1.Write a C program to Implement a 2-3-4 tree as an extension of the 2-3 tree.

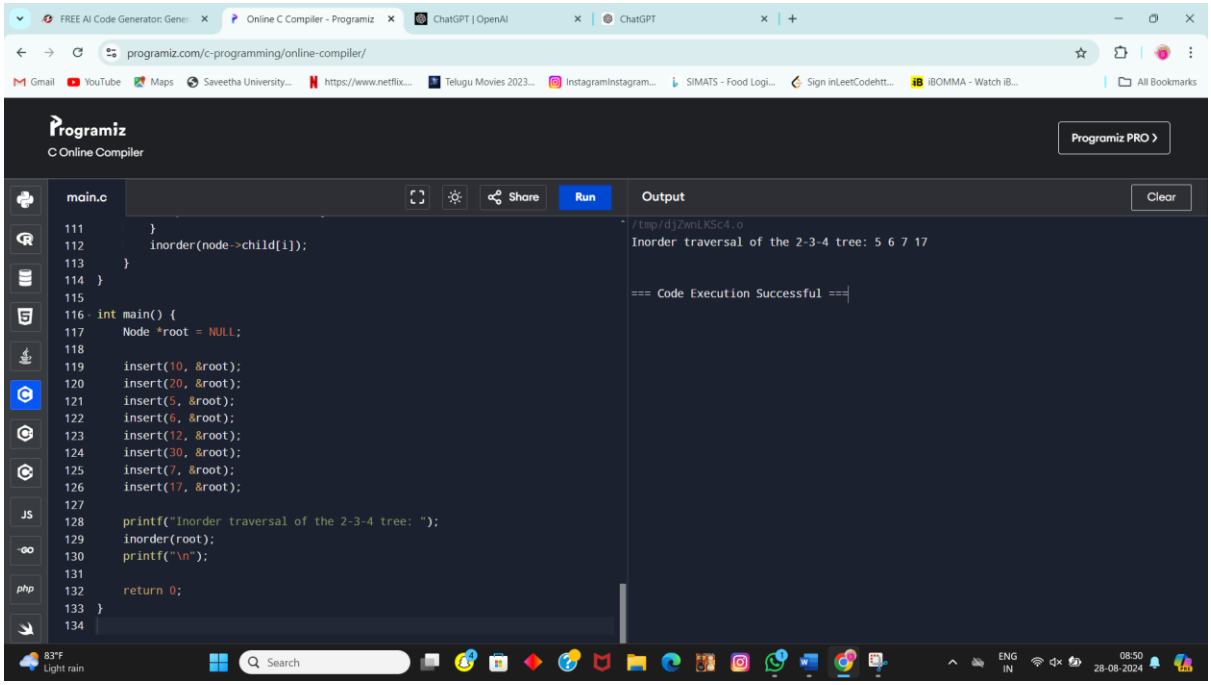
```
#include <stdio.h>
#include <stdlib.h>
#define MAX 3
#define MIN 1
typedef struct Node {
   int keys[MAX + 1], count;
   struct Node *child[MAX + 2];
}
Node;
Node* createNode(int key, Node *child) {
   Node *newNode;
   newNode = (Node*)malloc(sizeof(Node));
   newNode->keys[1] = key;
   newNode->count = 1;
   newNode->child[0] = child;
   newNode->child[1] = NULL;
   return newNode;
}
void insertValue(int key, int pos, Node *node, Node *child)
 {
   int j = node->count;
   while (j > pos) {
      node->keys[j + 1] = node->keys[j];
      node->child[j + 1] = node->child[j];
      j--;
   }
   node->keys[j + 1] = key;
   node->child[j + 1] = child;
   node->count++;
}
```

```
void splitNode(int key, int *pval, int pos, Node *node, Node *child, Node **newNode)
 {
 int median, j;
   if (pos > MIN)
      median = MIN + 1;
   else
      median = MIN;
   *newNode = (Node*)malloc(sizeof(Node));
   j = median + 1;
   while (j <= MAX)
{
      (*newNode)->keys[j - median] = node->keys[j];
      (*newNode)->child[j - median] = node->child[j];
      j++;
   }
   node->count = median;
   (*newNode)->count = MAX - median;
   if (pos <= MIN)
      insertValue(key, pos, node, child);
   else
      insertValue(key, pos - median, *newNode, child);
   *pval = node->keys[node->count];
   (*newNode)->child[0] = node->child[node->count];
   node->count--;
}
int setValue(int key, int *pval, Node *node, Node **child) {
   int pos;
   if (!node)
{
      *pval = key;
      *child = NULL;
```

```
        return 1;
    }
    if (key < node->keys[1]) {
        pos = 0;
    }
else
{
        for (pos = node->count; (key < node->keys[pos] && pos > 1); pos--);
        if (key == node->keys[pos]) {
            return 0;
        }
    }
    if (setValue(key, pval, node->child[pos], child)) {
        if (node->count < MAX) {
            insertValue(*pval, pos, node, *child);
            return 0;
        }
Else
 {
            splitNode(*pval, pval, pos, node, *child, child);
            return 1;
        }
    }
    return 0;
}
void insert(int key, Node **root) {
    int flag, i;
    Node *child;
    flag = setValue(key, &i, *root, &child);
    if (flag)
{
```

```
        Node *newNode = createNode(i, child);
        newNode->child[0] = *root;
        *root = newNode;
    }
}
void inorder(Node *node)
 {
    int i;
    if (node)
 {
        for (i = 0; i < node->count; i++) {
            inorder(node->child[i]);
            printf("%d ", node->keys[i + 1]);
        }
        inorder(node->child[i]);
    }
}
int main()
 {
    Node *root = NULL;
    insert(10, &root);
    insert(20, &root);
    insert(5, &root);
    insert(6, &root);
    insert(12, &root);
    insert(30, &root);
    insert(7, &root);
    insert(17, &root);
    printf("Inorder traversal of the 2-3-4 tree: ");
    inorder(root);
    printf("\n");
```

```
    return 0;
}
```



