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BRANCH :- Comps -B. **BRANCH:** B.
EXPERIMENT 6: Implement an ADT for storing an AVL Tree and performing given operations on it.
SUBJECT :- DS (DATA STRUCTURES).

CODE :-

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

struct AVLNode {
    int data;
    struct AVLNode* left;
    struct AVLNode* right;
    int height;
};

int max(int a, int b) {
    return (a > b) ? a : b;
}

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

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

struct AVLNode* createNode(int data) {
    struct AVLNode* newNode = (struct
AVLNode*)malloc(sizeof(struct AVLNode));
    newNode->data = data;
    newNode->left = NULL;
    newNode->right = NULL;
```

```
    newNode->height = 1;  // New node is initially added at
leaf, so its height is 1
    return newNode;
}

struct AVLNode* rotateRight(struct AVLNode* y) {
    struct AVLNode* x = y->left;
    struct AVLNode* T2 = x->right;

    x->right = y;
    y->left = T2;

    y->height = max(getHeight(y->left), getHeight(y->right)) +
1;
    x->height = max(getHeight(x->left), getHeight(x->right)) +
1;

    return x;
}

struct AVLNode* rotateLeft(struct AVLNode* x) {
    struct AVLNode* y = x->right;
    struct AVLNode* T2 = y->left;

    y->left = x;
    x->right = T2;

    x->height = max(getHeight(x->left), getHeight(x->right)) +
1;
    y->height = max(getHeight(y->left), getHeight(y->right)) +
1;

    return y;
}

struct AVLNode* insert(struct AVLNode* root, int data) {
    if (root == NULL) {
        return createNode(data);
    }
```

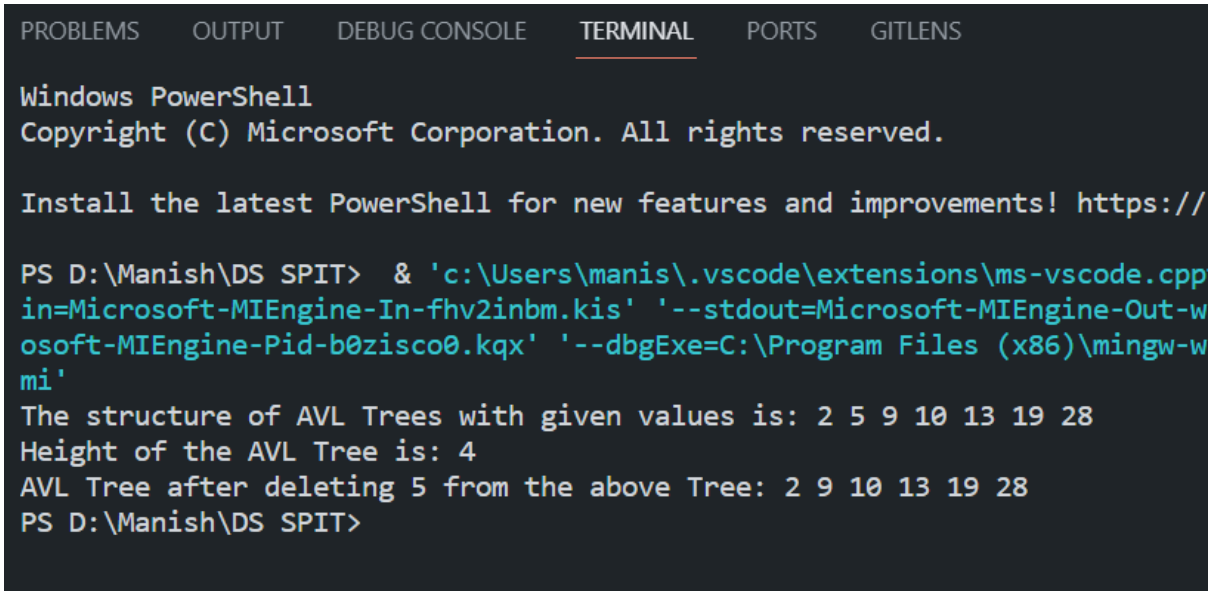
```
    if (data < root->data) {
        root->left = insert(root->left, data);
    } else if (data > root->data) {
        root->right = insert(root->right, data);
    } else {
        return root; // Duplicate data not allowed
    }

    root->height = 1 + max(getHeight(root->left),
getHeight(root->right));

    int balance = getBalance(root);

    if (balance > 1 && data < root->left->data) {
        return rotateRight(root);
    }

    if (balance < -1 && data > root->right->data) {
        return rotateLeft(root);
    }

    if (balance > 1 && data > root->left->data) {
        root->left = rotateLeft(root->left);
        return rotateRight(root);
    }

    if (balance < -1 && data < root->right->data) {
        root->right = rotateRight(root->right);
        return rotateLeft(root);
    }

    return root;
}

struct AVLNode* minValueNode(struct AVLNode* node) {
    struct AVLNode* current = node;
    while (current->left != NULL) {
        current = current->left;
    }
    return current;
```

