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DATA STRUCTURES (23CS3PCDST)

Submitted by

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in partial fulfillment for the award of the degree of BACHELOR OF ENGINEERING in COMPUTER SCIENCE AND ENGINEERING

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This is to certify that the Lab work entitled "DATA STRUCTURES" carried out by VACHAN.D.H (1BM22CS314), who is bonafide student of B. M. S. College of Engineering. It is in partial fulfillment for the award of Bachelor of Engineering in Computer Science and Engineering of the Visvesvaraya Technological University, Belgaum during the year 2023-24. The Lab report has been approved as it satisfies the academic requirements in respect of Data structures Lab - (23CS3PCDST) work prescribed for the said degree.

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Course outcomes:

CO1	Apply the concept of linear and nonlinear data structures.
CO2	Analyze data structure operations for a given problem
CO3	Design and develop solutions using the operations of linear and nonlinear data structure for a given specification.
CO4	Conduct practical experiments for demonstrating the operations of different

data structures.

Lab program 1:

Write a program to simulate the working of stack using an array with the following:

- a) Push
- b) Pop
- c) Display

The program should print appropriate messages for stack overflow, stack underflow.

```
#include <stdio.h>
#include <stdlib.h>
#define STACK_SIZE 5
void push(int st[], int *top) {
int item;
if (*top == STACK_SIZE - 1)
printf("Stack overflow\n");
else {
printf("\nEnter an item: ");
scanf("%d", &item);
(*top)++;
st[*top] = item;
}
}
void pop(int st[], int *top) {
if (*top == -1)
printf("Stack underflow\n");
else {
```

```
printf("\n%d item was deleted", st[(*top)]);
(*top)--;
}
}
void display(int st[], int *top) {
int i;
if (*top == -1) {
printf("Stack is empty\n");
return;
}
for (i = 0; i <= *top; i++)
printf("%d\t", st[i]);
}
int main() {
int st[STACK_SIZE], top = -1, c;
while (1) {
printf("\n1. Push\n2. Pop\n3. Display\n");
printf("\nEnter your choice: ");
scanf("%d", &c);
switch (c) {
case 1:
push(st, &top);
break;
case 2:
pop(st, &top);
```

```
break;
case 3:
display(st, &top);
break;
default:
printf("\nInvalid choice!!!");
exit(0);
}
return 0;
}
```

1. Push

2. Pop

3. Display

Enter your choice: 1

Enter an item: 23

1. Push

2. Pop

3. Display

Enter your choice: 1

Enter an item: 34

1. Push

2. Pop

3. Display

Enter your choice: 1

Enter an item: 21

1. Push

2. Pop

3. Display

Enter your choice: 1

```
Enter an item: 21
1. Push
2. Pop
3. Display
Enter your choice: 2
21 item was deleted
1. Push
2. Pop
3. Display
Enter your choice: 1
Enter an item: 43
1. Push
2. Pop
3. Display
Enter your choice: 4
Invalid choice!!!
Process returned 0 (0x0) execution time : 32.209 s
Press any key to continue.
```

Lab program 2:

WAP to convert a given valid parenthesized infix arithmetic expression to postfix expression. The expression consists of single character operands and the binary operators + (plus), - (minus), * (multiply) and / (divide).

```
#include <stdio.h>
#include <ctype.h>
#define SIZE 50
```

```
char stack[SIZE];
int top = -1;
void push(char elem) {
stack[++top] = elem;
}
char pop() {
return stack[top--];
}
int pr(char symbol) {
if (symbol == '^{\prime})
return 3;
else if (symbol == '*' || symbol == '/')
return 2;
else if (symbol == '+' | | symbol == '-')
return 1;
else
return 0;
}
int main() {
char infix[50], postfix[50], ch, elem;
int i = 0, k = 0;
printf("Enter Infix Expression: ");
scanf("%s", infix);
```

```
push('#');
while ((ch = infix[i++]) != '\0') {
if (ch == '(')
push(ch);
else if (isalnum(ch))
postfix[k++] = ch;
else if (ch == ')') {
while (stack[top] != '(')
postfix[k++] = pop();
elem = pop();
} else {
while (pr(stack[top]) >= pr(ch))
postfix[k++] = pop();
push(ch);
}
while (stack[top] != '#')
postfix[k++] = pop();
postfix[k] = '\0';
printf("\nPostfix Expression: %s\n", postfix);
return 0;
}
```

```
Enter Infix Expression: ACD+(B-C)

Postfix Expression: ACDBC-+

Process returned 0 (0x0) execution time: 35.229 s

Press any key to continue.
```

Lab program 3a:

WAP to simulate the working of a queue of integers using an array. Provide the following operations

