LAPORAN PRAKTIKUM
STRUKTUR DATA

MODUL 11
MULTI LINKED LIST

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Dosen
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PROGRAM STUDI STRUKTUR DATA
FAKULTAS INFORMATIKA
TELKOM UNIVERSITY PURWOKERTO
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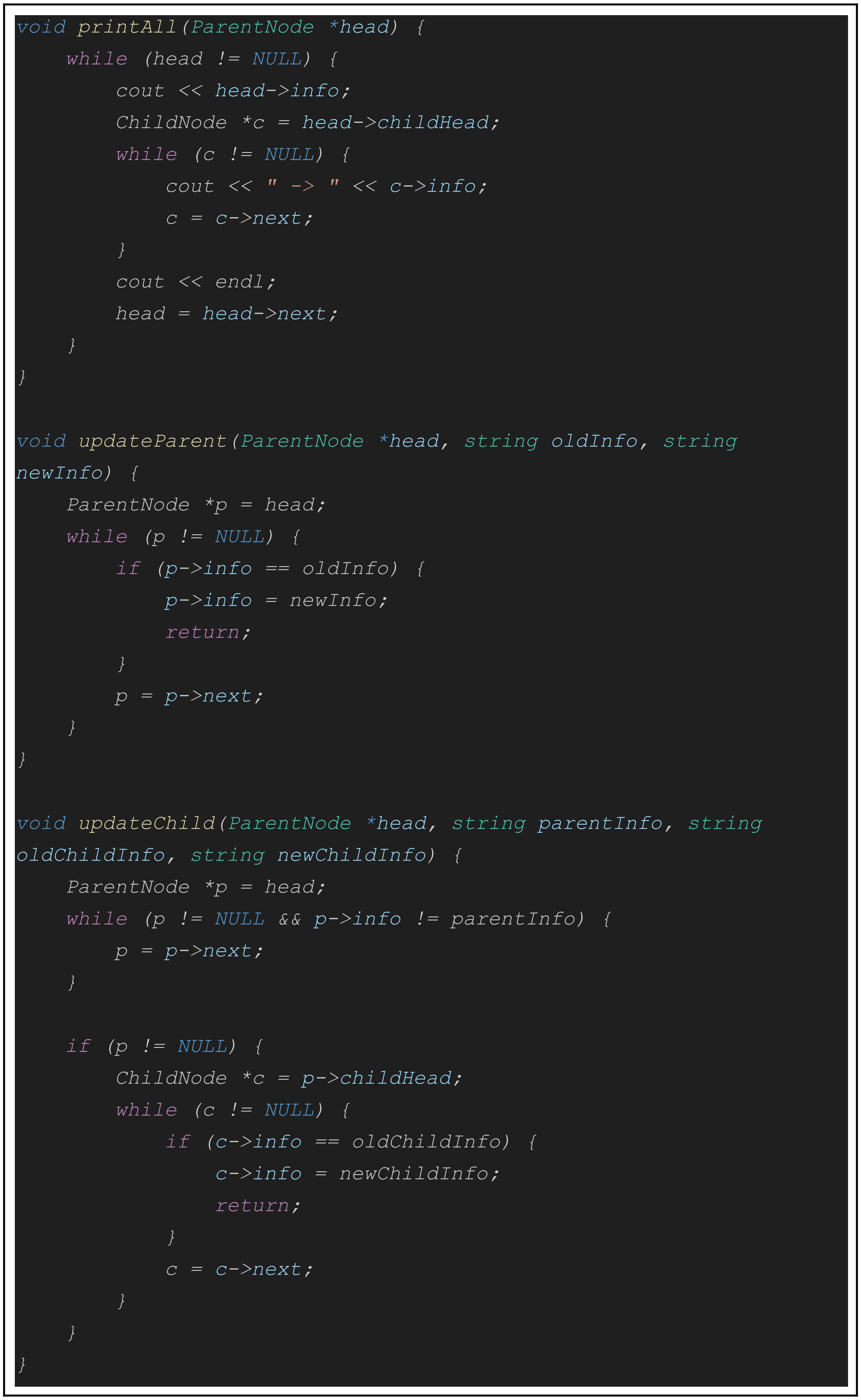
A. Dasar Teori

Multi Linked List adalah struktur data kompleks yang mengatur kumpulan linked list yang saling terhubung, umumnya terdiri dari list induk (parent list) dan list anak (child list). . Setiap elemen pada list induk dapat menunjuk ke sebuah list anak yang terpisah. Operasi pada list induk mirip dengan linked list biasa, namun operasi pada list anak membutuhkan penentuan posisi elemen induk terlebih dahulu. Karakteristik penting dari struktur ini adalah aturan penghapusan: penghapusan elemen induk harus diikuti dengan penghapusan otomatis seluruh elemen anak yang terhubung dengannya. Implementasinya sering menggunakan struct untuk elemen induk dan anak, umumnya diwakili sebagai Doubly Linked List untuk memudahkan navigasi (next dan prev).

