# VISVESVARAYA TECHNOLOGICAL UNIVERSITY

**"JnanaSangama", Belgaum -590014, Karnataka.**

**LAB REPORT**
**on**

# Analysis and Design of Algorithms

***Submitted by***

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***in partial fulfillment for the award of the degree of***
**BACHELOR OF ENGINEERING**
***in***
**COMPUTER SCIENCE AND ENGINEERING**

**B.M.S. COLLEGE OF ENGINEERING**
**(Autonomous Institution under VTU)**
**BENGALURU-560019**
**April-2024 to August-2024**

# B. M. S. College of Engineering,

**Bull Temple Road, Bangalore 560019**

(Affiliated to Visvesvaraya Technological University, Belgaum)

## Department of Computer Science and Engineering

## CERTIFICATE

This is to certify that the Lab work entitled “**Analysis and Design of Algorithms**” carried out by **ADITYA SINGH (1BM22CS022),** who is bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the academic semester April-2024 to August-2024. The Lab report has been approved as it satisfies the academic requirements in respect of an **Analysis and Design of Algorithms (23CS4PCADA)** work prescribed for the said degree.

| | |
|---|---|
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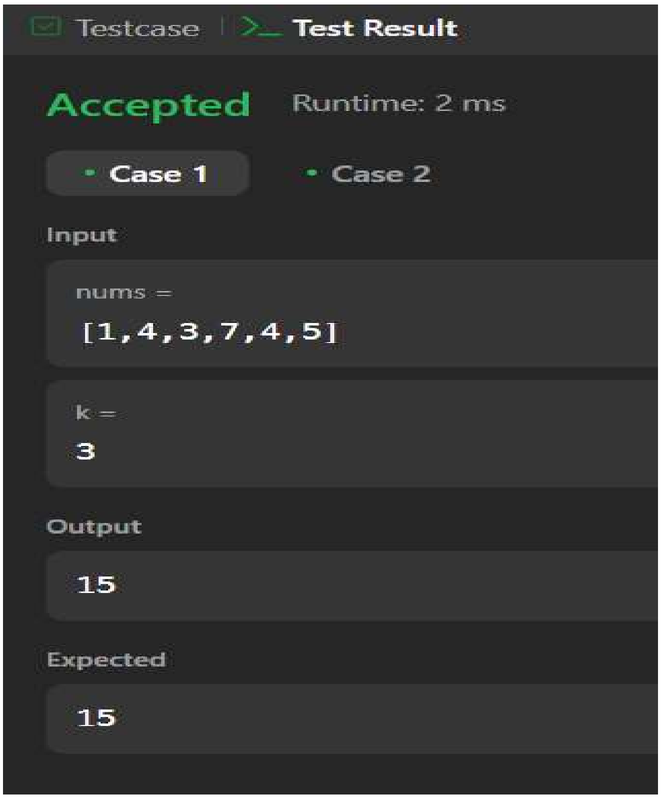
## Course Outcome

| | |
|---|---|
| CO1 | Analyze time complexity of Recursive and Non-recursive algorithms using asymptotic notations. |
| CO2 | Apply various design techniques for the given problem. |
| CO3 | Apply the knowledge of complexity classes P, NP, and NP-Complete and prove certain problems are NP-Complete |
| CO4 | Design efficient algorithms and conduct practical experiments to solve problems. |

Q1) Leetcode exercises.

```
int maximumScore(int* nums, int numsSize, int k) {
    int n=numsSize;
    int left=k;
    int right=k;
    int ans=nums[k];
    int currMin=nums[k];
    while(left>0 || right<n-1){
         if ((left > 0 ? nums[left - 1]: 0) < (right < n - 1 ? nums[right + 1] : 0)){
            right++;
            currMin=fmin(currMin, nums[right]);
         }
         else{
            left--;
            currMin=fmin(currMin, nums[left]);
         }
         ans = fmax(ans, currMin * (right - left + 1));
    }
    return ans;

}
```

OP:



Accepted Runtime: 2 ms

Input

nums =

```
[1,4,3,7,4,5]
```

k =

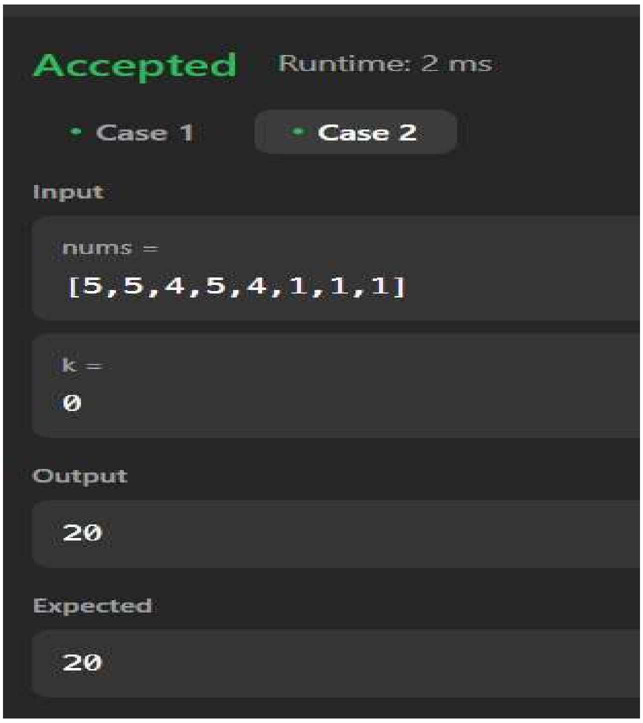
```
3
```

Output

```
15
```

Expected

```
15
```



Accepted Runtime: 2 ms

Input

nums =

```
[5,5,4,5,4,1,1,1]
```

k =

```
0
```

Output

```
20
```

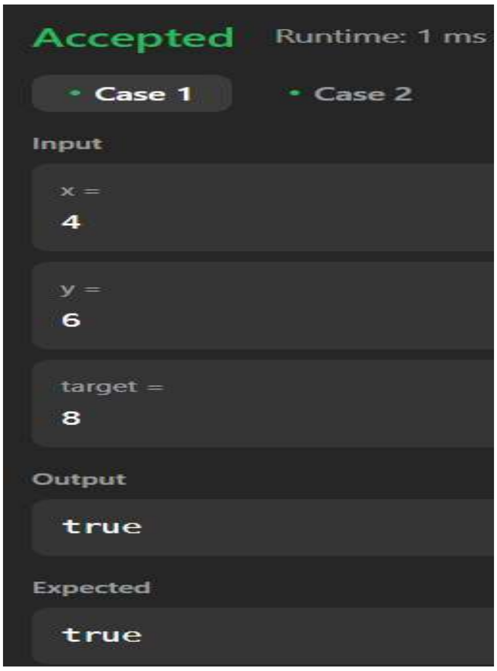
Expected

```
20
```

Q1b) Leetcode exercises.

```
bool canMeasureWater(int jug1, int jug2, int t) {
    if (jug1 + jug2 < t)
        return false;
    while (jug2 != 0) {
        int temp = jug2;
        jug2 = jug1 % jug2;
        jug1 = temp;
    }
    return t % jug1 == 0;
}
```

OP:



Accepted Runtime: 1 ms

Input

x =
4

y =
6

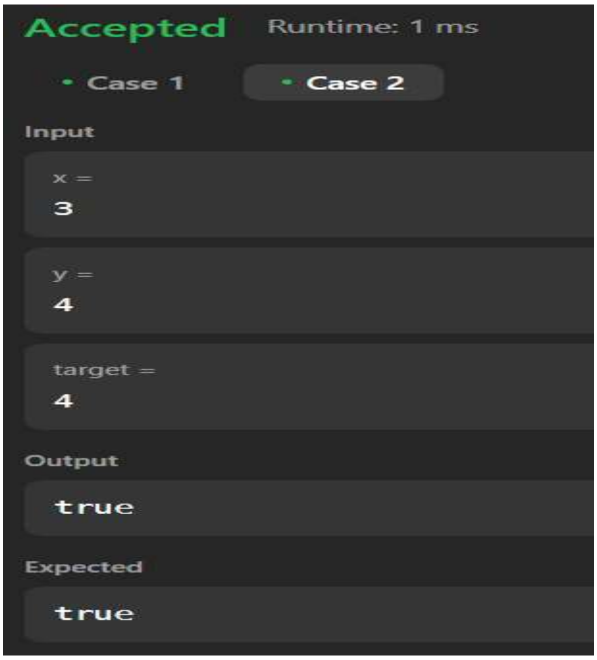
target =
8

Output

true

Expected

true



Accepted Runtime: 1 ms

Input

x =
3

y =
4

target =
4

Output

true

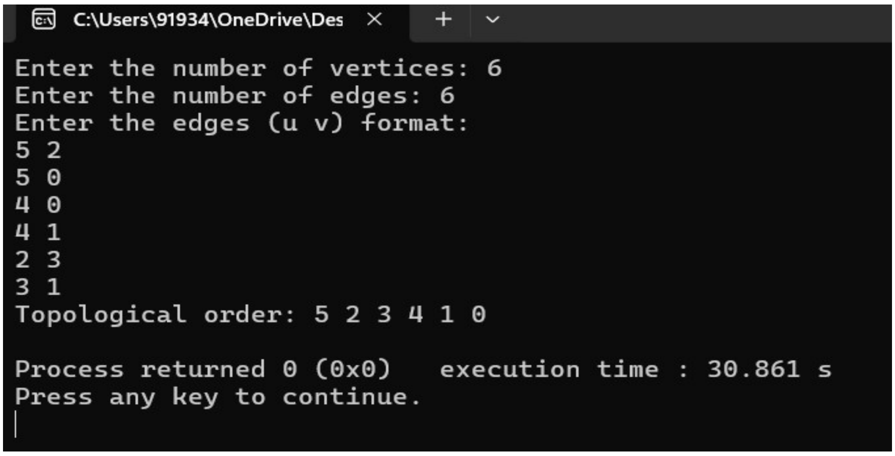
Expected

true

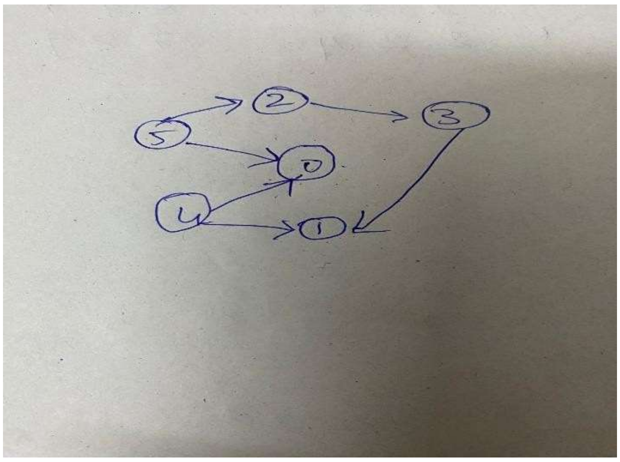
Q2) Write program to obtain the Topological ordering of vertices in a given digraph.

```
#include <stdio.h>

#include <stdlib.h>

#define MAX 100

void topologicalSort(int n, int adj[][MAX]) {

    int inDegree[MAX] = {0};

    int stack[MAX], top = -1;

    int topOrder[MAX], orderIndex = 0;

    for (int i = 0; i < n; i++) {

        for (int j = 0; j < n; j++) {

            if (adj[i][j] == 1) {

                inDegree[j]++;

            }

        }

    }

    for (int i = 0; i < n; i++) {

        if (inDegree[i] == 0) {

            stack[++top] = i;

        }

    }

    while (top != -1) {

        int u = stack[top--];

        topOrder[orderIndex++] = u;
        for (int i = 0; i < n; i++) {
            if (adj[u][i] == 1) {
                inDegree[i]--;
                if (inDegree[i] == 0) {
                    stack[++top] = i;
                }
            }
        }
    }
    if (orderIndex != n) {
        printf("The graph has a cycle, topological sort not possible.\n");
    } else {
        printf("Topological order: ");
        for (int i = 0; i < n; i++) {
            printf("%d ", topOrder[i]);
        }
        printf("\n");
    }
}
int main() {
    int n, e;
    int adj[MAX][MAX] = {0};
    printf("Enter the number of vertices: ");
    scanf("%d", &n);
    printf("Enter the number of edges: ");
    scanf("%d", &e);
    printf("Enter the edges (u v) format:\n");
    for (int i = 0; i < e; i++) {
        int u, v;
        scanf("%d %d", &u, &v);
        adj[u][v] = 1;
    }
    topologicalSort(n, adj);
    return 0;
}
```

op:



```
Enter the number of vertices: 6
Enter the number of edges: 6
Enter the edges (u v) format:
5 2
5 0
4 0
4 1
2 3
3 1
Topological order: 5 2 3 4 1 0

Process returned 0 (0x0)   execution time : 30.861 s
Press any key to continue.
```

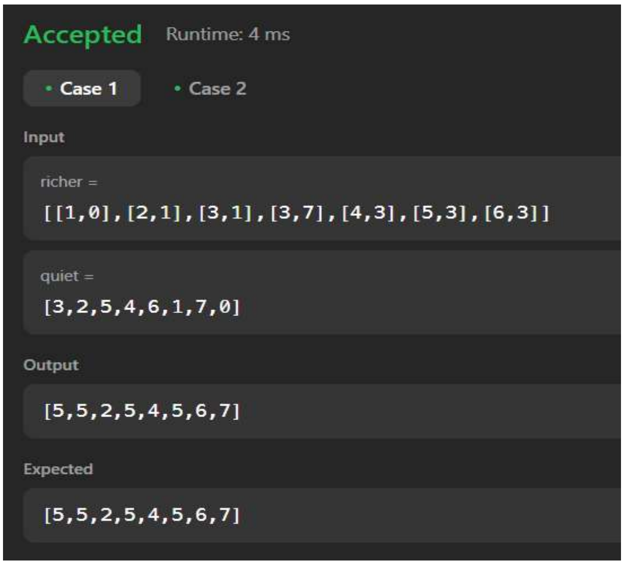


Q2 b) Leet code. Loud and Rich

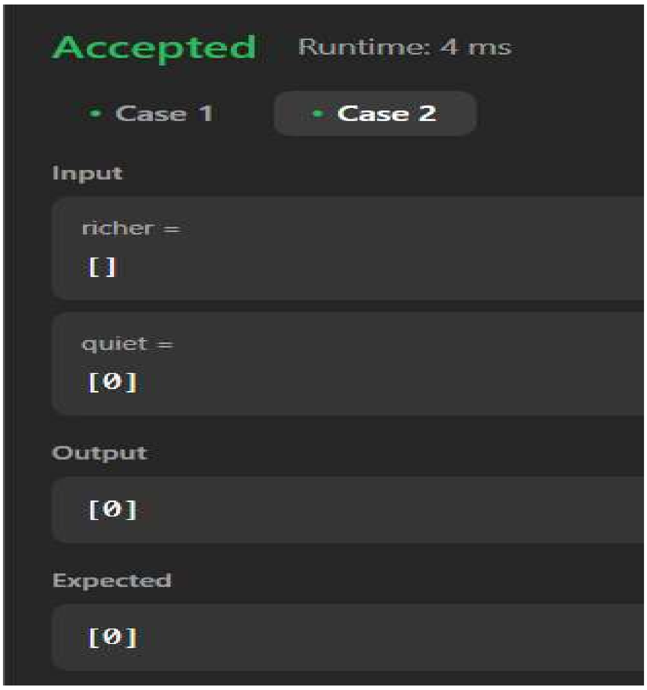
```
/**
 * Note: The returned array must be malloced, assume caller calls free().
 */
int* loudAndRich(int** richer, int richerSize, int* richerColSize, int* quiet, int quietSize, int* returnSize) {
   int* indegree = (int*)calloc(quietSize, sizeof(int));
   int* result = (int*)malloc(quietSize * sizeof(int));
   int* queue = (int*)malloc(quietSize * sizeof(int));
   int front = 0, rear = 0;
   int** adj = (int**)malloc(quietSize * sizeof(int*));
```

```
for (int i = 0; i < quietSize; i++) {
    adj[i] = (int*)malloc(quietSize * sizeof(int));
    result[i] = i;
}
int* adjSize = (int*)calloc(quietSize, sizeof(int));
for (int i = 0; i < richerSize; i++) {
    int a = richer[i][0];
    int b = richer[i][1];
    adj[a][adjSize[a]++] = b;
    indegree[b]++;
}
for (int i = 0; i < quietSize; i++) {
    if (indegree[i] == 0) {
        queue[rear++] = i;
    }
}
while (front < rear) {
    int u = queue[front++];
    for (int i = 0; i < adjSize[u]; i++) {
        int v = adj[u][i];
        if (quiet[result[v]] > quiet[result[u]]) {
            result[v] = result[u];
        }
        if (--indegree[v] == 0) {
                queue[rear++] = v;
            }
        }
    }

    *returnSize = quietSize;
    for (int i = 0; i < quietSize; i++) {
        free(adj[i]);
    }
    free(adj);
    free(indegree);
    free(queue);
    free(adjSize);

    return result;
}
```

op:



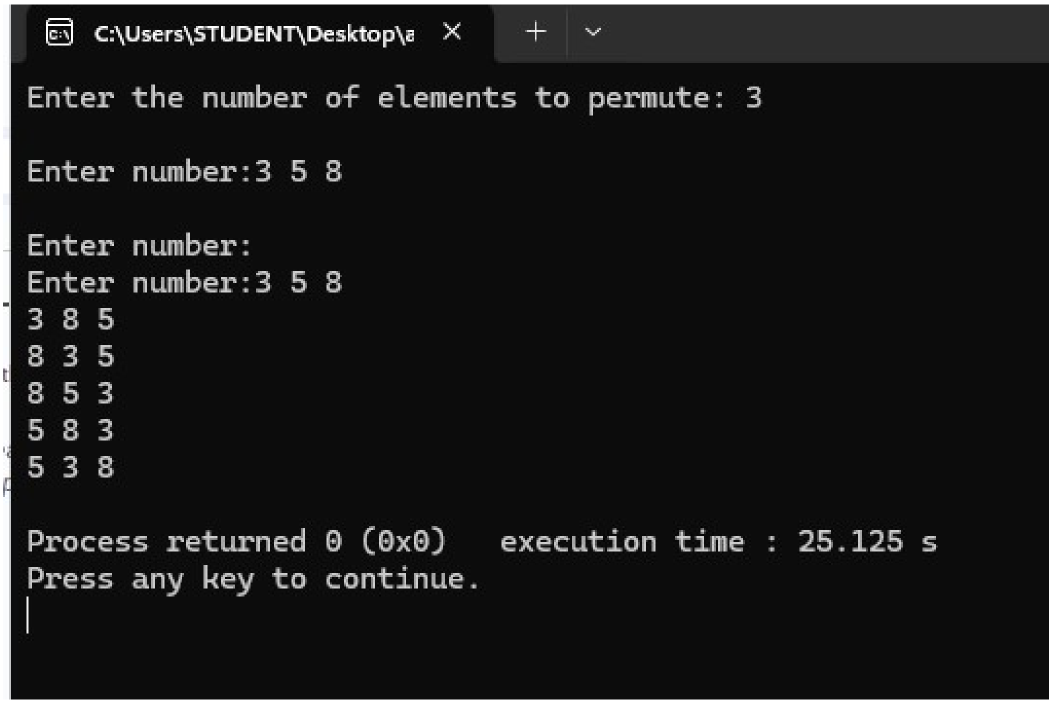
```
Input
richer =
[[1,0],[2,1],[3,1],[3,7],[4,3],[5,3],[6,3]]
quiet =
[3,2,5,4,6,1,7,0]
Output
[5,5,2,5,4,5,6,7]
Expected
[5,5,2,5,4,5,6,7]
```



```
Input
richer =
[]
quiet =
[0]
Output
[0]
Expected
[0]
```

Q3) Implement Johnson Trotter algorithm to generate permutations.

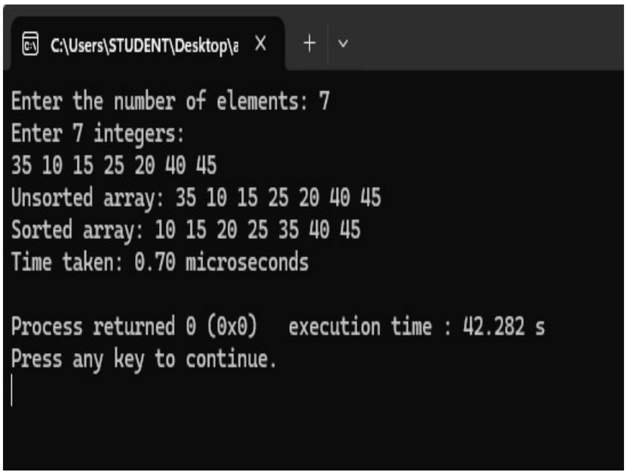
```
#include <stdio.h>

#include <stdlib.h>

#include <stdbool.h>

void printArray(int arr[], int size) {
    for (int i = 0; i < size; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
}
int searchArr(int arr[], int size, int x) {
    for (int i = 0; i < size; i++) {
        if (arr[i] == x) {
            return i;
        }
    }
    return -1;
}
void swap(int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}
void generatePermutations(int n) {
    int perm[n];
    int dir[n];
    int num;
    for (int i = 0; i < n; i++) {
        printf("\nEnter number:");
        scanf("%d",&num);

        perm[i] = num;

        dir[i] = 0;

    }

    while (1) {

        printArray(perm, n);

        int mobile = 0, mobileIndex = -1;

        for (int i = 0; i < n; i++) {

            if ((dir[i] == 0 && i != 0 && perm[i] > perm[i - 1]) || (dir[i] == 1 && i != n - 1 && perm[i] > perm[i + 1])) {

                if (perm[i] > mobile) {

                    mobile = perm[i];

                    mobileIndex = i;

                }

            }

        }

        if (mobileIndex == -1) {

            break;

        }

         if (dir[mobileIndex] == 0) {

            swap(&perm[mobileIndex], &perm[mobileIndex - 1]);

            swap(&dir[mobileIndex], &dir[mobileIndex - 1]);

            mobileIndex--;

        } else {
            swap(&perm[mobileIndex], &perm[mobileIndex + 1]);

            swap(&dir[mobileIndex], &dir[mobileIndex + 1]);

            mobileIndex++;

        }

        for (int i = 0; i < n; i++) {

            if (perm[i] > mobile) {

                dir[i] = !dir[i];

            }

        }

    }

}

int main() {

    int n;

    printf("Enter the number of elements to permute: ");

    scanf("%d", &n);

    if (n <= 0) {

        printf("Number of elements should be greater than 0.\n");

        return 1;

    }

    generatePermutations(n);

    return 0;

}
```



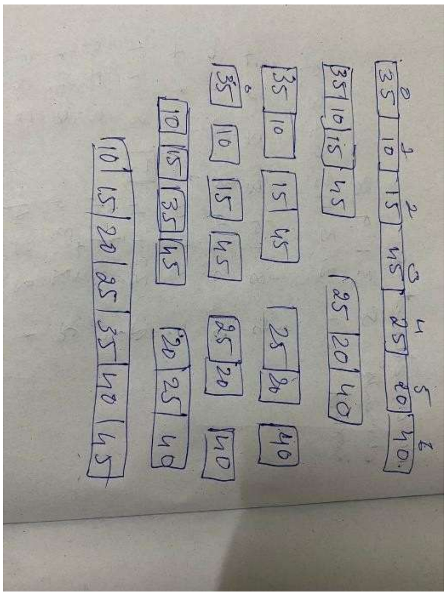
```
Enter the number of elements to permute: 3

Enter number:3 5 8

Enter number:
Enter number:3 5 8
3 8 5
8 3 5
8 5 3
5 8 3
5 3 8

Process returned 0 (0x0)   execution time : 25.125 s
Press any key to continue.
```

Q4.) Sort a given set of N integer elements using Merge Sort technique and compute its time taken. Run the program for different values of N and record the time taken to sort.

```
#include  <stdio.h>
#include <stdlib.h>
#include <time.h>
void merge(int arr[], int l, int m, int r) {
    int i, j, k;
    int n1 = m - l + 1;
    int n2 = r - m;
    int L[n1], R[n2];
    for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];
    i = 0;
    j = 0;
    k = l;
    while (i < n1 && j < n2) {
        if (L[i] <= R[j]) {
            arr[k] = L[i];
            i++;
        } else {
            arr[k] = R[j];
            j++;
        }
        k++;
    }
    while (i < n1) {
        arr[k] = L[i];
        i++;
        k++;
    }
    while (j < n2) {
        arr[k] = R[j];
        j++;
        k++;
    }
}
void mergeSort(int arr[], int l, int r) {
    if (l < r) {
        int m = l + (r - l) / 2;
        mergeSort(arr, l, m);
        mergeSort(arr, m + 1, r);
        merge(arr, l, m, r);
    }
}
int main() {
    int N;
    printf("Enter the number of elements: ");
    scanf("%d", &N);
    int arr[N];
    printf("Enter %d integers:\n", N);
    for (int i = 0; i < N; i++)
        scanf("%d", &arr[i]);
    printf("Unsorted array: ");
    for (int i = 0; i < N; i++)
        printf("%d ", arr[i]);
    printf("\n");
    struct timespec start, end;
    clock_gettime(CLOCK_MONOTONIC, &start);
    mergeSort(arr, 0, N - 1);
    clock_gettime(CLOCK_MONOTONIC, &end);
    double time_taken = (end.tv_sec - start.tv_sec) * 1e6 + (end.tv_nsec - start.tv_nsec) / 1e3;
    printf("Sorted array: ");
    for (int i = 0; i < N; i++)
        printf("%d ", arr[i]);
    printf("\n");
    printf("Time taken: %.2lf microseconds\n", time_taken);
    return 0;
}
```



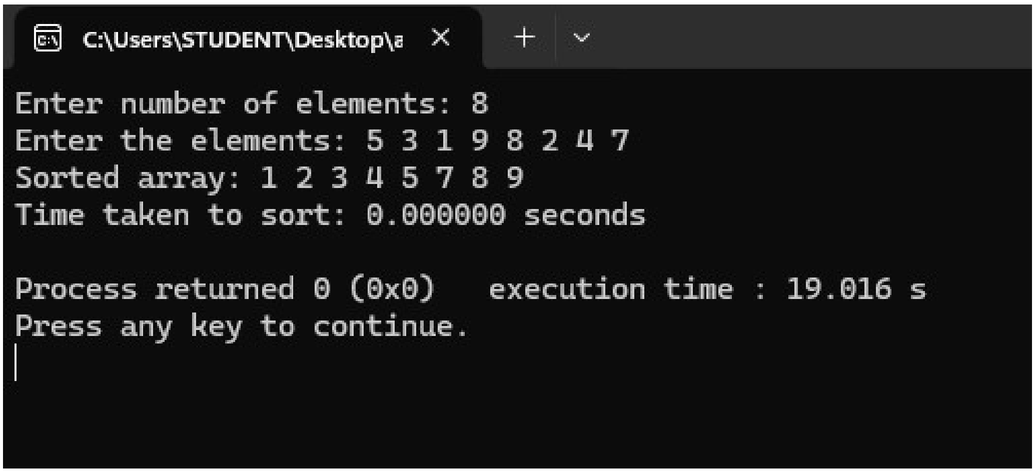
```
Enter the number of elements: 7
Enter 7 integers:
35 10 15 25 20 40 45
Unsorted array: 35 10 15 25 20 40 45
Sorted array: 10 15 20 25 35 40 45
Time taken: 0.70 microseconds

Process returned 0 (0x0)   execution time : 42.282 s
Press any key to continue.
```



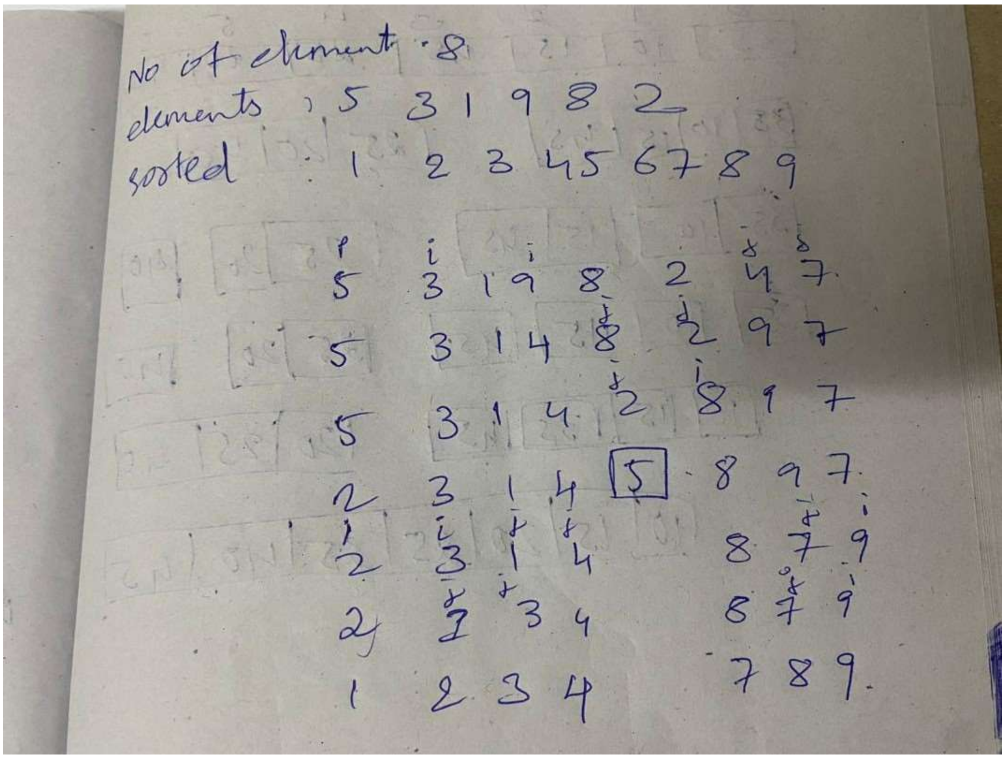
Q5) Sort a given set of N integer elements using Quick Sort technique and compute its time taken.

```
#include  <stdio.h>
#include <stdlib.h>
#include <time.h>
int partition(int arr[], int low, int high) {
    int pivot = arr[high];
    int i = (low - 1);
    for (int j = low; j <= high - 1; j++) {
        if (arr[j] < pivot) {
            i++;
            int temp = arr[i];
            arr[i] = arr[j];
            arr[j] = temp;
        }
    }
    int temp = arr[i + 1];
    arr[i + 1] = arr[high];
    arr[high] = temp;
    return (i + 1);
}
void quickSort(int arr[], int low, int high) {
    if (low < high) {
        int pi = partition(arr, low, high);
        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}
int main() {
    int n;
    printf("Enter number of elements: ");
    scanf("%d", &n);
    int arr[n];
    printf("Enter the elements: ");
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }
    clock_t start, end;
    double cpu_time_used;
    start = clock();
    quickSort(arr, 0, n - 1);
    end = clock();
    cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;
    printf("Sorted array: ");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
    printf("Time taken to sort: %f seconds\n", cpu_time_used);
    return 0;
}
```

op:



```
Enter number of elements: 8
Enter the elements: 5 3 1 9 8 2 4 7
Sorted array: 1 2 3 4 5 7 8 9
Time taken to sort: 0.000000 seconds

Process returned 0 (0x0)   execution time : 19.016 s
Press any key to continue.
```



No of element : 8

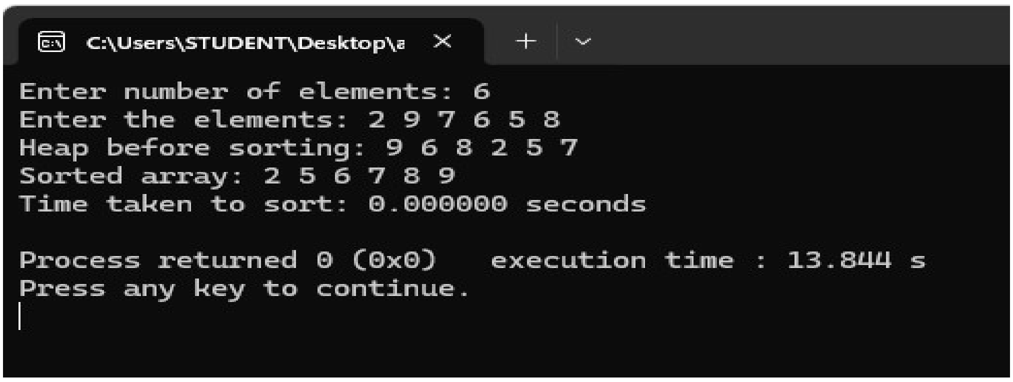
elements : 5 3 1 9 8 2

sorted : 1 2 3 45 67 8 9

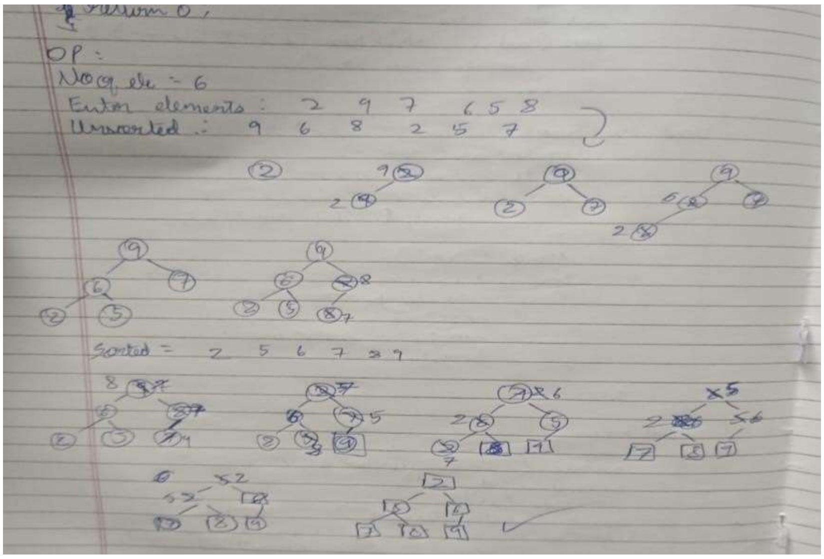
```
p    i    i          j  j
5    3   1 9   8   2    4  7
               j   j
5    3   1 4   8   2    9  7
               j   i
5    3   1 4   2   8    9  7

2    3   1 4  [5]  8    9  7
i    i   j j          j    i
2    3   1 4       8    7  9
     j   j            i j  i
2    1   3 4       8    7  9

1    2   3 4       7    8  9.
```

Q6) Sort a given set of N integer elements using Heap Sort technique and compute its time taken.

```
#include <stdio.h>

#include <stdlib.h>

#include <time.h>

void heapify(int arr[], int n, int i) {

    int largest = i;

    int left = 2 * i + 1;

    int right = 2 * i + 2;

    if (left < n && arr[left] > arr[largest])

        largest = left;

    if (right < n && arr[right] > arr[largest])

        largest = right;

    if (largest != i) {

        int temp = arr[i];

        arr[i] = arr[largest];

        arr[largest] = temp;

        heapify(arr, n, largest);

    }

}

void buildHeap(int arr[], int n) {

    int startIdx = (n / 2) - 1;

    for (int i = startIdx; i >= 0; i--) {

        heapify(arr, n, i);

    }

}

void heapSort(int arr[], int n) {
    buildHeap(arr, n);
    printf("Heap before sorting: ");
    for (int i = 0; i < n; i++) {
        printf("%d ", arr[i]);
    }
    printf("\n");
    for (int i = n - 1; i >= 0; i--) {
        int temp = arr[0];
        arr[0] = arr[i];
        arr[i] = temp;
        heapify(arr, i, 0);
    }
}
int main() {
    int n;
    printf("Enter number of elements: ");
    scanf("%d", &n);
    int arr[n];
    printf("Enter the elements: ");
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    clock_t start, end;
    double cpu_time_used;
    start = clock();
    heapSort(arr, n);

    end = clock();

    cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;

    printf("Sorted array: ");

    for (int i = 0; i < n; i++) {

        printf("%d ", arr[i]);

    }

    printf("\n");

    printf("Time taken to sort: %f seconds\n", cpu_time_used);

    return 0;

}
```



```
Enter number of elements: 6
Enter the elements: 2 9 7 6 5 8
Heap before sorting: 9 6 8 2 5 7
Sorted array: 2 5 6 7 8 9
Time taken to sort: 0.000000 seconds

Process returned 0 (0x0)   execution time : 13.844 s
Press any key to continue.
```



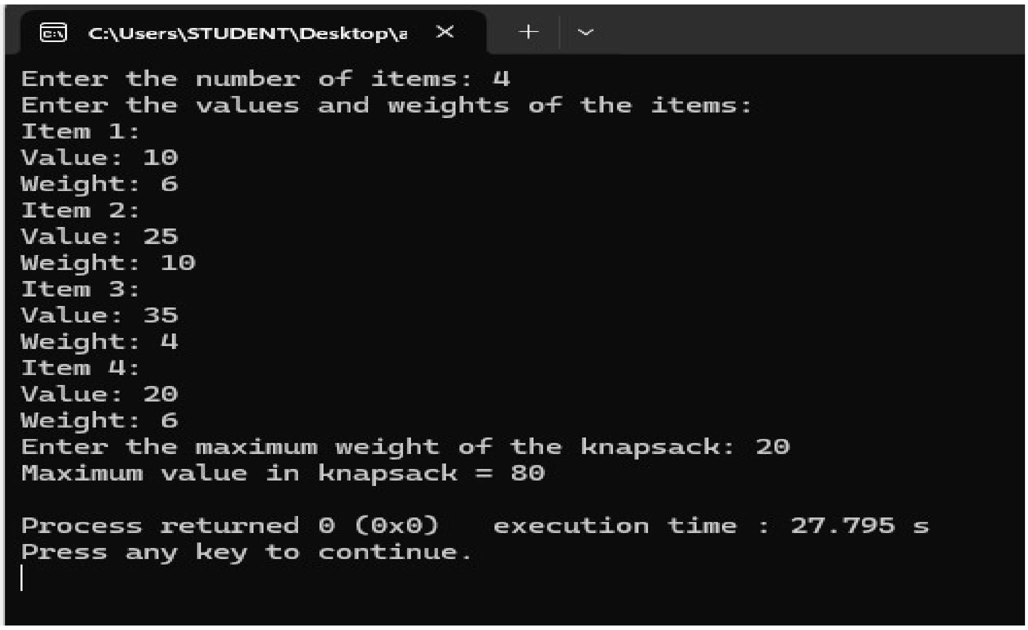
return 0;
}

OP:
No of ele = 6
Enter elements : 2 9 7 6 5 8
Unsorted : 9 6 8 2 5 7

Sorted = 2 5 6 7 8 9

Q7) Implement 0/1 Knapsack problem using dynamic programming.

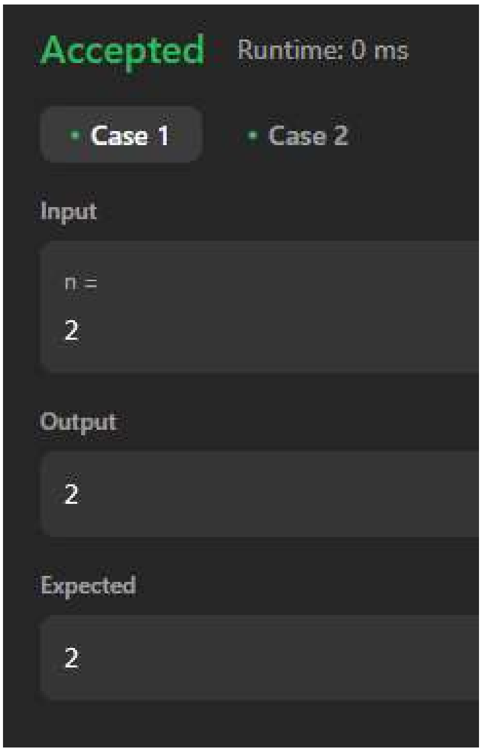
```
#include <stdio.h>
#include <stdlib.h>
struct Item {
    int value;
    int weight;
    double ratio;
};

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

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


    if (left < n && arr[left].ratio > arr[largest].ratio) {
        largest = left;
    }
    if (right < n && arr[right].ratio > arr[largest].ratio) {
        largest = right;
    }

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

void buildHeap(struct Item arr[], int n) {
    int startIdx = (n / 2) - 1;

    for (int i = startIdx; i >= 0; i--) {
        heapify(arr, n, i);
    }
}

int knapsack(int W, struct Item items[], int n) {
    int *K = (int *)calloc((W + 1), sizeof(int));

    for (int i = 0; i < n; i++) {
        for (int w = W; w >= items[i].weight; w--) {
            K[w] = max(K[w], items[i].value + K[w - items[i].weight]);
        }
    }

    int result = K[W];
    free(K);

    return result;

}


int max(int a, int b) {

    return (a > b) ? a : b;

}


int main() {

    int n, W;


    printf("Enter the number of items: ");

    scanf("%d", &n);


    struct Item* items = (struct Item*)malloc(n * sizeof(struct Item));


    printf("Enter the values and weights of the items:\n");

    for (int i = 0; i < n; i++) {

        printf("Item %d:\n", i + 1);

        printf("Value: ");

        scanf("%d", &items[i].value);

        printf("Weight: ");

        scanf("%d", &items[i].weight);

        items[i].ratio = (double)items[i].value / items[i].weight;

    }
    printf("Enter the maximum weight of the knapsack: ");
    scanf("%d", &W);

    buildHeap(items, n);

    int max_value = knapsack(W, items, n);
    printf("Maximum value in knapsack = %d\n", max_value);

    free(items);

    return 0;
}
```



```
Enter the number of items: 4
Enter the values and weights of the items:
Item 1:
Value: 10
Weight: 6
Item 2:
Value: 25
Weight: 10
Item 3:
Value: 35
Weight: 4
Item 4:
Value: 20
Weight: 6
Enter the maximum weight of the knapsack: 20
Maximum value in knapsack = 80

Process returned 0 (0x0)   execution time : 27.795 s
Press any key to continue.
```

Q7b) Leet Code: Egg Drop With 2 Eggs and N Floors

```
int twoEggDrop(int n) {
   if (n == 0) return 0;
   if (n == 1) return 1;
   if (n == 2) return 2;
   int bests[n + 1];
   bests[0] = 0;
   bests[1] = 1;
   bests[2] = 2;
   for (int col = 3; col <= n; ++col) {
      int bestThisCol = n;
      for (int row = 1; row <= col; ++row) {
         int breaks = 1 + row - 1;
         int survive = 1 + bests[col - row];
         if (bestThisCol > (breaks > survive ? breaks : survive)) {
            bestThisCol = (breaks > survive ? breaks : survive);
         }
      }
      bests[col] = bestThisCol;
   }
   return bests[n];
}
```



Accepted Runtime: 0 ms

Input

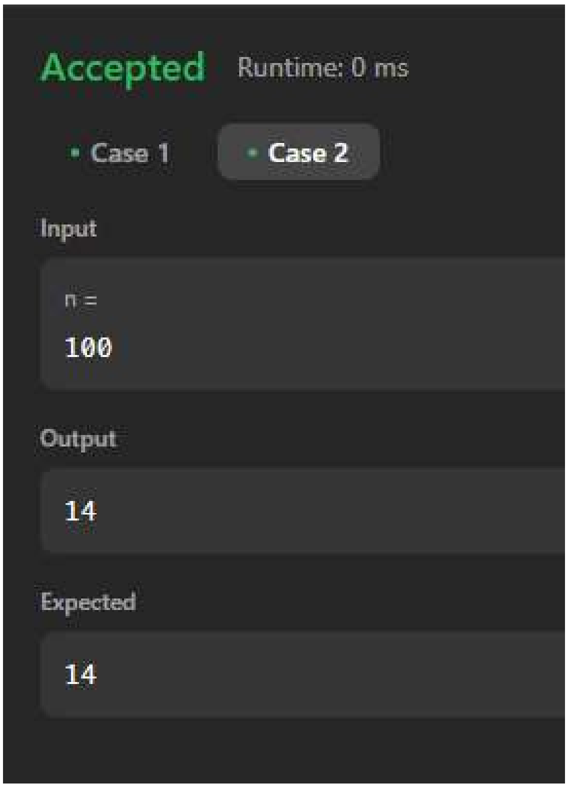
```
n =
2
```

Output

```
2
```

Expected

```
2
```



Accepted Runtime: 0 ms

Input

```
n =
100
```

Output

```
14
```

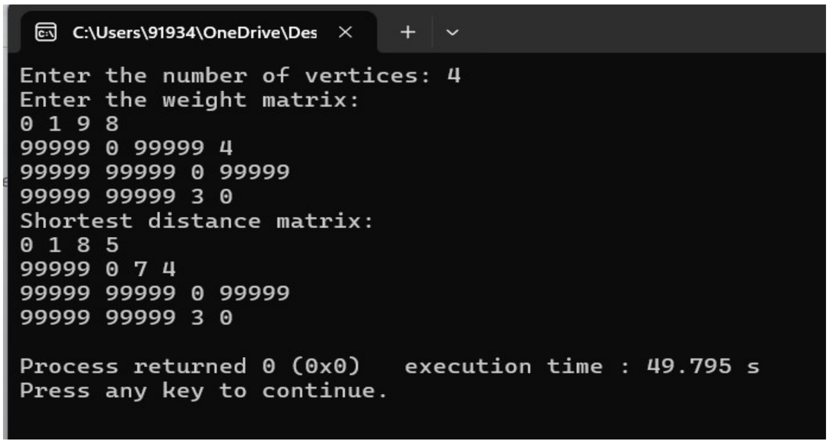
Expected

```
14
```

Q8) Implement All Pair Shortest paths problem using Floyd's algorithm.

```
#include <stdio.h>

#include <stdlib.h>

#include <limits.h>

#define INF 99999

void floydWarshall(int** graph, int V) {

    int** dist = (int**)malloc(V * sizeof(int*));

    for (int i = 0; i < V; i++) {

        dist[i] = (int*)malloc(V * sizeof(int));

        for (int j = 0; j < V; j++) {

            if (graph[i][j] == 0 && i != j) {

                dist[i][j] = INF; // Use INF to indicate no direct path

            } else {

                dist[i][j] = graph[i][j];

            }

        }

    }

    for (int k = 0; k < V; k++) {

        for (int i = 0; i < V; i++) {

            for (int j = 0; j < V; j++) {

                if (dist[i][k] != INF && dist[k][j] != INF && dist[i][k] + dist[k][j] < dist[i][j]) {

                    dist[i][j] = dist[i][k] + dist[k][j];

                }

            }
}
    }
    printf("Shortest distance matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (dist[i][j] == INF) {
                printf("INF ");
            } else {
                printf("%d ", dist[i][j]);
            }
        }
        printf("\n");
    }
    for (int i = 0; i < V; i++) {
        free(dist[i]);
    }
    free(dist);
}
int main() {
    int V;
    printf("Enter the number of vertices: ");
    scanf("%d", &V);
    int** graph = (int**)malloc(V * sizeof(int*));
    for (int i = 0; i < V; i++) {
        graph[i] = (int*)malloc(V * sizeof(int));
    }
    printf("Enter the weight matrix:\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            scanf("%d", &graph[i][j]);
        }
    }
    floydWarshall(graph, V);
    for (int i = 0; i < V; i++) {
        free(graph[i]);
    }
    free(graph);

    return 0;
}
```

OP:

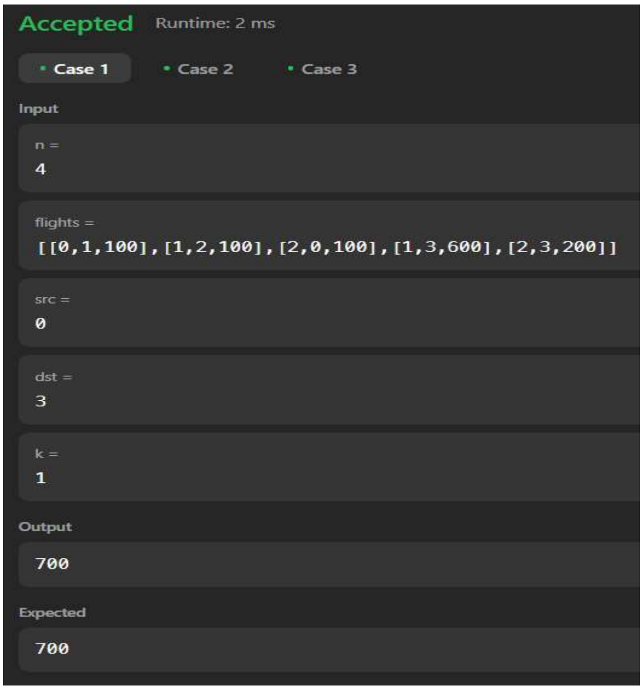


```
Enter the number of vertices: 4
Enter the weight matrix:
0 1 9 8
99999 0 99999 4
99999 99999 0 99999
99999 99999 3 0
Shortest distance matrix:
0 1 8 5
99999 0 7 4
99999 99999 0 99999
99999 99999 3 0

Process returned 0 (0x0)   execution time : 49.795 s
Press any key to continue.
```

Q 8b) Leet code.

```
int findCheapestPrice(int n, int** flights, int flightsSize, int* flightsColSize, int src, int dst, int k) {
    int* dp = (int*)malloc(n * sizeof(int));
    for (int i = 0; i < n; i++) {
        dp[i] = INT_MAX;
    }
    dp[src] = 0;
    for (int i = 0; i <= k; i++) {
        int* temp = (int*)malloc(n * sizeof(int));
        for (int j = 0; j < n; j++) {
            temp[j] = dp[j];
        }
        for (int f = 0; f < flightsSize; f++) {
            int* flight = flights[f];
            if (dp[flight[0]] != INT_MAX) {
                temp[flight[1]] = temp[flight[1]] < dp[flight[0]] + flight[2] ? temp[flight[1]] : dp[flight[0]]
+ flight[2];
            }
        }
        free(dp);
        dp = temp;
    }

    int result = dp[dst] == INT_MAX ? -1 : dp[dst];
    free(dp);

    return result;

}
```

op:



Input

n =
4

flights =
[[0,1,100],[1,2,100],[2,0,100],[1,3,600],[2,3,200]]

src =
0

dst =
3

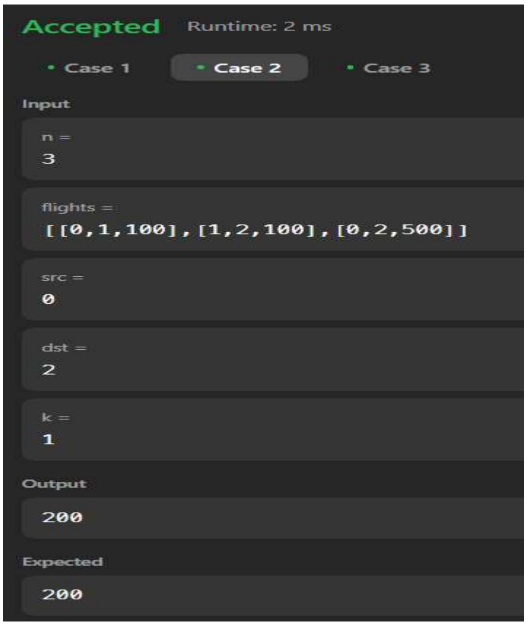
k =
1

Output

700

Expected

700



Input

n =
3

flights =
[[0,1,100],[1,2,100],[0,2,500]]

src =
0

dst =
2

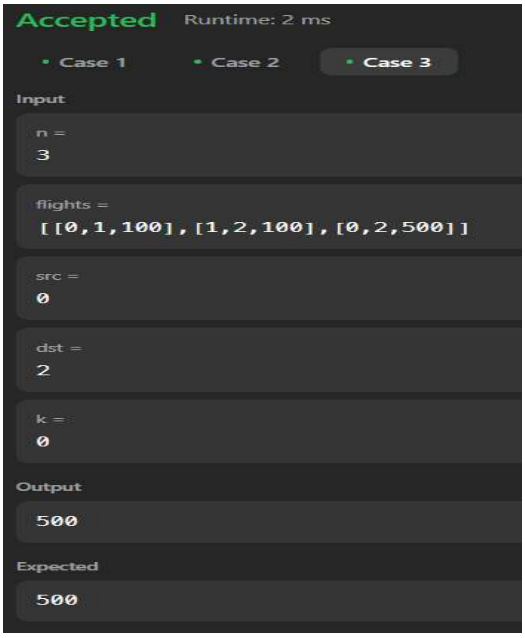
k =
1

Output

200

Expected

200



Input

n =
3

flights =
[[0,1,100],[1,2,100],[0,2,500]]

src =
0

dst =
2

k =
0

Output

500

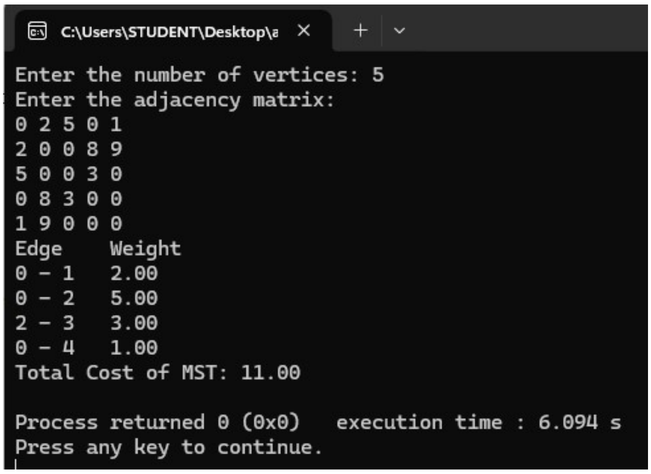
Expected

500

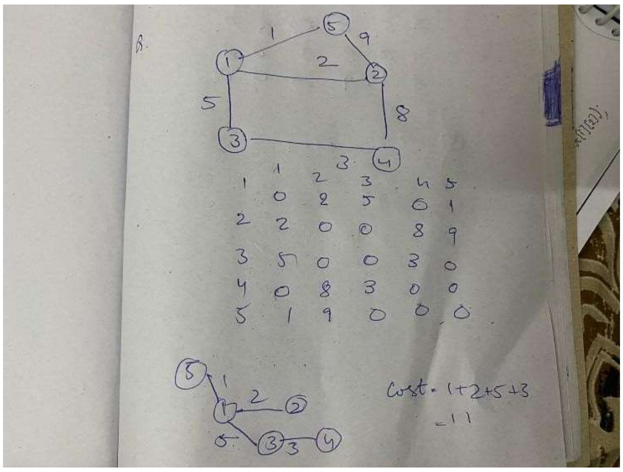
Q9a) Find Minimum Cost Spanning Tree of a given undirected graph using Prim’s algorithm.

```
#include <stdio.h>

#include <float.h>

#include <stdbool.h>

#define MAX 100

double minKey(double key[], bool mstSet[], int V) {

    double min = DBL_MAX;

    int min_index;



    for (int v = 0; v < V; v++) {

        if (mstSet[v] == false && key[v] < min) {

            min = key[v];

            min_index = v;

        }

    }

    return min_index;

}

void printMST(int parent[], double graph[MAX][MAX], int V) {

    double totalCost = 0.0;

    printf("Edge \tWeight\n");

    for (int i = 1; i < V; i++) {

        printf("%d - %d \t%.2lf \n", parent[i], i, graph[i][parent[i]]);

        totalCost += graph[i][parent[i]];

    }
    printf("Total Cost of MST: %.2lf\n", totalCost);
}
void primMST(double graph[MAX][MAX], int V) {
    int parent[MAX];
    double key[MAX];
    bool mstSet[MAX];
    for (int i = 0; i < V; i++) {
        key[i] = DBL_MAX;
        mstSet[i] = false;
    }
    key[0] = 0.0;
    parent[0] = -1;
    for (int count = 0; count < V - 1; count++) {
        int u = minKey(key, mstSet, V);
        mstSet[u] = true;
        for (int v = 0; v < V; v++) {
            if (graph[u][v] && mstSet[v] == false && graph[u][v] < key[v]) {
                parent[v] = u;
                key[v] = graph[u][v];
            }
        }
    }
    printMST(parent, graph, V);
}
```

```
int main() {
   int V;
   printf("Enter the number of vertices: ");
   scanf("%d", &V);
   double graph[MAX][MAX];
   printf("Enter the adjacency matrix:\n");
   for (int i = 0; i < V; i++) {
      for (int j = 0; j < V; j++) {
         scanf("%lf", &graph[i][j]);
      }
   }
   primMST(graph, V);
   return 0;
}
```



```
Enter the number of vertices: 5
Enter the adjacency matrix:
0 2 5 0 1
2 0 0 8 9
5 0 0 3 0
0 8 3 0 0
1 9 0 0 0
Edge    Weight
0 - 1   2.00
0 - 2   5.00
2 - 3   3.00
0 - 4   1.00
Total Cost of MST: 11.00

Process returned 0 (0x0)   execution time : 6.094 s
Press any key to continue.
```



|   | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | 2 | 5 | 0 | 1 |
| 2 | 2 | 0 | 0 | 8 | 9 |
| 3 | 5 | 0 | 0 | 3 | 0 |
| 4 | 0 | 8 | 3 | 0 | 0 |
| 5 | 1 | 9 | 0 | 0 | 0 |

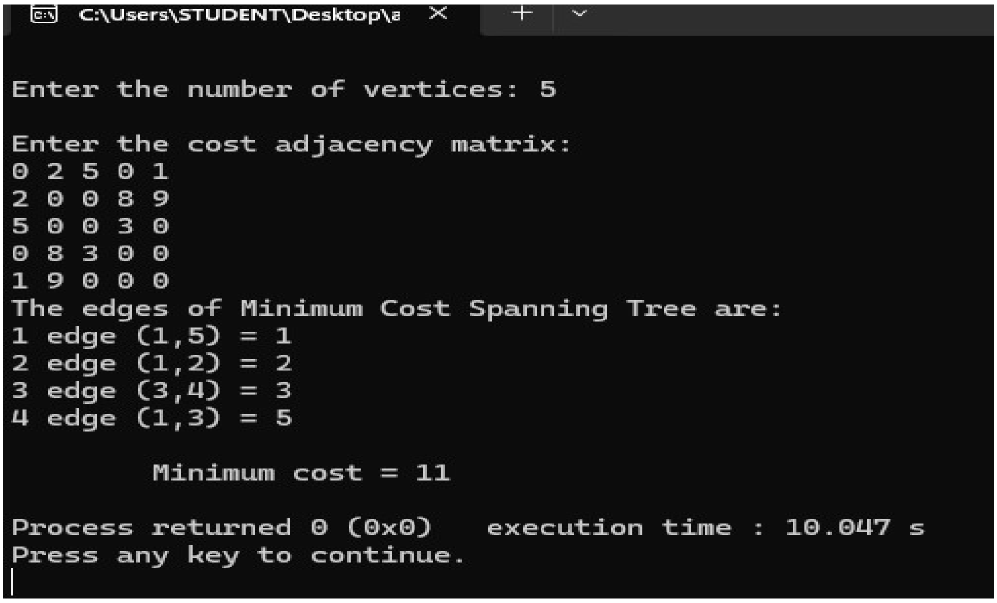
Cost = 1+2+5+3
=11

Q9b) Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal’s algorithm.

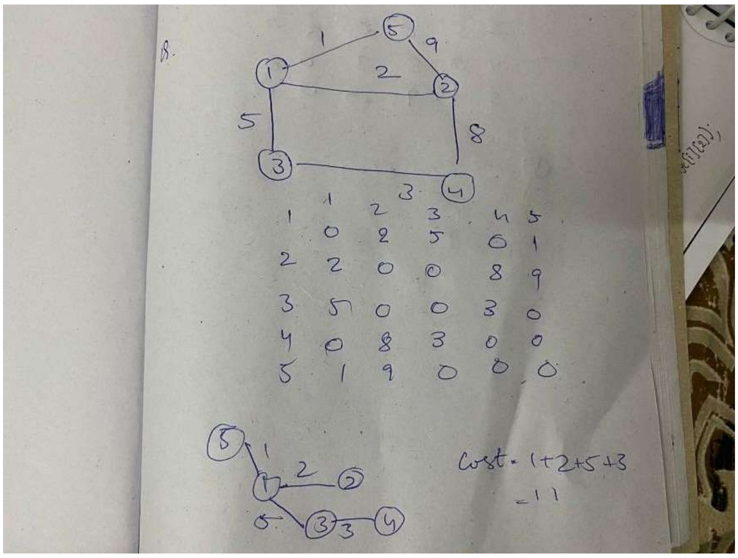
```
#include <stdio.h>
#include <stdlib.h>
int i, j, k, a, b, u, v, n, ne = 1;
int min, mincost = 0, cost[9][9], parent[9];
int find(int i) {
    while (parent[i])
        i = parent[i];
    return i;
}

int uni(int i, int j) {
    if (i != j) {
        parent[j] = i;
        return 1;
    }
    return 0;
}

int main() {
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);

    printf("\nEnter the cost adjacency matrix:\n");
```

```
for (i = 1; i <= n; i++) {
    for (j = 1; j <= n; j++) {
        scanf("%d", &cost[i][j]);
        if (cost[i][j] == 0)
            cost[i][j] = 999;
    }
}
printf("The edges of Minimum Cost Spanning Tree are:\n");
while (ne < n) {
    for (i = 1, min = 999; i <= n; i++) {
        for (j = 1; j <= n; j++) {
            if (cost[i][j] < min) {
                min = cost[i][j];
                a = u = i;
                b = v = j;
            }
        }
    }
    u = find(u);
    v = find(v);
    if (uni(u, v)) {
        printf("%d edge (%d,%d) = %d\n", ne++, a, b, min);
        mincost += min;
    }
```

```
        cost[a][b] = cost[b][a] = 999;
    }
    printf("\n\tMinimum cost = %d\n", mincost);
    return 0;
}
```



```
Enter the number of vertices: 5

Enter the cost adjacency matrix:
0 2 5 0 1
2 0 0 8 9
5 0 0 3 0
0 8 3 0 0
1 9 0 0 0
The edges of Minimum Cost Spanning Tree are:
1 edge (1,5) = 1
2 edge (1,2) = 2
3 edge (3,4) = 3
4 edge (1,3) = 5

        Minimum cost = 11

Process returned 0 (0x0)   execution time : 10.047 s
Press any key to continue.
```



|  | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | 2 | 5 | 0 | 1 |
| 2 | 2 | 0 | 0 | 8 | 9 |
| 3 | 5 | 0 | 0 | 3 | 0 |
| 4 | 0 | 8 | 3 | 0 | 0 |
| 5 | 1 | 9 | 0 | 0 | 0 |

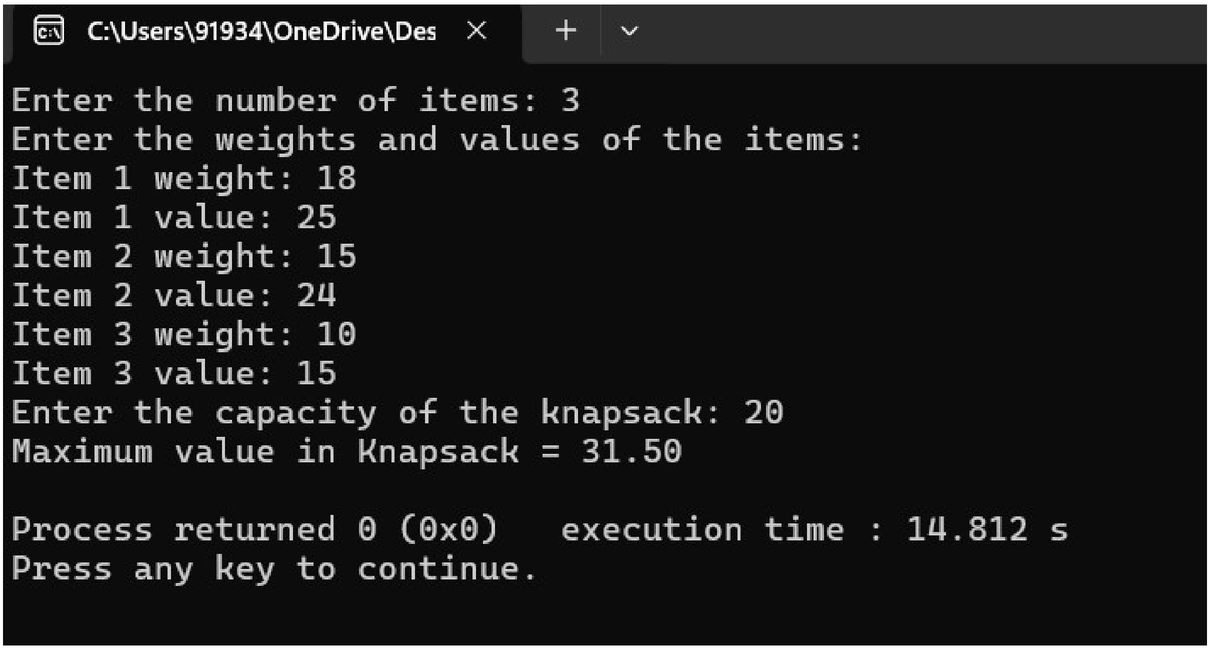
Cost. 1+2+5+3
=11

Q 10) Implement Fractional Knapsack using Greedy technique.

```
#include <stdio.h>

#include <stdlib.h>

double fractionalKnapsack(int n, double W, double weight[], double value[]) {

   double ratio[n];

  for (int i = 0; i < n; i++) {

       ratio[i] = value[i] / weight[i];

   }

   int index[n];

   for (int i = 0; i < n; i++) {

       index[i] = i;

   }

   for (int i = 0; i < n - 1; i++) {

       for (int j = i + 1; j < n; j++) {

           if (ratio[index[i]] < ratio[index[j]]) {

               int temp = index[i];

               index[i] = index[j];

               index[j] = temp;

           }

       }

   }


   double maxVal = 0.0;
```

```
    for (int i = 0; i < n && W > 0; i++) {
        int idx = index[i];
        if (weight[idx] <= W) {
            W -= weight[idx];
            maxVal += value[idx];
        } else {
            maxVal += value[idx] * (W / weight[idx]);
            break;
        }
    }
    return maxVal;
}

int main() {
    int n;
    double W;
    printf("Enter the number of items: ");
    scanf("%d", &n);

    double weight[n], value[n];
    printf("Enter the weights and values of the items:\n");
    for (int i = 0; i < n; i++) {
        printf("Item %d weight: ", i + 1);
        scanf("%lf", &weight[i]);
        printf("Item %d value: ", i + 1);

        scanf("%lf", &value[i]);

    }

    printf("Enter the capacity of the knapsack: ");

    scanf("%lf", &W);

    printf("Maximum value in Knapsack = %.2f\n", fractionalKnapsack(n, W, weight, value));

    return 0;

}
```

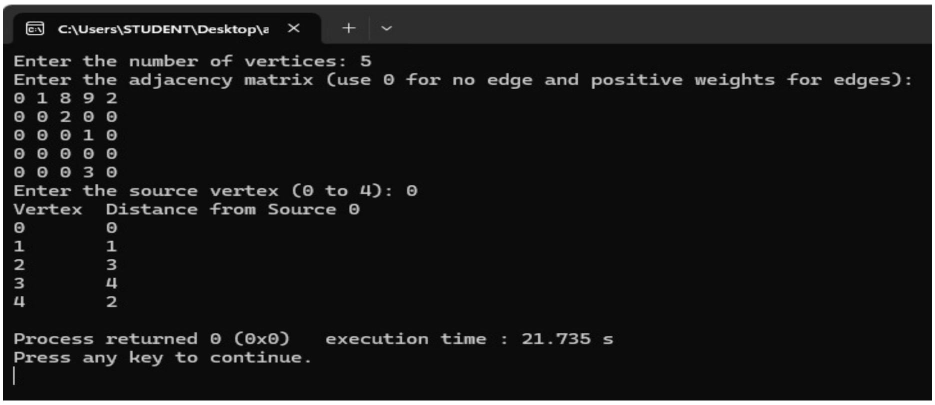
O/P



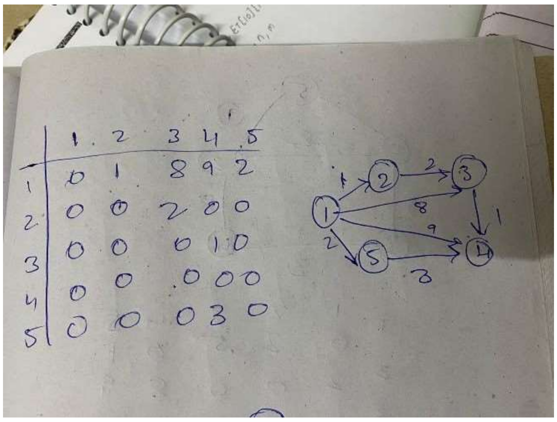
```
Enter the number of items: 3
Enter the weights and values of the items:
Item 1 weight: 18
Item 1 value: 25
Item 2 weight: 15
Item 2 value: 24
Item 3 weight: 10
Item 3 value: 15
Enter the capacity of the knapsack: 20
Maximum value in Knapsack = 31.50

Process returned 0 (0x0)   execution time : 14.812 s
Press any key to continue.
```

Q11) From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra’s algorithm.

```
#include <stdio.h>

#include <limits.h>

#include <stdbool.h>

#define MAX_VERTICES 100

int minDistance(int dist[], bool sptSet[], int V) {

    int min = INT_MAX, min_index;

    for (int v = 0; v < V; v++) {

        if (sptSet[v] == false && dist[v] <= min) {

            min = dist[v];

            min_index = v;

        }

    }

    return min_index;

}

void printSolution(int dist[], int V, int src) {

    printf("Vertex\tDistance from Source %d\n", src);

    for (int i = 0; i < V; i++) {

        printf("%d\t%d\n", i, dist[i]);

    }

}

void dijkstra(int graph[MAX_VERTICES][MAX_VERTICES], int src, int V) {
    int dist[V];
    bool sptSet[V];
    for (int i = 0; i < V; i++) {
        dist[i] = INT_MAX;
        sptSet[i] = false;
    }
    dist[src] = 0;
    for (int count = 0; count < V - 1; count++) {
        int u = minDistance(dist, sptSet, V);
        sptSet[u] = true;
        for (int v = 0; v < V; v++) {
            if (!sptSet[v] && graph[u][v] && dist[u] != INT_MAX && dist[u] + graph[u][v] < dist[v]) {
                dist[v] = dist[u] + graph[u][v];
            }
        }
    }
    printSolution(dist, V, src);
}
int main() {
    int V;
    printf("Enter the number of vertices: ");
    scanf("%d", &V);
    int graph[MAX_VERTICES][MAX_VERTICES];
    printf("Enter the adjacency matrix (use 0 for no edge and positive weights for edges):\n");
    for (int i = 0; i < V; i++) {

        for (int j = 0; j < V; j++) {

            scanf("%d", &graph[i][j]);

        }

    }  int src;

    printf("Enter the source vertex (0 to %d): ", V - 1);

    scanf("%d", &src);

    dijkstra(graph, src, V);

    return 0;

}
```



```
Enter the number of vertices: 5
Enter the adjacency matrix (use 0 for no edge and positive weights for edges):
0 1 8 9 2
0 0 2 0 0
0 0 0 1 0
0 0 0 0 0
0 0 0 3 0
Enter the source vertex (0 to 4): 0
Vertex  Distance from Source 0
0       0
1       1
2       3
3       4
4       2

Process returned 0 (0x0)   execution time : 21.735 s
Press any key to continue.
```



|   | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 8 | 9 | 2 |
| 2 | 0 | 0 | 2 | 0 | 0 |
| 3 | 0 | 0 | 0 | 1 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 3 | 0 |