- a) Insert
- b) Delete
- c) Display

The program should print appropriate messages for queue empty and queue overflow conditions.

```
#include <stdio.h>
#include <stdbool.h>
#define MAX_SIZE 5

typedef struct {
  int queue[MAX_SIZE];
  int front, rear;
  int size;
```

```
} Queue;
void initQueue(Queue *q) {
q->front = 0;
q->rear = -1;
q->size = 0;
bool isEmpty(Queue *q) {
return q->size == 0;
bool isFull(Queue *q) {
return q->size == MAX_SIZE;
}
void enqueue(Queue *q, int item) {
if (isFull(q)) {
printf("Queue Overflow! Cannot insert element.\n");
return;
q->rear = (q->rear + 1) % MAX_SIZE;
q->queue[q->rear] = item;
q->size++;
printf("Inserted %d into the queue.\n", item);
int dequeue(Queue *q) {
if (isEmpty(q)) {
printf("Queue Underflow! Cannot delete element.\n");
return -1;
int item = q->queue[q->front];
q->front++;
q->size--;
printf("Deleted %d from the queue.\n", item);
return item;
}
void display(Queue *q) {
if (isEmpty(q)) {
printf("Queue is empty.\n");
return;
printf("Queue elements: ");
for (int i = q->front; i <= q->rear; i++) {
printf("%d ", q->queue[i]);
printf("\n");
```

```
int main() {
Queue q;
initQueue(&q);
int choice, item;
do {
printf("\n1. Enqueue\n2. Dequeue\n3. Display\n4. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
if (isFull(&q)) {
printf("Queue Overflow. Cannot enqueue.\n");
} else {
printf("Enter element to enqueue: ");
scanf("%d", &item);
enqueue(&q, item);
}
break;
case 2:
dequeue(&q);
break;
case 3:
display(&q);
break;
case 4:
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
} while (choice != 4);
return 0;
Output:
```

```
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter element to enqueue: 6
Inserted 6 into the queue.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter element to enqueue: 7
Inserted 7 into the queue.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter element to enqueue: 4
Inserted 4 into the queue.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter element to enqueue: 8
Inserted 8 into the queue.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter element to enqueue: 9
Inserted 9 into the queue.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Queue Overflow. Cannot enqueue.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 3
Queue elements: 6 7 4 8 9
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Queue Overflow. Cannot enqueue.
```

```
4. Exit
 Enter your choice: 3
Queue elements: 6 7 4 8 9
 1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Queue Overflow. Cannot enqueue.
 1. Enqueue
 2. Dequeue
 3. Display
 4. Exit
Enter your choice: 2
Deleted 6 from the queue.
 1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Deleted 7 from the queue.
 1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Deleted 4 from the queue.
 1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Deleted 8 from the queue.
1. Enqueue
2. Dequeue
3. Display
 4. Exit
 Enter your choice: 2
Deleted 9 from the queue.
 1. Enqueue
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Queue Underflow! Cannot delete element.
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Queue Underflow! Cannot delete element.
 1. Enqueue
2. Dequeue
3. Display
 4. Exit
Enter your choice: 2
Queue Underflow! Cannot delete element.
 1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Queue Underflow! Cannot delete element.
```

Lab program 3b:

WAP to simulate the working of a circular queue of integers using an array. Provide the following operations.

- a) Insert
- b) Delete
- c) Display

The program should print appropriate messages for queue empty and queue overflow conditions.

```
#include <stdio.h>
#include <stdbool.h>
#define MAX_SIZE 5
typedef struct {
int queue[MAX_SIZE];
int front, rear;
int size;
} CircularQueue;
void initQueue(CircularQueue *cq) {
cq->front = 0;
cq->rear = -1;
cq->size = 0;
}
bool isEmpty(CircularQueue *cq) {
return cq->size == 0;
bool isFull(CircularQueue *cq) {
return cq->size == MAX_SIZE;
}
void enqueue(CircularQueue *cq, int item) {
if (isFull(cq)) {
printf("Queue Overflow! Cannot insert element.\n");
return;
cq->rear = (cq->rear + 1) % MAX_SIZE;
cq->queue[cq->rear] = item;
cq->size++;
printf("Inserted %d into the queue.\n", item);
```

```
int dequeue(CircularQueue *cq) {
if (isEmpty(cq)) {
printf("Queue Underflow! Cannot delete element.\n");
return -1;
int item = cq->queue[cq->front];
cq->front = (cq->front + 1) % MAX_SIZE;
cq->size--;
printf("Deleted %d from the queue.\n", item);
return item;
}
void display(CircularQueue *cq) {
if (isEmpty(cq)) {
printf("Queue is empty.\n");
return;
printf("Queue elements: ");
int i, count;
for (count = 0, i = cq->front; count < cq->size; count++, i = (i + 1) % MAX_SIZE) {
printf("%d", cq->queue[i]);
printf("\n");
int main() {
CircularQueue cq;
initQueue(&cq);
int choice, item;
printf("\n1. Insert\n2. Delete\n3. Display\n4. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter element to enqueue: ");
scanf("%d", &item);
enqueue(&cq, item);
break:
case 2:
dequeue(&cq);
break;
case 3:
display(&cq);
break;
case 4:
printf("Exiting...\n");
```

```
break:
default:
printf("Invalid choice! Please enter a valid option.\n");
} while (choice != 4);
return 0;
Output:
 1. Insert
 2. Delete
 3. Display
 4. Exit
 Enter your choice: 1
 Enter element to enqueue: 3
 Inserted 3 into the queue.
 1. Insert
 2. Delete
 3. Display
 4. Exit
 Enter your choice: 1
 Enter element to enqueue: 4
 Inserted 4 into the queue.
 1. Insert
 2. Delete
 3. Display
 4. Exit
 Enter your choice: 1
 Enter element to enqueue: 7
 Inserted 7 into the queue.
 1. Insert
 2. Delete
 3. Display
 4. Exit
 Enter your choice: 1
 Enter element to enqueue: 8
 Inserted 8 into the queue.
 1. Insert
 2. Delete
 3. Display
 4. Exit
 Enter your choice: 1
 Enter element to enqueue: 5
 Inserted 5 into the queue.
 1. Insert
 2. Delete
 3. Display
 4. Exit
 Enter your choice: 1
 Enter element to enqueue: 6
 Queue Overflow! Cannot insert element.
```

```
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 1
Enter element to enqueue: 9
Queue Overflow! Cannot insert element.
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Deleted 3 from the queue.
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Deleted 4 from the queue.
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Deleted 7 from the queue.
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Deleted 8 from the queue.
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Deleted 5 from the queue.
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Queue Underflow! Cannot delete element.
```

```
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 3
Queue is empty.

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 4
Exit
Enter your choice: 4
Exiting...

Process returned 0 (0x0) execution time: 35.708 s
Press any key to continue.
```

Lab program 4:

WAP to Implement Singly Linked List with following operations

- a) Create a linked list.
- b) Insertion of a node at first position, at any position and at end of list.
- c) Display the contents of the linked list.

