Q1. Write a program to find the mean and the median of the numbers stored in an array.

Code:

```
#include <stdio.h>

int main() {

   float marks[] = {20,90,12,59,30,44,99,19,39,73,85};
   int len = sizeof(marks)/sizeof(float);

   // mean
   int total = 0;
   for (int i = 0; i < len; ++i) {
      total += marks[i];
   }
   printf("The means marks are: %.2f\n", total / (float) len);


   // median
   // 1. sorting
   float temp;
   for (int i = 0; i<len - 1; i++) {
      for (int j = 0; j < len - i - 1; j++) {
         if (marks[j] > marks[j+1]) {
            temp = marks[j];
            marks[j] = marks[j+1];
            marks[j+1] = temp;
         }
      }
   }
   // 2. finding median
   if (len % 2 == 0) {
      temp = (marks[len/2 - 1] + marks[len/2])/2;
   } else {
      temp = marks[(len - 1)/2];
   }
   printf("The median marks are: %.2f", temp);
   return 0;
}
```

Output:

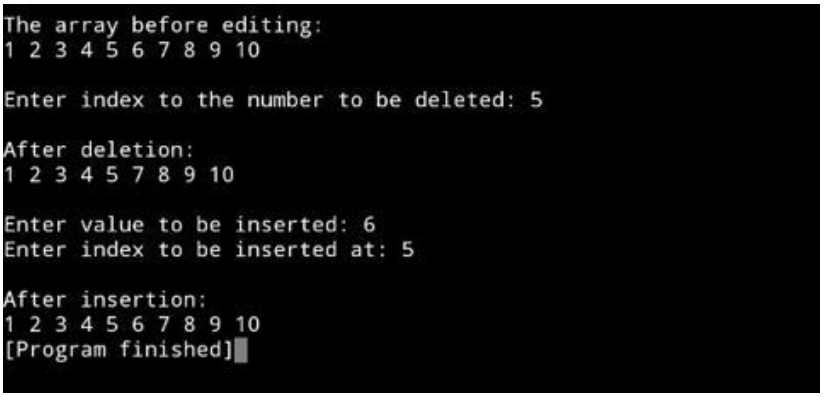
Q2. Write a program to insert one element in an array and delete an element from an array.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#define SIZE 10

int main() {

   int *ar;
   ar = (int *) malloc(SIZE * 4);
   for (int i = 0; i < SIZE; i++) {
      ar[i] = i+1;
   }
```

```
    puts("\nThe array before editing:");
    for (int i = 0; i < SIZE; i++) {
        printf("%d ", ar[i]);
    }puts("\n");

    //deletion
    int ind;
    printf("Enter index to the number to be deleted: ");
    scanf("%d", &ind);

    if (ind < SIZE) {
        for (int i = ind; i < SIZE - 1; i++) {
            ar[i] = ar[i+1];
        }
    }

    ar = (int *) realloc(ar, 4 * (SIZE - 1));

    puts("\nAfter deletion:");
    for (int i = 0; i < SIZE - 1; i++) {
        printf("%d ", ar[i]);
    }puts("\n");

    int val;
    printf("Enter value to be inserted: ");
    scanf("%d", &val);
    printf("Enter index to be inserted at: ");
    scanf("%d", &ind);

    ar = (int *) realloc(ar, SIZE * 4);
    if (ind < SIZE) {
        for (int i = SIZE - 1; i > ind; i--) {
            ar[i] = ar[i-1];
        }
    } ar[ind] = val;

    puts("\nAfter insertion:");
    for (int i = 0; i < SIZE; i++) {
        printf("%d ", ar[i]);
    }

}
```

Output:



Q3. Write a program to search for a number in an array.

Code:

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

```
int main() {
   int arr[] = {0,23,24,9,55,334,26,29,90,73,320}, val;
   int len = sizeof(arr)/sizeof(int);
   int x = len;
   printf("Enter value to be searched: ");
   scanf("%d", &val);
   printf("%d", val);
   for (int i = 0; i < len; i++){
      if (arr[i] == val) {
         x = i;
         break;
      }
   }
   x == len ? printf(" is not in the array.") :
   printf(" is at index number %d", x);
}
```

Output:

```
Enter value to be searched: 23
23 is at index number 1
[Program finished]
```

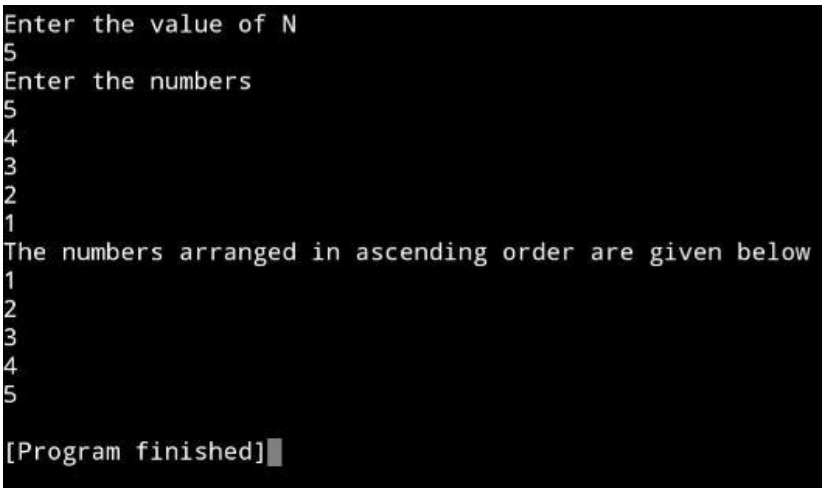
Q4. Write a program to sort an array.

Code:

```
   #include <stdio.h>
   void main()
   {
      int i, j, a, n;
      printf("Enter the value of N \n");
      scanf("%d", &n);
      int number[n];
      printf("Enter the numbers \n");
      for (i = 0; i < n; ++i)
         scanf("%d", &number[i]);
```

```
    for (i = 0; i < n; ++i)
    {
       for (j = i + 1; j < n; ++j)
       {
          if (number[i] > number[j])
          {
             a =  number[i];
             number[i] = number[j];
             number[j] = a;
          }
       }
    }
    printf("The numbers arranged in ascending order are given below \n");
    for (i = 0; i < n; ++i)
       printf("%d\n", number[i]);

  }
```

Output:



Q5. Write a program to merge two sorted arrays.

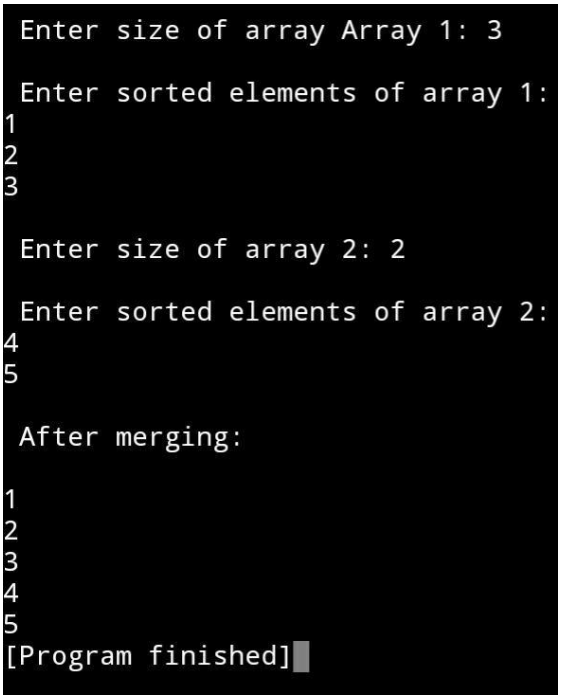
Code:

```
  #include <stdio.h>
  void main()
  {
```

```
int m, n, i, j, k = 0;
printf("\n Enter size of array Array 1: ");
scanf("%d", &m);

int array1[m];

printf("\n Enter sorted elements of array 1: \n");
for (i = 0; i < m; i++)
{
   scanf("%d", &array1[i]);
}

printf("\n Enter size of array 2: ");
scanf("%d", &n);

int array2[n], array3[m+n];

printf("\n Enter sorted elements of array 2: \n");
for (i = 0; i < n; i++)
{
   scanf("%d", &array2[i]);
}

i = 0;
j = 0;

while (i < m && j < n)
{
   if (array1[i] < array2[j])
   {
      array3[k] = array1[i];
      i++;
   }
```

