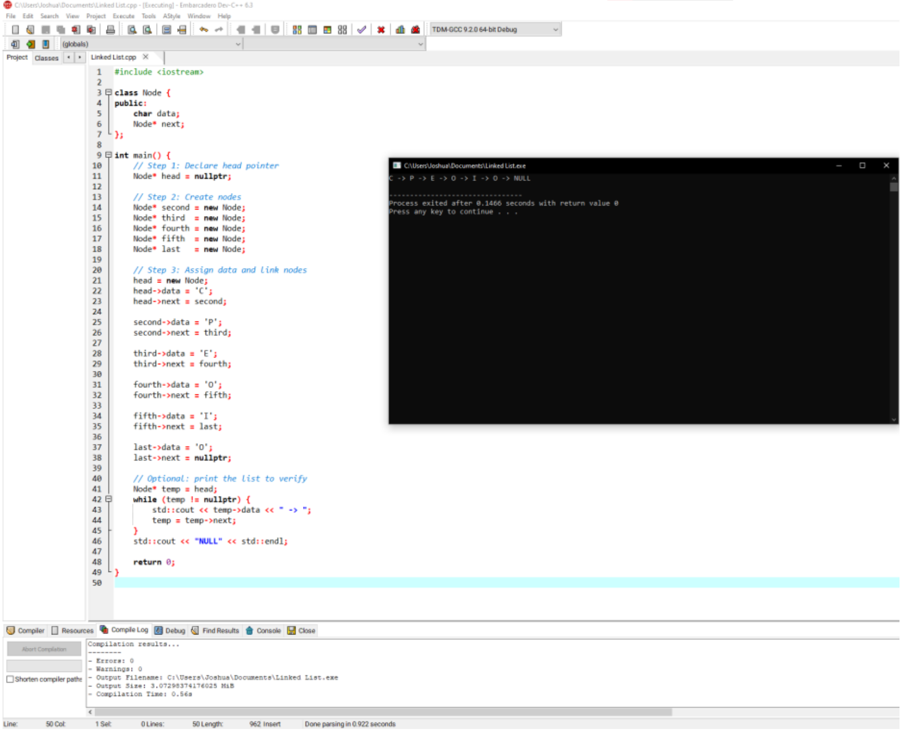
Activity No. <3>	
<Hands-on Activity 3.1 Linked Lists>	
Course Code: CPE010	**Program:** Computer Engineering
Course Title: Data Structures and Algorithms	**Date Performed: 8/14/25**
Section: CPE21S4	**Date Submitted: 8/14/25**
Name(s): Alcantara, Jason P.	**Instructor: Engr. Jimlord Quejado**

6. Output:



```cpp
#include <iostream>

class Node {
public:
    char data;
    Node* next;
};

int main() {
    // Step 1: Declare head pointer
    Node* head = nullptr;

    // Step 2: Create nodes
    Node* second = new Node;
    Node* third  = new Node;
    Node* fourth = new Node;
    Node* fifth  = new Node;
    Node* last   = new Node;

    // Step 3: Assign data and link nodes
    head = new Node;
    head->data = 'C';
    head->next = second;

    second->data = 'P';
    second->next = third;

    third->data = 'E';
    third->next = fourth;

    fourth->data = 'O';
    fourth->next = fifth;

    fifth->data = 'I';
    fifth->next = last;

    last->data = 'O';
    last->next = nullptr;

    // Optional: print the list to verify
    Node* temp = head;
    while (temp != nullptr) {
        std::cout << temp->data << " -> ";
        temp = temp->next;
    }
    std::cout << "NULL" << std::endl;

    return 0;
}
```

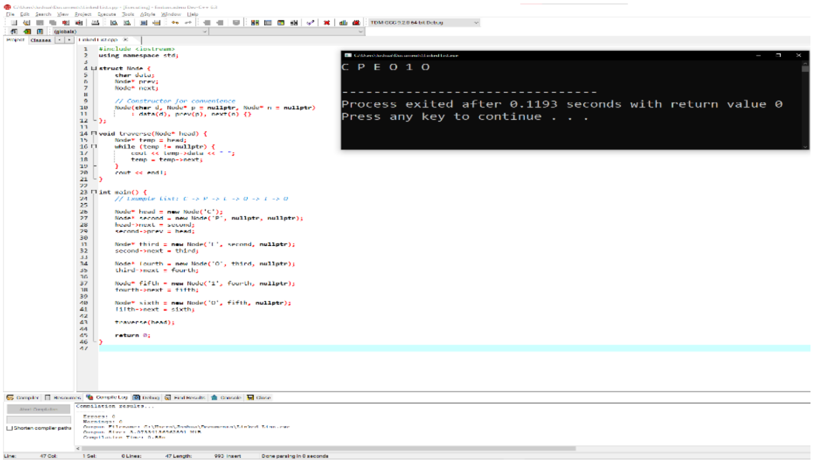
```
C -> P -> E -> O -> I -> O -> NULL

--------------------------------
Process exited after 0.1466 seconds with return value 0
Press any key to continue . . .
```

```
Compilation results...
--------
- Errors: 0
- Warnings: 0
- Output Filename: C:\Users\Joshua\Documents\Linked List.exe
- Output Size: 3.07298374176025 MiB
- Compilation Time: 0.56s
```

Discussion: I implemented linked list where I can store characters and display it on a sequence order by linking the nodes correctly.

Operation:

Traversal:

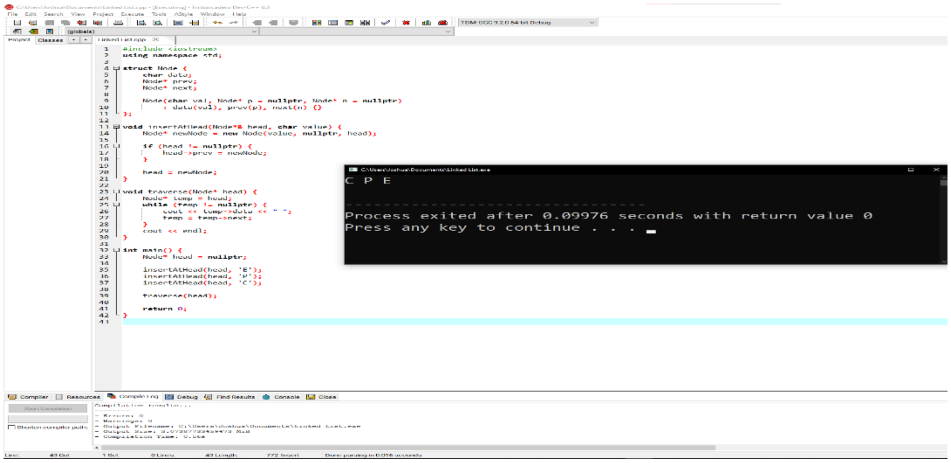


```cpp
#include <iostream>
using namespace std;

struct Node {
    char data;
    Node* prev;
    Node* next;

    // Constructor for convenience
    Node(char d, Node* p = nullptr, Node* n = nullptr)
        : data(d), prev(p), next(n) {}
};

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    // Example List: C -> P -> E -> O -> I -> O

    Node* head = new Node('C');
    Node* second = new Node('P', nullptr, nullptr);
    head->next = second;
    second->prev = head;

    Node* third = new Node('E', second, nullptr);
    second->next = third;

    Node* fourth = new Node('O', third, nullptr);
    third->next = fourth;

    Node* fifth = new Node('1', fourth, nullptr);
    fourth->next = fifth;

    Node* sixth = new Node('O', fifth, nullptr);
    fifth->next = sixth;

    traverse(head);

    return 0;
}
```

```
C P E O 1 O

--------------------------------
Process exited after 0.1193 seconds with return value 0
Press any key to continue . . .
```

```
Compilation results...
--------
- Errors: 0
- Warnings: 0
- Output Filename: C:\Users\Joshua\Documents\Linked List.exe
- Output Size: [illegible] MiB
- Compilation Time: 0.88s
```

Insertion at Head:

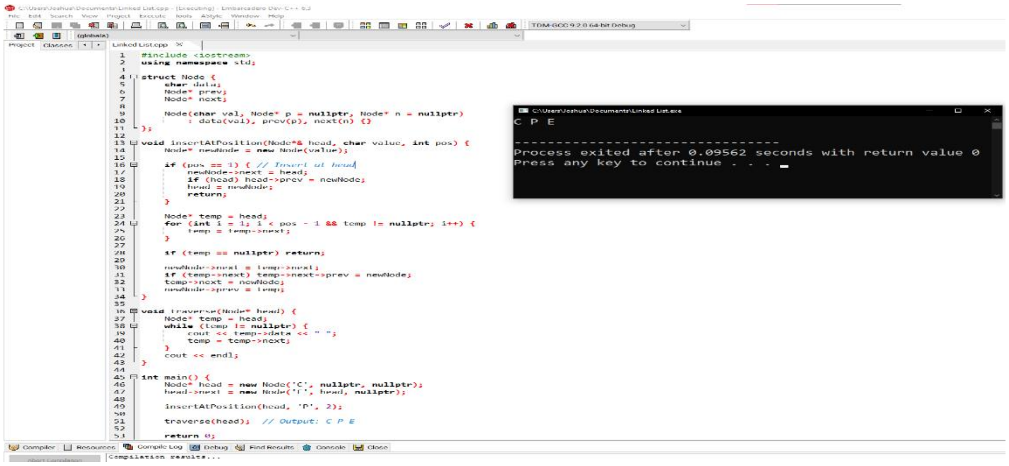


```cpp
#include <iostream>
using namespace std;

struct Node {
    char data;
    Node* prev;
    Node* next;

    Node(char val, Node* p = nullptr, Node* n = nullptr)
        : data(val), prev(p), next(n) {}
};

void insertAtHead(Node*& head, char value) {
    Node* newNode = new Node(value, nullptr, head);

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

    head = newNode;
}

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    Node* head = nullptr;

    insertAtHead(head, 'E');
    insertAtHead(head, 'P');
    insertAtHead(head, 'C');

    traverse(head);

    return 0;
}
```

```
C P E

--------------------------------
Process exited after 0.09976 seconds with return value 0
Press any key to continue . . .
```

```
Compilation results...
--------
- Errors: 0
- Warnings: 0
- Output Filename: C:\Users\Joshua\Documents\Linked List.exe
- Output Size: 3.07307732458473 MiB
- Compilation Time: 0.56s
```

Insertion at the end:

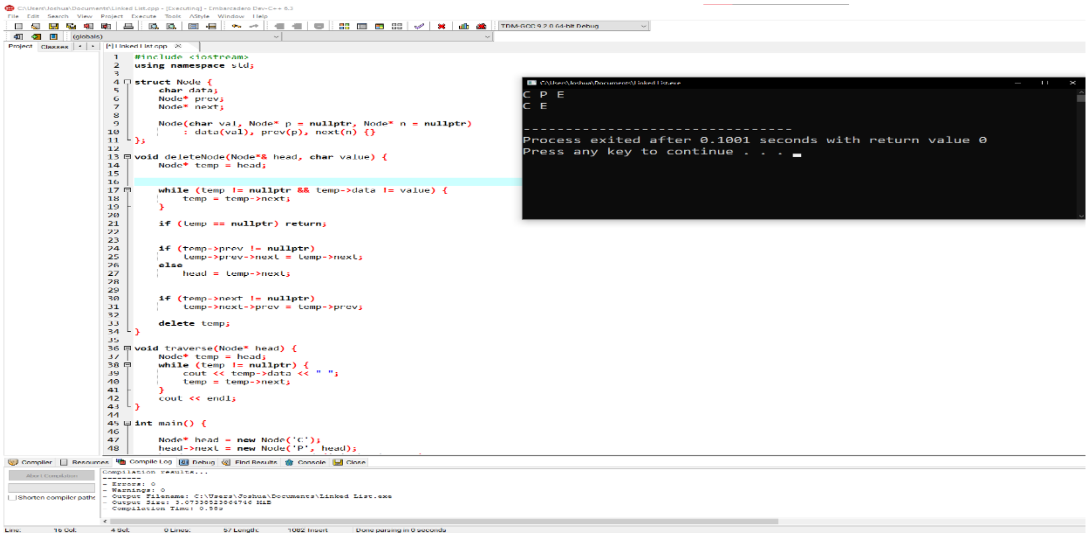


```cpp
#include <iostream>
using namespace std;

struct Node {
    char data;
    Node* prev;
    Node* next;

    Node(char val, Node* p = nullptr, Node* n = nullptr)
        : data(val), prev(p), next(n) {}
};

void insertAtPosition(Node*& head, char value, int pos) {
    Node* newNode = new Node(value);

    if (pos == 1) { // Insert at head
        newNode->next = head;
        if (head) head->prev = newNode;
        head = newNode;
        return;
    }

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

    if (temp == nullptr) return;

    newNode->next = temp->next;
    if (temp->next) temp->next->prev = newNode;
    temp->next = newNode;
    newNode->prev = temp;
}

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    Node* head = new Node('C', nullptr, nullptr);
    head->next = new Node('E', head, nullptr);

    insertAtPosition(head, 'P', 2);

    traverse(head);  // Output: C P E

    return 0;
```

```
C P E

--------------------------------
Process exited after 0.09562 seconds with return value 0
Press any key to continue . . .
```

```
Compilation results...
```