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

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

Node* createNode(int data) {
  Node *newNode = (Node*)malloc(sizeof(Node));
  if (newNode == NULL) {
    printf("Memory allocation failed!\n");
    exit(1);
```

```
}
newNode->data = data;
newNode->next = NULL;
return newNode;
}
Node* insertAtBeginning(Node *head, int data) {
Node *newNode = createNode(data);
newNode->next = head;
return newNode;
}
Node* insertAtPosition(Node *head, int data, int position) {
if (position < 1) {
printf("Invalid position!\n");
return head;
}
Node *newNode = createNode(data);
if (position == 1 | | head == NULL) {
newNode->next = head;
return newNode;
}
Node *current = head;
int count = 1;
```

```
while (count < position - 1 && current != NULL) {
current = current->next;
count++;
}
if (current == NULL) {
printf("Position out of range!\n");
return head;
}
newNode->next = current->next;
current->next = newNode;
return head;
}
Node* insertAtEnd(Node *head, int data) {
Node *newNode = createNode(data);
if (head == NULL) {
return newNode;
}
Node *current = head;
while (current->next != NULL) {
current = current->next;
current->next = newNode;
return head;
```

```
}
void displayList(Node *head) {
if (head == NULL) {
printf("List is empty.\n");
return;
}
Node *current = head;
printf("List elements: ");
while (current != NULL) {
printf("%d", current->data);
current = current->next;
}
printf("\n");
}
void freeList(Node *head) {
Node *current = head;
Node *temp;
while (current != NULL) {
temp = current;
current = current->next;
free(temp);
}
}
int main() {
```

```
Node *head = NULL;
int choice, data, position;
do {
printf("\n1. Insert at beginning\n2. Insert at position\n3. Insert at end\n4. Display\n5. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter data to insert at beginning: ");
scanf("%d", &data);
head = insertAtBeginning(head, data);
break;
case 2:
printf("Enter data to insert: ");
scanf("%d", &data);
printf("Enter position to insert at: ");
scanf("%d", &position);
head = insertAtPosition(head, data, position);
break;
case 3:
printf("Enter data to insert at end: ");
scanf("%d", &data);
head = insertAtEnd(head, data);
break;
case 4:
displayList(head);
break;
```

```
case 5:
freeList(head);
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
}
} while (choice != 5);
return 0;
}
```

```
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 1
Enter data to insert at beginning: 5
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 1
Enter data to insert at beginning: 8
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 1
Enter data to insert at beginning: 7
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 2
Enter data to insert: 6
Enter position to insert at: 2
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 4
List elements: 7 6 8 5
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 3
Enter data to insert at end: 6
```

```
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 3
Enter data to insert at end: 5
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 2
Enter data to insert: 8
Enter position to insert at: 5
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 4
List elements: 7 6 8 5 8 6 5
1. Insert at beginning
2. Insert at position
3. Insert at end
4. Display
5. Exit
Enter your choice: 5
Exiting...
Process returned 0 (0x0)
                           execution time : 68.611 s
Press any key to continue.
```

Lab program 5:

WAP to Implement Singly Linked List with following operations

- a) Create a linked list.
- b) Deletion of first element, specified element and last element in the list.
- c) Display the contents of the linked list.

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

typedef struct Node {
```

```
int data;
struct Node *next;
} Node;
Node* createNode(int data) {
Node *newNode = (Node*)malloc(sizeof(Node));
if (newNode == NULL) {
printf("Memory allocation failed!\n");
exit(1);
newNode->data = data;
newNode->next = NULL;
return newNode;
}
Node* insertAtBeginning(Node *head, int data) {
Node *newNode = createNode(data);
newNode->next = head;
return newNode;
}
Node* deleteFirstNode(Node *head) {
if (head == NULL) {
printf("List is empty. Nothing to delete.\n");
return NULL;
}
Node *temp = head;
```

```
head = head->next;
free(temp);
printf("Deleted the first node from the list.\n");
return head;
}
Node* deleteSpecifiedNode(Node *head, int key) {
Node *current = head;
Node *prev = NULL;
if (current != NULL && current->data == key) {
head = head->next;
free(current);
printf("Deleted node with key %d from the list.\n", key);
return head;
}
while (current != NULL && current->data != key) {
prev = current;
current = current->next;
}
if (current == NULL) {
printf("Key %d not found in the list.\n", key);
return head;
}
prev->next = current->next;
```

```
free(current);
printf("Deleted node with key %d from the list.\n", key);
return head;
}
Node* deleteLastNode(Node *head) {
if (head == NULL) {
printf("List is empty. Nothing to delete.\n");
return NULL;
}
if (head->next == NULL) {
free(head);
printf("Deleted the last node from the list.\n");
return NULL;
}
Node *prev = NULL;
Node *current = head;
while (current->next != NULL) {
prev = current;
current = current->next;
}
prev->next = NULL;
free(current);
printf("Deleted the last node from the list.\n");
```

```
return head;
}
void displayList(Node *head) {
if (head == NULL) {
printf("List is empty.\n");
return;
}
Node *current = head;
printf("List elements: ");
while (current != NULL) {
printf("%d", current->data);
current = current->next;
}
printf("\n");
}
void freeList(Node *head) {
Node *current = head;
Node *temp;
while (current != NULL) {
temp = current;
current = current->next;
free(temp);
}
}
```

```
int main() {
Node *head = NULL;
int choice, data, key;
do {
printf("\n1. Insert at beginning\n2. Delete first node\n3. Delete specified node\n4. Delete last
node\n5. Display\n6. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter data to insert at beginning: ");
scanf("%d", &data);
head = insertAtBeginning(head, data);
break;
case 2:
head = deleteFirstNode(head);
break;
case 3:
printf("Enter the key of node to delete: ");
scanf("%d", &key);
head = deleteSpecifiedNode(head, key);
break;
case 4:
head = deleteLastNode(head);
break;
case 5:
displayList(head);
```

```
break;
case 6:
freeList(head);
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
}
} while (choice != 6);
return 0;
}
```

```
    Insert at beginning
    Delete first node
    Delete specified node
    Delete last node

5. Display
6. Exit
Enter your choice: 1
Enter data to insert at beginning: 6

    Insert at beginning
    Delete first node
    Delete specified node
    Delete last node

5. Display
6. Exit
Enter your choice: 1
Enter data to insert at beginning: 8

    Insert at beginning
    Delete first node
    Delete specified node
    Delete last node

Display
5. Display
6. Exit
Enter your choice: 3
Enter the key of node to delete: 6
Deleted node with key 6 from the list.

    Insert at beginning
    Delete first node

    Delete specified node
    Delete last node

5. Display
6. Exit
Enter your choice: 1
Enter data to insert at beginning: 2

1. Insert at beginning
2. Delete first node
3. Delete specified node
4. Delete last node
5. Display
Enter your choice: 1
Enter data to insert at beginning: 4
1. Insert at beginning

    Delete first node
    Delete specified node
    Delete last node

5. Display
Enter your choice: 4
Deleted the last node from the list.

    Insert at beginning
    Delete first node
    Delete specified node
    Delete last node

5. Display
6. Exit
Enter your choice: 5
List elements: 4 2 8
```

