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LAB MANUAL

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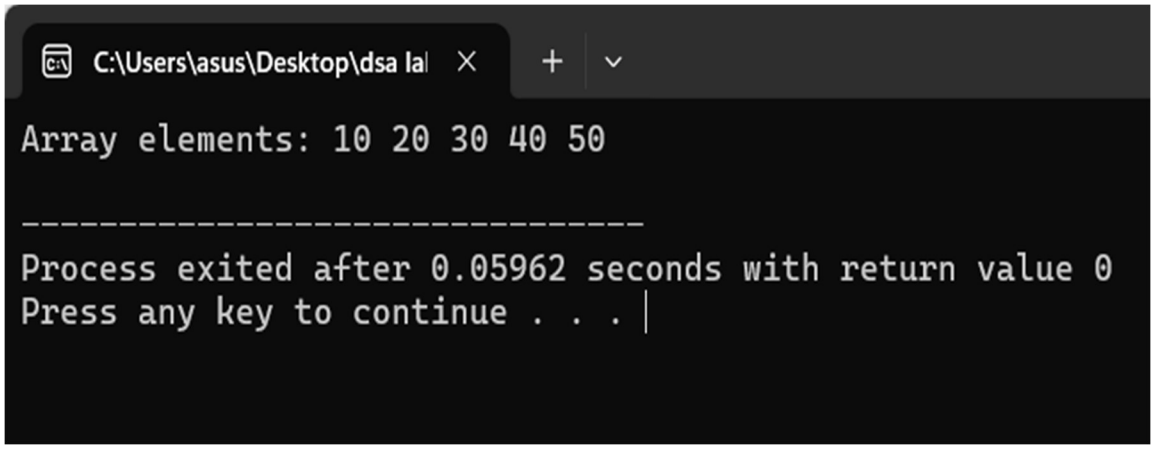
Lab 01 – Arrays

1. Array Traversing

```
#include <iostream>
using namespace std;

void traverseArray(int arr[], int size) {
    cout << "Array elements: ";
    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;
}

int main() {
```

```
    int arr[] = {10, 20, 30, 40, 50};
    int size = 5;
    traverseArray(arr, size);
    return 0;
}
```

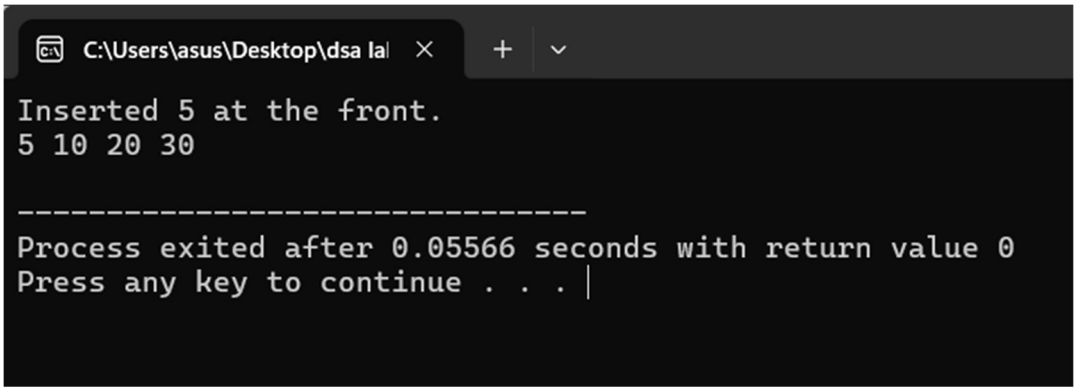


2. Insertion (Front, Mid, Last)

- **Insert at Front**

```
#include <iostream>
using namespace std;

void insertFront(int arr[], int &size, int element, int capacity) {
    if (size >= capacity) {
        cout << "Array is full. Cannot insert." << endl;
        return;
    }
    for (int i = size; i > 0; i--) {
        arr[i] = arr[i - 1];
    }
    arr[0] = element;
    size++;
    cout << "Inserted " << element << " at the front." << endl;
}

int main() {
    const int capacity = 10;
    int arr[capacity] = {10, 20, 30};
```

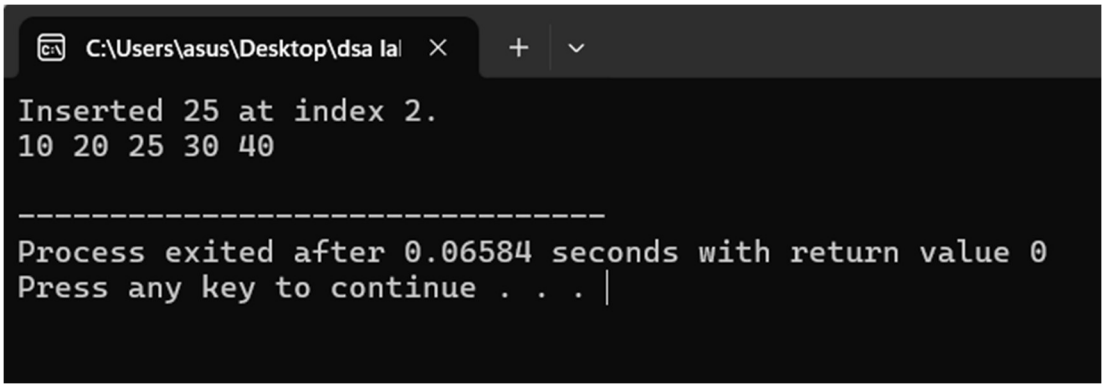
```
    int size = 3;

    insertFront(arr, size, 5, capacity);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```



- **Insert in Middle**

```
#include <iostream>
using namespace std;

void insertMid(int arr[], int &size, int element, int index, int capacity) {
    if (size >= capacity) {
        cout << "Array is full. Cannot insert." << endl;
        return;
    }
    for (int i = size; i > index; i--) {
        arr[i] = arr[i - 1];
    }
    arr[index] = element;
    size++;
    cout << "Inserted " << element << " at index " << index << "." <<
endl;
}
```

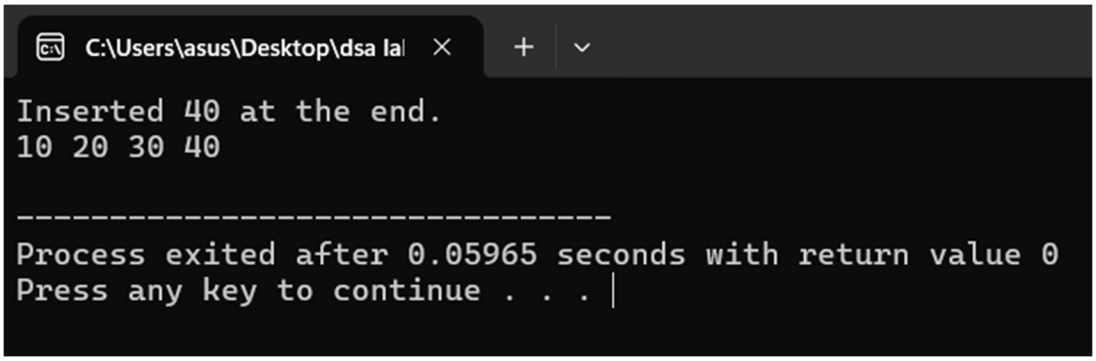
```
int main() {
    const int capacity = 10;
    int arr[capacity] = {10, 20, 30, 40};
    int size = 4;

    insertMid(arr, size, 25, 2, capacity);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```



- **Insert at Last**

```
#include <iostream>
using namespace std;

void insertLast(int arr[], int &size, int element, int capacity) {
    if (size >= capacity) {
        cout << "Array is full. Cannot insert." << endl;
        return;
    }
    arr[size++] = element;
    cout << "Inserted " << element << " at the end." << endl;
}
```

```
int main() {
    const int capacity = 10;
    int arr[capacity] = {10, 20, 30};
    int size = 3;

    insertLast(arr, size, 40, capacity);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```

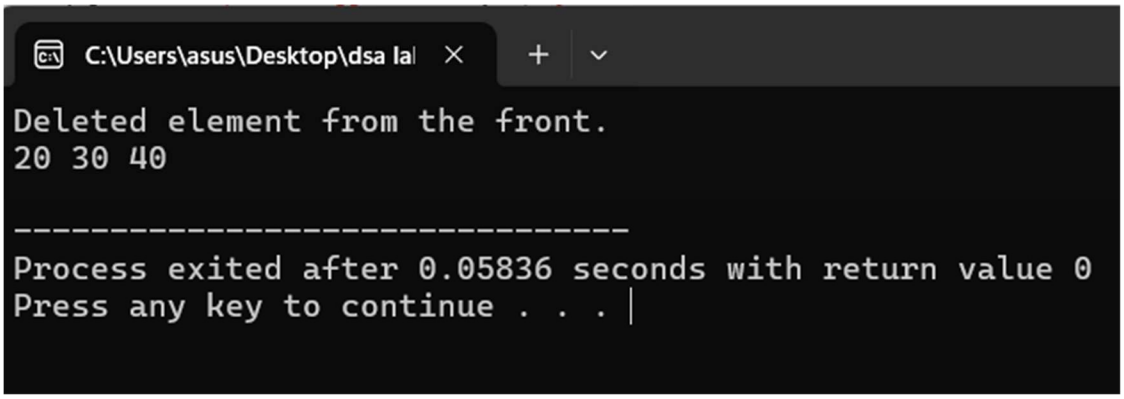


3. Deletion (Front, Mid, Last)

- **Delete from Front**

```
#include <iostream>
using namespace std;

void deleteFront(int arr[], int &size) {
    if (size <= 0) {
        cout << "Array is empty. Cannot delete." << endl;
        return;
    }
    for (int i = 0; i < size - 1; i++) {
        arr[i] = arr[i + 1];
    }
```

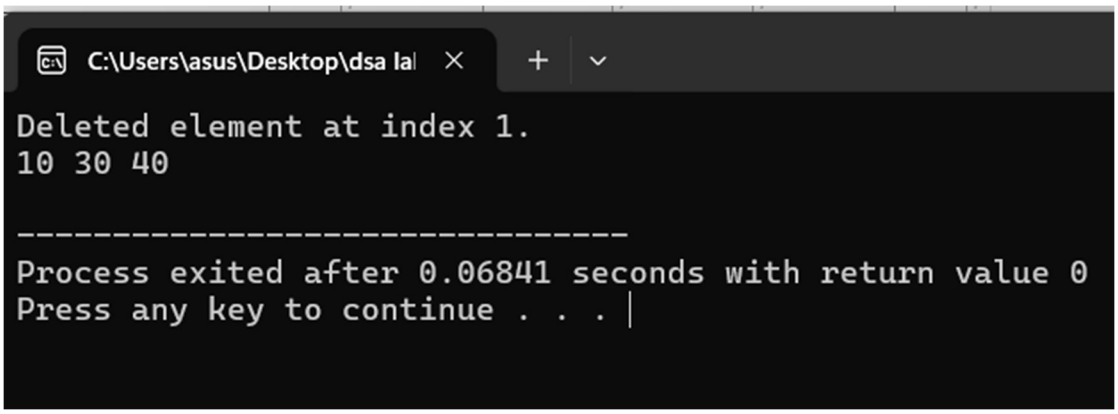
```
    size--;
    cout << "Deleted element from the front." << endl;
}

int main() {
    int arr[] = {10, 20, 30, 40};
    int size = 4;

    deleteFront(arr, size);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```



- **Delete from Middle**

```
#include <iostream>
using namespace std;

void deleteMid(int arr[], int &size, int index) {
    if (index < 0 || index >= size) {
        cout << "Invalid index." << endl;
        return;
    }
    for (int i = index; i < size - 1; i++) {
        arr[i] = arr[i + 1];
```

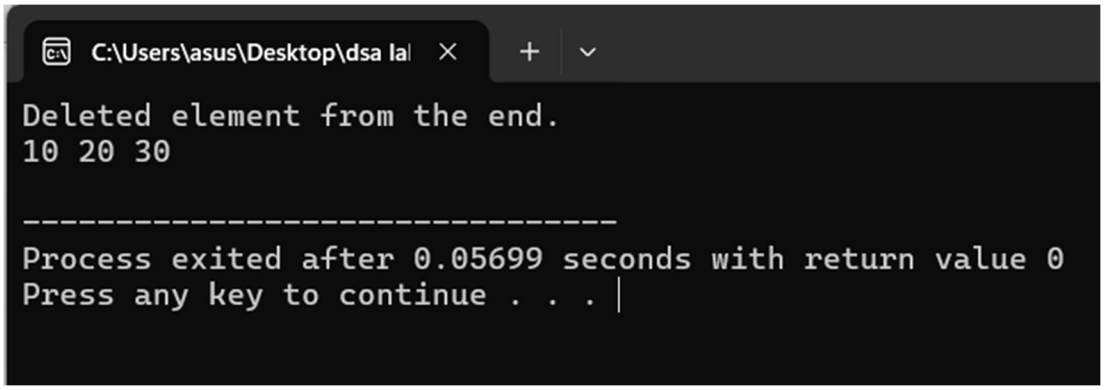
```
    }
    size--;
    cout << "Deleted element at index " << index << "." << endl;
}

int main() {
    int arr[] = {10, 20, 30, 40};
    int size = 4;

    deleteMid(arr, size, 1);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```



- **Delete from Last**

