ASSIGNMENT

COURSE TITLE	:	Data Structure Lab
COURSE CODE	:	CSE 222
ASSIGNMENT NO.	:	02
SUBMISSION DATE	:	29-05-2025

SUBMITTED TO

NAME	:	Nasrin Akter
DEPT. OF	:	Computer Science and Engineering (CSE) Bangladesh University of Business & Technology (BUBT)

SUBMITTED BY

NAME	:	Shadman Shahriar
ID NO.	:	20245103408
INTAKE	:	53
SECTION	:	1
PROGRAM	:	B.Sc. Engg. in CSE

Data Structure
Lab Work Assignments

Linked List

1. Implement a singly linked list with the following operations:

- Insert at the beginning, end and a given position.
- Delete from the beginning, end and a given position.
- Display the list.

Ans. Here is a C program implementing a singly linked list with the aforementioned operations:

```
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

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

struct node
{
    int data;
    struct node *next;
};

struct node *createNode(int data)
```

```c
{
    struct node *temp = NULL;
    temp = malloc(sizeof(struct node));
    temp->data = data;
}

void display(const char *message, struct node *start)
{
    struct node *temp = start;
    printf(message);
    printf("Head -> ");
    while (temp != NULL)
    {
        printf("[%d] -> ", temp->data);
        temp = temp->next;
    }
    printf("NULL\n");
}

struct node *insertStart(struct node *newNode, struct node
*start)
{
    newNode->next = start;
    return newNode;
}

void insertEnd(struct node *newNode, struct node *start)
{
    newNode->next = NULL;
    struct node *temp = start;
    while (temp->next != NULL)
        temp = temp->next;
    temp->next = newNode;
}

void insertAt(struct node *newNode, int position, struct
node *start)
{
```

```c
    struct node *temp = start;
    for (int i = 2; i <= position; i++)
    {
        if (i == position)
        {
            newNode->next = temp->next;
            temp->next = newNode;
        }
        temp = temp->next;
    }
}

struct node *deleteAtStart(struct node *head)
{
    return head->next;
}

void deleteAtEnd(struct node *start)
{
    struct node *temp = start;
    while (temp->next->next != NULL)
        temp = temp->next;
    temp->next = NULL;
}

void deleteAt(int position, struct node *start)
{
    struct node *temp = start;
    for (int i = 2; i <= position; i++)
    {
        if (i == position)
        {
            temp->next = temp->next->next;
        }
        temp = temp->next;
    }
}
```