Deletion of a node:

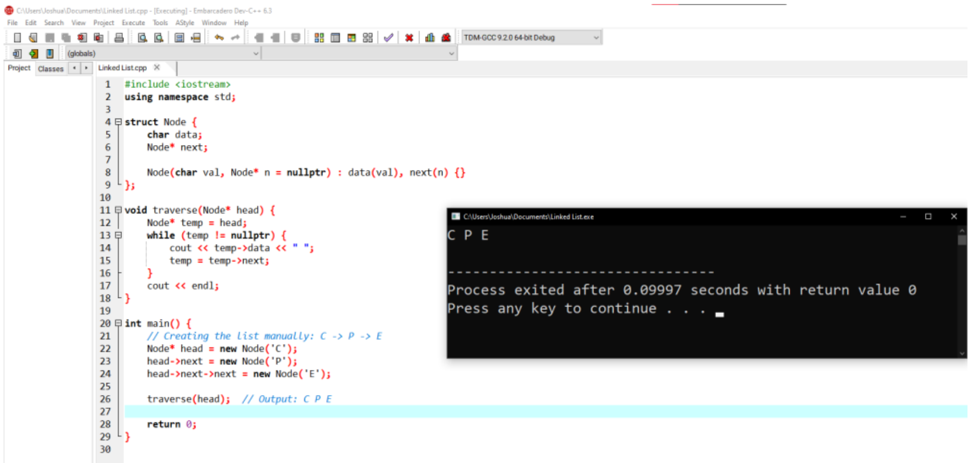


```cpp
#include <iostream>
using namespace std;

struct Node {
    char data;
    Node* prev;
    Node* next;

    Node(char val, Node* p = nullptr, Node* n = nullptr)
        : data(val), prev(p), next(n) {}
};

void deleteNode(Node*& head, char value) {
    Node* temp = head;


    while (temp != nullptr && temp->data != value) {
        temp = temp->next;
    }

    if (temp == nullptr) return;


    if (temp->prev != nullptr)
        temp->prev->next = temp->next;
    else
        head = temp->next;


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

    delete temp;
}

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {

    Node* head = new Node('C');
    head->next = new Node('P', head);
```

```
C P E
C E

--------------------------------
Process exited after 0.1001 seconds with return value 0
Press any key to continue . . .
```

```
Compilation results...
--------
- Errors: 0
- Warnings: 0
- Output Filename: C:\Users\Joshua\Documents\Linked List.exe
- Output Size: 3.07330523064746 MiB
- Compilation Time: 0.56s
```

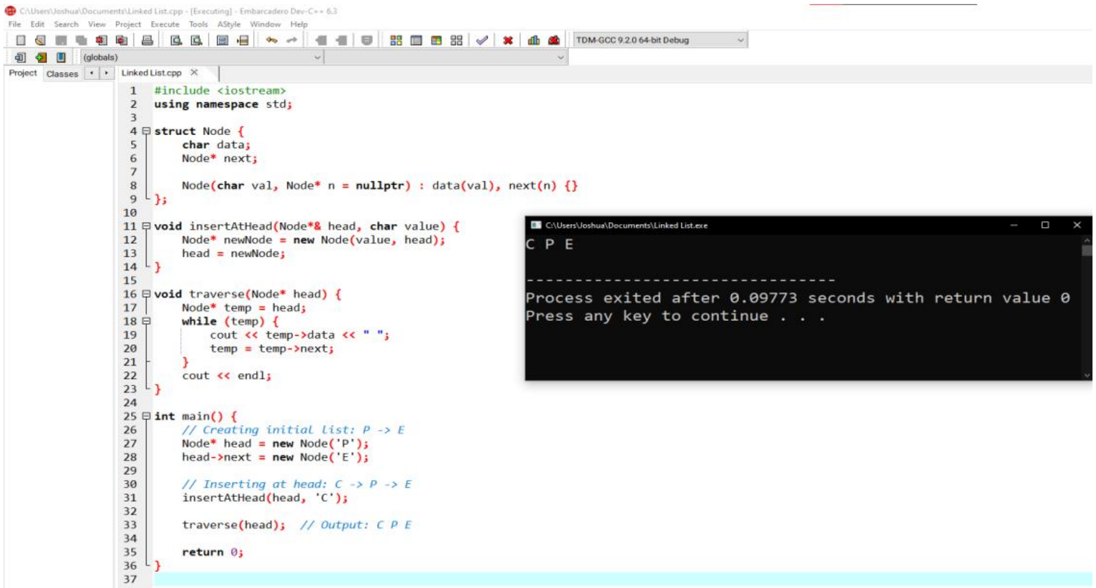
Source Code:


C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
C:\Users\Joshua\Documents\Linked List.exe

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

struct Node {
    char data;
    Node* next;

    Node(char val, Node* n = nullptr) : data(val), next(n) {}
};

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    // Creating the list manually: C -> P -> E
    Node* head = new Node('C');
    head->next = new Node('P');
    head->next->next = new Node('E');

