

ST STEPHEN COLLEGE

UNIVERSITY OF DELHI

COURSE :- BSC (PROG) COMPUTER SCIENCE

SEMESTER :- 3RD

YEAR :- 2025-2026

**PAPER NAME :- DESIGN AND ANALYSIS OF
ALGORITHMS**

UNIQUE PAPER CODE :- 2342572302

PRACTICAL FILE

ROLL NUMBER :- 24080582015

NAME :- VISHAL KUMAR JHA

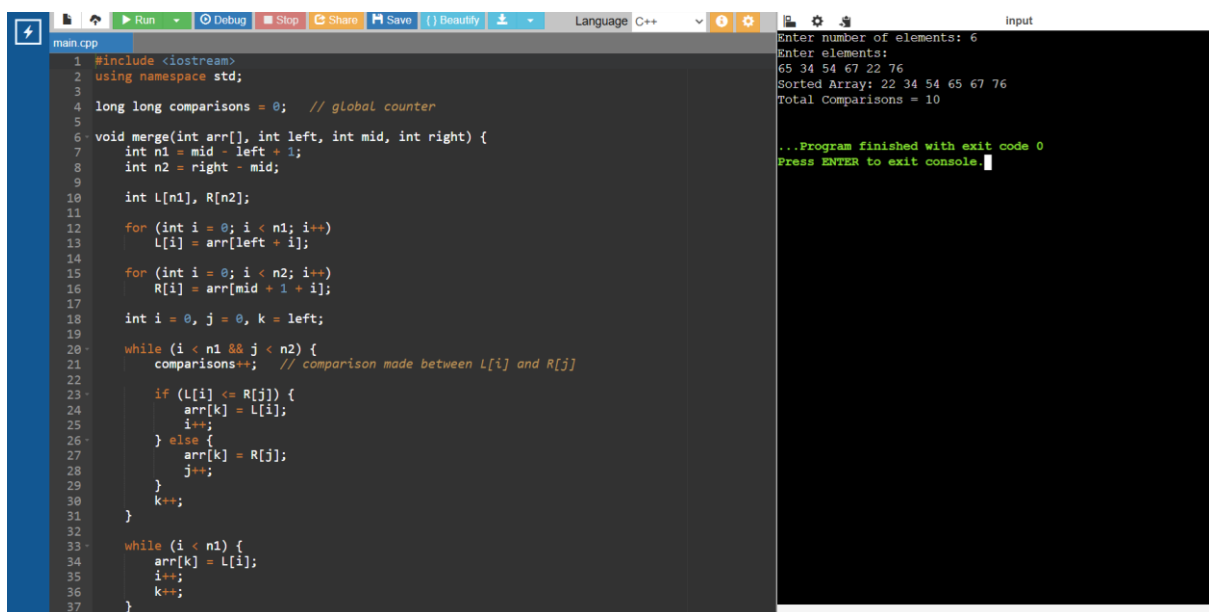
Practical 1 :- Write a program to sort the elements of an array using Insertion Sort (The program should report the number of comparisons).



```
1 #include <iostream>
2 using namespace std;
3
4 int main() {
5     int n;
6     cout << "Enter number of elements: ";
7     cin >> n;
8
9     int arr[n];
10    cout << "Enter elements:\n";
11    for (int i = 0; i < n; i++) {
12        cin >> arr[i];
13    }
14
15    int comparisons = 0;
16
17    // Insertion Sort
18    for (int i = 1; i < n; i++) {
19        int key = arr[i];
20        int j = i - 1;
21
22        while (j >= 0) {
23            comparisons++; // comparison made
24            if (arr[j] > key) {
25                arr[j + 1] = arr[j]; // shifting
26                j--;
27            } else {
28                break;
29            }
30        }
31        arr[j + 1] = key;
32    }
33
34    cout << "Sorted Array: ";
35    for (int i = 0; i < n; i++) {
36        cout << arr[i] << " ";
37    }
38
39    cout << "\nTotal Comparisons = " << comparisons << endl;
40
41    return 0;
42 }
43
```

Enter number of elements: 7
Enter elements:
7 6 5 4 3 2 1
Sorted Array: 1 2 3 4 5 6 7
Total Comparisons = 21
...Program finished with exit code 0
Press ENTER to exit console.