Lab program 6a:

WAP to Implement Single Link List with following operations

- a) Sort the linked list.
- b) Reverse the linked list.

c) Concatenation of two linked lists

```
#include <stdio.h>
#include <stdlib.h>
typedef struct Node {
int data;
struct Node *next;
} Node;
Node* createNode(int data) {
Node *newNode = (Node*)malloc(sizeof(Node));
if (newNode == NULL) {
printf("Memory allocation failed!\n");
exit(1);
}
newNode->data = data;
newNode->next = NULL;
return newNode;
}
Node* insertAtBeginning(Node *head, int data) {
Node *newNode = createNode(data);
newNode->next = head;
return newNode;
}
```

```
void displayList(Node *head) {
if (head == NULL) {
printf("List is empty.\n");
return;
}
Node *current = head;
printf("List elements: ");
while (current != NULL) {
printf("%d", current->data);
current = current->next;
}
printf("\n");
}
Node* sortLinkedList(Node *head) {
if (head == NULL | | head->next == NULL)
return head;
Node *prev = head;
Node *current = head->next;
while (current != NULL) {
Node *innerPrev = NULL;
Node *innerCurrent = head;
while (innerCurrent != current) {
if (innerCurrent->data > current->data) {
prev->next = current->next;
current->next = innerCurrent;
```

```
if (innerPrev == NULL)
head = current;
else
innerPrev->next = current;
current = prev->next;
break;
}
innerPrev = innerCurrent;
innerCurrent = innerCurrent->next;
if (innerCurrent == current) {
prev = current;
current = current->next;
}
}
return head;
}
Node* reverseLinkedList(Node *head) {
Node *prev = NULL;
Node *current = head;
Node *next = NULL;
while (current != NULL) {
next = current->next;
current->next = prev;
prev = current;
```

```
current = next;
}
head = prev;
return head;
}
Node* concatenateLinkedLists(Node *list1, Node *list2) {
if (list1 == NULL)
return list2;
if (list2 == NULL)
return list1;
Node *current = list1;
while (current->next != NULL) {
current = current->next;
}
current->next = list2;
return list1;
}
int main() {
Node *list1 = NULL;
Node *list2 = NULL;
list1 = insertAtBeginning(list1, 40);
list1 = insertAtBeginning(list1, 60);
```

```
list1 = insertAtBeginning(list1, 20);
printf("List 1:\n");
displayList(list1);
list1 = sortLinkedList(list1);
printf("Sorted List 1:\n");
displayList(list1);
list1 = reverseLinkedList(list1);
printf("Reversed List 1:\n");
displayList(list1);
list2 = insertAtBeginning(list2, 30);
list2 = insertAtBeginning(list2, 70);
list2 = insertAtBeginning(list2, 80);
printf("List 2:\n");
displayList(list2);
list2 = sortLinkedList(list2);
printf("Sorted List 2:\n");
displayList(list2);
list2 = reverseLinkedList(list2);
printf("Reversed List 2:\n");
displayList(list2);
```

```
Node *concatenatedList = concatenateLinkedLists(list1, list2);
printf("Concatenated List:\n");
displayList(concatenatedList);
return 0;
}
```

```
List 1:
List elements: 20 60 40
Sorted List 1:
List elements: 20 40 60
Reversed List 1:
List elements: 60 40 20
List 2:
List elements: 80 70 30
Sorted List 2:
List elements: 30 70 80
Reversed List 2:
List elements: 80 70 30
Concatenated List:
List elements: 60 40 20 80 70 30
                            execution time : 0.039 s
Process returned 0 (0x0)
Press any key to continue.
```

Lab program 6b:

WAP to implement Stack & Queues using Linked Representation

Stack

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

typedef struct StackNode {
int data;
```

```
struct StackNode* next;
} StackNode;
StackNode* createStackNode(int data) {
StackNode* newNode = (StackNode*)malloc(sizeof(StackNode));
if (newNode == NULL) {
printf("Memory allocation failed!\n");
exit(1);
}
newNode->data = data;
newNode->next = NULL;
return newNode;
}
int isEmpty(StackNode* root) {
return (root == NULL);
}
void push(StackNode** root, int data) {
StackNode* newNode = createStackNode(data);
newNode->next = *root;
*root = newNode;
printf("Pushed %d onto the stack.\n", data);
}
int pop(StackNode** root) {
if (isEmpty(*root)) {
```