```
#include <iostream>
using namespace std;

void deleteLast(int arr[], int &size) {
    if (size <= 0) {
        cout << "Array is empty. Cannot delete." << endl;
        return;
    }
    size--;
```

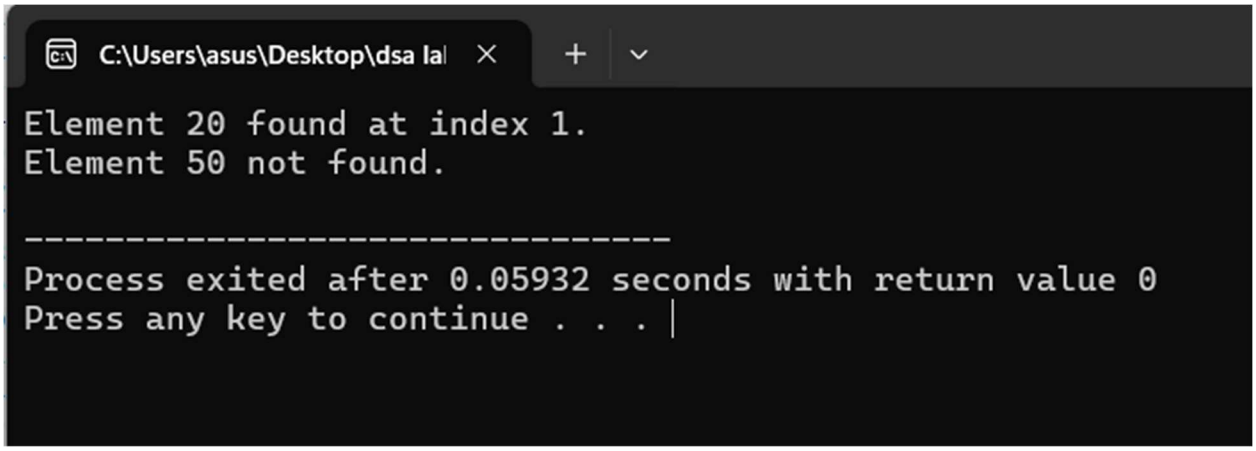
```
    cout << "Deleted element from the end." << endl;
}

int main() {
    int arr[] = {10, 20, 30, 40};
    int size = 4;

    deleteLast(arr, size);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```



4. Searching

```
#include <iostream>
using namespace std;

void searchElement(int arr[], int size, int element) {
    for (int i = 0; i < size; i++) {
        if (arr[i] == element) {
            cout << "Element " << element << " found at index " << i << "." <<
endl;
            return;
        }
    }
```

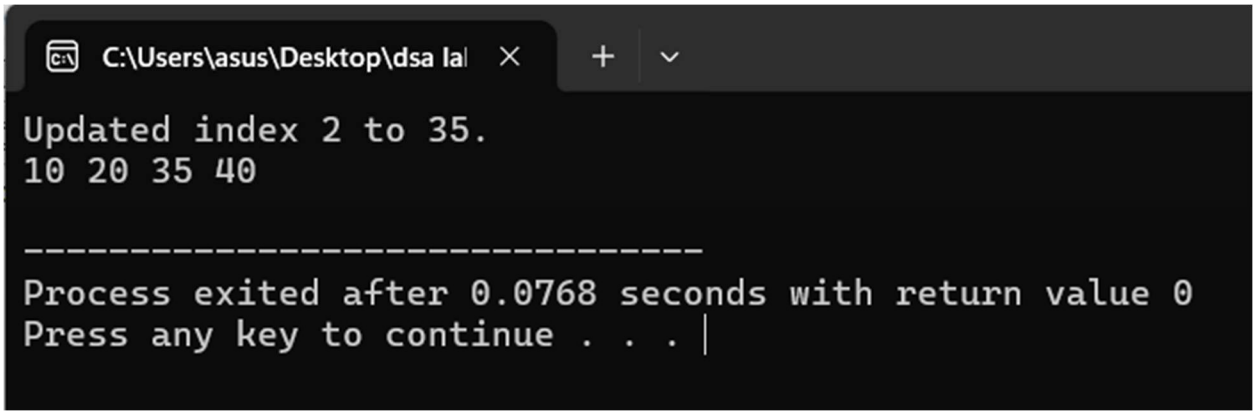
```
    cout << "Element " << element << " not found." << endl;
}

int main() {
    int arr[] = {10, 20, 30, 40};
    int size = 4;

    searchElement(arr, size, 20);
    searchElement(arr, size, 50);

    return 0;
}
```



5. Update

```
#include <iostream>
using namespace std;

void updateElement(int arr[], int size, int index, int newValue) {
    if (index < 0 || index >= size) {
        cout << "Invalid index." << endl;
        return;
    }
    arr[index] = newValue;
    cout << "Updated index " << index << " to " << newValue << "." << endl;
}

int main() {
    int arr[] = {10, 20, 30, 40};
```

```
    int size = 4;

    updateElement(arr, size, 2, 35);

    for (int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
    cout << endl;

    return 0;
}
```

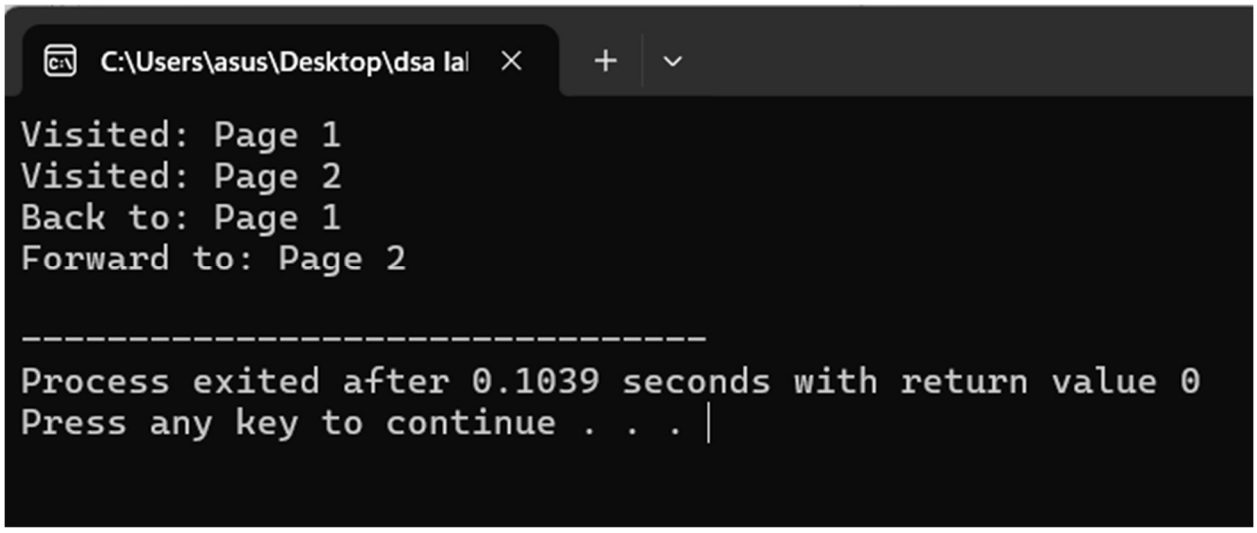


Lab 02- Stack

1. Browser Navigation (Back/Forward History)

```
#include <iostream>
#include <stack>
using namespace std;

class BrowserHistory {
    stack<string> backStack, forwardStack;

public:
    void visitPage(string page) {
        backStack.push(page);
```

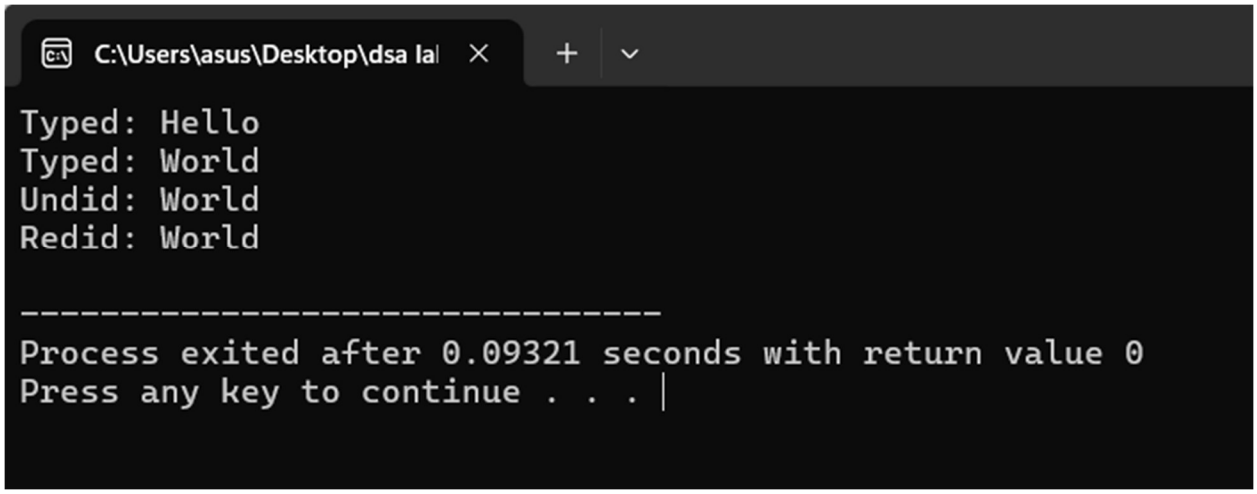
```
        while (!forwardStack.empty()) forwardStack.pop();  // Clear forward
stack
        cout << "Visited: " << page << endl;
    }

    void back() {
        if (backStack.empty()) {
            cout << "No pages in history!" << endl;
            return;
        }
        forwardStack.push(backStack.top());
        backStack.pop();
        cout << "Back to: " << (backStack.empty() ? "No page" :
backStack.top()) << endl;
    }

    void forward() {
        if (forwardStack.empty()) {
            cout << "No forward page!" << endl;
            return;
        }
        backStack.push(forwardStack.top());
        forwardStack.pop();
        cout << "Forward to: " << backStack.top() << endl;
    }
};

int main() {
    BrowserHistory browser;
    browser.visitPage("Page 1");
    browser.visitPage("Page 2");
    browser.back();
    browser.forward();
    return 0;
}
```



2. Undo/Redo in Text Editor

```
#include <iostream>
#include <stack>
using namespace std;

class TextEditor {
    stack<string> undoStack, redoStack;

public:
    void type(string text) {
        undoStack.push(text);
        while (!redoStack.empty()) redoStack.pop();
        cout << "Typed: " << text << endl;
    }

    void undo() {
        if (undoStack.empty()) {
            cout << "Nothing to undo!" << endl;
            return;
        }
        string lastText = undoStack.top();
        undoStack.pop();
        redoStack.push(lastText);
        cout << "Undid: " << lastText << endl;
    }
```

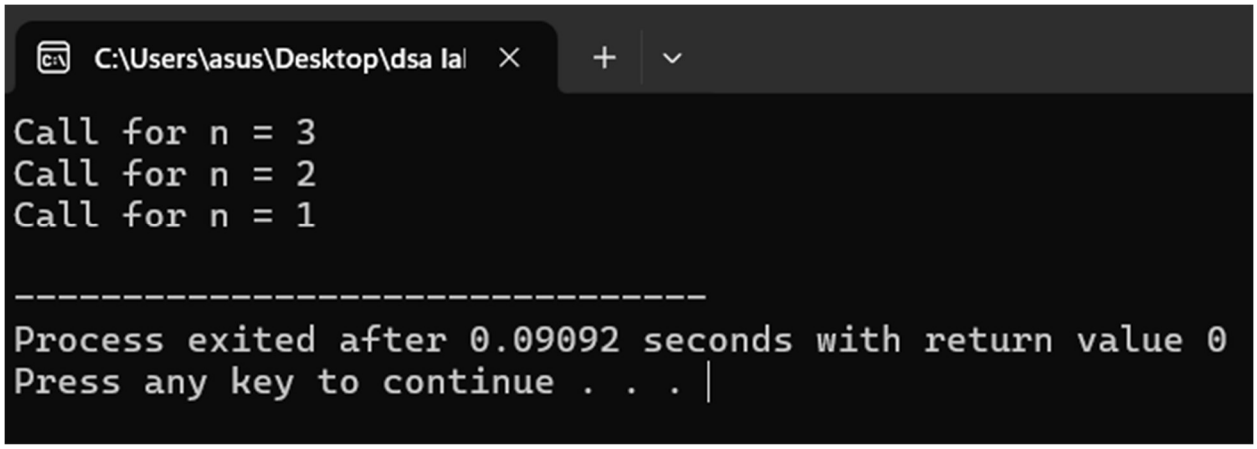
```
    void redo() {
        if (redoStack.empty()) {
            cout << "Nothing to redo!" << endl;
            return;
        }
        string lastText = redoStack.top();
        redoStack.pop();
        undoStack.push(lastText);
        cout << "Redid: " << lastText << endl;
    }
};

int main() {
    TextEditor editor;
    editor.type("Hello");
    editor.type("World");
    editor.undo();
    editor.redo();
    return 0;
}
```



