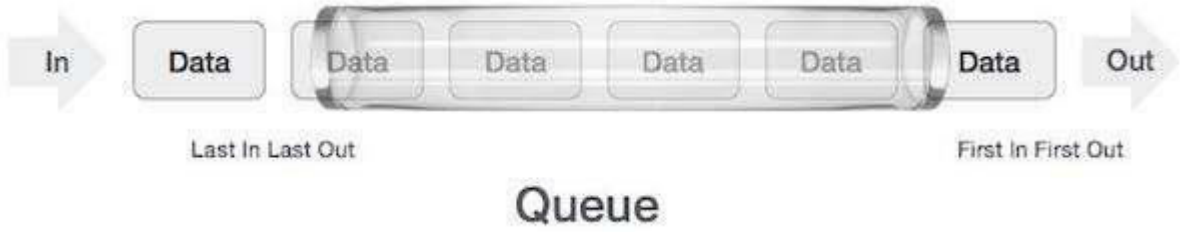
Queue:

Queue is an abstract data structure, somewhat similar to Stacks. Unlike stacks, a queue is open at both its ends. One end is always used to insert data (enqueue) and the other is used to remove data (dequeue). Queue follows First-In-First-Out methodology, i.e., the data item stored first will be accessed first.

A real-world example of queue can be a single-lane one-way road, where the vehicle enters first, exits first. More real-world examples can be seen as queues at the ticket windows and bus-stops.

Queue Representation:

As we now understand that in queue, we access both ends for different reasons. The following diagram given below tries to explain queue representation as data structure –



As in stacks, a queue can also be implemented using Arrays, Linked-lists, Pointers and Structures. For the sake of simplicity, we shall implement queues using one-dimensional array.

Basic Operations:

Queue operations may involve initializing or defining the queue, utilizing it, and then completely erasing it from the memory. Here we shall try to understand the basic operations associated with queues –

- **enqueue()** – add (store) an item to the queue.
- **dequeue()** – remove (access) an item from the queue.

Few more functions are required to make the above-mentioned queue operation efficient. These are −

- **peek()** − Gets the element at the front of the queue without removing it.
- **isfull()** − Checks if the queue is full.
- **isempty()** − Checks if the queue is empty.

In queue, we always dequeue (or access) data, pointed by **front** pointer and while enqueing (or storing) data in the queue we take help of **rear** pointer.

Let's first learn about supportive functions of a queue −

peek():

This function helps to see the data at the **front** of the queue. The algorithm of peek() function is as follows −

```
begin procedure peek

   return queue[front]

end procedure
```

Implementation of peek() function in C programming language −

```
int peek() {
   return queue[front];
}
```

isfull():

As we are using single dimension array to implement queue, we just check for the rear pointer to reach at MAXSIZE to determine that the queue is full. In case we maintain the queue in a circular linked-list, the algorithm will differ. Algorithm of isfull() function −

```
begin procedure isfull

   if rear equals to MAXSIZE
      return true
   else
```

```
      return false
   endif

end procedure
```

Implementation of isfull() function in C programming language –

```
bool isfull() {
   if(rear == MAXSIZE - 1)
      return true;
   else
      return false;
}
```

isempty():

Algorithm of isempty() function –

```
begin procedure isempty

   if front is less than MIN OR front is greater than rear
      return true
   else
      return
   false endif

end procedure
```

If the value of **front** is less than MIN or 0, it tells that the queue is not yet initialized, hence empty.

