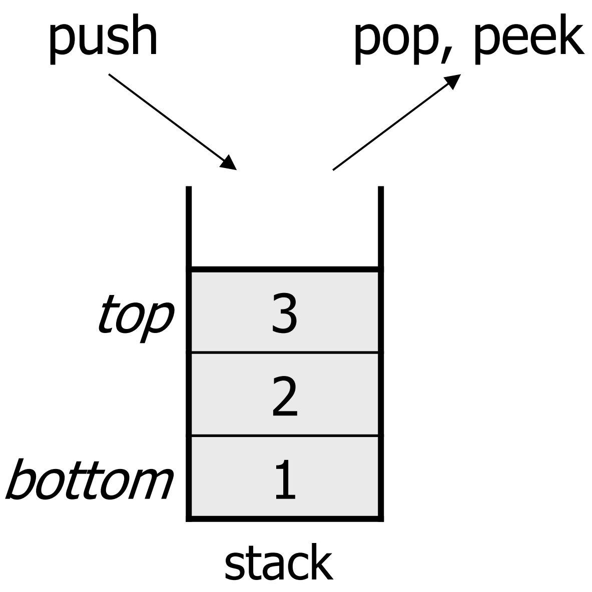
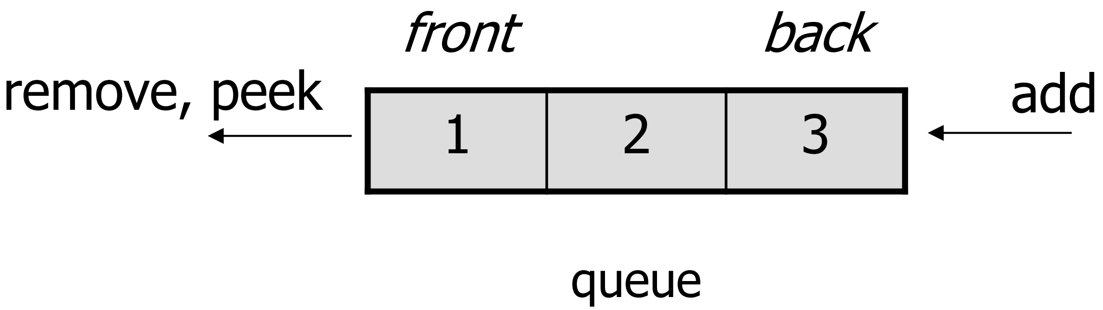
(PCM) Stacks & Queues

- Some collections are constrained, only use optimized 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

- 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

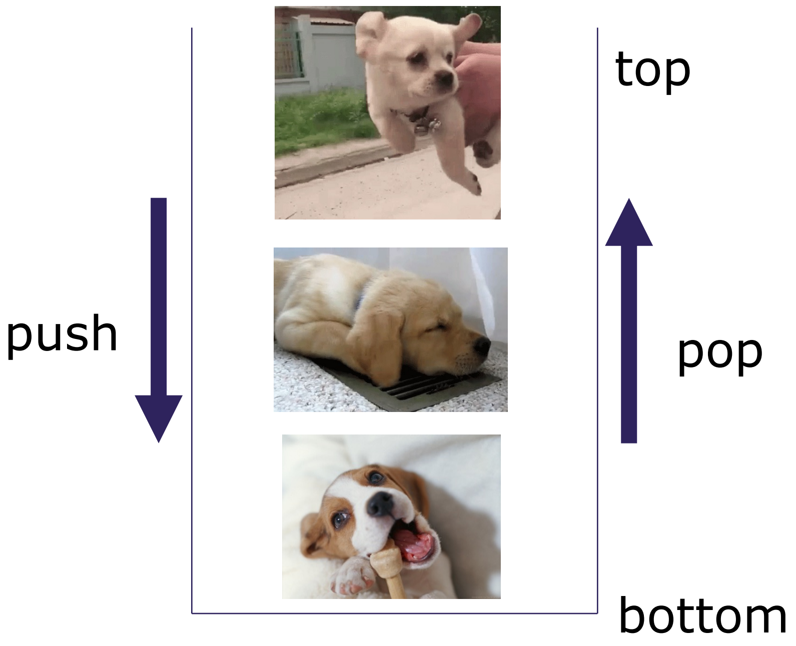
  - **Stack:** retrieves elements in reverse order as added.
    Operations: push, pop, peek, …
  - **Queue:** retrieves elements in same order as added.
    Operations: add, remove, peek, …

(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=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

