VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
On

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

B.M.S. COLLEGE OF ENGINEERING
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Department of Computer Science and Engineering

This is to certify that the Lab work entitled **"DATA STRUCTURES"** carried out by **VANITHA(1BM22CS317)**, 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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Index Sheet

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:

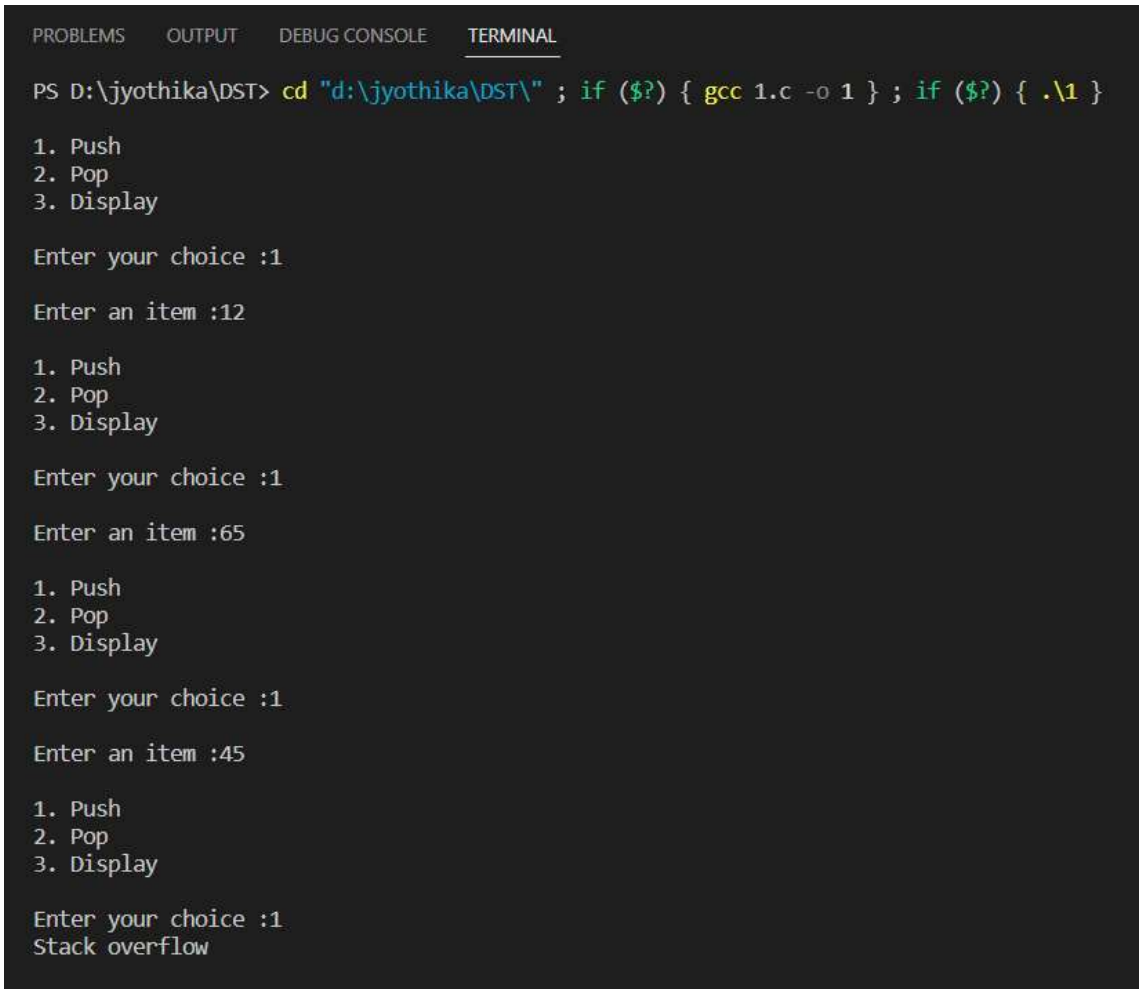
Write a program to simulate the working of stack using an array with the following:
a) Push
b) Pop
c) Display
The program should print appropriate messages for stack overflow, stack underflow.

```
#include <stdio.h>
#include<stdlib.h>
#define STACK_SIZE 5
```

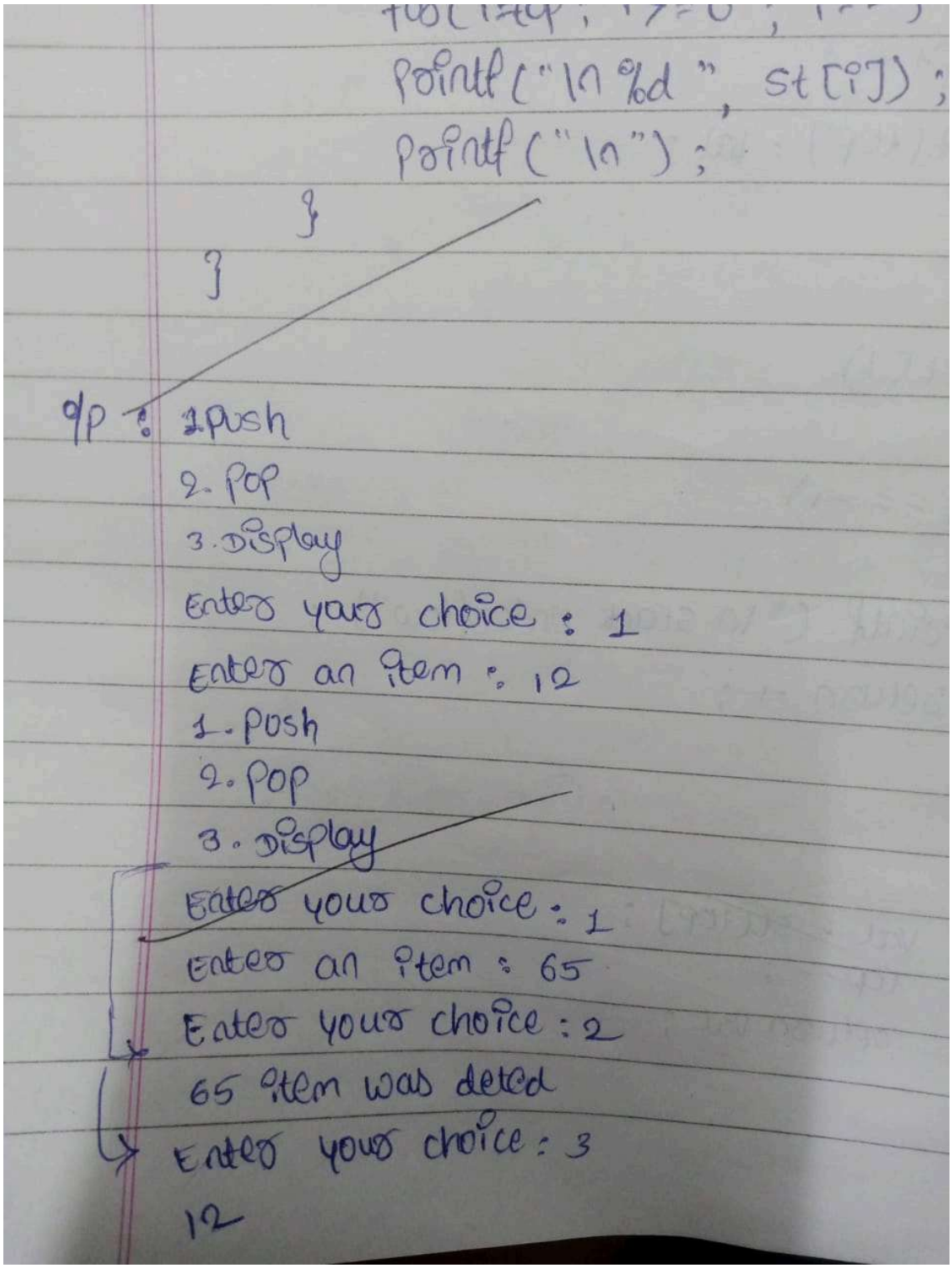
```
void push(int st[],int *top)
{
	int item;
	if(*top==STACK_SIZE-1)
		printf("Stack overflow\n");
	else
	{
		printf("\nEnter an item :");
		scanf("%d",&item);
		(*top)++;
		st[*top]=item;
	}
}
void pop(int st[],int *top)
{
	if(*top==-1)
		printf("Stack underflow\n");
	else
	{
		printf("\n%d item was deleted",st[(*top)--]);
	}
}
void display(int st[],int *top)
{
	int i;
	if(*top==-1)
		printf("Stack is empty\n");
	for(i=0;i<=*top;i++)
		printf("%d\t",st[i]);
}
void main()
{
	int st[10],top=-1, c,val_del;
	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);
            }
        }
}
```

Output:



```
1. Push
2. Pop
3. Display

Enter your choice :2

45 item was deleted
1. Push
2. Pop
3. Display

Enter your choice :2

65 item was deleted
1. Push
2. Pop
3. Display

Enter your choice :3
12
1. Push
2. Pop
3. Display

Enter your choice :2

12 item was deleted
1. Push
2. Pop
3. Display

Enter your choice :2
Stack underflow

1. Push
2. Pop
3. Display

Enter your choice :4

Invalid choice!!!
```


for(i=top; i>=0; i--)
printf("\n%d", st[i]);
printf("\n");
}
}
op: 1.Push
2. Pop
3. Display
Enter your choice : 1
Enter an item : 12
1. Push
2. Pop
3. Display
Enter your choice : 1
Enter an item : 65
Enter your choice : 2
65 item was deted
Enter your choice : 3
12

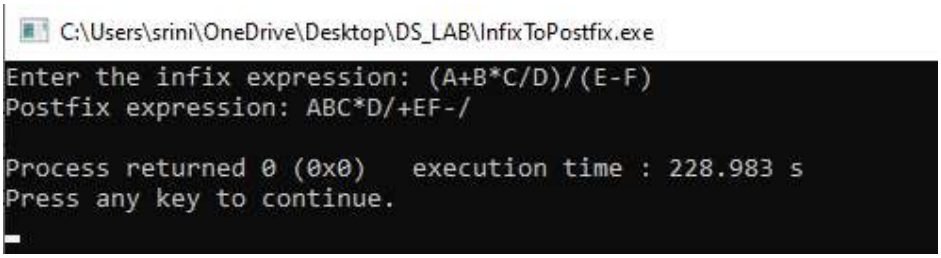
2.WAP to convert a given valid parenthesized infix arithmetic expression to postfix expression. The expression consists of single character operands and the binary operators + (plus), - (minus), * (multiply) and /(divide)