Here's the C programming code –

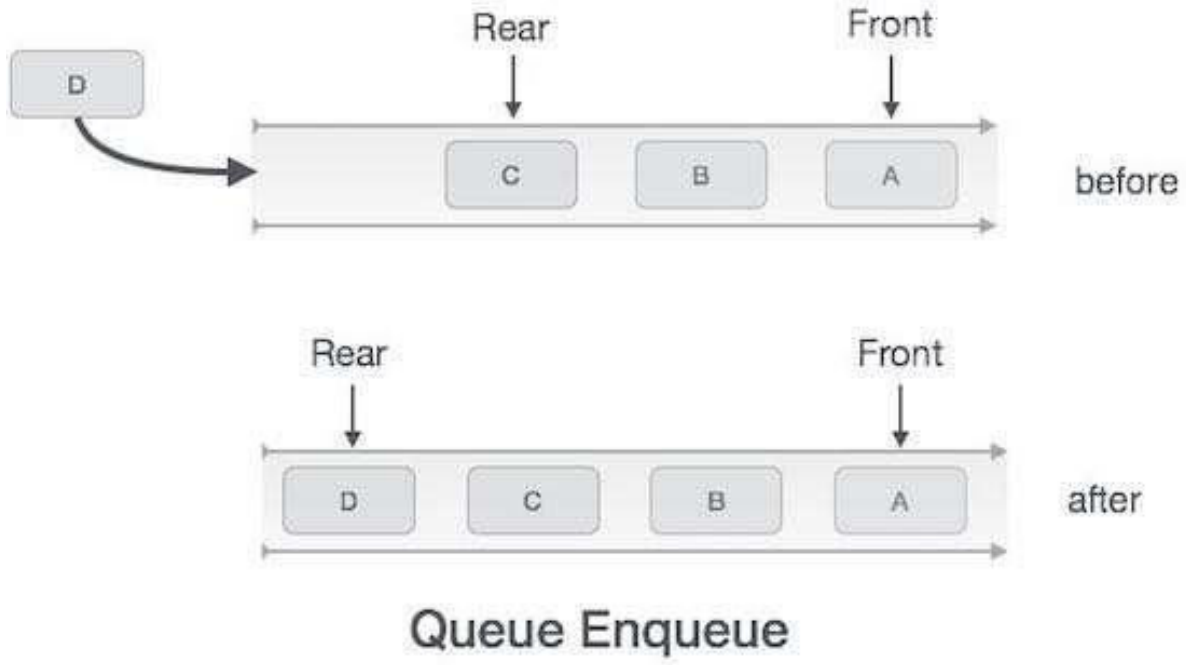
```
bool isempty() {
   if(front < 0 || front > rear)
      return true;
   else
      return false;
}
```

Enqueue Operation:

Queues maintain two data pointers, **front** and **rear**. Therefore, its operations are comparatively difficult to implement than that of stacks.

The following steps should be taken to enqueue (insert) data into a queue –

- **Step 1** – Check if the queue is full.
- **Step 2** – If the queue is full, produce overflow error and exit.
- **Step 3** – If the queue is not full, increment **rear** pointer to point the next empty space.
- **Step 4** – Add data element to the queue location, where the rear is pointing.
- **Step 5** – Return success.



Queue Enqueue

Sometimes, we also check to see if a queue is initialized or not, to handle any unforeseen situations.

Algorithm for enqueue Operation:

```
procedure enqueue(data)
   if queue is full
      return
   overflow endif

   rear ← rear + 1
   queue[rear] ← data
   return true

end procedure
```

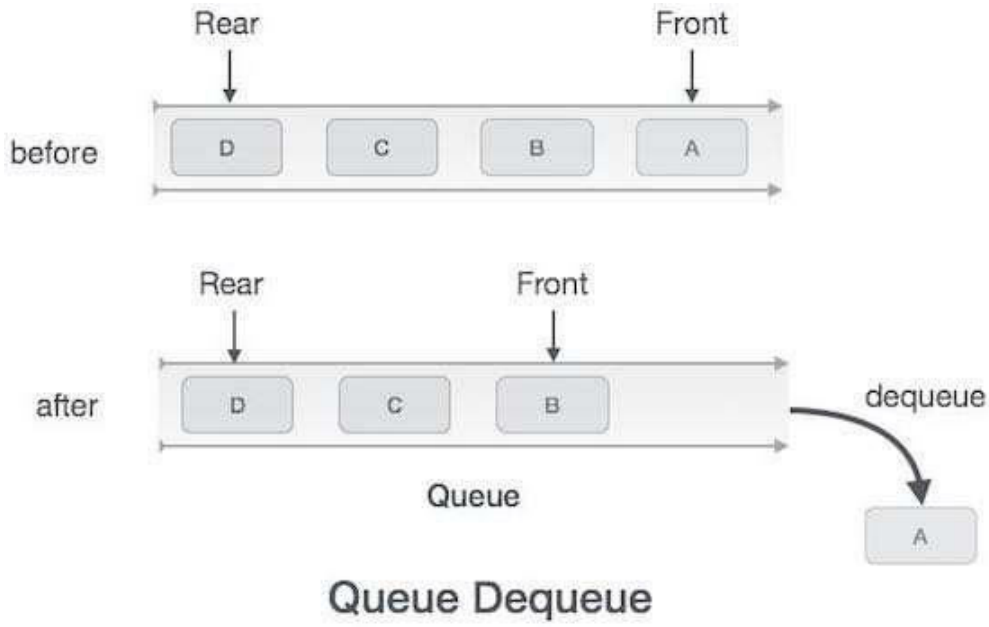
Implementation of enqueue() in C programming language –

```
int enqueue(int data)
   if(isfull())
      return 0;

   rear = rear + 1;
   queue[rear] = data;

   return 1;
end procedure
```