(PCM) 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

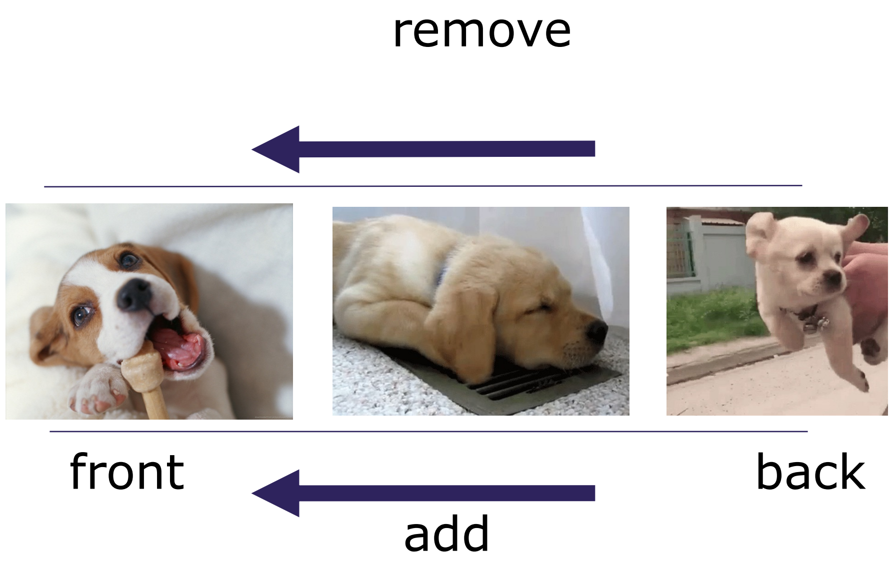
```
Stack<String> s = new Stack<String>();
s.push("a");
s.push("b");
s.push("c");                  // bottom ["a", "b", "c"] top
System.out.println(s.pop()); // "c"
```

- `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

`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);          // front [42, -3, 17] back
System.out.println(q.remove());   // 42
```

- **IMPORTANT**: When constructing a queue you must use a new `LinkedList` object instead of a new `Queue` object.
  - This has to do with a topic we'll discuss later called *interfaces*.

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- **Queue Manipulation**
- Stack Manipulation
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Practice : Think

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What is the return of this method?

```
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) 1
C) 5
D) 6
E) 12
F) 15
G) 25
H) Throws an error

Practice : Pair

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Practice : Think

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What is the return of this method?

```java
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);
    }

    // Still need to move back to the stack!
    return total;
}
```

A) 0
B) 1
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Practice : Pair

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```

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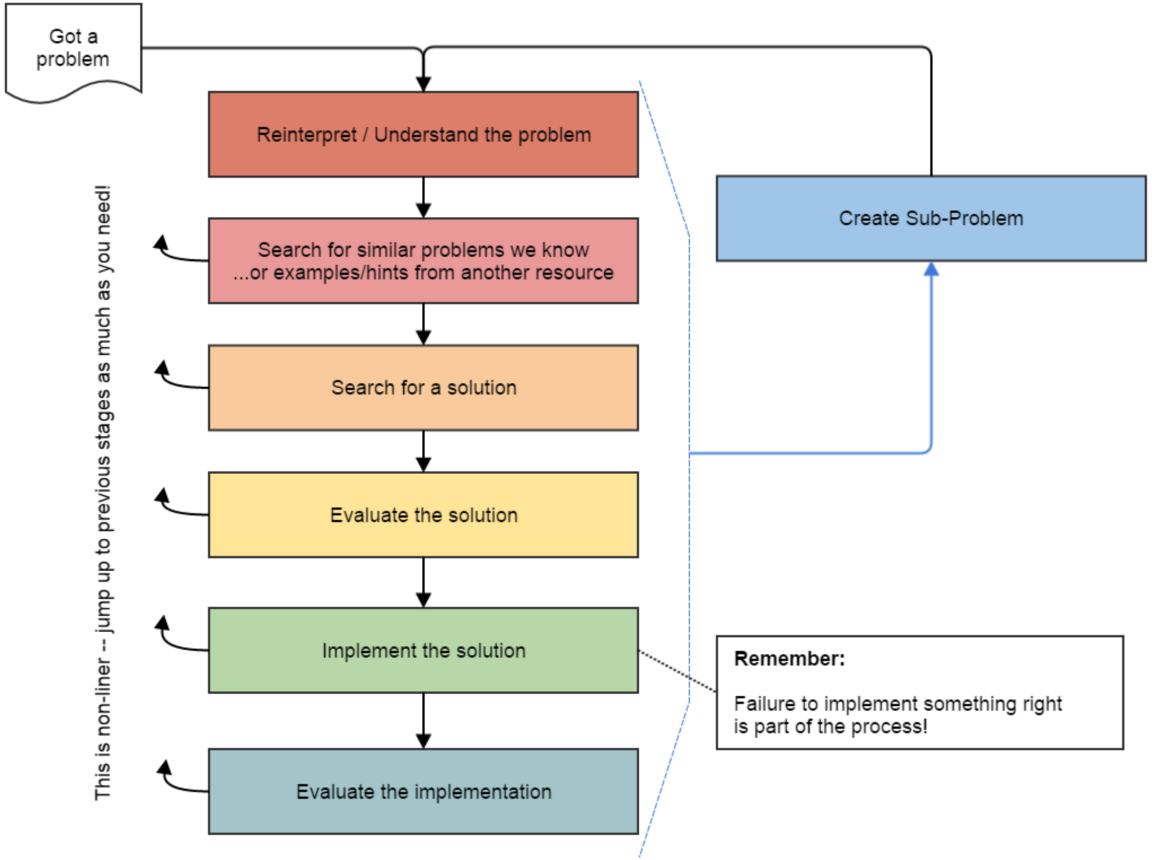
Problem Solving

- 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