DAA Assignment No:07

Write a code with complete simulation of the following

1)AVL Tree

2)Binary Heap

3)Max Heap

4)Heapyfy

1)AVL Tree

Program code:

```
#include <iostream>                 // AVL tree implementation in C++
using namespace std;
class Node {
   public:
  int key;
  Node *left;
  Node *right;
  int height;
};
int max(int a, int b);
int height(Node *N) {               // Calculate height
  if (N == NULL)
    return 0;
  return N->height;
}
int max(int a, int b) {
  return (a > b) ? a : b;
}
Node *newNode(int key) {          // New node creation
  Node *node = new Node();
  node->key = key;
  node->left = NULL;
```

```
  node->right = NULL;
  node->height = 1;
  return (node);
}

// Rotate right
Node *rightRotate(Node *y) {
  Node *x = y->left;
  Node *T2 = x->right;
  x->right = y;
  y->left = T2;
  y->height = max(height(y->left),
          height(y->right)) +
         1;
  x->height = max(height(x->left),
          height(x->right)) +
         1;
  return x;
}

// Rotate left
Node *leftRotate(Node *x) {
  Node *y = x->right;
  Node *T2 = y->left;
  y->left = x;
  x->right = T2;
  x->height = max(height(x->left),
          height(x->right)) +
         1;
  y->height = max(height(y->left),
          height(y->right)) +
```

```
      1;
  return y;
}

// Get the balance factor of each node
int getBalanceFactor(Node *N) {
  if (N == NULL)
    return 0;
  return height(N->left) -
      height(N->right);
}

// Insert a node
Node *insertNode(Node *node, int key) {
  // Find the correct postion and insert the node
  if (node == NULL)
    return (newNode(key));
  if (key < node->key)
    node->left = insertNode(node->left, key);
  else if (key > node->key)
    node->right = insertNode(node->right, key);
  else
    return node;

  // Update the balance factor of each node and
  // balance the tree
  node->height = 1 + max(height(node->left),
              height(node->right));
  int balanceFactor = getBalanceFactor(node);
  if (balanceFactor > 1) {
    if (key < node->left->key) {
```