1. Function Call Stack (Recursion)

```
#include <iostream>
#include <stack>
using namespace std;
```

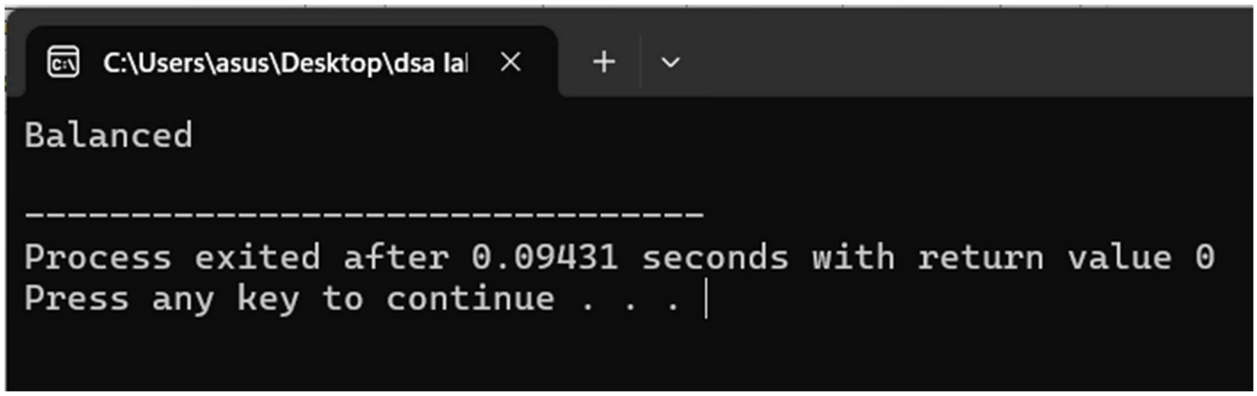
```
void recursiveFunction(int n) {
    stack<int> callStack;
    callStack.push(n);
    if (n > 0) {
        cout << "Call for n = " << n << endl;
        recursiveFunction(n - 1);
    }
    callStack.pop();
}

int main() {
    recursiveFunction(3);
    return 0;
}
```



2. Balancing Parentheses

```
#include <iostream>
#include <stack>
using namespace std;

bool isBalanced(string expression) {
    stack<char> s;
    for (char c : expression) {
        if (c == '(' || c == '{' || c == '[') {
            s.push(c);
        } else if (c == ')' || c == '}' || c == ']') {
            if (s.empty()) return false;
```

```
            char top = s.top();
            if ((c == ')' && top == '(') || (c == '}' && top == '{') || (c == ']' && top
== '[')) {
                s.pop();
            } else {
                return false;
            }
        }
    }
    return s.empty();
}

int main() {
    string expression = "({[()]})";
    cout << (isBalanced(expression) ? "Balanced" : "Not Balanced") << endl;
    return 0;
}
```

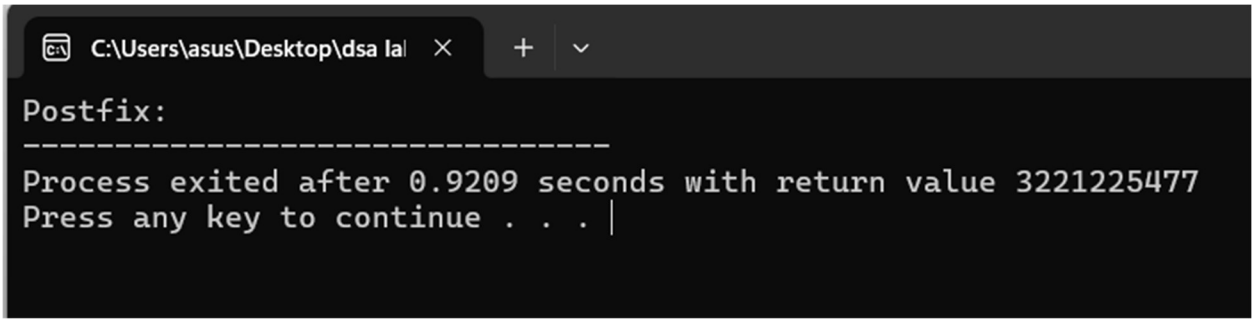


5. Infix to Postfix Conversion

```
#include <iostream>
#include <stack>
#include <cctype>
using namespace std;

int precedence(char c) {
    if (c == '+' || c == '-') return 1;
    if (c == '*' || c == '/') return 2;
```

```
    return 0;
}

string infixToPostfix(string infix) {
    stack<char> s;
    string postfix = "";

    for (char c : infix) {
        if (isalnum(c)) {
            postfix += c;
        } else if (c == '(') {
            s.push(c);
        } else if (c == ')') {
            while (!s.empty() && s.top() != '(') {
                postfix += s.top();
                s.pop();
            }
            s.pop();  // Remove '('
        } else {
            while (!s.empty() && precedence(s.top()) >= precedence(c)) {
                postfix += s.top();
                s.pop();
            }
            s.push(c);
        }
    }

    while (!s.empty()) {
        postfix += s.top();
        s.pop();
    }
    return postfix;
}

int main() {
    string infix = "A+B*(C^D-E)^(F+G*H)-I";
    cout << "Postfix: " << infixToPostfix(infix) << endl;
    return 0;
```

}

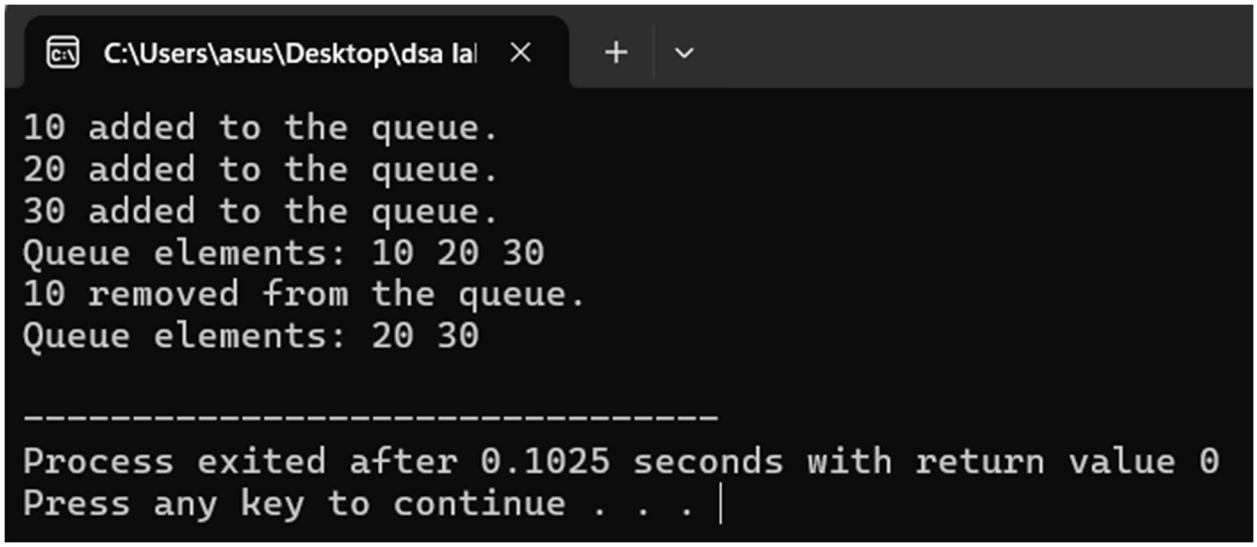


Lab 03 – Queue

1. Linear Queue (Array-Based)

```
#include <iostream>
using namespace std;

class LinearQueue {
    int* queue;
    int front, rear, size;

public:
    LinearQueue(int s) {
        size = s;
        queue = new int[size];
        front = rear = -1;
    }

    // Enqueue
    void enqueue(int value) {
        if (rear == size - 1) {
            cout << "Queue is full!" << endl;
        } else {
            if (front == -1) front = 0;
            queue[++rear] = value;
            cout << value << " added to the queue." << endl;
        }
    }
```

```
    // Dequeue
    void dequeue() {
        if (front == -1 || front > rear) {
            cout << "Queue is empty!" << endl;
        } else {
            cout << queue[front++] << " removed from the queue." << endl;
        }
    }

    // Display Queue
    void display() {
        if (front == -1 || front > rear) {
            cout << "Queue is empty!" << endl;
        } else {
            cout << "Queue elements: ";
            for (int i = front; i <= rear; ++i) {
                cout << queue[i] << " ";
            }
            cout << endl;
        }
    }
};

int main() {
    LinearQueue q(5);

    q.enqueue(10);
    q.enqueue(20);
    q.enqueue(30);
    q.display();

    q.dequeue();
    q.display();

    return 0;
}
```

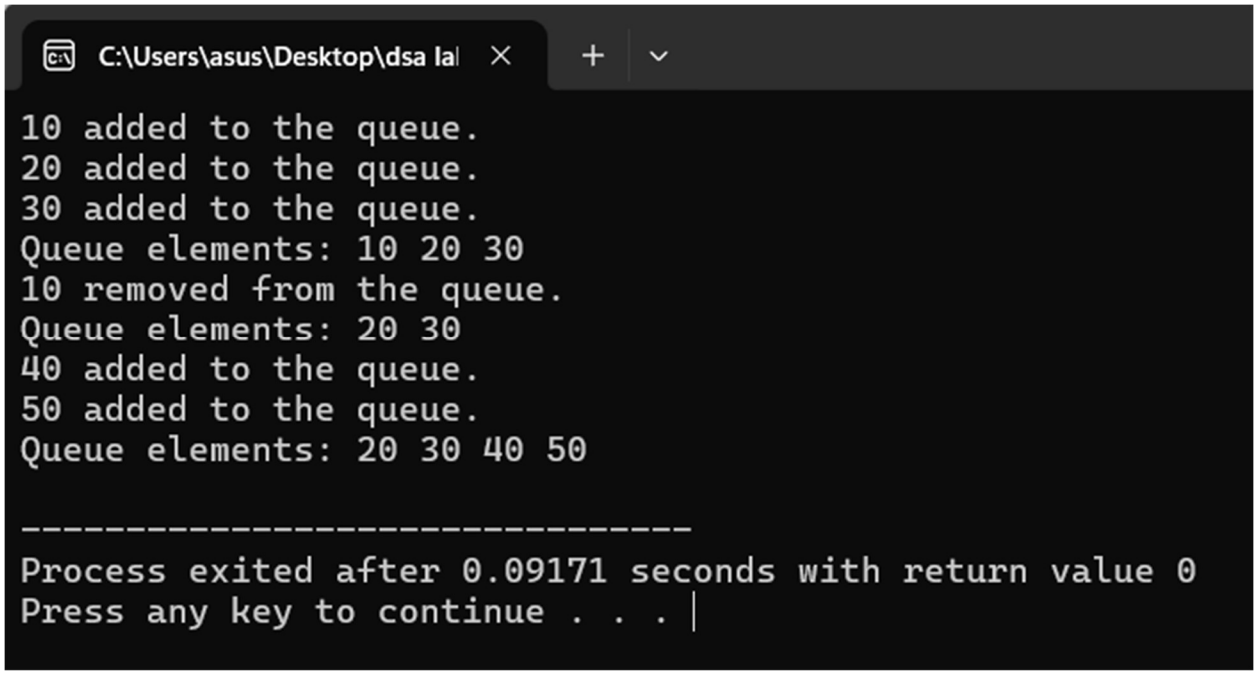


2. Circular Queue (Array-Based)

```
#include <iostream>
using namespace std;

class CircularQueue {
   int* queue;
   int front, rear, size;

public:
   CircularQueue(int s) {
      size = s;
      queue = new int[size];
      front = rear = -1;
   }

   // Enqueue
   void enqueue(int value) {
      if ((rear + 1) % size == front) {
         cout << "Queue is full!" << endl;
      } else {
         if (front == -1) front = 0;
         rear = (rear + 1) % size;
         queue[rear] = value;
         cout << value << " added to the queue." << endl;
```

```
        }
    }

    // Dequeue
    void dequeue() {
        if (front == -1) {
            cout << "Queue is empty!" << endl;
        } else {
            cout << queue[front] << " removed from the queue." << endl;
            if (front == rear) {
                front = rear = -1;  // Reset the queue after last element is
dequeued
            } else {
                front = (front + 1) % size;
            }
        }
    }

    // Display Queue
    void display() {
        if (front == -1) {
            cout << "Queue is empty!" << endl;
        } else {
            cout << "Queue elements: ";
            int i = front;
            while (i != rear) {
                cout << queue[i] << " ";
                i = (i + 1) % size;
            }
            cout << queue[rear] << endl;
        }
    }
};

int main() {
    CircularQueue q(5);

    q.enqueue(10);
```

```
    q.enqueue(20);
    q.enqueue(30);
    q.display();

    q.dequeue();
    q.display();

    q.enqueue(40);
    q.enqueue(50);
    q.display();

    return 0;
}
```



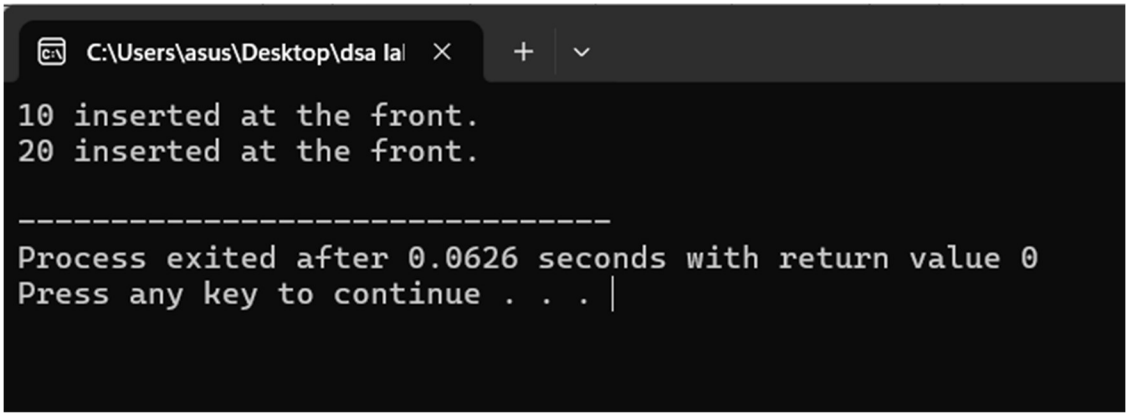
Lab 04 - Single Linked List (SLL)

1. **Playlist Management**: Music players use it to manage playlists.

