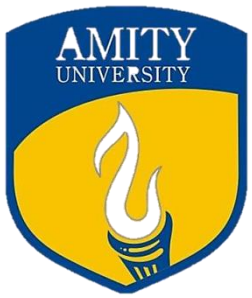
Data Structures using C

Lab File

Submitted to:

AMITY UNIVERSITY UTTTAR PARDESH



In partial fulfilment of the requirements for the award of the degree of Bachelor of technology

In

Computer Science & Engineering

By

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CSE 4-X Semester 3

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LIST OF EXPERIMENTS

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Lab 1

Program:

Write a menu driven program for the insertion of elements in the beginning, middle, and the end of a 1-D array.

Source Code:

```
#include<stdio.h>
void beginning(int new_element, int n, int arr[]) {
    for(int i = n; i > 0; i--) {
        arr[i] = arr[i - 1];
    }
    arr[0] = new_element;
    printf("New array: ");
    for(int i = 0; i <= n; i++){
        printf("%d ", arr[i]);
    } printf("\n\n");
}
void middle(int new_element, int arr[], int position, int n) {
    for(int i = n; i >= position; i--) {
        arr[i] = arr[i - 1];
        }
        arr[position] = new_element;
    printf("New array: ");
    for(int i = 0; i <= n; i++)
        printf("%d ", arr[i]);
     printf("\n\n");
}
void end(int new_element, int n, int arr[]) {
    arr[n] = new_element;
    printf("New array: ");
    for(int i = 0; i <= n; i++){
        printf("%d ", arr[i]);
    } printf("\n\n");
}
int main() {
    int arr[100];
    int n;
    int option;
    int new_element;
    int position;
    char repeat;

    printf("\n -> Insertion Option Menu:\n");
    printf("\nSelect the number for the task you want to perform.\n");
    printf("1- Beginning Insertion.\n2- Middle Insertion.\n3- End
Insertion.\n");
```

```
printf("\nCreate an array: \n");
printf("Enter number of elements: ");
scanf("%d", &n);
printf("\nEnter the %d elements of the array: \n", n);
for(int i = 0; i < n; i++){
    printf("Element %d: ", i);
    scanf("%d", &arr[i]);
}
printf("The array is: \n");
for(int i = 0; i < n; i++) {
    printf("%d ", arr[i]);
} printf("\n\n");

do {
    printf("Select the task (1-3): ");
    scanf("%d", &option);
    printf("\n");

    switch(option) {
            case 1:
                printf("Enter value to be inserted: ");
                scanf("%d", &new_element);
                beginning(new_element, n, arr);
                n = n + 1;
                break;
            case 2:
                printf("Enter value to be inserted: ");
                scanf("%d", &new_element);
                printf("Which position do you want to insert at: ");
                scanf("%d", &position);
                if(position < 0 || position > n) {
                    printf("Invalid position...\n");
                    n = n + 1;
                    break;
                }
                middle(new_element, arr, position, n);
                break;
            case 3:
                printf("Enter value to be inserted: ");
                scanf("%d", &new_element);
                n = n + 1;
                end(new_element, n, arr);
                break;
            default:
                printf("Selected option does not exist.\n");
                printf("Please choose from 1-3 only...\n\n");
                break;
        }
```

```
            printf("Do you want to continue (Y/N): ");
            scanf(" %c", &repeat);
            printf("\n");
    }
    while(repeat == 'Y' || repeat == 'y');

    return 0;
}
```

Output:

```
 -> Insertion Option Menu:

Select the number for the task you want to perform.
1- Beginning Insertion.
2- Middle Insertion.
3- End Insertion.

Create an array:
Enter number of elements: 5

Enter the 5 elements of the array:
Element 0: 2
Element 1: 4
Element 2: 6
Element 3: 8
Element 4: 10
The array is:
2 4 6 8 10

Select the task (1-3): 1

Enter value to be inserted: 1
New array: 1 2 4 6 8 10

Do you want to continue (Y/N): y

Select the task (1-3): 2

Enter value to be inserted: 5
Which position do you want to insert at: 3
New array: 1 2 4 5 6 8 10

Do you want to continue (Y/N): y

Select the task (1-3): 3

Enter value to be inserted: 11
New array: 1 2 4 5 6 8 10 11

Do you want to continue (Y/N): n

PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> ^C
```

Lab 2

Program:

Write a menu driven program for the deletion of elements from the beginning middle and end of a 1-D array.

Source Code:

```
#include<stdio.h>
 void beginning(int n, int arr[]) {
    for(int i = 0; i < n - 1; i++) {
        arr[i] = arr[i + 1];
    }
    n = n - 1;
    printf("New array: ");
    for(int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    } printf("\n\n");
}
void middle(int arr[], int position, int n) {
    for(int i = position; i <= n - 1; i++) {
        arr[i] = arr[i + 1];
        }
        n = n - 1;
    printf("New array: ");
    for(int i = 0; i < n; i++)
        printf("%d ", arr[i]);
     printf("\n\n");
}
void end(int n, int arr[]) {
    n = n - 1;
    printf("New array: ");
    for(int i = 0; i < n; i++){
        printf("%d ", arr[i]);
    } printf("\n\n");
}
 int main() {
    int arr[100];
    int n;
    int option;
    int position;
    char repeat;

    printf("\n -> Deletion Option Menu:\n");
    printf("\nSelect the number for the task you want to perform.\n");
    printf("1- First Element Deletion.\n2- Middle Element Deletion.\n3- Last
Element Deletion.\n");
```

```
    printf("\nCreate an array: \n");
    printf("Enter number of elements: ");
    scanf("%d", &n);
    printf("\nEnter the %d elements of the array: \n", n);
    for(int i = 0; i < n; i++){
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("The array is: \n");
    for(int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    } printf("\n\n");

    do {
        printf("Select the task (1-3): ");
        scanf("%d", &option);
        printf("\n");

        switch(option) {
                case 1:
                    beginning(n, arr);
                    n = n - 1;
                    break;
                case 2:
                    printf("Which position element do you want to delete: ");
                    scanf("%d", &position);
                    if(position < 0 || position > n) {
                        printf("Invalid position...\n");
                        break;
                    }
                    middle(arr, position, n);
                    n = n - 1;
                    break;
                case 3:
                    end(n, arr);
                    break;
                default:
                    printf("Selected option does not exist.\n");
                    printf("Please choose from 1-3 only...\n\n");
                    break;
            }
            printf("Do you want to continue (Y/N): ");
            scanf(" %c", &repeat);
            printf("\n");
    }
    while(repeat == 'Y' || repeat == 'y');
    return 0;
}
```

Output:

```
 -> Deletion Option Menu:

Select the number for the task you want to perform.
1- First Element Deletion.
2- Middle Element Deletion.
3- Last Element Deletion.

Create an array:
Enter number of elements: 8

Enter the 8 elements of the array:
Element 0: 2
Element 1: 4
Element 2: 6
Element 3: 8
Element 4: 10
Element 5: 12
Element 6: 14
Element 7: 16
The array is:
2 4 6 8 10 12 14 16

Select the task (1-3): 1

New array: 4 6 8 10 12 14 16

Do you want to continue (Y/N): y

Select the task (1-3): 2

Which position element do you want to delete: 4
New array: 4 6 8 10 14 16

Do you want to continue (Y/N): y

Select the task (1-3): 3

New array: 4 6 8 10 14

Do you want to continue (Y/N): n

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```

Lab 3

Program:

Write a program to perform linear search and binary search on a 1-D array.

Source Code:

```c
#include<stdio.h>
int linear_search(int arr[], int n, int val) {
    for(int i = 0; i < n; i++) {
        if(arr[i] == val) {
            return i;
        }
    }
    return  -1;
}
int binary_search(int arr[], int low, int high, int val) {
    if(high >= low) {
        int mid = low + (high - low) / 2;
        if(arr[mid] == val)
            return mid;
        if(arr[mid] > val)
            return binary_search(arr, low, mid-1, val);

        return binary_search(arr, mid+1, high, val);
    }
    return -1;
}

int main() {
    int arr[100], n, val, index, optn, contn;

    printf("\nNote: array must be sorted...\n");
    printf("Create an array:\n");
    printf("\nEnter the number of elements (n) in the array: ");
    scanf("%d", &n);
    printf("\nEnter the %d elements of the array:\n", n);
    for(int i = 0; i < n; i++) {
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("\nThe array created:\n");
    for(int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    } printf("\n\n");

    do {
        printf("Choose the search you want to perform:\n");
```

```
        printf(" 1- Linear search.\n 2- Binary search.\n");
        printf("Enter option: ");
        scanf("%d", &optn);

        switch(optn) {
            case 1:
                printf("\nLinear search:\n");
                printf("Enter the value you want to search: ");
                scanf("%d", &val);
                index = linear_search(arr, n, val);
                if(index == -1) {
                    printf("Element is not present in given array.\n");
                }
                else {
                    printf("The value %d is present in array at index: %d\n",
val, index);
                }
                break;
            case 2:
                printf("\nBinary search:\n");
                printf("Enter the value you want to search: ");
                scanf("%d", &val);
                index = binary_search(arr, 0, n-1, val);
                if(index == -1) {
                    printf("Element is not present in given array.\n");
                }
                else
                    printf("The value %d is present in array at index: %d\n",
val, index);
                break;
            default:
                printf("Incorrect option...\nPlease choose from provided
menu.\n");
                break;
        }
        printf("\nDo you want to continue(Y/N): ");
        scanf(" %c", &contn);
    }
    while(contn == 'Y' || contn == 'y');

    printf("\nProgram terminated successfully...\n\n");

    return 0;
}
```

Output:

```
Note: array must be sorted...
Create an array:

Enter the number of elements (n) in the array: 5

Enter the 5 elements of the array:
Element 0: 2
Element 1: 4
Element 2: 7
Element 3: 10
Element 4: 15

The array created:
2 4 7 10 15

Choose the search you want to perform:
 1- Linear search.
 2- Binary search.
Enter option: 1

Linear search:
Enter the value you want to search: 7
The value 7 is present in array at index: 2

Do you want to continue(Y/N): y
Choose the search you want to perform:
 1- Linear search.
 2- Binary search.
Enter option: 2

Binary search:
Enter the value you want to search: 10
The value 10 is present in array at index: 3

Do you want to continue(Y/N): n

Program terminated successfully...

PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 4

Program:

Write a menu driven program to perform operations on 2-D arrays. The program must perform the operations: addition, subtraction, multiplication, transpose, diagonal elements sum, print upper triangle, and print lower triangle.