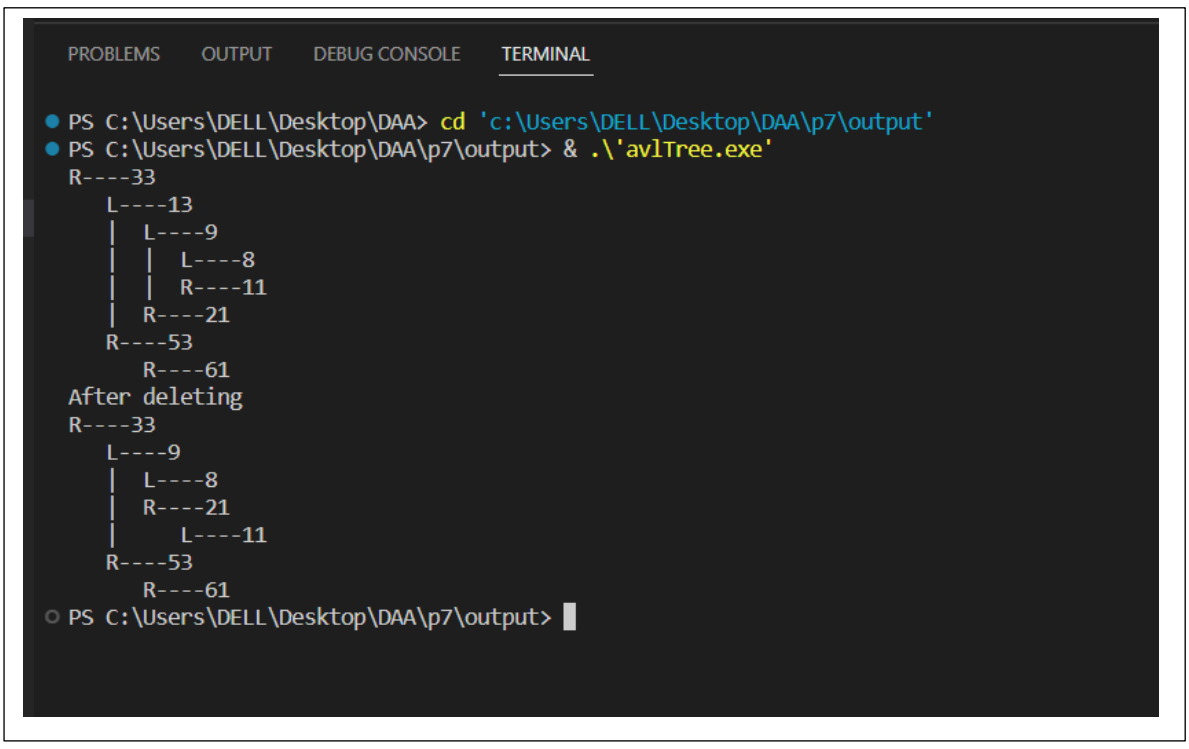
```
      return rightRotate(node);
    } else if (key > node->left->key) {
      node->left = leftRotate(node->left);
      return rightRotate(node);
    }
  }
  if (balanceFactor < -1) {
    if (key > node->right->key) {
      return leftRotate(node);
    } else if (key < node->right->key) {
      node->right = rightRotate(node->right);
      return leftRotate(node);
    }
  }
  return node;
}

// Node with minimum value
Node *nodeWithMimumValue(Node *node) {
  Node *current = node;
  while (current->left != NULL)
    current = current->left;
  return current;
}

// Delete a node
Node *deleteNode(Node *root, int key) {
  // Find the node and delete it
  if (root == NULL)
    return root;
  if (key < root->key)
```

```
  root->left = deleteNode(root->left, key);
else if (key > root->key)
  root->right = deleteNode(root->right, key);
else {
  if ((root->left == NULL) ||
    (root->right == NULL)) {
    Node *temp = root->left ? root->left : root->right;
    if (temp == NULL) {
      temp = root;
      root = NULL;
    } else
      *root = *temp;
    free(temp);
  } else {
    Node *temp = nodeWithMimumValue(root->right);
    root->key = temp->key;
    root->right = deleteNode(root->right,
                temp->key);
  }
}

if (root == NULL)
  return root;

// Update the balance factor of each node and
// balance the tree
root->height = 1 + max(height(root->left),
            height(root->right));
int balanceFactor = getBalanceFactor(root);
if (balanceFactor > 1) {
  if (getBalanceFactor(root->left) >= 0) {
```

```
      return rightRotate(root);
    } else {
      root->left = leftRotate(root->left);
      return rightRotate(root);
    }
  }
  if (balanceFactor < -1) {
    if (getBalanceFactor(root->right) <= 0) {
      return leftRotate(root);
    } else {
      root->right = rightRotate(root->right);
      return leftRotate(root);
    }
  }
  return root;
}

// Print the tree
void printTree(Node *root, string indent, bool last) {
  if (root != nullptr) {
    cout << indent;
    if (last) {
      cout << "R----";
      indent += "   ";
    } else {
      cout << "L----";
      indent += "|  ";
    }
    cout << root->key << endl;
    printTree(root->left, indent, false);
    printTree(root->right, indent, true);
```

```
  }
}

int main() {
  Node *root = NULL;
  root = insertNode(root, 33);
  root = insertNode(root, 13);
  root = insertNode(root, 53);
  root = insertNode(root, 9);
  root = insertNode(root, 21);
  root = insertNode(root, 61);
  root = insertNode(root, 8);
  root = insertNode(root, 11);
  printTree(root, "", true);
  root = deleteNode(root, 13);
  cout << "After deleting " << endl;
  printTree(root, "", true);
}
```

Output:



2)Binary Heap

A Binary Heap is a complete Binary Tree which is used to store data efficiently to get the max or min element based on its structure.

