PRIORITY QUEUES AND HEAPS

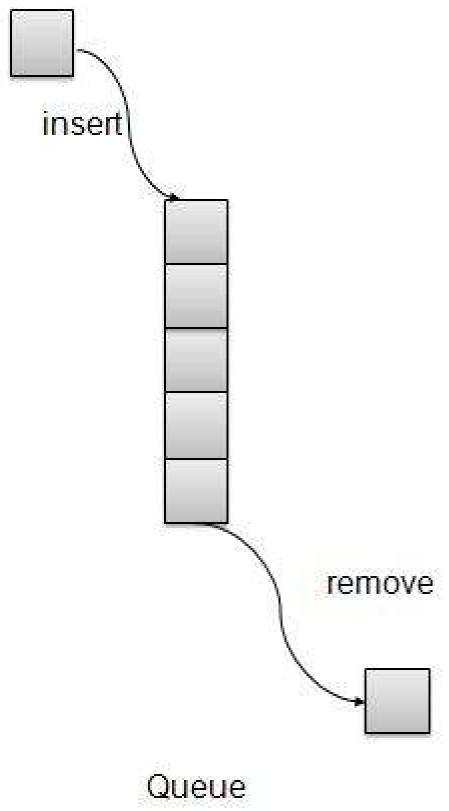
PRIORITY QUEUES

Priority Queue is more specialized data structure than Queue. Like ordinary queue, priority queue has same method but with a major difference. In Priority queue items are ordered by key value so that item with the lowest value of key is at front and item with the highest value of key is at rear or vice versa. So we're assigned priority to item based on its key value. Lower the value, higher the priority. Following are the principal methods of a Priority Queue.

Basic Operations

- **insert / enqueue** − add an item to the rear of the queue.
- **remove / dequeue** − remove an item from the front of the queue.

Priority Queue Representation

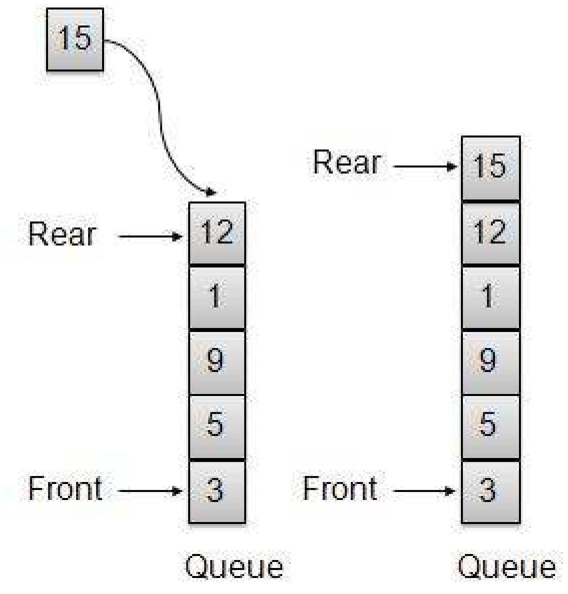


We're going to implement Queue using array in this article. There is few more operations supported by queue which are following.

- **Peek** − get the element at front of the queue.
- **isFull** − check if queue is full.
- **isEmpty** − check if queue is empty.

Insert / Enqueue Operation

Whenever an element is inserted into queue, priority queue inserts the item according to its order. Here we're assuming that data with high value has low priority.



One item inserted at rear end

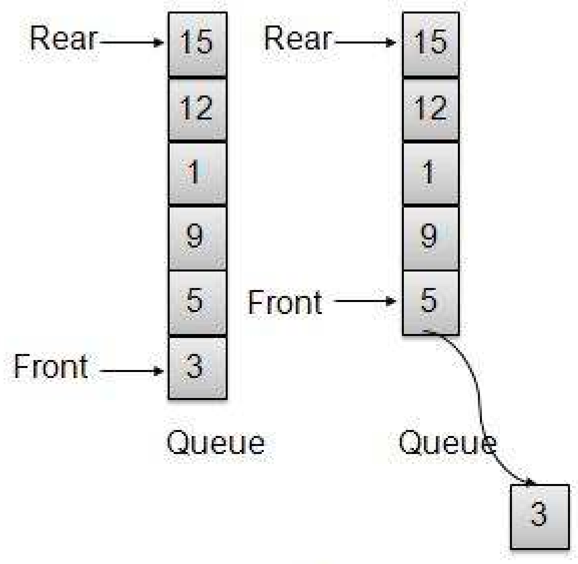
```
void insert(int data){
   int i = 0;

   if(!isFull()){
      // if queue is empty, insert the data

      if(itemCount == 0){
         intArray[itemCount++] = data;
      }else{
         // start from the right end of the queue
         for(i = itemCount - 1; i >= 0; i-- ){
            // if data is larger, shift existing item to right end
            if(data > intArray[i]){
               intArray[i+1] = intArray[i];
            }else{
               break;
            }
         }
         // insert the data
         intArray[i+1] = data;
         itemCount++;
      }
   }
}
```