2.Write a C program to perform the following operations:

a) Insert an element into a Splay tree.

b) Delete an element from a Splay tree.

c) Search for a key element in a Splay tree.

```
#include <stdio.h>
#include <stdlib.h>
typedef struct Node
 {
    int key;
    struct Node *left, *right;
}
 Node;
Node* newNode(int key)
{
    Node* node = (Node*)malloc(sizeof(Node));
    node->key = key;
```

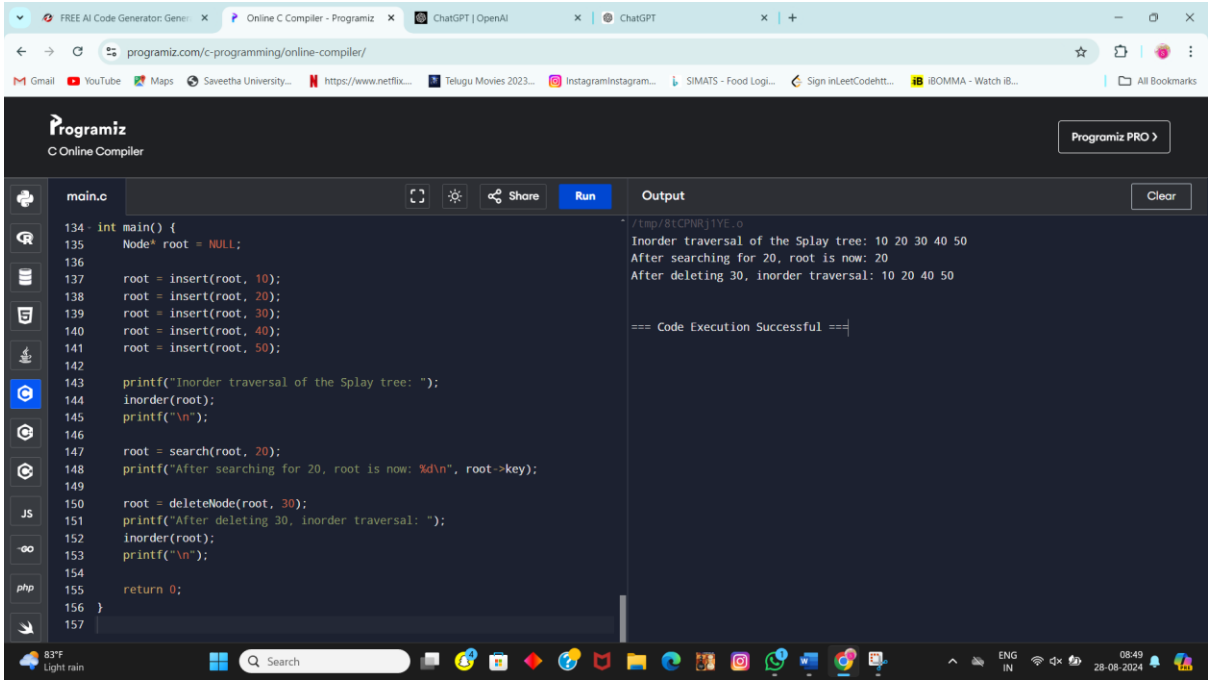
```
    node->left = node->right = NULL;
    return node;
}
Node* rightRotate(Node* x) {
    Node* y = x->left;
    x->left = y->right;
    y->right = x;
    return y;
}
Node* leftRotate(Node* x)
{
    Node* y = x->right;
    x->right = y->left;
 y->left = x;
    return y;
}
Node* splay(Node* root, int key)
 {
    if (!root || root->key == key)
        return root;
    if (key < root->key)
 {
        if (!root->left) return root;
        if (key < root->left->key)
{
            root->left->left = splay(root->left->left, key);
            root = rightRotate(root);
        }
        else if (key > root->left->key) {
            root->left->right = splay(root->left->right, key);
            if (root->left->right)
```

```
            root->left = leftRotate(root->left);
        }
        return root->left ? rightRotate(root) : root;
    }
    else
{
        if (!root->right) return root;
        if (key < root->right->key)
 {
            root->right->left = splay(root->right->left, key);
            if (root->right->left)
                root->right = rightRotate(root->right);
        }
                else if (key > root->right->key)
{
            root->right->right = splay(root->right->right, key);
            root = leftRotate(root);
        }
        return root->right ? leftRotate(root) : root;