```
        else
        {
            array3[k] = array2[j];
            j++;
        }
        k++;
    }

    if (i >= m)
    {
        while (j < n)
        {
            array3[k] = array2[j];
            j++;
            k++;
        }
    }

    if (j >= n)
    {
        while (i < m)
        {
            array3[k] = array1[i];
            i++;
            k++;
        }
    }

    printf("\n After merging: \n");
    for (i = 0; i < m + n; i++)
    {
        printf("\n%d", array3[i]);
    }

}
```

Output:



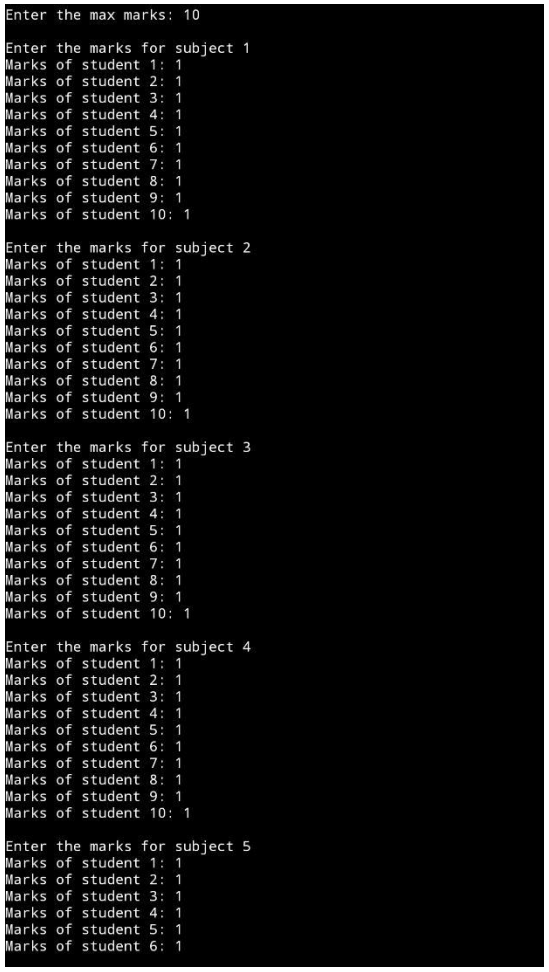
Q6. Write a program to store the marks obtained by 10 students in 5 courses in a two-dimensional array.

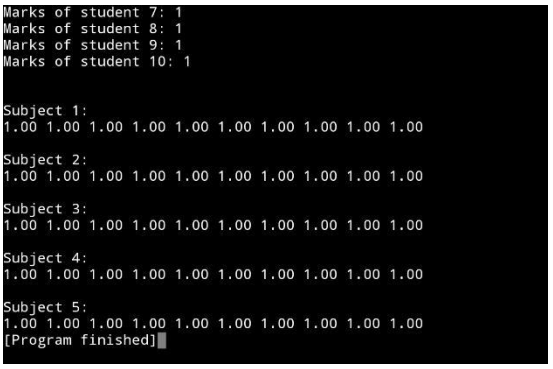
Code:

```
#include <stdio.h>


int main() {
   float score[5][10];
   int max;
   printf("Enter the max marks: ");
   scanf("%d", &max);


   for (int i = 0; i < 5; i++) {
      printf("\nEnter the marks for subject %d\n", i+1);
      for (int j = 0; j < 10; j++) {
         printf("Marks of student %d: ", j+1);
         scanf("%f", &score[i][j]);
         if (score[i][j] > max || score[i][j] < 0) {
            printf("Invalid marks!\n");
            if (j == 0) { j = 10; i--; } else {j--;}
         } }}
```

```
    for (int i = 0; i < 5; i++) {
        printf("\n\nSubject %d:\n", i+1);
        for (int j = 0; j < 10; j++) {
            printf("%.2f ", score[i][j]);
        }
    }
}
```

Output:





Q7. Write a program to implement a linked list.

Code:

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

struct node {
  int data;
  int key;
  struct node *next;
};

struct node *head = NULL;
struct node *current = NULL;

void printList() {
  struct node *ptr = head;
  printf("\n[ ");

  while(ptr != NULL) {
    printf("(%d,%d) ",ptr->key,ptr->data);
    ptr = ptr->next;
  }

  printf(" ]");
}

void insertFirst(int key, int data)
{
  struct node *link = (struct node*) malloc(sizeof(struct node));

  link->key = key;
  link->data = data;

  link->next = head;

  head = link;
}

struct node* deleteFirst()
{
  struct node *tempLink = head;

  head = head->next;

  return tempLink;
}

bool isEmpty() {
  return head == NULL;
}

int length() {
  int length = 0;
  struct node *current;

  for(current = head; current != NULL; current = current->next) {
    length++;
  }

  return length;
```

```
}

struct node* find(int key) {

   struct node* current = head;

   if(head == NULL) {
      return NULL;
   }

   while(current->key != key) {

      if(current->next == NULL) {
         return NULL;
      } else {
         current = current->next;
      }
   }

   return current;
}

struct node* delete(int key) {

   struct node* current = head;
   struct node* previous = NULL;

   if(head == NULL) {
      return NULL;
   }

   while(current->key != key) {

      if(current->next == NULL) {
         return NULL;
      } else {
         previous = current;
         current = current->next;
      }
   }

   if(current == head) {
      head = head->next;
   } else {
      previous->next = current->next;
   }

   return current;
}

void sort() {

   int i, j, k, tempKey, tempData;
   struct node *current;
   struct node *next;

   int size = length();
   k = size ;

   for ( i = 0 ; i < size - 1 ; i++, k-- ) {
      current = head;
      next = head->next;

      for ( j = 1 ; j < k ; j++ ) {
```

```
      if ( current->data > next->data ) {
        tempData = current->data;
        current->data = next->data;
        next->data = tempData;

        tempKey = current->key;
        current->key = next->key;
        next->key = tempKey;
      }

      current = current->next;
      next = next->next;
    }
  }
}

void reverse(struct node** head_ref) {
  struct node* prev   = NULL;
  struct node* current = *head_ref;
  struct node* next;

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

  *head_ref = prev;
}

void main() {
  insertFirst(1,10);
  insertFirst(2,20);
  insertFirst(3,30);
  insertFirst(4,1);
  insertFirst(5,40);
  insertFirst(6,56);

  printf("Original List: ");

  printList();

  while(!isEmpty()) {
    struct node *temp = deleteFirst();
    printf("\nDeleted value:");
    printf("(%d,%d) ",temp->key,temp->data);
  }

  printf("\nList after deleting all items: ");
  printList();
  insertFirst(1,10);
  insertFirst(2,20);
  insertFirst(3,30);
  insertFirst(4,1);
  insertFirst(5,40);
  insertFirst(6,56);

  printf("\nRestored List: ");
  printList();
  printf("\n");

  struct node *foundLink = find(4);
```

```
  if(foundLink != NULL) {
    printf("Element found: ");
    printf("(%d,%d) ",foundLink->key,foundLink->data);
    printf("\n");
  } else {
    printf("Element not found.");
  }

  delete(4);
  printf("List after deleting an item: ");
  printList();
  printf("\n");
  foundLink = find(4);

  if(foundLink != NULL) {
    printf("Element found: ");
    printf("(%d,%d) ",foundLink->key,foundLink->data);
    printf("\n");
  } else {
    printf("Element not found.");
  }

  printf("\n");
  sort();

  printf("List after sorting the data: ");
  printList();

  reverse(&head);
  printf("\nList after reversing the data: ");
  printList();
}
```

Output:

```
Original List:
[ (6,56) (5,40) (4,1) (3,30) (2,20) (1,10)  ]
Deleted value:(6,56)
Deleted value:(5,40)
Deleted value:(4,1)
Deleted value:(3,30)
Deleted value:(2,20)
Deleted value:(1,10)
List after deleting all items:
[  ]
Restored List:
[ (6,56) (5,40) (4,1) (3,30) (2,20) (1,10)  ]
Element found: (4,1)
List after deleting an item:
[ (6,56) (5,40) (3,30) (2,20) (1,10)  ]
Element not found.
List after sorting the data:
[ (1,10) (2,20) (3,30) (5,40) (6,56)  ]
List after reversing the data:
[ (6,56) (5,40) (3,30) (2,20) (1,10)  ]
[Program finished]
```

Q8. Write a program to insert a node in a linked list and delete a node from a linked list.