B. Guided (berisi screenshot source code & output program disertai penjelasannya)

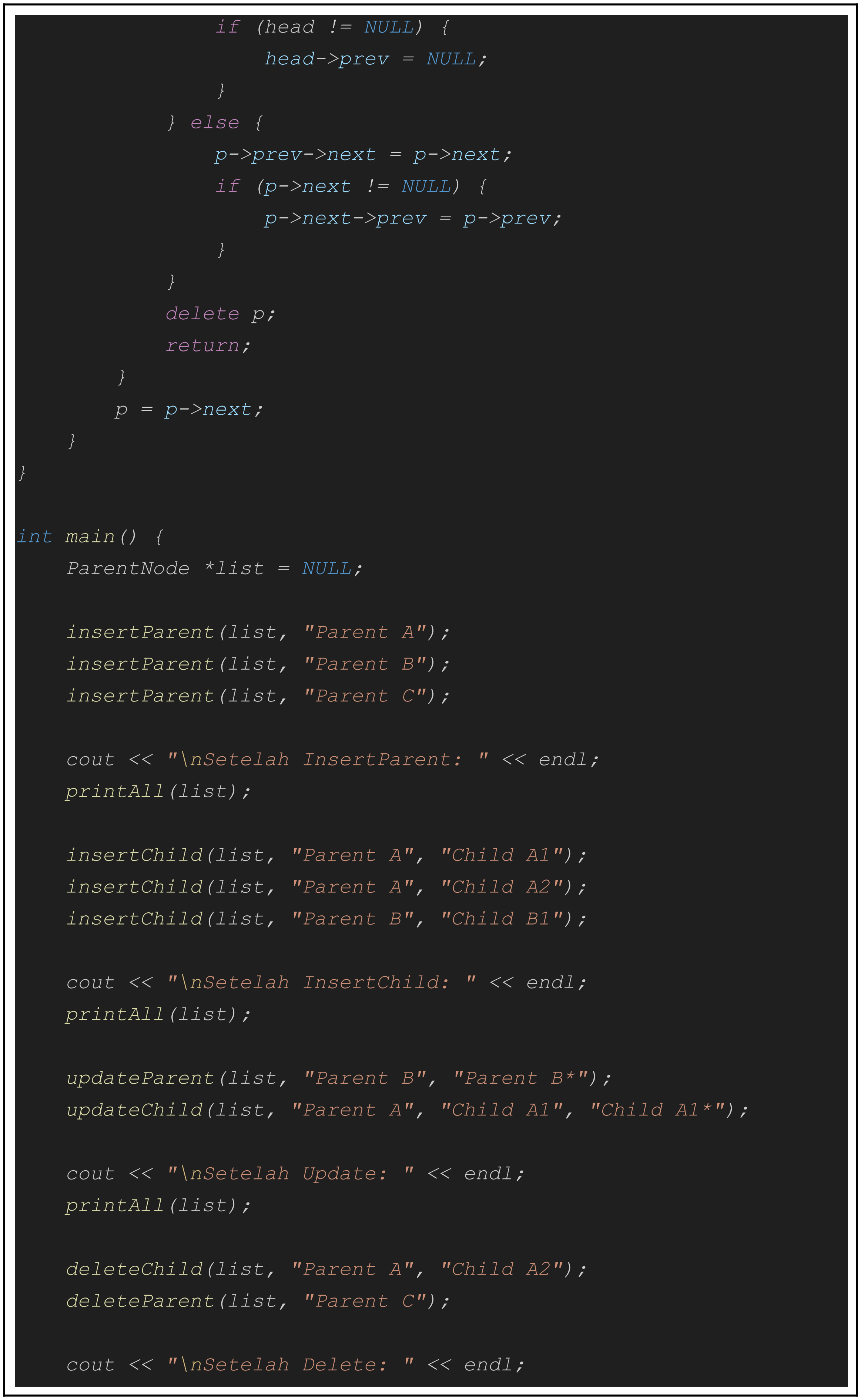
Guided 1

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

struct ChildNode {
    string info;
    ChildNode *next;
    ChildNode *prev;
};

struct ParentNode {
    string info;
    ChildNode *childHead;
    ParentNode *next;
    ParentNode *prev;
};

ParentNode *createParent(string info) {
    ParentNode *newNode = new ParentNode;
    newNode->info = info;
    newNode->childHead = NULL;
    newNode->next = NULL;
    newNode->prev = NULL;
    return newNode;
}

ChildNode *createChild(string info) {
    ChildNode *newNode = new ChildNode;
    newNode->info = info;
    newNode->next = NULL;
    newNode->prev = NULL;
    return newNode;
}

void insertParent(ParentNode *&head, string info) {
    ParentNode *newNode = createParent(info);
    if (head == NULL) {
        head = newNode;
    } else {
        ParentNode *temp = head;
        while (temp->next != NULL) {
            temp = temp->next;
        }
        temp->next = newNode;
        newNode->prev = temp;
    }
}

void insertChild(ParentNode *head, string parentInfo, string
childInfo) {
    ParentNode *p = head;
    while (p != NULL && p->info != parentInfo) {
        p = p->next;
    }

    if (p != NULL) {
        ChildNode *newChild = createChild(childInfo);
        if (p->childHead == NULL) {
            p->childHead = newChild;
        } else {
            ChildNode *c = p->childHead;
            while (c->next != NULL) {
                c = c->next;
            }
            c->next = newChild;
            newChild->prev = c;
        }
    }
}
```

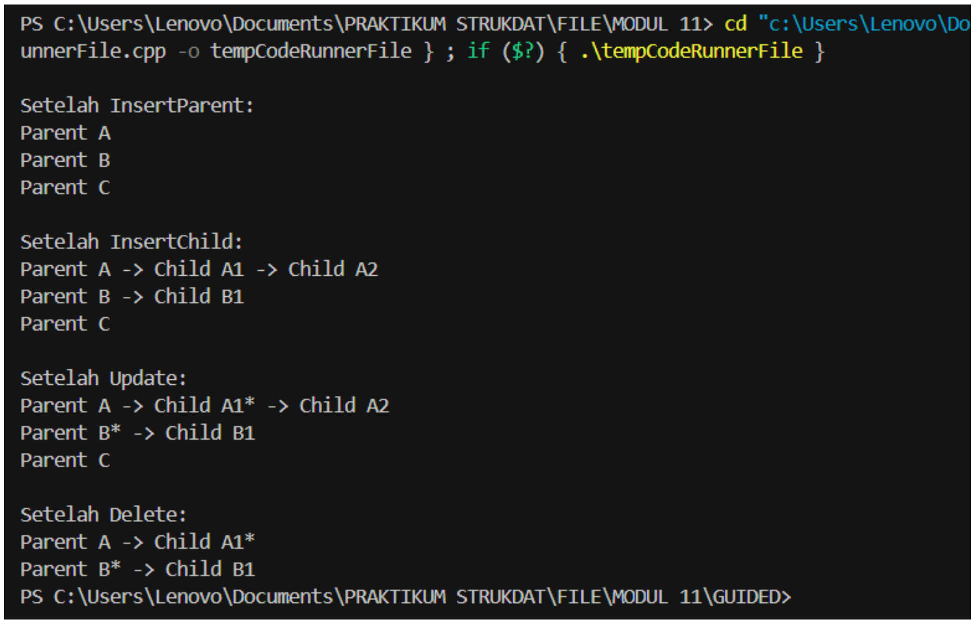


```cpp
void printAll(ParentNode *head) {
    while (head != NULL) {
        cout << head->info;
        ChildNode *c = head->childHead;
        while (c != NULL) {
            cout << " -> " << c->info;
            c = c->next;
        }
        cout << endl;
        head = head->next;
    }
}

void updateParent(ParentNode *head, string oldInfo, string
newInfo) {
    ParentNode *p = head;
    while (p != NULL) {
        if (p->info == oldInfo) {
            p->info = newInfo;
            return;
        }
        p = p->next;
    }
}

void updateChild(ParentNode *head, string parentInfo, string
oldChildInfo, string newChildInfo) {
    ParentNode *p = head;
    while (p != NULL && p->info != parentInfo) {
        p = p->next;
    }

    if (p != NULL) {
        ChildNode *c = p->childHead;
        while (c != NULL) {
            if (c->info == oldChildInfo) {
                c->info = newChildInfo;
                return;
            }
            c = c->next;
        }
    }
}
```

```cpp
void deleteChild(ParentNode *head, string parentInfo, string
childInfo) {
    ParentNode *p = head;
    while (p != NULL && p->info != parentInfo) {
        p = p->next;
    }

    if (p != NULL) {
        ChildNode *c = p->childHead;
        while (c != NULL) {
            if (c->info == childInfo) {
                if (c == p->childHead) {
                    p->childHead = c->next;
                    if (p->childHead != NULL) {
                        p->childHead->prev = NULL;
                    }
                } else {
                    c->prev->next = c->next;
                    if (c->next != NULL) {
                        c->next->prev = c->prev;
                    }
                }
                delete c;
                return;
            }
            c = c->next;
        }
    }
}

void deleteParent(ParentNode *&head, string info) {
    ParentNode *p = head;
    while (p != NULL) {
        if (p->info == info) {
            ChildNode *c = p->childHead;
            while (c != NULL) {
                ChildNode *tempC = c;
                c = c->next;
                delete tempC;
            }

            if (p == head) {
                head = p->next;
```


```cpp
                if (head != NULL) {
                    head->prev = NULL;
                }
            } else {
                p->prev->next = p->next;
                if (p->next != NULL) {
                    p->next->prev = p->prev;
                }
            }
            delete p;
            return;
        }
        p = p->next;
    }
}

int main() {
    ParentNode *list = NULL;

    insertParent(list, "Parent A");
    insertParent(list, "Parent B");
    insertParent(list, "Parent C");

    cout << "\nSetelah InsertParent: " << endl;
    printAll(list);

    insertChild(list, "Parent A", "Child A1");
    insertChild(list, "Parent A", "Child A2");
    insertChild(list, "Parent B", "Child B1");

    cout << "\nSetelah InsertChild: " << endl;
    printAll(list);

    updateParent(list, "Parent B", "Parent B*");
    updateChild(list, "Parent A", "Child A1", "Child A1*");

    cout << "\nSetelah Update: " << endl;
    printAll(list);

    deleteChild(list, "Parent A", "Child A2");
    deleteParent(list, "Parent C");

    cout << "\nSetelah Delete: " << endl;
    printAll(list);

    return 0;
}
```

Screenshots Output



```
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unnerFile.cpp -o tempCodeRunnerFile } ; if ($?) { .\tempCodeRunnerFile }

