FIND MAXIMUM AND MINIMUM:

1.Write a Program to find both the maximum and minimum values in the array. Implement using any programming language of your choice. Execute your code and provide the maximum and minimum values found.

Input : N= 8, a[] = {5,7,3,4,9,12,6,2}
Output : Min = 2, Max = 12
Test Cases :
Input : N= 9, a[] = {1,3,5,7,9,11,13,15,17}
Output : Min = 1, Max = 17
Test Cases :
Input : N= 10, a[] = {22,34,35,36,43,67, 12,13,15,17}
Output : Min 12, Max 67
PROGRAM:

```
def find_min_max(arr):
    if len(arr) == 0:
        return None, None

    min_val = arr[0]
    max_val = arr[0]

    for num in arr:
        if num < min_val:
            min_val = num
        if num > max_val:
            max_val = num

    return min_val, max_val

test_cases = [
    [5, 7, 3, 4, 9, 12, 6, 2],
    [1, 3, 5, 7, 9, 11, 13, 15, 17],
    [22, 34, 35, 36, 43, 67, 12, 13, 15, 17]
]

results = [find_min_max(case) for case in test_cases]
print(results)
```

2. Consider an array of integers sorted in ascending order: 2,4,6,8,10,12,14,18.
Write a Program to find both the maximum and minimum values in the array. Implement using any programming language of your choice. Execute your code and provide the maximum and minimum values found.
Input : N=8, 2,4,6,8,10,12,14,18.
Output : Min = 2, Max =18
Test Cases :

Input : N= 9, a[] = {11,13,15,17,19,21,23,35,37}
Output : Min = 11, Max = 37
Test Cases :
Input : N= 10, a[] = {22,34,35,36,43,67, 12,13,15,17}
Output : Min 12, Max 67
Program:

```
def find_min_max_sorted(arr):
    if len(arr) == 0:
        return None, None

    min_val = arr[0]
    max_val = arr[-1]

    return min_val, max_val

test_cases_sorted = [
    [2, 4, 6, 8, 10, 12, 14, 18],
    [11, 13, 15, 17, 19, 21, 23, 35, 37],
    [22, 34, 35, 36, 43, 67, 12, 13, 15, 17]
]

results_sorted = [find_min_max_sorted(case) for case in test_cases_sorted]
print(results_sorted)
```

MERGE SORT:

1.You are given an unsorted array 31,23,35,27,11,21,15,28. Write a program for Merge Sort and implement using any programming language of your choice.

Test Cases :
Input : N= 8, a[] = {31,23,35,27,11,21,15,28}
Output : 11,15,21,23,27,28,31,35
Test Cases :
Input : N= 10, a[] = {22,34,25,36,43,67, 52,13,65,17}
Output : 13,17,22,25,34,36,43,52,65,67

PROGRAM:

```
def merge_sort(arr):
    if len(arr) > 1:
        mid = len(arr) // 2
        left_half = arr[:mid]
        right_half = arr[mid:]

        merge_sort(left_half)
        merge_sort(right_half)

        i = j = k = 0
```

```
    while i < len(left_half) and j < len(right_half):
        if left_half[i] < right_half[j]:
            arr[k] = left_half[i]
            i += 1
        else:
            arr[k] = right_half[j]
            j += 1
        k += 1

    while i < len(left_half):
        arr[k] = left_half[i]
        i += 1
        k += 1

    while j < len(right_half):
        arr[k] = right_half[j]
        j += 1
        k += 1

  return arr

# Test cases
test_cases_merge_sort = [
  [31, 23, 35, 27, 11, 21, 15, 28],
  [22, 34, 25, 36, 43, 67, 52, 13, 65, 17]
]

results_merge_sort = [merge_sort(case) for case in test_cases_merge_sort]
print(results_merge_sort)
```

2.Implement the Merge Sort algorithm in a programming language of your choice and test it on the array 12,4,78,23,45,67,89,1. Modify your implementation to count the number of comparisons made during the sorting process. Print this count along with the sorted array.

Test Cases :
Input : N= 8, a[] = {12,4,78,23,45,67,89,1}
Output : 1,4,12,23,45,67,78,89
Test Cases :
Input : N= 7, a[] = {38,27,43,3,9,82,10}
Output : 3,9,10,27,38,43,82

Program:

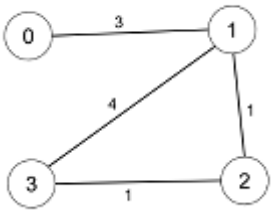
```
def merge_sort_with_comparisons(arr):
  comparisons = 0

  def merge_sort(arr):
```

```
        nonlocal comparisons
        if len(arr) > 1:
            mid = len(arr) // 2
            left_half = arr[:mid]
            right_half = arr[mid:]

            merge_sort(left_half)
            merge_sort(right_half)

            i = j = k = 0

            while i < len(left_half) and j < len(right_half):
                comparisons += 1
                if left_half[i] < right_half[j]:
                    arr[k] = left_half[i]
                    i += 1
                else:
                    arr[k] = right_half[j]
                    j += 1
                k += 1

            while i < len(left_half):
                arr[k] = left_half[i]
                i += 1
                k += 1

            while j < len(right_half):
                arr[k] = right_half[j]
                j += 1
                k += 1

        return arr

    sorted_array = merge_sort(arr)
    return sorted_array, comparisons

# Test cases
test_cases_comparisons = [
    [12, 4, 78, 23, 45, 67, 89, 1],
    [38, 27, 43, 3, 9, 82, 10]
]

for case in test_cases_comparisons:
    sorted_array, comparison_count = merge_sort_with_comparisons(case)
    print(f"Sorted array: {sorted_array}")
```

print(f"Number of comparisons: {comparison_count}")

ALL PAIR SHORTEST PATH: FLOYDS ALGORITHM

1. Implement Floyd's Algorithm to find the shortest path between all pairs of cities. Display the distance matrix before and after applying the algorithm. Identify and print the shortest path



Input: n = 4, edges = [[0,1,3],[1,2,1],[1,3,4],[2,3,1]], distanceThreshold = 4
Output: 3
Explanation: The figure above describes the graph.
The neighboring cities at a distanceThreshold = 4 for each city are:
City 0 -> [City 1, City 2]
City 1 -> [City 0, City 2, City 3]
City 2 -> [City 0, City 1, City 3]
City 3 -> [City 1, City 2]
Cities 0 and 3 have 2 neighboring cities at a distanceThreshold = 4, but we have to return city 3 since it has the greatest number.

Test cases :

a) You are given a small network of 4 cities connected by roads with the following distances:
City 1 to City 2: 3
City 1 to City 3: 8
City 1 to City 4: -4
City 2 to City 4: 1
City 2 to City 3: 4
City 3 to City 1: 2
City 4 to City 3: -5
City 4 to City 2: 6
Implement Floyd's Algorithm to find the shortest path between all pairs of cities. Display the distance matrix before and after applying the algorithm. Identify and print the shortest path from City 1 to City 3.
Input as above
Output : City 1 to City 3 = -9

b. Consider a network with 6 routers. The initial routing table is as follows:
Router A to Router B: 1
Router A to Router C: 5
Router B to Router C: 2
Router B to Router D: 1
Router C to Router E: 3

Router D to Router E: 1
Router D to Router F: 6
Router E to Router F: 2

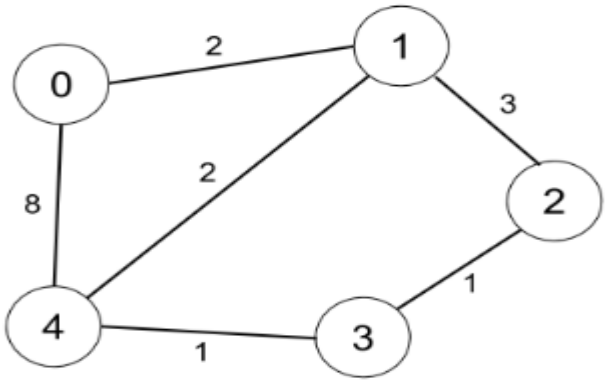
Write a Program to implement Floyd's Algorithm to calculate the shortest paths between all pairs of routers. Simulate a change where the link between Router B and Router D fails. Update the distance matrix accordingly. Display the shortest path from Router A to Router F before and after the link failure.
Input as above
Output : Router A to Router F = 5

Program:

```
import sys

def print_matrix(matrix):
    for row in matrix:
        print(" ".join(map(lambda x: f"{x:5}", row)))
    print()

def floyd_warshall(n, edges):
    dist = [[sys.maxsize] * n for _ in range(n)]

    for i in range(n):
        dist[i][i] = 0

    for u, v, w in edges:
        dist[u][v] = w

    print("Initial Distance Matrix:")
    print_matrix(dist)

    for k in range(n):
        for i in range(n):
            for j in range(n):
                if dist[i][j] > dist[i][k] + dist[k][j]:
                    dist[i][j] = dist[i][k] + dist[k][j]

    print("Distance Matrix after Floyd-Warshall Algorithm:")
    print_matrix(dist)

    return dist

def find_shortest_path(matrix, start, end):
    return matrix[start][end]

# Test Case a)
```

```
n = 4
edges = [[0, 1, 3], [0, 2, 8], [0, 3, -4], [1, 3, 1], [1, 2, 4], [2, 0, 2], [3, 2, -5], [3, 1, 6]]
dist_matrix = floyd_warshall(n, edges)
shortest_path_1_to_3 = find_shortest_path(dist_matrix, 0, 2)

print(f"The shortest path from City 1 to City 3 is {shortest_path_1_to_3}\n")

# Test Case b)
n = 6
edges = [[0, 1, 1], [0, 2, 5], [1, 2, 2], [1, 3, 1], [2, 4, 3], [3, 4, 1], [3, 5, 6], [4, 5, 2]]
dist_matrix_before_failure = floyd_warshall(n, edges)
shortest_path_A_to_F_before = find_shortest_path(dist_matrix_before_failure, 0, 5)

print(f"The shortest path from Router A to Router F before link failure is {shortest_path_A_to_F_before}\n")

# Simulating link failure between Router B and Router D
edges_with_failure = [[0, 1, 1], [0, 2, 5], [1, 2, 2], [2, 4, 3], [3, 4, 1], [3, 5, 6], [4, 5, 2]]
dist_matrix_after_failure = floyd_warshall(n, edges_with_failure)
shortest_path_A_to_F_after = find_shortest_path(dist_matrix_after_failure, 0, 5)

print(f"The shortest path from Router A to Router F after link failure is {shortest_path_A_to_F_after}\n")
```

2.Implement Floyd's Algorithm to find the shortest path between all pairs of cities. Display the distance matrix before and after applying the algorithm. Identify and print the shortest path



Input: n = 5, edges = [[0,1,2],[0,4,8],[1,2,3],[1,4,2],[2,3,1],[3,4,1]], distanceThreshold = 2
Output: 0
Explanation: The figure above describes the graph.
The neighboring cities at a distanceThreshold = 2 for each city are:
City 0 -> [City 1]
City 1 -> [City 0, City 4]
City 2 -> [City 3, City 4]

City 3 -> [City 2, City 4]
City 4 -> [City 1, City 2, City 3]
The city 0 has 1 neighboring city at a distanceThreshold = 2.

a) Test cases :
B to A 2
A TO C 3
C TO D 1
D TO A 6
C TO B 7
Find shortest path from C to A
Output = 7

b) Find shortest path from E to C

C TO A 2
A TO B 4
B TO C 1
B TO E 6
E TO A 1
A TO D 5
D TO E 2
E TO D 4
D TO C 1
C TO D 3

Output : E to C = 5

Program:

```
import sys

def print_matrix(matrix):
    for row in matrix:
        print(" ".join(map(lambda x: f"{x:5}", row)))
    print()

def floyd_warshall(n, edges):
    dist = [[sys.maxsize] * n for _ in range(n)]

    for i in range(n):
        dist[i][i] = 0

    for u, v, w in edges:
        dist[u][v] = w

    print("Initial Distance Matrix:")
```

```
    print_matrix(dist)

    for k in range(n):
        for i in range(n):
            for j in range(n):
                if dist[i][k] != sys.maxsize and dist[k][j] != sys.maxsize and dist[i][j] > dist[i][k] + dist[k][j]:
                    dist[i][j] = dist[i][k] + dist[k][j]

    print("Distance Matrix after Floyd-Warshall Algorithm:")
    print_matrix(dist)

    return dist

def find_shortest_path(matrix, start, end):
    return matrix[start][end]

n = 5
edges = [[0, 1, 2], [0, 4, 8], [1, 2, 3], [1, 4, 2], [2, 3, 1], [3, 4, 1]]
dist_matrix = floyd_warshall(n, edges)

print(f"The shortest path from City 2 to City 0 is {find_shortest_path(dist_matrix, 2, 0)}")
print(f"The shortest path from City 4 to City 2 is {find_shortest_path(dist_matrix, 4, 2)}")

# Additional Test Case a)
edges_a = [[1, 0, 2], [0, 2, 3], [2, 3, 1], [3, 0, 6], [2, 1, 7]]
n_a = 4
dist_matrix_a = floyd_warshall(n_a, edges_a)
shortest_path_C_to_A = find_shortest_path(dist_matrix_a, 2, 0)
print(f"The shortest path from City C to City A is {shortest_path_C_to_A}")

# Additional Test Case b)
edges_b = [[2, 0, 2], [0, 1, 4], [1, 2, 1], [1, 4, 6], [4, 0, 1], [0, 3, 5], [3, 4, 2], [4, 3, 4], [3, 2, 1], [2, 3, 3]]
n_b = 5
dist_matrix_b = floyd_warshall(n_b, edges_b)
shortest_path_E_to_C = find_shortest_path(dist_matrix_b, 4, 2)
print(f"The shortest path from City E to City C is {shortest_path_E_to_C}")
```