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

#define MAX 4
#define MIN 2

struct btreeNode {
    int val[MAX + 1], count;
    struct btreeNode *link[MAX + 1];
};

struct btreeNode *root;

/* creating new node */
struct btreeNode * createNode(int val, struct btreeNode *child) {
    struct btreeNode *newNode;
    newNode = (struct btreeNode *)malloc(sizeof(struct btreeNode));
    newNode->val[1] = val;
    newNode->count = 1;
    newNode->link[0] = root;
    newNode->link[1] = child;
    return newNode;
}

/* Places the value in appropriate position */
void addValToNode(int val, int pos, struct btreeNode *node,
                  struct btreeNode *child) {
    int j = node->count;
    while (j > pos) {
        node->val[j + 1] = node->val[j];
        node->link[j + 1] = node->link[j];
        j--;
    }
    node->val[j + 1] = val;
    node->link[j + 1] = child;
    node->count++;
}

/* split the node */
void splitNode (int val, int *pval, int pos, struct btreeNode *node,
  struct btreeNode *child, struct btreeNode **newNode) {
    int median, j;

    if (pos > MIN)
        median = MIN + 1;
    else
        median = MIN;

    *newNode = (struct btreeNode *)malloc(sizeof(struct btreeNode));
    j = median + 1;
    while (j <= MAX) {
```

```
            (*newNode)->val[j - median] = node->val[j];
            (*newNode)->link[j - median] = node->link[j];
            j++;
        }
        node->count = median;
        (*newNode)->count = MAX - median;

        if (pos <= MIN) {
            addValToNode(val, pos, node, child);
        } else {
            addValToNode(val, pos - median, *newNode, child);
        }
        *pval = node->val[node->count];
        (*newNode)->link[0] = node->link[node->count];
        node->count--;
}

/* sets the value val in the node */
int setValueInNode(int val, int *pval,
  struct btreeNode *node, struct btreeNode **child) {

        int pos;
        if (!node) {
            *pval = val;
            *child = NULL;
            return 1;
        }

        if (val < node->val[1]) {
            pos = 0;
        } else {
            for (pos = node->count;
                (val < node->val[pos] && pos > 1); pos--);
            if (val == node->val[pos]) {
                printf("Duplicates not allowed\n");
                return 0;
            }
        }
        if (setValueInNode(val, pval, node->link[pos], child)) {
            if (node->count < MAX) {
                addValToNode(*pval, pos, node, *child);
            } else {
                splitNode(*pval, pval, pos, node, *child, child);
                return 1;
            }
        }
        return 0;
}

/* insert val in B-Tree */
void insertion(int val) {
        int flag, i;
```

```
    struct btreeNode *child;

    flag = setValueInNode(val, &i, root, &child);
    if (flag)
        root = createNode(i, child);
}

/* copy successor for the value to be deleted */
void copySuccessor(struct btreeNode *myNode, int pos) {
    struct btreeNode *dummy;
    dummy = myNode->link[pos];

    for (;dummy->link[0] != NULL;)
        dummy = dummy->link[0];
    myNode->val[pos] = dummy->val[1];

}

/* removes the value from the given node and rearrange values */
void removeVal(struct btreeNode *myNode, int pos) {
    int i = pos + 1;
    while (i <= myNode->count) {
        myNode->val[i - 1] = myNode->val[i];
        myNode->link[i - 1] = myNode->link[i];
        i++;
    }
    myNode->count--;
}

/* shifts value from parent to right child */
void doRightShift(struct btreeNode *myNode, int pos) {
    struct btreeNode *x = myNode->link[pos];
    int j = x->count;

    while (j > 0) {
        x->val[j + 1] = x->val[j];
        x->link[j + 1] = x->link[j];
    }
    x->val[1] = myNode->val[pos];
    x->link[1] = x->link[0];
    x->count++;

    x = myNode->link[pos - 1];
    myNode->val[pos] = x->val[x->count];
    myNode->link[pos] = x->link[x->count];
    x->count--;
    return;
}

/* shifts value from parent to left child */
void doLeftShift(struct btreeNode *myNode, int pos) {
    int j = 1;
```

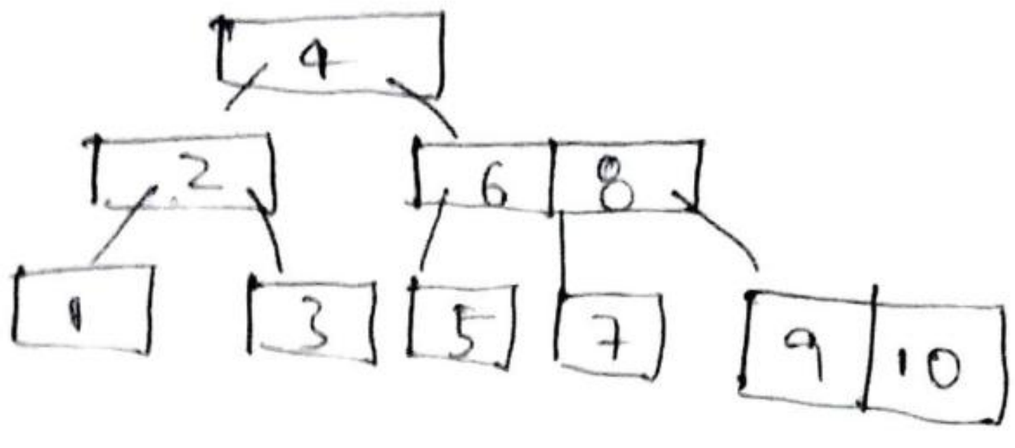
```
    struct btreeNode *x = myNode->link[pos - 1];

    x->count++;
    x->val[x->count] = myNode->val[pos];
    x->link[x->count] = myNode->link[pos]->link[0];

    x = myNode->link[pos];
    myNode->val[pos] = x->val[1];
    x->link[0] = x->link[1];
    x->count--;

    while (j <= x->count) {
        x->val[j] = x->val[j + 1];
        x->link[j] = x->link[j + 1];
        j++;
    }
    return;
}