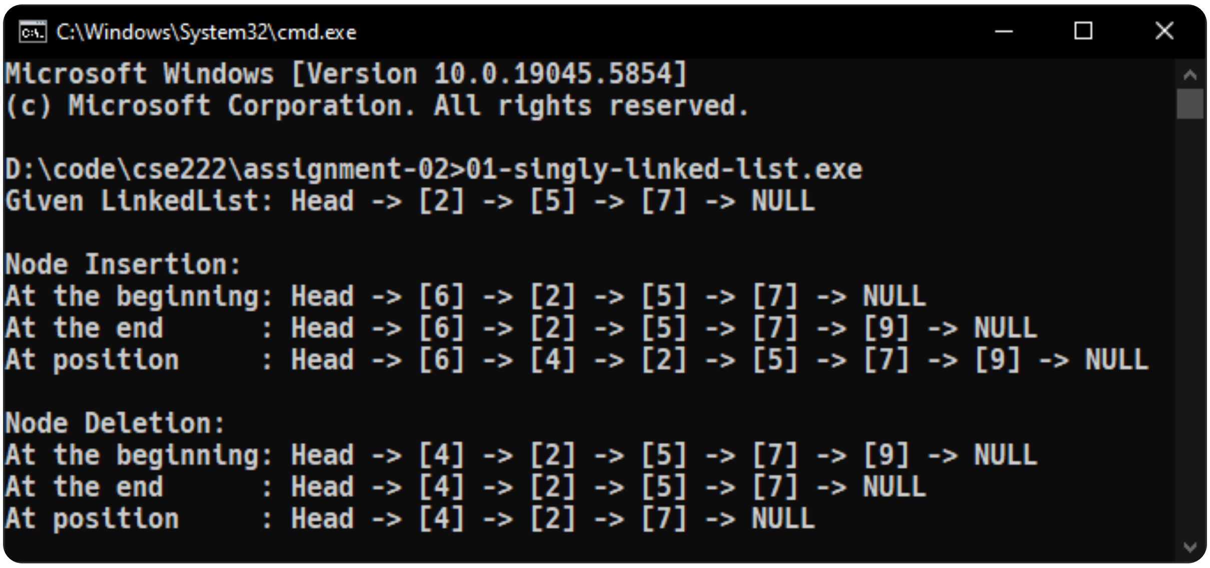
```c
int main()
{
    // =====================
    // === initial setup ===
    // =====================
    struct node *head = malloc(sizeof(struct node));
    struct node *one = createNode(2);
    struct node *two = createNode(5);
    struct node *three = createNode(7);

    one->next = two;
    two->next = three;
    three->next = NULL;

    head = one;
    display("Given LinkedList: ", head);

    printf("\nNode Insertion:\n");

    // =================================
    // === add node at the beginning ===
    // =================================
    struct node *four = createNode(6);
    head = insertStart(four, head);
    display("At the beginning: ", head);

    // ===========================
    // === add node at the end ===
    // ===========================
    struct node *five = createNode(9);
    insertEnd(five, head);
    display("At the end      : ", head);

    // =======================================
    // === add node at a specific position ===
    // =======================================
    struct node *six = createNode(4);
    insertAt(six, 2, head);
```

```c
    display("At position     : ", head);

    printf("\nNode Deletion:\n");

    // ======================================
    // === delete node from the beginning ===
    // ======================================
    head = deleteAtStart(head);
    display("At the beginning: ", head);

    // ================================
    // === delete node from the end ===
    // ================================
    deleteAtEnd(head);
    display("At the end      : ", head);

    // ============================================
    // === delete node from a specific position ===
    // ============================================
    deleteAt(3, head);
    display("At position     : ", head);

    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Given LinkedList: Head -> [2] -> [5] -> [7] -> NULL

Node Insertion:
At the beginning: Head -> [6] -> [2] -> [5] -> [7] -> NULL
At the end      : Head -> [6] -> [2] -> [5] -> [7] -> [9] -> NULL
At position     : Head -> [6] -> [4] -> [2] -> [5] -> [7] -> [9] -> NULL

Node Deletion:
```

```
At the beginning: Head -> [4] -> [2] -> [5] -> [7] -> [9] -> NULL
At the end       : Head -> [4] -> [2] -> [5] -> [7] -> NULL
At position      : Head -> [4] -> [2] -> [7] -> NULL
```



```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.19045.5854]
(c) Microsoft Corporation. All rights reserved.

D:\code\cse222\assignment-02>01-singly-linked-list.exe
Given LinkedList: Head -> [2] -> [5] -> [7] -> NULL

Node Insertion:
At the beginning: Head -> [6] -> [2] -> [5] -> [7] -> NULL
At the end       : Head -> [6] -> [2] -> [5] -> [7] -> [9] -> NULL
At position      : Head -> [6] -> [4] -> [2] -> [5] -> [7] -> [9] -> NULL

Node Deletion:
At the beginning: Head -> [4] -> [2] -> [5] -> [7] -> [9] -> NULL
At the end       : Head -> [4] -> [2] -> [5] -> [7] -> NULL
At position      : Head -> [4] -> [2] -> [7] -> NULL
```