Setelah InsertParent:
Parent A
Parent B
Parent C

Setelah InsertChild:
Parent A -> Child A1 -> Child A2
Parent B -> Child B1
Parent C

Setelah Update:
Parent A -> Child A1* -> Child A2
Parent B* -> Child B1
Parent C

Setelah Delete:
Parent A -> Child A1*
Parent B* -> Child B1
PS C:\Users\Lenovo\Documents\PRAKTIKUM STRUKDAT\FILE\MODUL 11\GUIDED>
```

Deskripsi:

Program C++ ini mengimplementasikan Multi Linked List yang menghubungkan List Induk (ParentNode, misalnya Pegawai) dan List Anak (ChildNode, misalnya Anak), di mana kedua list diimplementasikan sebagai Doubly Linked List. Setiap elemen induk memiliki penunjuk ke head list anaknya. Fungsi utama yang disediakan meliputi insertParent, insertChild, updateParent, updateChild, deleteChild, dan yang krusial, deleteParent yang secara otomatis menghapus elemen induk beserta seluruh elemen anak yang terhubung dengannya. Secara keseluruhan, kode ini mendemonstrasikan manajemen data hierarkis antara dua jenis linked list.

C. Unguided/Tugas (berisi screenshot source code & output program disertai penjelasannya)

Unguided 1

multilist.h

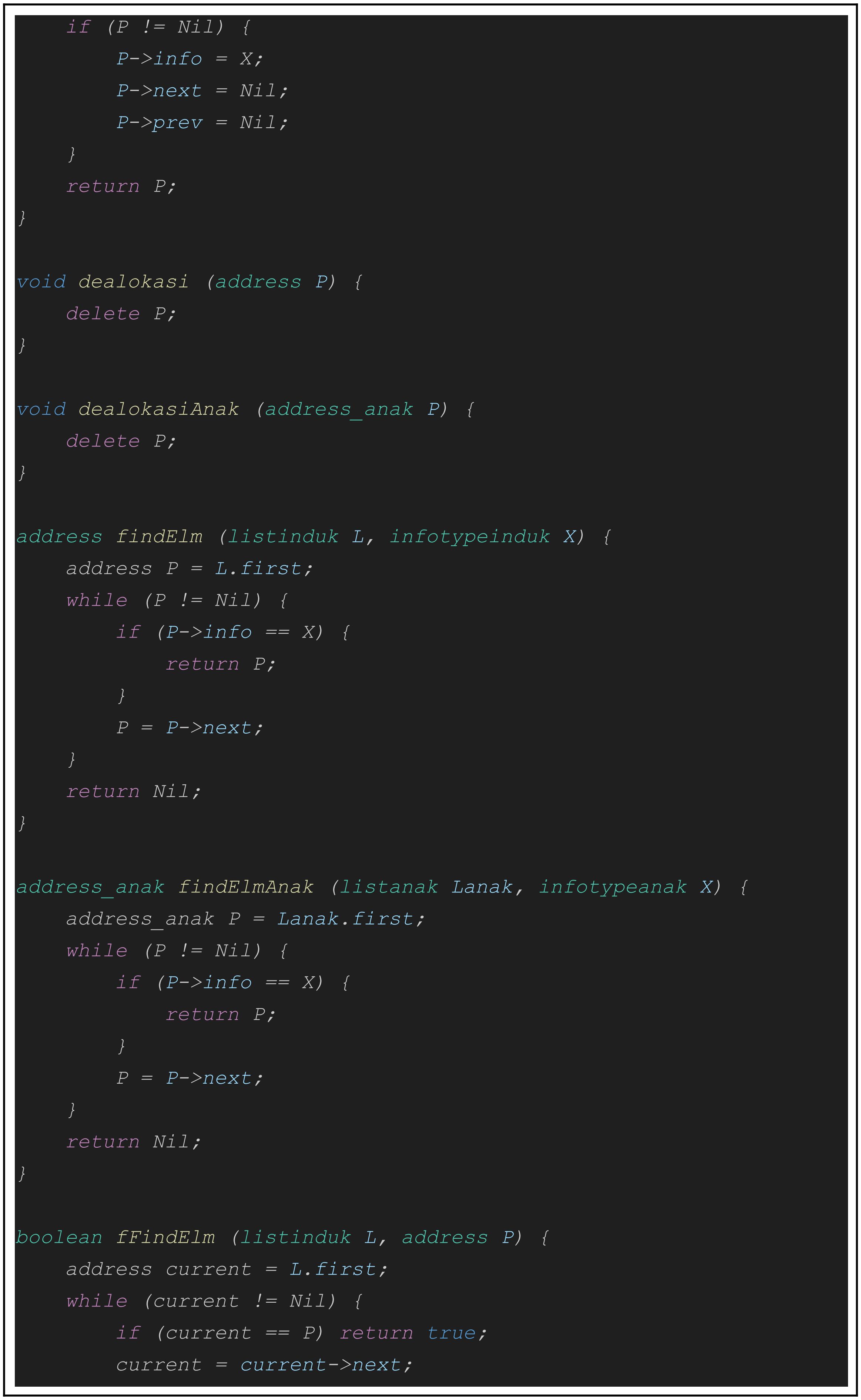
```
#ifndef MULTILIST_H_INCLUDED
#define MULTILIST_H_INCLUDED

#include <stddef.h>
#define Nil NULL

typedef int infotypeanak;
typedef int infotypeinduk;
typedef int boolean;
#define true 1
#define false 0

struct elemen_list_anak;
struct elemen_list_induk;

typedef struct elemen_list_induk *address;
typedef struct elemen_list_anak *address_anak;

struct elemen_list_anak {
    infotypeanak info;
    address_anak next;
    address_anak prev;
};

struct listanak {
    address_anak first;
    address_anak last;
};

struct elemen_list_induk {
    infotypeinduk info;
    listanak lanak;
    address next;
    address prev;
};

struct listinduk {
    address first;
    address last;
};
```

```
boolean ListEmpty (listinduk L);
boolean ListEmptyAnak (listanak L);

void CreateList (listinduk &L);
void CreateListAnak (listanak &L);

address alokasi (infotypeinduk X);
address_anak alokasiAnak (infotypeanak X);
void dealokasi (address P);
void dealokasiAnak (address_anak P);

address findElm (listinduk L, infotypeinduk X);
address_anak findElmAnak (listanak Lanak, infotypeanak X);
boolean fFindElm (listinduk L, address P);
boolean fFindElmAnak (listanak Lanak, address_anak P);
address findBefore (listinduk L, address P);
address_anak findBeforeAnak (listanak Lanak, infotypeinduk X,
address_anak P);

void insertFirst (listinduk &L, address P);
void insertAfter (listinduk &L, address P, address Prec);
void insertLast (listinduk &L, address P);
void insertFirstAnak (listanak &L, address_anak P);
void insertAfterAnak (listanak &L, address_anak P, address_anak
Prec);
void insertLastAnak (listanak &L, address_anak P);

void delFirst (listinduk &L, address &P);
void delLast (listinduk &L, address &P);
void delAfter (listinduk &L, address &P, address Prec);
void delP (listinduk &L, infotypeinduk X);

void delFirstAnak (listanak &L, address_anak &P);
void delLastAnak (listanak &L, address_anak &P);
void delAfterAnak (listanak &L, address_anak &P, address_anak
Prec);
void delPAnak (listanak &L, infotypeanak X);