    traverse(head);  // Output: C P E

    return 0;
}

```

```
C P E

--------------------------------
Process exited after 0.09997 seconds with return value 0
Press any key to continue . . .
```

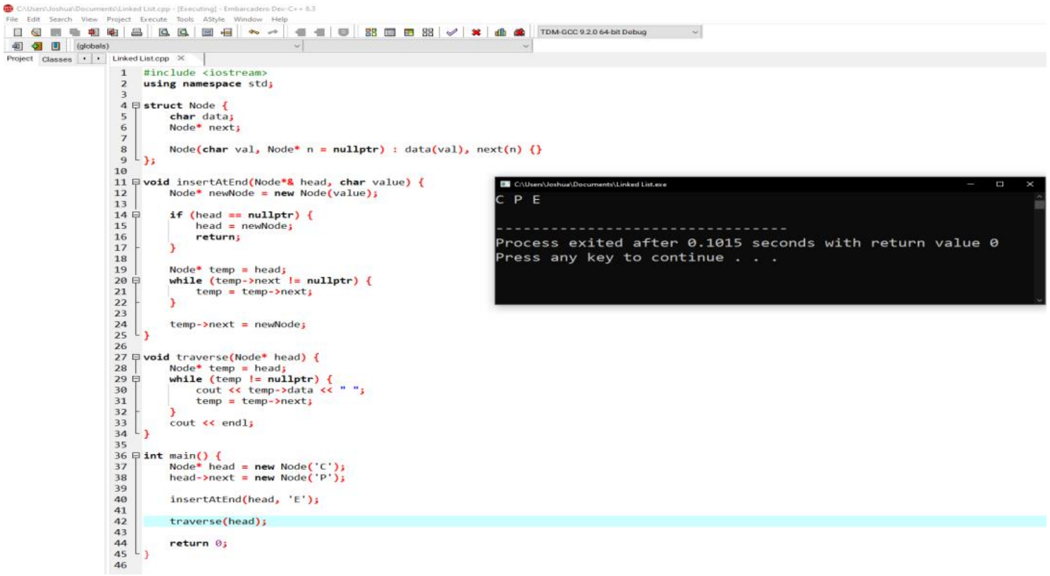
Source Code:


C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
C:\Users\Joshua\Documents\Linked List.exe

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

struct Node {
    char data;
    Node* next;

    Node(char val, Node* n = nullptr) : data(val), next(n) {}
};

void insertAtHead(Node*& head, char value) {
    Node* newNode = new Node(value, head);
    head = newNode;
}

void traverse(Node* head) {
    Node* temp = head;
    while (temp) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    // Creating initial list: P -> E
    Node* head = new Node('P');
    head->next = new Node('E');

    // Inserting at head: C -> P -> E
    insertAtHead(head, 'C');

    traverse(head);  // Output: C P E

    return 0;
}

```

```
C P E

--------------------------------
Process exited after 0.09773 seconds with return value 0
Press any key to continue . . .
```

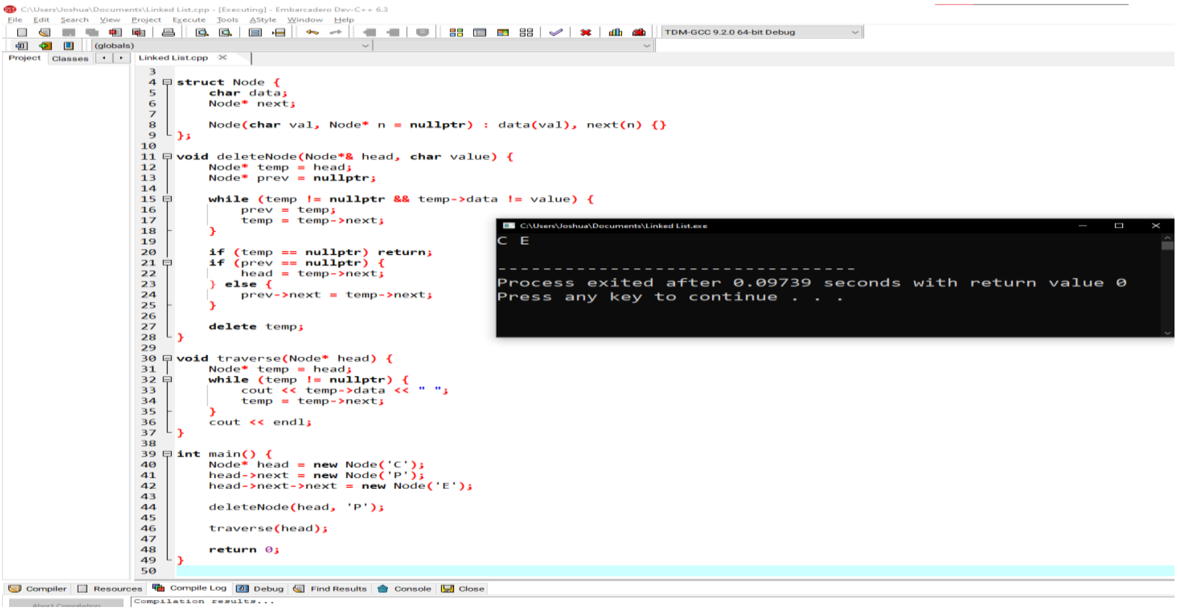
Source Code:


C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
C:\Users\Joshua\Documents\Linked List.exe

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

struct Node {
    char data;
    Node* next;

    Node(char val, Node* n = nullptr) : data(val), next(n) {}
};

void insertAtEnd(Node*& head, char value) {
    Node* newNode = new Node(value);

    if (head == nullptr) {
        head = newNode;
        return;
    }

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

    temp->next = newNode;
}

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    Node* head = new Node('C');
    head->next = new Node('P');

    insertAtEnd(head, 'E');

    traverse(head);

    return 0;
}

```

```
C P E

--------------------------------
Process exited after 0.1015 seconds with return value 0
Press any key to continue . . .
```

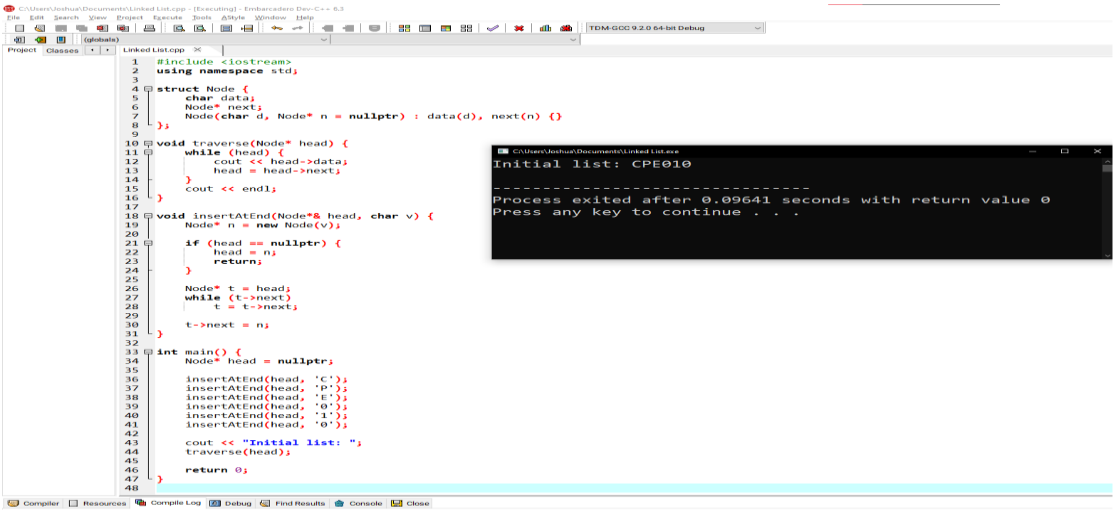
Source Code:



```cpp
struct Node {
    char data;
    Node* next;

    Node(char val, Node* n = nullptr) : data(val), next(n) {}
};

void deleteNode(Node*& head, char value) {
    Node* temp = head;
    Node* prev = nullptr;

    while (temp != nullptr && temp->data != value) {
        prev = temp;
        temp = temp->next;
    }

    if (temp == nullptr) return;
    if (prev == nullptr) {
        head = temp->next;
    } else {
        prev->next = temp->next;
    }

    delete temp;
}

void traverse(Node* head) {
    Node* temp = head;
    while (temp != nullptr) {
        cout << temp->data << " ";
        temp = temp->next;
    }
    cout << endl;
}

int main() {
    Node* head = new Node('C');
    head->next = new Node('P');
    head->next->next = new Node('E');

    deleteNode(head, 'P');

    traverse(head);

    return 0;
}
```

```
C E

--------------------------------
Process exited after 0.09739 seconds with return value 0
Press any key to continue . . .
```

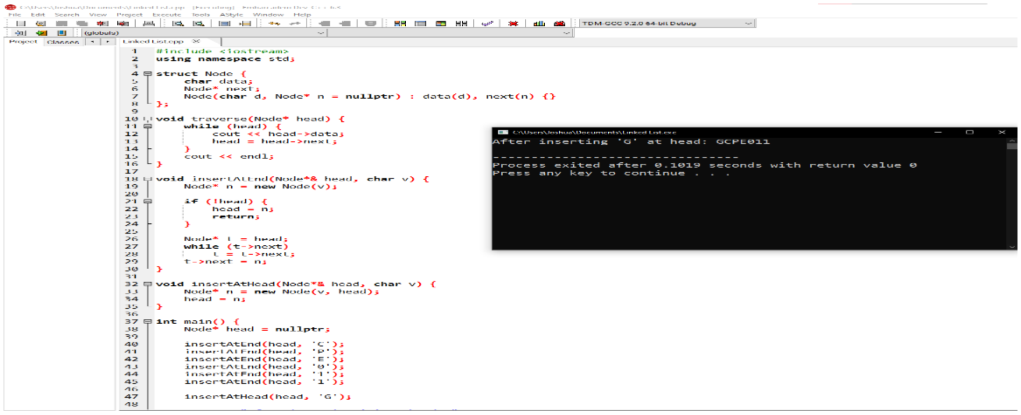
Table 3-3. Code and Analysis for Singly Linked Lists



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

struct Node {
    char data;
    Node* next;
    Node(char d, Node* n = nullptr) : data(d), next(n) {}
};

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

void insertAtEnd(Node*& head, char v) {
    Node* n = new Node(v);

    if (head == nullptr) {
        head = n;
        return;
    }

    Node* t = head;
    while (t->next)
        t = t->next;

    t->next = n;
}

int main() {
    Node* head = nullptr;

    insertAtEnd(head, 'C');
    insertAtEnd(head, 'P');
    insertAtEnd(head, 'E');
    insertAtEnd(head, '0');
    insertAtEnd(head, '1');
    insertAtEnd(head, '0');

    cout << "Initial list: ";
    traverse(head);

    return 0;
}
```

```
Initial list: CPE010

--------------------------------
Process exited after 0.09641 seconds with return value 0
Press any key to continue . . .
```

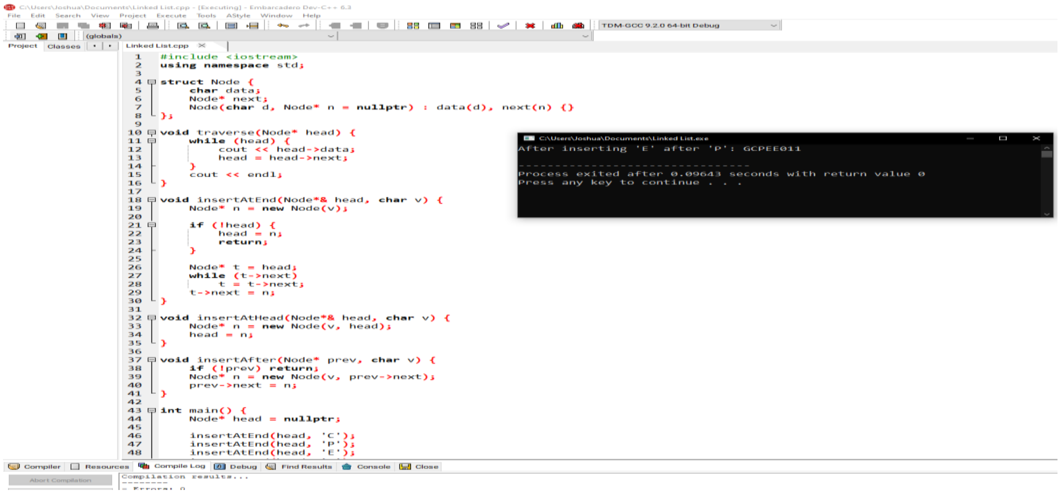
Analysis:
Traversing the list by making the head pointer pass. Function walks from node to node and prints the stored characters.



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

struct Node {
    char data;
    Node* next;
    Node(char d, Node* n = nullptr) : data(d), next(n) {}
};

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

void insertAtEnd(Node*& head, char v) {
    Node* n = new Node(v);

    if (!head) {
        head = n;
        return;
    }

    Node* t = head;
    while (t->next)
        t = t->next;
    t->next = n;
}

void insertAtHead(Node*& head, char v) {
    Node* n = new Node(v, head);
    head = n;
}

int main() {
    Node* head = nullptr;

    insertAtEnd(head, 'C');
    insertAtEnd(head, 'P');
    insertAtEnd(head, 'E');
    insertAtEnd(head, '0');
    insertAtEnd(head, '1');
    insertAtEnd(head, '1');