Figure - 1.1. Terminal output of task 1

Stack

2. Implement a stack using an array with the following operations:

- Push
- Pop
- Peek
- Display

Ans. Here is a C program that implements a stack using an array:

```c
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

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

struct stack
{
    int top, n;
    int *arr;
};

struct stack *createStack(int size)
{
    struct stack *stack = malloc(sizeof(struct stack));
    stack->n = size;
    stack->top = -1;
    stack->arr = malloc(size * sizeof(int));
    printf("Created stack with a capacity of %d\n", size);
    return stack;
```

```c
}

void deleteStack(struct stack *stack)
{
    free(stack->arr);
    free(stack);
    printf("The stack was deleted\n");
}

int isFull(struct stack *stack)
{
    return stack->top >= stack->n - 1;
}

int isEmpty(struct stack *stack)
{
    return stack->top < 0;
}

int push(struct stack *stack, int x)
{
    if (isFull(stack))
    {
        printf("Overflow\n");
        return 0;
    }
    stack->arr[++stack->top] = x;
    return 1;
}

int pop(struct stack *stack)
{
    if (isEmpty(stack))
    {
        printf("Underflow\n");
        return 0;
    }
    return stack->arr[stack->top--];
```

```
}

int peek(struct stack *stack)
{
    if (isEmpty(stack))
    {
        printf("Empty\n");
        return 0;
    }
    return stack->arr[stack->top];
}

void display(struct stack *stack)
{
    int n = stack->top;
    for (int i = 0; i <= n; i++)
    {
        printf("%d", stack->arr[i]);
        if (i != n)
            printf(", ");
    }
}

int main()
{
    struct stack *s = createStack(10);
    push(s, 122);
    push(s, 154);
    push(s, 408);

    printf("Popped element: %d\n", pop(s));
    printf("Top element    : %d\n", peek(s));

    printf("\nCurrent elements in stack:\n");
    display(s);

    printf("\n\b");
    deleteStack(s);
```

```
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Created stack with a capacity of 10
Popped element: 408
Top element    : 154

Current elements in stack:
122, 154
The stack was deleted
```

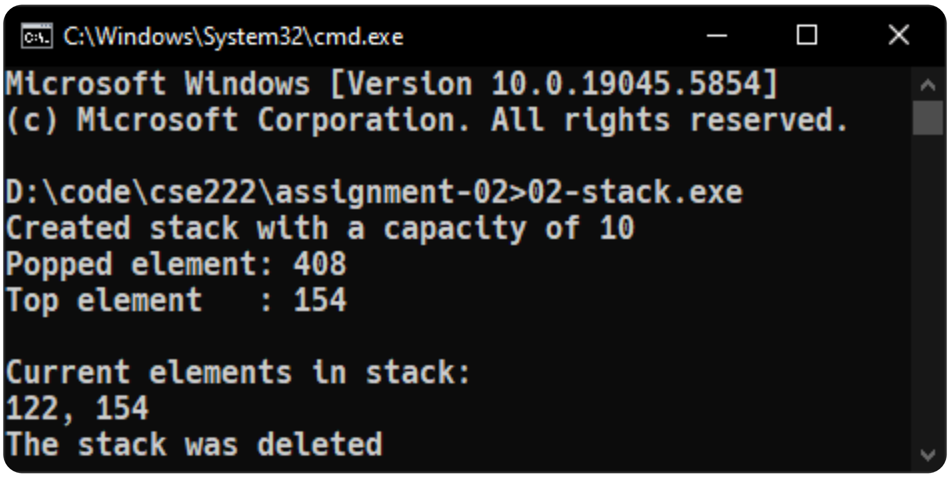


Figure - 1.2. Terminal output of task 2

Queue

3. Implement a queue using an array with the following operations:

- Enqueue
- Dequeue
- Peek
- Display

Ans. Here is a C implementation of a queue using an array:

```c
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

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

struct queue
{
    int *arr;
    int front;
    int rear;
    int n;
};

struct queue *createQueue(int n)
{
    struct queue *q = malloc(sizeof(struct queue));
    q->n = n;
    q->front = 0;
    q->rear = -1;
```

```c
    q->arr = (int *)malloc(n * sizeof(int));
    return q;
}

int isEmpty(struct queue *q)
{
    return q->front > q->rear;
}

void enqueue(struct queue *q, int x)
{
    if (q->rear < q->n - 1)
        q->arr[++q->rear] = x;
}

void dequeue(struct queue *q)
{
    if (!isEmpty(q))
        q->front++;
}

int peek(struct queue *q)
{
    return isEmpty(q) ? -1 : q->arr[q->front];
}

void display(struct queue *q)
{
    for (int i = q->front; i <= q->rear; i++)
        printf("%d ", q->arr[i]);
    printf("\n");
}

int main()
{
    struct queue *q = createQueue(100);
    enqueue(q, 1);
    enqueue(q, 2);
```

```c
    enqueue(q, 3);

    printf("Front element: %d\n", peek(q));

    dequeue(q);
    enqueue(q, 4);

    printf("Current q: ");
    display(q);
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Front element: 1
Current q: 2 3 4
```