/* merge nodes */
void mergeNodes(struct btreeNode *myNode, int pos) {
    int j = 1;
    struct btreeNode *x1 = myNode->link[pos], *x2 = myNode->link[pos - 1];

    x2->count++;
    x2->val[x2->count] = myNode->val[pos];
    x2->link[x2->count] = myNode->link[0];

    while (j <= x1->count) {
        x2->count++;
        x2->val[x2->count] = x1->val[j];
        x2->link[x2->count] = x1->link[j];
        j++;
    }

    j = pos;
    while (j < myNode->count) {
        myNode->val[j] = myNode->val[j + 1];
        myNode->link[j] = myNode->link[j + 1];
        j++;
    }
    myNode->count--;
    free(x1);
}

/* adjusts the given node */
void adjustNode(struct btreeNode *myNode, int pos) {
    if (!pos) {
        if (myNode->link[1]->count > MIN) {
            doLeftShift(myNode, 1);
        } else {
            mergeNodes(myNode, 1);
```

```
            }
        } else {
            if (myNode->count != pos) {
                if(myNode->link[pos - 1]->count > MIN) {
                    doRightShift(myNode, pos);
                } else {
                    if (myNode->link[pos + 1]->count > MIN) {
                        doLeftShift(myNode, pos + 1);
                    } else {
                        mergeNodes(myNode, pos);
                    }
                }
            } else {
                if (myNode->link[pos - 1]->count > MIN)
                    doRightShift(myNode, pos);
                else
                    mergeNodes(myNode, pos);
            }
        }
    }

    /* delete val from the node */
    int delValFromNode(int val, struct btreeNode *myNode) {
        int pos, flag = 0;
        if (myNode) {
            if (val < myNode->val[1]) {
                pos = 0;
                flag = 0;
            } else {
                for (pos = myNode->count;
                    (val < myNode->val[pos] && pos > 1); pos--);
                 if (val == myNode->val[pos]) {
                    flag = 1;
                } else {
                    flag = 0;
                }
            }
            if (flag) {
                if (myNode->link[pos - 1]) {
                    copySuccessor(myNode, pos);
                    flag = delValFromNode(myNode->val[pos], myNode->link[pos]);
                    if (flag == 0) {
                        printf("Given data is not present in B-Tree\n");
                    }
                } else {
                    removeVal(myNode, pos);
                }
            } else {
                flag = delValFromNode(val, myNode->link[pos]);
            }
            if (myNode->link[pos]) {
                if (myNode->link[pos]->count < MIN)
```

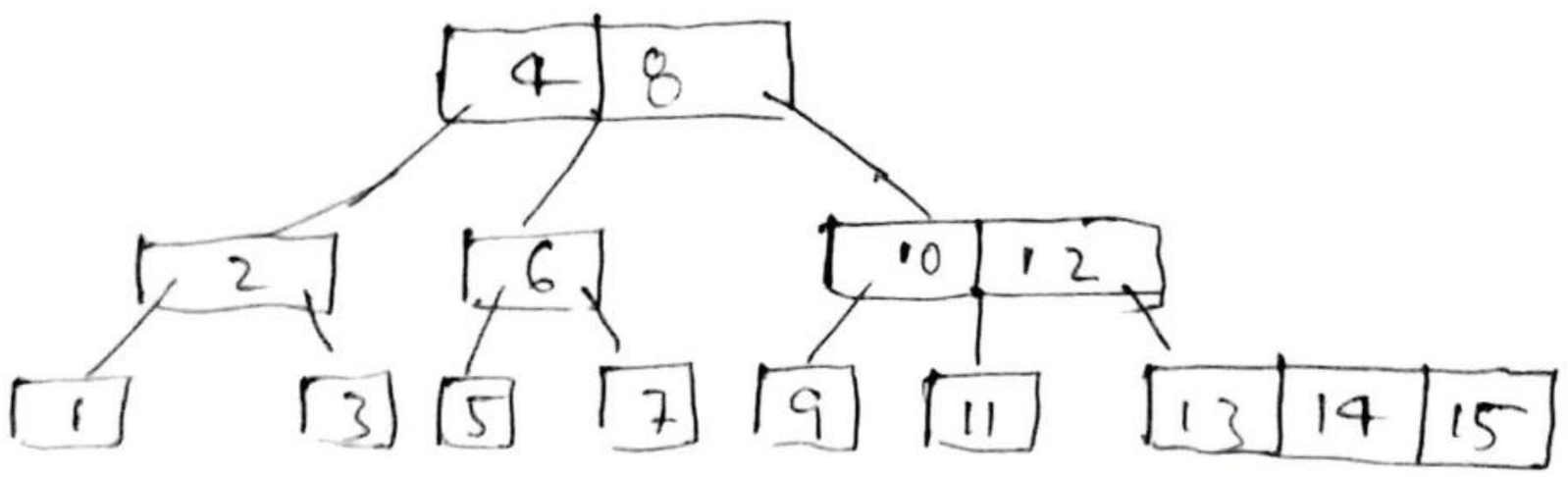
```
                adjustNode(myNode, pos);
            }
        }
        return flag;
}

/* delete val from B-tree */
void deletion(int val, struct btreeNode *myNode) {
        struct btreeNode *tmp;
        if (!delValFromNode(val, myNode)) {
                printf("Given value is not present in B-Tree\n");
                return;
        } else {
                if (myNode->count == 0) {
                        tmp = myNode;
                        myNode = myNode->link[0];
                        free(tmp);
                }
        }
        root = myNode;
        return;
}

/* search val in B-Tree */
void searching(int val, int *pos, struct btreeNode *myNode) {
        if (!myNode) {
                return;
        }

        if (val < myNode->val[1]) {
                *pos = 0;
        } else {
                for (*pos = myNode->count;
                        (val < myNode->val[*pos] && *pos > 1); (*pos)--);
                if (val == myNode->val[*pos]) {
                        printf("Given data %d is present in B-Tree", val);
                        return;
                }
        }
        searching(val, pos, myNode->link[*pos]);
        return;
}

/* B-Tree Traversal */
void traversal(struct btreeNode *myNode) {
        int i;
        if (myNode) {
                for (i = 0; i < myNode->count; i++) {
                        traversal(myNode->link[i]);
                        printf("%d ", myNode->val[i + 1]);
                }
                traversal(myNode->link[i]);
```