Source Code:

```
#include<stdio.h>
#define MAX 50
void array(int num, int n, int m, int a[MAX][MAX]) {
    printf("Enter the elements of the %d array:\n", num);
    for(int i = 0;i < n; i++) {
        printf("Row %d of array:\n", i);
        for(int j = 0; j < m; j++) {
            printf("Element %d: ", j);
            scanf("%d", &a[i][j]);
        }
    }
    printf("\nArray %d created:\n", num);
    for(int i = 0; i < n; i++) {
        printf("   ");
        for(int j = 0; j < m; j++) {
            printf("%d ", a[i][j]);
        }
        printf("\n");
    } printf("\n");
}
void addition(int n, int m, int a1[MAX][MAX], int a2[MAX][MAX]) {
    int a_result[MAX][MAX];
    for(int i = 0; i < n; i++) {
        printf(" ");
        for(int j = 0; j < m; j++) {
            a_result[i][j] = a1[i][j] + a2[i][j];
            printf("%d ", a_result[i][j]);
        }
        printf("\n");
    }
    printf("\n");
}
void subtraction(int n, int m, int a1[MAX][MAX], int a2[MAX][MAX]) {
    int a_result[MAX][MAX];
    for(int i = 0; i < n; i++) {
        printf(" ");
        for(int j = 0; j < m; j++) {
            a_result[i][j] = a1[i][j] - a2[i][j];
```

```
            printf("%d ", a_result[i][j]);
        }
        printf("\n");
    }
    printf("\n");
}
void multiplication(int n, int m, int a1[MAX][MAX], int a2[MAX][MAX]) {
    int a_result[MAX][MAX];
    for (int i = 0; i < n; i++) {
        for (int j = 0; j < m; j++) {
            a_result[i][j] = 0;
            for (int k = 0; k < n; k++) {
                a_result[i][j] += a1[i][k] * a2[k][j];
            }
            printf("%d\t", a_result[i][j]);
        }
        printf("\n");
    }
}
void transpose(int n, int m, int a[MAX][MAX]) {
    int a_result[MAX][MAX];
    for(int i = 0; i < n; i++) {
        for(int j = 0; j < m; j++) {
            a_result[i][j] = a[j][i];
            printf("%d ", a_result[i][j]);
        }
        printf("\n");
    }
    printf("\n");
}
void diagonal_Sum(int n, int m, int a[MAX][MAX], int optn) {
    int sum = 0;
    if(optn == 1) {
        for(int i = 0; i < n ; i++)
            for(int j = 0; j < m; j++) {
                if(i == j) {
                    sum += a[i][j];
                }
            }
    }
    Else {
        for(int i = 0; i < n; i++)
            for(int j = 0; j < m; j++) {
                int c = i + j;
                if(c == (n-1)) {
                    sum += a[i][j];
                }
            }
```

```
    }
    printf("Sum of diagonal is: %d\n", sum);
}
void upper_Triangle(int n, int m, int a[MAX][MAX]) {
    for(int i = 0; i < n; i++) {
        for(int j = 0; j < m; j++) {
            printf("%d ", a[i][j]);
        }
        m--;
        printf("\n");
    }
    printf("\n");
}
void lower_Triangle(int n, int m, int a[MAX][MAX]) {
    for(int i = 0; i < n; i++) {
        for(int j = 0; j < m; j++) {
            int c = i + j;
            if(c > (n-1)) {
                printf("%d ", a[i][j]);
            }
            else
                printf("  ");
        }
        printf("\n");
    }
    printf("\n");
}
int main() {
    int option, arrChoice;
    int n, m, num, transpose_of, up_tri, lo_tri, optn;
    int a1[MAX][MAX], a2[MAX][MAX];
    char exit;

    //Creating 2 2D arrays from user input:
    printf("Create array 1:\n");
    printf("Enter number of rows of array: ");
    scanf("%d", &n);
    printf("Enter number of columns of array: ");
    scanf("%d", &m);
    array(1, n, m, a1);

    printf("Create array 2:\n");
    array(2, n, m, a2);

    //Printing menu and taking option input:
    printf("\n****** 2D Array Operations ******\n\n");
    printf("Choose the operation you want to perform:\n");
```

```
    printf(" 0- Create new arrays.\n 1- Addition.\n 2- Subtraction.\n 3-
Multiplication.\n 4- Transpose.\n 5- Diagonal sum.\n 6- Upper triangle.\n 7-
Lower triangle.");
    do {
        printf("\nSelect operation: ");
        scanf("%d", &option);
        printf("\n");

        switch(option) {
            case 0:
                printf("Create array 1:\n");
                printf("Enter number of rows of array: ");
                scanf("%d", &n);
                printf("Enter number of columns of array: ");
                scanf("%d", &m);
                array(1, n, m, a1);
                printf("Create array 2:\n");
                array(2, n, m, a1);
                break;
            case 1:
                addition(n, m, a1, a2);
                break;
            case 2:
                subtraction(n, m, a1, a2);
                break;
            case 3:
                multiplication(n, m, a1, a2);
                break;
            case 4:
                printf("Choose array to transpose(1/2): ");
                scanf("%d", &transpose_of);
                if(transpose_of == 1) {
                    transpose(n, m, a1);
                }
                else {
                    transpose(n, m, a2);
                }
                break;
            case 5:
                printf("Choose diagonal:\n");
                printf(" 1- Decreasing diagonal.\n 2- Increasing
diagonal.\n");
                printf("Enter option: ");
                scanf("%d", &optn);
                printf("Choose array to sum the diagonal of(1/2): ");
                scanf("%d", &arrChoice);
                if(arrChoice == 1) {
                    diagonal_Sum(n, m, a1, optn);
```

```
                }
                else {
                    diagonal_Sum(n, m, a2, optn);
                }
                break;
            case 6:
                printf("Choose array to print upper triangle of(1/2): ");
                scanf("%d", &up_tri);
                if(up_tri == 1) {
                    upper_Triangle(n, m, a1);
                }
                else {
                    upper_Triangle(n, m, a2);
                }
                break;
            case 7:
                printf("Choose array to print lower triangle of(1/2): ");
                scanf("%d", &lo_tri);
                if(lo_tri == 1) {
                    lower_Triangle(n, m, a1);
                }
                else {
                    lower_Triangle(n, m, a2);
                }
                break;
            default:
                printf("Wrong option...\n");
                printf("Choose from given options (1 - 7).\n\n");
                break;
        }
        printf("Do you want to continue (Y/N): ");
        scanf(" %c", &exit);
    }
    while(exit == 'Y' || exit == 'y');
    printf("\nProgram terminated successfully...\n\n");
    return 0;
}
```

Output:

```
Create array 1:
Enter number of rows of array: 3
Enter number of columns of array: 3
Enter the elements of the 1 array:
Row 0 of array:
Element 0: 1
Element 1: 2
Element 2: 3
Row 1 of array:
Element 0: 4
Element 1: 5
Element 2: 6
Row 2 of array:
Element 0: 7
Element 1: 8
Element 2: 9

Array 1 created:
   1 2 3
   4 5 6
   7 8 9

Create array 2:
Enter the elements of the 2 array:
Row 0 of array:
Element 0: 9
Element 1: 8
Element 2: 7
Row 1 of array:
Element 0: 6
Element 1: 5
Element 2: 4
Row 2 of array:
Element 0: 3
Element 1: 2
Element 2: 1

Array 2 created:
   9 8 7
   6 5 4
   3 2 1
```

```
****** 2D Array Operations ******

Choose the operation you want to perform:
 0- Create new arrays.
 1- Addition.
 2- Subtraction.
 3- Multiplication.
 4- Transpose.
 5- Diagonal sum.
 6- Upper triangle.
 7- Lower triangle.
Select operation: 1

 10 10 10
 10 10 10
 10 10 10

Do you want to continue (Y/N): y

Select operation: 2

 -8 -6 -4
 -2 0 2
 4 6 8

Do you want to continue (Y/N): y

Select operation: 3

30      24      18
84      69      54
138     114     90
Do you want to continue (Y/N): y

Select operation: 4

Choose array to transpose(1/2): 1
1 4 7
2 5 8
3 6 9

Do you want to continue (Y/N): y

Select operation: 4

Choose array to transpose(1/2): 2
9 6 3
8 5 2
7 4 1
```

```
Do you want to continue (Y/N): y

Select operation: 5

Choose diagonal:
 1- Decreasing diagonal.
 2- Increasing diagonal.
Enter option: 1
Choose array to sum the diagonal of(1/2): 1
Sum of diagonal is: 15

Do you want to continue (Y/N): y

Select operation: 6

Choose array to print upper triangle of(1/2): 2
9 8 7
6 5
3

Do you want to continue (Y/N): y

Select operation: 7

Choose array to print lower triangle of(1/2): 1

    6
  8 9

Do you want to continue (Y/N): n

Program terminated successfully...

PS C:\Users\Faizan\Desktop\UNI STUFF\Semester 3\Data Structures in C>
```

Lab 5

Program:

Write a program to pass an array as a parameter to a function.

Source Code:

```
#include<stdio.h>
#define MAX 50
int array_multiple(int n, int m, int x, int arr[MAX][MAX]) {
    int new_arr[MAX][MAX];
    for(int i = 0; i < n; i++) {
        for(int j = 0; j < m; j++) {
            new_arr[i][j] = arr[i][j] * x;
            printf("%d ", new_arr[i][j]); }
        printf("\n");
    }
}
int main() {
    int n, m, x;
    int arr[MAX][MAX];

    printf("Create a 2-D array:\n");
    printf("Enter number of rows: ");
    scanf("%d", &n);
    printf("Enter number of columns: ");
    scanf("%d", &m);
    printf("Enter the elements of the array:\n");
    for(int i = 0;i < n; i++) {
        printf("Row %d of array:\n", i);
        for(int j = 0; j < m; j++) {
            printf("Element %d: ", j);
            scanf("%d", &arr[i][j]);  }
    }
    printf("\nArray created:\n");
    for(int i = 0; i < n; i++) {
        printf("   ");
        for(int j = 0; j < m; j++){
            printf("%d ", arr[i][j]);
        }
        printf("\n");
    } printf("\n");
    printf("Enter the multiple value: ");
    scanf("%d", &x);
    array_multiple(n, m, x, arr);

    return 0;
}
```

Output:

```
 } ; if ($?) { .\Array_parameter }
Create a 2-D array:
Enter number of rows: 2
Enter number of columns: 3
Enter the elements of the array:
Row 0 of array:
Element 0: 1
Element 1: 2
Element 2: 3
Row 1 of array:
Element 0: 4
Element 1: 5
Element 2: 6

Array created:
   1 2 3
   4 5 6

Enter the multiple value: 3
3 6 9
12 15 18
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 6

Program:

Write a menu driven program to implement the stack operations of PUSH, POP, and Display.

Source Code:

```c
#include<stdio.h>
#define MAX 5
int stack[MAX];
int top = -1;
void PUSH(int val) {
    printf("\nEnter value to push to stack: ");
    scanf("%d", &val);
    if(top == (MAX - 1)) {
        printf("\nStack is full.\nCannot PUSH new value to stack.\n");
    }
    else {
        top++;
        stack[top] = val;
        printf("%d pushed to stack.\n", val);
    }
}
void POP() {
    if(top == -1) {
        printf("Stack is empty.\n");
    }
    else {
        printf("%d popped from stack.\n", stack[top]);
        top--;
    }
}
void display() {
    if(top == -1) {
        printf("Stack is empty.\nNo Display...\n");
    }
    else {
        printf("Stack Display:\n");
        for(int i = top; i >= 0; i--) {
            printf("    %d\n", stack[i]);
        }
    }
}
int main() {
    int optn, val;
    char contn;
    printf("Stack operations:\n 1- PUSH.\n 2- POP.\n 3- Display stack.\n");
```

```
    do {
        printf("Enter option (1-3): ");
        scanf("%d", &optn);
        switch(optn) {
            case 1:
                PUSH(val);
                break;
            case 2:
                POP();
                break;
            case 3:
                display();
                break;
            default:
                printf("Incorrect option.\nPlease choose from given
options.\n");
                break;
        }
        printf("\nDo you want to continue (Y/N): ");
        scanf(" %c", &contn);
    }
    while(contn == 'Y' || contn == 'y');
    printf("\nProgram terminates successfully...\n\n");
    return 0;
}
```

Output:

```
s } ; if ($?) { .\Stack_Operations }
Stack operations:
 1- PUSH.
 2- POP.
 3- Display stack.
Enter option (1-4): 1

Enter value to push to stack: 10
10 pushed to stack.

Do you want to continue (Y/N): y
Enter option (1-4): 1

Enter value to push to stack: 20
20 pushed to stack.

Do you want to continue (Y/N): y
Enter option (1-4): 1

Enter value to push to stack: 30
30 pushed to stack.

Do you want to continue (Y/N): y
Enter option (1-4): 3
Stack Display:
    30
    20
    10

Do you want to continue (Y/N): y
Enter option (1-4): 2
30 popped from stack.

Do you want to continue (Y/N): n

Program terminates successfully...

PS C:\Users\Faizan\Desktop\UNI STUFF\Semester 3\Data Structures in C>
```

Lab 7

Program:

Write a menu driven program to implement the queue operations of enqueue, dequeue, and display.

Source Code:

```
#include<stdio.h>
#define MAX 10
int Q[MAX];
int F = -1, R = -1;
void enqueue(int val) {
    if(R == (MAX - 1)) {
        printf("Queue is full.\n");
    }
    else if(F == -1 && R == -1) {
        F = 0;
        R = 0;
        printf("\nEnter value to add to queue: ");
        scanf("%d", &val);
        Q[R] = val;
        printf("%d added to queue.\n", val);
    }
    else {
        R++;
        printf("\nEnter value to add to queue: ");
        scanf("%d", &val);
        Q[R] = val;
        printf("%d added to queue.\n", val);
    }
}
void dequeue() {
    if(F == -1 && R == -1) {
        printf("Queue is already empty.\n");
    }
    else if(F == (MAX - 1) && R == (MAX - 1)) {
        F = -1;
        R = -1;
    }
    else {
        printf("%d deleted from queue.\n", Q[F]);
        F++;
    }
}
void display() {
    printf("\nDisplay Queue:\n");
    printf("  ");
```

```
    for(int i = F; i <= R; i++)
        printf("%d ", Q[i]);
    printf("\n");
}
int main() {
    int val, optn;
    char contn;
    printf("\nQueue operations:\n 1- Insert in queue.\n 2- Delete from
queue.\n 3- Display queue.\n");
    do {
        printf("Enter option (1-3): ");
        scanf("%d", &optn);
        switch(optn) {
            case 1:
                enqueue(val);
                break;
            case 2:
                dequeue();
                break;
            case 3:
                display();
                break;
            default:
                printf("Incorrect option.\nChoose from given options (1-
3).\n");
                break;
        }
        printf("\nDo you want to continue (Y/N): ");
        scanf(" %c", &contn);
    }
    while(contn == 'Y' || contn == 'y');
    printf("\nProgram terminated successfully...\n\n");
    return 0;
}
```

Output:

```
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> cd "c:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
ns } ; if ($?) { .\Queue_Operations }

Queue operations:
 1- Insert in queue.
 2- Delete from queue.
 3- Display queue.
Enter option (1-3): 1

Enter value to add to queue: 10
10 added to queue.

Do you want to continue (Y/N): y
Enter option (1-3): 1

Enter value to add to queue: 20
20 added to queue.

Do you want to continue (Y/N): y
Enter option (1-3): 1

Enter value to add to queue: 30
30 added to queue.

Do you want to continue (Y/N): y
Enter option (1-3): 3

Display Queue:
  10 20 30

Do you want to continue (Y/N): y
Enter option (1-3): 2
10 deleted from queue.

Do you want to continue (Y/N): y
Enter option (1-3): 3

Display Queue:
  20 30

Do you want to continue (Y/N): n

Program terminated successfully...

PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 8

Program:

Write a program to take a string of parenthesis as input and to check whether the parenthesis are balanced or not with the use of stacks.

Source Code:

```
#include<stdio.h>
#include<string.h>
#define MAX 100
void parenthesis_check(char s[]) {
    char stack[MAX];
    int stack_index = -1;
    int len = strlen(s);
    char input[MAX];
    int input_index = -1;
    int flag = 0;
    for(int i = 0; i < len; i++) {
        char c = s[i];
        if(c == '(' || c == '[' || c == '{') {
            stack_index++;
            stack[stack_index]  = c;
        }
        else if(c == ')' || c == ']' || c == '}') {
            if(stack_index > -1) {
                if((c == ')' && stack[stack_index] == '(') || (c == ']' &&
stack[stack_index] == '[') || (c == '}' && stack[stack_index] == '{')) {
                    stack_index--;
                    // printf("%d \n", stack_index);
                }
                else {
                    // printf("Unbalanced!\n");
                    flag = 1;
    break;
                }
            }
            else if(stack_index == -1) {
                // printf("Unbalanced!\n");
                flag = 1;
    break;
            }
        }
    }
    if(stack_index == -1) {
        if(flag == 0) {
            printf("\nParenthesis string is balanced...\n\n");
        }
```

```
        else {
            printf("\nStirng is unbalanced...\n\n");
        }
    }
    else if(stack_index >= 0) {
        printf("\nString is unbalanced...\n\n");
    }
}
int main() {
    char string[MAX];
    printf("Parenthesis Checker:\n\n");
    printf("Enter parenthesis string: ");
    fgets(string, MAX, stdin);
    parenthesis_check(string);
    return 0;
}
```

Output:

```
Parenthesis Checker:

Enter parenthesis string: {()[([])[]]}

Parenthesis string is balanced...

PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> cd "c:\Users\Faizan\Deskt
sis_Checker.c -o Parenthesis_Checker } ; if ($?) { .\Parenthesis_Checker }
Parenthesis Checker:

Enter parenthesis string: {{()[([])[]]}}

String is unbalanced...

PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 9

Program:

Write a program to perform infix to prefix conversion on an expression and to perform evaluation of the prefix expression.

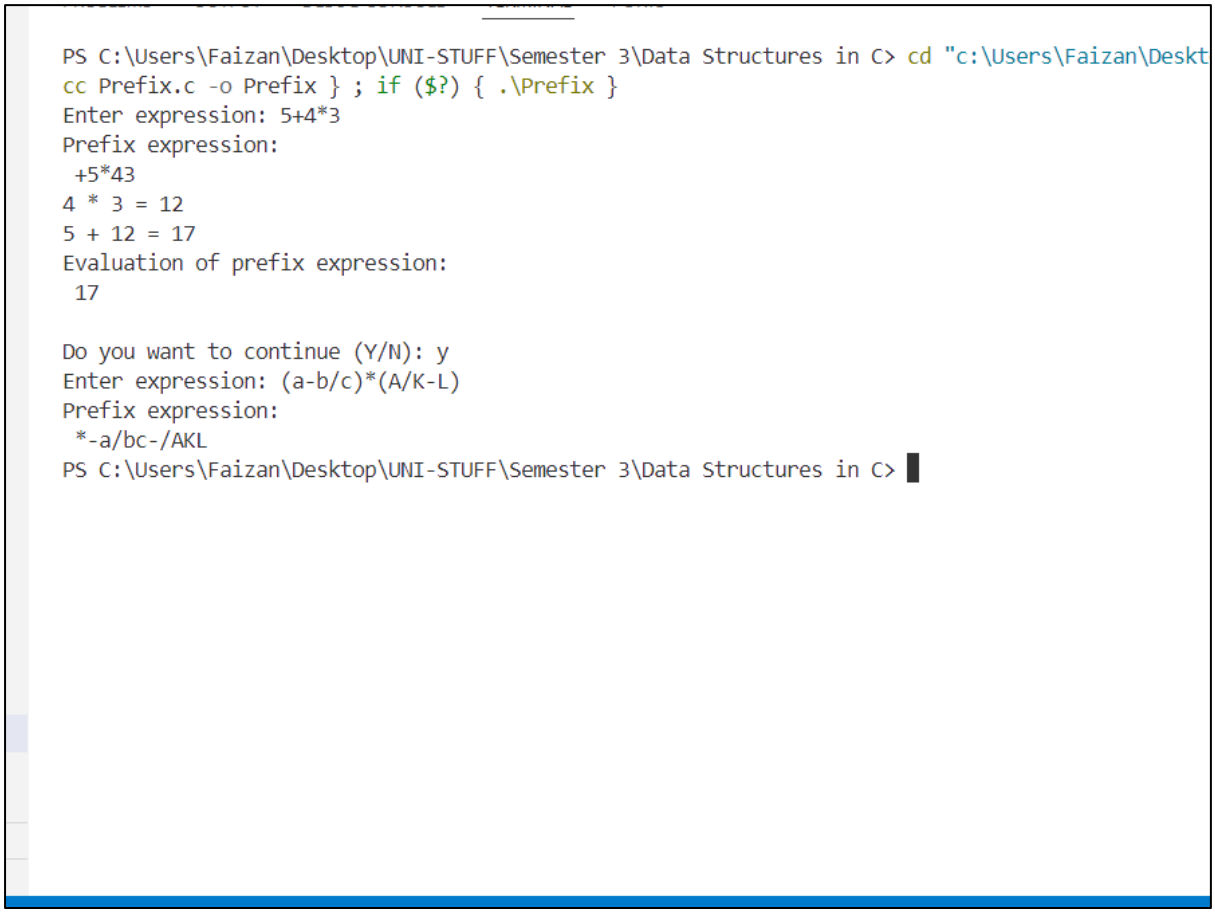
Source Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>
#define MAX 100
int precedence(char c) {
    if (c == '^')
        return 3;
    else if (c == '/' || c == '*')
        return 2;
    else if (c == '+' || c == '-')
        return 1;
    else
        return -1;
}
void ReverseString(char* str) {
    int len = strlen(str);
    for (int i = 0; i < len / 2; i++) {
        char temp = str[i];
        str[i] = str[len - 1 - i];
        str[len - 1 - i] = temp;
    }
}
void Prefix(char s[]) {
    char exp[MAX];
    int len = strlen(s);
    char stack[MAX];
    int stack_index = -1;
    int output_index = 0;
    ReverseString(s);
    for (int i = 0; i < len; i++) {
        char c = s[i];
        if (isdigit(c) || isalpha(c)) {
            exp[output_index++] = c;
        } else if (c == ')') {
            stack[++stack_index] = c;
        } else if (c == '(') {
            while (stack_index >= 0 && stack[stack_index] != ')') {
                exp[output_index++] = stack[stack_index--];
            }
```

```
            stack_index--;
        } else {
            while (stack_index >= 0 && precedence(c) <
precedence(stack[stack_index])) {
                exp[output_index++] = stack[stack_index--];
            }
            stack[++stack_index] = c;
        }
    }
    while (stack_index >= 0) {
        exp[output_index++] = stack[stack_index--];
    }
    exp[output_index] = '\0';
    ReverseString(exp);
    printf("Prefix expression:\n %s\n", exp);
    int evaluation[MAX];
    int eval_index = -1;
    for (int i = strlen(exp) - 1; i >= 0; i--) {
        char e = exp[i];
        if (isdigit(e)) {
            evaluation[++eval_index] = e - '0';
        } else if (e == '+' || e == '-' || e == '*' || e == '/') {
            int a = evaluation[eval_index--];
            int b = evaluation[eval_index--];
            int result = 0;
            if (e == '+') {
                result = a + b;
                printf("%d + %d = %d\n", a, b, result);
            } else if (e == '-') {
                result = a - b;
                printf("%d - %d = %d\n", a, b, result);
            } else if (e == '*') {
                result = a * b;
                printf("%d * %d = %d\n", a, b, result);
            } else if (e == '/') {
                result = a / b;
                printf("%d / %d = %d\n", a, b, result);
            }
            evaluation[++eval_index] = result;
        }
    }
    printf("Evaluation of prefix expression:\n %d\n", evaluation[eval_index]);
}
int main() {
    char exp[MAX];
    char contn;
    do {
        printf("Enter expression: ");
```

```
        fgets(exp, MAX, stdin);
        exp[strcspn(exp, "\n")] = '\0';
        Prefix(exp);
        int ch;
        while ((ch = getchar()) != '\n' && ch != EOF);
        printf("Do you want to continue (Y/N): ");
        scanf(" %c", &contn);
        while ((ch = getchar()) != '\n' && ch != EOF);
    }
    while(contn == 'y' || contn == 'Y');
    printf("\nProgram terminated successfully...\n\n");
    return 0;
}
```