Figure - 1.3. Terminal output of task 3

Binary Tree

4. Implement a binary tree and insert nodes into the binary tree recursively with the following traversals:

- In-order
- Pre-order
- Post-order

Ans. Here is a C++ program that satisfies the given conditions:

```
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

#include <iostream>
using namespace std;

struct node
{
    int data;
    node *left;
    node *right;

    node(int val)
    {
        data = val;
    }
};

node *createTree()
{
    int x;
```

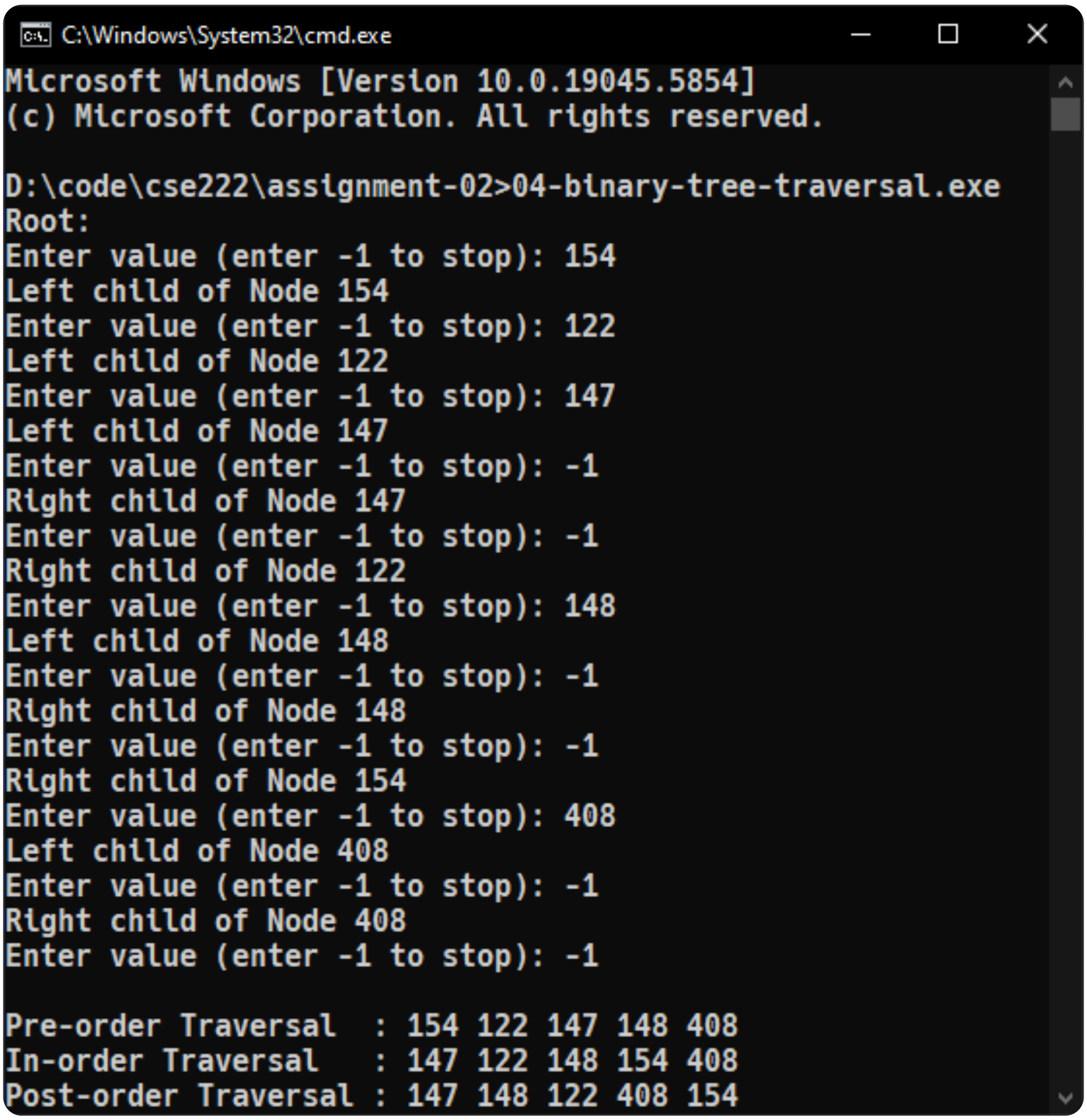
```
    cout << "Enter value (enter -1 to stop): ";
    cin >> x;

    if (x == -1)
        return NULL;

    node *Node = new node(x);
    cout << "Left child of Node " << x << endl;
    Node->left = createTree();

    cout << "Right child of Node " << x << endl;
    Node->right = createTree();

    return Node;
}

void preorder(node *root)
{
    if (root == NULL)
        return;

    cout << root->data << " ";
    preorder(root->left);
    preorder(root->right);
}

void inorder(node *root)
{
    if (root == NULL)
        return;

    inorder(root->left);
    cout << root->data << " ";
    inorder(root->right);
}

void postorder(node *root)
{
```

```
    if (root == NULL)
        return;

    postorder(root->left);
    postorder(root->right);
    cout << root->data << " ";
}

int main()
{
    cout << "Root:" << endl;
    node *root = createTree();

    cout << endl;
    cout << "Pre-order Traversal  : ";
    preorder(root);

    cout << endl;
    cout << "In-order Traversal   : ";
    inorder(root);

    cout << endl;
    cout << "Post-order Traversal : ";
    postorder(root);
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Root:
Enter value (enter -1 to stop): 154
Left child of Node 154
Enter value (enter -1 to stop): 122
Left child of Node 122
Enter value (enter -1 to stop): 147
Left child of Node 147
Enter value (enter -1 to stop): -1
```

```
Right child of Node 147
Enter value (enter -1 to stop): -1
Right child of Node 122
Enter value (enter -1 to stop): 148
Left child of Node 148
Enter value (enter -1 to stop): -1
Right child of Node 148
Enter value (enter -1 to stop): -1
Right child of Node 154
Enter value (enter -1 to stop): 408
Left child of Node 408
Enter value (enter -1 to stop): -1
Right child of Node 408
Enter value (enter -1 to stop): -1

Pre-order Traversal  : 154 122 147 148 408
In-order Traversal   : 147 122 148 154 408
Post-order Traversal : 147 148 122 408 154
```



```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.19045.5854]
(c) Microsoft Corporation. All rights reserved.

D:\code\cse222\assignment-02>04-binary-tree-traversal.exe
Root:
Enter value (enter -1 to stop): 154
Left child of Node 154
Enter value (enter -1 to stop): 122
Left child of Node 122
Enter value (enter -1 to stop): 147
Left child of Node 147
Enter value (enter -1 to stop): -1
Right child of Node 147
Enter value (enter -1 to stop): -1
Right child of Node 122
Enter value (enter -1 to stop): 148
Left child of Node 148
Enter value (enter -1 to stop): -1
Right child of Node 148
Enter value (enter -1 to stop): -1
Right child of Node 154
Enter value (enter -1 to stop): 408
Left child of Node 408
Enter value (enter -1 to stop): -1
Right child of Node 408
Enter value (enter -1 to stop): -1

Pre-order Traversal  : 154 122 147 148 408
In-order Traversal   : 147 122 148 154 408
Post-order Traversal : 147 148 122 408 154
```