```
    }
}

int main() {
    int val, ch;
    while (1) {
        printf("1. Insertion\t2. Deletion\n");
        printf("3. Searching\t4. Traversal\n");
        printf("5. Exit\nEnter your choice:");
        scanf("%d", &ch);
        switch (ch) {
            case 1:
                printf("Enter your input:");
                scanf("%d", &val);
                insertion(val);
                break;
            case 2:
                printf("Enter the element to delete:");
                scanf("%d", &val);
                deletion(val, root);
                break;
            case 3:
                printf("Enter the element to search:");
                scanf("%d", &val);
                searching(val, &ch, root);
                break;
            case 4:
                traversal(root);
                break;
            case 5:
                exit(0);
            default:
                printf("U have entered wrong option!!\n");
                break;
        }
        printf("\n");
    }
}
```

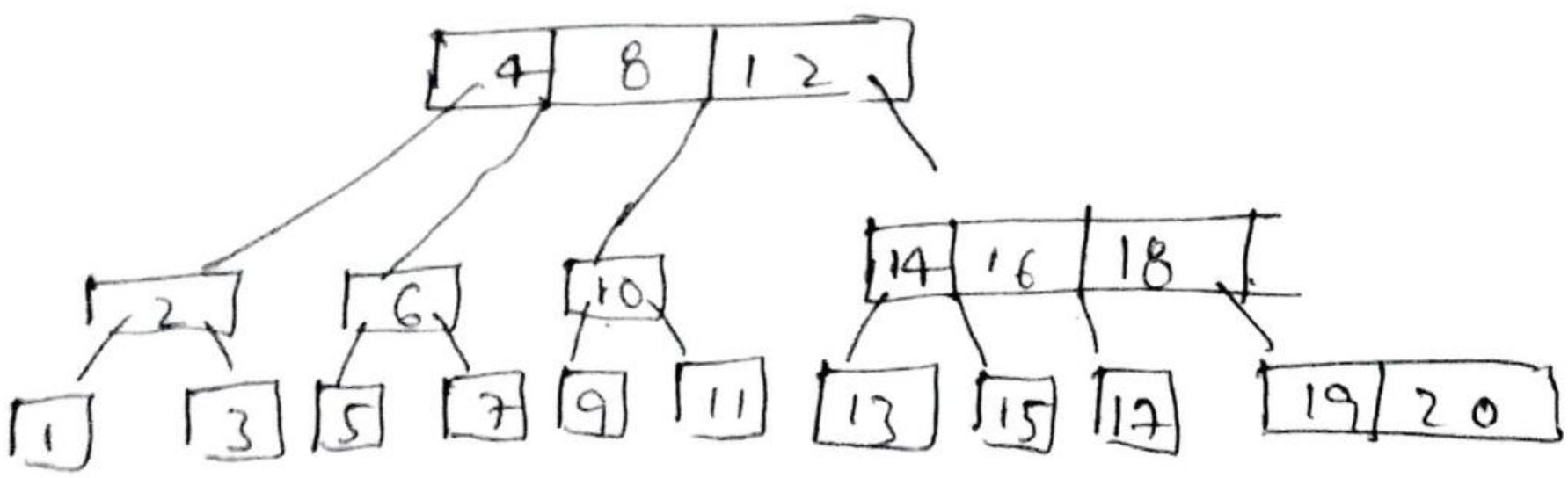
1. Insertion of 1st 10 records of order 4



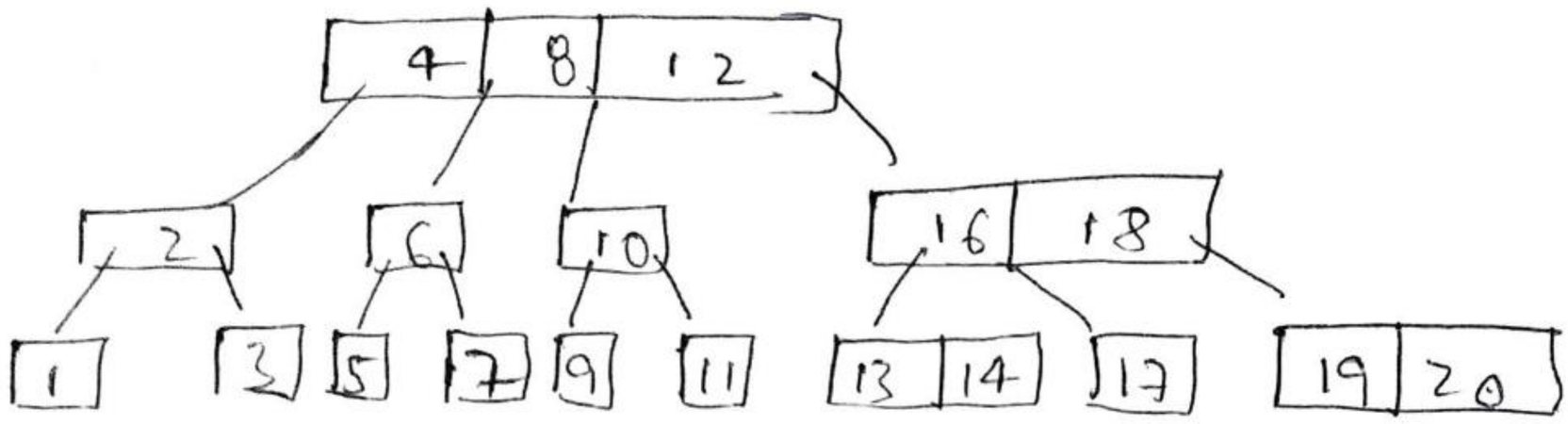
2. Insertion of 1st 15 records of order 4



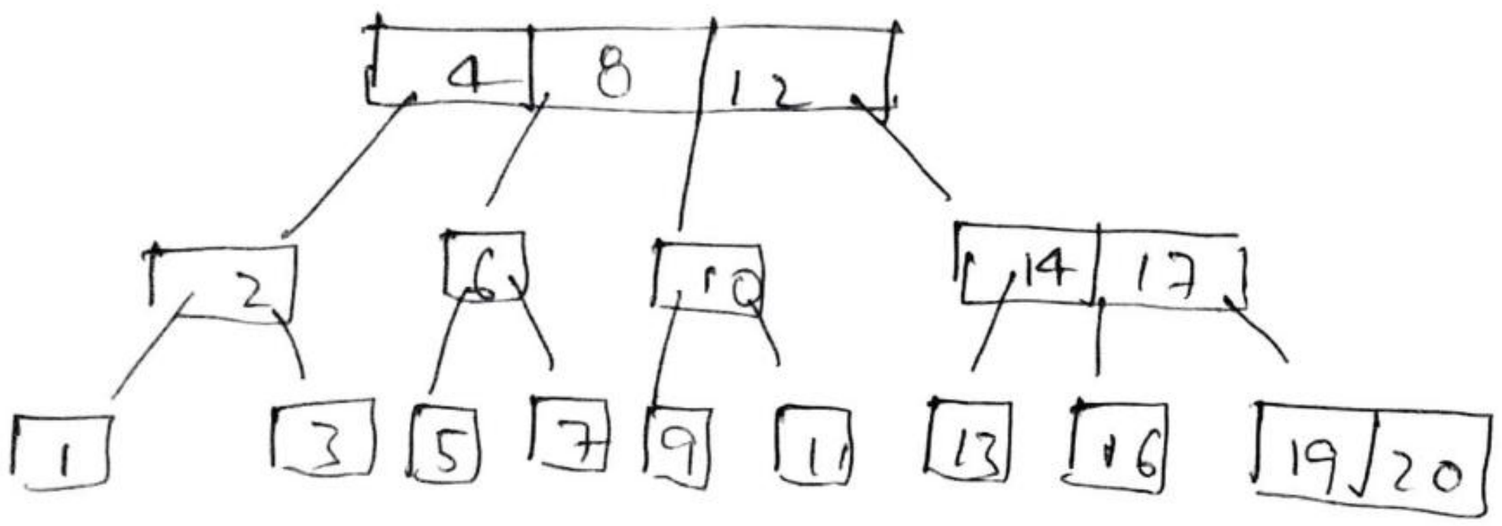
3. Insertion of 1st 20 records of order 4



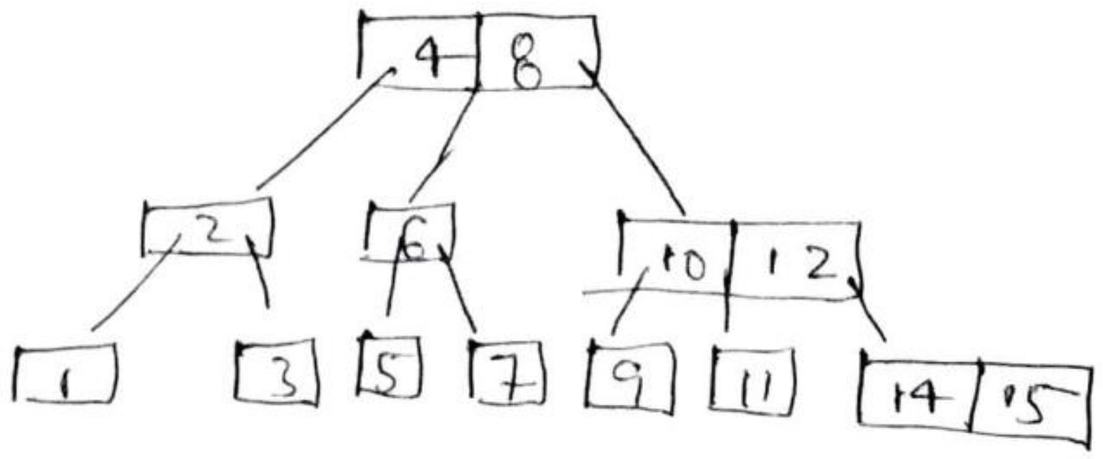
Deletion of 15 from the tree of (1st 20 records)



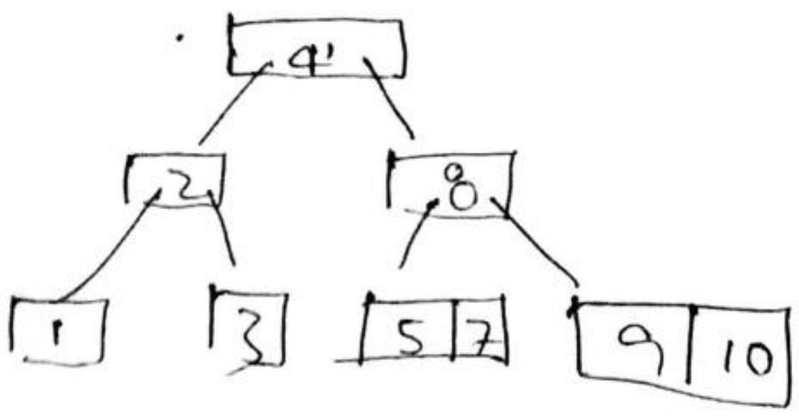
Deletion of 18 from the tree of 1st 20 records



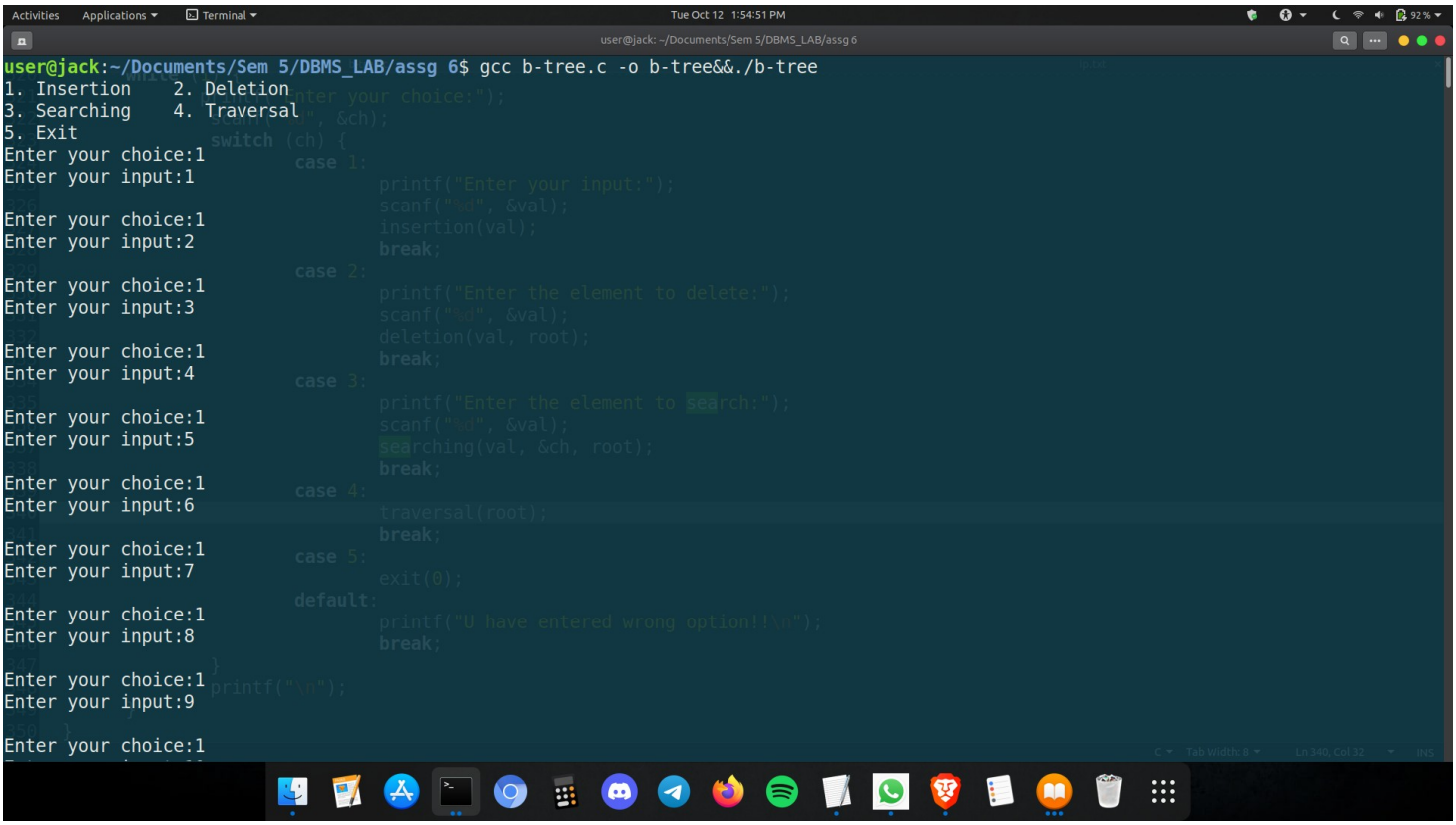
Deletion of 13 from the tree of 1st 15 records

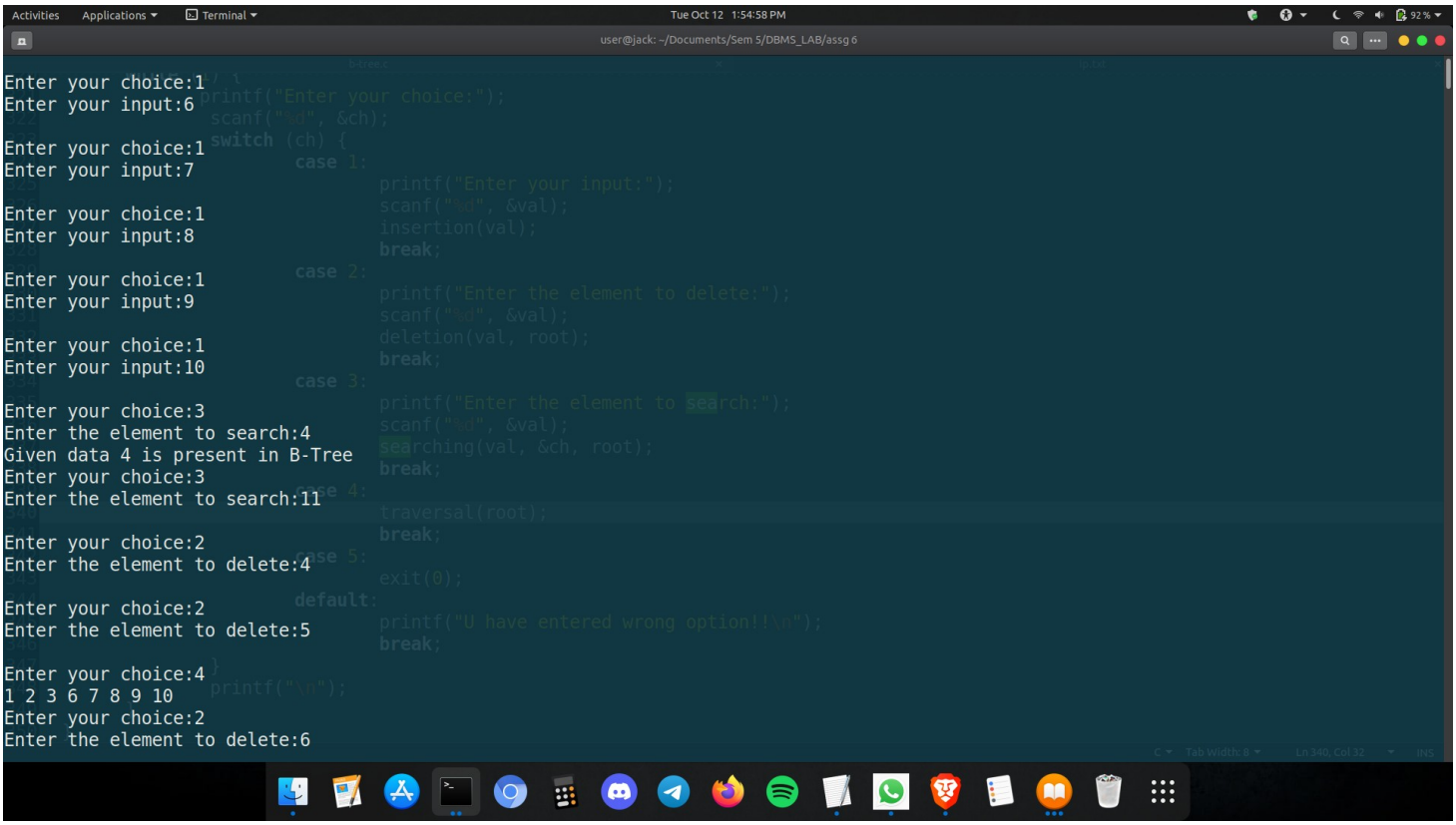


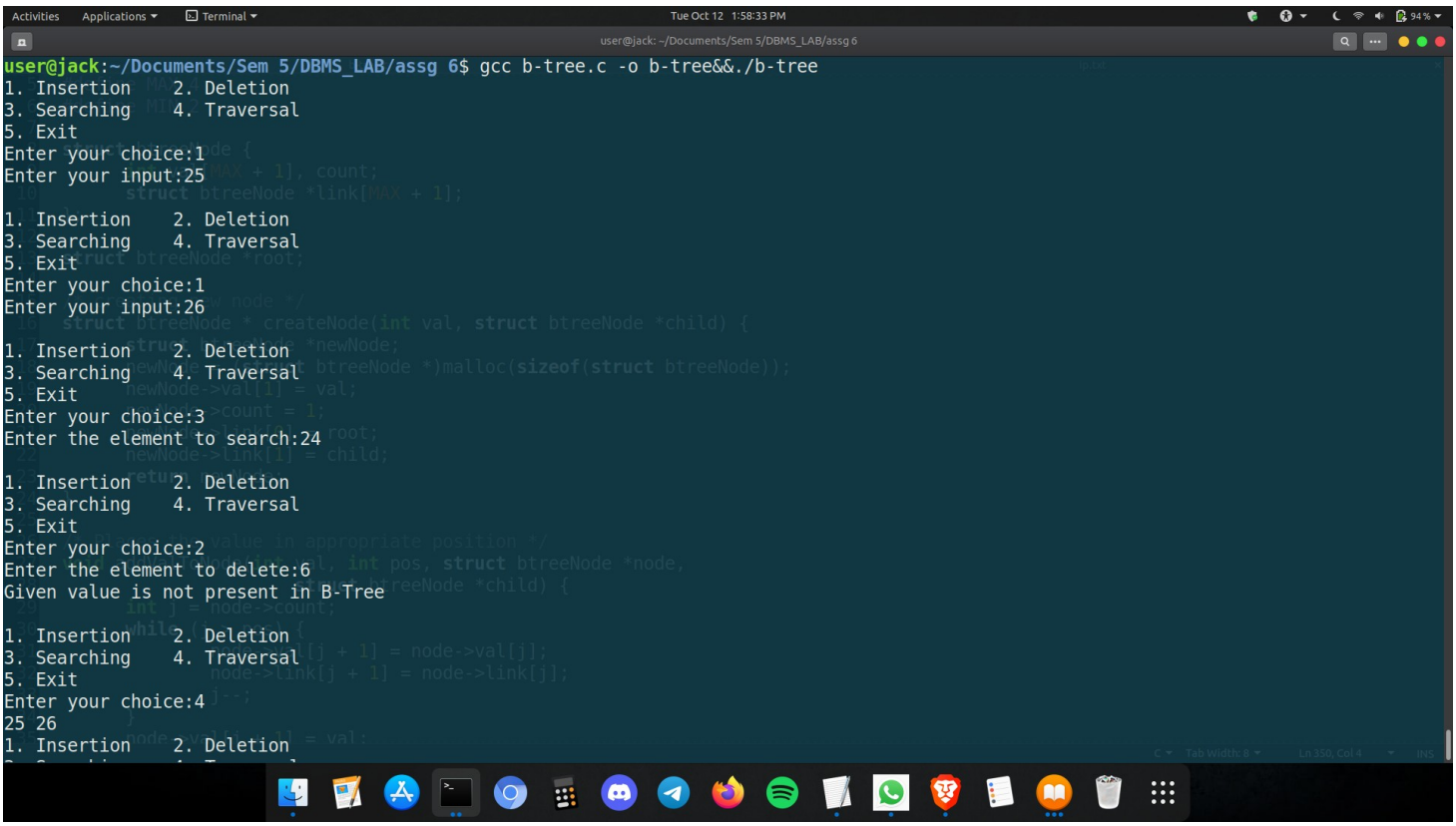
Deletion of 6 from the tree of 1st 10 records

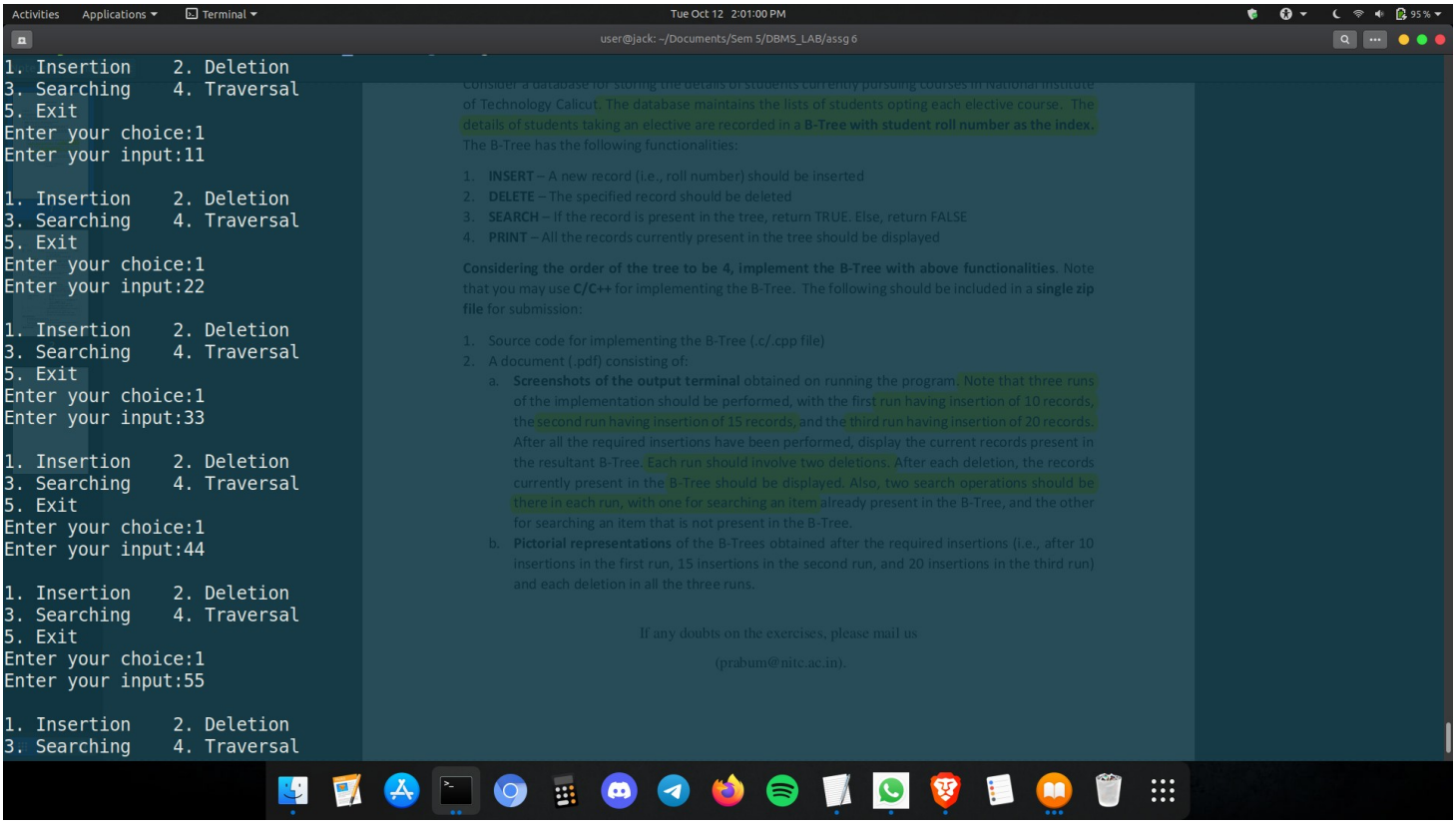


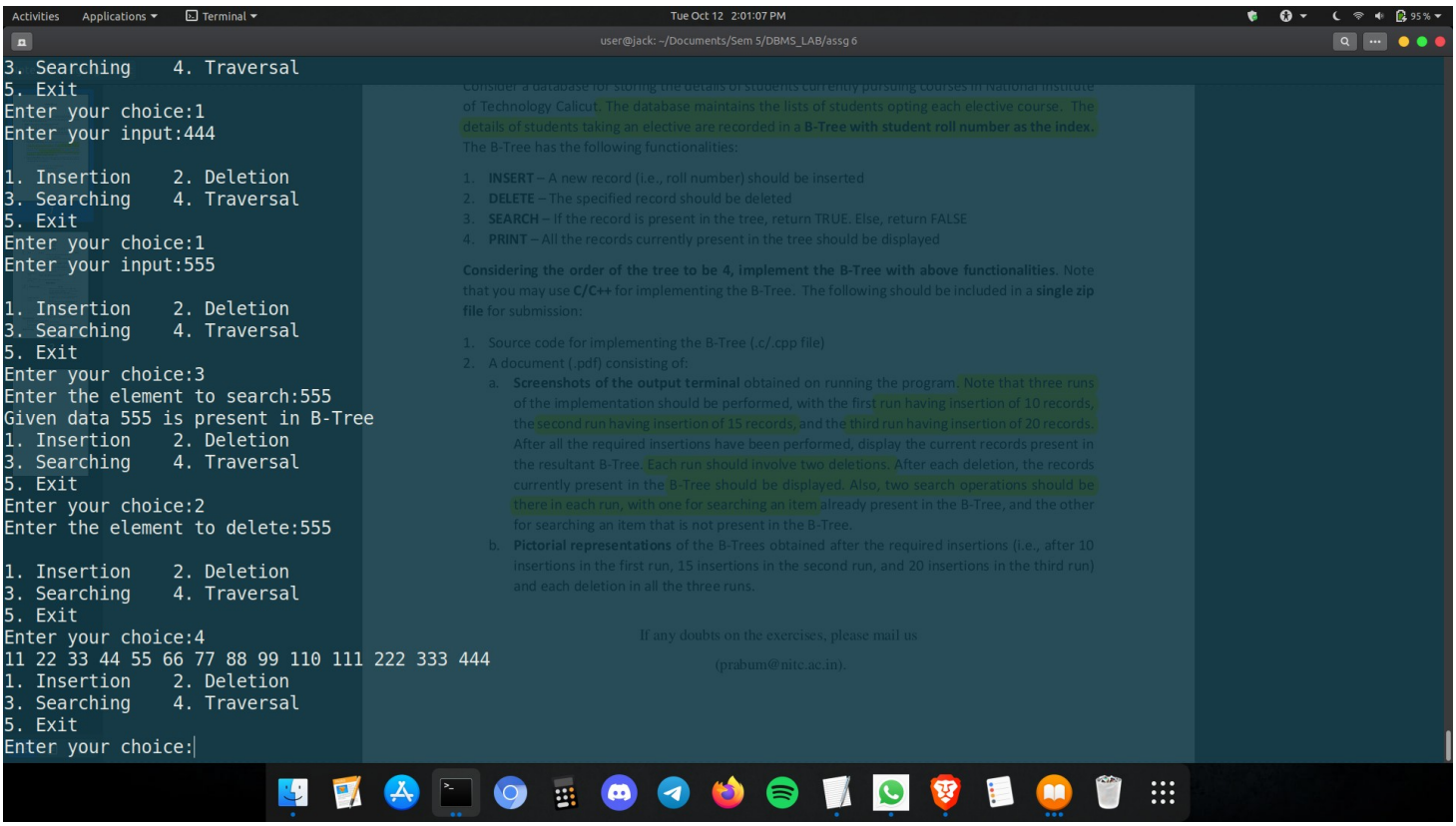
PANASA TEJA
DBMS LAB EX: 7

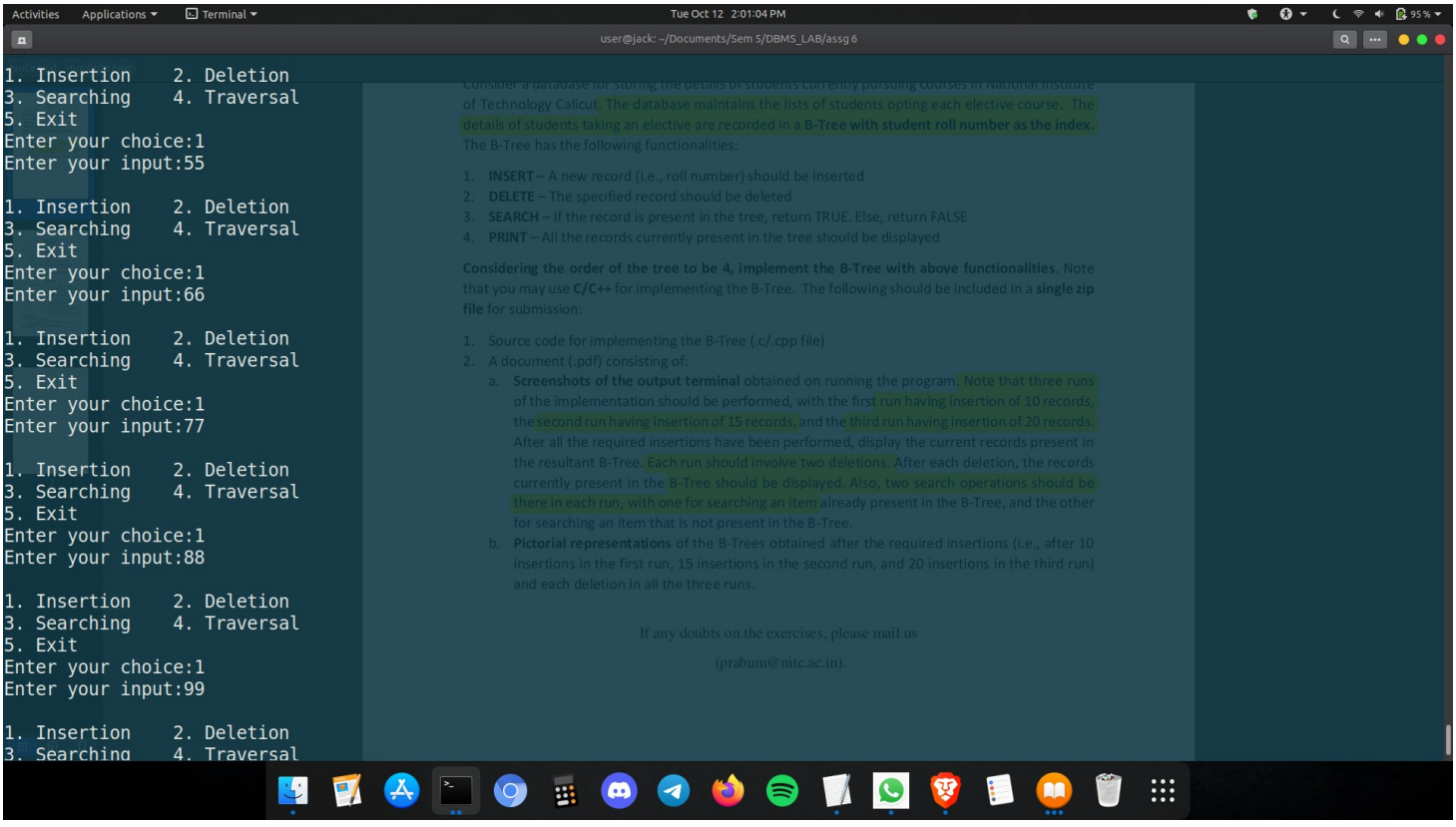





Activities Applications Terminal Tue Oct 12 1:58:33 PM
user@jack: ~/Documents/Sem 5/DBMS_LAB/assg 6