Practical 2 :- Write a program to sort the elements of an array using Merge Sort (The program should report the number of comparisons).



```
1 #include <iostream>
2 using namespace std;
3
4 long long comparisons = 0; // global counter
5
6 void merge(int arr[], int left, int mid, int right) {
7     int n1 = mid - left + 1;
8     int n2 = right - mid;
9
10    int L[n1], R[n2];
11
12    for (int i = 0; i < n1; i++)
13        L[i] = arr[left + i];
14
15    for (int i = 0; i < n2; i++)
16        R[i] = arr[mid + 1 + i];
17
18    int i = 0, j = 0, k = left;
19
20    while (i < n1 && j < n2) {
21        comparisons++; // comparison made between L[i] and R[j]
22
23        if (L[i] <= R[j]) {
24            arr[k] = L[i];
25            i++;
26        } else {
27            arr[k] = R[j];
28            j++;
29        }
30        k++;
31    }
32
33    while (i < n1) {
34        arr[k] = L[i];
35        i++;
36        k++;
37    }
38
39    while (j < n2) {
40        arr[k] = R[j];
41        j++;
42        k++;
43    }
44 }
45
46 int main() {
47     int n;
48     cout << "Enter number of elements: ";
49     cin >> n;
50
51     int arr[n];
52     cout << "Enter elements:\n";
53     for (int i = 0; i < n; i++) {
54         cin >> arr[i];
55     }
56
57     // Merge Sort
58     int left = 0, mid, right = n - 1;
59     mid = (left + right) / 2;
60
61     merge(arr, left, mid, right);
62
63     cout << "Sorted Array: ";
64     for (int i = 0; i < n; i++) {
65         cout << arr[i] << " ";
66     }
67
68     cout << "\nTotal Comparisons = " << comparisons << endl;
69
70     return 0;
71 }
72
```

Enter number of elements: 6
Enter elements:
65 34 54 67 22 76
Sorted Array: 22 34 54 65 67 76
Total Comparisons = 10
...Program finished with exit code 0
Press ENTER to exit console.

```
main.cpp
38
39     while (j < n2) {
40         arr[k] = R[j];
41         j++;
42         k++;
43     }
44 }
45
46 void mergeSort(int arr[], int left, int right) {
47     if (left < right) {
48         int mid = (left + right) / 2;
49
50         mergeSort(arr, left, mid);
51         mergeSort(arr, mid + 1, right);
52         merge(arr, left, mid, right);
53     }
54 }
55
56 int main() {
57     int n;
58     cout << "Enter number of elements: ";
59     cin >> n;
60
61     int arr[n];
62     cout << "Enter elements:\n";
63     for (int i = 0; i < n; i++) {
64         cin >> arr[i];
65     }
66
67     mergeSort(arr, 0, n - 1);
68
69     cout << "Sorted Array: ";
70     for (int i = 0; i < n; i++) {
71         cout << arr[i] << " ";
72     }
73
74     cout << "\nTotal Comparisons = " << comparisons << endl;
75 }
```

Practical 3 :- Write a program to sort the elements of an array using Heap Sort (The program should report the number of comparisons).

```
main.cpp
1 #include <iostream>
2 using namespace std;
3
4 long long comparisons = 0; // global comparison counter
5
6 void heapify(int arr[], int n, int i) {
7     int largest = i;
8     int left = 2 * i + 1;
9     int right = 2 * i + 2;
10
11     // Compare parent with left child
12     if (left < n) {
13         comparisons++; // comparison made
14         if (arr[left] > arr[largest]) {
15             largest = left;
16         }
17     }
18
19     // Compare parent with right child
20     if (right < n) {
21         comparisons++; // comparison made
22         if (arr[right] > arr[largest]) {
23             largest = right;
24         }
25     }
26
27     // If largest is not root
28     if (largest != i) {
29         swap(arr[i], arr[largest]);
30         heapify(arr, n, largest);
31     }
32 }
33
34 void heapSort(int arr[], int n) {
35     // Build max heap
36     for (int i = n / 2 - 1; i >= 0; i--) {
37         heapify(arr, n, i);
38     }
39 }
```

Input

```
Enter number of elements: 7
Enter elements:
98 43 65 22 12 56 89
Sorted Array: 12 22 43 56 65 89 98
Total Comparisons = 16

...Program finished with exit code 0
Press ENTER to exit console.
```

```
main.cpp
32 }
33
34 void heapSort(int arr[], int n) {
35     // Build max heap
36     for (int i = n / 2 - 1; i >= 0; i--) {
37         heapify(arr, n, i);
38     }
39
40     // Extract elements one by one
41     for (int i = n - 1; i > 0; i--) {
42         swap(arr[0], arr[i]);
43         heapify(arr, i, 0);
44     }
45 }
46
47 int main() {
48     int n;
49     cout << "Enter number of elements: ";
50     cin >> n;
51
52     int arr[n];
53     cout << "Enter elements:\n";
54     for (int i = 0; i < n; i++) {
55         cin >> arr[i];
56     }
57
58     heapSort(arr, n);
59
60     cout << "Sorted Array: ";
61     for (int i = 0; i < n; i++) {
62         cout << arr[i] << " ";
63     }
64
65     cout << "\nTotal Comparisons = " << comparisons << endl;
66
67     return 0;
68 }
69
```