    }
}
Node* insert(Node* root, int key) {
    if (!root)
        return newNode(key);
    root = splay(root, key);
    if (root->key == key) return root;
    Node* new_node = newNode(key);
    if (key < root->key) {
        new_node->right = root;
        new_node->left = root->left;
        root->left = NULL;
```

```
    }
Else
 {
        new_node->left = root;
        new_node->right = root->right;
        root->right = NULL;
    }
    return new_node;
}
Node* deleteNode(Node* root, int key) {
    if (!root) return NULL;
    root = splay(root, key);

    if (root->key != key) return root;
    Node* temp;
    if (!root->left)
{
        temp = root;
        root = root->right;
    }
Else
 {
        temp = root;
        root = splay(root->left, key);
        root->right = temp->right;
    }
    free(temp);
    return root;
}
Node* search(Node* root, int key) {
    return splay(root, key);
```

```
}
void inorder(Node* root) {
    if (root) {
        inorder(root->left);
        printf("%d ", root->key);
        inorder(root->right);
    }
}
int main()
 {
    Node* root = NULL;
    root = insert(root, 10);
    root = insert(root, 20);
    root = insert(root, 30);
    root = insert(root, 40);
    root = insert(root, 50);
    printf("Inorder traversal of the Splay tree: ");
    inorder(root);
    printf("\n");
    root = search(root, 20);
    printf("After searching for 20, root is now: %d\n", root->key);
    root = deleteNode(root, 30);
    printf("After deleting 30, inorder traversal: ");
    inorder(root);
    printf("\n");
    return 0;
}
```



3.Implement a Trie data structure to store a set of strings. The Trie should support the following operations:

Insert: Insert a string into the Trie.