    1. **Insertion at Front:**

    ```
    #include <iostream>
    using namespace std;
    ```

```
struct Node {
    int data;
    Node* next;
};

void insertFront(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;
    newNode->next = head;
    head = newNode;
    cout << value << " inserted at the front." << endl;
}

int main() {
    Node* head = nullptr;
    insertFront(head, 10);
    insertFront(head, 20);
    return 0;
}
```

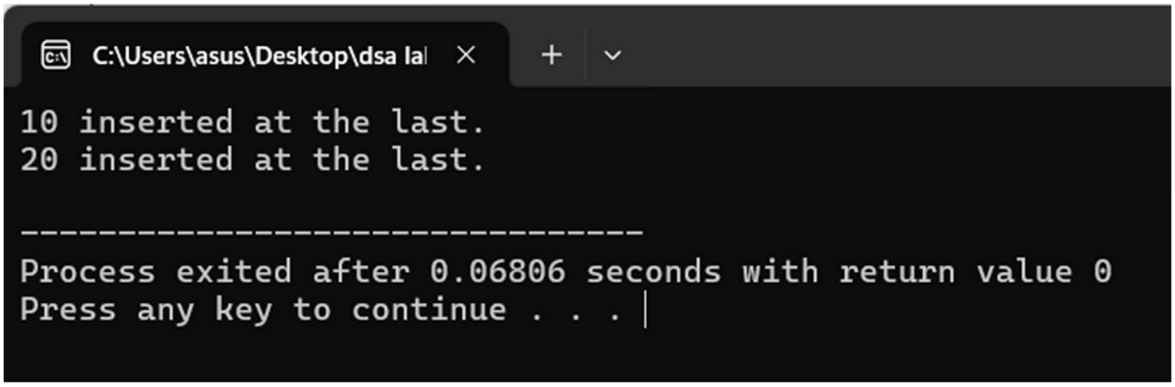


2. Insertion at End:

```
#include <iostream>

using namespace std;
```

```
struct Node {
    int data;
    Node* next;
};

void insertLast(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;
    newNode->next = nullptr;

    if (head == nullptr) {
        head = newNode;
        cout << value << " inserted at the last." << endl;
        return;
    }

    Node* temp = head;
    while (temp->next != nullptr) {
        temp = temp->next;
    }
    temp->next = newNode;
    cout << value << " inserted at the last." << endl;
}
```

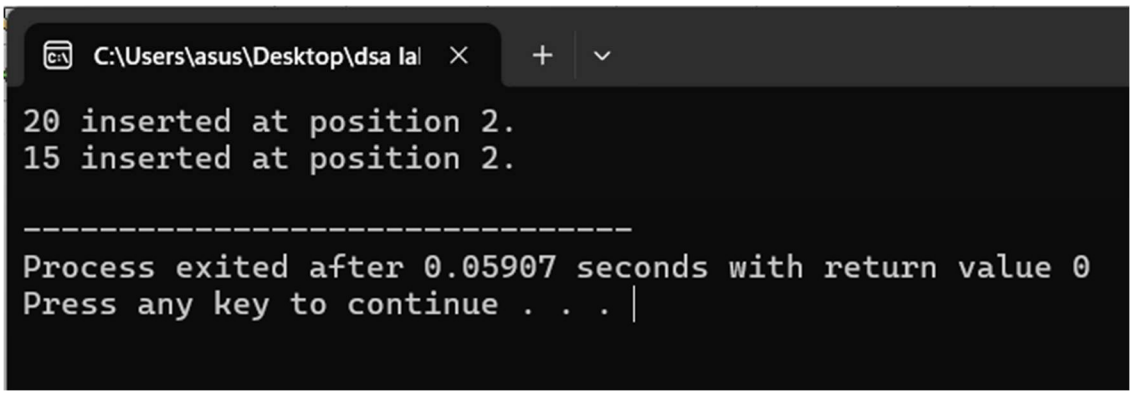
```
int main() {
    Node* head = nullptr;
    insertLast(head, 10);
    insertLast(head, 20);
    return 0;
}
```



3. Insertion at Middle (after a specific position):

```
#include <iostream>
using namespace std;

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

void insertMid(Node*& head, int value, int position) {
    if (position == 1) {
        Node* newNode = new Node();
        newNode->data = value;
        newNode->next = head;
        head = newNode;
        return;
    }

    Node* newNode = new Node();
    newNode->data = value;
```

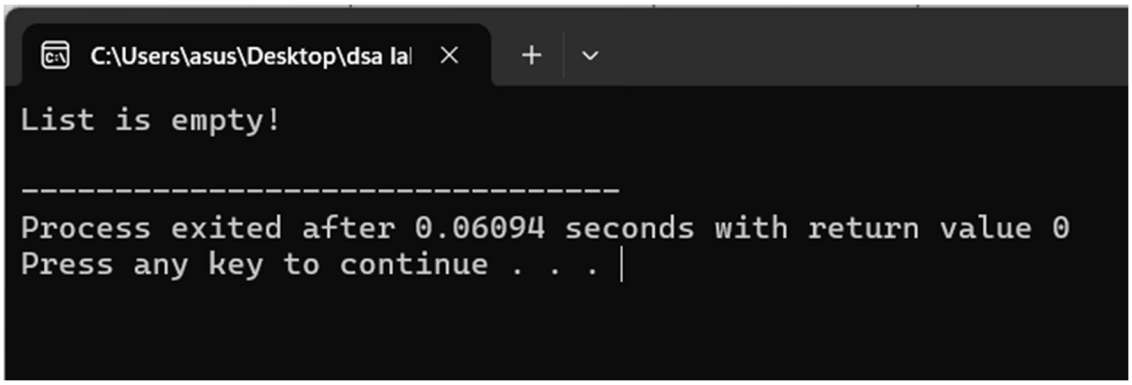
```
    Node* temp = head;

    for (int i = 1; i < position - 1 && temp != nullptr; i++) {
        temp = temp->next;
    }

    if (temp == nullptr) {
        cout << "Position out of range!" << endl;
        return;
    }

    newNode->next = temp->next;
    temp->next = newNode;
    cout << value << " inserted at position " << position << "." << endl;
}

int main() {
    Node* head = nullptr;
    insertMid(head, 10, 1); // Insert at position 1
    insertMid(head, 20, 2); // Insert at position 2
    insertMid(head, 15, 2); // Insert at position 2
    return 0;
}
```



4. **Deletion from Front:**

```
#include <iostream>
using namespace std;
```

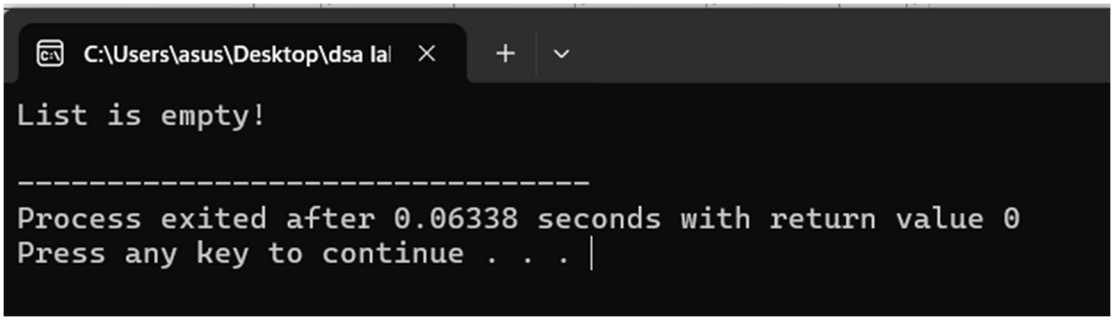
```
struct Node {
    int data;
    Node* next;
};

void deleteFront(Node*& head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    Node* temp = head;
    head = head->next;
    delete temp;
    cout << "Node deleted from the front." << endl;
}

int main() {
    Node* head = nullptr;
    deleteFront(head); // Testing on empty list
    return 0;
}
```



5. Deletion from Last

```
#include <iostream>
using namespace std;

struct Node {
    int data;
```

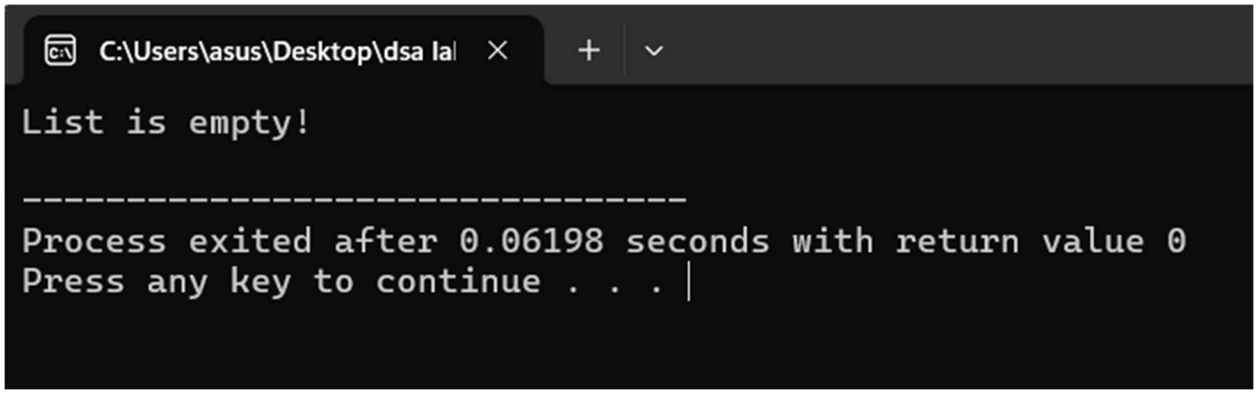
```
    Node* next;
};

void deleteLast(Node*& head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    Node* temp = head;
    if (temp->next == nullptr) {
        head = nullptr;
        delete temp;
        cout << "Node deleted from the last." << endl;
        return;
    }

    while (temp->next != nullptr && temp->next->next != nullptr) {
        temp = temp->next;
    }
    delete temp->next;
    temp->next = nullptr;
    cout << "Node deleted from the last." << endl;
}

int main() {
    Node* head = nullptr;
    deleteLast(head); // Testing on empty list
    return 0;
}
```



6.Deletion from Middle (Specific Position)

```
#include <iostream>
using namespace std;

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

void deleteMid(Node*& head, int position) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    if (position == 1) {
        Node* temp = head;
        head = head->next;
        delete temp;
        return;
    }

    Node* temp = head;
    for (int i = 1; i < position - 1 && temp != nullptr; i++) {
        temp = temp->next;
    }

    if (temp == nullptr || temp->next == nullptr) {
        cout << "Position out of range!" << endl;
        return;
    }

    Node* nodeToDelete = temp->next;
    temp->next = temp->next->next;
    delete nodeToDelete;
    cout << "Node deleted from position " << position << "." << endl;
}
```

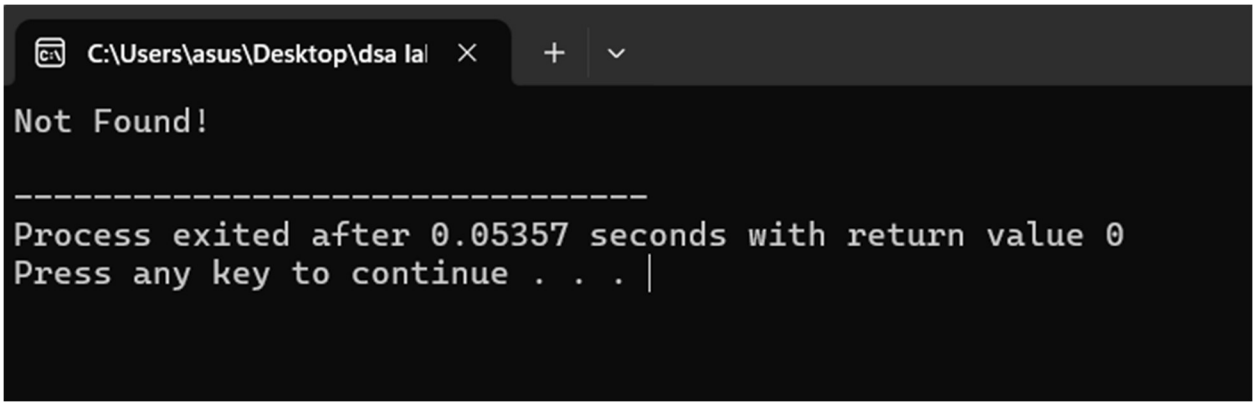
```
int main() {
    Node* head = nullptr;
    deleteMid(head, 2); // Testing on empty list
    return 0;
}
```