Program Code:

```
// A C++ program to demonstrate common Binary Heap Operations

#include<iostream>

#include<climits>

using namespace std;


// Prototype of a utility function to swap two integers

void swap(int *x, int *y);

// A class for Min Heap

class MinHeap

{

        int *harr; // pointer to array of elements in heap

        int capacity; // maximum possible size of min heap

        int heap_size; // Current number of elements in min heap

public:

        // Constructor

        MinHeap(int capacity);


        // to heapify a subtree with the root at given index

        void MinHeapify(int );


        int parent(int i) { return (i-1)/2; }


        // to get index of left child of node at index i

        int left(int i) { return (2*i + 1); }


        // to get index of right child of node at index i

        int right(int i) { return (2*i + 2); }
```

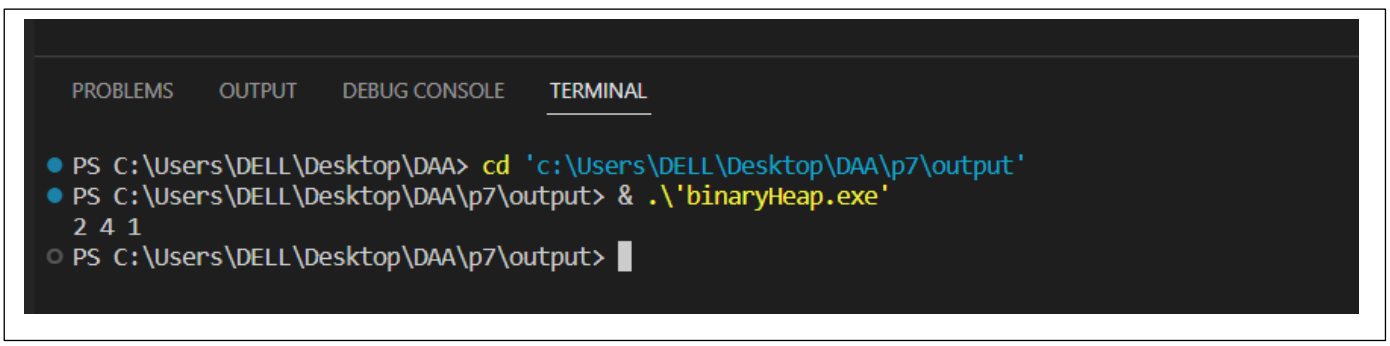
```
        // to extract the root which is the minimum element
        int extractMin();

        // Decreases key value of key at index i to new_val
        void decreaseKey(int i, int new_val);

        // Returns the minimum key (key at root) from min heap
        int getMin() { return harr[0]; }

        // Deletes a key stored at index i
        void deleteKey(int i);

        // Inserts a new key 'k'
        void insertKey(int k);
};
// Constructor: Builds a heap from a given array a[] of given size
MinHeap::MinHeap(int cap)
{
        heap_size = 0;
        capacity = cap;
        harr = new int[cap];
}
// Inserts a new key 'k'
void MinHeap::insertKey(int k)
{
        if (heap_size == capacity)
        {
                cout << "\nOverflow: Could not insertKey\n";
                return;
        }
        // First insert the new key at the end
        heap_size++;
        int i = heap_size - 1;
```

```
        harr[i] = k;

        // Fix the min heap property if it is violated
        while (i != 0 && harr[parent(i)] > harr[i])
        {
        swap(&harr[i], &harr[parent(i)]);
        i = parent(i);
        }
}
// Decreases value of key at index 'i' to new_val. It is assumed that
// new_val is smaller than harr[i].
void MinHeap::decreaseKey(int i, int new_val)
{
        harr[i] = new_val;
        while (i != 0 && harr[parent(i)] > harr[i])
        {
        swap(&harr[i], &harr[parent(i)]);
        i = parent(i);
        }
}
// Method to remove minimum element (or root) from min heap
int MinHeap::extractMin()
{
        if (heap_size <= 0)
                return INT_MAX;
        if (heap_size == 1)
        {
                heap_size--;
                return harr[0];
        }

        // Store the minimum value, and remove it from heap
        int root = harr[0];
```

```
        harr[0] = harr[heap_size-1];
        heap_size--;
        MinHeapify(0);

        return root;
}
// This function deletes key at index i. It first reduced value to minus
// infinite, then calls extractMin()
void MinHeap::deleteKey(int i)
{
        decreaseKey(i, INT_MIN);
        extractMin();
}

// A recursive method to heapify a subtree with the root at given index
// This method assumes that the subtrees are already heapified
void MinHeap::MinHeapify(int i)
{
        int l = left(i);
        int r = right(i);
        int smallest = i;
        if (l < heap_size && harr[l] < harr[i])
                smallest = l;
        if (r < heap_size && harr[r] < harr[smallest])
                smallest = r;
        if (smallest != i)
        {
                swap(&harr[i], &harr[smallest]);
                MinHeapify(smallest);
        }
}

// A utility function to swap two elements
```

```
void swap(int *x, int *y)
{
	int temp = *x;
	*x = *y;
	*y = temp;
}

// Driver program to test above functions
int main()
{
	MinHeap h(11);
	h.insertKey(3);
	h.insertKey(2);
	h.deleteKey(1);
	h.insertKey(15);
	h.insertKey(5);
	h.insertKey(4);
	h.insertKey(45);
	cout << h.extractMin() << " ";
	cout << h.getMin() << " ";
	h.decreaseKey(2, 1);
	cout << h.getMin();
	return 0;
}
```