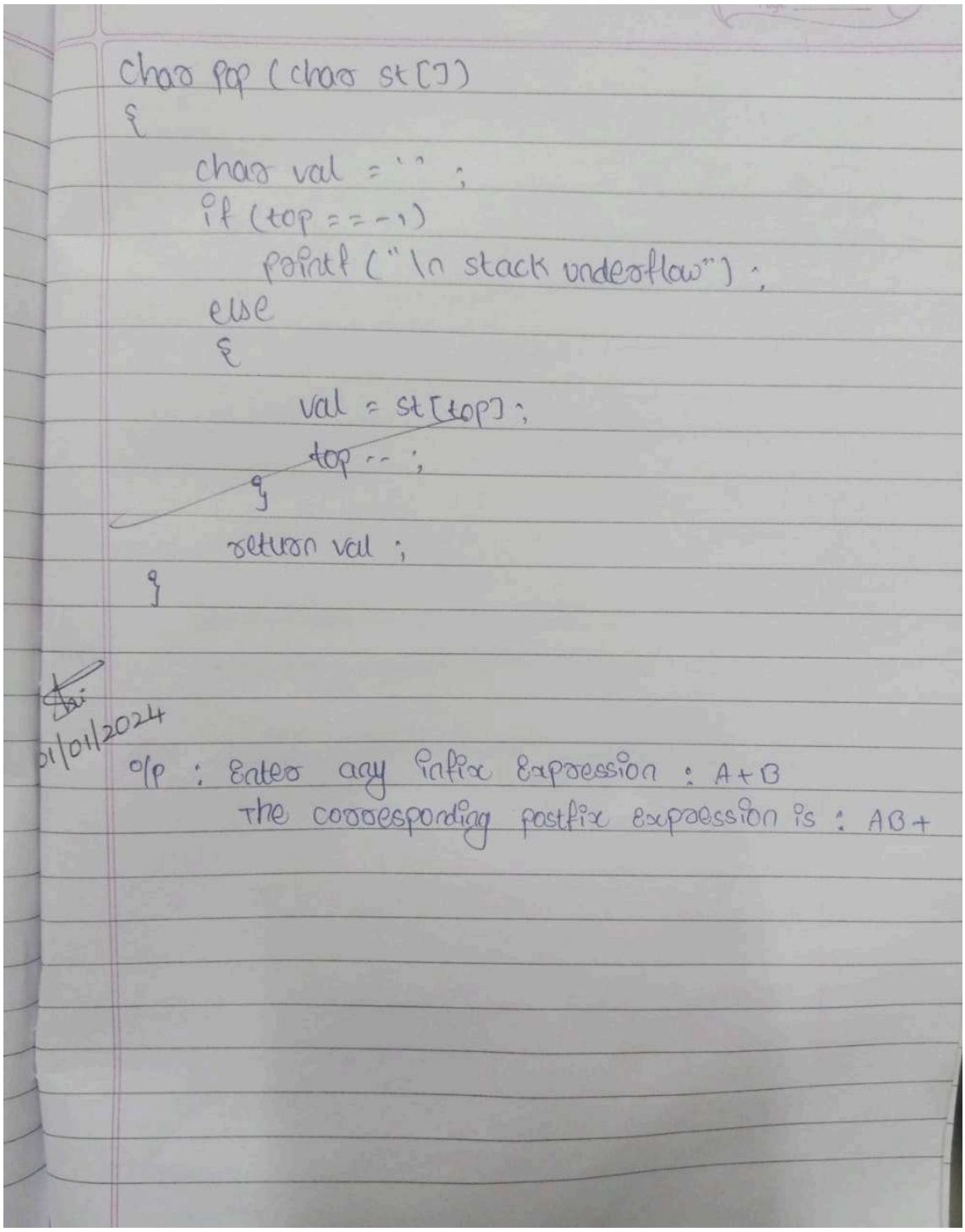
```
#include <stdio.h>
#include <stdlib.h>

#define MAX_SIZE 100

// Stack implementation
typedef struct {
    char data[MAX_SIZE];
    int top;
} Stack;

void initialize(Stack* stack) {
    stack->top = -1;
}

void push(Stack* stack, char item) {
    if (stack->top < MAX_SIZE - 1) {
        stack->data[++stack->top] = item;
    } else {
        printf("Error: Stack overflow\n");
        exit(EXIT_FAILURE);
    }
}

char pop(Stack* stack) {
    if (stack->top >= 0) {
```

```
        return stack->data[stack->top--];
    } else {
        printf("Error: Stack underflow\n");
        exit(EXIT_FAILURE);
    }
}

int isOperator(char ch) {
    return (ch == '+' || ch == '-' || ch == '*' || ch == '/');
}

int precedence(char operator) {
    if (operator == '+' || operator == '-')
        return 1;
    if (operator == '*' || operator == '/')
        return 2;
    return 0; // Default case
}

void infixToPostfix(char infix[], char postfix[]) {
    Stack stack;
    initialize(&stack);

    int i = 0, j = 0;

    while (infix[i] != '\0') {
        char currentSymbol = infix[i];

        if (currentSymbol == '(') {
```

```
            push(&stack, currentSymbol);
        } else if (isalnum(currentSymbol)) {
            postfix[j++] = currentSymbol;
        } else if (isOperator(currentSymbol)) {
            while (stack.top >= 0 && precedence(stack.data[stack.top]) >=
precedence(currentSymbol)) {
                postfix[j++] = pop(&stack);
            }
            push(&stack, currentSymbol);
        } else if (currentSymbol == ')') {
            while (stack.top >= 0 && stack.data[stack.top] != '(') {
                postfix[j++] = pop(&stack);
            }
            if (stack.top >= 0 && stack.data[stack.top] == '(') {
                pop(&stack); // Pop '(' from stack
            } else {
                printf("Error: Mismatched parentheses\n");
                exit(EXIT_FAILURE);
            }
        }

        i++;
    }

    // Pop remaining operators from stack
    while (stack.top >= 0) {
        if (stack.data[stack.top] == '(') {
            printf("Error: Mismatched parentheses\n");
            exit(EXIT_FAILURE);
        }
```

```
        postfix[j++] = pop(&stack);
    }

    postfix[j] = '\0'; // Null-terminate the postfix expression
}

int main() {
    char infix[MAX_SIZE], postfix[MAX_SIZE];

    printf("Enter the infix expression: ");
    scanf("%s", infix);

    infixToPostfix(infix, postfix);

    printf("Postfix expression: %s\n", postfix);

    return 0;
}
```





```
char pop (char st[])
{
    char val = '';
    if (top == -1)
        printf ("\n stack underflow");
    else
    {
        val = st[top];
        top--;
    }
    return val;
}
```

01/01/2024

o/p : Enter any infix expression : A+B
the corresponding postfix expression is : AB+

3.write a program to simulate the working of the queue of integers using an array. Provide the following operations: Insert, delete, display. The program should print appropriate message for overflow and underflow condition.

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

#define MAX_SIZE 5

typedef struct {
    int data[MAX_SIZE];
    int front, rear;
} Queue;

void initialize(Queue* queue) {
    queue->front = -1;
    queue->rear = -1;
}

int isEmpty(Queue* queue) {
    return (queue->front == -1 && queue->rear == -1);
}

int isFull(Queue* queue) {
    return ((queue->rear + 1) % MAX_SIZE == queue->front);
}

void enqueue(Queue* queue, int value) {
    if (isFull(queue)) {
        printf("Error: Queue Overflow\n");
```

```
        exit(EXIT_FAILURE);
    }

    if (isEmpty(queue)) {
        queue->front = 0; // Initialize front for the first element
    }

    queue->rear = (queue->rear + 1) % MAX_SIZE; // Circular increment for wrapping around
    queue->data[queue->rear] = value;

    printf("Enqueued %d\n", value);
}

int dequeue(Queue* queue) {
    int value;

    if (isEmpty(queue)) {
        printf("Error: Queue Underflow\n");
        exit(EXIT_FAILURE);
    }

    value = queue->data[queue->front];

    if (queue->front == queue->rear) {
        // Last element in the queue
        initialize(queue);
    } else {
        queue->front = (queue->front + 1) % MAX_SIZE; // Circular increment for wrapping
around
    }
```

```
    printf("Dequeued %d\n", value);

    return value;
}

void display(Queue* queue) {
    if (isEmpty(queue)) {
        printf("Queue is empty\n");
        return;
    }

    printf("Queue: ");
    int i = queue->front;

    do {
        printf("%d ", queue->data[i]);
        i = (i + 1) % MAX_SIZE; // Circular increment for wrapping around
    } while (i != (queue->rear + 1) % MAX_SIZE);

    printf("\n");
}

int main() {
    Queue myQueue;
    initialize(&myQueue);

    int choice, value;
```

```
    do {
        printf("\nMenu:\n");
        printf("1. Enqueue\n");
        printf("2. Dequeue\n");
        printf("3. Display\n");
        printf("4. Exit\n");

        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the value to enqueue: ");
                scanf("%d", &value);
                enqueue(&myQueue, value);
                break;
            case 2:
                dequeue(&myQueue);
                break;
            case 3:
                display(&myQueue);
                break;
            case 4:
                printf("Exiting program.\n");
                break;
            default:
                printf("Invalid choice. Please enter a valid option.\n");
        }
    } while (choice != 4);
```

```
    return 0;
}
```

C:\Users\srini\OneDrive\Desktop\ArrayQueue.exe

```
Menu:
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter the value to enqueue: 10
Enqueued 10

Menu:
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 1
Enter the value to enqueue: 20
Enqueued 20