2. Searching for an Element

```
#include <iostream>
using namespace std;

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

bool search(Node* head, int value) {
    Node* temp = head;
    while (temp != nullptr) {
        if (temp->data == value) {
            return true;
        }
        temp = temp->next;
    }
    return false;
}

int main() {
    Node* head = nullptr;
```

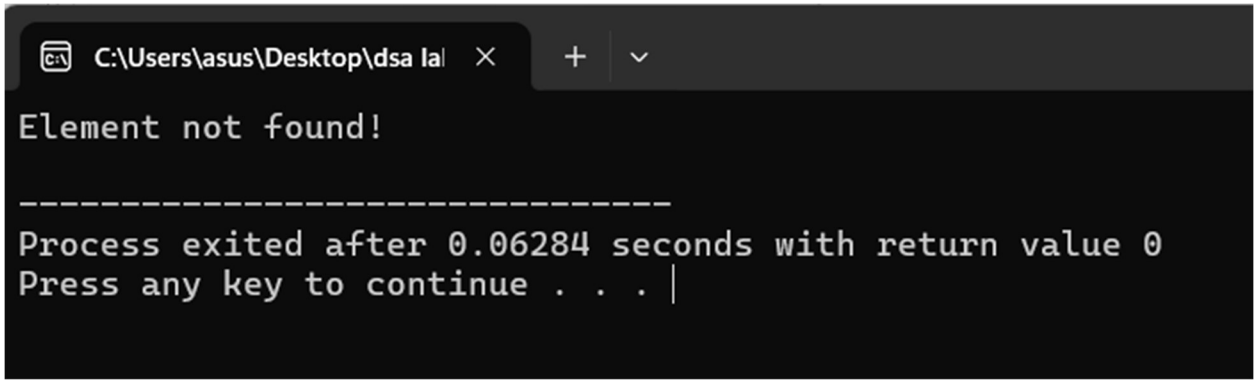
```
    if (search(head, 10)) {
        cout << "Found!" << endl;
    } else {
        cout << "Not Found!" << endl;
    }
    return 0;
}
```



3. Updating an Element

```
#include <iostream>
using namespace std;

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

void update(Node* head, int oldValue, int newValue) {
    Node* temp = head;
    while (temp != nullptr) {
        if (temp->data == oldValue) {
            temp->data = newValue;
            cout << "Node with value " << oldValue << " updated to " <<
newValue << "." << endl;
            return;
        }
        temp = temp->next;
    }
    cout << "Element not found!" << endl;
```

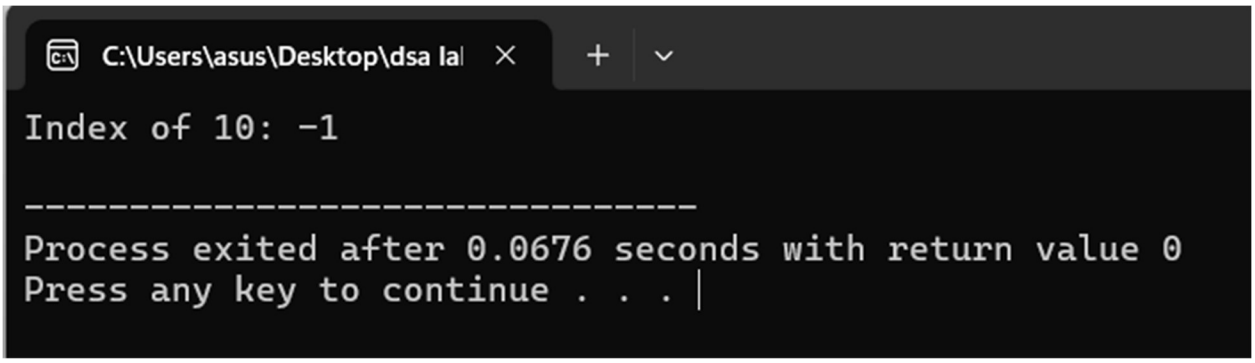
```
}

int main() {
    Node* head = nullptr;
    update(head, 10, 20); // Testing on empty list
    return 0;
}
```



4. Finding Index of an Element

```
#include <iostream>
using namespace std;

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

int findIndex(Node* head, int value) {
    Node* temp = head;
    int index = 0;

    while (temp != nullptr) {
        if (temp->data == value) {
            return index;
        }
        temp = temp->next;
        index++;
    }
```

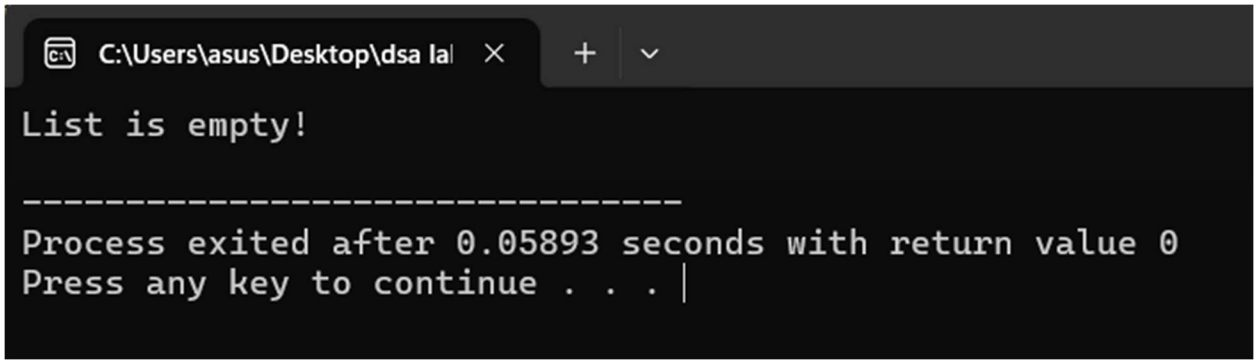
```
    return -1; // Not found
}

int main() {
    Node* head = nullptr;
    cout << "Index of 10: " << findIndex(head, 10) << endl; // Testing on
empty list
    return 0;
}
```



5. Traversing the List

```
#include <iostream>
using namespace std;

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

void traverse(Node* head) {
    Node* temp = head;
    if (temp == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    cout << "List elements: ";
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
```

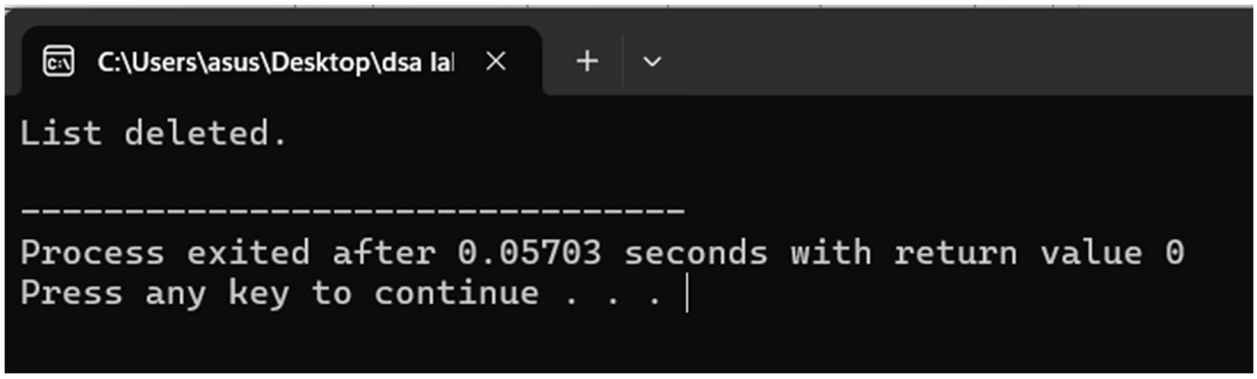
```
    }
    cout << endl;
}

int main() {
    Node* head = nullptr;
    traverse(head); // Testing on empty list
    return 0;
}
```



11. Deleting the List

```
#include <iostream>
using namespace std;

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

void deleteList(Node*& head) {
    Node* temp;
    while (head != nullptr) {
        temp = head;
        head = head->next;
        delete temp;
    }
    cout << "List deleted." << endl;
}

int main() {
```

```
    Node* head = nullptr;
    deleteList(head); // Testing on empty list
    return 0;
}
```

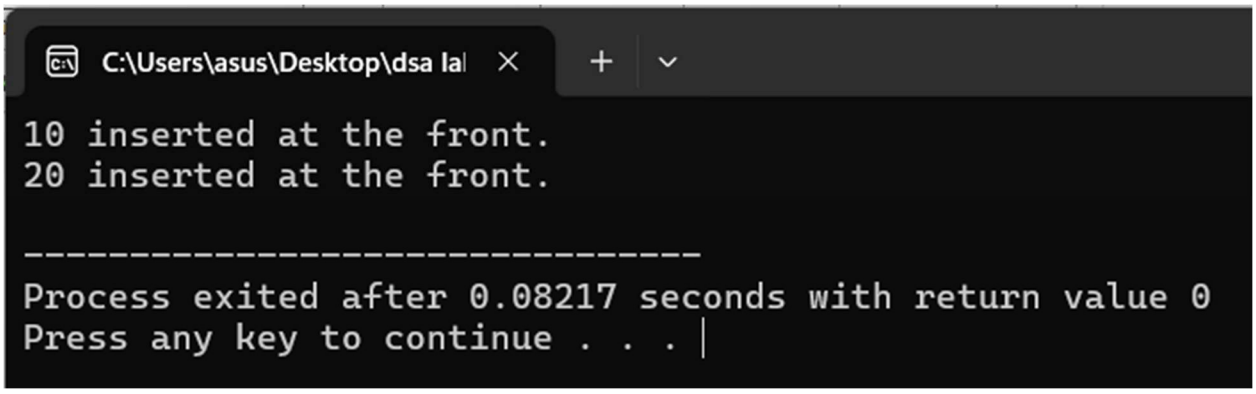


Lab 05 - Double Linked List (DLL)

1. Insertion at the Front

```
#include <iostream>

using namespace std;


struct Node {
    int data;
    Node* next;
    Node* prev;
};


void insertFront(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;
```

```
    newNode->next = head;
    newNode->prev = nullptr;

    if (head != nullptr) {
        head->prev = newNode;
    }
    head = newNode;
    cout << value << " inserted at the front." << endl;
}

int main() {
    Node* head = nullptr;
    insertFront(head, 10);
    insertFront(head, 20);
    return 0;
}
```

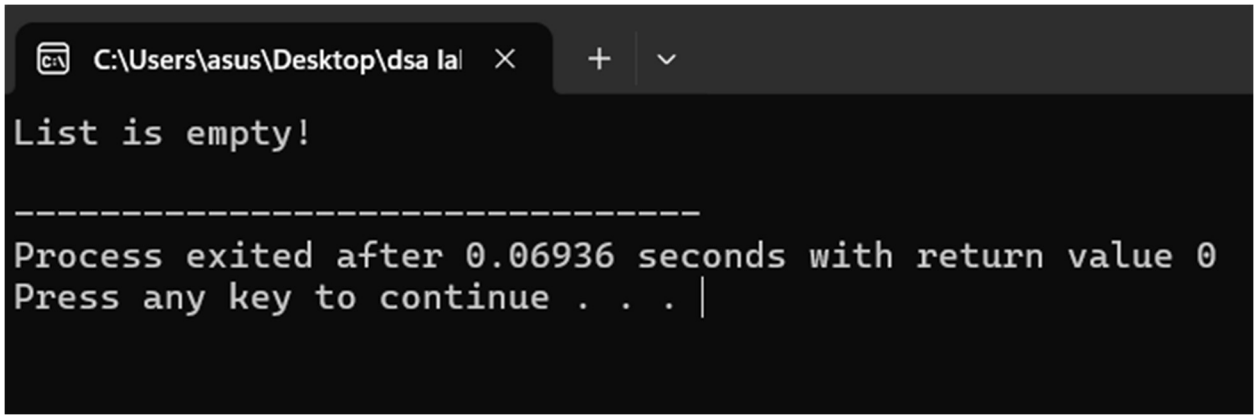


2. Insertion at the Last

```
#include <iostream>
```

```
using namespace std;

struct Node {
    int data;
    Node* next;
    Node* prev;
};

void insertLast(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;
    newNode->next = nullptr;

    if (head == nullptr) {
        newNode->prev = nullptr;
        head = newNode;
        cout << value << " inserted at the last." << endl;
        return;
    }

    Node* temp = head;
    while (temp->next != nullptr) {
        temp = temp->next;
    }
```

