CS 106B, Lecture 6
Queues

reading:

Programming Abstractions in C++, Chapter 5.3

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Based on slides created by Marty Stepp, Chris Gregg, Keith Schwarz, Julie Zelenski, Jerry Cain, Eric Roberts, Mehran Sahami, Stuart Reges, Cynthia Lee, and others

Big O

What is the Big O?

```
Vector<int> v;
for (int x = 1; x <= N; x += 2) {
    v.add(x);
}
while (!v.isEmpty()) {
   cout << v.remove(0) << endl;
}
```

Plan for Today

- Another collection: the **Queue**

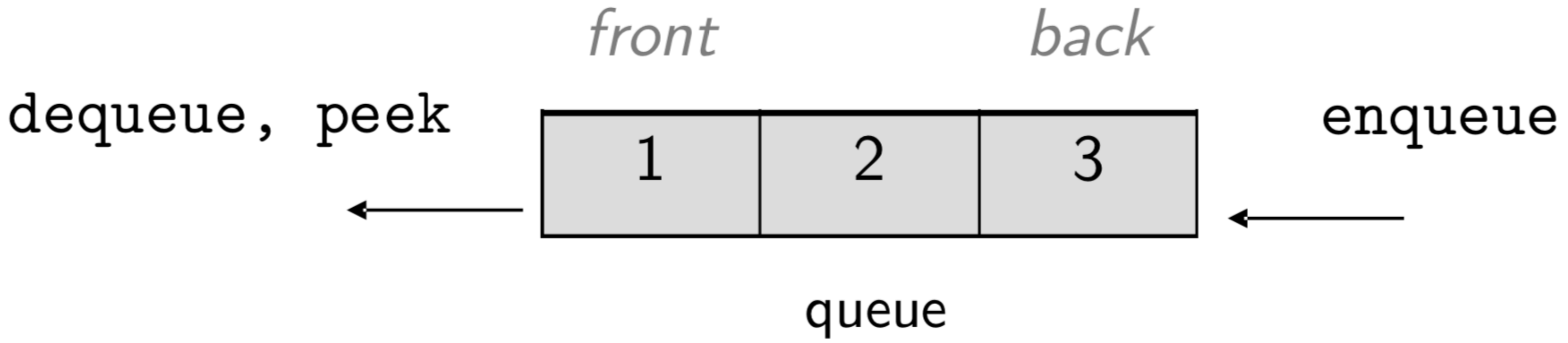
Queue

- What if we want to remove from the bottom instead of the top?
- We want "First In First Out" – FIFO

- Real World
  - Lines at the dining hall (No cutting!)
  - Escalators
  - Anything first-come first-serve
- Computers
  - Sending jobs to a printer
  - Call services (being put on hold)

Queue

- Queue: ADT that retrieves elements in the order they were added.
  - There are no indexes (just like a stack)
  - Can only add to the end of the queue and remove from the front.
- Operations
  - enqueue: add an element to the back
  - dequeue: remove the front element
  - peek: examine (but do NOT remove) the front element



Queue Syntax

```
#include "queue.h"
Queue<string> strs;
strs.enqueue("Hello");
strs.enqueue("World");
cout << strs.peek() << endl; // "Hello"
cout << strs << endl; // {"Hello", "World"}
strs.dequeue(); // strs = {"World"}
```

`q.dequeue()`	O(1)	removes front value and returns it; throws error if queue is empty
`q.enqueue(value)`	O(1)	places given value at back of queue
`q.isEmpty()`	O(1)	returns true of queue has no elements
`q.peek()`	O(1)	returns front value without removing; throws an error if queue is empty
`q.size()`	O(1)	returns number of elements in queue

Queue Question?

```
Queue<int> queue;
for (int i = 1; i <= 6; i++) {
    queue.enqueue(i);
}
for (int i = 0; i < queue.size(); i++) {
    cout << queue.dequeue() << " ";
}
cout << queue << " size " << queue.size() << endl;
```

A. 1 2 3 4 5 6 {} size 0
B. 1 2 3 {4, 5, 6} size 3
C. 1 2 3 4 5 6 {1, 2, 3, 4, 5, 6} size 6

D. none of the above

Exercise

Write a function **repeat** that accepts a queue of integers and replaces every element with two copies of itself. For example:

{1, 2, 3} becomes {1, 1, 2, 2, 3, 3}

Solution

```
void repeat(Queue<int>& q) {
    int size = q.size();
    for (int i = 0; i < size; i++) {
        int n = q.dequeue();
        q.enqueue(n);
        q.enqueue(n);
    }
}
```

Queue Tips

- You cannot access a queue's elements by index.
- Instead, you dequeue elements out of the queue one at a time.

```
// process (and empty!) an entire queue
while (!q.isEmpty()) {
    do something with q.dequeue();
}
```

- Be careful iterating over a queue if you are changing it.

```
// Save the size before changing the queue
int size = q.size();
for (int i = 0; i < size; i++) {
    // do something with q.dequeue();
}
```

Mixing Stacks and Queues

How can we reverse the order of elements in a queue?

Mixing Stacks and Queues

How can we reverse the order of elements in a queue?

```
Queue<int> q {1, 2, 3};      // q={1, 2, 3}
Stack<int> s;
while (!q.isEmpty()) {
    s.push(q.dequeue());     // q={} s={1, 2, 3}
}
while (!s.isEmpty()) {
    q.enqueue(s.pop());      // q={3, 2, 1} s={}
}
cout << q << endl;
```

Exercise

Write a function **mirror** that accepts a queue of strings and appends the queue's contents to itself in reverse order. For example:

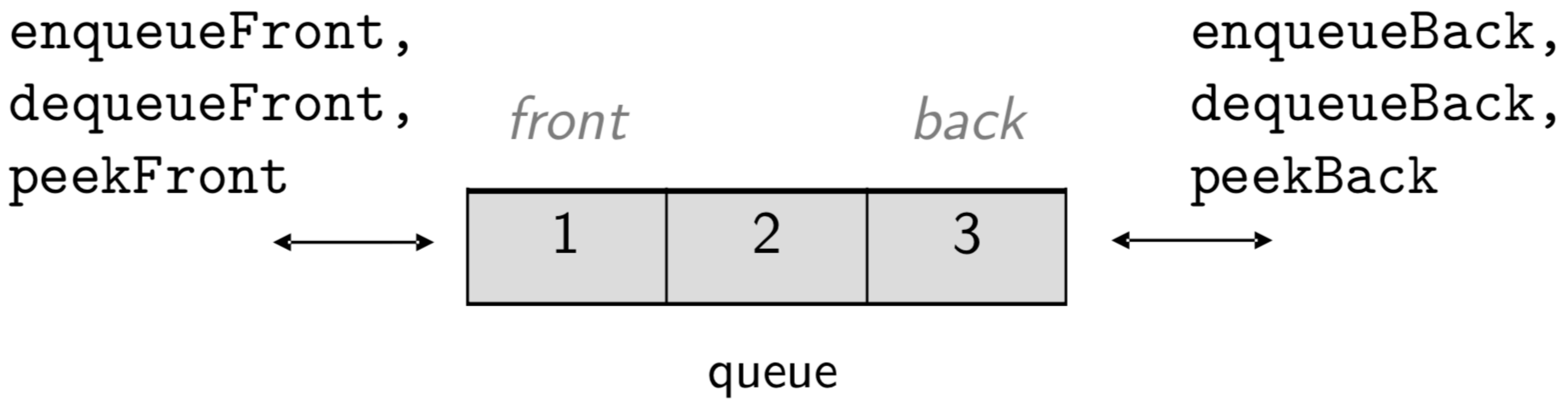
{"a", "b", "c"} becomes {"a", "b", "c", "c ", "b", "a"}

Solution

```
void mirror(Queue<string>& q) {
       Stack<string> s;
       int size = q.size();
       for (int i = 0; i < size; i++) {
           string str = q.dequeue();
           s.push(str);
           q.enqueue(str);
       }
       while (!s.isEmpty()) {
           q.enqueue(s.pop());
       }
}
```

Deque

- Deque (“deck”): double-ended queue
  - Can add/remove from either end
- Basic Operations
  - enqueueFront, enqueueBack
  - dequeueFront, dequqeBack
  - peekFront, peekBack
- Get queue and stack functionality in one data structure!



Look Ahead

- Assignment 1 (Game of Life) due Wednesday, July 3, at 5PM. You can work in a pair.
- No class on July 4th
  - There is no section on July 4th either. This means section attendance for this week is optional. We will record a section on Wednesday, right after class in the same room.
  - We recommend if you have a section on Wednesday to still attend, and if you have a section on Thursday to watch the taped section online or stay after lecture on Wednesday.