Remove / Dequeue Operation

Whenever an element is to be removed from queue, queue get the element using item count. Once element is removed. Item count is reduced by one.



One Item removed from front

```
int removeData(){
   return intArray[--itemCount];
}
```

Demo Program

PriorityQueueDemo.c

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <stdbool.h>
#define MAX 6

int intArray[MAX];
int itemCount = 0;

int peek(){
   return intArray[itemCount - 1];
}

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

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

int size(){
   return itemCount;
}

void insert(int data){
   int i = 0;

   if(!isFull()){
      // if queue is empty, insert the data
      if(itemCount == 0){
         intArray[itemCount++] = data;
      }else{
         // start from the right end of the queue

         for(i = itemCount - 1; i >= 0; i-- ){
            // if data is larger, shift existing item to right end
            if(data > intArray[i]){
               intArray[i+1] = intArray[i];
            }else{
               break;
            }
         }

         // insert the data
         intArray[i+1] = data;
         itemCount++;
      }
   }
}

int removeData(){
   return intArray[--itemCount];
}

int main() {
```

```
/* insert 5 items */
insert(3);
insert(5);
insert(9);
insert(1);
insert(12);

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

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

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

// remove one item
int num = removeData();
printf("Element removed: %d\n",num);

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

// insert more items
insert(16);

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

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

// ----------------------
// index : 0   1  2 3 4 5
// ----------------------
// queue : 16 15 12 9 5 3
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 then it would produce following result −

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

HEAPS

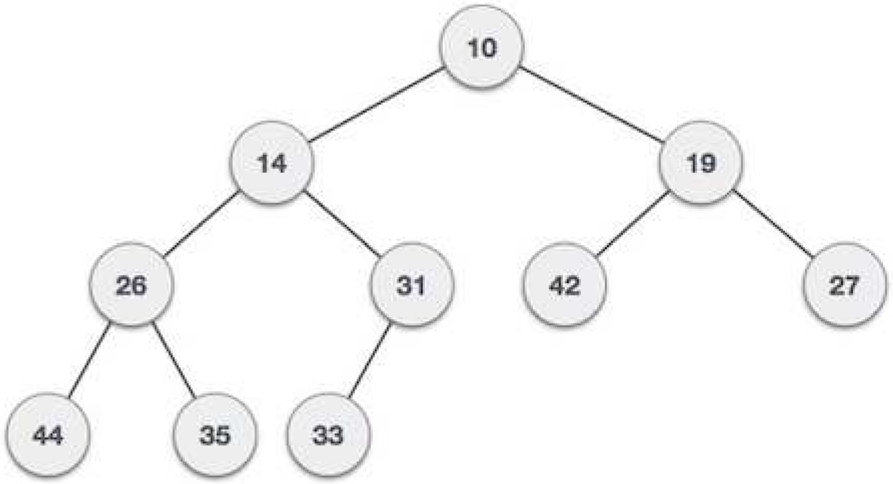
Heap is a special case of balanced binary tree data structure where the root-node key is compared with its children and arranged accordingly. If **α** has child node **β** then −

key(α) ≥ key(β)