Figure - 1.4. Terminal output of task 4

Binary Tree

5. Count the total number of nodes and leaf nodes in a binary tree.

Ans. Here is a C++ program that counts the total number of nodes and leaf nodes in a binary tree using recursion:

```
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

#include <iostream>
using namespace std;

struct node
{
    int data;
    node *left;
    node *right;

    node(int val)
    {
        data = val;
        left = NULL;
        right = NULL;
    }
};

int countNodes(node *root)
{
    if (root == NULL)
        return 0;
```

```cpp
    int l = countNodes(root->left);
    int r = countNodes(root->right);
    return 1 + l + r;
}

int countLeafNodes(node *root)
{

    if (root == NULL)
        return 0;
    if (root->left == NULL && root->right == NULL)
        return 1;
    return countLeafNodes(root->left) +
countLeafNodes(root->right);
}

int main()
{
    // binary tree structure:
    //          154
    //         /    \
    //       122    408
    //      /   \
    //    147   148
    node *root = new node(154);
    root->left = new node(122);
    root->right = new node(408);
    root->left->left = new node(147);
    root->left->right = new node(148);

    cout << "Total Nodes: " << countNodes(root) << endl;
    cout << " Leaf Nodes: " << countLeafNodes(root) <<
endl;
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Total Nodes: 5
 Leaf Nodes: 3
```

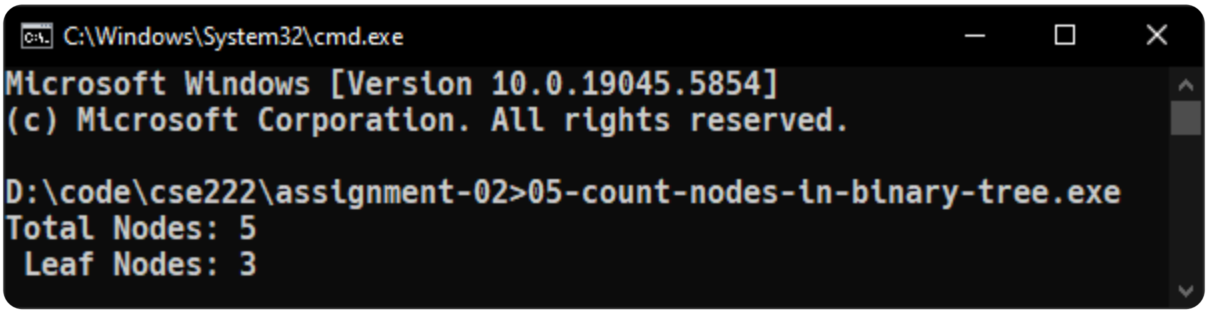


Figure - 1.5. Terminal output of task 5

Binary Search Tree

6. Implement a Binary Search Tree (BST) with In-order Traversal.

Ans. Here is a C++ program implementing the Binary Search Tree (BST) with in-order traversal:

```
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

#include <iostream>
using namespace std;

struct node
{
    int key;
    struct node *left, *right;
};

struct node *newNode(int item)
{
    struct node *temp = (struct node *)malloc(sizeof(struct
node));
    temp->key = item;
    temp->left = temp->right = NULL;
    return temp;
}

void inorder(struct node *root)
{
    if (root != NULL)
```

```
    {
        inorder(root->left);
        cout << root->key << " ";
        inorder(root->right);
    }
}

struct node *insert(struct node *node, int key)
{
    if (node == NULL)
        return newNode(key);
    if (key < node->key)
        node->left = insert(node->left, key);
    else
        node->right = insert(node->right, key);

    return node;
}

int main()
{
    struct node *root = NULL;
    int x;
    while (x != -1)
    {
        cout << "Enter value (-1 to stop): ";
        cin >> x;
        if (x != -1)
            root = insert(root, x);
    }

    cout << "Inorder traversal:" << endl;
    inorder(root);
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Enter value (-1 to stop): 154
Enter value (-1 to stop): 122
Enter value (-1 to stop): 408
Enter value (-1 to stop): 147
Enter value (-1 to stop): 148
Enter value (-1 to stop): -1
Inorder traversal:
122 147 148 154 408
```