void printInfo (listinduk L);
void printInfoAnak (listanak Lanak);
int nbList (listinduk L);
int nbListAnak (listanak Lanak);
```

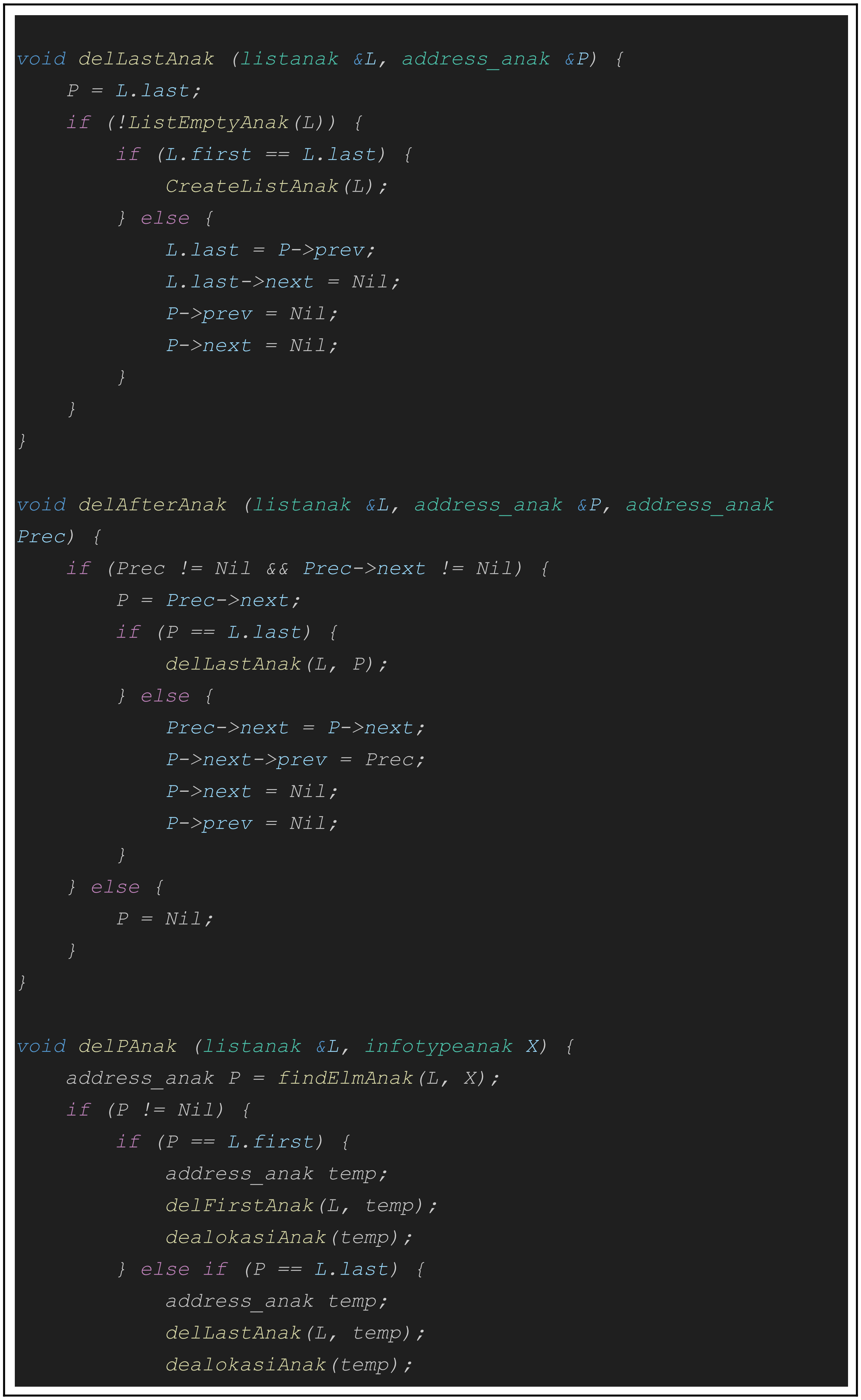
```
void delAll (listinduk &L);

#endif
```

multilist.cpp

```
#include "multilist.h"
#include <iostream>

using namespace std;

boolean ListEmpty (listinduk L) {
    return L.first == Nil;
}

boolean ListEmptyAnak (listanak L) {
    return L.first == Nil;
}

void CreateList (listinduk &L) {
    L.first = Nil;
    L.last = Nil;
}

void CreateListAnak (listanak &L) {
    L.first = Nil;
    L.last = Nil;
}

address alokasi (infotypeinduk X) {
    address P = new elemen_list_induk;
    if (P != Nil) {
        P->info = X;
        CreateListAnak(P->lanak);
        P->next = Nil;
        P->prev = Nil;
    }
    return P;
}

address_anak alokasiAnak (infotypeanak X) {
    address_anak P = new elemen_list_anak;
```



```
    if (P != Nil) {
        P->info = X;
        P->next = Nil;
        P->prev = Nil;
    }
    return P;
}

void dealokasi (address P) {
    delete P;
}

void dealokasiAnak (address_anak P) {
    delete P;
}

address findElm (listinduk L, infotypeinduk X) {
    address P = L.first;
    while (P != Nil) {
        if (P->info == X) {
            return P;
        }
        P = P->next;
    }
    return Nil;
}

address_anak findElmAnak (listanak Lanak, infotypeanak X) {
    address_anak P = Lanak.first;
    while (P != Nil) {
        if (P->info == X) {
            return P;
        }
        P = P->next;
    }
    return Nil;
}

boolean fFindElm (listinduk L, address P) {
    address current = L.first;
    while (current != Nil) {
        if (current == P) return true;
        current = current->next;
    }
    return false;
}

boolean fFindElmAnak (listanak Lanak, address_anak P) {
    address_anak current = Lanak.first;
    while (current != Nil) {
        if (current == P) return true;
        current = current->next;
    }
    return false;
}

address findBefore (listinduk L, address P) {
    if (P == L.first || P == Nil) return Nil;
    return P->prev;
}

address_anak findBeforeAnak (listanak Lanak, infotypeinduk X,
address_anak P) {
    if (P == Lanak.first || P == Nil) return Nil;
    return P->prev;
}

void insertFirst (listinduk &L, address P) {
    P->next = L.first;
    if (!ListEmpty(L)) {
        L.first->prev = P;
    } else {
        L.last = P;
    }
    L.first = P;
    P->prev = Nil;
}

void insertAfter (listinduk &L, address P, address Prec) {
    if (Prec == L.last) {
        insertLast(L, P);
        return;
    }
    P->next = Prec->next;
    P->prev = Prec;
    Prec->next->prev = P;
    Prec->next = P;
}

void insertLast (listinduk &L, address P) {
    if (ListEmpty(L)) {
        insertFirst(L, P);
    } else {
        L.last->next = P;
        P->prev = L.last;
        L.last = P;
        P->next = Nil;
    }
}

void insertFirstAnak (listanak &L, address_anak P) {
    P->next = L.first;
    if (!ListEmptyAnak(L)) {
        L.first->prev = P;
    } else {
        L.last = P;
    }
    L.first = P;
    P->prev = Nil;
}

void insertAfterAnak (listanak &L, address_anak P, address_anak
Prec) {
    if (Prec == L.last) {
        insertLastAnak(L, P);
        return;
    }
    P->next = Prec->next;
    P->prev = Prec;
    Prec->next->prev = P;
    Prec->next = P;
}