user@jack:~/Documents/Sem 5/DBMS_LAB/assg 6$ gcc b-tree.c -o b-tree&&./b-tree
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:25
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:26
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:3
Enter the element to search:24
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:2
Enter the element to delete:6
Given value is not present in B-Tree
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:4
25 26
1. Insertion 2. Deletion


Activities Applications Terminal Tue Oct 12 2:01:00 PM
user@jack: ~/Documents/Sem 5/DBMS_LAB/assg 6
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:11
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:22
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:33
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:44
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:55
1. Insertion 2. Deletion
3. Searching 4. Traversal
of Technology Calicut. The database maintains the lists of students opting each elective course. The details of students taking an elective are recorded in a B-Tree with student roll number as the index.
The B-Tree has the following functionalities:
1. INSERT – A new record (i.e., roll number) should be inserted
2. DELETE – The specified record should be deleted
3. SEARCH – If the record is present in the tree, return TRUE. Else, return FALSE
4. PRINT – All the records currently present in the tree should be displayed
Considering the order of the tree to be 4, implement the B-Tree with above functionalities. Note that you may use C/C++ for implementing the B-Tree. The following should be included in a single zip file for submission:
1. Source code for implementing the B-Tree (.c/.cpp file)
2. A document (.pdf) consisting of:
a. Screenshots of the output terminal obtained on running the program. Note that three runs of the implementation should be performed, with the first run