    insertAtHead(head, 'G');
```

```
After inserting 'G' at head: GCPE011

--------------------------------
Process exited after 0.1019 seconds with return value 0
Press any key to continue . . .
```

Analysis: **Insert a head creates a new node wherein next points to the previous head, then reassigns head.**



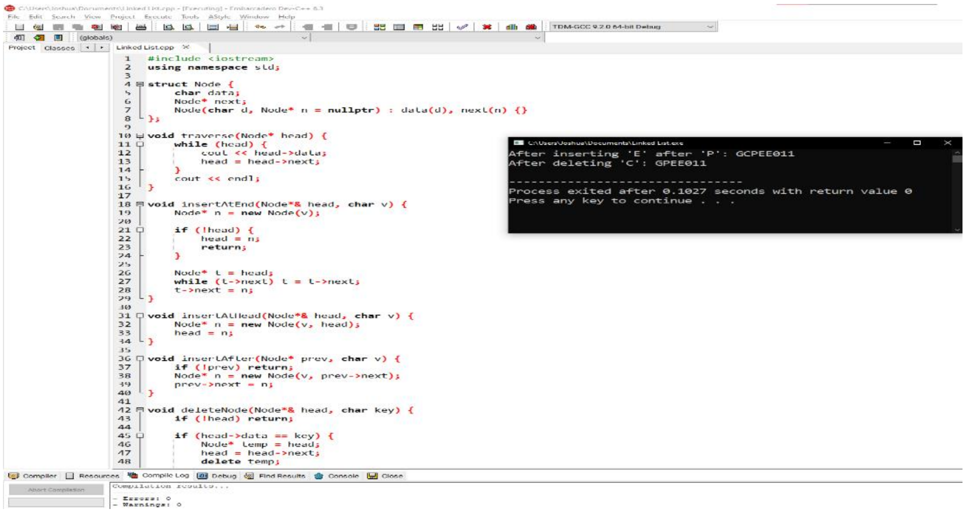
C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
Compiler Resources Compile Log Debug Find Results Console Close
Abort Compilation

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

struct Node {
    char data;
    Node* next;
    Node(char d, Node* n = nullptr) : data(d), next(n) {}
};

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

void insertAtEnd(Node*& head, char v) {
    Node* n = new Node(v);

    if (!head) {
        head = n;
        return;
    }

    Node* t = head;
    while (t->next)
        t = t->next;
    t->next = n;
}

void insertAtHead(Node*& head, char v) {
    Node* n = new Node(v, head);
    head = n;
}

void insertAfter(Node* prev, char v) {
    if (!prev) return;
    Node* n = new Node(v, prev->next);
    prev->next = n;
}

int main() {
    Node* head = nullptr;

    insertAtEnd(head, 'C');
    insertAtEnd(head, 'P');
    insertAtEnd(head, 'E');
```

```
Compilation results...
--------
- Errors: 0
```

```
After inserting 'E' after 'P': GCPEE011

--------------------------------
Process exited after 0.09643 seconds with return value 0
Press any key to continue . . .
```

Analysis: It finds node “P”, allocate new node and adjust the next pointers.



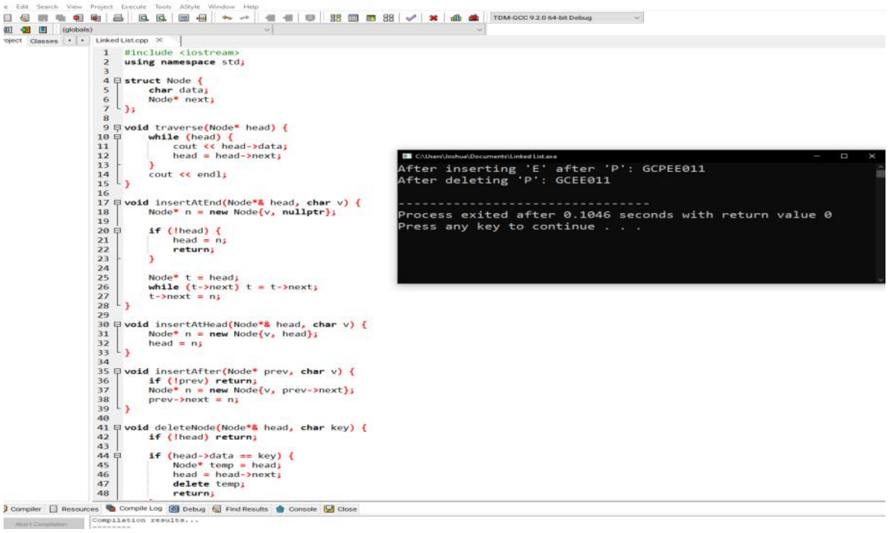
C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
Compiler Resources Compile Log Debug Find Results Console Close
Abort Compilation

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

struct Node {
    char data;
    Node* next;
    Node(char d, Node* n = nullptr) : data(d), next(n) {}
};

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

void insertAtEnd(Node*& head, char v) {
    Node* n = new Node(v);

    if (!head) {
        head = n;
        return;
    }

    Node* t = head;
    while (t->next) t = t->next;
    t->next = n;
}

void insertAtHead(Node*& head, char v) {
    Node* n = new Node(v, head);
    head = n;
}

void insertAfter(Node* prev, char v) {
    if (!prev) return;
    Node* n = new Node(v, prev->next);
    prev->next = n;
}

void deleteNode(Node*& head, char key) {
    if (!head) return;

    if (head->data == key) {
        Node* temp = head;
        head = head->next;
        delete temp;
```

