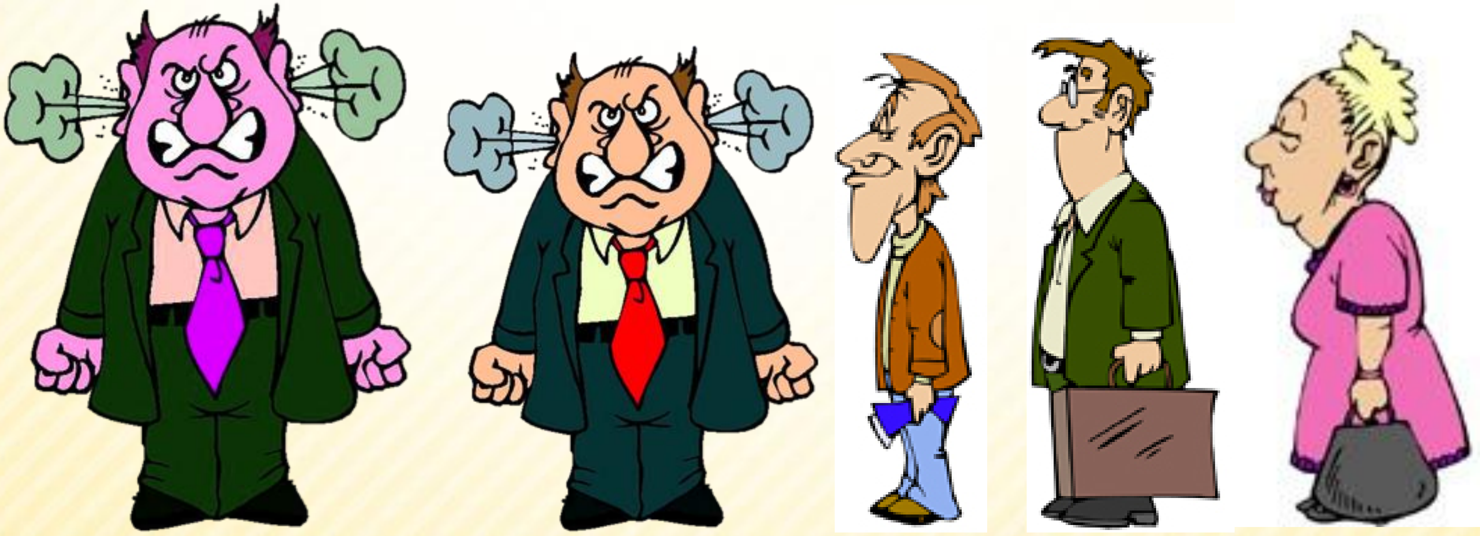
UCF

STACK & QUEUES

COP 3502

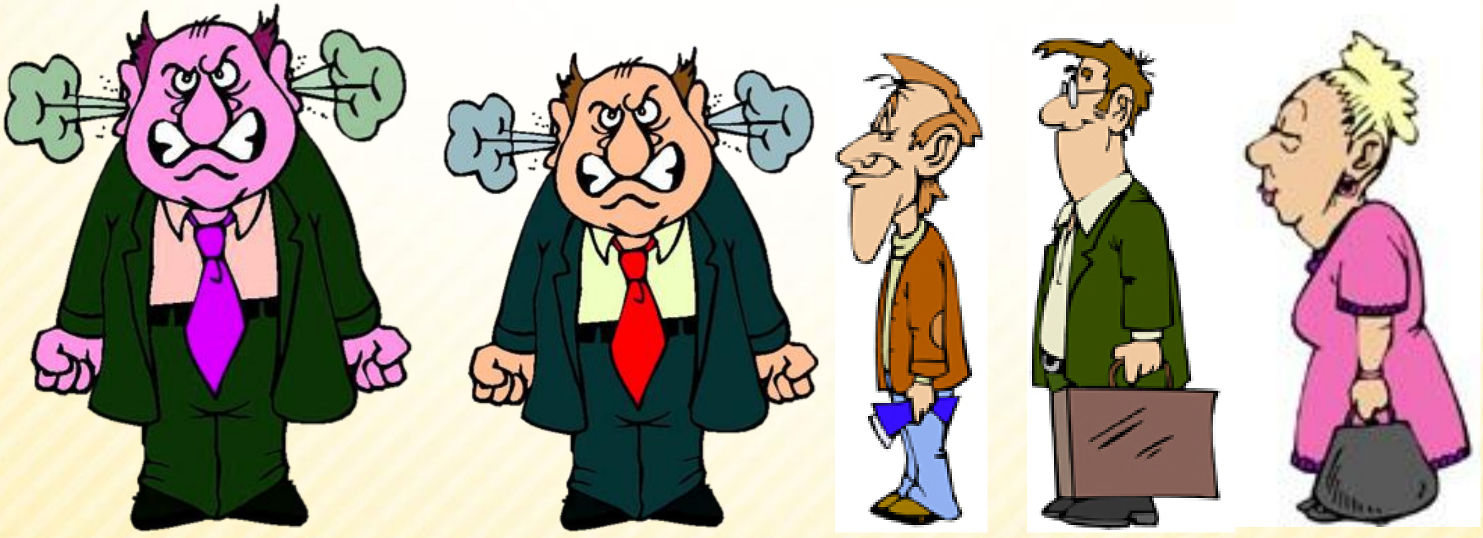
Queues

- If we wanted to simulate customers waiting in a line to be served,
  - We wouldn’t use a stack…
    - LIFO is only going to make the person that got in line first mad.