Output:



Lab 10

Program:

Write a program to perform infix to postfix conversion on an expression and to perform evaluation of the postfix expression.

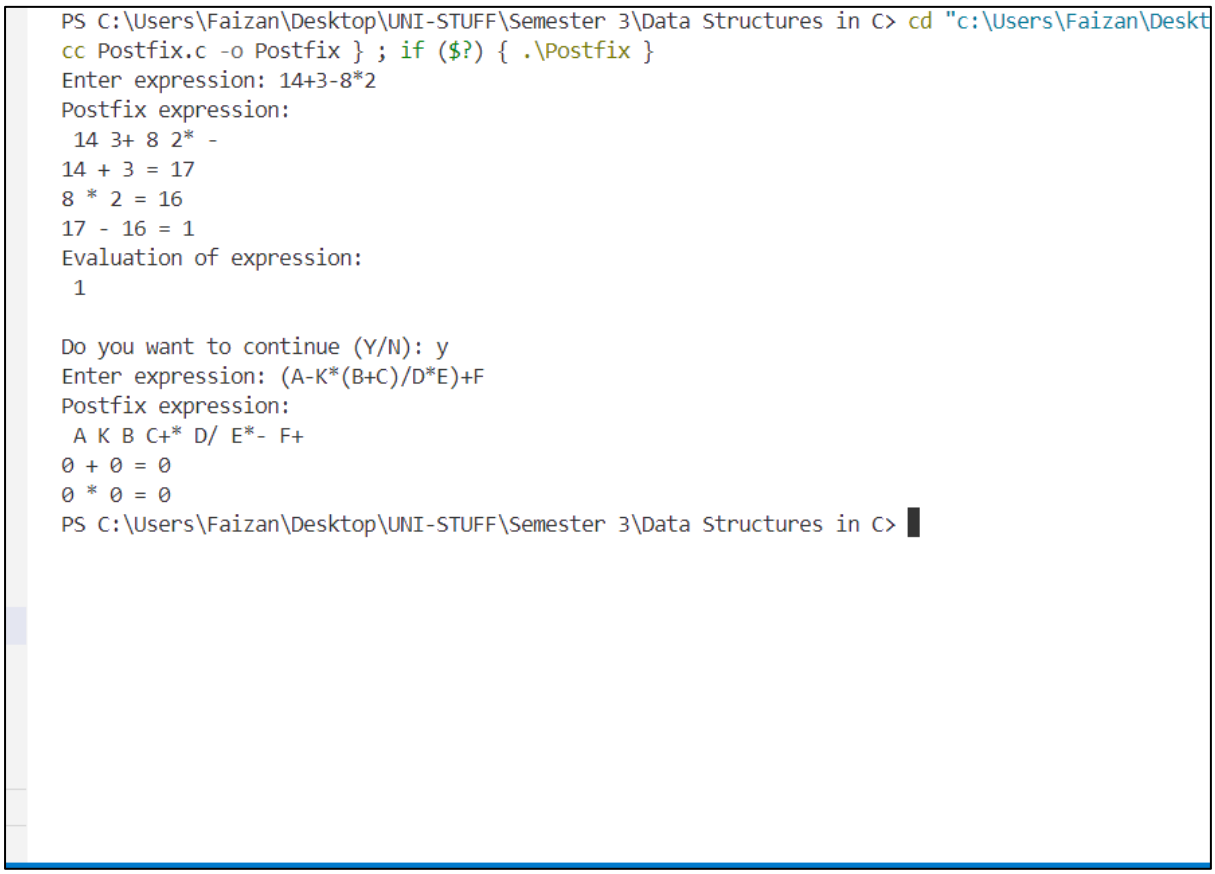
Source Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>
#define MAX 100
int precedence(char c) {
    if (c == '^')
        return 3;
    else if (c == '/' || c == '*')
        return 2;
    else if (c == '+' || c == '-')
        return 1;
    else
        return -1;
}
void Postfix(char s[]) {
    char output_exp[MAX];
    int output_index = 0;
    int len = strlen(s);
    char stack[MAX];
    int stack_index = -1;
    for (int i = 0; i < len; i++) {
        char c = s[i];
        if ((c >= 'a' && c <= 'z') || (c >= 'A' && c <= 'Z') || (c >= '0' && c
<= '9')) {
            output_exp[output_index++] = c;
        }
        else if (c == '(') {
            stack[++stack_index] = c;
        }
        else if (c == ')') {
            while (stack_index >= 0 && stack[stack_index] != '(') {
                output_exp[output_index++] = stack[stack_index--];
            }
            stack_index--;
        }
        else {
            while (stack_index >= 0 && (precedence(s[i]) <
precedence(stack[stack_index]) ||
```

```
                                        precedence(s[i]) ==
precedence(stack[stack_index]))) {
                output_exp[output_index++] = stack[stack_index--];
            }
            output_exp[output_index++] = ' ';
            stack[++stack_index] = c;
        }
    }
    while (stack_index >= 0) {
        output_exp[output_index++] = stack[stack_index--];
        output_exp[output_index++] = ' ';
    }
    output_exp[output_index] = '\0';
    printf("Postfix expression:\n %s\n", output_exp);
    int evaluation[MAX];
    int eval_index = -1;
    int i = 0;
    while (output_exp[i] != '\0') {
        if (isdigit(output_exp[i])) {
            int num = 0;
            while (isdigit(output_exp[i])) {
                num = num * 10 + (output_exp[i] - '0');
                i++;
            }
            evaluation[++eval_index] = num;
        } else if (output_exp[i] == ' ') {
            i++;
        } else if (output_exp[i] == '+' || output_exp[i] == '-' ||
output_exp[i] == '*' || output_exp[i] == '/') {
            int b = evaluation[eval_index--];
            int a = evaluation[eval_index--];
            int result = 0;
            if (output_exp[i] == '+') {
                result = a + b;
                printf("%d + %d = %d\n", a, b, result);
            } else if (output_exp[i] == '-') {
                result = a - b;
                printf("%d - %d = %d\n", a, b, result);
            } else if (output_exp[i] == '*') {
                result = a * b;
                printf("%d * %d = %d\n", a, b, result);
            } else if (output_exp[i] == '/') {
                result = a / b;
                printf("%d / %d = %d\n", a, b, result);
            }
            evaluation[++eval_index] = result;
            i++;
        } else {
```

```
            i++;
        }
    }
    printf("Evaluation of expression:\n %d\n", evaluation[eval_index]);
}
int main() {
    char exp[MAX];
    char contn;
    int ch;
    do {
        printf("Enter expression: ");
        fgets(exp, MAX, stdin);
        exp[strcspn(exp, "\n")] = '\0';
        Postfix(exp);
        while ((ch = getchar()) != '\n' && ch != EOF);
        printf("Do you want to continue (Y/N): ");
        scanf(" %c", &contn);
        while ((ch = getchar()) != '\n' && ch != EOF);
    }
    while (contn == 'y' || contn == 'Y');
    printf("\nProgram terminated successfully...\n\n");
    return 0;
}
```

Output:



Lab 11

Program:

Write a menu driven program to perform the operations of Tower of Hanoi, Factorial, and Fibonacci.

Source code:

```
#include<stdio.h>
int step = 1;
void TOH(int n, char S, char D, char A){
    if(n == 1) {
        printf("Step %d: Move disk from tower %d to tower %d\n", step++, S,
D);
    }
    else{
        TOH(n-1, S, A, D);
        printf("Step %d: Move disk from tower %d to tower %d.\n", step++, S,
D);
        TOH(n-1, A, D, S);
    }
}
int Factorial(int n){
    if(n == 0 || n == 1)
        return 1;
    else
        return n * Factorial(n-1);
}
void Fibonacci(int n){
    int a = 0, b = 1, next;
    if(n == 0) {
        printf("Enter a positive number.\n");
        return;
    }
    printf("Fibonacci for %d terms:\n", n);
    for(int i = 0; i < n; i++) {
        if(i == 0)
            printf("%d ", a);
        else if(i == 1)
            printf("%d ", b);
        else {
            next = a + b;
            a = b;
            b = next;
            printf("%d ", next);
        }
    }
    printf("\n");
```

```
}
int main(){
    int n, optn;
    int Tsource, Tdest, Taux;
    char contn;
    printf("Operations:\n 1- Tower of Hanoi.\n 2- Factorial.\n 3-
Fibonacci.\n");
    do {
        printf("Enter option: ");
        scanf("%d", &optn);
        switch(optn) {
            case 1:
                printf("Enter number of rings: ");
                scanf("%d", &n);
                printf("Enter source tower: ");
                scanf("%d", &Tsource);
                printf("Enter destination tower: ");
                scanf("%d", &Tdest);
                TOH(n, Tsource, Tdest, Taux);
                printf("Total steps: %d\n", step-1);
                break;
            case 2:
                printf("Enter number for factorial: ");
                scanf("%d", &n);
                printf("Factorial of %d is: %d", n, Factorial(n));
                break;
            case 3:
                printf("Enter number of terms in Fibonacci: ");
                scanf("%d", &n);
                Fibonacci(n);
                break;
            default:
                printf("\nIncorrect option.\nChoose from given options(1-
3).\n");
                break;
        }
        printf("\nDo you want to continue(Y/N): ");
        scanf(" %c", &contn);
    }
    while(contn == 'Y' || contn == 'y');
    printf("\nProgram terminated successfully...\n\n");
    return 0;
}
```

Output:

```
 TOH } ; if ($?) { .\TOH }
Operations:
 1- Tower of Hanoi.
 2- Factorial.
 3- Fibonacci.
Enter option: 1
Enter number of rings: 3
Enter source tower: 1
Enter destination tower: 3
Step 1: Move disk from tower 1 to tower 3
Step 2: Move disk from tower 1 to tower 0.
Step 3: Move disk from tower 3 to tower 0
Step 4: Move disk from tower 1 to tower 3.
Step 5: Move disk from tower 0 to tower 1
Step 6: Move disk from tower 0 to tower 3.
Step 7: Move disk from tower 1 to tower 3
Total steps: 7

Do you want to continue(Y/N): y
Enter option: 2
Enter number for factorial: 7
Factorial of 7 is: 5040
Do you want to continue(Y/N): y
Enter option: 3
Enter number of terms in Fibonacci: 10
Fibonacci for 10 terms:
0 1 1 2 3 5 8 13 21 34

Do you want to continue(Y/N): n

Program terminated successfully...

PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 12.1

Program:

Write a program to perform Bubble sorting on an array of size n. Take the elements and size of array from user.

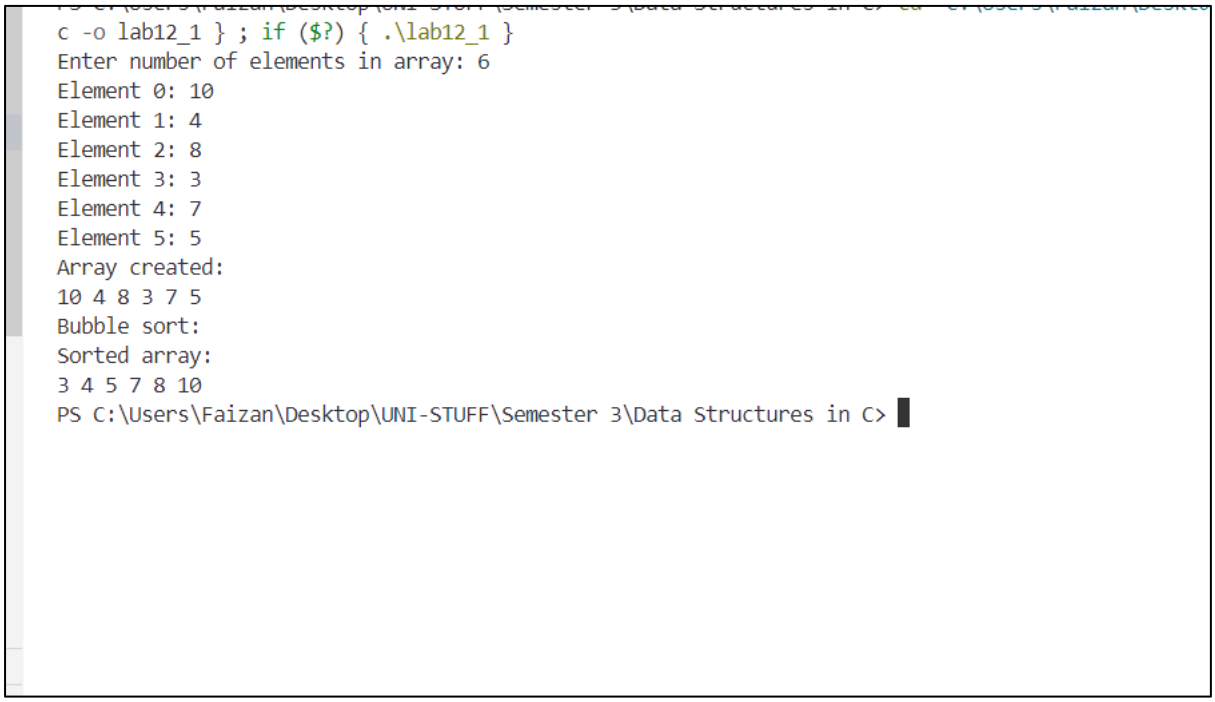
Source code:

```c
#include<stdio.h>
#define MAX 100
void bubble_sort(int n, int a[MAX]){
    for(int i = 0; i < n; i++){
        for(int j = 0; j < (n-1); j++){
            if(a[j] > a[j+1]) {
                int temp = a[j];
                a[j] = a[j+1];
                a[j+1] = temp;
            }
        }
    }
    printf("Sorted array:\n");
    for(int i = 0; i < n; i++){
        printf("%d ", a[i]);
    }
}
int main(){
    int n, arr[MAX];
    printf("Enter number of elements in array: ");
    scanf("%d", &n);
    for(int i = 0; i < n; i++){
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("Array created:\n");
    for(int i = 0; i < n; i++)
    {
        printf("%d ", arr[i]);
    }
    printf("\nBubble sort:\n");

    bubble_sort(n, arr);


    return 0;
}
```

Output:


c -o lab12_1 } ; if ($?) { .\lab12_1 }
Enter number of elements in array: 6
Element 0: 10
Element 1: 4
Element 2: 8
Element 3: 3
Element 4: 7
Element 5: 5
Array created:
10 4 8 3 7 5
Bubble sort:
Sorted array:
3 4 5 7 8 10
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>

Lab 12.2

Program:

Write a program to perform Selection sorting on an array of size n. Take the elements and size of array from user.

Source code:

```c
#include <stdio.h>
#define MAX 100
void selectionSort(int arr[MAX], int n) {
    for (int i = 0; i < n - 1; i++) {
        int min = i;
        for (int j = i + 1; j < n; j++) {
            if (arr[j] < arr[min]) {
                min = j;
            }
        }
        int temp = arr[min];
        arr[min] = arr[i];
        arr[i] = temp;
    }
}
int main() {
    int arr[MAX];
    int n;
    printf("Enter n: ");
    scanf("%d", &n);
    printf("Create array:\n");
    for(int i = 0; i < n; i++){
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("Unsorted array: \n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
    selectionSort(arr, n);
    printf("Sorted array: \n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
    return 0;
}
```

Output:

```
cc lab12_2.c -o lab12_2 } ; if ($?) { .\lab12_2 }
Enter n: 6
Create array:
Element 0: 15
Element 1: 7
Element 2: 6
Element 3: 9
Element 4: 4
Element 5: 12
Unsorted array:
15 7 6 9 4 12
Sorted array:
4 6 7 9 12 15
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 12.3

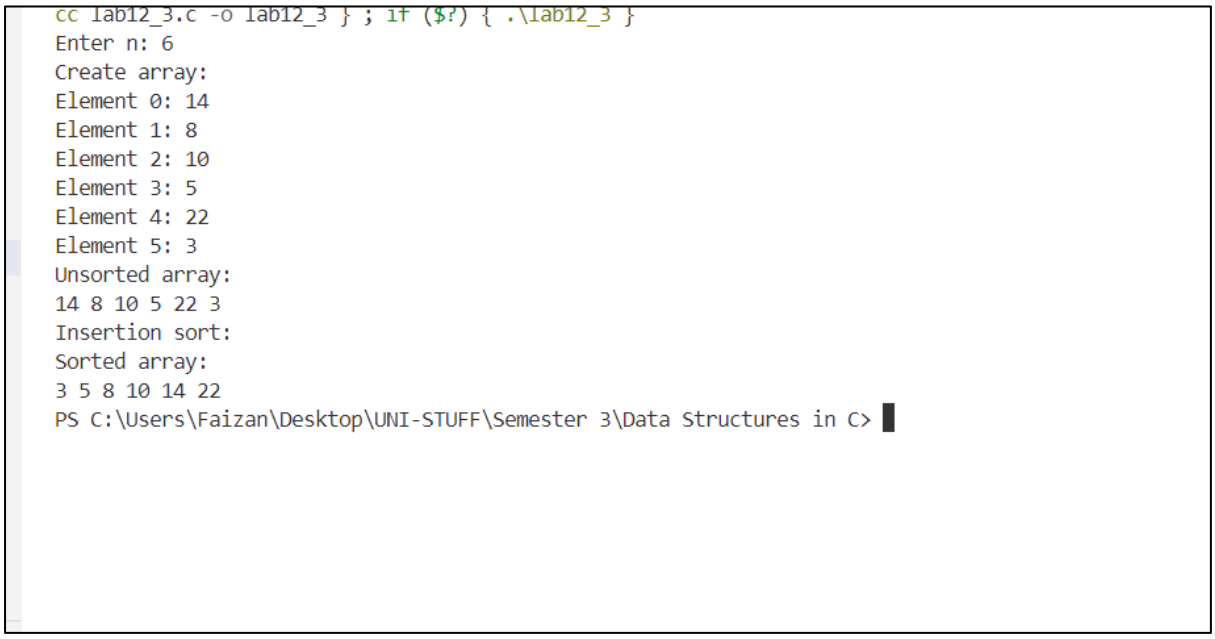
Program:

Write a program to perform Insertion sorting on an array of size n. Take the elements and size of array from user.

Source code:

```c
#include<stdio.h>
#define MAX 100
void insertionSort(int n, int arr[MAX]){
    for(int i = 0; i < n; i++){
        int key = arr[i];
        int j = i-1;
        while(j >= 0 && arr[j] > key){
            arr[j+1] = arr[j];
            j = j - 1;
        }
        arr[j+1] = key;
    }
}
int main(){
    int n, arr[MAX];
    printf("Enter n: ");
    scanf("%d", &n);
    printf("Create array:\n");
    for(int i = 0; i < n; i++){
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("Unsorted array: \n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("Insertion sort:\n");
    insertionSort(n, arr);
    printf("Sorted array: \n");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
    return 0;
}
```

Output:


cc lab12_3.c -o lab12_3 } ; if ($?) { .\lab12_3 }
Enter n: 6
Create array:
Element 0: 14
Element 1: 8
Element 2: 10
Element 3: 5
Element 4: 22
Element 5: 3
Unsorted array:
14 8 10 5 22 3
Insertion sort:
Sorted array:
3 5 8 10 14 22
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>

Lab 13.1

Program:

Write a program to perform Insertion and Deletion from the beginning, middle, and the end of a Singly Linked List.

Source code:

```
#include<stdio.h>
#include<stdlib.h>
typedef struct Node {
    int data;
    struct Node* next;
} Node;
Node* createNode(int data) {
    Node* NN = (Node*)malloc(sizeof(Node));
    if(NN == NULL) {
        printf("List overflow...\n");
        exit(1);
    }
    NN->data = data;
    NN->next = NULL;
    return NN;
}

void insert_beginning(Node** start, int data) {
    Node* NN = createNode(data);
    NN->next = *start;
    *start = NN;
}

void insert_middle(Node** start, int data, int position) {
    if(position < 0){
        printf("Invalid position...\n");
        return;
    }
    if(position == 0){
        insert_beginning(start, data);
        return;
    }
    Node* NN = createNode(data);
    Node* temp = *start;
    for(int i = 0; temp != NULL && i < (position-1); i++)
    {
        temp = temp->next;
    }
    if(temp == NULL) {
        printf("Incorrect position...\n");
```

```
        free(NN);
        return;
    }
    NN->next = temp->next;
    temp->next = NN;
}

void insert_end(Node** start, int data) {
    Node* NN = createNode(data);
    if(*start == NULL) {
        *start = NN;
        return;
    }
    Node* end = *start;
    while(end->next != NULL) {
        end = end->next;
    }
    end->next = NN;
}

void delete_beginning(Node** start) {
    if(*start == NULL){
        printf("List underflow.\n");
        return;
    }
    Node* temp = *start;
    *start = temp->next;
    free(temp);
}

void delete_middle(Node** start, int position) {
    if(*start == NULL){
        printf("List underflow.\n");
        return;
    }
    if(position == 0){
        delete_beginning(start);
        return;
    }
    Node* temp = *start;
    for (int i = 0; temp != NULL && i < position - 1; i++) {
        temp = temp->next;
    }
    if (temp == NULL || temp->next == NULL) {
        printf("Incorrect position.\n");
        return;
    }
    Node* NN = temp->next;
```

```
    temp->next = NN->next;
    free(NN);
}

void delete_end(Node** start) {
    if(*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    if((*start)->next == NULL) {
        free(*start);
        *start = NULL;
        return;
    }
    Node* temp = *start;
    while((temp->next)->next != NULL) {
        temp = temp->next;
    }
    free(temp->next);
    temp->next = NULL;
}

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

int main()
{
    Node* start = NULL;
    int val, position, optn;
    char contn;

    printf("Linked List:\n Insert:\n  1- Beginning.\n  2- Middle.\n  3- End.\n
Delete:\n  4- Beginning.\n  5- Middle.\n  6- End.\n  7- Display.\n\n");

    do {
        printf("Enter option: ");
        scanf("%d", &optn);

        switch(optn){
            case 1:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_beginning(&start, val);
```

```
                break;
            case 2:
                printf("Enter value: ");
                scanf("%d", &val);
                printf("Enter position: ");
                scanf("%d", &position);
                insert_middle(&start, val, position);
                break;
            case 3:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_end(&start, val);
                break;
            case 4:
                delete_beginning(&start);
                break;
            case 5:
                printf("Enter position: ");
                scanf("%d", &position);
                delete_middle(&start, position);
                break;
            case 6:
                delete_end(&start);
                break;
            case 7:
                printf("Linked List display:\n");
                display(start);
                break;
            default:
                printf("Incorrect option...\n");
                break;
        }
        printf("Do you want to continue(Y/N): ");
        scanf(" %c", &contn);
    }
    while(contn == 'Y' || contn == 'y');

    printf("\nProgram terminated successfully...\n");

    return 0;
}
```

Output:

```
{ .\SingleLinkedList }
Linked List:
 Insert:
  1- Beginning.
  2- Middle.
  3- End.
 Delete:
  4- Beginning.
  5- Middle.
  6- End.
  7- Display.

Enter option: 1
Enter value: 10
Do you want to continue(Y/N): y
Enter option: 3
Enter value: 20
Do you want to continue(Y/N): y
Enter option: 2
Enter value: 15
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
10 -> 15 -> 20 -> NULL
Do you want to continue(Y/N): y
Enter option: 5
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
10 -> 20 -> NULL
Do you want to continue(Y/N): y
Enter option: 6
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
10 -> NULL
Do you want to continue(Y/N): y
Enter option: 4
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
NULL
Do you want to continue(Y/N): n

Program terminated successfully...
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 13.2

Program:

Write a program to perform Insertion and Deletion from the beginning, middle, and the end of a Doubly Linked List.

Source code:

```c
#include <stdio.h>
#include <stdlib.h>
typedef struct Node {
    int data;
    struct Node* next;
    struct Node* prev;
} Node;
Node* createNode(int data) {
    Node* NN = (Node*)malloc(sizeof(Node));
    if (NN == NULL) {
        printf("List overflow...\n");
        exit(1);
    }
    NN->data = data;
    NN->next = NULL;
    NN->prev = NULL;
    return NN;
}
void insert_beginning(Node** start, int data) {
    Node* NN = createNode(data);
    NN->next = *start;
    if (*start != NULL) {
        (*start)->prev = NN;
    }
    *start = NN;
}
void insert_middle(Node** start, int data, int position) {
    if (position < 0) {
        printf("Invalid position...\n");
        return;
    }
    if (position == 0) {
        insert_beginning(start, data);
        return;
    }
    Node* NN = createNode(data);
    Node* temp = *start;
    for (int i = 0; temp != NULL && i < (position - 1); i++) {
        temp = temp->next;
    }
```

```
    if (temp == NULL) {
        printf("Incorrect position...\n");
        free(NN);
        return;
    }
    NN->next = temp->next;
    NN->prev = temp;
    if (temp->next != NULL) {
        temp->next->prev = NN;
    }
    temp->next = NN;
}

void insert_end(Node** start, int data) {
    Node* NN = createNode(data);
    if (*start == NULL) {
        *start = NN;
        return;
    }
    Node* end = *start;
    while (end->next != NULL) {
        end = end->next;
    }
    end->next = NN;
    NN->prev = end;
}

void delete_beginning(Node** start) {
    if (*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    Node* temp = *start;
    *start = temp->next;
    if (*start != NULL) {
        (*start)->prev = NULL;
    }
    free(temp);
}

void delete_middle(Node** start, int position) {
    if (*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    if (position == 0) {
        delete_beginning(start);
        return;
```

```
    }
    Node* temp = *start;
    for (int i = 0; temp != NULL && i < position; i++) {
        temp = temp->next;
    }
    if (temp == NULL) {
        printf("Incorrect position.\n");
        return;
    }
    if (temp->prev != NULL) {
        temp->prev->next = temp->next;
    }
    if (temp->next != NULL) {
        temp->next->prev = temp->prev;
    }
    free(temp);
}
void delete_end(Node** start) {
    if (*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    if ((*start)->next == NULL) {
        free(*start);
        *start = NULL;
        return;
    }
    Node* temp = *start;
    while (temp->next != NULL) {
        temp = temp->next;
    }
    temp->prev->next = NULL;
    free(temp);
}
void display(Node* node) {
    while (node != NULL) {
        printf("%d <-> ", node->data);
        node = node->next;
    }
    printf("NULL\n");
}
int main() {
    Node* start = NULL;
    int val, position, optn;
    char contn;

    printf("Doubly Linked List:\n Insert:\n  1- Beginning.\n  2- Middle.\n  3-
End.\n Delete:\n  4- Beginning.\n  5- Middle.\n  6- End.\n  7- Display.\n\n");
```

```
    do {
        printf("Enter option: ");
        scanf("%d", &optn);
        switch (optn) {
            case 1:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_beginning(&start, val);
                break;
            case 2:
                printf("Enter value: ");
                scanf("%d", &val);
                printf("Enter position: ");
                scanf("%d", &position);
                insert_middle(&start, val, position);
                break;
            case 3:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_end(&start, val);
                break;
            case 4:
                delete_beginning(&start);
                break;
            case 5:
                printf("Enter position: ");
                scanf("%d", &position);
                delete_middle(&start, position);
                break;
            case 6:
                delete_end(&start);
                break;
            case 7:
                printf("Doubly Linked List display:\n");
                display(start);
                break;
            default:
                printf("Incorrect option...\n");
                break;
        }
        printf("Do you want to continue(Y/N): ");
        scanf(" %c", &contn);
    } while (contn == 'Y' || contn == 'y');
    printf("\nProgram terminated successfully...\n");
    return 0;
}
```