Code:

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

```
#include <string.h>
#include <stdlib.h>
#include <stdbool.h>

struct node {
  int data;
  int key;
  struct node *next;
};

struct node *head = NULL;
struct node *current = NULL;

void printList() {
  struct node *ptr = head;
  printf("\n[ ");

  while(ptr != NULL) {
    printf("(%d,%d) ",ptr->key,ptr->data);
    ptr = ptr->next;
  }

  printf(" ]");
}

void insertFirst(int key, int data)
{
  struct node *link = (struct node*) malloc(sizeof(struct node));

  link->key = key;
  link->data = data;

  link->next = head;

  head = link;
}

struct node* deleteFirst()
{
  struct node *tempLink = head;

  head = head->next;

  return tempLink;
}

bool isEmpty() {
  return head == NULL;
}

int length() {
  int length = 0;
  struct node *current;

  for(current = head; current != NULL; current = current->next) {
    length++;
  }

  return length;
}

struct node* find(int key) {

  struct node* current = head;
```

```
   if(head == NULL) {
      return NULL;
   }

   while(current->key != key) {

      if(current->next == NULL) {
         return NULL;
      } else {
         current = current->next;
      }
   }

   return current;
}

struct node* delete(int key) {

   struct node* current = head;
   struct node* previous = NULL;

   if(head == NULL) {
      return NULL;
   }

   while(current->key != key) {

      if(current->next == NULL) {
         return NULL;
      } else {
         previous = current;
         current = current->next;
      }
   }

   if(current == head) {
      head = head->next;
   } else {
      previous->next = current->next;
   }

   return current;
}

void sort() {

   int i, j, k, tempKey, tempData;
   struct node *current;
   struct node *next;

   int size = length();
   k = size ;

   for ( i = 0 ; i < size - 1 ; i++, k-- ) {
      current = head;
      next = head->next;

      for ( j = 1 ; j < k ; j++ ) {

         if ( current->data > next->data ) {
            tempData = current->data;
            current->data = next->data;
            next->data = tempData;
```

```
         tempKey = current->key;
         current->key = next->key;
         next->key = tempKey;
       }

       current = current->next;
       next = next->next;
     }
   }
}

void reverse(struct node** head_ref) {
   struct node* prev   = NULL;
   struct node* current = *head_ref;
   struct node* next;

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

   *head_ref = prev;
}

void main() {
   insertFirst(1,10);
   insertFirst(2,20);
   insertFirst(3,30);
   insertFirst(4,1);
   insertFirst(5,40);
   insertFirst(6,56);

   printf("Original List: ");

   printList();

   while(!isEmpty()) {
      struct node *temp = deleteFirst();
      printf("\nDeleted value:");
      printf("(%d,%d) ",temp->key,temp->data);
   }

   printf("\nList after deleting all items: ");
   printList();
   insertFirst(1,10);
   insertFirst(2,20);
   insertFirst(3,30);
   insertFirst(4,1);
   insertFirst(5,40);
   insertFirst(6,56);

   printf("\nRestored List: ");
   printList();
   printf("\n");

   struct node *foundLink = find(4);

   if(foundLink != NULL) {
      printf("Element found: ");
      printf("(%d,%d) ",foundLink->key,foundLink->data);
      printf("\n");
```

```
  } else {
    printf("Element not found.");
  }

  delete(4);
  printf("List after deleting an item: ");
  printList();
  printf("\n");
  foundLink = find(4);

  if(foundLink != NULL) {
    printf("Element found: ");
    printf("(%d,%d) ",foundLink->key,foundLink->data);
    printf("\n");
  } else {
    printf("Element not found.");
  }

  printf("\n");
  sort();

  printf("List after sorting the data: ");
  printList();

  reverse(&head);
  printf("\nList after reversing the data: ");
  printList();
}
```

Output:

```
Original List:
[ (6,56) (5,40) (4,1) (3,30) (2,20) (1,10)  ]
Deleted value:(6,56)
Deleted value:(5,40)
Deleted value:(4,1)
Deleted value:(3,30)
Deleted value:(2,20)
Deleted value:(1,10)
List after deleting all items:
[  ]
Restored List:
[ (6,56) (5,40) (4,1) (3,30) (2,20) (1,10)  ]
Element found: (4,1)
List after deleting an item:
[ (6,56) (5,40) (3,30) (2,20) (1,10)  ]
Element not found.
List after sorting the data:
[ (1,10) (2,20) (3,30) (5,40) (6,56)  ]
List after reversing the data:
[ (6,56) (5,40) (3,30) (2,20) (1,10)  ]
[Program finished]
```

Q9. Write a program to print the elements of a linked list in reverse order without disturbing the linked list.

Code:

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

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

void printReverse(struct Node* head)
{
   if (head == NULL)
      return;

   printReverse(head->next);

   printf("%d  ", head->data);
}

void push(struct Node** head_ref, char new_data)
{
   struct Node* new_node =
         (struct Node*) malloc(sizeof(struct Node));

   new_node->data  = new_data;

   new_node->next = (*head_ref);

   (*head_ref)    = new_node;
}

int main()
{
   struct Node* head = NULL;
   push(&head, 4);
   push(&head, 3);
   push(&head, 2);
   push(&head, 1);
   printReverse(head);
   return 0;
}
```

Output:

```
4  3  2  1
[Program finished]
```

Q10. Write a program to reverse a linked list.

Code:

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

struct Node
{
```

```
    int data;
    struct Node* next;
};

static void reverse(struct Node** head_ref)
{
    struct Node* prev   = NULL;
    struct Node* current = *head_ref;
    struct Node* next;
    while (current != NULL)
    {
        next  = current->next;
        current->next = prev;
        prev = current;
        current = next;
    }
    *head_ref = prev;
}

void push(struct Node** head_ref, int new_data)
{
    struct Node* new_node =
            (struct Node*) malloc(sizeof(struct Node));

    new_node->data  = new_data;

    new_node->next = (*head_ref);

    (*head_ref)    = new_node;
}

void printList(struct Node *head)
{
    struct Node *temp = head;
    while(temp != NULL)
    {
        printf("%d  ", temp->data);
        temp = temp->next;
    }
}

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

     push(&head, 20);
     push(&head, 4);
     push(&head, 15);
     push(&head, 85);

     printf("Given linked list\n");
     printList(head);
     reverse(&head);
     printf("\nReversed Linked list \n");
     printList(head);
     getchar();
}
```

```
Given linked list
85  15  4  20
Reversed Linked list
20  4  15  85
```

Output:

Q11. Write a program to add two polynomials using linked lists.
Code:

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

typedef struct link {
   int coeff;
   int pow;
   struct link * next;
} my_poly;

void my_create_poly(my_poly **);
void my_show_poly(my_poly *);
void my_add_poly(my_poly **, my_poly *, my_poly *);

int main(void) {
   int ch;
   do {
      my_poly * poly1, * poly2, * poly3;

      printf("\nCreate 1st expression\n");
      my_create_poly(&poly1);
      printf("\nStored the 1st expression");
      my_show_poly(poly1);

      printf("\nCreate 2nd expression\n");
      my_create_poly(&poly2);
      printf("\nStored the 2nd expression");
      my_show_poly(poly2);

      my_add_poly(&poly3, poly1, poly2);
      my_show_poly(poly3);

      printf("\nAdd two more expressions? (Y = 1/N = 0): ");
      scanf("%d", &ch);
   } while (ch);
   return 0;
}

void my_create_poly(my_poly ** node) {
   int flag;
   int coeff, pow;
   my_poly * tmp_node;
   tmp_node = (my_poly *) malloc(sizeof(my_poly));
   *node = tmp_node;
   do {
      printf("\nEnter Coeff:");
      scanf("%d", &coeff);
      tmp_node->coeff = coeff;
      printf("\nEnter Pow:");
      scanf("%d", &pow);
      tmp_node->pow = pow;

      tmp_node->next = NULL;

      printf("\nContinue adding more terms to the polynomial list?(Y = 1/N = 0): ");
      scanf("%d", &flag);
      printf("\nFLAG: %c\n", flag);
      if(flag) {
         tmp_node->next = (my_poly *) malloc(sizeof(my_poly));
         tmp_node = tmp_node->next;
         tmp_node->next = NULL;
      }
   } while (flag);
```