void insertLastAnak (listanak &L, address_anak P) {
    if (ListEmptyAnak(L)) {
        insertFirstAnak(L, P);
    } else {
        L.last->next = P;
        P->prev = L.last;
        L.last = P;
        P->next = Nil;
    }
}

void delFirst (listinduk &L, address &P) {
    P = L.first;
    if (!ListEmpty(L)) {
        if (L.first == L.last) {
            CreateList(L);
        } else {
            L.first = P->next;
            L.first->prev = Nil;
            P->next = Nil;
            P->prev = Nil;
        }
    }
}

void delLast (listinduk &L, address &P) {
    P = L.last;
    if (!ListEmpty(L)) {
        if (L.first == L.last) {
            CreateList(L);
        } else {
            L.last = P->prev;
            L.last->next = Nil;
            P->prev = Nil;
            P->next = Nil;
        }
    }
}

void delAfter (listinduk &L, address &P, address Prec) {
    if (Prec != Nil && Prec->next != Nil) {
        P = Prec->next;
        if (P == L.last) {
            delLast(L, P);
        } else {
            Prec->next = P->next;
            P->next->prev = Prec;
            P->next = Nil;
            P->prev = Nil;
        }
    } else {
        P = Nil;
    }
}

void delP (listinduk &L, infotypeinduk X) {
    address P = findElm(L, X);
    if (P != Nil) {
        address_anak c = P->lanak.first;
        while (c != Nil) {
            address_anak tempC = c;
            c = c->next;
            dealokasiAnak(tempC);
        }

        if (P == L.first) {
            delFirst(L, P);
        } else if (P == L.last) {
            delLast(L, P);
        } else {
            P->prev->next = P->next;
            P->next->prev = P->prev;
            P->next = Nil;
            P->prev = Nil;
        }
        dealokasi(P);
    }
}

void delFirstAnak (listanak &L, address_anak &P) {
    P = L.first;
    if (!ListEmptyAnak(L)) {
        if (L.first == L.last) {
            CreateListAnak(L);
        } else {
            L.first = P->next;
            L.first->prev = Nil;
            P->next = Nil;
            P->prev = Nil;
        }
    }
}
```

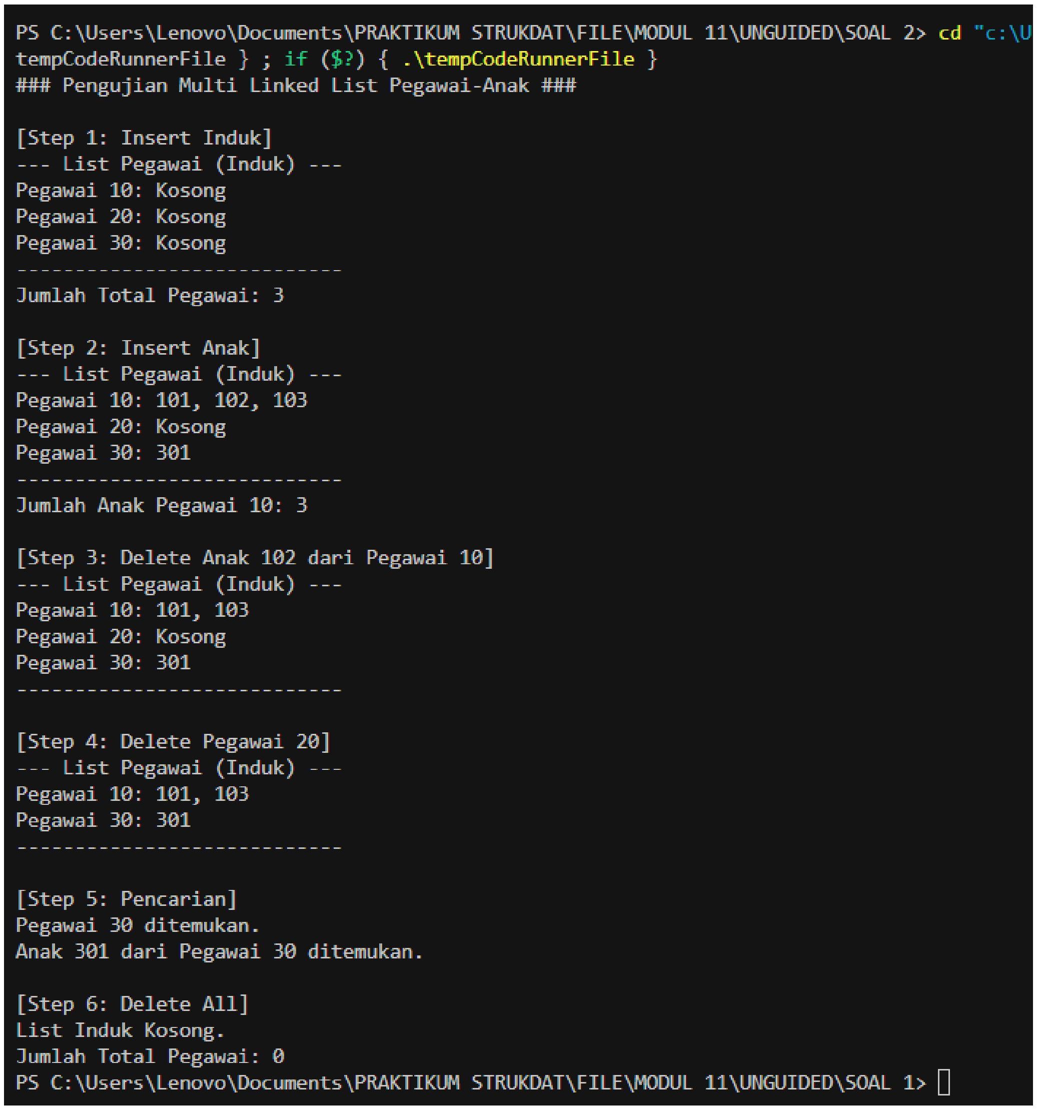


```
void delLastAnak (listanak &L, address_anak &P) {
    P = L.last;
    if (!ListEmptyAnak(L)) {
        if (L.first == L.last) {
            CreateListAnak(L);
        } else {
            L.last = P->prev;
            L.last->next = Nil;
            P->prev = Nil;
            P->next = Nil;
        }
    }
}

void delAfterAnak (listanak &L, address_anak &P, address_anak
Prec) {
    if (Prec != Nil && Prec->next != Nil) {
        P = Prec->next;
        if (P == L.last) {
            delLastAnak(L, P);
        } else {
            Prec->next = P->next;
            P->next->prev = Prec;
            P->next = Nil;
            P->prev = Nil;
        }
    } else {
        P = Nil;
    }
}

void delPAnak (listanak &L, infotypeanak X) {
    address_anak P = findElmAnak(L, X);
    if (P != Nil) {
        if (P == L.first) {
            address_anak temp;
            delFirstAnak(L, temp);
            dealokasiAnak(temp);
        } else if (P == L.last) {
            address_anak temp;
            delLastAnak(L, temp);
            dealokasiAnak(temp);
        } else {
            P->prev->next = P->next;
            if (P->next != Nil) {
                P->next->prev = P->prev;
            }
            dealokasiAnak(P);
        }
    }
}

void printInfoAnak (listanak Lanak) {
    address_anak P = Lanak.first;
    if (ListEmptyAnak(Lanak)) {
        cout << "Kosong";
        return;
    }
    while (P != Nil) {
        cout << P->info;
        if (P->next != Nil) {
            cout << ", ";
        }
        P = P->next;
    }
}

void printInfo (listinduk L) {
    address P = L.first;
    if (ListEmpty(L)) {
        cout << "List Induk Kosong." << endl;
        return;
    }
    cout << "--- List Pegawai (Induk) ---" << endl;
    while (P != Nil) {
        cout << "Pegawai " << P->info << ": ";
        printInfoAnak(P->lanak);
        cout << endl;
        P = P->next;
    }
    cout << "----------------------------" << endl;
}

int nbList (listinduk L) {
    int count = 0;
    address P = L.first;
    while (P != Nil) {
        count++;
        P = P->next;
    }
    return count;
}

int nbListAnak (listanak Lanak) {
    int count = 0;
    address_anak P = Lanak.first;
    while (P != Nil) {
        count++;
        P = P->next;
    }
    return count;
}

void delAll (listinduk &L) {
    address P;
    while (!ListEmpty(L)) {
        delFirst(L, P);

        address_anak c = P->lanak.first;
        while (c != Nil) {
            address_anak tempC = c;
            c = c->next;
            dealokasiAnak(tempC);
        }
        dealokasi(P);
    }
    L.last = Nil;
}
```

main.cpp