Menu:
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 3
Queue: 10 20
```

```
Menu:
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 2
Dequeued 10

Menu:
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: 3
Queue: 20

Menu:
1. Enqueue
2. Dequeue
3. Display
4. Exit
Enter your choice: Queue: 20
```

output :

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 1
Enter element to insert : 10

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice : 1
Enter element to insert : 20

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice : 3
Queue is :
10
20

1. Insert
2. Delete
3. Display
4. Exit
Enter your choice : 2
Deleted element is : 10

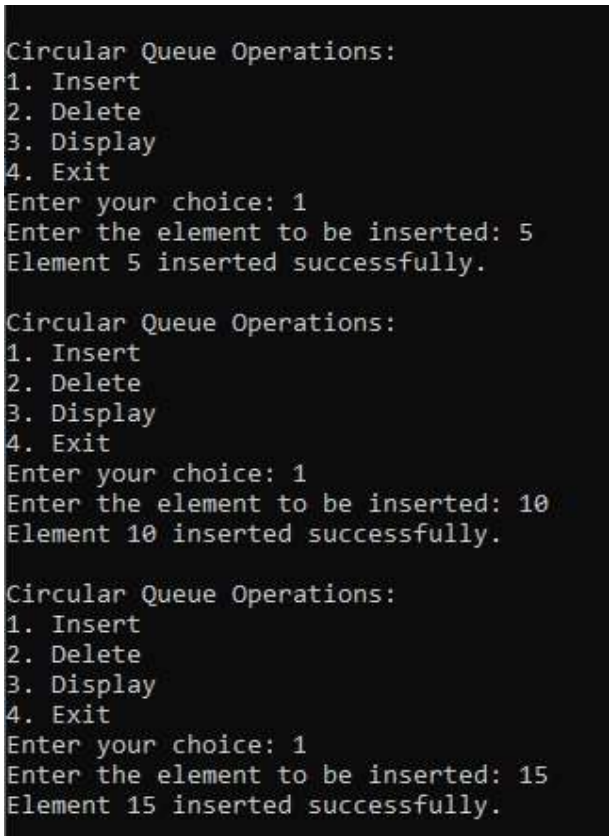
4.write a program to simulate the working of a circular queue using an array. Provide the following operations: insert, delete & display. The program should print appropriate message for queue empty and queue overflow conditions.

```
#include <stdio.h>

#define MAX_SIZE 5

int front = -1, rear = -1;
int queue[MAX_SIZE];

// Function to check if the queue is empty
int isEmpty() {
    return (front == -1 && rear == -1);
}

// Function to check if the queue is full
int isFull() {
    return (front == (rear + 1) % MAX_SIZE);
}

// Function to insert an element into the queue
void insert(int item) {
    if (isFull()) {
        printf("Queue Overflow: Unable to insert element.\n");
        return;
    } else if (isEmpty()) {
        front = rear = 0;
    } else {
        rear = (rear + 1) % MAX_SIZE;
```

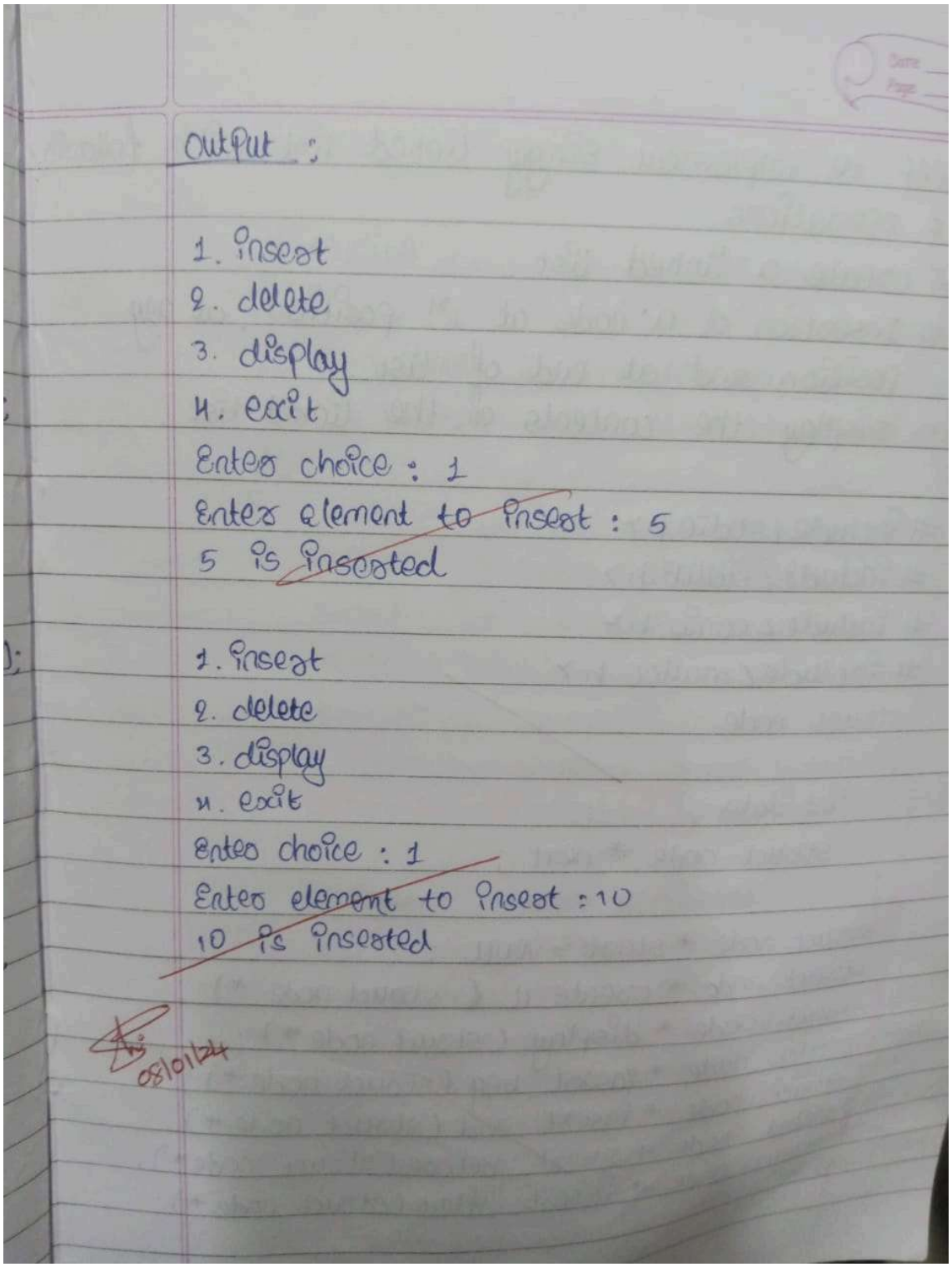
```
    }

    queue[rear] = item;
    printf("Element %d inserted successfully.\n", item);
}

// Function to delete an element from the queue
void delete() {
    if (isEmpty()) {
        printf("Queue Underflow: Unable to delete element.\n");
        return;
    } else if (front == rear) {
        printf("Element %d deleted successfully.\n", queue[front]);
        front = rear = -1;
    } else {
        printf("Element %d deleted successfully.\n", queue[front]);
        front = (front + 1) % MAX_SIZE;
    }
}

// Function to display the elements of the queue
void display() {
    if (isEmpty()) {
        printf("Queue is empty.\n");
        return;
    }

    printf("Queue elements: ");
    int i = front;
```

```
    do {
        printf("%d ", queue[i]);
        i = (i + 1) % MAX_SIZE;
    } while (i != (rear + 1) % MAX_SIZE);
    printf("\n");
}

int main() {
    int choice, item;

    do {
        printf("\nCircular Queue Operations:\n");
        printf("1. Insert\n");
        printf("2. Delete\n");
        printf("3. Display\n");
        printf("4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the element to be inserted: ");
                scanf("%d", &item);
                insert(item);
                break;
            case 2:
                delete();
                break;
            case 3:
```

```
            display();
            break;
        case 4:
            printf("Exiting program.\n");
            break;
        default:
            printf("Invalid choice. Please enter a valid option.\n");
    }
  } while (choice != 4);

  return 0;
}
```



```
Circular Queue Operations:
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 3
Queue elements: 5 10 15

Circular Queue Operations:
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 2
Element 5 deleted successfully.

Circular Queue Operations:
1. Insert
2. Delete
3. Display
4. Exit
Enter your choice: 3
Queue elements: 10 15
```



Output :

1. insert
2. delete
3. display
4. exit
Enter choice : 1
Enter element to insert : 5
5 is inserted

1. insert
2. delete
3. display
4. exit
Enter choice : 1
Enter element to insert : 10
10 is inserted

08/01/24

5.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.

Display the contents of the linked list.

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

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

// Function to create a new node
struct Node* createNode(int value) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    if (newNode == NULL) {
        printf("Memory allocation failed.\n");
        exit(1);
    }
    newNode->data = value;
    newNode->next = NULL;
    return newNode;
}

// Function to insert a node at the first position
struct Node* insertAtFirst(struct Node* head, int value) {
    struct Node* newNode = createNode(value);
```

```
    newNode->next = head;
    head = newNode;
    printf("Node with value %d inserted at the beginning.\n", value);
    return head;
}

// Function to insert a node at any position
struct Node* insertAtPosition(struct Node* head, int value, int position) {
    if (position < 1) {
        printf("Invalid position. Position should be greater than 0.\n");
        return head;
    }

    struct Node* newNode = createNode(value);

    if (position == 1) {
        newNode->next = head;
        head = newNode;
        printf("Node with value %d inserted at position %d.\n", value, position);
        return head;
    }

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

    if (temp == NULL) {
        printf("Invalid position. Position exceeds the length of the list.\n");
```

```
        return head;
    }

    newNode->next = temp->next;
    temp->next = newNode;
    printf("Node with value %d inserted at position %d.\n", value, position);
    return head;
}

// Function to insert a node at the end of the list
struct Node* insertAtEnd(struct Node* head, int value) {
    struct Node* newNode = createNode(value);

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

    printf("Node with value %d inserted at the end.\n", value);
    return head;
}

// Function to display the contents of the linked list
void display(struct Node* head) {
```

```
    if (head == NULL) {
        printf("Linked list is empty.\n");
        return;
    }

    printf("Linked list elements: ");
    struct Node* temp = head;
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}

int main() {
    struct Node* head = NULL;
    int choice, value, position;

    do {
        printf("\nSingly Linked List Operations:\n");
        printf("1. Insert at First\n");
        printf("2. Insert at Any Position\n");
        printf("3. Insert at End\n");
        printf("4. Display\n");
        printf("5. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
```

```
            case 1:
                printf("Enter the value to insert at the first position: ");
                scanf("%d", &value);
                head = insertAtFirst(head, value);
                break;
            case 2:
                printf("Enter the value to insert: ");
                scanf("%d", &value);
                printf("Enter the position to insert at: ");
                scanf("%d", &position);
                head = insertAtPosition(head, value, position);
                break;
            case 3:
                printf("Enter the value to insert at the end: ");
                scanf("%d", &value);
                head = insertAtEnd(head, value);
                break;
            case 4:
                display(head);
                break;
            case 5:
                printf("Exiting program.\n");
                break;
            default:
            printf("Invalid choice. Please enter a valid option.\n");
        }
    } while (choice != 5);
    return 0;
}
```

```
Singly Linked List Operations:
1. Insert at First
2. Insert at Any Position
3. Insert at End
4. Display
5. Exit
Enter your choice: 1
Enter the value to insert at the first position: 10
Node with value 10 inserted at the beginning.

Singly Linked List Operations:
1. Insert at First
2. Insert at Any Position
3. Insert at End
4. Display
5. Exit
Enter your choice: 1
Enter the value to insert at the first position: 20
Node with value 20 inserted at the beginning.
```

```
Singly Linked List Operations:
1. Insert at First
2. Insert at Any Position
3. Insert at End
4. Display
5. Exit
Enter your choice: 3
Enter the value to insert at the end: 30
Node with value 30 inserted at the end.

Singly Linked List Operations:
1. Insert at First
2. Insert at Any Position
3. Insert at End
4. Display
5. Exit
Enter your choice: 2
Enter the value to insert: 25
Enter the position to insert at: 3
Node with value 25 inserted at position 3.

Singly Linked List Operations:
1. Insert at First
2. Insert at Any Position
3. Insert at End
4. Display
5. Exit
Enter your choice: 4
Linked list elements: 20 10 25 30
```