```
}

void my_show_poly(my_poly * node) {
   printf("\nThe polynomial expression is:\n");
   while(node != NULL) {
      printf("%dx^%d", node->coeff, node->pow);
      node = node->next;
      if(node != NULL)
         printf(" + ");
   }
}

void my_add_poly(my_poly ** result, my_poly * poly1, my_poly * poly2) {
   my_poly * tmp_node;
   tmp_node = (my_poly *) malloc(sizeof(my_poly));
   tmp_node->next = NULL;
   *result = tmp_node;

   while(poly1 && poly2) {
      if (poly1->pow > poly2->pow) {
         tmp_node->pow = poly1->pow;
         tmp_node->coeff = poly1->coeff;
         poly1 = poly1->next;
      }
      else if (poly1->pow < poly2->pow) {
         tmp_node->pow = poly2->pow;
         tmp_node->coeff = poly2->coeff;
         poly2 = poly2->next;
      }
      else {
         tmp_node->pow = poly1->pow;
         tmp_node->coeff = poly1->coeff + poly2->coeff;
         poly1 = poly1->next;
         poly2 = poly2->next;
      }

      if(poly1 && poly2) {
         tmp_node->next = (my_poly *) malloc(sizeof(my_poly));
         tmp_node = tmp_node->next;
         tmp_node->next = NULL;
      }
   }

   while(poly1 || poly2)
      {
      tmp_node->next = (my_poly *) malloc(sizeof(my_poly));
      tmp_node = tmp_node->next;
      tmp_node->next = NULL;

      if(poly1) {
         tmp_node->pow = poly1->pow;
         tmp_node->coeff = poly1->coeff;
         poly1 = poly1->next;
      }
      if(poly2) {
         tmp_node->pow = poly2->pow;
         tmp_node->coeff = poly2->coeff;
         poly2 = poly2->next;
      }
   }

   printf("\nAddition Complete");
}
```

Output:

```
Create 1st expression

Enter Coeff:2

Enter Pow:2

Continue adding more terms to the polynomial list?(Y = 1/N = 0)
: 1

FLAG:

Enter Coeff:1

Enter Pow:1

Continue adding more terms to the polynomial list?(Y = 1/N = 0)
: 1

FLAG:

Enter Coeff:1

Enter Pow:0

Continue adding more terms to the polynomial list?(Y = 1/N = 0)
: 0

FLAG:

Stored the 1st expression
The polynomial expression is:
2x^2 + 1x^1 + 1x^0
Create 2nd expression

Enter Coeff:2

Enter Pow:2

Continue adding more terms to the polynomial list?(Y = 1/N = 0)
: 1


Continue adding more terms to the polynomial list?(Y = 1/N = 0)
: 0

FLAG:

Stored the 2nd expression
The polynomial expression is:
2x^2 + 1x^1 + 1x^0
Addition Complete
The polynomial expression is:
4x^2 + 2x^1 + 2x^0
Add two more expressions? (Y = 1/N = 0): 0

[Program finished]
```

Q12. Write a program to implement a doubly-linked list.

Code:

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

struct node {
  int data;
  int key;

  struct node *next;
  struct node *prev;
};

struct node *head = NULL;

struct node *last = NULL;

struct node *current = NULL;

bool isEmpty() {
  return head == NULL;
}

int length() {
  int length = 0;
  struct node *current;

  for(current = head; current != NULL; current = current->next){
    length++;
  }

  return length;
}
```

```
void displayForward() {

  struct node *ptr = head;

  printf("\n[ ");

  while(ptr != NULL) {
    printf("(%d,%d) ",ptr->key,ptr->data);
    ptr = ptr->next;
  }

  printf(" ]");
}

void displayBackward() {

  struct node *ptr = last;

  printf("\n[ ");

  while(ptr != NULL) {

    printf("(%d,%d) ",ptr->key,ptr->data);

    ptr = ptr ->prev;

  }

}

void insertFirst(int key, int data) {

  struct node *link = (struct node*) malloc(sizeof(struct node));
  link->key = key;
```

```
   link->data = data;

   if(isEmpty()) {
      last = link;
   } else {
      head->prev = link;
   }

   link->next = head;

   head = link;
}

void insertLast(int key, int data) {

   struct node *link = (struct node*) malloc(sizeof(struct node));
   link->key = key;
   link->data = data;

   if(isEmpty()) {
      last = link;
   } else {
      last->next = link;

      link->prev = last;
   }

   last = link;
}

struct node* deleteFirst() {

   struct node *tempLink = head;

   if(head->next == NULL){
```

```
    last = NULL;
  } else {
    head->next->prev = NULL;
  }

  head = head->next;
  return tempLink;
}


struct node* deleteLast() {
  struct node *tempLink = last;

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

  last = last->prev;

  return tempLink;
}


struct node* delete(int key) {

  struct node* current = head;
  struct node* previous = NULL;

  if(head == NULL) {
    return NULL;
  }

  while(current->key != key) {
```

```
      if(current->next == NULL) {
        return NULL;
      } else {
        previous = current;

        current = current->next;
      }
    }

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

    if(current == last) {
      last = current->prev;
    } else {
      current->next->prev = current->prev;
    }

    return current;
}

bool insertAfter(int key, int newKey, int data) {
    struct node *current = head;

    if(head == NULL) {
      return false;
    }

    while(current->key != key) {

      if(current->next == NULL) {
```

```
      return false;
    } else {
      current = current->next;
    }
  }

  struct node *newLink = (struct node*) malloc(sizeof(struct node));
  newLink->key = newKey;
  newLink->data = data;

  if(current == last) {
    newLink->next = NULL;
    last = newLink;
  } else {
    newLink->next = current->next;
    current->next->prev = newLink;
  }

  newLink->prev = current;
  current->next = newLink;
  return true;
}

void main() {
  insertFirst(1,10);
  insertFirst(2,20);
  insertFirst(3,30);
  insertFirst(4,1);
  insertFirst(5,40);
  insertFirst(6,56);

  printf("\nList (First to Last): ");
  displayForward();

  printf("\n");
```

```
  printf("\nList (Last to first): ");
  displayBackward();

  printf("\nList , after deleting first record: ");
  deleteFirst();
  displayForward();

  printf("\nList , after deleting last record: ");
  deleteLast();
  displayForward();

  printf("\nList , insert after key(4) : ");
  insertAfter(4,7, 13);
  displayForward();

  printf("\nList  , after delete key(4) : ");
  delete(4);
  displayForward();
}
```

Output:

```
List (First to Last):
[ (6,56) (5,40) (4,1) (3,30) (2,20) (1,10)  ]

List (Last to first):
[ (1,10) (2,20) (3,30) (4,1) (5,40) (6,56)
List , after deleting first record:
[ (5,40) (4,1) (3,30) (2,20) (1,10)  ]
List , after deleting last record:
[ (5,40) (4,1) (3,30) (2,20)  ]
List , insert after key(4) :
[ (5,40) (4,1) (7,13) (3,30) (2,20)  ]
List  , after delete key(4) :
[ (5,40) (7,13) (3,30) (2,20)  ]
[Program finished]
```

Q13. Write a program to implement a stack using an array.

Code:

```
#include <stdio.h>
#define SIZE 3
```

```
int arr[SIZE], top = -1;

void peek() {
   top == -1 ? printf("Stack is empty!\n") : printf("%d\n", arr[top]);
}

void push(int val) {
   if (top == SIZE - 1) {
      printf("Overflow!\n");
   } else {
      arr[++top] = val;
      printf("Successfully pushed %d!\n", val);
   }
}

int pop() {
   if (top == -1) {
      printf("Underflow!\n");
   } else {
      int temp = arr[top--];
      return temp;
   }
}

int main() {
  peek();

  push(3);
  push(4);
  push(5);
  push(6);

  peek();
```

```
  printf("Popped %d", pop());
  printf("\nPopped %d", pop());
  printf("\nPopped %d\n", pop());
  pop();
}
```

Output:

```
Stack is empty!
Successfully pushed 3!
Successfully pushed 4!
Successfully pushed 5!
Overflow!
5
Popped 5
Popped 4
Popped 3
Underflow!

[Program finished]
```

Q14. Write a program to implement a stack using a linked list.