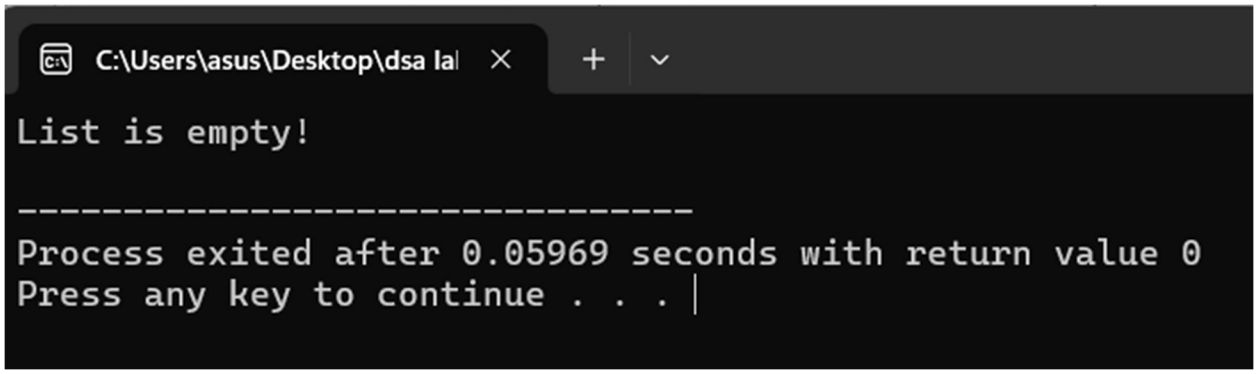
```
    temp->next = newNode;
    newNode->prev = temp;
    cout << value << " inserted at the last." << endl;
}

int main() {
    Node* head = nullptr;
    insertLast(head, 10);
    insertLast(head, 20);
    return 0;
}
```



1. **Deletion from the Last**

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* next;
    Node* prev;
};
```

```
void deleteLast(Node*& head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    if (head->next == nullptr) {
        delete head;
        head = nullptr;
        cout << "Node deleted from the last." << endl;
        return;
    }

    Node* temp = head;
    while (temp->next != nullptr) {
        temp = temp->next;
    }

    temp->prev->next = nullptr;
    delete temp;
    cout << "Node deleted from the last." << endl;
}

int main() {
    Node* head = nullptr;
    deleteLast(head); // Test on an empty list
    return 0;
}
```



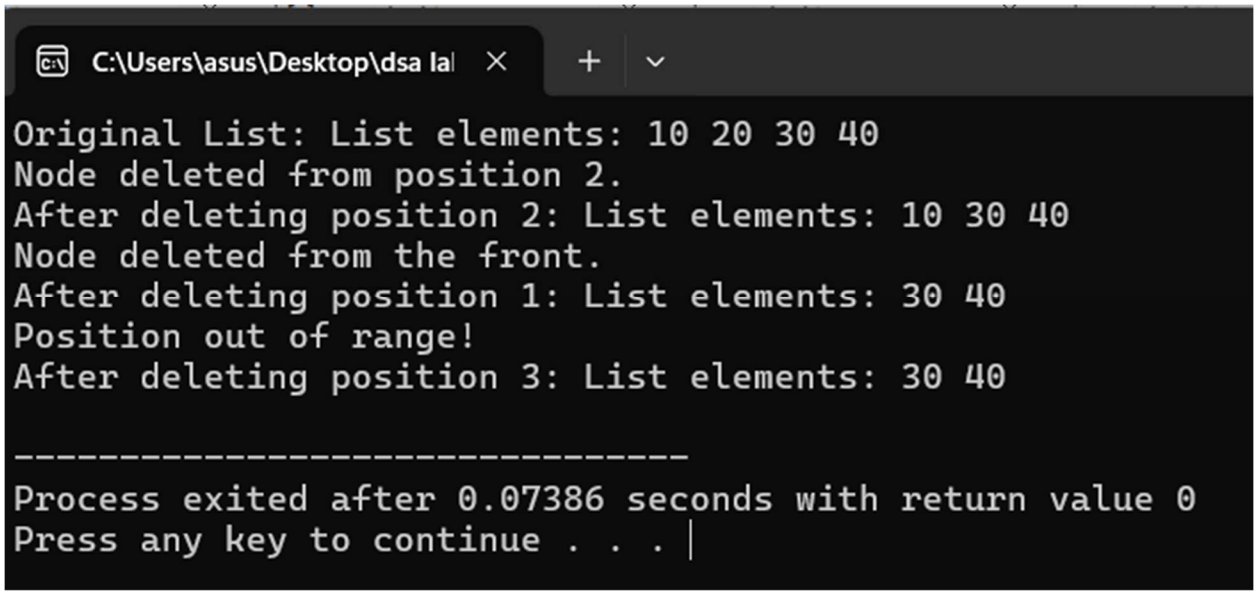
2. Deletion from the Middle (Specific Position)

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* next;
    Node* prev;
};

// Function to delete a node from the front
void deleteFront(Node*& head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    Node* temp = head;
    head = head->next;

    if (head != nullptr) {
        head->prev = nullptr;
    }

    delete temp;
    cout << "Node deleted from the front." << endl;
}

// Function to delete a node from a specific position
void deleteMid(Node*& head, int position) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    if (position == 1) {
        deleteFront(head); // Reuse deleteFront
        return;
```

```
    }

    Node* temp = head;
    for (int i = 1; i < position && temp != nullptr; i++) {
        temp = temp->next;
    }

    if (temp == nullptr) {
        cout << "Position out of range!" << endl;
        return;
    }

    if (temp->next != nullptr) {
        temp->next->prev = temp->prev;
    }

    if (temp->prev != nullptr) {
        temp->prev->next = temp->next;
    }

    delete temp;
    cout << "Node deleted from position " << position << "." << endl;
}

// Function to traverse and display the list
void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    cout << "List elements: ";
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
```

```
}

// Function to insert a node at the end for testing
void insertLast(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;
    newNode->next = nullptr;

    if (head == nullptr) {
        newNode->prev = nullptr;
        head = newNode;
        return;
    }

    Node* temp = head;
    while (temp->next != nullptr) {
        temp = temp->next;
    }

    temp->next = newNode;
    newNode->prev = temp;
}

int main() {
    Node* head = nullptr;

    // Insert nodes for testing
    insertLast(head, 10);
    insertLast(head, 20);
    insertLast(head, 30);
    insertLast(head, 40);

    cout << "Original List: ";
    traverse(head);

    deleteMid(head, 2); // Delete the node at position 2
    cout << "After deleting position 2: ";
    traverse(head);
```

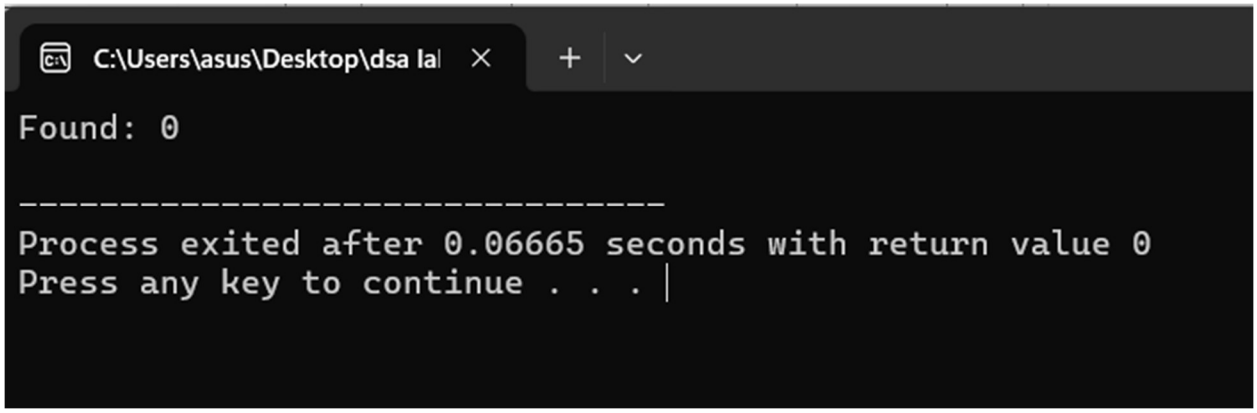
```
    deleteMid(head, 1); // Delete the node at position 1
    cout << "After deleting position 1: ";
    traverse(head);

    deleteMid(head, 3); // Delete the node at position 3
    cout << "After deleting position 3: ";
    traverse(head);

    return 0;
}
```



3. Searching

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* next;
    Node* prev;
};

bool search(Node* head, int value) {
    Node* temp = head;
    while (temp != nullptr) {
```

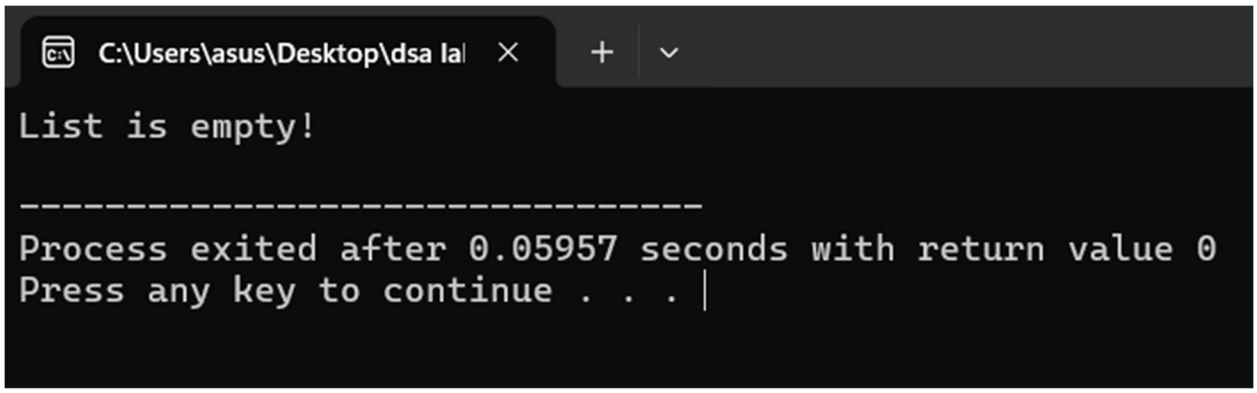
```
        if (temp->data == value) {
            return true;
        }
        temp = temp->next;
    }
    return false;
}

int main() {
    Node* head = nullptr;
    cout << "Found: " << search(head, 10) << endl; // Test on an empty list
    return 0;
}
```



4. Traversing the List

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* next;
    Node* prev;
};

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
```

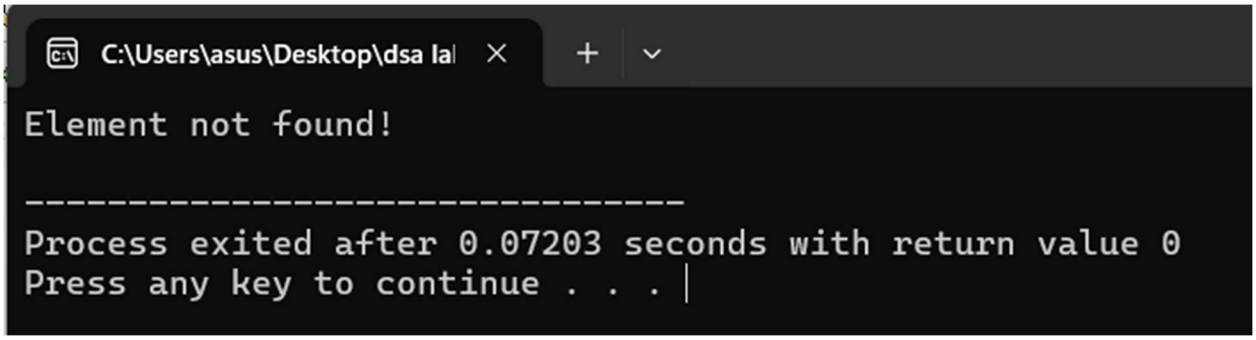
```
    Node* temp = head;
    cout << "List elements: ";
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    Node* head = nullptr;
    traverse(head); // Test on an empty list
    return 0;
}
```



5. Update a Node

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* next;
    Node* prev;
};

void update(Node* head, int oldValue, int newValue) {
    Node* temp = head;
    while (temp != nullptr) {
```

```
        if (temp->data == oldValue) {
            temp->data = newValue;
            cout << "Updated value " << oldValue << " to " << newValue <<
endl;
            return;
        }
        temp = temp->next;
    }
    cout << "Element not found!" << endl;
}

int main() {
    Node* head = nullptr;
    update(head, 10, 20); // Test on an empty list
    return 0;
}
```



Lab 06 - Circular Linked List

What is Circular Linked List?

A Circular Linked List is a type of linked list where the last node points back to the first node, forming a loop.

Advantages:

1. **Continuous Traversal**: No need to reset the pointer; you can keep looping through the list.

2. **Efficient Memory Use**: Useful for tasks that require circular or repeated processing.

Applications:

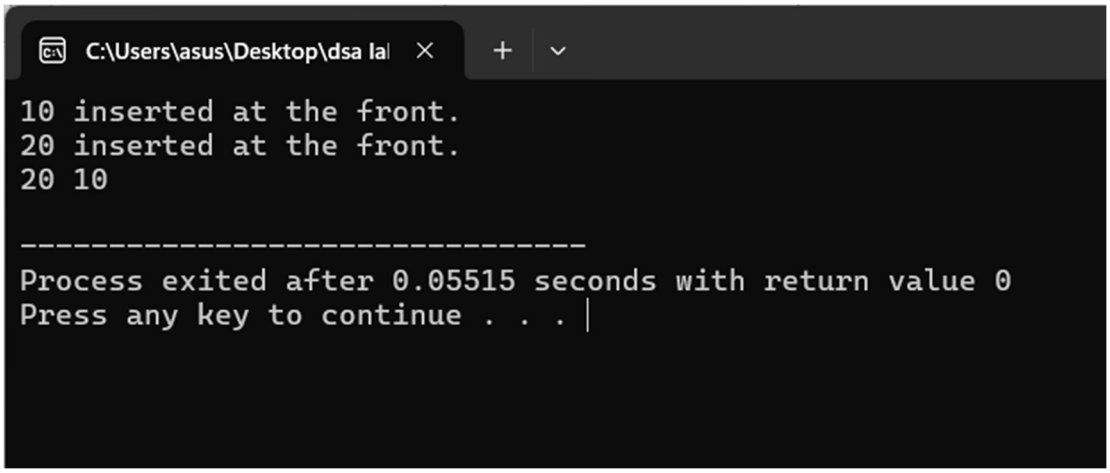
1. **Round Robin Scheduling** in OS.
2. **Circular Buffers** for data handling.
3. **Music Playlists** that loop indefinitely.
4. **Circular Queues** for continuous processing.

Example:

1. Insertion at Front