Dequeue Operation:

Accessing data from the queue is a process of two tasks – access the data where **front** is pointing and remove the data after access. The following steps are taken to perform **dequeue** operation –

- **Step 1** – Check if the queue is empty.
- **Step 2** – If the queue is empty, produce underflow error and exit.
- **Step 3** – If the queue is not empty, access the data where **front** is pointing.
- **Step 4** – Increment **front** pointer to point to the next available data element.
- **Step 5** – Return success.



Queue Dequeue

Algorithm for dequeue Operation:

```
procedure dequeue if
   queue is empty
      return
   underflow end if

   data = queue[front]
   front ← front + 1

   return true
end procedure
```

Implementation of dequeue() in C programming language –

```
int dequeue() {
   if(isempty())
      return 0;
   int data = queue[front];
   front = front + 1;

   return data;
}
```

Queue Program in C:

Implementation in C:

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <stdbool.h>

#define MAX 6

int intArray[MAX];
int front = 0;
int rear = -1;
int itemCount = 0;

int peek(){
   return intArray[front];
}

bool isEmpty(){
   return itemCount == 0;
}
bool isFull(){
   return itemCount == MAX;
}

int size(){
   return itemCount;
}

void insert(int data){

   if(!isFull()){
```

```
      if(rear == MAX-
         1){ rear = -1;
      }

      intArray[++rear] = data;
      itemCount++;
   }
}

int removeData(){
   int data = intArray[front++];

   if(front == MAX){
      front = 0;
   }
   itemCount--;
   return data;
}

int main() {
   /* insert 5 items */
   insert(3);
   insert(5);
   insert(9);
   insert(1);
   insert(12);

   // front : 0
   // rear  : 4
   // ------------------
   // index : 0 1 2 3 4
   // ------------------
   // queue  :  3  5  9  1
   12 insert(15);

   // front : 0
   // rear  : 5
```

```
// ---------------------
// index : 0 1 2 3 4  5
// ---------------------
// queue : 3 5 9 1 12 15

if(isFull()){
   printf("Queue is full!\n");
}

// remove one item
int num = removeData();

printf("Element removed: %d\n",num);
// front : 1
// rear  : 5
// -------------------
// index : 1 2 3 4  5
// -------------------
// queue : 5 9 1 12 15

// insert       more
items insert(16);

// front : 1
// rear  : -1
// ----------------------
// index : 0 1 2 3 4 5 //
----------------------
// queue : 16 5 9 1 12 15

// As  queue  is  full,  elements  will  not  be
inserted. insert(17);
insert(18);

// ----------------------
// index : 0 1 2 3 4 5 //
----------------------
```

```
   // queue : 16 5 9 1 12 15 printf("Element at
   front: %d\n",peek());

   printf("----------------------\n");
   printf("index : 5 4 3 2 1 0\n");
   printf("----------------------\n");
   printf("Queue: ");

   while(!isEmpty()){
      int n = removeData();
      printf("%d ",n);
   }
}
```

If we compile and run the above program, it will produce the following result –

```
Queue is full!
Element removed: 3
Element at front: 5
----------------------
index : 5 4 3 2 1 0
----------------------
Queue: 5 9 1 12 15 16
```

References:

1. "Data Structures & Algorithm" , Tutorials Point India (https://www.tutorialspoint.com)