having insertion of 10 records, the second run having insertion of 15 records, and the third run having insertion of 20 records. After all the required insertions have been performed, display the current records present in the resultant B-Tree. Each run should involve two deletions. After each deletion, the records currently present in the B-Tree should be displayed. Also, two search operations should be there in each run, with one for searching an item already present in the B-Tree, and the other for searching an item that is not present in the B-Tree.
b. Pictorial representations of the B-Trees obtained after the required insertions (i.e., after 10 insertions in the first run, 15 insertions in the second run, and 20 insertions in the third run) and each deletion in all the three runs.
If any doubts on the exercises, please mail us
(prabum@nitc.ac.in).


Activities
Applications
Terminal
Tue Oct 12 2:01:07 PM
user@jack: ~/Documents/Sem 5/DBMS_LAB/assg 6
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:444
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:555
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:3
Enter the element to search:555
Given data 555 is present in B-Tree
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:2
Enter the element to delete:555
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:4
11 22 33 44 55 66 77 88 99 110 111 222 333 444
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:


Activities
Applications
Terminal
Tue Oct 12 2:01:04 PM
user@jack: ~/Documents/Sem 5/DBMS_LAB/assg 6
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:55
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:66
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:77
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:88
1. Insertion 2. Deletion
3. Searching 4. Traversal
5. Exit
Enter your choice:1
Enter your input:99
1. Insertion 2. Deletion
3. Searching 4. Traversal