```
}

struct AVLNode* delete(struct AVLNode* root, int data) {
    if (root == NULL) {
        return root;
    }

    if (data < root->data) {
        root->left = delete(root->left, data);
    } else if (data > root->data) {
        root->right = delete(root->right, data);
    } else {
        if (root->left == NULL || root->right == NULL) {
            struct AVLNode* temp = root->left ? root->left :
root->right;

            if (temp == NULL) {
                temp = root;
                root = NULL;
            } else {
                *root = *temp;
            }
            free(temp);
        } else {
            struct AVLNode* temp = minValueNode(root->right);
            root->data = temp->data;
            root->right = delete(root->right, temp->data);
        }
    }

    if (root == NULL) {
        return root;
    }

    root->height = 1 + max(getHeight(root->left),
getHeight(root->right));

    int balance = getBalance(root);

    if (balance > 1 && getBalance(root->left) >= 0) {
```

```
        return rotateRight(root);
    }

    if (balance > 1 && getBalance(root->left) < 0) {
        root->left = rotateLeft(root->left);
        return rotateRight(root);
    }

    if (balance < -1 && getBalance(root->right) <= 0) {
        return rotateLeft(root);
    }

    if (balance < -1 && getBalance(root->right) > 0) {
        root->right = rotateRight(root->right);
        return rotateLeft(root);
    }

    return root;
}

void displayAVLTree(struct AVLNode* root) {
    if (root != NULL) {
        displayAVLTree(root->left);
        printf("%d ", root->data);
        displayAVLTree(root->right);
    }
}

void freeAVLTree(struct AVLNode* root) {
    if (root == NULL) {
        return;
    }

    freeAVLTree(root->left);
    freeAVLTree(root->right);
    free(root);
}

int main() {
    struct AVLNode* root = NULL;
```

```
    root = insert(root, 28);
    root = insert(root, 9);
    root = insert(root, 13);
    root = insert(root, 2);
    root = insert(root, 5);
    root = insert(root, 19);
    root = insert(root, 10);

    printf("The structure of AVL Trees with given values is:
");
    displayAVLTree(root);
    printf("\n");

    printf("Height of the AVL Tree is: %d\n", getHeight(root));

    root = delete(root, 5);
    printf("AVL Tree after deleting 5 from the above Tree: ");
    displayAVLTree(root);
    printf("\n");

    freeAVLTree(root);