```
printf("Stack Underflow! Cannot pop element.\n");
return -1;
}
int popped = (*root)->data;
StackNode* temp = *root;
*root = (*root)->next;
free(temp);
return popped;
}
int peek(StackNode* root) {
if (isEmpty(root)) {
printf("Stack is empty.\n");
return -1;
}
return root->data;
}
void displayStack(StackNode* root) {
if (isEmpty(root)) {
printf("Stack is empty.\n");
return;
}
printf("Stack elements: ");
while (root != NULL) {
printf("%d ", root->data);
root = root->next;
```

```
}
printf("\n");
}
int main() {
StackNode* stack = NULL;
int choice, data;
do {
printf("\n1. Push\n2. Pop\n3. Peek\n4. Display\n5. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter data to push onto the stack: ");
scanf("%d", &data);
push(&stack, data);
break;
case 2:
printf("Popped %d from the stack.\n", pop(&stack));
break;
case 3:
printf("Top element of the stack: %d\n", peek(stack));
break;
case 4:
displayStack(stack);
break;
```

```
case 5:
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
}
} while (choice != 5);
return 0;
}
```

```
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 1
Enter data to push onto the stack: 6
Pushed 6 onto the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 1
Enter data to push onto the stack: 5
Pushed 5 onto the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 1
Enter data to push onto the stack: 3
Pushed 3 onto the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 2
Popped 3 from the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 3
Top element of the stack: 5
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 4
Stack elements: 5 6 2
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 5
Exiting...
Process returned 0 (0x0) execution time : 142.839 s
Press any key to continue.
```

Queue:

#include <stdio.h>

#include <stdlib.h>

```
typedef struct QueueNode {
int data;
struct QueueNode* next;
} QueueNode;
typedef struct {
QueueNode* front;
QueueNode* rear;
} Queue;
QueueNode* createQueueNode(int data) {
QueueNode* newNode = (QueueNode*)malloc(sizeof(QueueNode));
if (newNode == NULL) {
printf("Memory allocation failed!\n");
exit(1);
}
newNode->data = data;
newNode->next = NULL;
return newNode;
}
Queue* createQueue() {
Queue* queue = (Queue*)malloc(sizeof(Queue));
if (queue == NULL) {
printf("Memory allocation failed!\n");
exit(1);
}
queue->front = queue->rear = NULL;
```

```
return queue;
}
int isEmpty(Queue* queue) {
return (queue->front == NULL);
}
void enqueue(Queue* queue, int data) {
QueueNode* newNode = createQueueNode(data);
if (isEmpty(queue)) {
queue->front = queue->rear = newNode;
} else {
queue->rear->next = newNode;
queue->rear = newNode;
}
printf("Enqueued %d into the queue.\n", data);
}
int dequeue(Queue* queue) {
if (isEmpty(queue)) {
printf("Queue Underflow! Cannot dequeue element.\n");
return -1;
}
int dequeued = queue->front->data;
QueueNode* temp = queue->front;
queue->front = queue->front->next;
if (queue->front == NULL) {
queue->rear = NULL;
}
```

```
free(temp);
return dequeued;
}
int peek(Queue* queue) {
if (isEmpty(queue)) {
printf("Queue is empty.\n");
return -1;
return queue->front->data;
}
void displayQueue(Queue* queue) {
if (isEmpty(queue)) {
printf("Queue is empty.\n");
return;
printf("Queue elements: ");
QueueNode* current = queue->front;
while (current != NULL) {
printf("%d ", current->data);
current = current->next;
}
printf("\n");
}
int main() {
Queue* queue = createQueue();
int choice, data;
```

```
do {
printf("\n1. Enqueue\n2. Dequeue\n3. Peek\n4. Display\n5. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter data to enqueue into the queue: ");
scanf("%d", &data);
enqueue(queue, data);
break;
case 2:
printf("Dequeued %d from the queue.\n", dequeue(queue));
break;
case 3:
printf("Front element of the queue: %d\n", peek(queue));
break;
case 4:
displayQueue(queue);
break;
case 5:
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
} while (choice != 5);
return 0;
}
```

```
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 1
Enter data to push onto the stack: 6
Pushed 6 onto the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 1
Enter data to push onto the stack: 5
Pushed 5 onto the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 1
Enter data to push onto the stack: 3
Pushed 3 onto the stack.
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 2
Popped 3 from the stack.
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 3
Top element of the stack: 5
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 4
Stack elements: 5 6 2
1. Push
2. Pop
3. Peek
4. Display
5. Exit
Enter your choice: 5
Exiting...
Process returned 0 (0x0) execution time : 142.839 s
Press any key to continue.
```

Lab program 7:

WAP to Implement doubly link list with primitive operations

- a) Create a doubly linked list.
- b) Insert a new node to the left of the node.
- c) Delete the node based on a specific value
- d) Display the contents of the list

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

typedef struct Node {
  int data;
  struct Node* prev;
  struct Node* next;
} Node;
Node* createNode(int data) {
```

```
Node* newNode = (Node*)malloc(sizeof(Node));
if (newNode == NULL) {
printf("Memory allocation failed!\n");
exit(1);
}
newNode->data = data;
newNode->prev = NULL;
newNode->next = NULL;
return newNode;
}
void insertLeft(Node** head, Node* node, int data) {
Node* newNode = createNode(data);
newNode->next = node;
newNode->prev = node->prev;
if (node->prev != NULL) {
node->prev->next = newNode;
} else {
*head = newNode;
}
node->prev = newNode;
}
void deleteNode(Node** head, int key) {
Node* current = *head;
while (current != NULL) {
if (current->data == key) {
```

```
if (current->prev != NULL) {
current->prev->next = current->next;
} else {
*head = current->next;
}
if (current->next != NULL) {
current->next->prev = current->prev;
}
free(current);
return;
}
current = current->next;
}
printf("Node with value %d not found in the list.\n", key);
}
void displayList(Node* head) {
if (head == NULL) {
printf("List is empty.\n");
return;
}
printf("List elements: ");
while (head != NULL) {
printf("%d ", head->data);
head = head->next;
}
printf("\n");
```

```
}
void freeList(Node* head) {
Node* current = head;
Node* temp;
while (current != NULL) {
temp = current;
current = current->next;
free(temp);
}
}
int main() {
Node* head = NULL;
int choice, data, value;
do {
printf("\n1. Create a Doubly Linked List\n2. Insert a new node to the left of a node\n3. Delete a node
based on a specific value\n4. Display the contents of the list\n5. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter the number of elements to create the list: ");
scanf("%d", &data);
printf("Enter the elements: ");
for (int i = 0; i < data; ++i) {
int value;
```