Output :

*** Main menu ***

1. create linked list 2. Display 3. Insert_beg
4. Insert_end 5. Insert_before 6. Insert_after

Enter your choice : 3
Enter the data : 10

Enter your choice : 4
Enter the data : 40

Enter your choice : 5
Enter the value before which data has to be
inserted : 40
Enter the data : 20

Enter your choice : 6
Enter the data : 30
Enter the value after which data has to be
inserted : 20

6.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.

Display the contents of the linked list.

```
#include <stdio.h>
#include <stdlib.h>
struct Node {
    int data;
    struct Node* next;
};

struct Node* createNode(int value) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    if (newNode == NULL) {
        printf("Memory allocation failed.\n");
        exit(1);
    }
    newNode->data = value;
    newNode->next = NULL;
    return newNode;
}

struct Node* insertAtEnd(struct Node* head, int value) {
    struct Node* newNode = createNode(value);

    if (head == NULL) {
        head = newNode;
    } else {
```

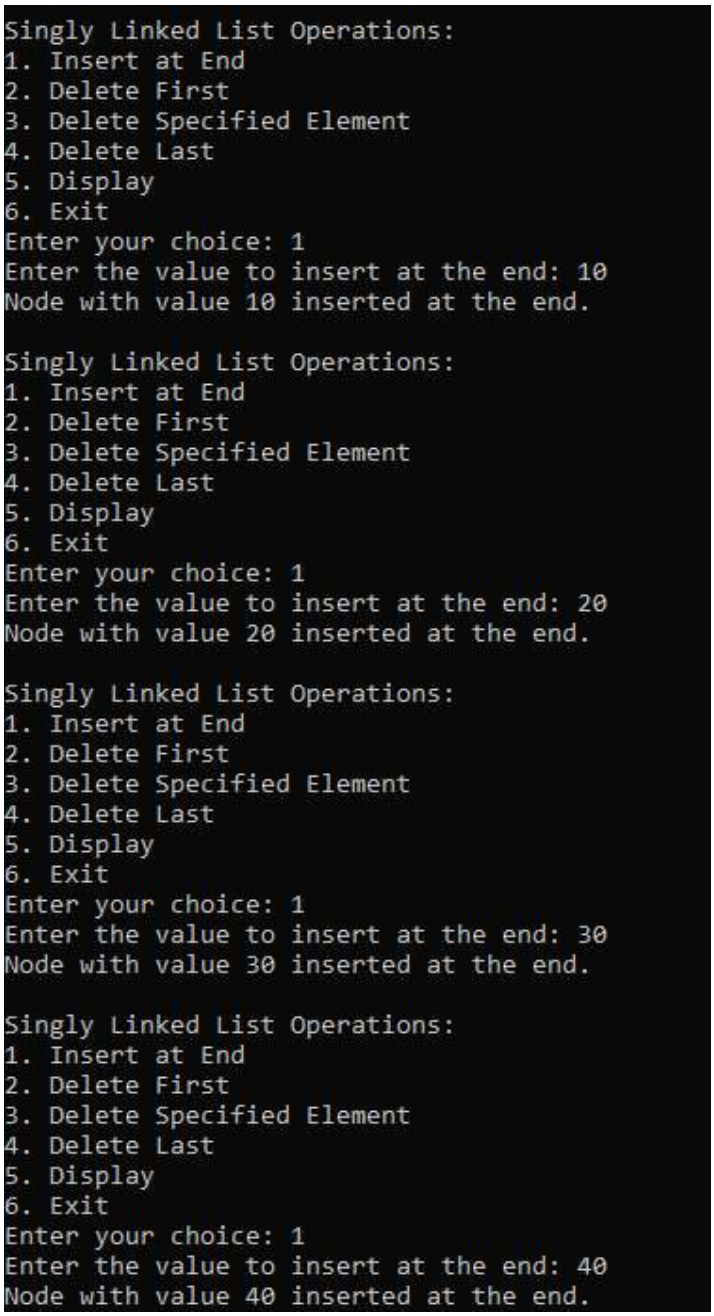
```
        struct Node* temp = head;
        while (temp->next != NULL) {
            temp = temp->next;
        }
        temp->next = newNode;
    }

    printf("Node with value %d inserted at the end.\n", value);
    return head;
}


struct Node* deleteFirst(struct Node* head) {
    if (head == NULL) {
        printf("Linked list is empty. Cannot delete.\n");
        return head;
    }

    struct Node* temp = head;
    head = head->next;
    free(temp);
    printf("First element deleted successfully.\n");
    return head;
}

struct Node* deleteElement(struct Node* head, int value) {
    if (head == NULL) {
        printf("Linked list is empty. Cannot delete.\n");
        return head;
```

```
    }

    struct Node* temp = head;
    struct Node* prev = NULL;

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

    if (temp == NULL) {
        printf("Element %d not found in the linked list. Cannot delete.\n", value);
        return head;
    }

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

    free(temp);
    printf("Element %d deleted successfully.\n", value);
    return head;
}

struct Node* deleteLast(struct Node* head) {
    if (head == NULL) {
        printf("Linked list is empty. Cannot delete.\n");
```

```
        return head;
    }

    if (head->next == NULL) {
        free(head);
        head = NULL;
        printf("Last element deleted successfully.\n");
        return head;
    }

    struct Node* temp = head;
    struct Node* prev = NULL;

    while (temp->next != NULL) {
        prev = temp;
        temp = temp->next;
    }

    prev->next = NULL;
    free(temp);
    printf("Last element deleted successfully.\n");
    return head;
}

void display(struct Node* head) {
    if (head == NULL) {
        printf("Linked list is empty.\n");
        return;
    }
```

```
    printf("Linked list elements: ");
    struct Node* temp = head;
    while (temp != NULL) {
        printf("%d ", temp->data);
        temp = temp->next;
    }
    printf("\n");
}

int main() {
    struct Node* head = NULL;
    int choice, value;

    do {
        printf("\nSingly Linked List Operations:\n");
        printf("1. Insert at End\n");
        printf("2. Delete First\n");
        printf("3. Delete Specified Element\n");
        printf("4. Delete Last\n");
        printf("5. Display\n");
        printf("6. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter the value to insert at the end: ");
                scanf("%d", &value);
```

```
            head = insertAtEnd(head, value);
            break;
        case 2:
            head = deleteFirst(head);
            break;
        case 3:
            printf("Enter the value to delete: ");
            scanf("%d", &value);
            head = deleteElement(head, value);
            break;
        case 4:
            head = deleteLast(head);
            break;
        case 5:
            display(head);
            break;
        case 6:
            printf("Exiting program.\n");
            break;
        default:
            printf("Invalid choice. Please enter a valid option.\n");
      }
   } while (choice != 6);

   return 0;
}
```


Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 1
Enter the value to insert at the end: 10
Node with value 10 inserted at the end.
Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 1
Enter the value to insert at the end: 20
Node with value 20 inserted at the end.
Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 1
Enter the value to insert at the end: 30
Node with value 30 inserted at the end.
Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 1
Enter the value to insert at the end: 40
Node with value 40 inserted at the end.

```
Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 2
First element deleted successfully.

Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 3
Enter the value to delete: 30
Element 30 deleted successfully.

Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 4
Last element deleted successfully.

Singly Linked List Operations:
1. Insert at End
2. Delete First
3. Delete Specified Element
4. Delete Last
5. Display
6. Exit
Enter your choice: 5
Linked list elements: 20
```

```
        preptr->next = ptr->next;
        free(ptr)
        return (start);
};
```

output :

```
*** main menu ***
1. create linked list  2. display  3. delete_beg
4. delete_end  5. delete_node

Enter your choice : 1
Enter -1 to end
Enter the data : 10
Enter the data : 20
Enter the data : 30
Enter the data : 40
Enter the data : -1
Enter your choice : 2
10 20 30 40
Enter your choice : 3
Enter your choice : 4
Enter your choice : 2
20 30
Enter your choice : 5
Enter value to be deleted : 20
```