    return 0;
}
```

Output:



Algorithm:

Structures:

- Define a structure for AVLNode with fields: `data` (integer), `left` (pointer to AVLNode), `right` (pointer to AVLNode), and `height` (integer).

Helper Functions:

- `max(a, b)`: Returns the maximum of two integers `a` and `b`.

- `getHeight(node)`: Returns the height of the AVL tree starting from the given `node`.

- `getBalance(node)`: Returns the balance factor of the AVL tree at the given `node`.

AVLNode Creation:

- Create a function `createNode(data)` that allocates memory for an AVLNode, initializes its data, left, and right pointers to NULL, and sets its height to 1.

Right Rotation:

- Create a function `rotateRight(y)` that performs a right rotation at node `y`. It returns the new root of the rotated subtree.

Left Rotation:

- Create a function `rotateLeft(x)` that performs a left rotation at node `x`. It returns the new root of the rotated subtree.

Insertion:

- Create a function `insert(root, data)` for inserting a new node with `data` into the AVL tree rooted at `root`.

- If `root` is NULL, create a new node with the given data and return it.

- If `data` is less than `root->data`, insert it in the left subtree and update the height.

- If `data` is greater than `root->data`, insert it in the right subtree and update the height.

- Update the height of the current node.

- Calculate the balance factor of the current node.

- Perform appropriate rotations to balance the tree, if necessary.

- Return the new root of the subtree.

Find Minimum Node:

- Create a function `minValueNode(node)` that finds and returns the node with the minimum value in the given subtree rooted at `node`.

Deletion:

- Create a function `delete(root, data)` to delete a node with `data` from the AVL tree rooted at `root`.

- If `root` is NULL, return `root`.

- If `data` is less than `root->data`, delete it from the left subtree.

- If `data` is greater than `root->data`, delete it from the right subtree.

- If the node to be deleted has one or no child, replace it with the non-empty child or NULL.

- If the node to be deleted has two children, replace it with the in-order successor (node with the minimum value in the right subtree) and delete the in-order successor.

- Update the height of the current node.

- Calculate the balance factor of the current node.

- Perform appropriate rotations to balance the tree, if necessary.

- Return the new root of the subtree.

Display AVL Tree:

- Create a function `displayAVLTree(root)` to display the AVL tree in in-order traversal.

Free AVL Tree:

- Create a function `freeAVLTree(root)` to free the memory allocated for the AVL tree using post-order traversal.

Main Function:

- In the `main` function, initialize the AVL tree, insert nodes, display the tree, get the height, delete nodes, and free the memory.

Experiment No. 6

* Aim :- Implement an ADT for storing an AVL tree and performing given operations on it.

* Theory :-

An AVL tree is a self-balancing Binary search tree where the difference between heights of left subtree and right subtrees of any node cannot be more than one.

- Left Rotation :-

When node is added into right subtree of right subtree, if the tree gets out of balance, we do single left rotation.

- Right Rotation :-

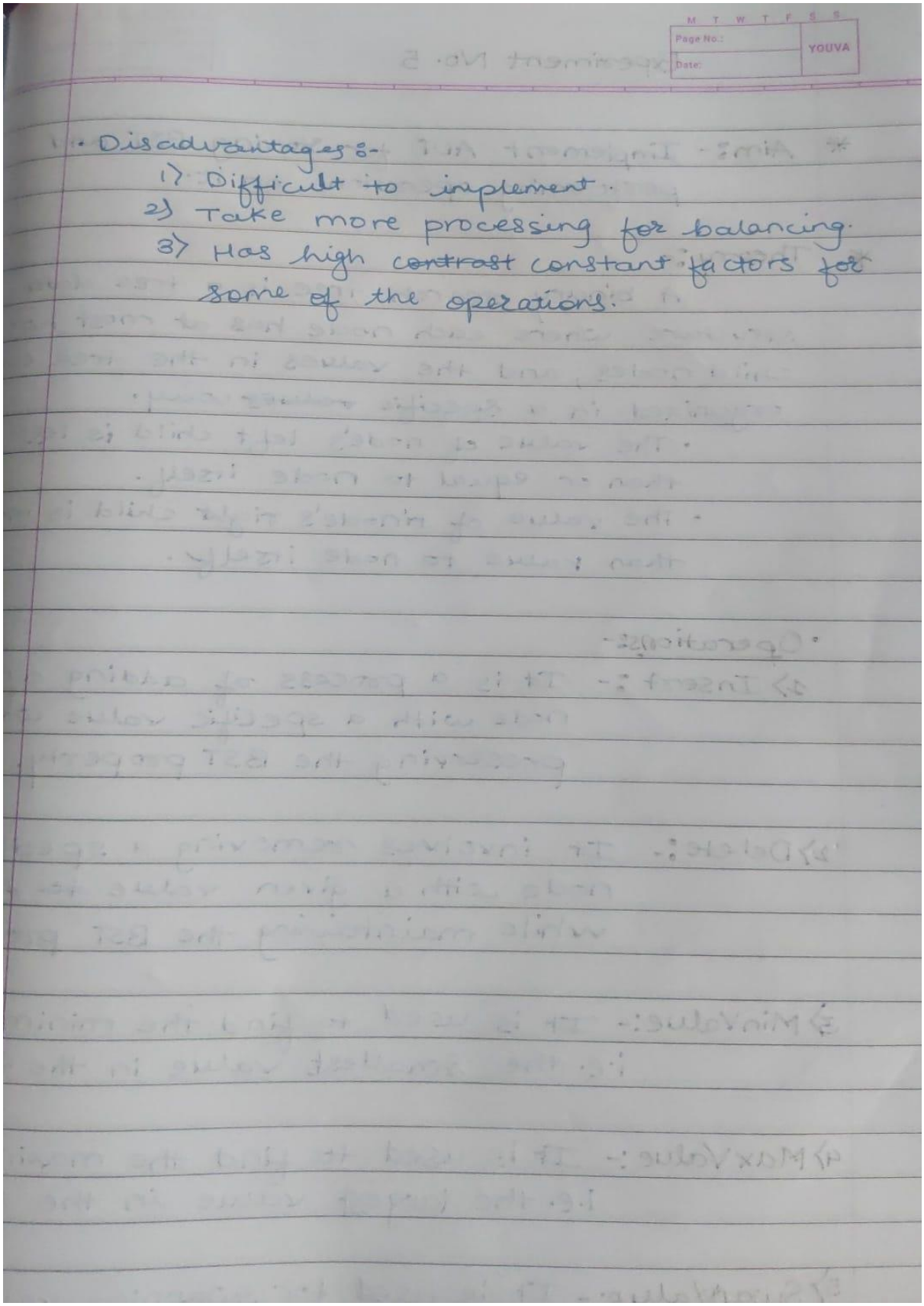
If a node is added to left subtree, AVL tree may get out of balance, we do single right rotation.

- Applications of AVL tree :-

1) Software that need optimize search.
2) It is applied in corporate areas.
3) Used in storyline games.

- Advantages :-

1) Can self-balance themselves.
2) It is surely not skewed.
3) Better search complexity time.



• Disadvantages :-

1) Difficult to implement.
2) Take more processing for balancing.
3) Has high ~~contrast~~ constant factors for some of the operations.

Conclusion:

Hence, by completing this experiment I came to know about implement an ADT for storing an AVL Tree and performing given operations on it.