Practical 4 :- Write a program to sort the elements of an array using Quick Sort (The program should report the number of comparisons).

```
main.cpp
1 #include <iostream>
2 using namespace std;
3
4 long long comparisons = 0; // global comparison counter
5
6 int partitionArray(int arr[], int low, int high) {
7     int pivot = arr[high]; // choose last element as pivot
8     int i = low - 1;
9
10    for (int j = low; j < high; j++) {
11        comparisons++; // comparison made between arr[j] and pivot
12
13        if (arr[j] <= pivot) {
14            i++;
15            swap(arr[i], arr[j]);
16        }
17    }
18
19    swap(arr[i + 1], arr[high]);
20    return i + 1; // pivot index after partition
21 }
22
23 void quickSort(int arr[], int low, int high) {
24     if (low < high) {
25         int pi = partitionArray(arr, low, high);
26
27         quickSort(arr, low, pi - 1); // Left part
28         quickSort(arr, pi + 1, high); // right part
29     }
30 }
31
32 int main() {
33     int n;
34     cout << "Enter number of elements: ";
35     cin >> n;
36
```

```
input
Enter number of elements: 8
Enter elements:
43 34 12 56 34 89 432 9
Sorted Array: 9 12 34 34 43 56 89 432
Total Comparisons = 19

...Program finished with exit code 0
Press ENTER to exit console.
```

```

31
32 int main() {
33     int n;
34     cout << "Enter number of elements: ";
35     cin >> n;
36
37     int arr[n];
38     cout << "Enter elements:\n";
39     for (int i = 0; i < n; i++) {
40         cin >> arr[i];
41     }
42
43     quickSort(arr, 0, n - 1);
44
45     cout << "Sorted Array: ";
46     for (int i = 0; i < n; i++) {
47         cout << arr[i] << " ";
48     }
49
50     cout << "\nTotal Comparisons = " << comparisons << endl;
51
52     return 0;
53 }
54

```

Practical 5 :- Write a program to multiply two matrices using the Strassen's algorithm for matrix multiplication.

```

1 #include <iostream>
2 using namespace std;
3
4 int main() {
5     int A[2][2], B[2][2], C[2][2];
6
7     cout << "Enter elements of first 2x2 matrix:\n";
8     for (int i = 0; i < 2; i++)
9         for (int j = 0; j < 2; j++)
10             cin >> A[i][j];
11
12     cout << "Enter elements of second 2x2 matrix:\n";
13     for (int i = 0; i < 2; i++)
14         for (int j = 0; j < 2; j++)
15             cin >> B[i][j];
16
17     // Strassen's 7 products
18     int M1 = (A[0][0] + A[1][1]) * (B[0][0] + B[1][1]);
19     int M2 = (A[1][0] + A[1][1]) * B[0][0];
20     int M3 = A[0][0] * (B[0][1] - B[1][1]);
21     int M4 = A[1][1] * (B[1][0] - B[0][0]);
22     int M5 = (A[0][0] + A[0][1]) * B[1][1];
23     int M6 = (A[1][0] - A[0][0]) * (B[0][0] + B[0][1]);
24     int M7 = (A[0][1] - A[1][1]) * (B[1][0] + B[1][1]);
25
26     // Result matrix
27     C[0][0] = M1 + M4 - M5 + M7;
28     C[0][1] = M3 + M5;
29     C[1][0] = M2 + M4;
30     C[1][1] = M1 - M2 + M3 + M6;
31
32     cout << "\nResultant Matrix (A * B using Strassen):\n";
33     for (int i = 0; i < 2; i++) {
34         for (int j = 0; j < 2; j++)
35             cout << C[i][j] << " ";
36         cout << endl;
37     }
38 }

```

Input

```

Enter elements of first 2x2 matrix:
4 5 6 7
Enter elements of second 2x2 matrix:
9 5 2 8

Resultant Matrix (A * B using Strassen):
46 60
68 86

...Program finished with exit code 0
Press ENTER to exit console.