Queues

- We would want to use FIFO
  - First In First Out, or 1st in line 1st one to get served.
- Instead of push and pop, we have the operations
  - Enqueue and Dequeue that add/remove elements from the list.



Sidenote: Abstract Data Type

- Queues are another example of an abstract data type (ADT)
  - ADT - Something that is not built into the language, and it is defined in terms of its behavior.
  - So if I tell you to use ***MY*** implementation of a queue to simulate customer wait times
    - You wouldn’t need to know how I implemented it, you could just call the functions – Enqueue, Dequeue, etc.

Queue Basic Operations

- **Enqueue:**
  - Inserts an element at the back of the queue
  - Returns 1 if successful, 0 otherwise.
- **Dequeue:**
  - Removes the element at the front of the queue.
  - Returns the removed element.
- **Peek**
  - Looks at the element at the front of the queue without removing it.
  - Returns the front element.
- **isEmpty**
  - Checks to see if the queue is empty.
  - Returns true or false.
- **isFull**
  - Checks to see if the queue is full.
  - Returns true or false.

Queue Example

Starting Queue:

3	5	7	9	11
front				back

Time 1:

3	5	7	9	11	13

Time 2:

5	7	9	11	13

Time 3:

5	7	9	11	13	15

Time 4:

7	9	11	13	15

Time 5:

9	11	13	15

TIME	OPERATION
1	Enqueue(13)
2	Dequeue()
3	Enqueue(15)
4	Dequeue()
5	Dequeue()

Queues - Array Implementation

- What would we need for an array implementation?
  - We need an array obviously
  - And we need to keep track of the front and the back.

BAD Queue Implementation Example

Starting Queue:

3	5	7	9	11	
front				back	

Time 1:

3	5	7	9	11	13
front					back

Time 2:

5	7	9	11	13	
front				back	

Time 3:

5	7	9	11	13	15
front					back

Time 4:

7	9	11	13	15	
front				back	

Time 5:

9	11	13	15		
front			back		

TIME	OPERATION
1	Enqueue(13)
2	Dequeue()
3	Enqueue(15)
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Notice that you have to Shift the contents of the Array over each time front changes

Queues: Array Implementation

```
struct queue {
    int *elements;
    int front;
    int numElements;
};
```

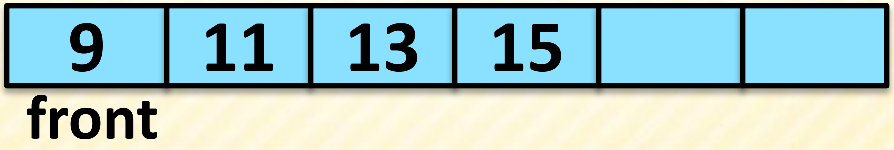
- We will use the following revamped idea to store our queue structure:
    - Keep track of the array, the front, and the current number of elements.

Queues: Array Implementation

```
struct queue {
    int *elements;
    int front;
    int numElements;
};
```

- Enqueue:
  - We’ll simply add the given element to the index “back” in the array.
  - BUT we’re not storing “back”!!!!!
  - What must we do instead?
    - Add it to the index: front + numElements
    - But what if this goes outside the bounds of our array?

numElements = 4

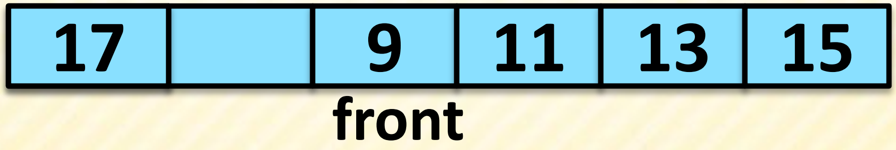


Queues: Array Implementation

```
struct queue {
    int *elements;
    int front;
    int numElements;
    int queueSize;
};
```

- Enqueue(17):
  - Add it to the index: front + numElements
    - But what if this goes outside the bounds of our array?
    - Front = 2, plus numElements = 4, gives us 6
    - We can mod by the queueSize
    - (front + numElements) % queueSize = 0

numElements = 5



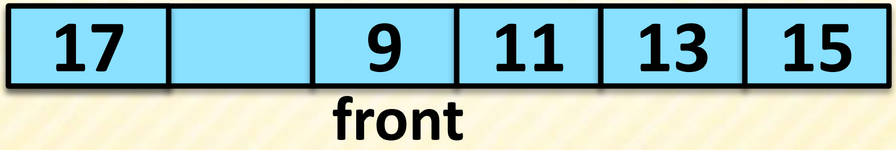
17		9	11	13	15

Queues: Array Implementation

```
struct queue {
    int *elements;
    int front;
    int numElements;
    int queueSize;
};
```

- So we’re allowing our array to essentially wrap around.
  - This way we don’t have to copy the contents of our array over if front or back moves

numElements = 5



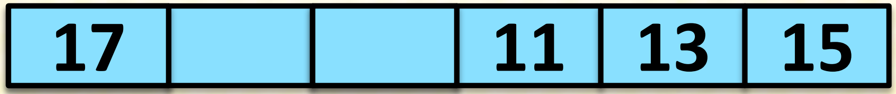
17		9	11	13	15

Queues: Array Implementation

```
struct queue {
     int *elements;
     int front;
     int numElements;
     int queueSize;
};
```

- Dequeue
  - If the numElements > 0
    - numElements--;
    - front = (front + 1) % queueSize

numElements = 4



17			11	13	15

front front

Q's - Dynamically Allocated Array

```
struct queue {
     int *elements;
     int front;
     int numElements;
     int queueSize;
};
```

- What if our numElements == queueSize?
  - We can realloc more memory for our array and update queueSize!
  - But we also need to make sure we copy over the wraparound values correctly.

Q's - Dynamically Allocated Array

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```
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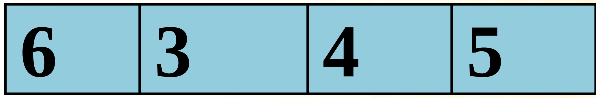


6	3	4	5

front

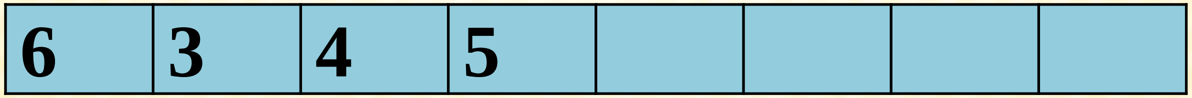
say queueSize = 4

Enqueue(12);

elements = (int *)realloc(elements, 2*queueSize*sizeof(int));

queueSize = 2*queueSize;

BUT where do front and back go? Does this look right?



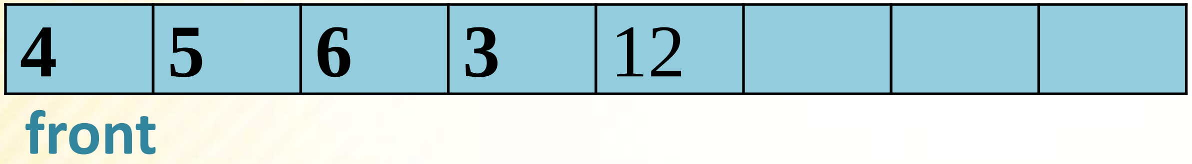
6	3	4	5				

front

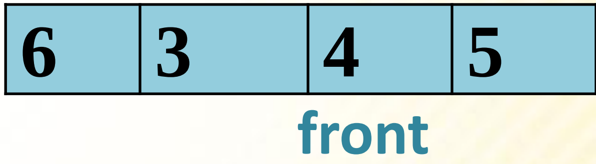
Q's - Dynamically Allocated Array

```
struct queue {
    int *elements;
    int front;
    int numElements;
    int queueSize;
};
```

- So what we really need to do, is reset front = 0
  - And copy the elements accordingly:



4	5	6	3	12			



6	3	4	5

say queueSize = 4

Enqueue(12);

  - In code we could do:

```
for (i=front, j=0; i<queueSize; i++, j++)
    temp[j] = values[i];
for (i=0; i<front; i++, j++)
    temp[j] = values[i];
```

Queues - Linked List Implementation

- We are going to need a linked list
    - So we'll use the same node implementation as before.
- But we'll need to keep track of the front and the back.
    - Otherwise either enqueue or dequeue would require an O(n) traversal each time.
- So we'll keep a front and back pointer inside of a structure called queue.

```
struct node {
    int data;
    struct node *next;
};
struct queue {
    struct node *front;
    struct node *back;
};
```

Stack Application

- 2 examples:
  1) Checking if we have matching parentheses
  2) Reading in a list of numbers from a user and printing it in backwards order.

```
// Either prints (1) More right paren’s than left, (2)
More left paren’s than right, or (3) Paren’s are balanced
void ParenMatch();

void main(){
      printf("Give input expression without blanks:  \n");
      char *InputExpression = malloc(100*sizeof(char));
      scanf("%s", InputExpression);
      ParenMatch(InputExpression);
}
```