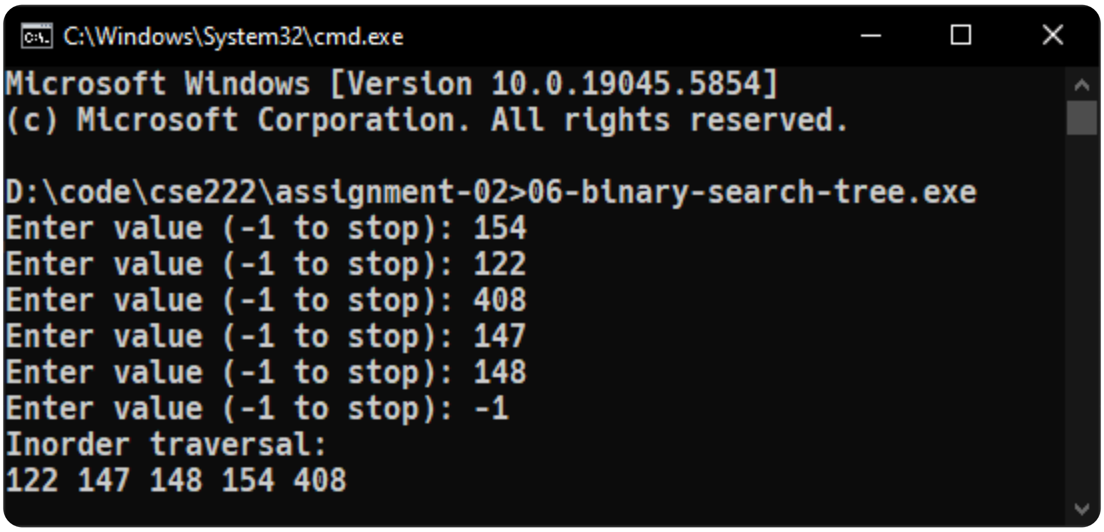


Figure - 1.6. Terminal output of task 6

Recursion

7A. Write recursive function for factorial of a number.

Ans. Here is a C implementation of recursive factorial:

```c
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

#include <stdio.h>
int factorial(int n)
{
    if (n >= 1)
        return n * factorial(n - 1);
    else
        return 1;
}

int main()
{
    printf("%d", factorial(4));
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
24
```

7B. Write recursive function for the fibonacci series.

Ans. Here is a C implementation of recursive fibonacci series:

```c
/**
 * =====================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * =====================
 */

#include <stdio.h>
int fibonacci(int n)
{
    int fib;
    if (n > 2)
        fib = fibonacci(n - 1) + fibonacci(n - 2);
    else if (n == 2)
        fib = 1;
    else
        fib = 0;
    return fib;
}
int main()
{
    int n = 10;
    for (int i = 1; i <= n + 1; i++)
        printf("%d ", fibonacci(i));
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
0 1 1 2 3 5 8 13 21 34 55
```

7C. Implement Binary Search using recursion.

Ans. Here is a C implementation of recursive binary search:

```c
/**
 * ======================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * ======================
 */

#include <stdio.h>
int binarySearch(int arr[], int left, int right, int key)
{
    if (right >= left)
    {
        int mid = left + (right - left) / 2;

        if (arr[mid] == key)
            return mid;
        if (arr[mid] > key)
            return binarySearch(arr, left, mid - 1, key);
        return binarySearch(arr, mid + 1, right, key);
    }
    return -1;
}

int main(void)
{
    int arr[] = {2, 5, 8, 12, 16, 23, 38, 56, 72, 91};
    int size = sizeof(arr) / sizeof(arr[0]);

    int key = 23;
    int index = binarySearch(arr, 0, size - 1, key);

    if (index == -1)
```

```
        printf("NOT Found");
    else
        printf("%d found at index %d", key, index);
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
23 found at index 5
```

Figure - 1.7. Terminal output of task 7C

7D. Implement Tower of Hanoi using recursion.