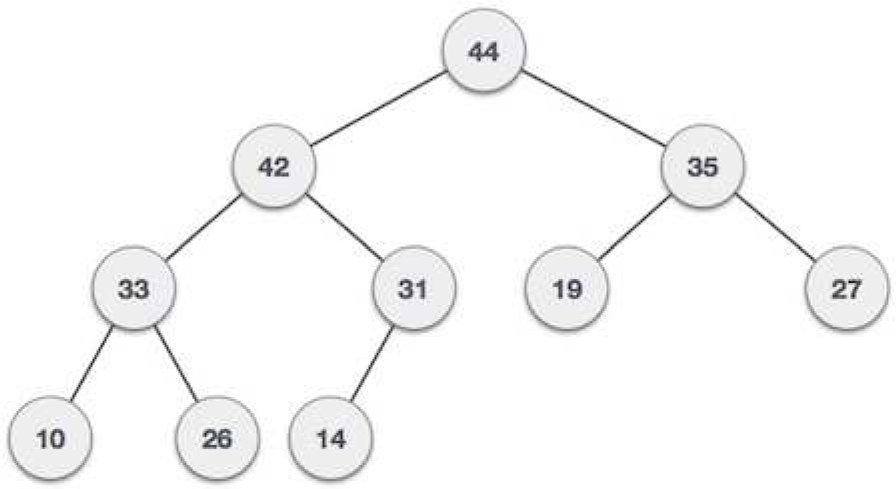
As the value of parent is greater than that of child, this property generates **Max Heap**. Based on this criteria, a heap can be of two types −

```
For Input → 35 33 42 10 14 19 27 44 26 31
```

Min-Heap − Where the value of the root node is less than or equal to either of its children.



Max-Heap − Where the value of the root node is greater than or equal to either of its children.



Both trees are constructed using the same input and order of arrival.

Max Heap Construction Algorithm

We shall use the same example to demonstrate how a Max Heap is created. The procedure to create Min Heap is similar but we go for min values instead of max values.

We are going to derive an algorithm for max heap by inserting one element at a time. At any point of time, heap must maintain its property. While insertion, we also assume that we are inserting a node in an already heapified tree.

```
Step 1 − Create a new node at the end of heap.
Step 2 − Assign new value to the node.
Step 3 − Compare the value of this child node with its parent.
Step 4 − If value of parent is less than child, then swap them.
Step 5 − Repeat step 3 & 4 until Heap property holds.
```

Note − In Min Heap construction algorithm, we expect the value of the parent node to be less than that of the child node.

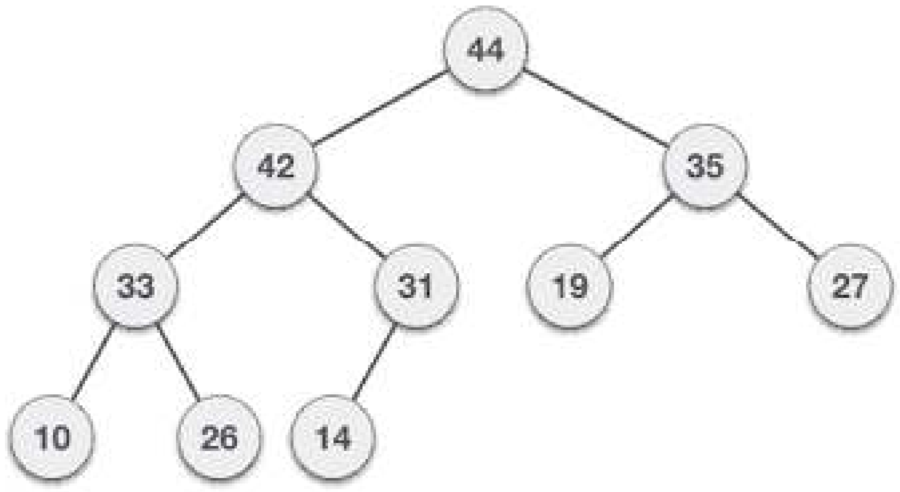
Let's understand Max Heap construction by an animated illustration. We consider the same input sample that we used earlier.

Input 35 33 42 10 14 19 27 44 26 31

Max Heap Deletion Algorithm

Let us derive an algorithm to delete from max heap. Deletion in Max (or Min) Heap always happens at the root to remove the Maximum (or minimum) value.

Step 1 − Remove root node.
Step 2 − Move the last element of last level to root.
Step 3 − Compare the value of this child node with its parent.
Step 4 − If value of parent is less than child, then swap them.
Step 5 − Repeat step 3 & 4 until Heap property holds.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