Code:

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

struct node
{
   int info;
   struct node *ptr;
}*top,*top1,*temp;

int topelement();
void push(int data);
void pop();
void empty();
void display();
void destroy();
void stack_count();
void create();
```

```
int count = 0;

void main()
{
   int no, ch, e;

   printf("\n 1 - Push");
   printf("\n 2 - Pop");
   printf("\n 3 - Top");
   printf("\n 4 - Empty");
   printf("\n 5 - Exit");
   printf("\n 6 - Dipslay");
   printf("\n 7 - Stack Count");
   printf("\n 8 - Destroy stack");

   create();

   while (1)
   {
      printf("\n Enter choice : ");
      scanf("%d", &ch);

      switch (ch)
      {
      case 1:
         printf("Enter data : ");
         scanf("%d", &no);
         push(no);
         break;
      case 2:
         pop();
         break;
      case 3:
         if (top == NULL)
```

```
            printf("No elements in stack");
        else
        {
            e = topelement();
            printf("\n Top element : %d", e);
        }
        break;
    case 4:
        empty();
        break;
    case 5:
        exit(0);
    case 6:
        display();
        break;
    case 7:
        stack_count();
        break;
    case 8:
        destroy();
        break;
    default :
        printf(" Wrong choice, Please enter correct choice  ");
        break;
    }
  }
}

void create()
{
  top = NULL;
}

void stack_count()
{
```

```
    printf("\n No. of elements in stack : %d", count);
}

void push(int data)
{
    if (top == NULL)
    {
        top =(struct node *)malloc(1*sizeof(struct node));
        top->ptr = NULL;
        top->info = data;
    }
    else
    {
        temp =(struct node *)malloc(1*sizeof(struct node));
        temp->ptr = top;
        temp->info = data;
        top = temp;
    }
    count++;
}

void display()
{
    top1 = top;

    if (top1 == NULL)
    {
        printf("Stack is empty");
        return;
    }

    while (top1 != NULL)
    {
        printf("%d ", top1->info);
        top1 = top1->ptr;
```

```
    }
  }

void pop()
{
    top1 = top;

    if (top1 == NULL)
    {
        printf("\n Error : Trying to pop from empty stack");
        return;
    }
    else
        top1 = top1->ptr;
    printf("\n Popped value : %d", top->info);
    free(top);
    top = top1;
    count--;
}

int topelement()
{
    return(top->info);
}

void empty()
{
    if (top == NULL)
        printf("\n Stack is empty");
    else
        printf("\n Stack is not empty with %d elements", count);
}

void destroy()
{
```

```
    top1 = top;

    while (top1 != NULL)
    {
        top1 = top->ptr;
        free(top);
        top = top1;
        top1 = top1->ptr;
    }
    free(top1);
    top = NULL;

    printf("\n All stack elements destroyed");
    count = 0;
}
```

Output:

```
 1 - Push
 2 - Pop
 3 - Top
 4 - Empty
 5 - Exit
 6 - Dipslay
 7 - Stack Count
 8 - Destroy stack
 Enter choice : 8

 All stack elements destroyed
 Enter choice : 7

 No. of elements in stack : 0
 Enter choice : 6
Stack is empty
 Enter choice : 4

 Stack is empty
 Enter choice : 3
No elements in stack
 Enter choice : 2

 Error : Trying to pop from empty stack
 Enter choice : 1
Enter data : 1

 Enter choice : 6
1
 Enter choice : 5

[Program finished]
```

Q15. Write a program to implement a queue using an array.

Code:

```
#include <stdio.h>
#define MAX 10

int queue[MAX];
int f = -1, r = -1, size = -1;

void enqueue(int val) {
   if(size < MAX) {
      if (size < 0) {
         queue[0] = val;
         f++; r++;
         size = 1;
      } else if (r == MAX-1) {
         queue[0] = val;
         r = 0;
         size++;
      } else {
         queue[++r] = val;
         size++;
      }
   } else {
      printf("Queue is full\n");
   }
}

int dequeue() {
   if (size < 0) {
      printf("Queue is empty\n");
   } else {
      size--;
      f++;
   }
}
```

```
void display()
{
   int i;
   if( r >= f ) {
      for (i = f; i <= r; i++) {
         printf("%d ",queue[i]);
      }
   } else {
      for (i = f; i < MAX; i++) {
         printf("%d ",queue[i]);
      }
      for (i = 0; i <= r; i++) {
         printf("%d ",queue[i]);
      }
   }
}

int main()
{
   enqueue(24);
   enqueue(9);
   enqueue(22);
   enqueue(93);
   display();
   dequeue();
   printf("\nAfter dequeue\n");
   display();
   enqueue(8);
   enqueue(63);
   enqueue(57);
   enqueue(900);
   dequeue();
   enqueue(84);
   enqueue(73);
```

```
    printf("\nAfter enqueue\n");
    display();
    return 0;
}
```

Output:

Q16. Write a program to implement a queue using a linked list.

Code:

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

struct node
{
    int info;
    struct node *ptr;
}*front,*rear,*temp,*front1;

int frontelement();
void enq(int data);
void deq();
void empty();
void display();
void create();
void queuesize();

int count = 0;

void main()
{
```

```
int no, ch, e;

printf("\n 1 - Enque");
printf("\n 2 - Deque");
printf("\n 3 - Front element");
printf("\n 4 - Empty");
printf("\n 5 - Exit");
printf("\n 6 - Display");
printf("\n 7 - Queue size");
create();
while (1)
{
   printf("\n Enter choice : ");
   scanf("%d", &ch);
   switch (ch)
   {
   case 1:
      printf("Enter data : ");
      scanf("%d", &no);
      enq(no);
      break;
   case 2:
      deq();
      break;
   case 3:
      e = frontelement();
      if (e != 0)
         printf("Front element : %d", e);
      else
         printf("\n No front element in Queue as queue is empty");
      break;
   case 4:
      empty();
      break;
   case 5:
```

```
            exit(0);
        case 6:
            display();
            break;
        case 7:
            queuesize();
            break;
        default:
            printf("Wrong choice, Please enter correct choice  ");
            break;
        }
    }
}

void create()
{
    front = rear = NULL;
}

void queuesize()
{
    printf("\n Queue size : %d", count);
}

void enq(int data)
{
    if (rear == NULL)
    {
        rear = (struct node *)malloc(1*sizeof(struct node));
        rear->ptr = NULL;
        rear->info = data;
        front = rear;
    }
    else
    {
```

```
        temp=(struct node *)malloc(1*sizeof(struct node));
        rear->ptr = temp;
        temp->info = data;
        temp->ptr = NULL;

        rear = temp;
    }
    count++;
}

void display()
{
    front1 = front;

    if ((front1 == NULL) && (rear == NULL))
    {
        printf("Queue is empty");
        return;
    }
    while (front1 != rear)
    {
        printf("%d ", front1->info);
        front1 = front1->ptr;
    }
    if (front1 == rear)
        printf("%d", front1->info);
}

void deq()
{
    front1 = front;

    if (front1 == NULL)
    {
        printf("\n Error: Trying to display elements from empty queue");
```

```
        return;
    }
    else
        if (front1->ptr != NULL)
        {
            front1 = front1->ptr;
            printf("\n Dequed value : %d", front->info);
            free(front);
            front = front1;
        }
        else
        {
            printf("\n Dequed value : %d", front->info);
            free(front);
            front = NULL;
            rear = NULL;
        }
        count--;
}

int frontelement()
{
    if ((front != NULL) && (rear != NULL))
        return(front->info);
    else
        return 0;
}

void empty()
{
     if ((front == NULL) && (rear == NULL))
        printf("\n Queue empty");
    else
       printf("Queue not empty");
}
```

Output:

```
 1 - Enque
 2 - Deque
 3 - Front element
 4 - Empty
 5 - Exit
 6 - Display
 7 - Queue size
 Enter choice : 7

 Queue size : 0
 Enter choice : 6
Queue is empty
 Enter choice : 4

 Queue empty
 Enter choice : 3

 No front element in Queue as queue is empty
 Enter choice : 2

 Error: Trying to display elements from empty queue
 Enter choice : 1
Enter data : 1

 Enter choice : 6
1
 Enter choice : 5

[Program finished]
```

Q17. Write a program to implement a circular queue using an array.