```
#include "multilist.h"
#include "multilist.cpp"
#include <iostream>

using namespace std;

int main() {
    listinduk PegawaiList;
    CreateList(PegawaiList);

    cout << "### Pengujian Multi Linked List Pegawai-Anak ###" <<
endl;

    address p1 = alokasi(10);
    address p2 = alokasi(20);
    address p3 = alokasi(30);

    insertFirst(PegawaiList, p1);
    insertLast(PegawaiList, p3);
    insertAfter(PegawaiList, p2, p1);

    cout << "\n[Step 1: Insert Induk]" << endl;
    printInfo(PegawaiList);
    cout << "Jumlah Total Pegawai: " << nbList(PegawaiList) <<
endl;

    address_anak a1 = alokasiAnak(101);
    address_anak a2 = alokasiAnak(102);
    address_anak a3 = alokasiAnak(103);

    insertFirstAnak(p1->lanak, a1);
    insertAfterAnak(p1->lanak, a2, a1);
    insertLastAnak(p1->lanak, a3);

    address_anak c1 = alokasiAnak(301);
    insertLastAnak(p3->lanak, c1);

    cout << "\n[Step 2: Insert Anak]" << endl;
    printInfo(PegawaiList);
    cout << "Jumlah Anak Pegawai 10: " << nbListAnak(p1->lanak) <<
endl;

    cout << "\n[Step 3: Delete Anak 102 dari Pegawai 10]" << endl;
    delPAnak(p1->lanak, 102);
    printInfo(PegawaiList);

    cout << "\n[Step 4: Delete Pegawai 20]" << endl;
    delP(PegawaiList, 20);
    printInfo(PegawaiList);

    address foundP = findElm(PegawaiList, 30);
    cout << "\n[Step 5: Pencarian]" << endl;
    if (foundP != Nil) {
        cout << "Pegawai 30 ditemukan." << endl;
    }
    address_anak foundA = findElmAnak(foundP->lanak, 301);
    if (foundA != Nil) {
        cout << "Anak 301 dari Pegawai 30 ditemukan." << endl;
    }

    cout << "\n[Step 6: Delete All]" << endl;
    delAll(PegawaiList);
    printInfo(PegawaiList);
    cout << "Jumlah Total Pegawai: " << nbList(PegawaiList) <<
endl;

    return 0;
}
```

Screenshots Output



```
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tempCodeRunnerFile } ; if ($?) { .\tempCodeRunnerFile }
### Pengujian Multi Linked List Pegawai-Anak ###

[Step 1: Insert Induk]
--- List Pegawai (Induk) ---
Pegawai 10: Kosong
Pegawai 20: Kosong
Pegawai 30: Kosong
----------------------------
Jumlah Total Pegawai: 3

[Step 2: Insert Anak]
--- List Pegawai (Induk) ---
Pegawai 10: 101, 102, 103
Pegawai 20: Kosong
Pegawai 30: 301
----------------------------
Jumlah Anak Pegawai 10: 3

[Step 3: Delete Anak 102 dari Pegawai 10]
--- List Pegawai (Induk) ---
Pegawai 10: 101, 103
Pegawai 20: Kosong
Pegawai 30: 301
----------------------------

[Step 4: Delete Pegawai 20]
--- List Pegawai (Induk) ---
Pegawai 10: 101, 103
Pegawai 30: 301
----------------------------

[Step 5: Pencarian]
Pegawai 30 ditemukan.
Anak 301 dari Pegawai 30 ditemukan.

[Step 6: Delete All]
List Induk Kosong.
Jumlah Total Pegawai: 0
PS C:\Users\Lenovo\Documents\PRAKTIKUM STRUKDAT\FILE\MODUL 11\UNGUIDED\SOAL 1>
```

Unguided 2

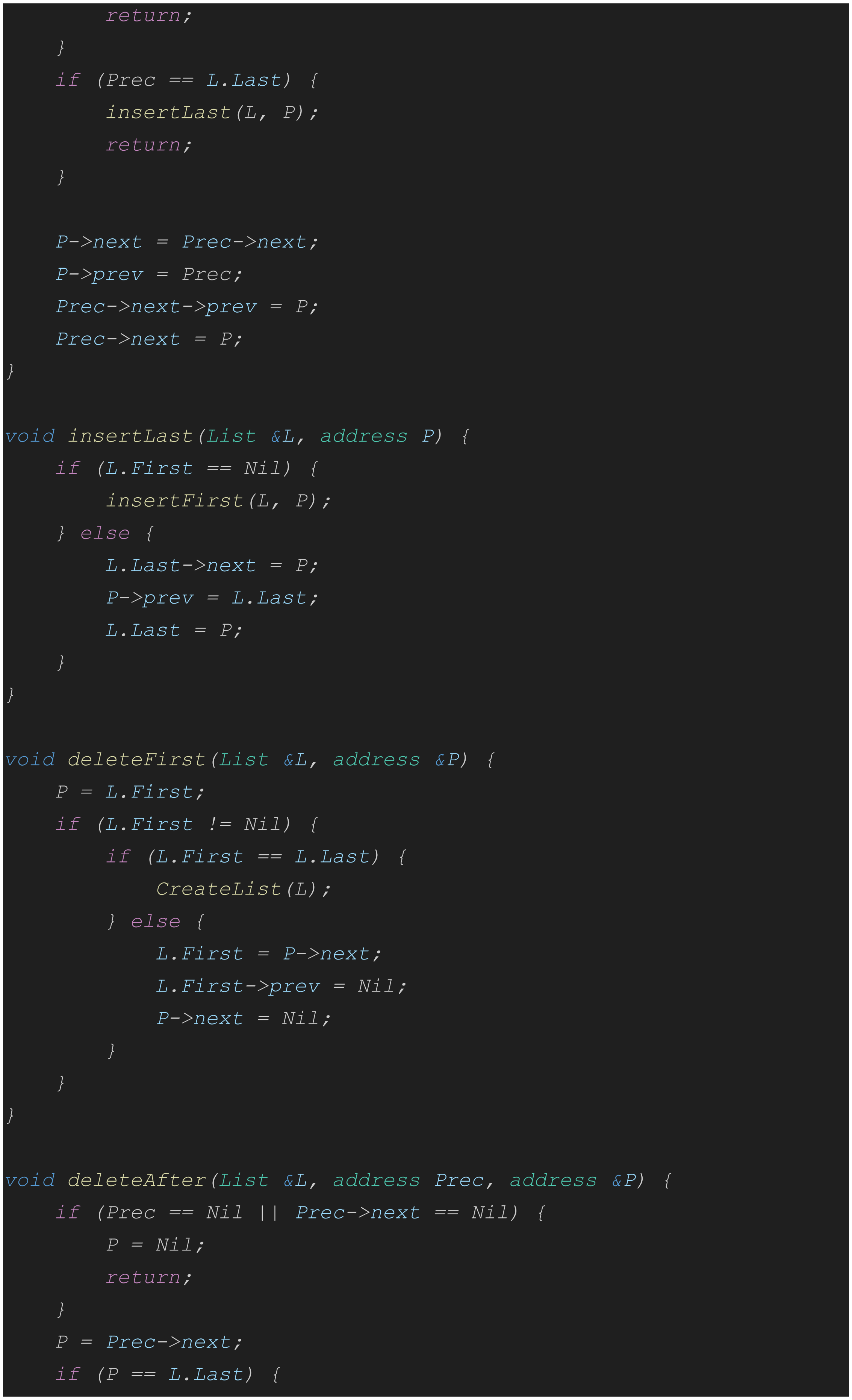
cirularlist.h