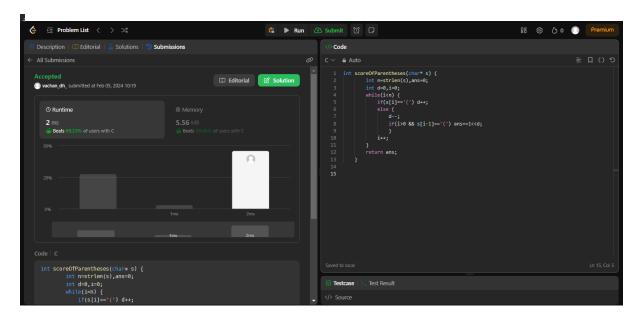
```
scanf("%d", &value);
if (head == NULL) {
head = createNode(value);
} else {
Node* temp = head;
while (temp->next != NULL) {
temp = temp->next;
}
Node* newNode = createNode(value);
temp->next = newNode;
newNode->prev = temp;
}
}
break;
case 2:
if (head == NULL) {
printf("List is empty. Create a list first.\n");
break;
}
printf("Enter the value of the node to the left of which you want to insert a new node: ");
scanf("%d", &value);
printf("Enter the data of the new node: ");
scanf("%d", &data);
Node* current = head;
while (current != NULL && current->data != value) {
current = current->next;
}
```

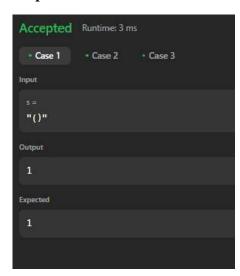
```
if (current == NULL) {
printf("Node with value %d not found in the list.\n", value);
} else {
insertLeft(&head, current, data);
}
break;
case 3:
if (head == NULL) {
printf("List is empty. Create a list first.\n");
break;
}
printf("Enter the value of the node you want to delete: ");
scanf("%d", &data);
deleteNode(&head, data);
break;
case 4:
displayList(head);
break;
case 5:
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
}
} while (choice != 5);
freeList(head);
return 0;
```

```
1. Create a Doubly Linked List
2. Insert a new node to the left of a node
3. Delete a node based on a specific value
4. Display the contents of the list
5. Exit
Enter your choice: 1
Enter the number of elements to create the list: 5
Enter the elements: 3
6
1. Create a Doubly Linked List
2. Insert a new node to the left of a node
3. Delete a node based on a specific value
4. Display the contents of the list
5. Exit
Enter your choice: 2
Enter the value of the node to the left of which you want to insert a new node: 7
Enter the data of the new node: 8
1. Create a Doubly Linked List
2. Insert a new node to the left of a node
3. Delete a node based on a specific value
4. Display the contents of the list
5. Exit
Enter your choice: 4
List elements: 3 4 5 6 8 7
1. Create a Doubly Linked List
2. Insert a new node to the left of a node
3. Delete a node based on a specific value
4. Display the contents of the list
5. Exit
Enter your choice: 3
Enter the value of the node you want to delete: 8
1. Create a Doubly Linked List
2. Insert a new node to the left of a node
3. Delete a node based on a specific value
4. Display the contents of the list
5. Exit
Enter your choice: 4
List elements: 3 4 5 6 7
1. Create a Doubly Linked List
2. Insert a new node to the left of a node
3. Delete a node based on a specific value
4. Display the contents of the list
5. Exit
Enter your choice: 5
Exiting...
```

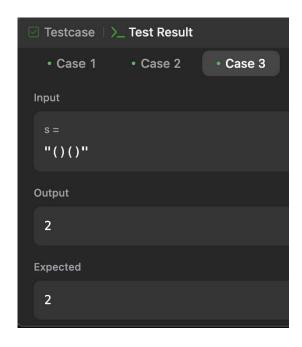
LeetCode Problem:

ScoreOfParentheses:









Lab program 8:

Write a program

- a) To construct a binary Search tree.
- b) To traverse the tree using all the methods i.e., in-order, preorder andpost order
- c) To display the elements in the tree.

```
#include <stdio.h>
#include <stdlib.h>
typedef struct TreeNode {
int data;
struct TreeNode* left;
struct TreeNode* right;
} TreeNode;
TreeNode* createNode(int data) {
TreeNode* newNode = (TreeNode*)malloc(sizeof(TreeNode));
if (newNode == NULL) {
printf("Memory allocation failed!\n");
exit(1);
newNode->data = data;
newNode->left = NULL;
newNode->right = NULL;
return newNode;
}
TreeNode* insertNode(TreeNode* root, int data) {
if (root == NULL) {
```

```
return createNode(data);
}
if (data < root->data) {
root->left = insertNode(root->left, data);
} else if (data > root->data) {
root->right = insertNode(root->right, data);
}
return root;
}
void inorderTraversal(TreeNode* root) {
if (root != NULL) {
inorderTraversal(root->left);
printf("%d ", root->data);
inorderTraversal(root->right);
}
}
void preorderTraversal(TreeNode* root) {
if (root != NULL) {
printf("%d ", root->data);
preorderTraversal(root->left);
preorderTraversal(root->right);
}
}
void postorderTraversal(TreeNode* root) {
```

```
if (root != NULL) {
postorderTraversal(root->left);
postorderTraversal(root->right);
printf("%d ", root->data);
}
}
void displayTree(TreeNode* root) {
printf("Elements in the tree (inorder traversal): ");
inorderTraversal(root);
printf("\n");
}
int main() {
TreeNode* root = NULL;
int choice, data;
do {
printf("\n1. Insert\n2. Inorder Traversal\n3. Preorder Traversal\n4. Postorder Traversal\n5. Display
Tree\n6. Exit\n");
printf("Enter your choice: ");
scanf("%d", &choice);
switch (choice) {
case 1:
printf("Enter data to insert into the tree: ");
scanf("%d", &data);
root = insertNode(root, data);
break;
case 2:
```

```
printf("Inorder Traversal: ");
inorderTraversal(root);
printf("\n");
break;
case 3:
printf("Preorder Traversal: ");
preorderTraversal(root);
printf("\n");
break;
case 4:
printf("Postorder Traversal: ");
postorderTraversal(root);
printf("\n");
break;
case 5:
displayTree(root);
break;
case 6:
printf("Exiting...\n");
break;
default:
printf("Invalid choice! Please enter a valid option.\n");
}
} while (choice != 6);
return 0;
}
```

```
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 1
Enter data to insert into the tree: 3
1. Insert

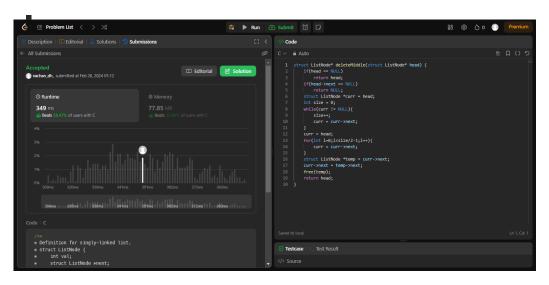
    Inorder Traversal
    Preorder Traversal

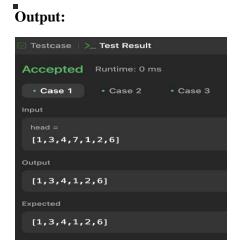
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 1
Enter data to insert into the tree: 6
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 1
Enter data to insert into the tree: 7
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 1
Enter data to insert into the tree: 4
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 2
Inorder Traversal: 3 4 6 7
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 3
Preorder Traversal: 3 6 4 7
```

```
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 4
Postorder Traversal: 4 7 6 3
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 5
Elements in the tree (inorder traversal): 3 4 6 7
1. Insert
2. Inorder Traversal
3. Preorder Traversal
4. Postorder Traversal
5. Display Tree
6. Exit
Enter your choice: 6
Exiting...
Process returned 0 (0x0) execution time : 19.580 s
Press any key to continue.
```

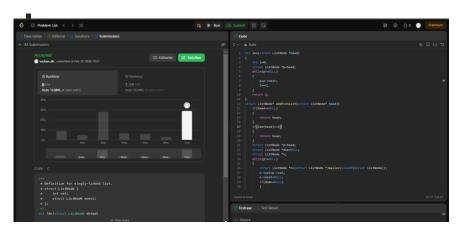
Leet Code Problem:

Delete the Middle Node Of a Linked List:





Odd Even Linked List:







Lab program 9:

Write a Program to traverse a graph using BFS method.

```
#include <stdio.h>
void bfs(int a[10][10], int n, int u) {
int f = 0, r = -1, q[10] = \{0\}, v, s[10] = \{0\};
printf("The nodes visited from %d: ", u);
q[++r] = u;
s[u] = 1;
printf("%d", u);
while (f \le r) {
u = q[f++];
for (v = 0; v < n; v++) {
if (a[u][v] == 1 \&\& s[v] == 0) {
printf("%d ", v);
s[v] = 1;
q[++r] = v;
}
}
}
printf("\n");
}
int main() {
int n, a[10][10], source, i, j;
```

```
printf("\nEnter the number of nodes: ");
scanf("%d", &n);
printf("\nEnter the adjacency matrix:\n");
for (i = 0; i < n; i++) {
  for (j = 0; j < n; j++) {
    scanf("%d", &a[i][j]);
  }
}
for (source = 0; source < n; source++) {
    bfs(a, n, source);
}
return 0;
}</pre>
```

```
Enter the number of nodes: 4

Enter the adjacency matrix:
1 0 1 0
0 0 1 1
0 1 0 1
1 0 0 1
The nodes visited from 0: 0 2 1 3
The nodes visited from 1: 1 2 3 0
The nodes visited from 2: 2 1 3 0
The nodes visited from 3: 3 0 2 1

Process returned 0 (0x0) execution time: 29.157 s
Press any key to continue.
```

b)Write a program to check wheater given graph is connected or not using DFS method

