National University of Computer & Emerging

Sciences

Queues

Queues

Queues

"A ***Queue*** is a special kind of list, where items are inserted at one end (***the rear***) And deleted at the other end (***the front***)"

Other Name:

- First In First Out (FIFO)

Queues

A queue is like a line of people waiting for a bank teller. The queue has a **front** and a **rear**.

Rear Front

Queues

- New people must enter the queue at the rear.

Front

Rear

Queues

When an item is taken from the queue, it always comes from the front.

Front

Rear

Some examples

- Billing counter
  - Booking movie tickets
  - Queue for paying bills

- A print queue
- Vehicles on toll-tax bridge •

Luggage checking machine

- Some others?

Applications of Queues

- Operating system
  - multi-user/multitasking environments, where several users or task may be requesting the same resource

simultaneously.

- Communication Software
  - queues to hold *information* received over networks and dial up connections. (Information can be transmitted faster than it can be processed, so is placed in a queue waiting to be processed)

Common Operations (Queue ADT)

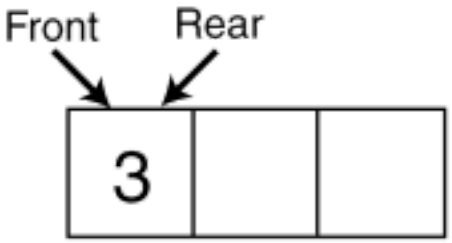
1. **MAKENULL(Q):** Makes Queue Q be an empty list.

2. FRONT(*Q*): Returns the first element on Queue Q.

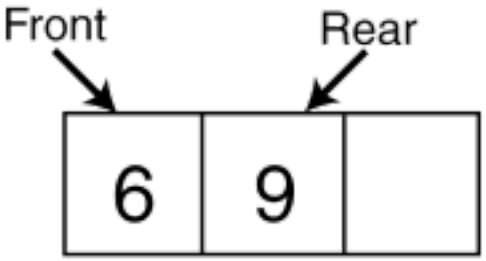
3. ENQUEUE(*x*,*Q*): Inserts element x at the end of Queue Q.

4. DEQUEUE(*Q*): Deletes the first element of *Q.* **5. EMPTY(*Q*):** Returns true if and only if Q is an empty queue.

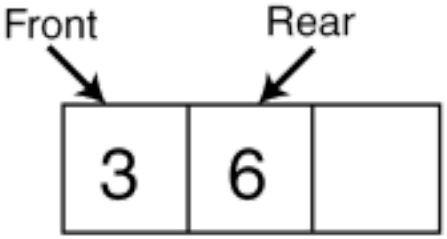
Enqueue(3);



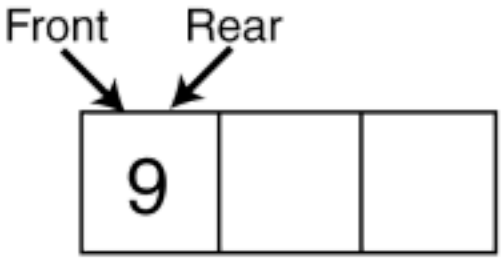
Dequeue();



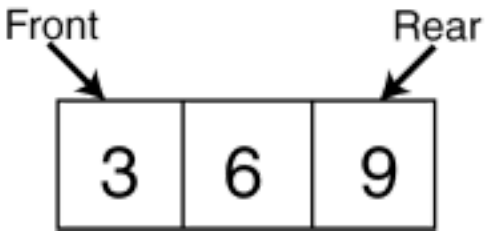
Enqueue(6);



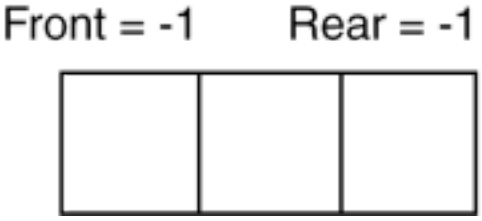
Dequeue();



Enqueue(9);



Dequeue();



Implementation

- Static
  - Queue is implemented by an array, and size of queue remains fix
- Dynamic
  - A **queue** can be **implemented** as a **linked list**, and *expand* or *shrink* with each *enqueue* or *dequeue* operation.

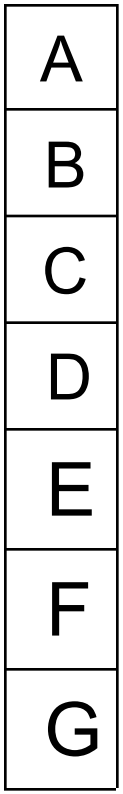
Array Implementation

- Signify *zero* index as front.
- Dequeue
  - Shift elements to the left
  - Expensive!
- Enqueue
  - Need to save index of last item inserted
    - On Enqueue, increment index
    - On Dequeue, decrement index

Alternative Array Implementation

- Use two counters that signify rear and front

Front Rear



First Element

Second
Element
.
.

Last Element *maxlength*

When queue is empty both front and rear are set to -1

While enqueueing increment rear by 1, and while dequeueing increment front by 1

When there is only one value in the Queue, both rear and front have same index

Queues

Array Implementation

5 4

0 1 2 3 4 5 6 7 8

0 1 2 3 4 5 6 7 8

5

0 1 2 3 4 5 6 7 8

Front= -1 Rear = -1

Front= 0 Rear = 0

Front= 0 Rear = 1

Queues

Array Implementation

5 4 6 7 8 7 6

0 1 2 3 4 5 6 7 8 Front=0

Rear=6

8 7 6

0 1 2 3 4 5 6 7 8 Front=4

Rear=6

Queues

Array Implementation

7 6 12 67

0 1 2 3 4 5 6 7 8 Front=5

Rear=8

How can we insert more elements? Rear index can not move beyond the last element….

Solution: Using circular queue

- Allow rear to wrap around the array.

```
if(rear == queueSize-1)
rear = 0;
else
```

rear++;

- Or use module arithmetic

  rear = (rear + 1) % queueSize;

7 6 12 67

0 1 2 3 4 5 6 7 8

Front=5

Rear=8

Enqueue 39 Rear=(Rear+1) mod Queue Size = (8+1) mod 9 = 0 39 7

6 12 67

0 1 2 3 4 5 6 7 8

Front=5
Rear=0

How to determine empty and full Queues?

- It can be somewhat tricky

- Number of approaches
  - A counter indicating number of values in the queue can be used (we will use this approach)
  - Later, we will see another approach

Implementation

```
class IntQueue
{
```

```
private:
        int *queueArray;
        int queueSize;
        int front;
        int rear;
        int numItems;
public:
        IntQueue(int);
 ~IntQueue(void);
 void enqueue(int);
 int dequeue(void);
 bool isEmpty(void);
 bool isFull(void);
 void clear(void);
};
```

Note, the member function clear, which clears the queue by resetting the front and rear indices, and setting the numItems to 0.

Queues

```
IntQueue::IntQueue(int s)
//constructor {
    queueArray = new int[s];
```

```
    queueSize = s;
    front = -1;
    rear = -1;
    numItems = 0;
}


IntQueue::~IntQueue(void) //destructor
{
     delete [] queueArray;
}
```


Queues

```
//*************************************************
```

```
* // Function isEmpty returns true if the
queue * // is empty, and false otherwise. *
//*************************************
*

bool IntQueue::isEmpty(void)
{
      if (numItems)
            return false;
      else
            return true;
}
```

```
//****************************************
* // Function isFull returns true if the
queue * // is full, and false otherwise. *
//****************************************
*

bool IntQueue::isFull(void)
{
      if (numItems < queueSize)
            return false;
      else
            return true;
}
```

Queues

```
//****************************************
* // Function enqueue inserts the value in
num * // at the rear of the queue. *
//****************************************
*

void IntQueue::enqueue(int num)
{
      if (isFull())
            cout << "The queue is full.\n";
      else
      {
            // Calculate the new rear position
```

```
            rear = (rear + 1) % queueSize;
            // Insert new item
            queueArray[rear] = num;
            // Update item count
            numItems++;
        }
}
```


Queues

```
//*****************************************
* // Function dequeue removes the value at the
* // front of the queue, and copies it into
num.*
//*****************************************
*

bool IntQueue::dequeue(int &num)
{
        if (isEmpty())
        {
                cout << "The queue is empty.\n";
```

```
            return false;
        }

        // Move front
        front = (front + 1) % queueSize;
        // Retrieve the front item
        num = queueArray[front];
        // Update item count
        numItems--;
        return true;
}
```


Queues

```
//*****************************************
* // Function clear resets the front and
rear * // indices, and sets numItems to 0. *
//*****************************************
*
```

```
void IntQueue::clear(void)
{
        front = - 1;
        rear = - 1;
        numItems = 0;
}
```


//Program demonstrating the IntQueue class

```
void main(void)
{
        IntQueue iQueue(5);

        cout << "Enqueuing 5 items...\n";
```

```
        // Enqueue 5 items.
        for (int x = 0; x < 5; x++)
                iQueue.enqueue(x);

        // Attempt to enqueue a 6th item.
        cout << "Now attempting to enqueue again...\n";
        iQueue.enqueue(5);

        // Deqeue and retrieve all items in the queue
        cout << "The values in the queue were:\n";
        while (!iQueue.isEmpty())
        {
                int value;
                iQueue.dequeue(value);
                cout << value << endl;
        }
}
```


Queues

Program Output

```
Enqueuing 5 items...
Now attempting to enqueue
again... The queue is full.
```

```
The values in the queue
were: 0

1

2

3

4
```