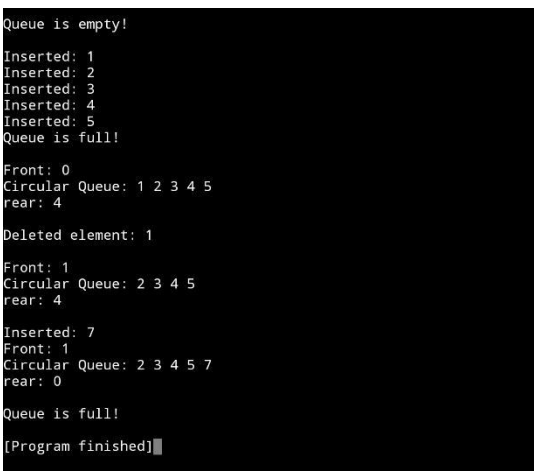
Code:

```
#include <stdio.h>

#define SIZE 5


int cirqueue[SIZE], f = -1, r = -1;


int isFull() {
   if ((f == r + 1) || (f == 0 && r == SIZE - 1)) { return 1; }
   return 0;
}


int isEmpty() {
   if (f == -1) { return 1; }
   return 0;
```

```
}

void enqueue(int val) {
   if (isFull()) { printf("\nQueue is full!\n"); }
   else {
      if (f == -1) { f = 0; }
      r = (r + 1) % SIZE;
      cirqueue[r] = val;
      printf("\nInserted: %d", val);
   }
}

int dequeue() {
   int val;
   if (isEmpty()) {
      printf("\nQueue is empty!\n");
   } else {
      val = cirqueue[f];
      if (f == r) { f = r = -1;}
      else {
      f = (f + 1) % SIZE;
      } printf("\nDeleted element: %d \n", val);
      return val;
   }
}

void display() {
   int i;
   if (isEmpty())
      printf("\nEmpty Queue\n");
   else {
      printf("\nFront: %d ", f);
      printf("\nCircular Queue: ");
      for (i = f; i != r; i = (i + 1) % SIZE) {
         printf("%d ", cirqueue[i]);
```

```
        }
        printf("%d ", cirqueue[i]);
        printf("\nrear: %d \n", r);
    }
}

int main() {
    dequeue();

    enqueue(1);
    enqueue(2);
    enqueue(3);
    enqueue(4);
    enqueue(5);

    enqueue(6);

    display();
    dequeue();

    display();

    enqueue(7);
    display();

    enqueue(8);

    return 0;
}
```

Output:



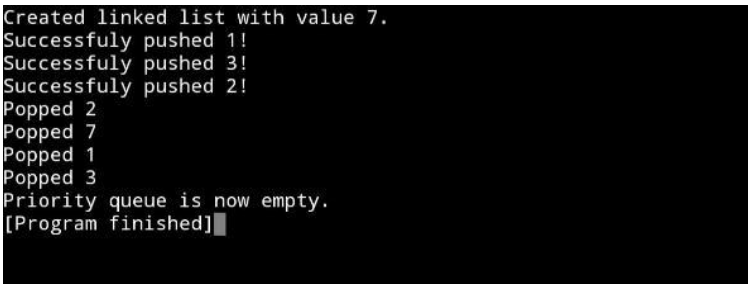
Q18. Write a program to implement a priority queue using a linked list.

Code:

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

typedef struct node {
   int val;
   int priority;
   struct node* next;
} Node;
Node* initNode(int v, int p) {
   Node* temp = (Node*) malloc( sizeof(Node) );
   temp -> val = v;
   temp -> priority = p;
   temp -> next = NULL;
   return temp;
}

int peek(Node** head) {
   return (*head) -> val;
}
void pop(Node** head) {
  Node* temp = *head;
  (*head) = (*head) -> next;
  free(temp);
}
void push(Node** head, int v, int p) {
   Node* first = (*head);
   Node* temp = initNode(v, p);
   if ((*head) -> priority > p) {
      temp -> next = *head;
      (*head) = temp;
   } else {
      while (first -> next != NULL && first -> next -> priority < p) {
         first = first -> next;
```

```
        }
        temp -> next = first -> next;
        first -> next = temp;
    } printf("Successfuly pushed %d!\n", v);
}
int isEmpty(Node** head) {
    return (*head) == NULL;
}
int main() {
    Node* pq = initNode(7, 1);
    printf("Created linked list with value 7.\n");
    push(&pq, 1, 2);
    push(&pq, 3, 3);
    push(&pq, 2, 0);
    while (!isEmpty(&pq)) {
        printf("Popped %d\n", peek(&pq));
        pop(&pq);
    }
    printf("Priority queue is now empty.");
    return 0;
}
```

Output:



Q19. Write a program to implement a double-ended queue using a linked list.

Code:

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

typedef struct node {
    int data;
```

```
    struct node *prev, *next;
} Node;

Node *head = NULL, *end = NULL;

Node* initNode(int data) {
    Node *new = (Node *) malloc(sizeof (Node));
    new -> data = data;
    new -> next = new -> prev = NULL;
    return new;
}

void makeEnds() {
    head = initNode(0);
    end = initNode(0);
    head -> next = end;
    end -> prev = head;
}

void enqueueFront(int data) {
    Node *new, *temp;
    new = initNode(data);
    temp = head -> next;
    head -> next = new;
    new -> prev = head;
    new -> next = temp;
    temp -> prev = new;
}

void enqueueRear(int data) {
    Node *new, *temp;
    new = initNode(data);
    temp = end -> prev;
    end -> prev = new;
    new -> next = end;
```

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

void dequeueFront() {
    Node *temp;
    if (head -> next == end) {
        printf("Queue is empty\n");
    } else {
        temp = head -> next;
        head -> next = temp -> next;
        temp -> next -> prev = head;
        free(temp);
    } return;
}

void dequeueRear()  {
    Node *temp;
    if (end -> prev == head) {
        printf("Queue is empty\n");
    } else {
        temp = end -> prev;
        end -> prev = temp -> prev;
        temp -> prev -> next = end;
        free(temp);
    } return;
}

void display() {
    Node *temp;

    if (head -> next == end) {
        printf("Queue is empty\n");
        return;
    }
```

```
    temp = head -> next;
    while (temp != end) {
        printf("%-3d", temp -> data);
        temp = temp -> next;
    }
    printf("\n");
}

int main() {
    makeEnds();

    enqueueFront(23);
    enqueueRear(29);
    enqueueRear(30);
    enqueueFront(40);
    display();

    dequeueFront();
    dequeueRear();
    display();

    dequeueFront();
    dequeueRear();
    display();
    return 0;
}
```

Output:

Q20. Write a program to construct a binary tree and display its preorder, inorder and postorder traversals.

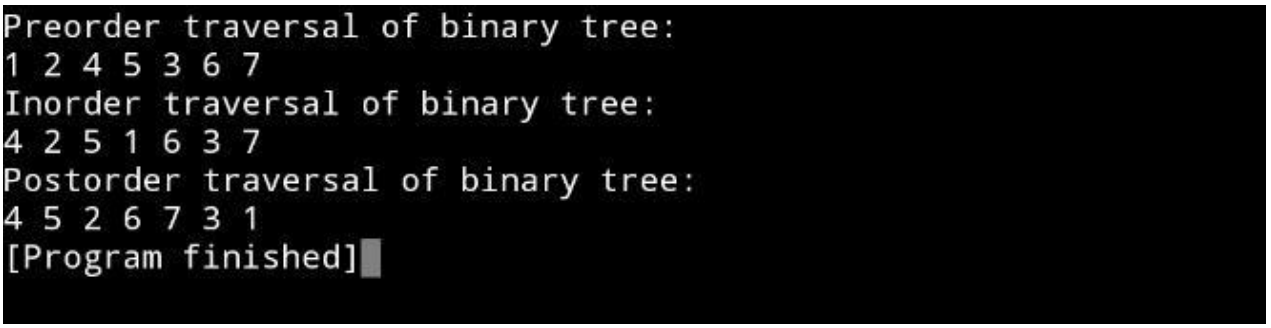
Code:

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

typedef struct node {
   int data;
   struct node* left;
   struct node* right;
} Node;

Node* newNode(int data) {
   Node* node = (Node*) malloc(sizeof(Node));
   node -> data = data;
   node -> left = NULL;
   node -> right = NULL;
   return node;
}

void Postorder(Node* node) {
   if (node == NULL) { return; }

   Postorder(node -> left);

   Postorder(node -> right);

   printf("%d ", node -> data);
}

void Inorder(Node* node)
{
   if (node == NULL) { return; }

   Inorder(node -> left);
```

```
    printf("%d ", node -> data);

    Inorder(node -> right);
}

void Preorder(Node* node)
{
    if (node == NULL) { return; }

    printf("%d ", node -> data);

    Preorder(node -> left);

    Preorder(node -> right);
}

int main()
{
    Node* base = newNode(1);
    base -> left = newNode(2);
    base -> right = newNode(3);
    base -> left -> left = newNode(4);
    base -> left -> right = newNode(5);
    base -> right -> left = newNode(6);
    base -> right -> right = newNode(7);

    printf("\nPreorder traversal of binary tree:\n");
    Preorder(base);

    printf("\nInorder traversal of binary tree:\n");
    Inorder(base);

    printf("\nPostorder traversal of binary tree:\n");
    Postorder(base);
    return 0;
```

}

Output:



Q21. Write a program to construct a binary search tree.