Output:

```
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> cd "c:\Users\Faizan\Deskto
st } ; if ($?) { .\DoubleLinkedList }
Doubly Linked List:
 Insert:
  1- Beginning.
  2- Middle.
  3- End.
 Delete:
  4- Beginning.
  5- Middle.
  6- End.
  7- Display.

Enter option: 1
Enter value: 10
Do you want to continue(Y/N): y
Enter option: 3
Enter value: 20
Do you want to continue(Y/N): y
Enter option: 2
Enter value: 15
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Doubly Linked List display:
10 <-> 15 <-> 20 <-> NULL
Do you want to continue(Y/N): y
Enter option: 5
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Doubly Linked List display:
10 <-> 20 <-> NULL
Do you want to continue(Y/N): y
Enter option: 6
Do you want to continue(Y/N): y
Enter option: 7
Doubly Linked List display:
10 <-> NULL
Do you want to continue(Y/N): y
Enter option: 4
Do you want to continue(Y/N): y
Enter option: 7
Doubly Linked List display:
NULL
Do you want to continue(Y/N): n

Program terminated successfully...
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 14.1

Program:

Write a program to perform Insertion and Deletion from the beginning, middle, and the end of a circular Singly Linked List.

Source code:

```
#include<stdio.h>
#include<stdlib.h>
typedef struct Node {
    int data;
    struct Node* next;
} Node;
Node* createNode(int data) {
    Node* NN = (Node*)malloc(sizeof(Node));
    if(NN == NULL) {
        printf("List overflow...\n");
        exit(1);
    }
    NN->data = data;
    NN->next = NULL;
    return NN;
}
void insert_beginning(Node** start, int data) {
    Node* NN = createNode(data);
    if(*start == NULL) {
        *start = NN;
        NN->next = *start;
    } else {
        Node* temp = *start;
        while(temp->next != *start) {
            temp = temp->next;
        }
        temp->next = NN;
        NN->next = *start;
        *start = NN;
    }
}
void insert_middle(Node** start, int data, int position) {
    if(position < 0) {
        printf("Invalid position...\n");
        return;
    }
    if(position == 0) {
        insert_beginning(start, data);
        return;
    }
```

```
    Node* NN = createNode(data);
    Node* temp = *start;
    for(int i = 0; i < position - 1 && temp->next != *start; i++) {
        temp = temp->next;
    }
    if(temp->next == *start && position > 1) {
        printf("Incorrect position...\n");
        free(NN);
        return;
    }
    NN->next = temp->next;
    temp->next = NN;
}
void insert_end(Node** start, int data) {
    Node* NN = createNode(data);
    if(*start == NULL) {
        *start = NN;
        NN->next = *start;
    } else {
        Node* temp = *start;
        while(temp->next != *start) {
            temp = temp->next;
        }
        temp->next = NN;
        NN->next = *start;
    }
}
void delete_beginning(Node** start) {
    if(*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    Node* temp = *start;
    if(temp->next == *start) {
        free(temp);
        *start = NULL;
    } else {
        Node* last = *start;
        while(last->next != *start) {
            last = last->next;
        }
        *start = temp->next;
        last->next = *start;
        free(temp);
    }
}
void delete_middle(Node** start, int position) {
    if(*start == NULL) {
```

```
        printf("List underflow.\n");
        return;
    }
    if(position == 0) {
        delete_beginning(start);
        return;
    }
    Node* temp = *start;
    for(int i = 0; i < position - 1 && temp->next != *start; i++) {
        temp = temp->next;
    }
    if(temp->next == *start) {
        printf("Incorrect position.\n");
        return;
    }
    Node* NN = temp->next;
    temp->next = NN->next;
    free(NN);
}
void delete_end(Node** start) {
    if(*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    Node* temp = *start;
    if(temp->next == *start) {
        free(temp);
        *start = NULL;
        return;
    }
    Node* prev = NULL;
    while(temp->next != *start) {
        prev = temp;
        temp = temp->next;
    }
    free(temp);
    prev->next = *start;
}
void display(Node* node) {
    if(node == NULL) {
        printf("List is empty.\n");
        return;
    }
    Node* temp = node;
    do {
        printf("%d -> ", temp->data);
        temp = temp->next;
    } while(temp != node);
```

```
    printf("(back to start)\n");
}
int main() {
    Node* start = NULL;
    int val, position, optn;
    char contn;
    printf("Linked List:\n Insert:\n  1- Beginning.\n  2- Middle.\n  3- End.\n
Delete:\n  4- Beginning.\n  5- Middle.\n  6- End.\n  7- Display.\n\n");
    do {
        printf("Enter option: ");
        scanf("%d", &optn);
        switch(optn) {
            case 1:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_beginning(&start, val);
                break;
            case 2:
                printf("Enter value: ");
                scanf("%d", &val);
                printf("Enter position: ");
                scanf("%d", &position);
                insert_middle(&start, val, position);
                break;
            case 3:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_end(&start, val);
                break;
            case 4:
                delete_beginning(&start);
                break;
            case 5:
                printf("Enter position: ");
                scanf("%d", &position);
                delete_middle(&start, position);
                break;
            case 6:
                delete_end(&start);
                break;
            case 7:
                printf("Linked List display:\n");
                display(start);
                break;
            default:
                printf("Incorrect option...\n");
                break;
        }
```

```
        printf("Do you want to continue(Y/N): ");
        scanf(" %c", &contn);
    } while(contn == 'Y' || contn == 'y');
    printf("\nProgram terminated successfully...\n");
    return 0;
}
```

Output:

```
Linked List:
 Insert:
  1- Beginning.
  2- Middle.
  3- End.
 Delete:
  4- Beginning.
  5- Middle.
  6- End.
  7- Display.

Enter option: 1
Enter value: 10
Do you want to continue(Y/N): y
Enter option: 3
Enter value: 20
Do you want to continue(Y/N): y
Enter option: 3
Enter value: 40
Do you want to continue(Y/N): y
Enter option: 2
Enter value: 30
Enter position: 2
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
10 -> 20 -> 30 -> 40 -> (back to start)
Do you want to continue(Y/N): y
Enter option: 5
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
10 -> 30 -> 40 -> (back to start)
Do you want to continue(Y/N): y
Enter option: 6
Do you want to continue(Y/N): y
Enter option: 4
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
30 -> (back to start)
Do you want to continue(Y/N): y
Enter option: 4
Do you want to continue(Y/N): y
Enter option: 7
Linked List display:
List is empty.
Do you want to continue(Y/N): n

Program terminated successfully...
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 14.2

Program:

Write a program to perform Insertion and Deletion from the beginning, middle, and the end of a circular Doubly Linked List.

Source code:

```
#include <stdio.h>
#include <stdlib.h>
typedef struct Node {
    int data;
    struct Node* next;
    struct Node* prev;
} Node;
Node* createNode(int data) {
    Node* NN = (Node*)malloc(sizeof(Node));
    if (NN == NULL) {
        printf("List overflow...\n");
        exit(1);
    }
    NN->data = data;
    NN->next = NN;
    NN->prev = NN;
    return NN;
}
void insert_beginning(Node** start, int data) {
    Node* NN = createNode(data);
    if (*start == NULL) {
        *start = NN;
    } else {
        Node* last = (*start)->prev;
        NN->next = *start;
        NN->prev = last;
        last->next = NN;
        (*start)->prev = NN;
    }
    *start = NN;
}
void insert_middle(Node** start, int data, int position) {
    if (position < 0) {
        printf("Invalid position...\n");
        return;
    }
    if (position == 0) {
        insert_beginning(start, data);
        return;
    }
```

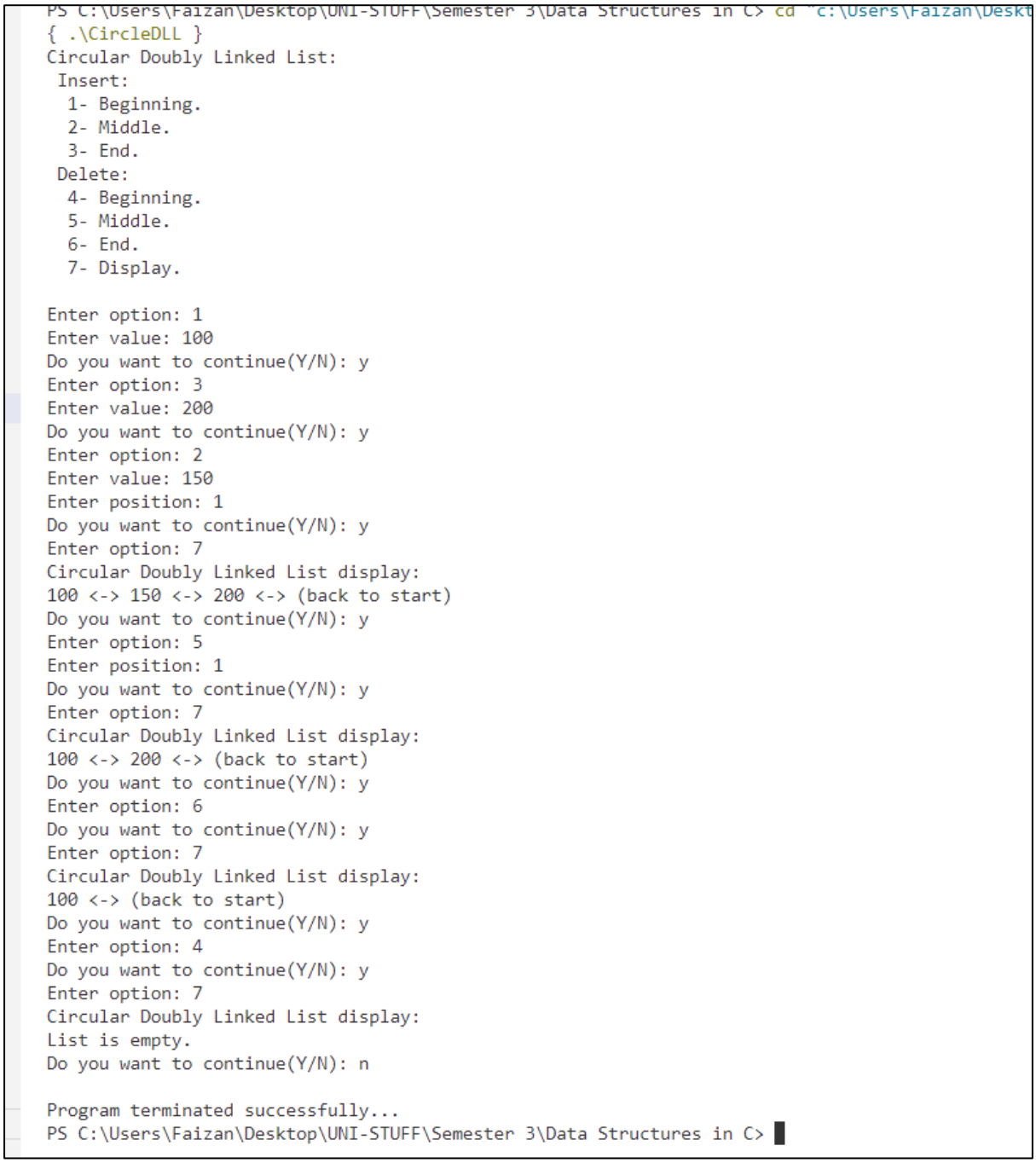
```
    Node* NN = createNode(data);
    Node* temp = *start;
    for (int i = 0; i < position - 1 && temp->next != *start; i++) {
        temp = temp->next;
    }
    if (temp->next == *start && position > 1) {
        printf("Incorrect position...\n");
        free(NN);
        return;
    }
    NN->next = temp->next;
    NN->prev = temp;
    temp->next->prev = NN;
    temp->next = NN;
}
void insert_end(Node** start, int data) {
    if (*start == NULL) {
        insert_beginning(start, data);
    } else {
        Node* NN = createNode(data);
        Node* last = (*start)->prev;
        last->next = NN;
        NN->prev = last;
        NN->next = *start;
        (*start)->prev = NN;
    }
}
void delete_beginning(Node** start) {
    if (*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    Node* temp = *start;
    if (temp->next == *start) {
        free(temp);
        *start = NULL;
    } else {
        Node* last = temp->prev;
        *start = temp->next;
        last->next = *start;
        (*start)->prev = last;
        free(temp);
    }
}
void delete_middle(Node** start, int position) {
    if (*start == NULL) {
        printf("List underflow.\n");
        return;
```

```
    }
    if (position == 0) {
        delete_beginning(start);
        return;
    }
    Node* temp = *start;
    for (int i = 0; i < position && temp->next != *start; i++) {
        temp = temp->next;
    }
    if (temp->next == *start && position > 0) {
        printf("Incorrect position.\n");
        return;
    }
    temp->prev->next = temp->next;
    temp->next->prev = temp->prev;
    free(temp);
}
void delete_end(Node** start) {
    if (*start == NULL) {
        printf("List underflow.\n");
        return;
    }
    Node* last = (*start)->prev;
    if (last == *start) {
        free(last);
        *start = NULL;
    } else {
        Node* secondLast = last->prev;
        secondLast->next = *start;
        (*start)->prev = secondLast;
        free(last);
    }
}
void display(Node* node) {
    if (node == NULL) {
        printf("List is empty.\n");
        return;
    }
    Node* temp = node;
    do {
        printf("%d <-> ", temp->data);
        temp = temp->next;
    } while (temp != node);
    printf("(back to start)\n");
}
int main() {
    Node* start = NULL;
    int val, position, optn;
```

```
    char contn;
    printf("Circular Doubly Linked List:\n Insert:\n  1- Beginning.\n  2-
Middle.\n  3- End.\n Delete:\n  4- Beginning.\n  5- Middle.\n  6- End.\n  7-
Display.\n\n");
    do {
        printf("Enter option: ");
        scanf("%d", &optn);
        switch (optn) {
            case 1:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_beginning(&start, val);
                break;
            case 2:
                printf("Enter value: ");
                scanf("%d", &val);
                printf("Enter position: ");
                scanf("%d", &position);
                insert_middle(&start, val, position);
                break;
            case 3:
                printf("Enter value: ");
                scanf("%d", &val);
                insert_end(&start, val);
                break;
            case 4:
                delete_beginning(&start);
                break;
            case 5:
                printf("Enter position: ");
                scanf("%d", &position);
                delete_middle(&start, position);
                break;
            case 6:
                delete_end(&start);
                break;
            case 7:
                printf("Circular Doubly Linked List display:\n");
                display(start);
                break;
            default:
                printf("Incorrect option...\n");
                break;
        }
        printf("Do you want to continue(Y/N): ");
        scanf(" %c", &contn);
    } while (contn == 'Y' || contn == 'y');
    printf("\nProgram terminated successfully...\n");
```

```
    return 0;
}
```