```
#include <iostream>
using namespace std;

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

void insertFront(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;

    if (head == nullptr) {
        newNode->next = newNode;
        head = newNode;
    } else {
        Node* temp = head;
        while (temp->next != head) {
            temp = temp->next;
        }
        newNode->next = head;
        temp->next = newNode;
        head = newNode;
    }
```

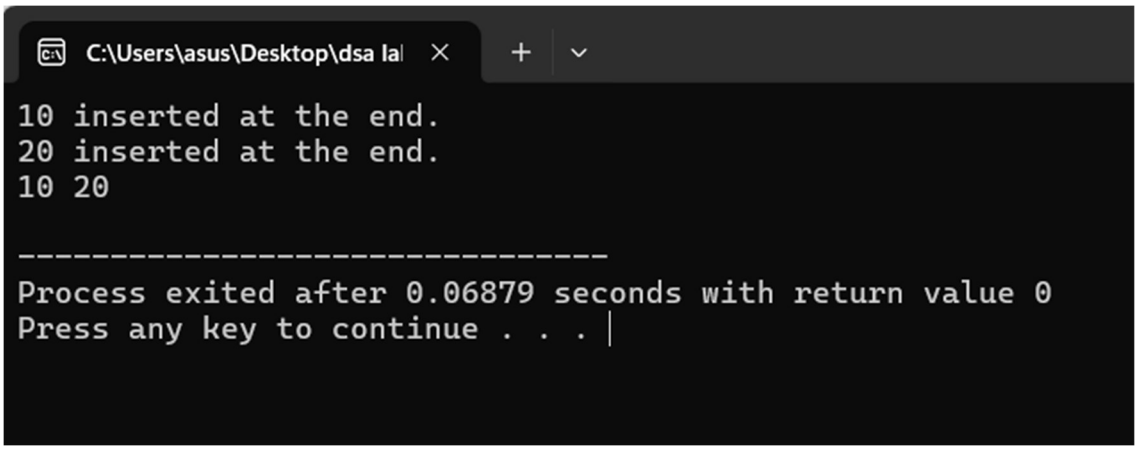
```
    cout << value << " inserted at the front." << endl;
}

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    Node* temp = head;
    do {
        cout << temp->data << " ";
        temp = temp->next;
    } while (temp != head);
    cout << endl;
}

int main() {
    Node* head = nullptr;

    insertFront(head, 10);
    insertFront(head, 20);
    traverse(head);

    return 0;
}
```



2. Insertion at Last

```
#include <iostream>
using namespace std;

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

void insertLast(Node*& head, int value) {
    Node* newNode = new Node();
    newNode->data = value;

    if (head == nullptr) {
        newNode->next = newNode;
        head = newNode;
    } else {
        Node* temp = head;
        while (temp->next != head) {
            temp = temp->next;
        }
        temp->next = newNode;
        newNode->next = head;
    }
    cout << value << " inserted at the end." << endl;
}

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    Node* temp = head;
    do {
        cout << temp->data << " ";
        temp = temp->next;
    } while (temp != head);
    cout << endl;
}
```

```
int main() {
    Node* head = nullptr;

    insertLast(head, 10);
    insertLast(head, 20);
    traverse(head);

    return 0;
}
```

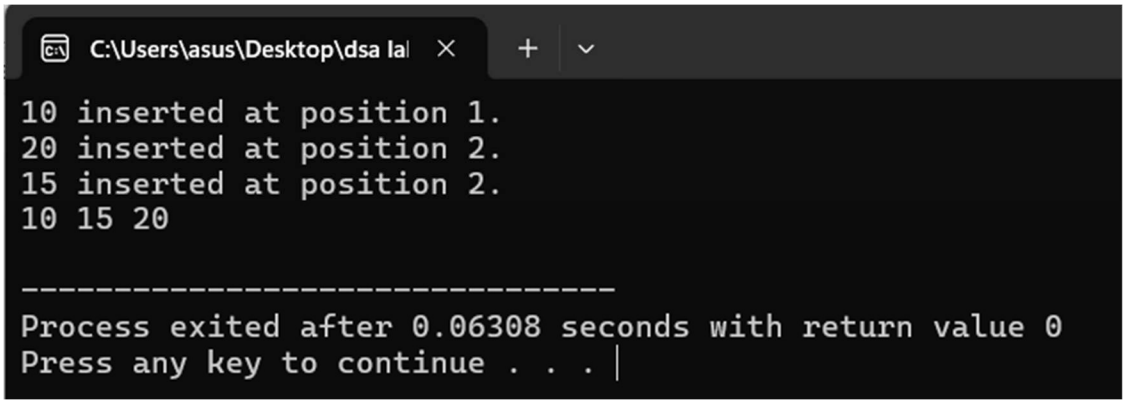


3. Insertion at a Specific Position

```
#include <iostream>
using namespace std;

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

void insertMid(Node*& head, int value, int position) {
    if (position == 1) {
        Node* newNode = new Node();
        newNode->data = value;

        if (head == nullptr) {
            newNode->next = newNode;
            head = newNode;
```

```
        } else {
            Node* temp = head;
            while (temp->next != head) {
                temp = temp->next;
            }
            newNode->next = head;
            temp->next = newNode;
            head = newNode;
        }
        cout << value << " inserted at position 1." << endl;
        return;
    }

    Node* temp = head;
    for (int i = 1; i < position - 1 && temp->next != head; i++) {
        temp = temp->next;
    }

    if (temp->next == head && position > 2) {
        cout << "Position out of range!" << endl;
        return;
    }

    Node* newNode = new Node();
    newNode->data = value;
    newNode->next = temp->next;
    temp->next = newNode;

    cout << value << " inserted at position " << position << "." << endl;
}

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    Node* temp = head;
    do {
```

```
        cout << temp->data << " ";
        temp = temp->next;
    } while (temp != head);
    cout << endl;
}

int main() {
    Node* head = nullptr;

    insertMid(head, 10, 1);
    insertMid(head, 20, 2);
    insertMid(head, 15, 2);
    traverse(head);

    return 0;
}
```

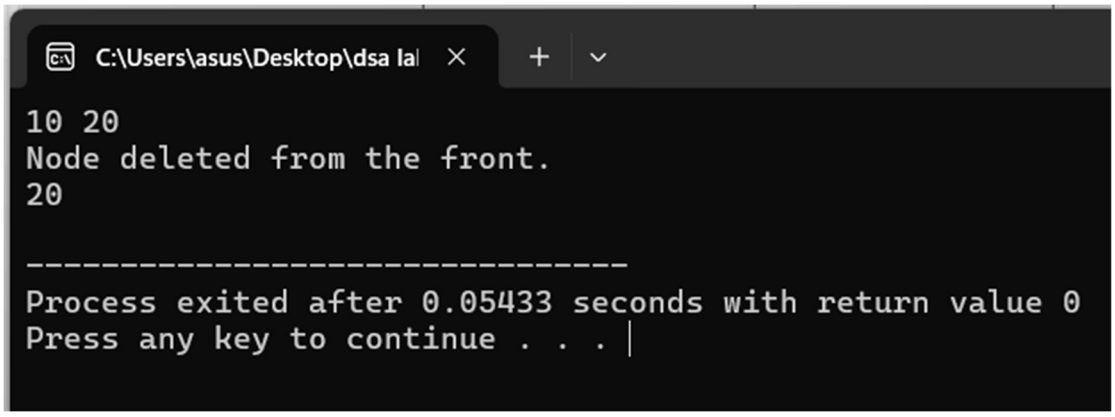


4. Deletion from Front

```
#include <iostream>
using namespace std;

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

void deleteFront(Node*& head) {
```

```
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    if (head->next == head) {
        delete head;
        head = nullptr;
    } else {
        Node* temp = head;
        Node* last = head;
        while (last->next != head) {
            last = last->next;
        }

        head = head->next;
        last->next = head;
        delete temp;
    }
    cout << "Node deleted from the front." << endl;
}

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    Node* temp = head;
    do {
        cout << temp->data << " ";
        temp = temp->next;
    } while (temp != head);
    cout << endl;
}

int main() {
    Node* head = nullptr;
```

```
    // Example: Inserting some nodes
    Node* newNode = new Node();
    newNode->data = 10;
    head = newNode;
    head->next = head;

    Node* second = new Node();
    second->data = 20;
    second->next = head;
    head->next = second;

    traverse(head);
    deleteFront(head);
    traverse(head);

    return 0;
}
```

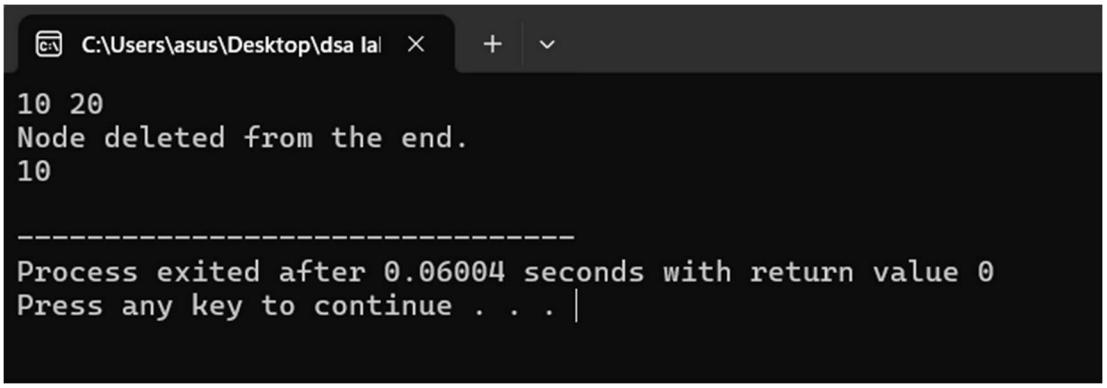


5.Deletion from Last

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* next;
};
```

```
void deleteLast(Node*& head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }

    if (head->next == head) {
        delete head;
        head = nullptr;
    } else {
        Node* temp = head;
        Node* prev = nullptr;
        while (temp->next != head) {
            prev = temp;
            temp = temp->next;
        }
        prev->next = head;
        delete temp;
    }
    cout << "Node deleted from the end." << endl;
}

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    Node* temp = head;
    do {
        cout << temp->data << " ";
        temp = temp->next;
    } while (temp != head);
    cout << endl;
}

int main() {
    Node* head = nullptr;
```

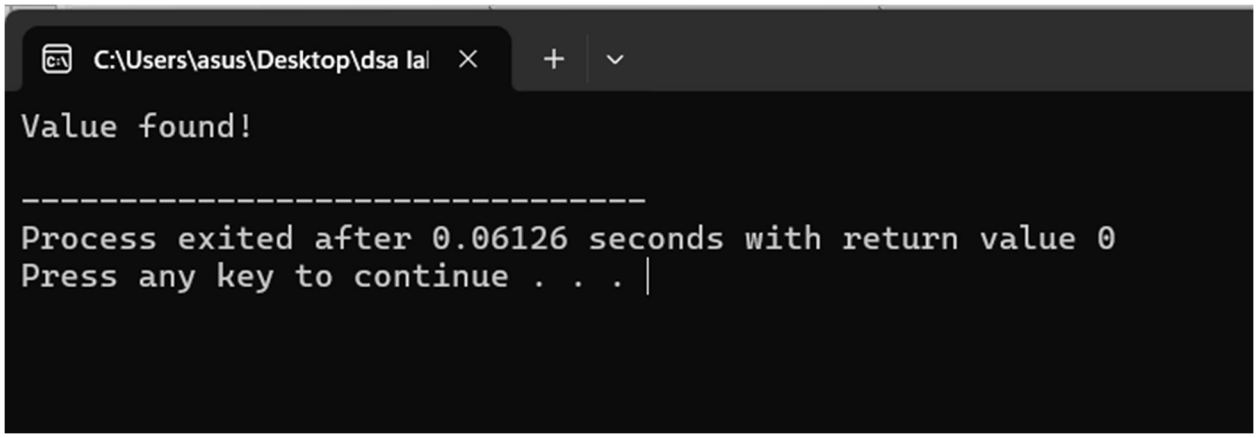
```
    // Example: Inserting some nodes
    Node* newNode = new Node();
    newNode->data = 10;
    head = newNode;
    head->next = head;

    Node* second = new Node();
    second->data = 20;
    second->next = head;
    head->next = second;

    traverse(head);
    deleteLast(head);
    traverse(head);

    return 0;
}
```



7.Searching

```
#include <iostream>
using namespace std;

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

bool search(Node* head, int value) {
```

