DSA LAB
Lab Assignment number 14

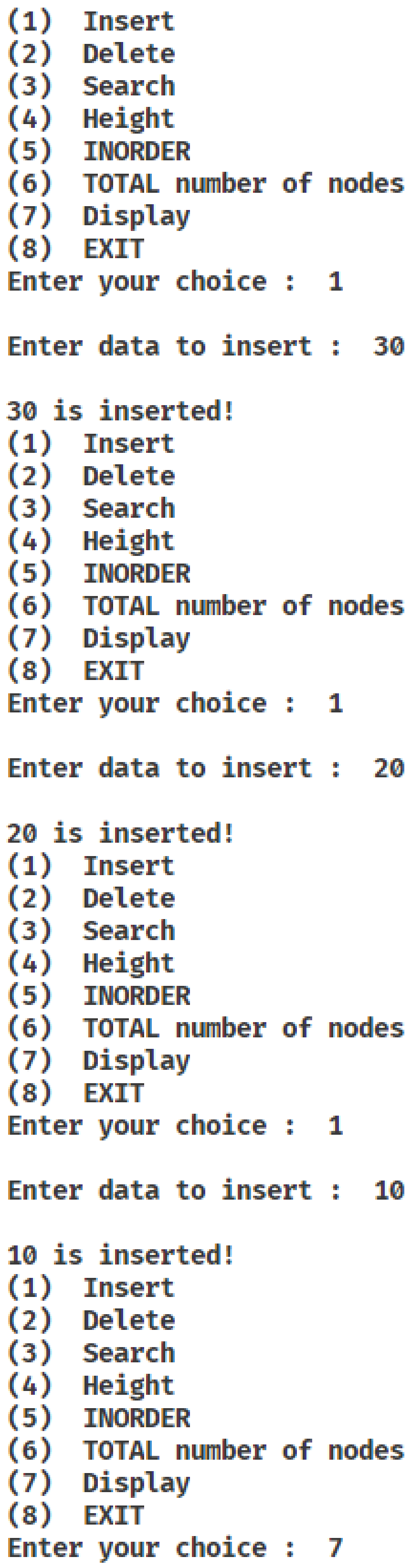
Name: Aamir Ansari **Batch:** A **Roll no:** 01

```
// code
#include <stdio.h>
#include <stdlib.h>

struct node {    // stucture of node
   struct node *left;
   int data;
   struct node *right;
   int height;
};

// declaring root
struct node *root = NULL;

struct node *findMax(struct node *root) {
   while (root->right != NULL) {
      root = root->right;
   }
   return root;
}

struct node *findMin(struct node *root) {
   while (root->left != NULL) {
      root = root->left;
   }
   return root;
}

int max (int n1, int n2) {
   return ((n1 > n2) ? n1 : n2);
}

int height (struct node *root) {
   if (root == NULL) {
      return 0;
   }
   return root->height;
}

struct node *getNewNode(int data) {    // initialises and allocates memory for newNode
   struct node *newNode;
   newNode = (struct node *)malloc(sizeof(struct node));
   newNode->data  = data;
   newNode->left  = NULL;
   newNode->right = NULL;
   newNode->height = 1;
   return newNode;
```

```
}

int getBalance(struct node *root) {
    if (root == NULL) {
        return 0;
    }
    return (height(root->left) - height(root->right));
}

struct node *rightRotate(struct node *root) {
    struct node *rootLeft = root->left;
    struct node *rootLeftRight = rootLeft->right;

    // rotation
    rootLeft->right = root;
    root->left = rootLeftRight;

    // updation of height
    root->height = max(height(root->left), height(root->right)) + 1;
    rootLeft->height = max(height(rootLeft->left), height(rootLeft->right)) + 1;

    // back tracking of root
    return rootLeft;
}

struct node *leftRotate(struct node *root) {
    struct node *rootRight = root->right;
    struct node *rootRightLeft = rootRight->left;

    // rotation
    rootRight->left = root;
    root->right = rootRightLeft;

    // updation of height
    root->height = max(height(root->left), height(root->right)) + 1;
    rootRight->height = max(height(rootRight->left), height(rootRight->right)) + 1;

    // back tracking of root
    return rootRight;
}

struct node *insert (struct node *root, int data) {    // inserts in the avl tree
    if (root == NULL) {    // base case
        root = getNewNode(data);
        return root;
    }
    if (data < root->data) {    // insertion in right sub-tree
        root->left = insert(root->left, data);
    }
    else if (data > root->data) {    // insertion in left sub-tree
        root->right = insert(root->right, data);
    }
    else {    // return root if value is equal
        return root;
    }

    // updating height of ancestor node
    root->height = max(height(root->left), height(root->right)) + 1;

    // balance factor
    int balance = getBalance(root);

    // ROTATIONS
    if ((balance > 1) && (data < root->left->data)) {    // LEFT-LEFT
        return rightRotate(root);
    }
    else if ((balance < -1) && (data > root->right->data)) {    // RIGHT-RIGHT
        return leftRotate(root);
    }
    else if ((balance > 1) && (data > root->left->data)) {    // LEFT-RIGHT
        root->left = leftRotate(root->left);
        return rightRotate(root);
    }
    else if ((balance < -1) && (data < root->right->data)) {    // RIGHT-LEFT
        root->right = rightRotate(root->right);
        return leftRotate(root);
    }
    return root;
}

struct node *delete(struct node *root, int val) {
    // deletion of node
    if (root == NULL) {    // empty tree
        return root;
    }
    else if (val < root->data) {    // finding node in left sub-tree
        root->left = delete (root->left, val);
    }
    else if (val > root->data) {    // finding node in right sub-tree
        root->right = delete (root->right, val);
    }
    else {    // found the node
        if (root->right == NULL && root->left == NULL) {    // deleting leaf node
            free(root);
            root = NULL;
        } else if (root->right == NULL) {    // deleting a node with only left sub-tree
            struct node *temp = root;
            root = root->left;
            free(temp);
        } else if (root->left == NULL) {    // deleting a node with only right sub-tree
            struct node *temp = root;
            root = root->right;
            free(temp);
        } else {    // deleting nodes with two sub-trees
```

```
            // storing address of node with min value in right sub-tree
            struct node *temp = findMin(root->right);
            root->data = temp->data;
            root->right = delete (root->right, temp->data);
        }
    }