```
Compilation results...
--------
- Errors: 0
- Warnings: 0
```

```
After inserting 'E' after 'P': GCPEE011
After deleting 'C': GPEE011

--------------------------------
Process exited after 0.1027 seconds with return value 0
Press any key to continue . . .
```

Analysis: Delete a node by locating the node before the desired target. Changing its next to skip the target node.



Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
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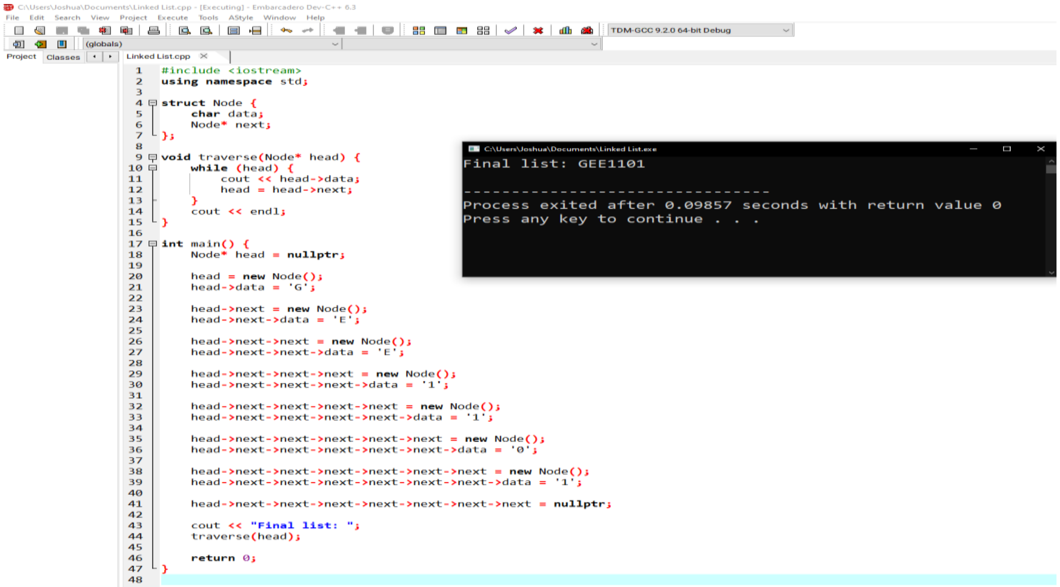
Compiler Resources Compile Log Debug Find Results Console Close
Abort Compilation

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

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

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

void insertAtEnd(Node*& head, char v) {
    Node* n = new Node{v, nullptr};

    if (!head) {
        head = n;
        return;
    }

    Node* t = head;
    while (t->next) t = t->next;
    t->next = n;
}

void insertAtHead(Node*& head, char v) {
    Node* n = new Node{v, head};
    head = n;
}

void insertAfter(Node* prev, char v) {
    if (!prev) return;
    Node* n = new Node{v, prev->next};
    prev->next = n;
}

void deleteNode(Node*& head, char key) {
    if (!head) return;

    if (head->data == key) {
        Node* temp = head;
        head = head->next;
        delete temp;
        return;
```

```
Compilation results...
--------
```

```
After inserting 'E' after 'P': GCPEE011
After deleting 'P': GCEE011

--------------------------------
Process exited after 0.1046 seconds with return value 0
Press any key to continue . . .
```

Analysis: Applying deletion again to remove “P”.

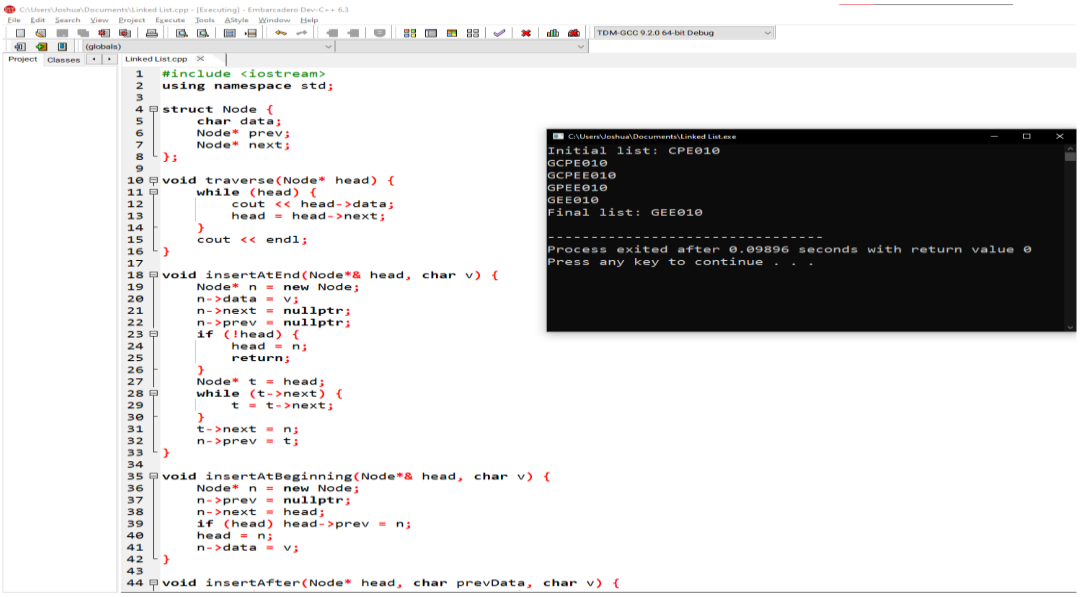

C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
C:\Users\Joshua\Documents\Linked List.exe

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

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

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

int main() {
    Node* head = nullptr;

    head = new Node();
    head->data = 'G';

    head->next = new Node();
    head->next->data = 'E';

    head->next->next = new Node();
    head->next->next->data = 'E';

    head->next->next->next = new Node();
    head->next->next->next->data = '1';

    head->next->next->next->next = new Node();
    head->next->next->next->next->data = '1';

    head->next->next->next->next->next = new Node();
    head->next->next->next->next->next->data = '0';

    head->next->next->next->next->next->next = new Node();
    head->next->next->next->next->next->next->data = '1';

    head->next->next->next->next->next->next->next = nullptr;

    cout << "Final list: ";
    traverse(head);

    return 0;
}
```

```
Final list: GEE1101

--------------------------------
Process exited after 0.09857 seconds with return value 0
Press any key to continue . . .
```

Analysis: Displaying the result after all operations.

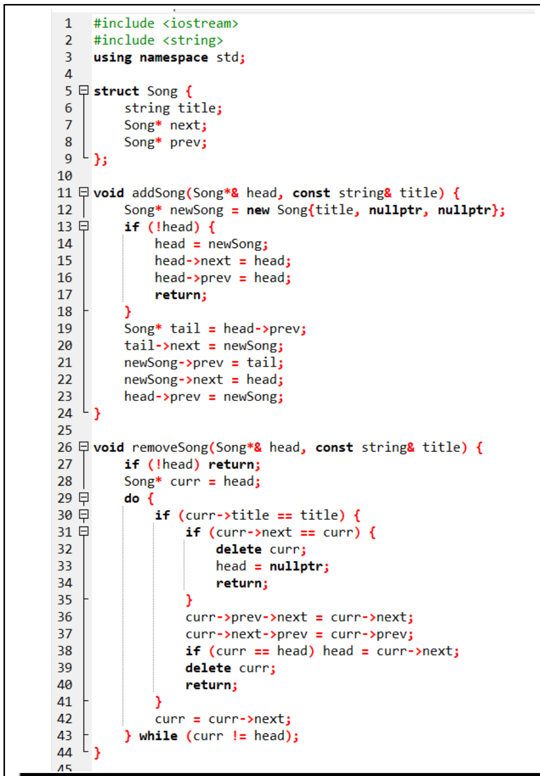
Table 3-4. Modified Operations for Doubly Linked Lists


C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
TDM-GCC 9.2.0 64-bit Debug
(globals)
Project Classes
Linked List.cpp
C:\Users\Joshua\Documents\Linked List.exe

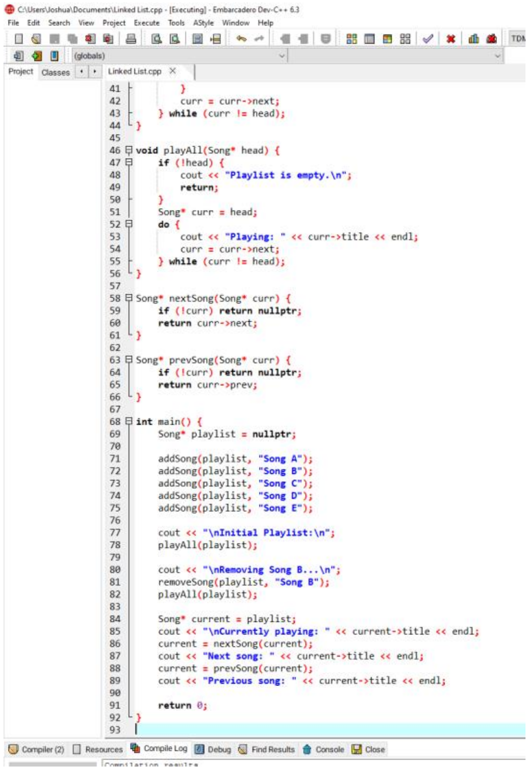
```cpp
#include <iostream>
using namespace std;