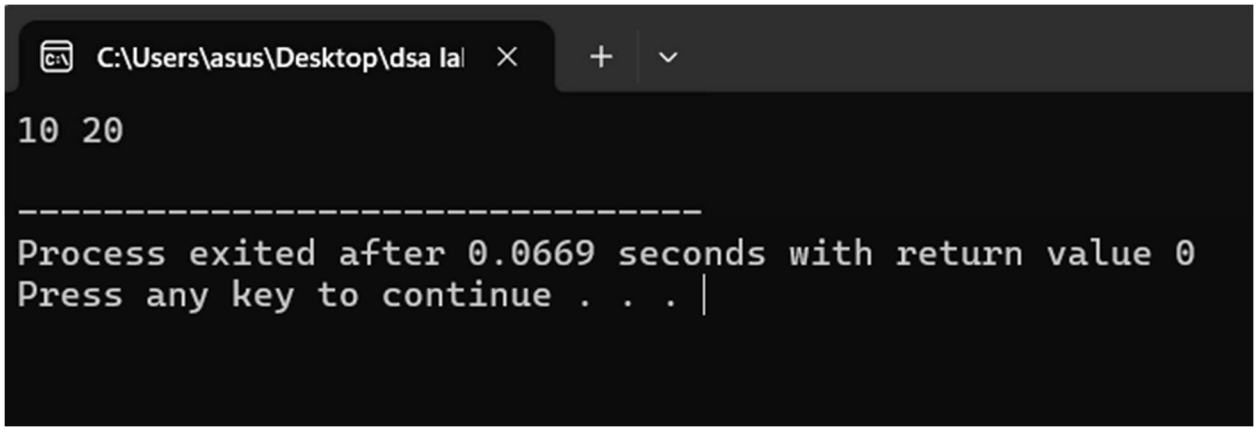
```
    if (head == nullptr) {
        return false;
    }

    Node* temp = head;
    do {
        if (temp->data == value) {
            return true;
        }
        temp = temp->next;
    } while (temp != head);

    return false;
}

int main() {
    Node* head = nullptr;

    // Example: Creating a circular linked list
    Node* newNode = new Node();
    newNode->data = 10;
    head = newNode;
    head->next = head;

    Node* second = new Node();
    second->data = 20;
    second->next = head;
    head->next = second;

    if (search(head, 20)) {
        cout << "Value found!" << endl;
    } else {
        cout << "Value not found!" << endl;
    }

    return 0;
}
```



8. Traversing

```
#include <iostream>
using namespace std;

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

void traverse(Node* head) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
    Node* temp = head;
    do {
        cout << temp->data << " ";
        temp = temp->next;
    } while (temp != head);
    cout << endl;
}

int main() {
    Node* head = nullptr;

    // Example: Creating a circular linked list
    Node* newNode = new Node();
```

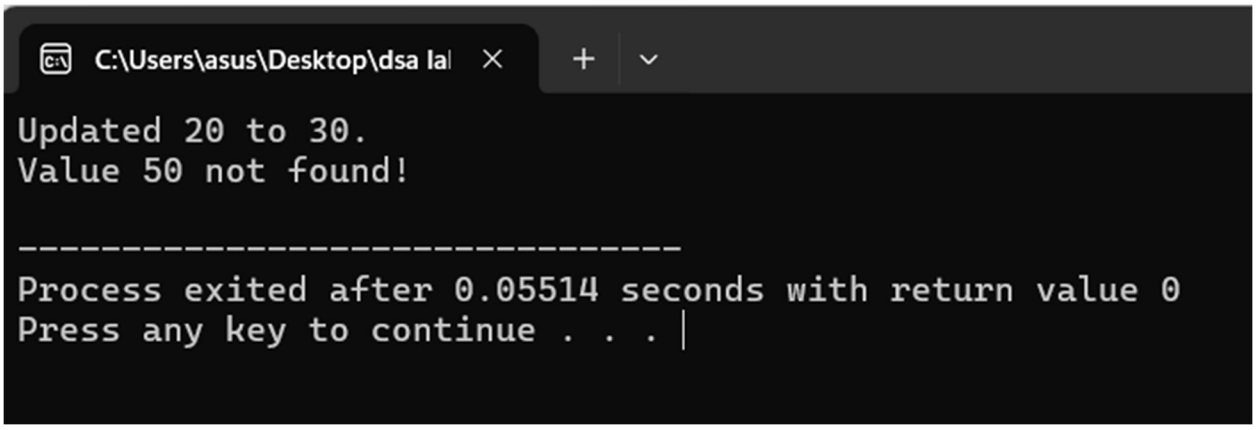
```
    newNode->data = 10;
    head = newNode;
    head->next = head;

    Node* second = new Node();
    second->data = 20;
    second->next = head;
    head->next = second;

    traverse(head);

    return 0;
}
```



9.Update

```
#include <iostream>
using namespace std;

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

void update(Node* head, int oldValue, int newValue) {
    if (head == nullptr) {
        cout << "List is empty!" << endl;
        return;
    }
```

```
    Node* temp = head;
    do {
        if (temp->data == oldValue) {
            temp->data = newValue;
            cout << "Updated " << oldValue << " to " << newValue << "." <<
endl;
            return;
        }
        temp = temp->next;
    } while (temp != head);

    cout << "Value " << oldValue << " not found!" << endl;
}

int main() {
    Node* head = nullptr;

    // Example: Creating a circular linked list
    Node* newNode = new Node();
    newNode->data = 10;
    head = newNode;
    head->next = head;

    Node* second = new Node();
    second->data = 20;
    second->next = head;
    head->next = second;

    update(head, 20, 30);
    update(head, 50, 60);

    return 0;
}
```

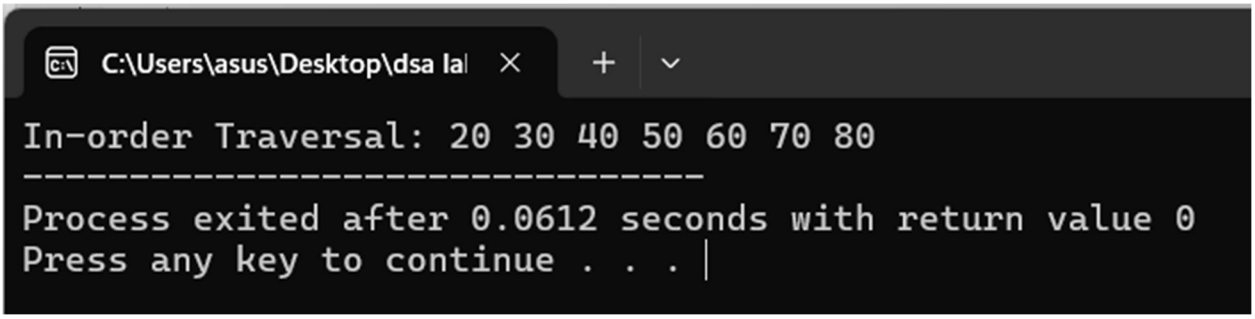


Lab 07 - Binary Search Tree (BST)

1. Insertion in Binary Search Tree

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* left;
    Node* right;
};

Node* insert(Node* root, int value) {
    if (root == nullptr) {
        root = new Node();
        root->data = value;
        root->left = root->right = nullptr;
    } else if (value < root->data) {
        root->left = insert(root->left, value);
    } else {
        root->right = insert(root->right, value);
    }
    return root;
}

void inorderTraversal(Node* root) {
    if (root == nullptr) return;
```

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

int main() {
    Node* root = nullptr;
    root = insert(root, 50);
    insert(root, 30);
    insert(root, 20);
    insert(root, 40);
    insert(root, 70);
    insert(root, 60);
    insert(root, 80);

    cout << "In-order Traversal: ";
    inorderTraversal(root);
    return 0;
}
```



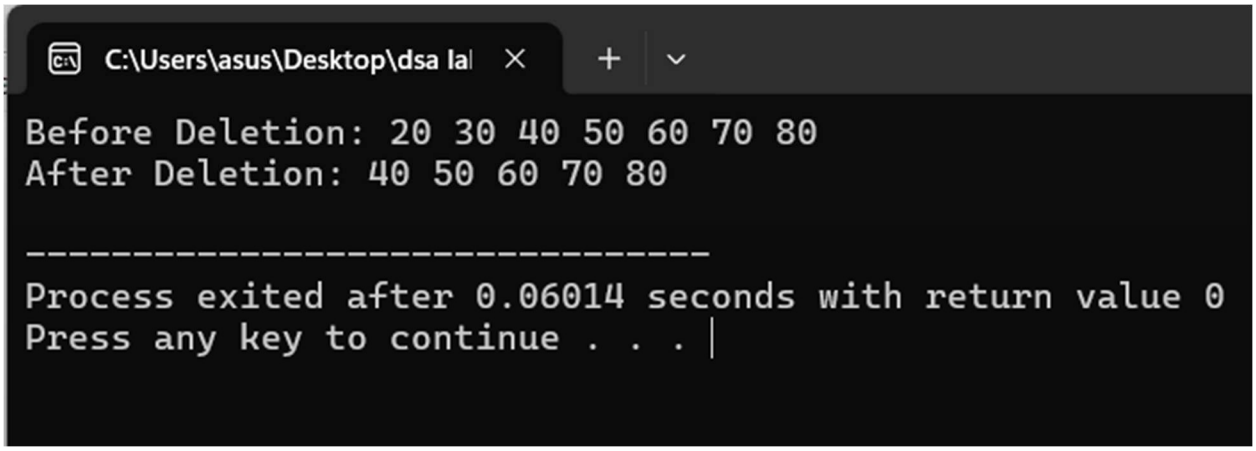
2. Deletion in Binary Search Tree

```
#include <iostream>
using namespace std;

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

    // Constructor to initialize node
    Node(int value) {
```

```
        data = value;
        left = right = nullptr;
    }
};

// Insert function for Binary Search Tree
Node* insert(Node* root, int value) {
    if (root == nullptr) {
        return new Node(value);  // Create and return a new node if root is
null
    }

    if (value < root->data) {
        root->left = insert(root->left, value);  // Insert in the left subtree
    } else {
        root->right = insert(root->right, value);  // Insert in the right subtree
    }

    return root;
}

// Find the minimum value node in a given tree
Node* findMin(Node* root) {
    while (root->left != nullptr) root = root->left;
    return root;
}

// Delete a node from the binary search tree
Node* deleteNode(Node* root, int value) {
    if (root == nullptr) return root;

    if (value < root->data) {
        root->left = deleteNode(root->left, value);  // Traverse left subtree
    } else if (value > root->data) {
        root->right = deleteNode(root->right, value);  // Traverse right subtree
    } else {
        // Node with only one child or no child
        if (root->left == nullptr) {
```

```
            Node* temp = root->right;
            delete root;
            return temp;
        } else if (root->right == nullptr) {
            Node* temp = root->left;
            delete root;
            return temp;
        }

        // Node with two children: get the inorder successor
        Node* temp = findMin(root->right);

        root->data = temp->data;  // Copy inorder successor's data to this
node

        root->right = deleteNode(root->right, temp->data);  // Delete inorder
successor
    }

    return root;
}

// In-order traversal of the binary search tree
void inorderTraversal(Node* root) {
    if (root == nullptr) return;
    inorderTraversal(root->left);
    cout << root->data << " ";
    inorderTraversal(root->right);
}

int main() {
    Node* root = nullptr;

    // Insert values into the binary search tree
    root = insert(root, 50);
    insert(root, 30);
    insert(root, 20);
    insert(root, 40);
```

```
    insert(root, 70);
    insert(root, 60);
    insert(root, 80);

    // Before Deletion
    cout << "Before Deletion: ";
    inorderTraversal(root);
    cout << endl;

    // Delete nodes
    root = deleteNode(root, 20);  // Delete node with value 20
    root = deleteNode(root, 30);  // Delete node with value 30

    // After Deletion
    cout << "After Deletion: ";
    inorderTraversal(root);
    cout << endl;

    return 0;
}
```



3. Searching in Binary Search Tree

```
#include <iostream>
using namespace std;

struct Node {
    int data;
    Node* left;
```

```
    Node* right;

    // Constructor to initialize node
    Node(int value) {
        data = value;
        left = right = nullptr;
    }
};

// Insert function for Binary Search Tree
Node* insert(Node* root, int value) {
    if (root == nullptr) {
        return new Node(value);  // Create and return a new node if root is
null
    }

    if (value < root->data) {
        root->left = insert(root->left, value);  // Insert in the left subtree
    } else {
        root->right = insert(root->right, value);  // Insert in the right subtree
    }

    return root;
}

// Search function for Binary Search Tree
bool search(Node* root, int value) {
    if (root == nullptr) return false;  // Base case: if root is null, value is not
found
    if (root->data == value) return true;  // If root's data matches the value,
return true

    if (value < root->data) {
        return search(root->left, value);  // Search in the left subtree
    } else {
        return search(root->right, value);  // Search in the right subtree
    }
}
```

```
int main() {
    Node* root = nullptr;

    // Insert values into the binary search tree
    root = insert(root, 50);
    insert(root, 30);
    insert(root, 20);
    insert(root, 40);
    insert(root, 70);
    insert(root, 60);
    insert(root, 80);

    // Perform search operations
    cout << "Searching for 40: " << (search(root, 40) ? "Found" : "Not Found")
<< endl;
    cout << "Searching for 100: " << (search(root, 100) ? "Found" : "Not
Found") << endl;

    return 0;
}
```