Search: Search for a given string in the Trie.

Delete: Delete a string from the Trie.

Prefix Search: Find all words in the Trie that start with a given prefix.

```
#include <stdio.h>

#include <stdlib.h>

#include <string.h>

#define ALPHABET_SIZE 26

typedef struct TrieNode

 {

   struct TrieNode* children[ALPHABET_SIZE];

   int isEndOfWord;

}

 TrieNode;


TrieNode* createNode()

{

   TrieNode* node = (TrieNode*)malloc(sizeof(TrieNode));
```

```
    node->isEndOfWord = 0;
    for (int i = 0; i < ALPHABET_SIZE; i++)
        node->children[i] = NULL;
    return node;
}
void insert(TrieNode* root, const char* key)
{
    TrieNode* current = root;
    while (*key) {
        int index = *key - 'a';
        if (!current->children[index])
            current->children[index] = createNode();
        current = current->children[index];
        key++;
    }
    current->isEndOfWord = 1;
}
int search(TrieNode* root, const char* key)
 {
    TrieNode* current = root;
    while (*key) {
        int index = *key - 'a';
        if (!current->children[index])
            return 0;
        current = current->children[index];
        key++;
    }
    return current && current->isEndOfWord;
}
int hasChildren(TrieNode* node)
{
```

```
    for (int i = 0; i < ALPHABET_SIZE; i++)
        if (node->children[i])
            return 1;
    return 0;
}
int delete(TrieNode* root, const char* key, int depth)
 {
    if (!root) return 0;
    if (*key)
{
        int index = *key - 'a';
        if (delete(root->children[index], key + 1, depth + 1))
 {
            free(root->children[index]);
            root->children[index] = NULL;
            return !hasChildren(root) && !root->isEndOfWord;
        }
    }
Else
 {
        if (root->isEndOfWord)
 {
            root->isEndOfWord = 0;
            return !hasChildren(root);
        }
    }
    return 0;
}

void prefixSearchHelper(TrieNode* root, char* prefix)
{
```

```
    if (root->isEndOfWord) printf("%s\n", prefix);
    for (int i = 0; i < ALPHABET_SIZE; i++)
{
        if (root->children[i])
 {
            char nextChar = 'a' + i;
            size_t len = strlen(prefix);
            prefix[len] = nextChar;
            prefix[len + 1] = '\0';
            prefixSearchHelper(root->children[i], prefix);
            prefix[len] = '\0';
        }
    }
}
void prefixSearch(TrieNode* root, const char* prefix) {
    TrieNode* current = root;
    while (*prefix) {
        int index = *prefix - 'a';
        if (!current->children[index])
            return;
        current = current->children[index];
        prefix++;
    }
    char buffer[100] = "";
    strcpy(buffer, prefix);
    prefixSearchHelper(current, buffer);
}

int main()
{
    TrieNode* root = createNode();
```

```
    insert(root, "hello");
    insert(root, "hell");
    insert(root, "heaven");
    insert(root, "heavy");
    printf("Search for 'hell': %s\n", search(root, "hell") ? "Found" : "Not Found");
    printf("Search for 'hello': %s\n", search(root, "hello") ? "Found" : "Not Found");
    printf("Search for 'heavens': %s\n", search(root, "heavens") ? "Found" : "Not Found");
    printf("\nWords with prefix 'he':\n");
    prefixSearch(root, "he");
    delete(root, "hell", 0);
    printf("\nAfter deleting 'hell':\n");
    printf("Search for 'hell': %s\n", search(root, "hell") ? "Found" : "Not Found");
    printf("\nWords with prefix 'he':\n");
    prefixSearch(root, "he");
    return 0;
}
```