    // updation of height
    root->height = max(height(root->left), height(root->right)) + 1;

    // check balance factor
    int balance = getBalance(root);

    // ROTATIONS
    if ((balance > 1) && (getBalance(root->left)>=0)) {    // LEFT-LEFT
        return rightRotate(root);
    }
    else if ((balance < -1) && (getBalance(root->right)<=0)) {    // RIGHT-RIGHT
        return leftRotate(root);
    }
    else if ((balance > 1) && (getBalance(root->left)<0)) {    // LEFT-RIGHT
        root->left = leftRotate(root->left);
        return rightRotate(root);
    }
    else if ((balance < -1) && (getBalance(root->right)>0)) {    // RIGHT-LEFT
        root->right = rightRotate(root->right);
        return leftRotate(root);
    }
    return root;
}

void search(struct node *root, int val) {
    if (root->data == val) {
        printf("\n%d is present in the tree", val);
        return;
    }
    if ((root->right == NULL && root->left == NULL) || root == NULL) {
        printf("\nNot present");
        return;
    }
    if (val <= root->data) {    // search in left sub-tree
        search(root->left, val);
    }
    else {    // search in right sub-tree
        search(root->right, val);
    }
}

int countAllNodes(struct node *root) {
    if (root == NULL) {
        return 0;
    }
    else {
        return countAllNodes(root->left) + countAllNodes(root->right) + 1;
    }
}

void inOrderTraversal (struct node *root) {
    if (root == NULL) {
        return;
    }
    inOrderTraversal(root->left);
    printf("%d  ", root->data);
    inOrderTraversal(root->right);
}

void display(struct node *root, int space) {
    if (root == NULL)
        return;

    // Increase distance between levels
    space += 7;

    // Process right child first
    display(root->right, space);

    // Print current node after space
    printf("\n");
    for (int i = 5; i < space; i++) {
        printf(" ");
    }
    printf("%d\n", root->data);

    // Process left child
    display(root->left, space);
}

int main() {
    struct node *temp;
    int data, i, choice, val;

    while (1) {
        printf("\n(1)  Insert");
        printf("\n(2)  Delete");
        printf("\n(3)  Search");
        printf("\n(4)  Height");
        printf("\n(5)  INORDER");
        printf("\n(6)  TOTAL number of nodes");
        printf("\n(7)  Display");
        printf("\n(8)  EXIT");
        printf("\nEnter your choice :  ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("\nEnter data to insert :  ");
                scanf("%d", &data);
                root = insert(root, data);
                printf("\n%d is inserted!", data);
                break;

            case 2:
                printf("\nEnter a value to delete :  ");
                scanf("%d", &val);
                root = delete (root, val);
                printf("\n%d is deleted!", val);
                break;

            case 3:
                printf("\nEnter a number to Search");
                scanf("%d", &data);
                search(root, data);
                break;

            case 4:
                printf("\nHeight of tree is :  %d", height(root));
                break;

            case 5:
                printf("\nIN-ORDER :  ");
                inOrderTraversal(root);
                break;

            case 6:
                printf("\nTotal number of nodes :  %d", countAllNodes(root));
                break;

            case 7:
                display(root, 0);
                break;

            case 8:
                printf("\n*** E X I T I N G ***\n");
                exit(1);
                break;

            default:
                printf("\n*** I N V A L I D ***");
        }
    }
    return 0;
}
```

// output



```
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  1

Enter data to insert :  30

30 is inserted!
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  1

Enter data to insert :  20

20 is inserted!
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  1

Enter data to insert :  10

10 is inserted!
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  7
```

```
         30

  20

         10

(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  3

Enter a number to Search30

30 is present in the tree
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  4

Height of tree is :  2
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  6

Total number of nodes :  3
(1)  Insert
(2)  Delete
(3)  Search
(4)  Height
(5)  INORDER
(6)  TOTAL number of nodes
(7)  Display
(8)  EXIT
Enter your choice :  8

*** E X I T I N G ***
```