# DATA STRUCTURES AND ALGORITHMS

Circular Queue Data Structure

By
Zainab Malik



## Content





## Limitation of Linear Queue

The only limitation of a linear queue is that- If the last position of the queue is occupied, it is not possible to enqueue anymore elements even though some positions are vacant.

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| Enqueue(g) | 5 | 3 | | | | d | e | f |

**Error: Queue is overflow**

- **Solution: Circular Queue**
  - This limitation can be overcome by moving the rear back to index '0', if front is >0



## Circular Queue

- Circular Queue is the advanced form of Queue data structure.
- Like a linear Queue, elements are added from an end i.e. **rear**, and removed from another end that is known as the **front**.
- It also ensures the first-in-first-out (FIFO) or last-in-last-out (LILO) order of insertion and deletion.
- However, Unlike linear queue, in circular queue rear is reset to index '0', if there are some vacant slots at the beginning.



## Linear Queue vs. Circular Queue

**Linear Queue**

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| Enqueue(g) | 5 | 3 | | | | d | e | f |

**Error: Queue is overflow**

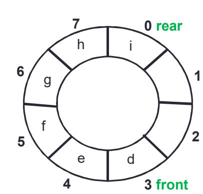
**Circular Queue**

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| Enqueue(g) | 0 | 3 | g | | | d | e | f |



## Circular Queue

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| Enqueue(i) | 0 | 3 | i | | | d | e | f | g | h |



# Operations of Queue

- The common operations of queue are as follow:
  - enqueue()
  - dequeue()
  - isEmpty()
  - isFull()
  - frontValue()
  - rearValue()



# Operations of Queue-Enqueue(item)

Enqueue (queue, item)

1. If queue is already full: //front=0 & rear=size-1 or rear+1=front
2. Display an error of "overflow"
3. If queue is empty and this is the first item to be inserted in that queue //rear==front==-1
4. Increment rear and front both
5. Insert item at rear index
6. If queue is not empty and there are some vacant slots in the begining: // front > 0 and rear==size-1
7. Set rear=0
8. Insert item at rear index
9. Else: there are some slots after rear
10. Increment rear
11. Insert item at rear index



# QUEUE- Enqueue Operation

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| - | -1 | -1 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Enqueue(a) | ~~-1~~ 0 | ~~-1~~ 0 | a | | | | | |

Increment rear and front both and then insert item at rear

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Enqueue(g) | 5 | 0 | a | b | c | d | e | f |

Overflow because front is at 0 and rear is at size-1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Enqueue(e) | ~~3~~ 4 | 2 | | | c | d | e | |

Increment rear and then Insert item at rear index

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Enqueue(g) | ~~5~~ 0 | 2 | g | | c | d | e | f |

If queue is not empty (front > 0 and rear==size-1) then set rear=0 and Insert item at rear index



# Operations of Queue-Dequeue()

Dequeue (queue):

1. If Queue is already empty: // front==rear==-1
2. Display an error of "underflow"
3. If there is only one element in the queue //front==rear && front!=-1
4. Save value of front index in a variable Data
5. Set front and rear both to -1
6. Return Data
7. If there are more than one elements with conditions front==size-1 &&front>rear
8. Save value of front index in a variable Data
9. set front=0
10. Return Data
11. Else: there are some elements after front
12. Save value of front index in a variable Data
13. Increment front
14. Return Data



# QUEUE- Dequeue Operation

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| - | -1 | -1 | | | | | | |

underflow

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dequeue() | ~~-2~~ -1 | ~~-2~~ -1 | | | ~~c~~ | | | |

Save front value as Data, set rear and front both at -1and then return Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dequeue() | 5 | ~~0~~ 1 | ~~a~~ | b | c | d | e | f |

**front < rear:** Save front value as Data, increment front and then return Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dequeue() | 4 | ~~2~~ 3 | | | ~~c~~ | d | e | |

**front < rear:** Save front value as Data, increment front and then return Data

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dequeue() | 1 | ~~5~~ 0 | g | b | | | | ~~f~~ |

**front == size-1:** Save front value as Data, set front=0 and then return Data



# Enqueue - Dequeue Operations

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| Dequeue() | 5 | ~~1~~ 2 | | ~~b~~ | c | d | e | f |
| Dequeue() | 5 | ~~-2~~ 3 | | | ~~c~~ | d | e | f |
| Enqueue(g) | ~~5~~ 0 | 3 | g | | | d | e | f |
| Dequeue() | 0 | ~~3~~ 4 | g | | | ~~d~~ | e | f |
| Enqueue(b) | ~~0~~ 1 | 4 | g | b | | | e | f |
| Enqueue(j) | ~~1~~ 2 | 4 | g | b | j | | e | f |
| Enqueue(k) | ~~2~~ 3 | 4 | g | b | j | k | e | f |
| Dequeue() | 3 | ~~4~~ 5 | g | b | j | k | ~~e~~ | f |

| Total Enqueue | Total Dequeue | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | DD | EE | FF |
| | | | | GG | HH | II | | | MM |
| | | | | AA | | | | | FF |
| | | | | | MM | NN | | | |



## Operations of Queue-isFull()

**isFull():**

1. If front=0 && rear==size-1 or rear+1==front:
2. Return true
3. Otherwise:
4. Return false

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| isFull()-True | 5 | 0 | a | b | c | d | e | f |
| isFull()-False | 5 | 3 | | | | d | e | f |
| isFull()- False | 3 | 0 | a | b | c | d | | |
| isFull()- True | 3 | 4 | g | h | i | j | e | f |



## Operations of Queue-isFull()

**isEmpty():**

1. If rear and front are at -1:
2. Return true
3. Otherwise:
4. Return false

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| isEmpty()-True | -1 | -1 | | | | | | |
| isEmpty()-False | 5 | 3 | | | | d | e | f |
| isEmpty()-False | 3 | 0 | a | b | c | d | | |
| isEmpty()-False | 3 | 4 | g | h | i | j | e | f |



## Operations of Queue-frontValue()

frontValue():

1. If rear and front are at -1:
2. Display error "underflow"
3. Otherwise:
4. Return value at front index

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| frontValue() **Error** | -1 | -1 | | | | | | |
| frontValue() e | 3 | 4 | g | h | i | j | e | f |



## Operations of Queue-rearValue()

rearValue():

1. If rear and front are at -1:
2. Display error "underflow"
3. Otherwise:
4. Return value at rear index

| Operation | Rear | front | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| rearValue() **Error** | -1 | -1 | | | | | | |
| rearValue() j | 3 | 4 | g | h | i | j | e | f |



## Applications of Queue

- It is used in all those application where FIFO/LILO order is mandatory.
- It is used for scheduling purpose
- It can be used for buffering of data packets, where order of packets must be maintained

Thank You