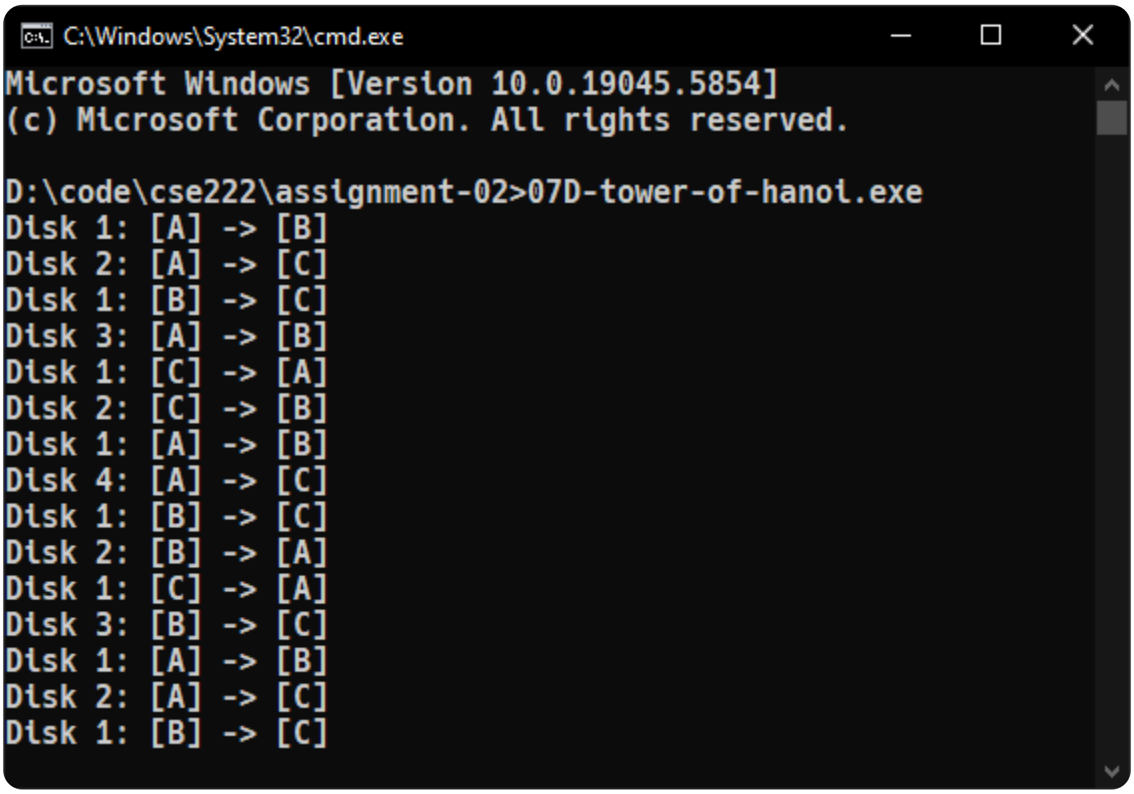
Ans. Here is a C implementation of the tower of hanoi using recursion:

```
/**
 * =====================
 * Name: Shadman Shahriar
 * ID  : 20245103408
 * =====================
 */

#include <stdio.h>
void hanoi(int n, char S, char D, char A)
{
    if (n == 0)
        return;
```

```
    hanoi(n - 1, S, A, D);
    printf("Disk %d: [%c] → [%c]\n", n, S, D);
    hanoi(n - 1, A, D, S);
}

int main()
{
    int n = 4;
    hanoi(n, 'A', 'C', 'B');
    return 0;
}
```

Output: The code yields the following output in the terminal:

```
Disk 1: [A] → [B]
Disk 2: [A] → [C]
Disk 1: [B] → [C]
Disk 3: [A] → [B]
Disk 1: [C] → [A]
Disk 2: [C] → [B]
Disk 1: [A] → [B]
Disk 4: [A] → [C]
Disk 1: [B] → [C]
Disk 2: [B] → [A]
Disk 1: [C] → [A]
Disk 3: [B] → [C]
Disk 1: [A] → [B]
Disk 2: [A] → [C]
Disk 1: [B] → [C]
```



```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.19045.5854]
(c) Microsoft Corporation. All rights reserved.

D:\code\cse222\assignment-02>07D-tower-of-hanoi.exe
Disk 1: [A] -> [B]
Disk 2: [A] -> [C]
Disk 1: [B] -> [C]
Disk 3: [A] -> [B]
Disk 1: [C] -> [A]
Disk 2: [C] -> [B]
Disk 1: [A] -> [B]
Disk 4: [A] -> [C]
Disk 1: [B] -> [C]
Disk 2: [B] -> [A]
Disk 1: [C] -> [A]
Disk 3: [B] -> [C]
Disk 1: [A] -> [B]
Disk 2: [A] -> [C]
Disk 1: [B] -> [C]
```

Figure - 1.8. Terminal output of task 7D