24.01.24

7. SLL-sort,reverse,concatination.

```
#include <stdio.h>
#include <stdlib.h>
struct node
{
   int data;
   struct node *next;
};
struct node *head=NULL;

void create()
{
   struct node *new_node,*ptr;
   int num;
   printf("\n enter -1 to end\n");
   printf("enter data: \n");
   scanf("%d",&num);
   while(num!=-1)
   {
      new_node=(struct node*)malloc(sizeof(struct node));
      new_node->data=num;
      if(head==NULL)
      {
         new_node->next=NULL;
         head=new_node;
      }
      else
      {
         ptr=head;
```

```
            while(ptr->next!=NULL)
                ptr=ptr->next;
            new_node->next=NULL;
            ptr->next=new_node;
        }
        printf("enter data:");
        scanf("%d",&num);
    }
}

void display()
{
    struct node *ptr;
    ptr=head;
    while(ptr!=NULL)
    {
        printf("%d \n",ptr->data);
        ptr=ptr->next;
    }
}



void sort()
{
    struct node *ptr1,*ptr2;
    int temp;
    ptr1=head;
    while(ptr1->next!=NULL)
    {
```

```
        ptr2=ptr1->next;
        while(ptr2!=NULL)
        {
           if(ptr1->data > ptr2->data)
           {
              temp=ptr1->data;
              ptr1->data=ptr2->data;
              ptr2->data=temp;
           }
           ptr2=ptr2->next;
        }
        ptr1=ptr1->next;
    }
}

void con()
{
    struct node *new_node,*h1,*h2,*ptr;
    int i,n,m;
    printf("enter no. of elements in 1st list:\n");
    scanf("%d",&n);
    h1=NULL;
    for(i=0;i<n;i++)
    {
        printf("enter data:\n");
        new_node=malloc(sizeof(struct node));
        scanf("%d",&new_node->data);
        new_node->next=NULL;
        if(h1==NULL)
```

```
    {
       h1=new_node;
    }
    else
    {
     ptr=h1;
     while(ptr->next!=NULL)
     {
        ptr=ptr->next;
     }
     ptr->next=new_node;
    }
}
printf("enter no. of elements in 2nd list:\n");
scanf("%d",&m);
h2=NULL;
for(i=0;i<m;i++)
{
    printf("enter data:\n");
    new_node=malloc(sizeof(struct node));
    scanf("%d",&new_node->data);
    new_node->next=NULL;
    if(h2==NULL)
    {
       h2=new_node;
    }
    else
    {
     ptr=h2;
```

```
        while(ptr->next!=NULL)
        {
           ptr=ptr->next;
        }
        ptr->next=new_node;
      }
   }
   concatenate(h1,h2);
}

void concatenate(struct node *h1,struct node *h2)
{
   struct node *ptr;
   head=h1;
   ptr=head;
   if(h1==NULL && h2==NULL)
   {
      printf("list is empty!");
   }
   else
   {
      while(ptr->next!=NULL)
      {
         ptr=ptr->next;
      }
      ptr->next=h2;
      display();
   }
}
```

```
void reverse()
{
   struct node *current , *ptr , *temp;
   ptr=NULL;
   current=head;
   while(current!=NULL)
   {
      temp=current->next;
      current->next=ptr;
      ptr=current;
      current=temp;
   }
   head=ptr;
   display();
}

void main()
{
   int choice;
   while(1)
   {
      printf("\n Enter \n 1:create \n 2:sort \n 3:concatenate \n 4:reverse \n 5:exit");
      scanf("%d",&choice);
      switch(choice)
      {
      case 1:
         create();
         break;
```

```
        case 2:
            sort();
            display();
            break;
        case 3:
            con();
            break;
        case 4:
            reverse();
            break;
        case 5:
            exit(0);
        default:
            printf("invalid input");
        }
    }
}
```

```
 1:create
 2:sort
 3:concatenate
 4:reverse
 5:exit
 Enter your choice :  1

 enter -1 to end
enter data:
10
enter data:15
enter data:5
enter data:45
enter data:30
enter data:20
enter data:-1

 1:create
 2:sort
 3:concatenate
 4:reverse
 5:exit
 Enter your choice :  2
5
10
15
20
30
45
```

```
 1:create
 2:sort
 3:concatenate
 4:reverse
 5:exit
 Enter your choice :  3
enter no. of elements in 1st list:
3
enter data:
5
enter data:
10
enter data:
15
enter no. of elements in 2nd list:
3
enter data:
20
enter data:
30
enter data:
45
5
10
15
20
30
45
```

```
 1:create
 2:sort
 3:concatenate
 4:reverse
 5:exit
 Enter your choice :  4
45
30
20
15
10
5
```

Output for program 1 (concatenation, reverse, sort)

1. Insert into list 1
2. Insert into list 2
3. sort list 1
4. Reverse list 2
5. Concatenate lists
6. print lists
7. Exit

→ Enter your choice : 1
Enter data to insert (list 1) : 10

→ Enter your choice : 2
Enter data to insert (list 2) : 20

→ Enter your choice : 3
list 1 sorted

→ Enter your choice : 1
Enter data to insert (list 1) : 6

→ Enter your choice : 3
list 1 sorted

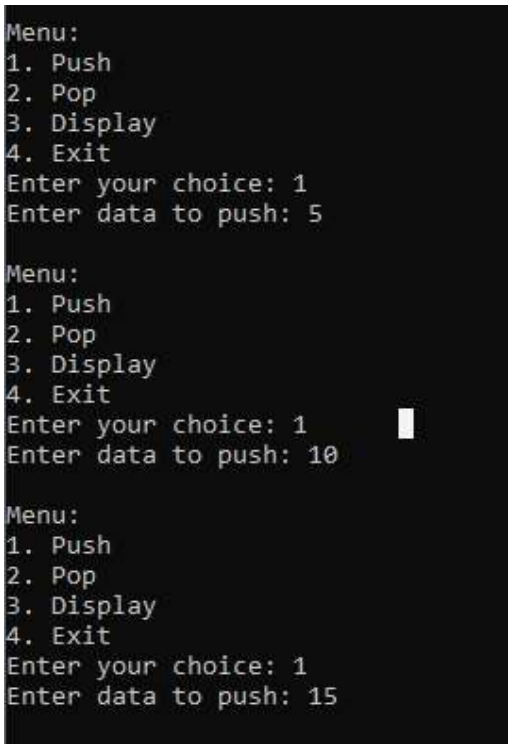
8a. Stack implementation using single linked list

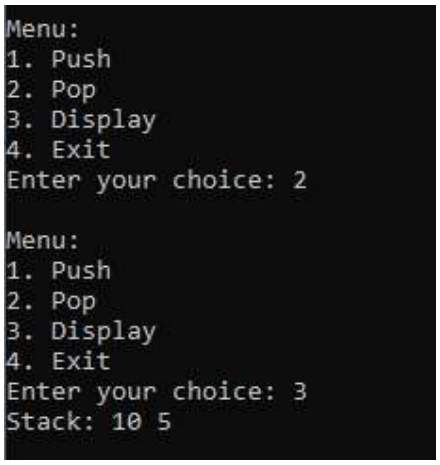
```
#include <stdio.h>
#include <stdlib.h>

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

// Function to create a new node
struct Node* createNode(int data) {
    struct Node* newNode = (struct Node*)malloc(sizeof(struct Node));
    if (newNode == NULL) {
        printf("Memory allocation failed.\n");
        exit(EXIT_FAILURE);
    }
    newNode->data = data;
    newNode->next = NULL;
    return newNode;
}

// Function to push an element onto the stack
struct Node* push(struct Node* top, int data) {
    struct Node* newNode = createNode(data);
    newNode->next = top;
    return newNode;
}
```

```
// Function to pop an element from the stack
struct Node* pop(struct Node* top) {
    if (top == NULL) {
        printf("Stack underflow. Cannot pop.\n");
        return NULL;
    }

    struct Node* temp = top;
    top = top->next;
    free(temp);
    return top;
}

// Function to display the elements of the stack
void displayStack(struct Node* top) {
    printf("Stack: ");
    while (top != NULL) {
        printf("%d ", top->data);
        top = top->next;
    }
    printf("\n");
}

// Function to free the memory allocated for the stack
void freeStack(struct Node* top) {
    while (top != NULL) {
        struct Node* temp = top;
        top = top->next;
```

```
        free(temp);
    }
}

int main() {
    struct Node* top = NULL;
    int choice, data;

    do {
        printf("\nMenu:\n");
        printf("1. Push\n");
        printf("2. Pop\n");
        printf("3. Display\n");
        printf("4. Exit\n");

        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                printf("Enter data to push: ");
                scanf("%d", &data);
                top = push(top, data);
                break;

            case 2:
                top = pop(top);
                break;
```

```
            case 3:
                displayStack(top);
                break;

            case 4:
                printf("Exiting the program.\n");
                break;

            default:
                printf("Invalid choice! Please enter a valid option.\n");
        }

    } while (choice != 4);

    // Free the memory allocated for the stack before exiting
    freeStack(top);

    return 0;
}
```


Menu:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter data to push: 5
Menu:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter data to push: 10
Menu:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 1
Enter data to push: 15


Menu:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 2
Menu:
1. Push
2. Pop
3. Display
4. Exit
Enter your choice: 3
Stack: 10 5