```
#ifndef CIRCULARLIST_H_INCLUDED
#define CIRCULARLIST_H_INCLUDED

#include <string>
#include <stddef.h>
#define Nil NULL

using namespace std;

typedef struct {
    string nama;
    string nim;
    char jenis_kelamin;
    float ipk;
} infotype;

typedef struct ElmList *address;

typedef struct ElmList {
    infotype info;
    address next;
    address prev;
} ElmList;

typedef struct {
    address First;
    address Last;
} List;

void CreateList(List &L);
address alokasi(infotype x);
void dealokasi(address P);
void insertFirst(List &L, address P);
void insertAfter(List &L, address Prec, address P);
void insertLast(List &L, address P);
void deleteFirst(List &L, address &P);
void deleteAfter(List &L, address Prec, address &P);
void deleteLast(List &L, address &P);
address findElm(List L, infotype x);
void printInfo(List L);
```

```
address createData (string nama, string nim, char jenis_kelamin, 
float ipk);

#endif
```

circularlist.cpp

```
#include "circularlist.h"
#include <iostream>

void CreateList(List &L) {
    L.First = Nil;
    L.Last = Nil;
}

address alokasi(infotype x) {
    address P = new ElmList;
    if (P != Nil) {
        P->info = x;
        P->next = Nil;
        P->prev = Nil;
    }
    return P;
}

void dealokasi(address P) {
    delete P;
}

void insertFirst(List &L, address P) {
    P->next = L.First;
    if (L.First != Nil) {
        L.First->prev = P;
    } else {
        L.Last = P;
    }
    L.First = P;
}

void insertAfter(List &L, address Prec, address P) {
    if (Prec == Nil) {
        insertFirst(L, P);
```



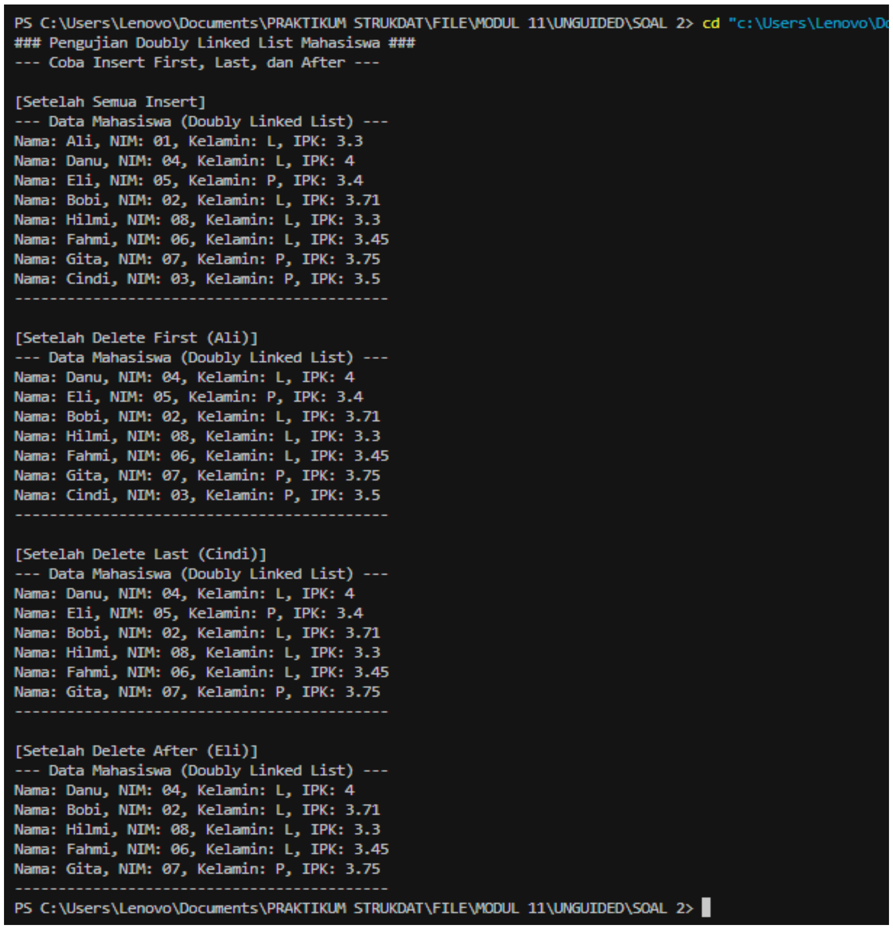
```
        return;
    }
    if (Prec == L.Last) {
        insertLast(L, P);
        return;
    }

    P->next = Prec->next;
    P->prev = Prec;
    Prec->next->prev = P;
    Prec->next = P;
}

void insertLast(List &L, address P) {
    if (L.First == Nil) {
        insertFirst(L, P);
    } else {
        L.Last->next = P;
        P->prev = L.Last;
        L.Last = P;
    }
}

void deleteFirst(List &L, address &P) {
    P = L.First;
    if (L.First != Nil) {
        if (L.First == L.Last) {
            CreateList(L);
        } else {
            L.First = P->next;
            L.First->prev = Nil;
            P->next = Nil;
        }
    }
}

void deleteAfter(List &L, address Prec, address &P) {
    if (Prec == Nil || Prec->next == Nil) {
        P = Nil;
        return;
    }
    P = Prec->next;
    if (P == L.Last) {
        deleteLast(L, P);
        return;
    }

    Prec->next = P->next;
    P->next->prev = Prec;
    P->next = Nil;
    P->prev = Nil;
}

void deleteLast(List &L, address &P) {
    P = L.Last;
    if (L.Last != Nil) {
        if (L.First == L.Last) {
            CreateList(L);
        } else {
            L.Last = P->prev;
            L.Last->next = Nil;
            P->prev = Nil;
        }
    }
}

address findElm(List L, infotype x) {
    address P = L.First;
    while (P != Nil) {
        if (P->info.nim == x.nim) {
            return P;
        }
        P = P->next;
    }
    return Nil;
}

void printInfo(List L) {
    address P = L.First;
    if (P == Nil) {
        cout << "List Mahasiswa Kosong." << endl;
        return;
    }
    cout << "--- Data Mahasiswa (Doubly Linked List) ---" << endl;
    while (P != Nil) {
        cout << "Nama: " << P->info.nama
```

```
             << ", NIM: " << P->info.nim
             << ", Kelamin: " << P->info.jenis_kelamin
             << ", IPK: " << P->info.ipk << endl;
        P = P->next;
    }
    cout << "--------------------------------------------" << endl;
}

address createData (string nama, string nim, char jenis_kelamin,
float ipk) {
    infotype x;
    x.nama = nama;
    x.nim = nim;
    x.jenis_kelamin = jenis_kelamin;
    x.ipk = ipk;
    address P = alokasi(x);
    return P;
}
```

main.cpp