Output:



```
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> cd "c:\Users\Faizan\Deskt
{ .\CircleDLL }
Circular Doubly Linked List:
 Insert:
  1- Beginning.
  2- Middle.
  3- End.
 Delete:
  4- Beginning.
  5- Middle.
  6- End.
  7- Display.

Enter option: 1
Enter value: 100
Do you want to continue(Y/N): y
Enter option: 3
Enter value: 200
Do you want to continue(Y/N): y
Enter option: 2
Enter value: 150
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Circular Doubly Linked List display:
100 <-> 150 <-> 200 <-> (back to start)
Do you want to continue(Y/N): y
Enter option: 5
Enter position: 1
Do you want to continue(Y/N): y
Enter option: 7
Circular Doubly Linked List display:
100 <-> 200 <-> (back to start)
Do you want to continue(Y/N): y
Enter option: 6
Do you want to continue(Y/N): y
Enter option: 7
Circular Doubly Linked List display:
100 <-> (back to start)
Do you want to continue(Y/N): y
Enter option: 4
Do you want to continue(Y/N): y
Enter option: 7
Circular Doubly Linked List display:
List is empty.
Do you want to continue(Y/N): n

Program terminated successfully...
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 15.1

Program:

Write a program to perform Merge sorting on a user defined array of size n.

Source code:

```
#include<stdio.h>
#include<stdlib.h>
#define MAX 100
void merge(int a[], int left, int mid, int right) {
    int i, j, k;
    int n1 = mid - left + 1;
    int n2 = right - mid;
    int arrLeft[n1], arrRight[n2];
    for(i = 0; i < n1; i++) {
        arrLeft[i] = a[left + i];
    }
    for(j = 0; j < n2; j++) {
        arrRight[j] = a[mid + 1 + j];
    }
    i = 0;
    j = 0;
    k = left;
    while(i < n1 && j < n2)
    {
        if(arrLeft[i] <= arrRight[j])
        {
            a[k] = arrLeft[i];
            i++;
        }
        else {
            a[k] = arrRight[j];
            j++;
        }
        k++;
    }

    while(i < n1) {
        a[k] = arrLeft[i];
        i++;
        k++;
    }
    while(j < n2) {
        a[k] = arrRight[j];
        j++;
        k++;
    }
```

```
}

void mergeSort(int a[], int left, int right)
{
    if(left < right) {
        int mid = left + (right - left) / 2;

        mergeSort(a, left, mid);
        mergeSort(a, mid+1, right);
        merge(a, left, mid, right);
    }
}

int main()
{
    int arr[MAX];
    int n;

    printf("Enter numbr of elements of array: ");
    scanf("%d", &n);
    printf("Create array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("Array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("%d ", arr[i]);
    }
    printf("\n");
    mergeSort(arr, 0, n-1);
    printf("\nSorted array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("%d ", arr[i]);
    }

    return 0;
}
```

Output:

```
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> cd "c:\User
cc merge.c -o merge } ; if ($?) { .\merge }
Enter numbr of elements of array: 8
Create array:
Element 0: 6
Element 1: 4
Element 2: 8
Element 3: 5
Element 4: 9
Element 5: 7
Element 6: 11
Element 7: 15
Array:
6 4 8 5 9 7 11 15

Sorted array:
4 5 6 7 8 9 11 15
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 15.2

Program:

Write a program to perform Quick sorting on a user defined array of size n.

Source code:

```c
#include <stdio.h>

#define MAX 100

void swap(int* a, int* b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

int partition(int a[], int low, int high) {
    int pivot = a[high];
    int i = (low - 1);

    for (int j = low; j < high; j++) {
        if (a[j] < pivot) {
            i++;
            swap(&a[i], &a[j]);
        }
    }
    swap(&a[i + 1], &a[high]);
    return (i + 1);
}

void quickSort(int a[], int low, int high) {
    if (low < high) {
        int P = partition(a, low, high);
        quickSort(a, low, P-1);
        quickSort(a, P+1, high);
    }
}

void printArray(int a[], int size) {
    for (int i = 0; i < size; i++)
        printf("%d ", a[i]);
    printf("\n");
}

int main() {
    int arr[MAX];
    int n;
```

```c
    printf("Enter numbr of elements of array: ");
    scanf("%d", &n);
    printf("Create array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("Array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("%d ", arr[i]);
    }
    printf("\n");
    quickSort(arr, 0, n - 1);
    printf("\nSorted array:\n");
    printPrray(arr, n);
    return 0;
}
```

Output:

```
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C> cd "c:\Users\Faizan\D
cc quick.c -o quick } ; if ($?) { .\quick }
Enter numbr of elements of array: 8
Create array:
Element 0: 19
Element 1: 12
Element 2: 20
Element 3: 7
Element 4: 18
Element 5: 32
Element 6: 5
Element 7: 1
Array:
19 12 20 7 18 32 5 1

Sorted array:
1 5 7 12 18 19 20 32
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```

Lab 15.3

Program:

Write a program to perform Heap sorting on a user defined array of size n.

Source code:

```c
#include <stdio.h>

#define MAX 100

void swap(int* a, int* b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

void heapify(int a[], int n, int i) {
    int largest = i;
    int left = 2 * i + 1;
    int right = 2 * i + 2;

    if (left < n && a[left] > a[largest])
        largest = left;

    if (right < n && a[right] > a[largest])
        largest = right;

    if (largest != i) {
        swap(&a[i], &a[largest]);
        heapify(a, n, largest);
    }
}

void heapSort(int a[], int n) {
    for (int i = n / 2 - 1; i >= 0; i--)
        heapify(a, n, i);

    for (int i = n - 1; i >= 0; i--) {
        swap(&a[0], &a[i]);
        heapify(a, i, 0);
    }
}

void printArray(int a[], int size) {
    for (int i = 0; i < size; i++)
        printf("%d ", a[i]);
    printf("\n");
```

```
}

int main() {
    int arr[MAX];
    int n;
    printf("Enter numbr of elements of array: ");
    scanf("%d", &n);
    printf("Create array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("Element %d: ", i);
        scanf("%d", &arr[i]);
    }
    printf("Array:\n");
    for(int i = 0; i < n; i++)
    {
        printf("%d ", arr[i]);
    }
    printf("\n");
    heapSort(arr, n);
    printf("\nSorted array:\n");
    printArray(arr, n);
    return 0;
}
```

Output:

```
cc heap.c -o heap } ; if ($?) { .\heap }
Enter numbr of elements of array: 15
Create array:
Element 0: 63
Element 1: 19
Element 2: 7
Element 3: 90
Element 4: 81
Element 5: 36
Element 6: 54
Element 7: 48
Element 8: 99
Element 9: 23
Element 10: 20
Element 11: 8
Element 12: 43
Element 13: 60
Element 14: 39
Array:
63 19 7 90 81 36 54 48 99 23 20 8 43 60 39

Sorted array:
7 8 19 20 23 36 39 43 48 54 60 63 81 90 99
PS C:\Users\Faizan\Desktop\UNI-STUFF\Semester 3\Data Structures in C>
```