→ Enter your choice : 6
List1 : 6 10
List2 : 20

→ Enter your choice : 5
Lists concatenated

→ Enter your choice : 6
List 1 : 6 10 20

2(a) Output for stack implementation using LS

Menu
1. Push
2. POP
3. Display
4. Exit

→ Enter your choice : 1
Enter data to push : 60

→ Enter your choice : 1
Enter data to push : 70

8b. Queue implementation using single linked list

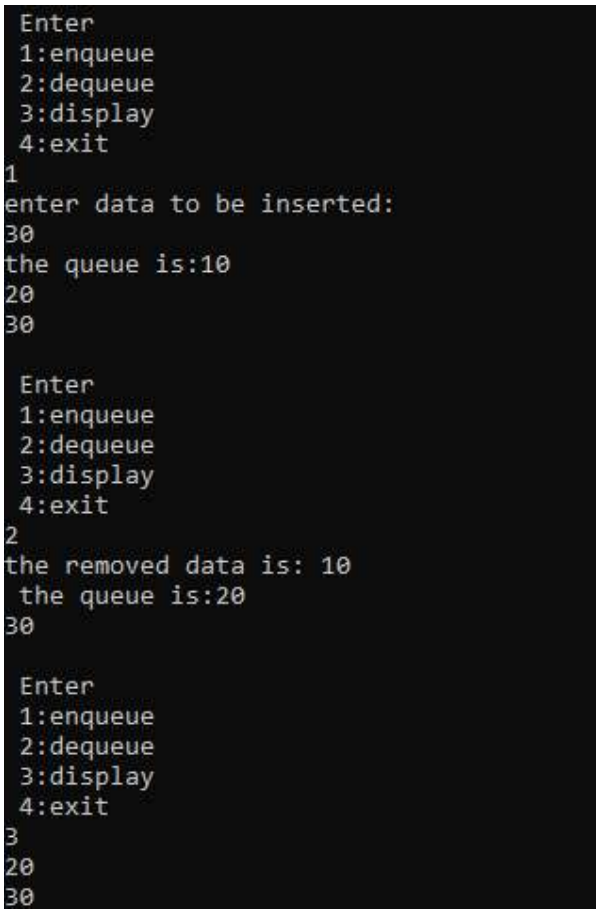
```
#include <stdio.h>
#include <stdlib.h>
struct node
{
   int data;
   struct node *next;
};
struct node *front=NULL , *rear=NULL;

void enqueue();
void dequeue();
void display();
int main()
{
   int choice;
   while(1)
   {
      printf("\n Enter \n 1:enqueue \n 2:dequeue \n 3:display \n 4:exit \n");
      scanf("%d",&choice);
      switch(choice)
      {
      case 1:
         enqueue();
         printf("the queue is:");
         display();
         break;
      case 2:
```

```
            dequeue();
            printf("\n the queue is:");
            display();
            break;
        case 3:
            display();
            break;
        case 4:
            exit(0);
        default:
            printf("Invalid Input!");
        }
    }
    return 0;
}

void enqueue()
{
    int val;
    printf("enter data to be inserted:\n");
    scanf("%d",&val);
    struct node *temp;
    temp=(struct node *)malloc(sizeof(struct node));
    temp->data=val;
    temp->next=NULL;
    if(front==NULL && rear==NULL)
    {
        front=rear=temp;
    }
```

```
    else
    {
        rear->next=temp;
        rear=temp;
    }
}

void dequeue()
{
    struct node *temp;
    temp=front;
    front=front->next;
    printf("the removed data is: %d ",temp->data);
    free(temp);
}

void display()
{
    struct node *temp;
    temp=front;
    if(front==NULL)
    {
        printf("Queue is empty!");
    }
    else
    {
        while(temp!=NULL)
        {
            printf("%d \n",temp->data);
```

```
        temp=temp->next;
      }
   }
}
```

```
 Enter
 1:enqueue
 2:dequeue
 3:display
 4:exit
1
enter data to be inserted:
10
the queue is:10

 Enter
 1:enqueue
 2:dequeue
 3:display
 4:exit
1
enter data to be inserted:
20
the queue is:10
20
```


Enter
1:enqueue
2:dequeue
3:display
4:exit
1
enter data to be inserted:
30
the queue is:10
20
30
Enter
1:enqueue
2:dequeue
3:display
4:exit
2
the removed data is: 10
the queue is:20
30
Enter
1:enqueue
2:dequeue
3:display
4:exit
3
20
30

→ Enter your choice : 2
popped succesfully

→ Enter your choice : 3
60

2.b) Output for queue implementation using u

Main menu
1. Enqueue
2. Dequeue
3. Display
4. Exit

→ Enter your choice : 1
Enter data to Enqueue : 10

→ Enter your choice : 1
Enter data to Enqueue : 20

→ Enter your choice : 3
10 20

→ Enter your choice : 2
→ Enter your choice : 3
30/01/24 20

9. 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

```
#include <stdio.h>
#include <stdlib.h>
struct node
{
   struct node *prev;
   int data;
   struct node *next;
}*head=NULL;

void display();
void create();
void insert_left();
void delete_node();

struct node *new_node,*ptr;
void main()
{
   int choice;
   printf("1:create \n 2:insert_left \n 3:delete_node\n 4:exit");
   while(1)
   {
      printf("\nenter choice: \t");
      scanf("%d",&choice);
      switch(choice)
```

```
        {
        case 1:
            create();
            break;
        case 2:
            insert_left();
            break;
        case 3:
            delete_node();
            break;
        case 4:
            exit(0);
        default:
            printf("invalid input");
        }
    }
}

void create()
{
    int val;
    printf("\nenter -1 to end");
    printf("\nenter data:\t");
    scanf("%d",&val);
    while(val!=-1)
    {
        new_node=malloc(sizeof(struct node));
        new_node->data=val;
        if(head==NULL)
```

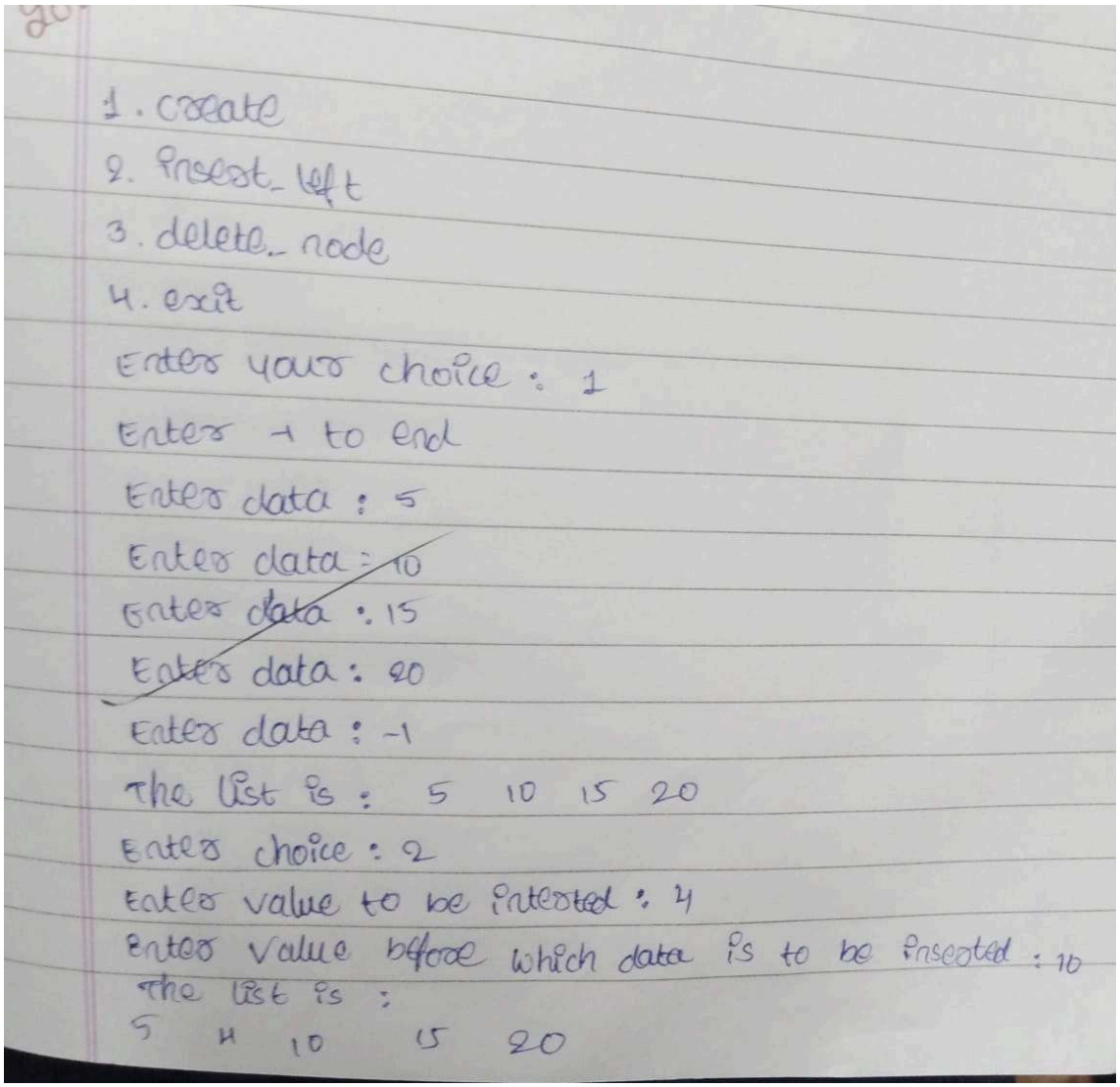
```
        {
            new_node->prev=NULL;
            new_node->next=NULL;
            head=new_node;
        }
        else
        {
            ptr=head;
            while(ptr->next!=NULL)
                ptr=ptr->next;
            ptr->next=new_node;
            new_node->prev=ptr;
            new_node->next = NULL;
        }
        printf("\n enter data:\t");
        scanf("%d",&val);
    }
    display();
}

void display()
{
    if(head==NULL)
        printf("the list is empty");
    else
    {
        ptr=head;
        printf("\n The list is:\n");
        while(ptr!=NULL)
```

```
        {
            printf("%d \t",ptr->data);
            ptr=ptr->next;
        }
    }
}

void insert_left()
{
    int val,d;
    printf("enter value to be inserted:");
    scanf("%d",&val);
    printf("enter value before which data is to be inserted:");
    scanf("%d",&d);
    new_node=malloc(sizeof(struct node));
    new_node->data=val;
    if(head==NULL)
    {
        new_node->prev=NULL;
        new_node->next=NULL;
        head=new_node;
    }
    else
    {
        ptr=head;
        while(ptr->data!=d)
            ptr=ptr->next;
        if(ptr==head)
        {
```

```
            new_node->prev=NULL;
            new_node->next=head;
            head->prev=new_node;
            head=new_node;
        }
        else
        {
            new_node->next=ptr;
            new_node->prev=ptr->prev;
            ptr->prev->next=new_node;
            ptr->prev=new_node;
        }
    }
    display();
}

void delete_node()
{
    if(head==NULL)
        printf("\n the list is empty");
    else
    {
        int val;
        printf("enter value to be deleted:\n");
        scanf("%d",&val);
        ptr=head;
        while(ptr->data!=val)
            ptr=ptr->next;
        if(ptr==head)
```

```
        {
            head=head->next;
            head->prev=NULL;
            free(ptr);
        }
        else
        {
            ptr->prev->next=ptr->next;
            ptr->next->prev=ptr->prev;
            free(ptr);
        }
    }
    display();
}
```

```
1:create
 2:insert_left
 3:delete_node
 4:exit
enter choice:   1

enter -1 to end
enter data:     5

 enter data:    10

 enter data:    15

 enter data:    20

 enter data:    -1

 The list is:
5       10      15      20
enter choice:   2
enter value to be inserted:4
enter value before which data is to be inserted:10

 The list is:
5       4       10      15      20
enter choice:   3
enter value to be deleted:
15

 The list is:
5       4       10      20
enter choice:   4

Process returned 0 (0x0)   execution time : 76.304 s
Press any key to continue.
```


1. create
2. insert_left
3. delete_node
4. exit
Enter your choice : 1
Enter -1 to end
Enter data : 5
Enter data : 10
Enter data : 15
Enter data : 20
Enter data : -1
The list is : 5 10 15 20
Enter choice : 2
Enter value to be inserted : 4
Enter value before which data is to be inserted : 10
The list is :
5 4 10 15 20

10. Write a program.

a. To construct Binary Search tree

b. Traverse the tree using inorder , postorder, preorder.

c. Display the elements in the tree.