Output:



3)Max Heap

Program Code:

```
#include <iostream>
using namespace std;
void max_heap(int *a, int m, int n) {
  int j, t;
  t = a[m];
  j = 2 * m;
  while (j <= n) {
    if (j < n && a[j+1] > a[j])
      j = j + 1;
    if (t > a[j])
      break;
    else if (t <= a[j]) {
      a[j / 2] = a[j];
      j = 2 * j;
    }
  }
  a[j/2] = t;
  return;
}
void build_maxheap(int *a,int n) {
  int k;
  for(k = n/2; k >= 1; k--) {
    max_heap(a,k,n);
  }
}
int main() {
  int n, i;
  cout<<"enter no of elements of array\n";
  cin>>n;
  int a[30];
```

```
  for (i = 1; i <= n; i++) {
    cout<<"enter elements"<<" "<<(i)<<endl;
    cin>>a[i];
  }
  build_maxheap(a,n);
  cout<<"Max Heap\n";
  for (i = 1; i <= n; i++) {
    cout<<a[i]<<endl;
  }
}
```

Output:

4)Heapyfy

Program Code:

```
// C++ program for building Heap from Array
#include <bits/stdc++.h>
using namespace std;

// To heapify a subtree rooted with node i which is
// an index in arr[]. N is size of heap
void heapify(int arr[], int N, int i)
{
	int largest = i; // Initialize largest as root
	int l = 2 * i + 1; // left = 2*i + 1
	int r = 2 * i + 2; // right = 2*i + 2

	// If left child is larger than root
	if (l < N && arr[l] > arr[largest])
		largest = l;

	// If right child is larger than largest so far
	if (r < N && arr[r] > arr[largest])
		largest = r;

	// If largest is not root
	if (largest != i) {
		swap(arr[i], arr[largest]);

		// Recursively heapify the affected sub-tree
		heapify(arr, N, largest);
	}
}
```

```
// Function to build a Max-Heap from the given array
void buildHeap(int arr[], int N)
{
	// Index of last non-leaf node
	int startIdx = (N / 2) - 1;

	// Perform reverse level order traversal
	// from last non-leaf node and heapify
	// each node
	for (int i = startIdx; i >= 0; i--) {
		heapify(arr, N, i);
	}
}

// A utility function to print the array
// representation of Heap
void printHeap(int arr[], int N)
{
	cout << "Array representation of Heap is:\n";

	for (int i = 0; i < N; ++i)
		cout << arr[i] << " ";
	cout << "\n";
}

// Driver Code
int main()
{
	// Binary Tree Representation
	// of input array
```

```
        //                  1
        //               /      \
        //             3          5
        //           /   \      /   \
        //         4      6    13    10
        //       /  \    /  \
        //      9    8  15   17
        int arr[] = {1, 3, 5, 4, 6, 13, 10, 9, 8, 15, 17};

        int N = sizeof(arr) / sizeof(arr[0]);

        // Function call
        buildHeap(arr, N);
        printHeap(arr, N);
        // Final Heap:
        //                    17
        //                 /      \
        //               15         13
        //             /    \      /   \
        //           9       6    5    10
        //         /   \    /  \
        //        4    8   3    1

        return 0;
}
```

Output: