AFRAAZ HUSSAIN
20BDS0374
DESIGN AND ANALYSIS OF ALGORITHMS
LAB ASSESSMENT 4

QUESTION:

Write a C program to find a pattern in a given text using Knuth-Morris-Pratt algorithm.

PSEUDOCODE:

```
function computeLPSArray(char* pattern, int patternLength, int* lPSArray):
    length, lPSArray[0], index = 0, 0, 1
    while index < patternLengthgth:
        if pattern[index] = pattern[length]:
            length++
            lPSArray[index] = length
            index++
        else:
            if length not 0 then length = lPSArray[length - 1]
            else:
                lPSArray[index] = 0
                index++

function knuthMorrisPratt(char* text, char* pattern):
    textLength, patternLength = len(text), len(pattern)
    computeLPSArray(pattern, patternLength, lPSArray)
    index, secondaryIndex = 0
    while index < textLength:
        if pattern[secondaryIndex] = text[index]:
            secondaryIndex++
            index++
        if secondaryIndex = patternLength:
            printf("Pattern found at index %d\n", index - secondaryIndex)
            secondaryIndex = lPSArray[secondaryIndex - 1]
        else if index < textLength and pattern[secondaryIndex] not 
text[index]:
            if secondaryIndex not 0 then secondaryIndex = 
lPSArray[secondaryIndex - 1]
            else index = index + 1

function main():
    char text[1000], pattern[1000] = input()
    knuthMorrisPratt(text, pattern)
```

CODE:

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

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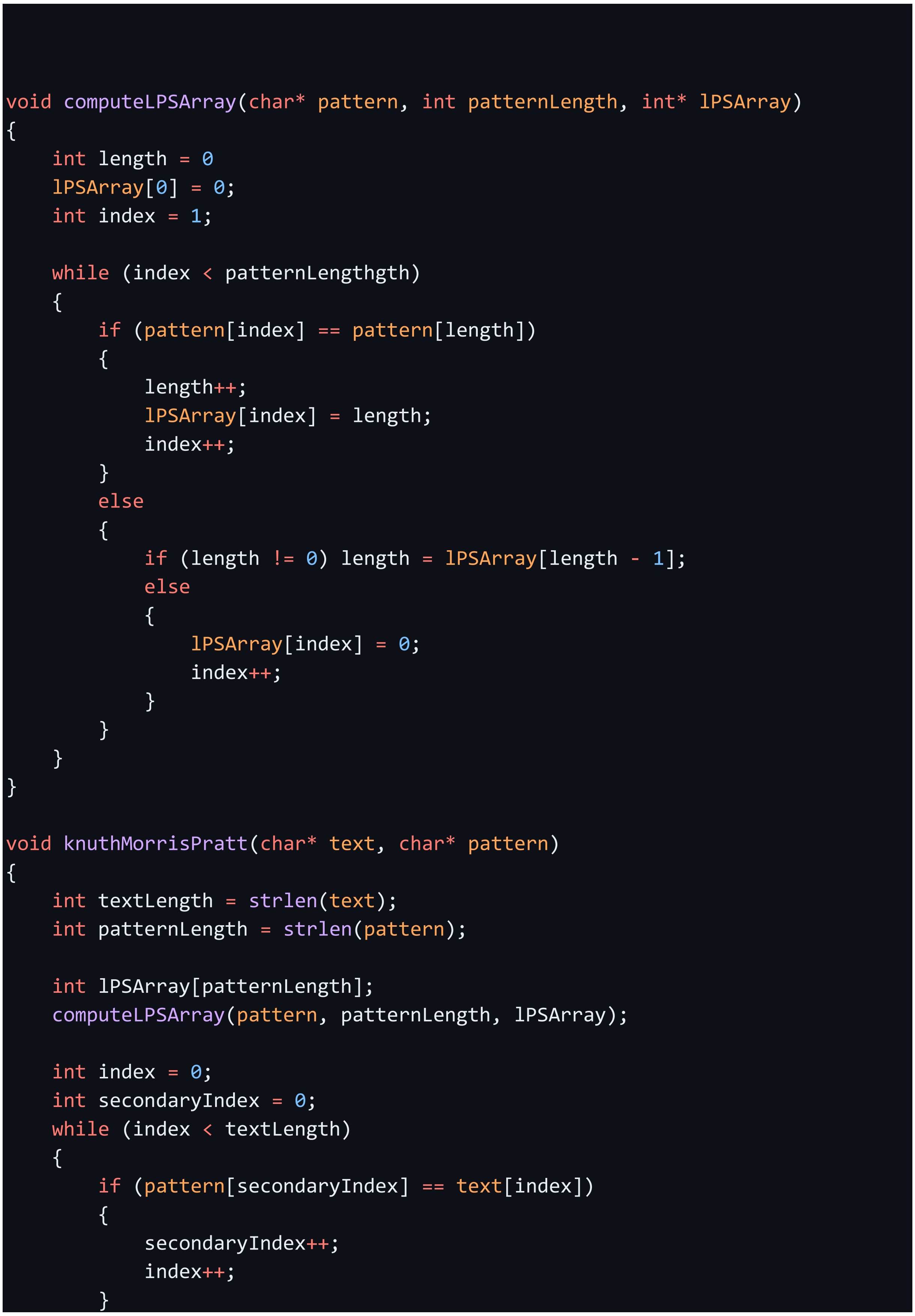
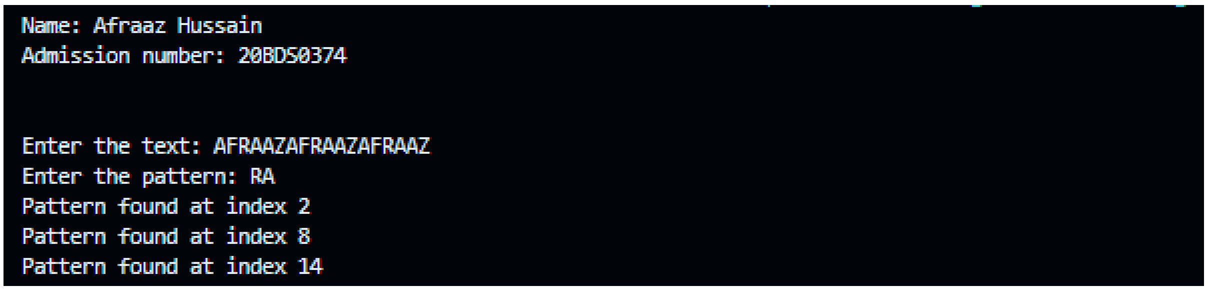


```
void computeLPSArray(char* pattern, int patternLength, int* lPSArray)
{
    int length = 0
    lPSArray[0] = 0;
    int index = 1;

    while (index < patternLengthgth)
    {
        if (pattern[index] == pattern[length])
        {
            length++;
            lPSArray[index] = length;
            index++;
        }
        else
        {
            if (length != 0) length = lPSArray[length - 1];
            else
            {
                lPSArray[index] = 0;
                index++;
            }
        }
    }
}

void knuthMorrisPratt(char* text, char* pattern)
{
    int textLength = strlen(text);
    int patternLength = strlen(pattern);

    int lPSArray[patternLength];
    computeLPSArray(pattern, patternLength, lPSArray);

    int index = 0;
    int secondaryIndex = 0;
    while (index < textLength)
    {
        if (pattern[secondaryIndex] == text[index])
        {
            secondaryIndex++;
            index++;
        }
        if (secondaryIndex == patternLength)
        {
            printf("Pattern found at index %d\n", index - secondaryIndex);
            secondaryIndex = lPSArray[secondaryIndex - 1];
        }

        else if (index < textLength && pattern[secondaryIndex] != text[index])
        {
            if (secondaryIndex != 0) secondaryIndex = lPSArray[secondaryIndex
- 1];
            else index = index + 1;
        }
    }
}



int main()
{
    printf("Name: Afraaz Hussain\nAdmission number: 20BDS0374\n\n\n");

    char text[1000], pattern[1000];

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

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

    knuthMorrisPratt(text, pattern);

    return 0;
}
```

OUTPUT:



```
Name: Afraaz Hussain
Admission number: 20BDS0374


Enter the text: AFRAAZAFRAAZAFRAAZ
Enter the pattern: RA
Pattern found at index 2
Pattern found at index 8
Pattern found at index 14
```

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QUESTION:

Consider set of points Q as input and find the smallest convex polygon P for which each point in Q is either on the boundary of P or in its interior using Graham's Scan algorithm.

PSEUDOCODE:

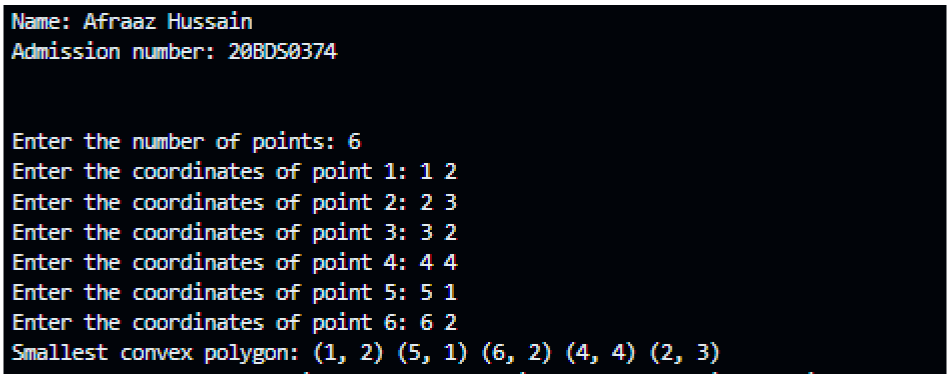
```
structure:
    int: xCoordinate, yCoordinate
as Point

function orientation(Point p, Point q, Point r):
    value = (q.yCoordinate - p.yCoordinate) * (r.xCoordinate - q.xCoordinate)
- (q.xCoordinate - p.xCoordinate) * (r.yCoordinate - q.yCoordinate)

    // For co-linear points
    if value = 0 return 0

    // For clockwise pairs
    else if value > 0 return 1

    // For counter-clockwise pairs
    else return 2

function comparePoints(const void* vp1, const void* vp2):
    Point* pointOne = (Point*)vp1
    Point* pointTwo = (Point*)vp2
    int currentOrientation = orientation((Point){0, 0}, *pointOne, *pointTwo)
    if currentOrientation = 0:
        int distanceOne = pointOne -> xCoordinate * pointOne -> xCoordinate +
pointOne -> yCoordinate * pointOne -> yCoordinate
        int distanceTwo = pointTwo -> xCoordinate * pointTwo -> xCoordinate +
pointTwo -> yCoordinate * pointTwo -> yCoordinate
        return distanceOne - distanceTwo
    else return -1 if currentOrientation = 2 else 1

function printConvexHull(Point* points, int numberOfPoints):
    // When there aren't enough ponts for a convex hull
    if numberOfPoints < 3 then return
    qsort(points, numberOfPoints, sizeof(Point), comparePoints)
    int: hull[numberOfPoints]
    top, hull[0], hull[1] = 2, 0, 1
    for index from 2 to numberOfPoints:
        while (top > 0 and orientation(points[hull[top - 1]],
points[hull[top]], points[index]) not 2) do top--
        hull[++top] = index
    print("Smallest convex polygon: ")
    for index from 0 to top:
        print("(%d, %d) ", points[hull[index]].xCoordinate,
points[hull[index]].yCoordinate)
    print("\n")

function main():
    int: numberOfPoints, index
    numberOfPoints = input()

    Point* points = malloc(numberOfPoints * sizeof(Point))
    for index from 0 to numberOfPoints:
        &points[index].xCoordinate, &points[index].yCoordinate = input()

    printConvexHull(points, numberOfPoints)

    free(points)
    return
```

CODE:

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



typedef struct
{
    int xCoordinate, yCoordinate;
} Point;



int orientation(Point p, Point q, Point r)
{
    int value = (q.yCoordinate - p.yCoordinate) * (r.xCoordinate -
q.xCoordinate) - (q.xCoordinate - p.xCoordinate) * (r.yCoordinate -
q.yCoordinate);

    // For co-linear points
    if (value == 0) return 0;

    // For clockwise pairs
    else if (value > 0) return 1;
    // For counter-clockwise pairs
    else return 2;
}

int comparePoints(const void* vp1, const void* vp2)
{
    Point* pointOne = (Point*)vp1;
    Point* pointTwo = (Point*)vp2;
    int currentOrientation = orientation((Point){0, 0}, *pointOne, *pointTwo);
    if (currentOrientation == 0)
    {
        int distanceOne = pointOne -> xCoordinate * pointOne -> xCoordinate +
pointOne -> yCoordinate * pointOne -> yCoordinate;
        int distanceTwo = pointTwo -> xCoordinate * pointTwo -> xCoordinate +
pointTwo -> yCoordinate * pointTwo -> yCoordinate;
        return distanceOne - distanceTwo;
    }
    else return (currentOrientation == 2) ? -1 : 1;
}

void printConvexHull(Point* points, int numberOfPoints)
{
    // When there aren't enough ponts for a convex hull
    if (numberOfPoints < 3) return;

    qsort(points, numberOfPoints, sizeof(Point), comparePoints);

    int hull[numberOfPoints];
    int top = 2;
    hull[0] = 0;
    hull[1] = 1;
    for (int index = 2; index < numberOfPoints; index++)
    {
        while (top > 0 && orientation(points[hull[top - 1]],
points[hull[top]], points[index]) != 2) top--;
        hull[++top] = index;
    }

    printf("Smallest convex polygon: ");
    for (int index = 0; index <= top; index++) printf("(%d, %d) ",
points[hull[index]].xCoordinate, points[hull[index]].yCoordinate);
    printf("\n");
}
```

```
int main()
{
    printf("Name: Afraaz Hussain\nAdmission number: 20BDS0374\n\n\n");

    int numberOfPoints, index;
    printf("Enter the number of points: ");
    scanf("%d", &numberOfPoints);

    Point* points = malloc(numberOfPoints * sizeof(Point));
    for (index = 0; index < numberOfPoints; index++)
    {
        printf("Enter the coordinates of point %d: ", index + 1);
        scanf("%d %d", &points[index].xCoordinate,
&points[index].yCoordinate);
    }

    printConvexHull(points, numberOfPoints);

    free(points);
    return 0;
}
```

OUTPUT:



```
Name: Afraaz Hussain
Admission number: 20BDS0374


Enter the number of points: 6
Enter the coordinates of point 1: 1 2
Enter the coordinates of point 2: 2 3
Enter the coordinates of point 3: 3 2
Enter the coordinates of point 4: 4 4
Enter the coordinates of point 5: 5 1
Enter the coordinates of point 6: 6 2
Smallest convex polygon: (1, 2) (5, 1) (6, 2) (4, 4) (2, 3)
```

QUESTION:

Consider set of points Q as input and find the smallest convex polygon P for which each point in Q is either on the boundary of P or in its interior using Jarvis March algorithm.

PSEUDOCODE:

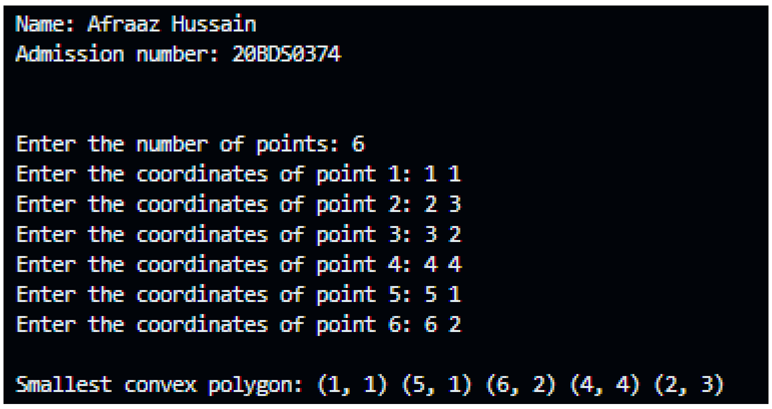
```
structure:
    int: xCoordinate, yCoordinate
as Point

function orientation(Point p, Point q, Point r):
    value = (q.yCoordinate - p.yCoordinate) * (r.xCoordinate - q.xCoordinate)
- (q.xCoordinate - p.xCoordinate) * (r.yCoordinate - q.yCoordinate)

    // For co-linear points
    if value = 0 then return 0

    // For clockwise pairs
    else if value > 0 then return 1

    // For counter-clockwise pairs
    else return 2

function printConvexHull(Point* points, int numberOfPoints):
    // When there aren't enough ponts for a convex hull
    if numberOfPoints < 3 then return

    int*: hull = malloc(numberOfPoints * sizeof(int))
    leftmost = 0
    for index from 1 to numberOfPoints do if (points[index].xCoordinate <
points[leftmost].xCoordinate) then leftmost = index

    int p = leftmost, q
    int index = 0
    do:
        hull[index++] = p
        q = (p + 1) % numberOfPoints
        for secondaryIndex from 0 to numberOfPoints do if
(orientation(points[p], points[secondaryIndex], points[q]) = 2) then q =
secondaryIndex
        p = q
    while p not leftmost

    print("\nSmallest convex polygon: ")
    for index from 0 to numberOfPoints:
        secondaryIndex = hull[index]
        print("(%d, %d) ", points[secondaryIndex].xCoordinate,
points[secondaryIndex].yCoordinate)
    print("\n")
    free(hull)

function main():
    int: numberOfPoints, index
    numberOfPoints = input()
    Point* points = malloc(numberOfPoints * sizeof(Point))
    for index from 0 to numberOfPoints:
        &points[index].xCoordinate, &points[index].yCoordinate = input()
    printConvexHull(points, numberOfPoints)
    free(points)
    return
```

CODE:

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



typedef struct
{
    int xCoordinate, yCoordinate;
} Point;



int orientation(Point p, Point q, Point r)
{
    int value = (q.yCoordinate - p.yCoordinate) * (r.xCoordinate -
q.xCoordinate) - (q.xCoordinate - p.xCoordinate) * (r.yCoordinate -
q.yCoordinate);

    // For co-linear points
    if (value == 0) return 0;

    // For clockwise pairs
    else if (value > 0) return 1;

    // For counter-clockwise pairs
    else return 2;
}
```

```c
void printConvexHull(Point* points, int numberOfPoints)
{
    // When there aren't enough ponts for a convex hull
    if (numberOfPoints < 3) return;

    int* hull = malloc(numberOfPoints * sizeof(int));
    int leftmost = 0;
    for (int index = 1; index < numberOfPoints; index++)  if
(points[index].xCoordinate < points[leftmost].xCoordinate) leftmost = index;

    int p = leftmost, q;
    int index = 0;
    do
    {
        hull[index++] = p;
        q = (p + 1) % numberOfPoints;
        for (int secondaryIndex = 0; secondaryIndex < numberOfPoints;
secondaryIndex++) if (orientation(points[p], points[secondaryIndex],
points[q]) == 2) q = secondaryIndex;
        p = q;
    }
    while (p != leftmost);

    printf("\nSmallest convex polygon: ");
    for (int index = 0; index < numberOfPoints; index++)
    {
        int secondaryIndex = hull[index];
        printf("(%d, %d) ", points[secondaryIndex].xCoordinate,
points[secondaryIndex].yCoordinate);
    }
    printf("\n");

    free(hull);
}



int main()
{
    printf("Name: Afraaz Hussain\nAdmission number: 20BDS0374\n\n\n");

    int numberOfPoints;
    printf("Enter the number of points: ");
    scanf("%d", &numberOfPoints);
    Point* points = malloc(numberOfPoints * sizeof(Point));
    for (int index = 0; index < numberOfPoints; index++)
    {
        printf("Enter the coordinates of point %d: ", index + 1);
        scanf("%d %d", &points[index].xCoordinate,
&points[index].yCoordinate);
    }

    printConvexHull(points, numberOfPoints);

    free(points);
    return 0;
}
```

OUTPUT:



```
Name: Afraaz Hussain
Admission number: 20BDS0374


Enter the number of points: 6
Enter the coordinates of point 1: 1 1
Enter the coordinates of point 2: 2 3
Enter the coordinates of point 3: 3 2
Enter the coordinates of point 4: 4 4
Enter the coordinates of point 5: 5 1
Enter the coordinates of point 6: 6 2

Smallest convex polygon: (1, 1) (5, 1) (6, 2) (4, 4) (2, 3)
```

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QUESTION:

Implement Floyd-Warshall algorithm and find the shortest path between each pair of vertices in the given graph G.

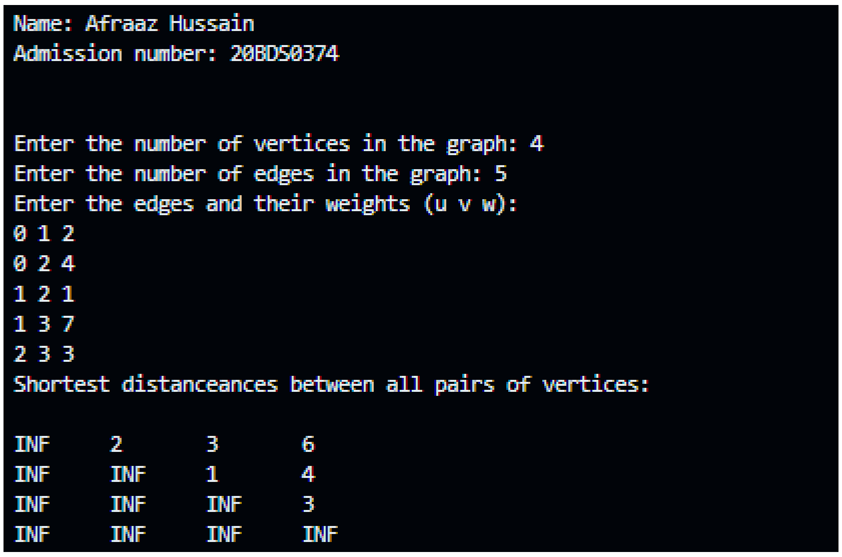
PSEUDOCODE:

```
define maximumNumberOfVertices 100 // maximum number of vertices in the graph

int: graph[maximumNumberOfVertices][maximumNumberOfVertices] // adjacency matrix of the graph
int: distance[maximumNumberOfVertices][maximumNumberOfVertices] // matrix to store the shortest distanceances between pairs of vertices

function floydWarshall(int numberOfVertices):
    int: index, secondaryIndex, tertiaryIndex
    for index from 0 to numberOfVertices do for secondaryIndex from 0 to numberOfVertices do distance[index][secondaryIndex] = graph[index][secondaryIndex]
    for tertiaryIndex from 0 to numberOfVertices:
        for (index from 0 to numberOfVertices:
            for secondaryIndex from 0 to numberOfVertices:
                if (distance[index][tertiaryIndex] not INT_MAX and distance[tertiaryIndex][secondaryIndex] not INT_MAX and distance[index][tertiaryIndex] + distance[tertiaryIndex][secondaryIndex] < distance[index][secondaryIndex]):
                    distance[index][secondaryIndex] = distance[index][tertiaryIndex] + distance[tertiaryIndex][secondaryIndex]

function main():

    int: index, secondaryIndex, u, v, w

    numberOfVertices, numberOfEdges = input()

    // initialize the adjacency matrix with all entries set to infinity
    for (index = 0 index < numberOfVertices index++) for (secondaryIndex = 0 secondaryIndex < numberOfVertices secondaryIndex++) graph[index][secondaryIndex] = INT_MAX

    // read the edges and their weights
    print("Enter the edges and their weights (u v w):\n")
    for index from 0 to numberOfEdges:
        u, v, w = input()
        graph[u][v] = w
    // run the Floyd-Warshall algorithm
    floydWarshall(numberOfVertices)
    // print the shortest distanceances between all pairs of vertices
    print("Shortest distanceances between all pairs of vertices:\n\n")
    for index from 0 to numberOfVertices:
        for (secondaryIndex from 0 to numberOfVertices:
            if distance[index][secondaryIndex] = INT_MAX then print("INF\t")
            else print("%d\t", distance[index][secondaryIndex])
        print("\n")
    return
```

CODE:

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

#define maximumNumberOfVertices 100 // maximum number of vertices in the graph



int graph[maximumNumberOfVertices][maximumNumberOfVertices]; // adjacency
matrix of the graph
int distance[maximumNumberOfVertices][maximumNumberOfVertices]; // matrix to
store the shortest distanceances between pairs of vertices



void floydWarshall(int numberOfVertices)
{
    int index, secondaryIndex, tertiaryIndex;
    for (index = 0; index < numberOfVertices; index++) for (secondaryIndex =
0; secondaryIndex < numberOfVertices; secondaryIndex++)
distance[index][secondaryIndex] = graph[index][secondaryIndex];
    for (tertiaryIndex = 0; tertiaryIndex < numberOfVertices; tertiaryIndex++)
    {
        for (index = 0; index < numberOfVertices; index++)
        {
            for (secondaryIndex = 0; secondaryIndex < numberOfVertices;
secondaryIndex++)
            {
                if (distance[index][tertiaryIndex] != INT_MAX &&
distance[tertiaryIndex][secondaryIndex] != INT_MAX &&
distance[index][tertiaryIndex] + distance[tertiaryIndex][secondaryIndex] <
distance[index][secondaryIndex])
                {
                    distance[index][secondaryIndex] =
distance[index][tertiaryIndex] + distance[tertiaryIndex][secondaryIndex];
                }
            }
        }
    }
}



int main()
{
    printf("Name: Afraaz Hussain\nAdmission number: 20BDS0374\n\n\n");

    int numberOfVertices, numberOfEdges, index, secondaryIndex, u, v, w;

    printf("Enter the number of vertices in the graph: ");
    scanf("%d", &numberOfVertices);

    printf("Enter the number of edges in the graph: ");
    scanf("%d", &numberOfEdges);

    // initialize the adjacency matrix with all entries set to infinity
    for (index = 0; index < numberOfVertices; index++) for (secondaryIndex =
0; secondaryIndex < numberOfVertices; secondaryIndex++)
graph[index][secondaryIndex] = INT_MAX;

    // read the edges and their weights
    printf("Enter the edges and their weights (u v w):\n");
    for (index = 0; index < numberOfEdges; index++)
    {
        scanf("%d %d %d", &u, &v, &w);
        graph[u][v] = w;
    }

    // run the Floyd-Warshall algorithm
    floydWarshall(numberOfVertices);

    // print the shortest distanceances between all pairs of vertices
    printf("Shortest distanceances between all pairs of vertices:\n\n");
    for (index = 0; index < numberOfVertices; index++)
    {
        for (secondaryIndex = 0; secondaryIndex < numberOfVertices;
secondaryIndex++)
        {
            if (distance[index][secondaryIndex] == INT_MAX) printf("INF\t");
            else printf("%d\t", distance[index][secondaryIndex]);
        }
        printf("\n");
    }
    return 0;
}
```

OUTPUT:



```
Name: Afraaz Hussain
Admission number: 20BDS0374


Enter the number of vertices in the graph: 4
Enter the number of edges in the graph: 5
Enter the edges and their weights (u v w):
0 1 2
0 2 4
1 2 1
1 3 7
2 3 3
Shortest distanceances between all pairs of vertices:

INF     2       3       6
INF     INF     1       4
INF     INF     INF     3
INF     INF     INF     INF
```

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QUESTION:

Implement Ford Fulkerson algorithm to compute the max-flow of a given graph.

PSEUDOCODE:

```
define maximumNumberOfVertices 100 // maximum number of vertices in the graph

int: graph[maximumNumberOfVertices][maximumNumberOfVertices] // adjacency
matrix of the graph
int: parent[maximumNumberOfVertices] // array to store the parent of each
vertex in the augmenting path
int: visited[maximumNumberOfVertices] // array to keep track of visited
vertices during DFS
int: numberOfVertices // number of vertices in the graph

function min(int firstNumber, int secondNumber) return (firstNumber <
secondNumber) ? firstNumber : secondNumber

// find an augmenting path from the source to the sink in the residual graph
function depthFirstSearch(int source, int sink, int minimumFlow):
    int index
    visited[source] = 1
    if source = sink then return minimumFlow

    for index from 0 to numberOfVertices:
        if not visited[index] and graph[source][index] > 0:
            parent[index] = source
            flow = depthFirstSearch(index, sink, min(minimumFlow,
graph[source][index]))
            if flow > 0:
                graph[source][index] -= flow
                graph[index][source] += flow
                return flow
    return

// compute the maximum flow from the source to the sink in the given graph
function maximumFlow(int source, int sink):
    maximumFlow = 0
    while True:
        memset(visited, 0, sizeof(visited))
        int flow = depthFirstSearch(source, sink, INT_MAX)
        if flow = 0 then break
        maximumFlow += flow
    return maximumFlow
```

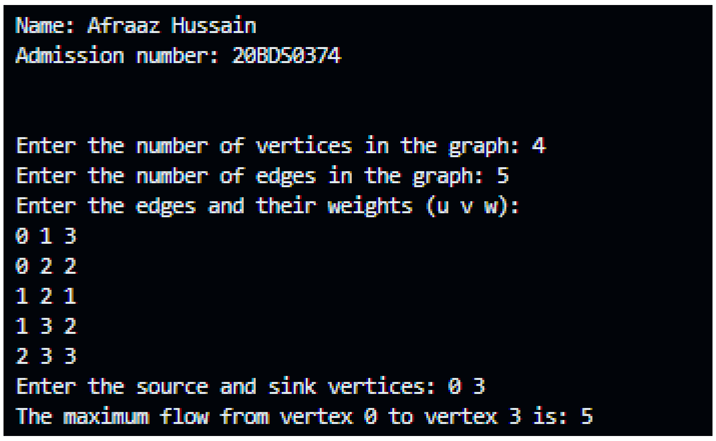
```
function main():
    numberOfVertices = input()
    numberOfEdges = input()

    // initialize the adjacency matrix with all entries set to 0
    memset(graph, 0, sizeof(graph))
    // read the edges and their weights
    print("Enter the edges and their weights (u v w):\n")
    for index from 0 to numberOfEdges:
        scanf("%d %d %d", &u, &v, &w)
        graph[u][v] += w
    source, sink = input()
    // compute the maximum flow from the source to the sink
    maximumFlowValue = maximumFlow(source, sink)
    // print the maximum flow
    print("The maximum flow from vertex %d to vertex %d is: %d\n", source,
sink, maximumFlowValue)
    return
```

CODE:

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

#define maximumNumberOfVertices 100 // maximum number of vertices in the graph



int graph[maximumNumberOfVertices][maximumNumberOfVertices]; // adjacency
matrix of the graph
int parent[maximumNumberOfVertices]; // array to store the parent of each
vertex in the augmenting path
int visited[maximumNumberOfVertices]; // array to keep track of visited
vertices during DFS
int numberOfVertices; // number of vertices in the graph



int min(int firstNumber, int secondNumber) return (firstNumber <
secondNumber) ? firstNumber : secondNumber;



// find an augmenting path from the source to the sink in the residual graph
int depthFirstSearch(int source, int sink, int minimumFlow)
```

```c
{
    int index;
    visited[source] = 1;

    if (source == sink) return minimumFlow;

    for (index = 0; index < numberOfVertices; index++)
    {
        if (!visited[index] && graph[source][index] > 0)
        {
            parent[index] = source;
            int flow = depthFirstSearch(index, sink, min(minimumFlow,
graph[source][index]));
            if (flow > 0)
            {
                graph[source][index] -= flow;
                graph[index][source] += flow;
                return flow;
            }
        }
    }
    return 0;
}

// compute the maximum flow from the source to the sink in the given graph
int maximumFlow(int source, int sink)
{
    int index, secondaryIndex, maximumFlow = 0;
    while (1)
    {
        memset(visited, 0, sizeof(visited));
        int flow = depthFirstSearch(source, sink, INT_MAX);
        if (flow == 0) break;
        maximumFlow += flow;
    }
    return maximumFlow;
}



int main()
{
    printf("Name: Afraaz Hussain\nAdmission number: 20BDS0374\n\n\n");

    int numberOfEdges, index, secondaryIndex, u, v, w, source, sink;
    printf("Enter the number of vertices in the graph: ");
    scanf("%d", &numberOfVertices);

    printf("Enter the number of edges in the graph: ");
    scanf("%d", &numberOfEdges);

    // initialize the adjacency matrix with all entries set to 0
    memset(graph, 0, sizeof(graph));
    // read the edges and their weights
    printf("Enter the edges and their weights (u v w):\n");
    for (index = 0; index < numberOfEdges; index++) {
        scanf("%d %d %d", &u, &v, &w);
        graph[u][v] += w;
    }
    printf("Enter the source and sink vertices: ");
    scanf("%d %d", &source, &sink);

    // compute the maximum flow from the source to the sink
    int maximumFlowValue = maximumFlow(source, sink);

    // print the maximum flow
    printf("The maximum flow from vertex %d to vertex %d is: %d\n", source,
sink, maximumFlowValue);
    return 0;
}
```

OUTPUT:



```
Name: Afraaz Hussain
Admission number: 20BDS0374


Enter the number of vertices in the graph: 4
Enter the number of edges in the graph: 5
Enter the edges and their weights (u v w):
0 1 3
0 2 2
1 2 1
1 3 2
2 3 3
Enter the source and sink vertices: 0 3
The maximum flow from vertex 0 to vertex 3 is: 5
```