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

void traverse(Node* head) {
    while (head) {
        cout << head->data;
        head = head->next;
    }
    cout << endl;
}

void insertAtEnd(Node*& head, char v) {
    Node* n = new Node;
    n->data = v;
    n->next = nullptr;
    n->prev = nullptr;
    if (!head) {
        head = n;
        return;
    }
    Node* t = head;
    while (t->next) {
        t = t->next;
    }
    t->next = n;
    n->prev = t;
}

void insertAtBeginning(Node*& head, char v) {
    Node* n = new Node;
    n->prev = nullptr;
    n->next = head;
    if (head) head->prev = n;
    head = n;
    n->data = v;
}

void insertAfter(Node* head, char prevData, char v) {
```

```
Initial list: CPE010
GCPE010
GCPEE010
GPEE010
GEE010
Final list: GEE010

--------------------------------
Process exited after 0.09896 seconds with return value 0
Press any key to continue . . .
```

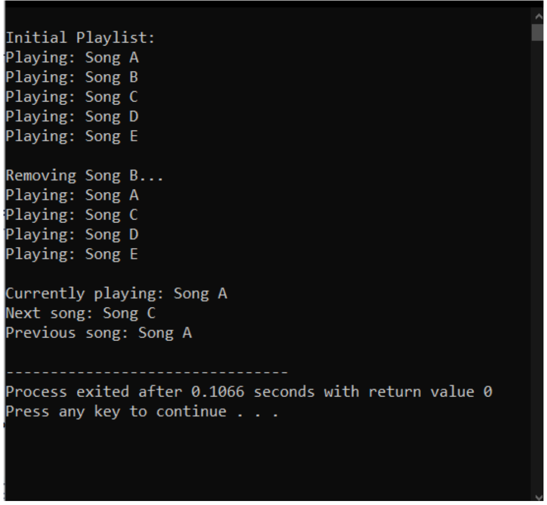
7. Supplementary Activity:



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

struct Song {
    string title;
    Song* next;
    Song* prev;
};

void addSong(Song*& head, const string& title) {
    Song* newSong = new Song{title, nullptr, nullptr};
    if (!head) {
        head = newSong;
        head->next = head;
        head->prev = head;
        return;
    }
    Song* tail = head->prev;
    tail->next = newSong;
    newSong->prev = tail;
    newSong->next = head;
    head->prev = newSong;
}

void removeSong(Song*& head, const string& title) {
    if (!head) return;
    Song* curr = head;
    do {
        if (curr->title == title) {
            if (curr->next == curr) {
                delete curr;
                head = nullptr;
                return;
            }
            curr->prev->next = curr->next;
            curr->next->prev = curr->prev;
            if (curr == head) head = curr->next;
            delete curr;
            return;
        }
        curr = curr->next;
    } while (curr != head);
}
```


C:\Users\Joshua\Documents\Linked List.cpp - [Executing] - Embarcadero Dev-C++ 6.3
File Edit Search View Project Execute Tools AStyle Window Help
(globals)
Project Classes
Linked List.cpp
Compiler (2) Resources Compile Log Debug Find Results Console Close
Compilation results

```cpp
        }
        curr = curr->next;
    } while (curr != head);
}

void playAll(Song* head) {
    if (!head) {
        cout << "Playlist is empty.\n";
        return;
    }
    Song* curr = head;
    do {
        cout << "Playing: " << curr->title << endl;
        curr = curr->next;
    } while (curr != head);
}

Song* nextSong(Song* curr) {
    if (!curr) return nullptr;
    return curr->next;
}

Song* prevSong(Song* curr) {
    if (!curr) return nullptr;
    return curr->prev;
}

int main() {
    Song* playlist = nullptr;

    addSong(playlist, "Song A");
    addSong(playlist, "Song B");
    addSong(playlist, "Song C");
    addSong(playlist, "Song D");
    addSong(playlist, "Song E");

    cout << "\nInitial Playlist:\n";
    playAll(playlist);

    cout << "\nRemoving Song B...\n";
    removeSong(playlist, "Song B");
    playAll(playlist);

    Song* current = playlist;
    cout << "\nCurrently playing: " << current->title << endl;
    current = nextSong(current);
    cout << "Next song: " << current->title << endl;
    current = prevSong(current);
    cout << "Previous song: " << current->title << endl;

    return 0;
}
```



```
Initial Playlist:
Playing: Song A
Playing: Song B
Playing: Song C
Playing: Song D
Playing: Song E

Removing Song B...
Playing: Song A
Playing: Song C
Playing: Song D
Playing: Song E

Currently playing: Song A
Next song: Song C
Previous song: Song A

--------------------------------
Process exited after 0.1066 seconds with return value 0
Press any key to continue . . .
```

8. Conclusion: In this activity 3.1 Linked Lists, I understand how to revise the single linked lists with connection to doubly linked lists, which gave us an idea how did pointers work. We need to be careful in moving to the next and previous pointers. In general I need to study and learn more to improve my skills to organize my codes just to look clean and neat so it that it can understand it easily.

9. Assessment Rubric