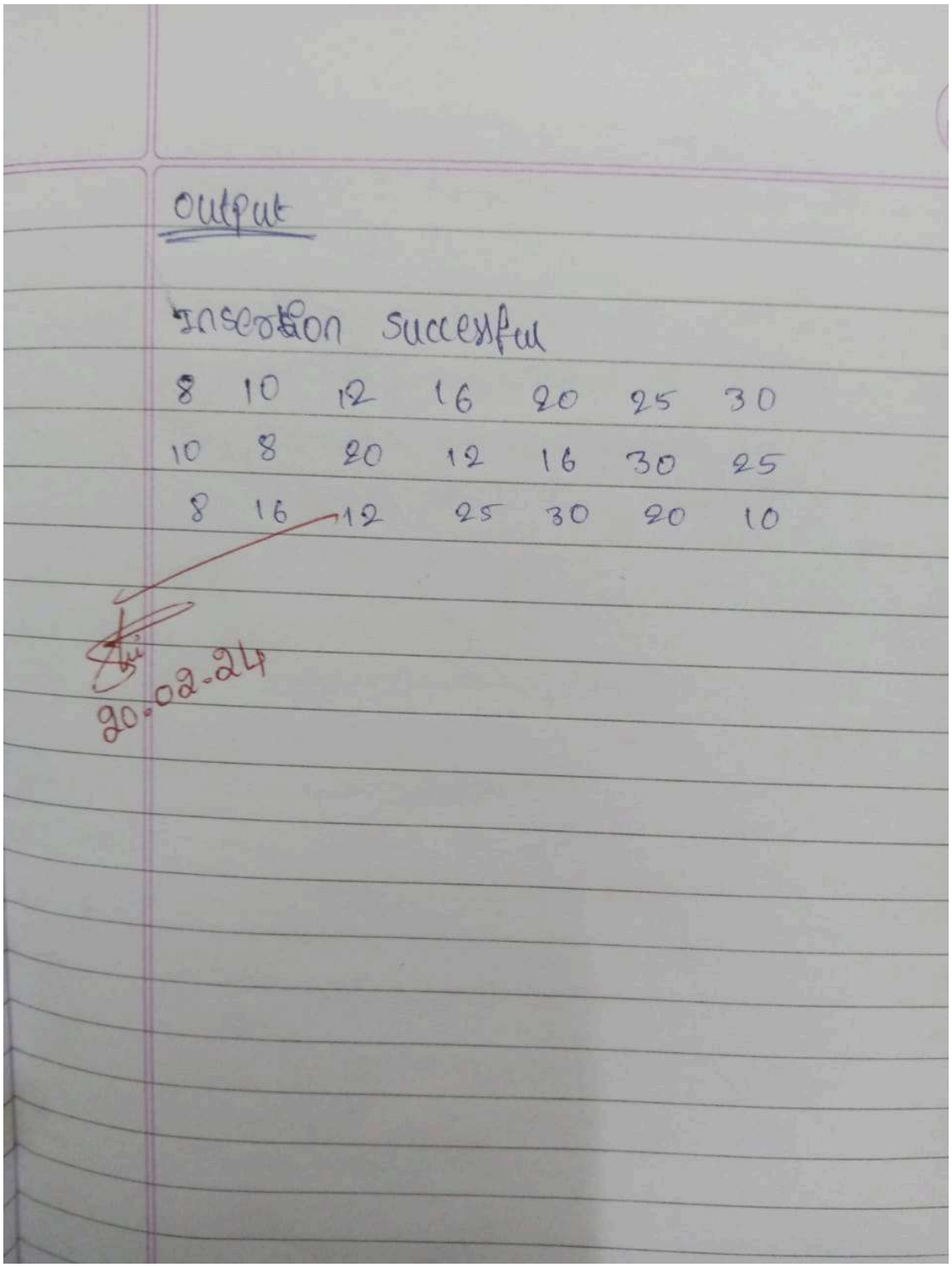
```
#include <stdio.h>
#include <stdlib.h>
struct node
{
   int data;
   struct node *left,*right;
}*root;
struct node *create()
{
   struct node *temp;
   int val;
   printf("enter data:");
   scanf("%d",&val);
   temp = malloc(sizeof(struct node));
   temp->data = val;
   temp->left=temp->right=NULL;
   return temp;
};

void insert(struct node *root,struct node *temp)
{
   if(temp->data<root->data)
   {
      if(root->left!=NULL)
```

```
            insert(root->left,temp);
        else
            root->left=temp;
    }
    if(temp->data>root->data)
    {
        if(root->right!=NULL)
            insert(root->right,temp);
        else
            root->right=temp;
    }
}
void inorder(struct node *root)
{
    if(root!=NULL)
    {
        inorder(root->left);
        printf("%d \t",root->data);
        inorder(root->right);
    }
}
void preorder(struct node *root)
{
    if(root!=NULL)
    {
        printf("%d \t",root->data);
        preorder(root->left);
        preorder(root->right);
    }
```

```
}
void postorder(struct node *root)
{
   if(root!=NULL)
   {
      postorder(root->left);
      postorder(root->right);
      printf("%d \t",root->data);
   }
}
void main()
{
   int n,choice;
   struct node *temp;
   root=NULL;
   printf("enter no. of elements in tree");
   scanf("%d",&n);
   for(int i=0;i<n;i++)
   {
      temp=create();
      if(root==NULL)
         root=temp;
      else
         insert(root,temp);
   }
   printf("\n1:inorder \n2:preorder \n3:postorder \n4:exit");
   while(1)
   {
      printf("\nenter choice:");
```

```
        scanf("%d",&choice);
        switch(choice)
        {
        case 1:
           printf("Inorder:");
           inorder(root);
           break;
        case 2:
           printf("preorder:");
           preorder(root);
           break;
        case 3:
           printf("postorder:");
           postorder(root);
        case 4:
           exit(0);
        default:
           printf("INVALID INPUT");
        }
    }
}
```

```
enter no. of elements in tree : 5
enter data:10
enter data:20
enter data:30
enter data:40
enter data:50

1:inorder
2:preorder
3:postorder
4:exit
enter choice : 1
Inorder:10      20      30      40      50
enter choice : 2
preorder : 10   20      30      40      50
enter choice : 3
postorder : 50  40      30      20      10
Process returned 0 (0x0)   execution time : 19.720 s
Press any key to continue.
```


Output
Insertion successful
8 10 12 16 20 25 30
10 8 20 12 16 30 25
8 16 12 25 30 20 10
20.02.24

11. BFS

```
#include<stdio.h>
void bfs (int a[10] [10], int n, int u)
{
   int f, r,q[10], v;
   int s[10]={0};

   printf("the nodes visited from %d:",u);
   f=0;
   r=-1;
   q[++r]=u;
   s[u]=1;
   printf("%d", u);
   while(f<=r)
   {
      u=q[f++];
      for(v=0;v<n;v++)
      {
         if(a[u][v])
         {
            if(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 no of nodes:");
    scanf("%d",&n);
    printf("\nEnter the adjacency matrix:");
    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;
}
```

```
enter no of nodes:7

Enter the adjacency matrix:0 1 1 1 1 0 0
1 0 0 1 0 1 0
1 0 0 0 0 0 1
1 1 0 0 0 1 0
1 0 0 0 0 0 1
0 1 0 1 0 0 0
0 0 1 0 1 0 0
the nodes visited from 0:0123456
the nodes visited from 1:1035246
the nodes visited from 2:2061345
the nodes visited from 3:3015246
the nodes visited from 4:4061235
the nodes visited from 5:5130246
the nodes visited from 6:6240135

Process returned 0 (0x0)   execution time : 84.688 s
Press any key to continue.
```

Output for program 1 (BFS)

Enter no of nodes : 7

Enter the adjacency matrix : 0 1 1 1 1 0 0

1 0 0 1 0 1 0

1 0 0 0 0 0 1

1 1 0 0 0 1 0

1 0 0 0 0 0 1

0 1 0 1 0 0 0

0 0 1 0 1 0 0

The nodes visited from 0 : 0123456

The nodes visited from 1 : 1035246

2 : 2061345

3 : 3015246

4 : 4061235

5 : 5130246

6 : 6240135

Output for program 2 (DFS)

Enter number of nodes :

4

Enter the adjacency matrix

0 1 0 0

0 0 1 0

0 0 0 1

1 0 0 0

Graph is connected

26.02.24

12. DFS

```
#include<stdio.h>
#include<conio.h>
int a[1][10];
void dfs(int n, int cost[10][10], int u, int s[])
{
int v;
s[u]=1;
for(v=0;v<n;v++)
{
if((cost[u][v]==1) && (s[v]==0))
dfs(n,cost,v,s);

}
}

void main()
{
int n,i,j,cost[10][10],s[10],con,flag;

printf("Enter the number of nodes\n");
scanf("%d", &n);
printf("Enter the adjacency matrix\n");
for(i=0;i<n;i++)
{
for(j=0;j<n;j++)
scanf("%d", &cost[i][j]);
```

```
}
con=0;
for(j=0;j<n;j++)
{
for(i=0;i<n;i++)
s[i]=0;
dfs(n,cost,j,s);
flag=0;
for(i=0;i<n;i++)
{
if(s[i]==0)
flag=1;

}
if(flag==0)
con=1;
}
if(con==1)
printf("Graph is connected\n");
else
printf("Graph is not connected\n");
getch();
}
```