Code:

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

struct btnode
{
   int value;
   struct btnode *l;
   struct btnode *r;
}*root = NULL, *temp = NULL, *t2, *t1;

void delete1();
void insert();
void delete();
void inorder(struct btnode *t);
void create();
void search(struct btnode *t);
void preorder(struct btnode *t);
void postorder(struct btnode *t);
void search1(struct btnode *t,int data);
int smallest(struct btnode *t);
int largest(struct btnode *t);

int flag = 1;

void main()
{
   int ch;

   printf("\nOPERATIONS ---");
   printf("\n1 - Insert an element into tree\n");
   printf("2 - Delete an element from the tree\n");
   printf("3 - Inorder Traversal\n");
   printf("4 - Preorder Traversal\n");
   printf("5 - Postorder Traversal\n");
   printf("6 - Exit\n");
   while(1)
   {
      printf("\nEnter your choice : ");
      scanf("%d", &ch);
      switch (ch)
      {
      case 1:
         insert();
         break;
```

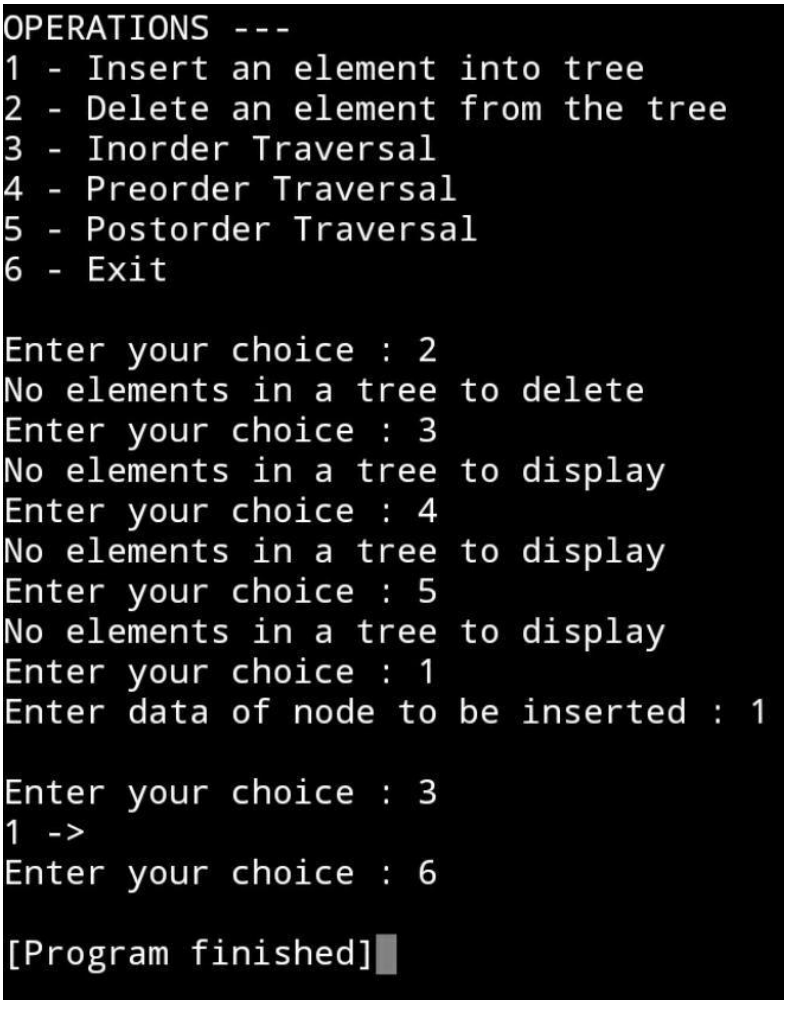
```
        case 2:
           delete();
           break;
        case 3:
           inorder(root);
           break;
        case 4:
           preorder(root);
           break;
        case 5:
           postorder(root);
           break;
        case 6:
           exit(0);
        default :
           printf("Wrong choice, Please enter correct choice  ");
           break;
        }
     }
}

void insert()
{
   create();
   if (root == NULL)
      root = temp;
   else
      search(root);
}

void create()
{
   int data;

   printf("Enter data of node to be inserted : ");
   scanf("%d", &data);
   temp = (struct btnode *)malloc(1*sizeof(struct btnode));
   temp->value = data;
   temp->l = temp->r = NULL;
}

void search(struct btnode *t)
{
   if ((temp->value > t->value) && (t->r != NULL))
      search(t->r);
   else if ((temp->value > t->value) && (t->r == NULL))
      t->r = temp;
   else if ((temp->value < t->value) && (t->l != NULL))
      search(t->l);
   else if ((temp->value < t->value) && (t->l == NULL))
      t->l = temp;
}

void inorder(struct btnode *t)
{
   if (root == NULL)
   {
      printf("No elements in a tree to display");
      return;
   }
   if (t->l != NULL)
      inorder(t->l);
   printf("%d -> ", t->value);
   if (t->r != NULL)
```

```
        inorder(t->r);
}

void delete()
{
   int data;

   if (root == NULL)
   {
      printf("No elements in a tree to delete");
      return;
   }
   printf("Enter the data to be deleted : ");
   scanf("%d", &data);
   t1 = root;
   t2 = root;
   search1(root, data);
}

void preorder(struct btnode *t)
{
   if (root == NULL)
   {
      printf("No elements in a tree to display");
      return;
   }
   printf("%d -> ", t->value);
   if (t->l != NULL)
      preorder(t->l);
   if (t->r != NULL)
      preorder(t->r);
}

void postorder(struct btnode *t)
{
   if (root == NULL)
   {
      printf("No elements in a tree to display ");
      return;
   }
   if (t->l != NULL)
      postorder(t->l);
   if (t->r != NULL)
      postorder(t->r);
   printf("%d -> ", t->value);
}

void search1(struct btnode *t, int data)
{
   if ((data>t->value))
   {
      t1 = t;
      search1(t->r, data);
   }
   else if ((data < t->value))
   {
      t1 = t;
      search1(t->l, data);
   }
   else if ((data==t->value))
   {
      delete1(t);
   }
}
```

```
void delete1(struct btnode *t)
{
   int k;

   if ((t->l == NULL) && (t->r == NULL))
   {
      if (t1->l == t)
      {
         t1->l = NULL;
      }
      else
      {
         t1->r = NULL;
      }
      t = NULL;
      free(t);
      return;
   }

   else if ((t->r == NULL))
   {
      if (t1 == t)
      {
         root = t->l;
         t1 = root;
      }
      else if (t1->l == t)
      {
         t1->l = t->l;

      }
      else
      {
         t1->r = t->l;
      }
      t = NULL;
      free(t);
      return;
   }

   else if (t->l == NULL)
   {
      if (t1 == t)
      {
         root = t->r;
         t1 = root;
      }
      else if (t1->r == t)
         t1->r = t->r;
      else
         t1->l = t->r;
      t == NULL;
      free(t);
      return;
   }

   else if ((t->l != NULL) && (t->r != NULL))
   {
      t2 = root;
      if (t->r != NULL)
      {
         k = smallest(t->r);
         flag = 1;
```

```
        }
        else
        {
           k =largest(t->l);
           flag = 2;
        }
        search1(root, k);
        t->value = k;
     }

  }

  int smallest(struct btnode *t)
  {
     t2 = t;
     if (t->l != NULL)
     {
        t2 = t;
        return(smallest(t->l));
     }
     else
        return (t->value);
  }

  int largest(struct btnode *t)
  {
     if (t->r != NULL)
     {
        t2 = t;
        return(largest(t->r));
     }
     else
        return(t->value);
  }
```

Output:

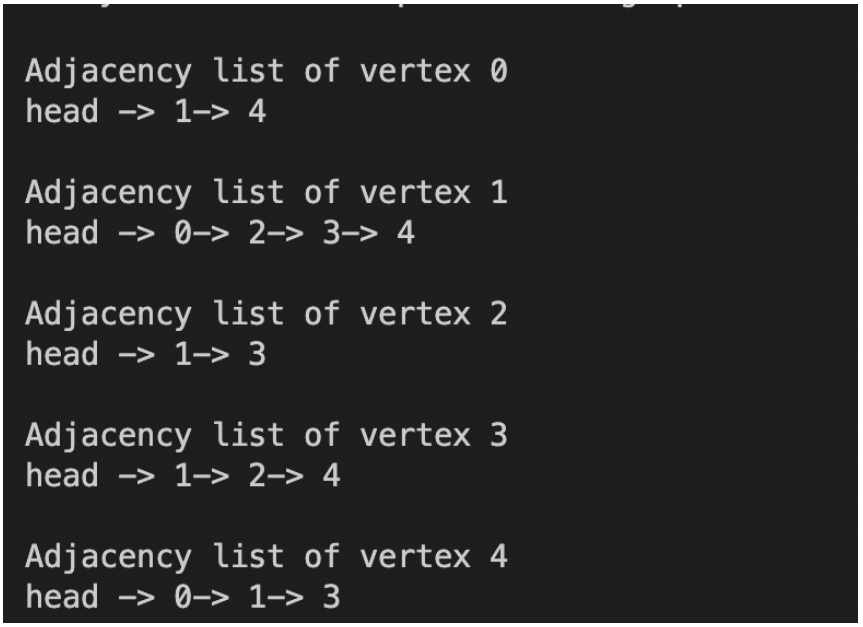


22. Write a program to construct a tree.