```
#include "circularlist.h"
#include "circularlist.cpp"
#include <iostream>

using namespace std;

int main() {
    List L;
    address P1 = Nil;
    address P2 = Nil;
    address P_del = Nil;
    infotype x;

    CreateList(L);
    cout << "### Pengujian Doubly Linked List Mahasiswa ###" <<
endl;
    cout << "--- Coba Insert First, Last, dan After ---" << endl;

    P1 = createData("Danu", "04", 'L', 4.0);
    insertFirst(L, P1);

    P1 = createData("Fahmi", "06", 'L', 3.45);
    insertLast(L, P1);

    P1 = createData("Bobi", "02", 'L', 3.71);
    x.nim = "04";
    P2 = findElm(L, x);
    if (P2 != Nil) {
        insertAfter(L, P2, P1);
    }

    P1 = createData("Ali", "01", 'L', 3.3);
    insertFirst(L, P1);

    P1 = createData("Gita", "07", 'P', 3.75);
    insertLast(L, P1);
    x.nim = "07";
    P2 = findElm(L, x);
    P1 = createData("Cindi", "03", 'P', 3.5);
    if (P2 != Nil) {
        insertAfter(L, P2, P1);
    }

    x.nim = "02";
    P2 = findElm(L, x);
    P1 = createData("Hilmi", "08", 'L', 3.3);
    if (P2 != Nil) {
        insertAfter(L, P2, P1);
    }

    x.nim = "04";
    P2 = findElm(L, x);
    P1 = createData("Eli", "05", 'P', 3.4);
    if (P2 != Nil) {
        insertAfter(L, P2, P1);
    }

    cout << "\n[Setelah Semua Insert]" << endl;
    printInfo(L);

    deleteFirst(L, P_del);
    if (P_del != Nil) dealokasi(P_del);
    cout << "\n[Setelah Delete First (Ali)]" << endl;
    printInfo(L);
    deleteLast(L, P_del);
    if (P_del != Nil) dealokasi(P_del);
    cout << "\n[Setelah Delete Last (Cindi)]" << endl;
    printInfo(L);

    x.nim = "04";
    P2 = findElm(L, x);
    if (P2 != Nil) {
        deleteAfter(L, P2, P_del);
        if (P_del != Nil) dealokasi(P_del);
    }
    cout << "\n[Setelah Delete After (Eli)]" << endl;
    printInfo(L);

    return 0;
}
```

Screenshots Output



```
PS C:\Users\Lenovo\Documents\PRAKTIKUM STRUKDAT\FILE\MODUL 11\UNGUIDED\SOAL 2> cd "c:\Users\Lenovo\D
### Pengujian Doubly Linked List Mahasiswa ###
--- Coba Insert First, Last, dan After ---

[Setelah Semua Insert]
--- Data Mahasiswa (Doubly Linked List) ---
Nama: Ali, NIM: 01, Kelamin: L, IPK: 3.3
Nama: Danu, NIM: 04, Kelamin: L, IPK: 4
Nama: Eli, NIM: 05, Kelamin: P, IPK: 3.4
Nama: Bobi, NIM: 02, Kelamin: L, IPK: 3.71
Nama: Hilmi, NIM: 08, Kelamin: L, IPK: 3.3
Nama: Fahmi, NIM: 06, Kelamin: L, IPK: 3.45
Nama: Gita, NIM: 07, Kelamin: P, IPK: 3.75
Nama: Cindi, NIM: 03, Kelamin: P, IPK: 3.5
-------------------------------------------

[Setelah Delete First (Ali)]
--- Data Mahasiswa (Doubly Linked List) ---
Nama: Danu, NIM: 04, Kelamin: L, IPK: 4
Nama: Eli, NIM: 05, Kelamin: P, IPK: 3.4
Nama: Bobi, NIM: 02, Kelamin: L, IPK: 3.71
Nama: Hilmi, NIM: 08, Kelamin: L, IPK: 3.3
Nama: Fahmi, NIM: 06, Kelamin: L, IPK: 3.45
Nama: Gita, NIM: 07, Kelamin: P, IPK: 3.75
Nama: Cindi, NIM: 03, Kelamin: P, IPK: 3.5
-------------------------------------------

[Setelah Delete Last (Cindi)]
--- Data Mahasiswa (Doubly Linked List) ---
Nama: Danu, NIM: 04, Kelamin: L, IPK: 4
Nama: Eli, NIM: 05, Kelamin: P, IPK: 3.4
Nama: Bobi, NIM: 02, Kelamin: L, IPK: 3.71
Nama: Hilmi, NIM: 08, Kelamin: L, IPK: 3.3
Nama: Fahmi, NIM: 06, Kelamin: L, IPK: 3.45
Nama: Gita, NIM: 07, Kelamin: P, IPK: 3.75
-------------------------------------------

[Setelah Delete After (Eli)]
--- Data Mahasiswa (Doubly Linked List) ---
Nama: Danu, NIM: 04, Kelamin: L, IPK: 4
Nama: Bobi, NIM: 02, Kelamin: L, IPK: 3.71
Nama: Hilmi, NIM: 08, Kelamin: L, IPK: 3.3
Nama: Fahmi, NIM: 06, Kelamin: L, IPK: 3.45
Nama: Gita, NIM: 07, Kelamin: P, IPK: 3.75
-------------------------------------------
PS C:\Users\Lenovo\Documents\PRAKTIKUM STRUKDAT\FILE\MODUL 11\UNGUIDED\SOAL 2>
```

Deskripsi:

Program C++ ini menyajikan implementasi Doubly Linked List (Daftar Berantai Ganda) yang berfungsi untuk mengelola koleksi data mahasiswa, meliputi Nama, NIM, Jenis Kelamin, dan IPK. Struktur ini memungkinkan setiap elemen memiliki penunjuk ke elemen setelahnya (next) dan sebelumnya (prev). Secara keseluruhan, program ini menyediakan 11 fungsi dasar (ADT) yang lengkap untuk manipulasi list, mulai dari pembuatan list kosong (CreateList) dan alokasi data, hingga operasi penyisipan dan penghapusan di awal, tengah, dan akhir list. Selain itu, terdapat fungsi pencarian elemen berdasarkan NIM (findElm) dan fungsi untuk menampilkan seluruh isi list (printInfo), menjadikannya model yang efisien untuk pengelolaan data mahasiswa secara dinamis dan terurut.

D. Kesimpulan

Kesimpulannya, kedua program tersebut menguji variasi struktur data berantai yang kompleks. Program pertama fokus pada Multi Linked List, yang menunjukkan hubungan hierarkis antara list induk dan anak. Program ini menekankan prinsip bahwa penghapusan elemen induk harus diikuti dengan penghapusan semua elemen anak yang terikat, sesuai dengan kebutuhan data hierarkis. Sementara itu, program kedua menyajikan implementasi Doubly Linked List murni, yang penting karena berfungsi sebagai fondasi struktural yang digunakan untuk membangun elemen-elemen list pada program Multi Linked List. Secara kolektif, kedua program ini secara efektif menguji pemahaman pengguna terhadap manajemen memori dinamis dan manipulasi pointer untuk operasi dasar list di berbagai tingkat kerumitan.

E. Referensi

Raharjo, Budi. 2025. *Buku Pemrograman C++ Mudah dan Cepat Menjadi Master C.*

Wikipedia contributors. (2024, 8 Mei). C++. Wikipedia, Ensiklopedia Bebas. Diakses pada 2 Desember 2025, dari https://id.wikipedia.org/wiki/C%2B%2B