#include <stdio.h>

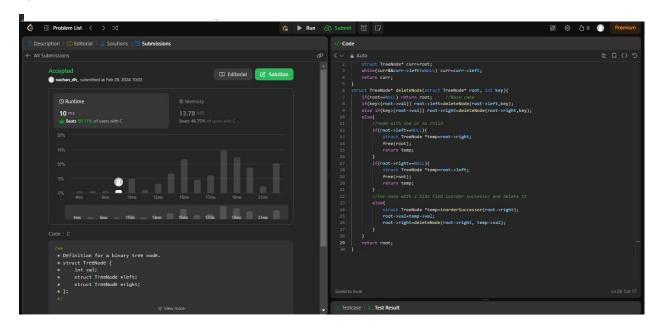
```
}
printf("Enter the adjacency matrix:\n");
for (i = 1; i <= n; i++) {
for (j = 1; j \le n; j++) {
scanf("%d", &a[i][j]);
}
}
dfs(1);
for (i = 1; i <= n; i++) {
if (s[i]) {
count++;
}
}
if (count == n) {
printf("Graph is connected\n");
} else {
printf("Graph is not connected\n");
}
return 0;
}
```

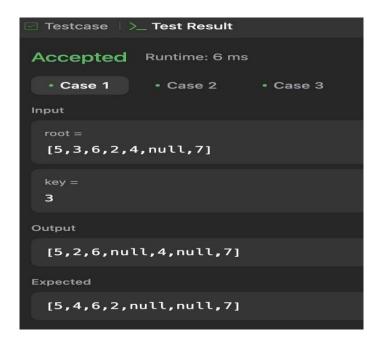
```
Enter number of vertices: 4
Enter the adjacency matrix:
0 0 1 0
1 0 1 1
1 1 1 1
0 0 0 1
Graph is connected

Process returned 0 (0x0) execution time: 24.628 s
Press any key to continue.
```

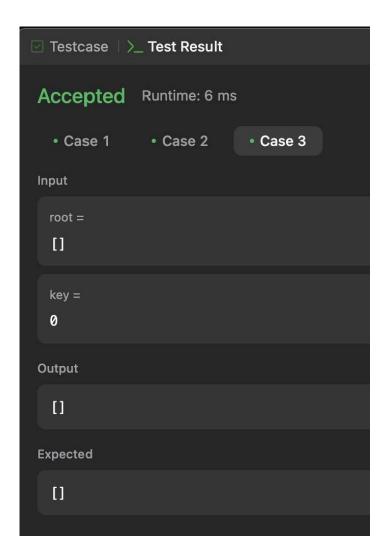
LeetCode Problem:

a)Delete Node In BST

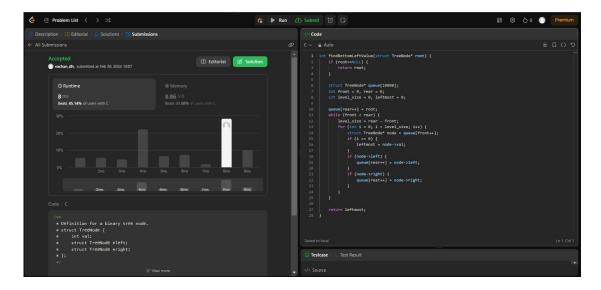






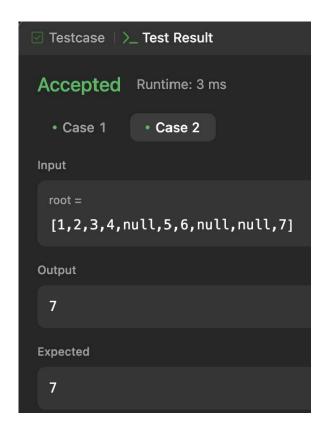


b)Find Bottom Left Tree Value



j





Lab Program 10:

Given a File of N employee records with a set K of Keys(4-digit) which uniquely determine the records in file F. Assume that file F is maintained in memory by a Hash Table (HT) of m memory locations with L as the set of memory addresses (2-digit) of locations in HT. Let the keys in K and addresses in L are integers. Design and develop a Program in C that uses Hash function H: $K \rightarrow L$ as $K \rightarrow L$ as $K \rightarrow L$ and $K \rightarrow L$ mod m (remainder method), and implement hashing technique to map a given key K to the address space L. Resolve the collision (if any) using linear probing.

```
#include <stdio.h>
#include <stdlib.h>
#define MAX EMPLOYEES 100
#define HT_SIZE 10
typedef struct {
int key;
} Employee;
typedef struct {
Employee* entries[HT SIZE];
} HashTable;
int hash(int key) {
return key % HT_SIZE;
}
void initHashTable(HashTable* ht) {
for (int i = 0; i < HT_SIZE; i++) {
ht->entries[i] = NULL;
```

```
}
}
void insertEmployee(HashTable* ht, Employee* emp) {
int index = hash(emp->key);
while (ht->entries[index] != NULL) {
index = (index + 1) % HT_SIZE;
}
ht->entries[index] = emp;
}
void displayHashTable(HashTable* ht) {
printf("\nHash Table:\n");
for (int i = 0; i < HT_SIZE; i++) {
if (ht->entries[i] != NULL) {
printf("Index %d: Key %d\n", i, ht->entries[i]->key);
} else {
printf("Index %d: Empty\n", i);
}
}
}
int main() {
HashTable ht;
initHashTable(&ht);
```

```
int n;
printf("Enter the number of employee records: ");
scanf("%d", &n);
printf("Enter the employee keys:\n");
for (int i = 0; i < n; i++) {
Employee* emp = (Employee*)malloc(sizeof(Employee));
if (emp == NULL) {
printf("Memory allocation failed!\n");
exit(1);
}
scanf("%d", &emp->key);
insertEmployee(&ht, emp);
}
displayHashTable(&ht);
return 0;
}
```

```
Enter the number of employee records: 5
Enter the employee keys:
34
23
45
67
78
Hash Table:
Index 0: Empty
Index 1: Empty
Index 2: Empty
Index 3: Key 23
Index 4: Key 34
Index 5: Key 45
Index 6: Empty
Index 7: Key 67
Index 8: Key 78
Index 9: Empty
Process returned 0 (0x0) execution time : 11.057 s
Press any key to continue.
```