```
#include <bits/stdc++.h>
using namespace std;

// A utility function to add an edge in an
// undirected graph.
void addEdge(vector<int> adj[], int u, int v)
{
  adj[u].push_back(v);
  adj[v].push_back(u);
}

// A utility function to print the adjacency list
// representation of graph
void printGraph(vector<int> adj[], int V)
{
  for (int v = 0; v < V; ++v)
  {
     cout << "\n Adjacency list of vertex " << v
          << "\n head ";
     for (auto x : adj[v])
        cout << "-> " << x;
     printf("\n");
  }
}

// Driver code
int main()
{
  int V = 5;
  vector<int> adj[V];
  addEdge(adj, 0, 1);
  addEdge(adj, 0, 4);
  addEdge(adj, 1, 2);
  addEdge(adj, 1, 3);
```

```
  addEdge(adj, 1, 4);
  addEdge(adj, 2, 3);
  addEdge(adj, 3, 4);
  printGraph(adj, V);
  return 0;
}
```

Output :



23. Write a program to calculate the distance between two vertices in a graph

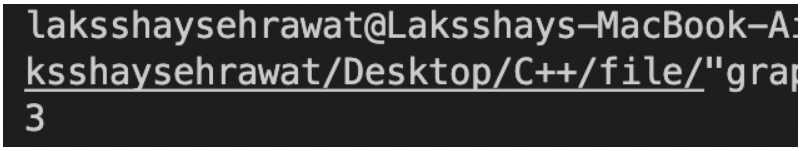
code:

```
#include <bits/stdc++.h>
using namespace std;
int minEdgeBFS(vector<int> edges[], int u,
           int v, int n)
{
  vector<bool> visited(n, 0);
  vector<int> distance(n, 0);
  queue<int> Q;
  distance[u] = 0;
  Q.push(u);
  visited[u] = true;
  while (!Q.empty())
```

```
  {
    int x = Q.front();
    Q.pop();
    for (int i = 0; i < edges[x].size(); i++)
    {
      if (visited[edges[x][i]])
        continue;
      distance[edges[x][i]] = distance[x] + 1;
      Q.push(edges[x][i]);
      visited[edges[x][i]] = 1;
    }
  }
  return distance[v];
}
void addEdge(vector<int> edges[], int u, int v)
{
  edges[u].push_back(v);
  edges[v].push_back(u);
}
int main()
{
  int n = 9;
  vector<int> edges[9];
  addEdge(edges, 0, 1);
  addEdge(edges, 0, 7);
  addEdge(edges, 1, 7);
  addEdge(edges, 1, 2);
  addEdge(edges, 2, 3);
  addEdge(edges, 2, 5);
  addEdge(edges, 2, 8);
  addEdge(edges, 3, 4);
  addEdge(edges, 3, 5);
  addEdge(edges, 4, 5);
  addEdge(edges, 5, 6);
  addEdge(edges, 6, 7);
```

```
  addEdge(edges, 7, 8);
  int u = 0;
  int v = 5;
  cout << minEdgeBFS(edges, u, v, n) << endl;
  return 0;
}
```

Output :



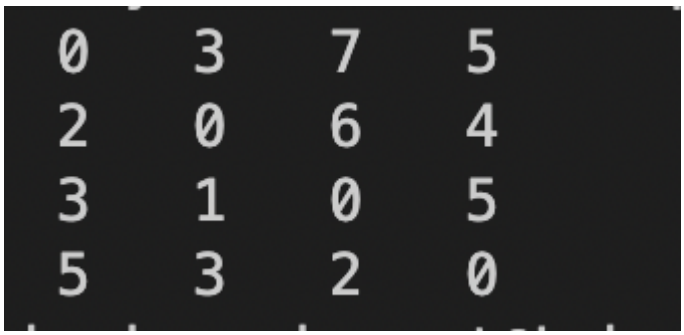
24. Write a program to calculate the distances between every pairs of vertices in a graph

code :

```
#include <stdio.h>
#define nV 4
#define INF 999
void printMatrix(int matrix[][nV]);
void floydWarshall(int graph[][nV])
{
  int matrix[nV][nV], i, j, k;
  for (i = 0; i < nV; i++)
    for (j = 0; j < nV; j++)
      matrix[i][j] = graph[i][j];
  for (k = 0; k < nV; k++)
  {
    for (i = 0; i < nV; i++)
    {
      for (j = 0; j < nV; j++)
      {
        if (matrix[i][k] + matrix[k][j] < matrix[i][j])
          matrix[i][j] = matrix[i][k] + matrix[k][j];
      }
    }
  }
  printMatrix(matrix);
```

```
}
void printMatrix(int matrix[][nV])
{
  for (int i = 0; i < nV; i++)
  {
    for (int j = 0; j < nV; j++)
    {
      if (matrix[i][j] == INF)
        printf("%4s", "INF");
      else
        printf("%4d", matrix[i][j]);
    }
    printf("\n");
  }
}
int main()
{
  int graph[nV][nV] = {{0, 3, INF, 5},
                       {2, 0, INF, 4},
                       {INF, 1, 0, INF},
                       {INF, INF, 2, 0}};
  floydWarshall(graph);
}
```

Output :



25.Write a program to construct a minimal spanning tree of a graph

Code :

```
#include <bits/stdc++.h>
using namespace std;

class DSU
{
  int *parent;
  int *rank;

public:
  DSU(int n)
  {
     parent = new int[n];
     rank = new int[n];

     for (int i = 0; i < n; i++)
     {
        parent[i] = -1;
        rank[i] = 1;
     }
  }

  // Find function
  int find(int i)
  {
     if (parent[i] == -1)
        return i;

     return parent[i] = find(parent[i]);
  }
  // union function
  void unite(int x, int y)
  {
```

```
        int s1 = find(x);
        int s2 = find(y);

        if (s1 != s2)
        {
            if (rank[s1] < rank[s2])
            {
                parent[s1] = s2;
                rank[s2] += rank[s1];
            }
            else
            {
                parent[s2] = s1;
                rank[s1] += rank[s2];
            }
        }
    }
};

class Graph
{
    vector<vector<int>> edgelist;
    int V;

public:
    Graph(int V) { this->V = V; }

    void addEdge(int x, int y, int w)
    {
        edgelist.push_back({w, x, y});
    }

    void kruskals_mst()
    {
        // 1. Sort all edges
```

```
    sort(edgelist.begin(), edgelist.end());

    // Initialize the DSU
    DSU s(V);
    int ans = 0;
    cout << "Following are the edges in the "
         "constructed MST"
       << endl;
    for (auto edge : edgelist)
    {
      int w = edge[0];
      int x = edge[1];
      int y = edge[2];

      // take that edge in MST if it does form a cycle
      if (s.find(x) != s.find(y))
      {
        s.unite(x, y);
        ans += w;
        cout << x << " -- " << y << " == " << w
           << endl;
      }
    }
    cout << "Minimum Cost Spanning Tree: " << ans;
  }
};
int main()
{

  Graph g(4);
  g.addEdge(0, 1, 10);
  g.addEdge(1, 3, 15);
  g.addEdge(2, 3, 4);
  g.addEdge(2, 0, 6);
  g.addEdge(0, 3, 5);
```

```
    g.kruskals_mst();
    return 0;
}
```