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

Output for program 1 (BFS)

Enter no of nodes : 7

Enter the adjacency matrix : 0 1 1 1 1 0 0

1 0 0 1 0 1 0

1 0 0 0 0 0 1

1 1 0 0 0 1 0

1 0 0 0 0 0 1

0 1 0 1 0 0 0

0 0 1 0 1 0 0

The nodes visited from 0 : 0123456

The nodes visited from 1 : 1035246

2 : 2061345

3 : 3015246

4 : 4061235

5 : 5130246

6 : 6240135

Output for program 2 (DFS)

Enter number of nodes :

4

Enter the adjacency matrix

0 1 0 0

0 0 1 0

0 0 0 1

1 0 0 0

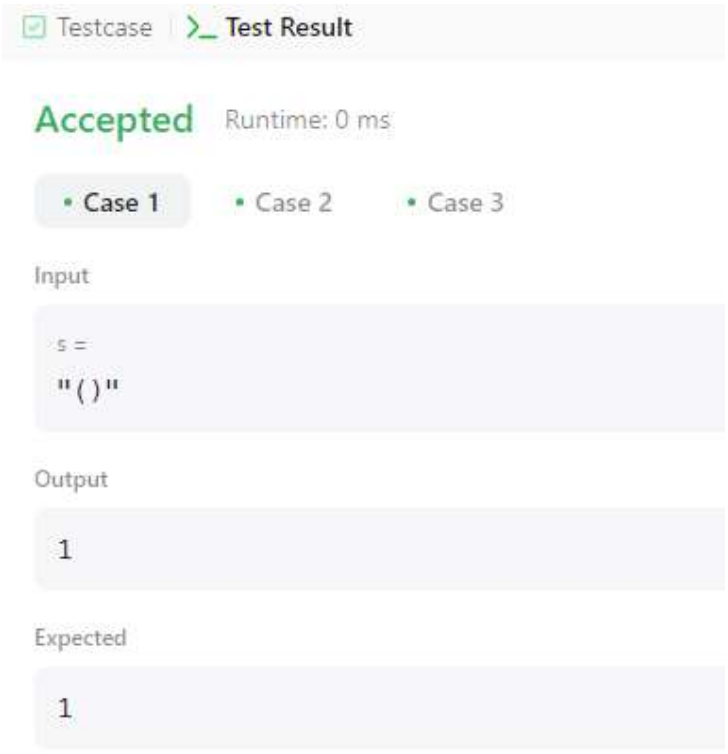
Graph is connected

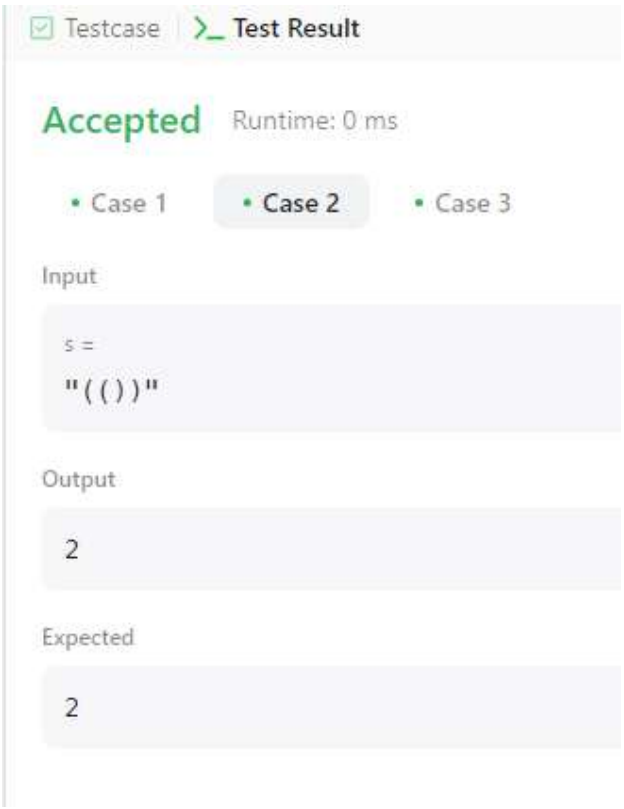
26.02.24

13. Leetcode Programs

1. Score of parentheses

```c
int scoreOfParentheses(char *s) {
int stack[50];
int top = -1;
int score = 0;

for (int i = 0; s[i] != '\0'; i++) {
if (s[i] == '(') {
stack[++top] = score;
score = 0;
} else {
score = stack[top--] + (score == 0 ? 1 : 2 * score);
}
}

return score;
}
```




Testcase
Test Result
Accepted
Runtime: 0 ms
• Case 1
• Case 2
• Case 3
Input
s =
"(()())"
Output
2
Expected
2


Accepted
Runtime: 0 ms
• Case 1
• Case 2
• Case 3
Input
s =
"()()()"
Output
2
Expected
2

2. Delete the middle node of the linked list

```
 */
struct ListNode* deleteMiddle(struct ListNode* head) {
    struct ListNode* ptr=head;
    struct ListNode* preptr=NULL;
    int count=0;
    if(head==NULL){
        return head;
    }
    else if(head->next==NULL){
        free(head);
        return NULL;
    }
    else{
        while(ptr!=NULL){
            count++;
            ptr=ptr->next;
        }
        int n=0;
        ptr=head;
        while(n!=count/2){
            preptr=ptr;
            ptr=ptr->next;
            n++;
        }
        preptr->next=ptr->next;
        free(ptr);
    }
    return head;
}
```

Accepted Runtime: 0 ms

• Case 1 • Case 2 • Case 3

Input

head =
[1,2,3,4]

Output

[1,2,4]

Expected

[1,2,4]

Accepted Runtime: 0 ms

• Case 1 • Case 2 • Case 3

Input

head =
[2,1]

Output

[2]

Expected

[2]

3. Odd even linked list

```c
struct ListNode* oddEvenList(struct ListNode* head) {
    if (head == NULL || head->next == NULL) {
        return head;
    }

    struct ListNode *odd = head;
    struct ListNode *even = head->next;
    struct ListNode *even_head = even;

    while (even != NULL && even->next != NULL) {
        odd->next = even->next;
        odd = odd->next;
        even->next = odd->next;
        even = even->next;
    }

    odd->next = even_head;

    return head;
}
```

4.Find bottom left tree

```c
int findBottomLeftValue(struct TreeNode* root) {
    if (root == NULL) {
        return -1;
    }

    struct TreeNode** queue = (struct TreeNode**)malloc(pow(10, 4) * sizeof(struct TreeNode*));
    int front = 0, rear = 0;
    int leftmostValue = 0;

    queue[rear++] = root;

    while (front < rear) {
        int levelSize = rear - front;

        for (int i = 0; i < levelSize; i++) {
            struct TreeNode* currentNode = queue[front++];

            if (i == 0) {
                leftmostValue = currentNode->val;
            }

            if (currentNode->left) {
                queue[rear++] = currentNode->left;
            }

            if (currentNode->right) {
                queue[rear++] = currentNode->right;
            }
        }
    }

    free(queue);
    return leftmostValue;
}
```

Accepted Runtime: 0 ms

• Case 1 • Case 2

Input

root =

[2,1,3]

Output

1

Expected

1

Accepted Runtime: 0 ms

• Case 1 • Case 2

Input

root =

[1,2,3,4,null,5,6,null,null,7]

Output

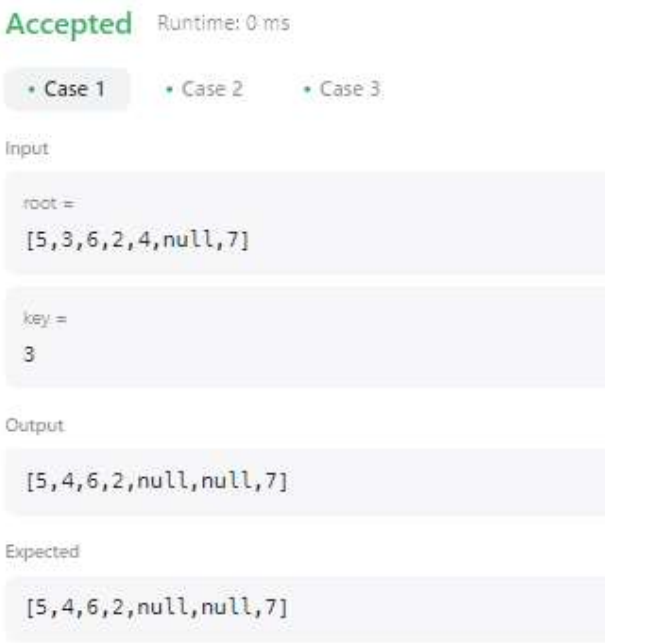
7

Expected

7

5. Delete node in BST

```c
struct TreeNode* findMin(struct TreeNode* node) {
    while (node->left != NULL) {
        node = node->left;
    }
    return node;
}

struct TreeNode* deleteNode(struct TreeNode* root, int key) {
    if (root == NULL) {
        return root;
    } else if (key < root->val) {
        root->left = deleteNode(root->left, key);
    } else if (key > root->val) {
        root->right = deleteNode(root->right, key);
    } else {
        if (root->left == NULL && root->right == NULL) {
            free(root);
            root = NULL;
        } else if (root->left == NULL) {
            struct TreeNode *ptr = root;
            root = root->right;
            free(ptr);
        } else if (root->right == NULL) {
            struct TreeNode *ptr = root;
            root = root->left;
            free(ptr);
        } else {
            struct TreeNode *temp = findMin(root->right);
            root->val = temp->val;
            root->right = deleteNode(root->right, temp->val);
        }
    }
    return root;
```



Accepted Runtime: 0 ms

- Case 1
- **Case 2**
- Case 3

Input

root =

```
[5,3,6,2,4,null,7]
```

key =

```
0
```

Output

```
[5,3,6,2,4,null,7]
```

Expected

```
[5,3,6,2,4,null,7]
```

Accepted Runtime: 0 ms

- Case 1
- Case 2
- **Case 3**

Input

root =

```
[]
```

key =

```
0
```

Output

```
[]
```

Expected

```
[]
```