```

Practical 6 :- Write a program to sort the elements of an array using Count Sort

```
main.cpp
1 #include <iostream>
2 using namespace std;
3
4 int main() {
5     int n;
6     cout << "Enter number of elements: ";
7     cin >> n;
8
9     int arr[n];
10    cout << "Enter elements:\n";
11    for (int i = 0; i < n; i++)
12        cin >> arr[i];
13
14    // Find maximum element
15    int maxVal = arr[0];
16    for (int i = 1; i < n; i++)
17        if (arr[i] > maxVal)
18            maxVal = arr[i];
19
20    // Create count array
21    int count[maxVal + 1] = {0};
22
23    // Store frequency of each element
24    for (int i = 0; i < n; i++)
25        count[arr[i]]++;
26
27    // Reconstruct the sorted array
28    int index = 0;
29    for (int i = 0; i <= maxVal; i++) {
30        while (count[i] > 0) {
31            arr[index++] = i;
32            count[i]--;
33        }
34    }
35}
```

Enter number of elements: 7
Enter elements:
43 56 98 21 34 67 2
Sorted Array: 2 21 34 43 56 67 98
...Program finished with exit code 0
Press ENTER to exit console.

```
36 // Output sorted array
37 cout << "Sorted Array: ";
38 for (int i = 0; i < n; i++)
39     cout << arr[i] << " ";
40
41 cout << endl;
42 return 0;
43 }
44
```

Practical 7 :- Display the data stored in a given graph using the Breadth-First Search algorithm

```
main.cpp
1 #include <iostream>
2 #include <queue>
3 #include <vector>
4 using namespace std;
5
6 void BFS(int start, vector<vector<int>>& graph, int n) {
7     vector<bool> visited(n, false);
8     queue<int> q;
9
10    visited[start] = true;
11    q.push(start);
12
13    cout << "BFS Traversal: ";
14
15    while (!q.empty()) {
16        int node = q.front();
17        q.pop();
18        cout << node << " ";
19
20        for (int adj : graph[node]) {
21            if (!visited[adj]) {
22                visited[adj] = true;
23                q.push(adj);
24            }
25        }
26    }
27 }
28
29 int main() {
30     int n, edges;
31     cout << "Enter number of vertices: ";
32     cin >> n;
33
34     cout << "Enter number of edges: ";
35     cin >> edges;
36
37     vector<vector<int>> graph(n);
38 }
```

Enter number of vertices: 5
Enter number of edges: 6
Enter edges (u v):
0 1
0 2
1 3
1 4
2 3
3 4
Enter starting vertex: 0
BFS Traversal: 0 1 2 3 4
...Program finished with exit code 0
Press ENTER to exit console.

Practical 8 :- Display the data stored in a given graph using the Depth-First Search algorithm.

```

main.cpp
1 #include <iostream>
2 #include <vector>
3 using namespace std;
4
5 void DFS(int node, vector<vector<int>>& graph, vector<bool>& visited) {
6     visited[node] = true;
7     cout << node << " ";
8
9     for (int adj : graph[node]) {
10        if (!visited[adj]) {
11            DFS(adj, graph, visited);
12        }
13    }
14 }
15
16 int main() {
17     int n, edges;
18     cout << "Enter number of vertices: ";
19     cin >> n;
20
21     cout << "Enter number of edges: ";
22     cin >> edges;
23
24     vector<vector<int>> graph(n);
25     cout << "Enter edges (u v):\n";
26
27     for (int i = 0; i < edges; i++) {
28         int u, v;
29         cin >> u >> v;
30         graph[u].push_back(v);
31         graph[v].push_back(u); // undirected graph
32     }
33
34     int start;
35     cout << "Enter starting vertex: ";
36     cin >> start;
37
38     vector<bool> visited(n, false);
39
40     cout << "DFS Traversal: ";
41     DFS(start, graph, visited);
42
43     return 0;
44 }
45

```

Enter number of vertices: 5
Enter number of edges: 6
Enter edges (u v):
0 1
0 2
1 3
1 4
2 3
3 4
Enter starting vertex: 0
DFS Traversal: 0 1 3 2 4
...Program finished with exit code 0
Press ENTER to exit console.

```

33
34     int start;
35     cout << "Enter starting vertex: ";
36     cin >> start;
37
38     vector<bool> visited(n, false);
39
40     cout << "DFS Traversal: ";
41     DFS(start, graph, visited);
42
43     return 0;
44 }
45

```

Practical 9 :- Write a program to determine a minimum spanning tree of a graph using the Prim's algorithm.

```

main.cpp
1 #include <iostream>
2 using namespace std;
3
4 #define INF 999999
5
6 int main() {
7     int n;
8     cout << "Enter number of vertices: ";
9     cin >> n;
10
11     int graph[20][20];
12     cout << "Enter adjacency matrix (0 for no edge):\n";
13
14     for (int i = 0; i < n; i++) {
15         for (int j = 0; j < n; j++) {
16             cin >> graph[i][j];
17             if (graph[i][j] == 0 && i != j)
18                 graph[i][j] = INF; // treat 0 as no edge
19         }
20     }
21
22     int visited[20] = {0};
23     visited[0] = 1; // start from vertex 0
24
25     int edges = 0;
26     int minCost = 0;
27
28     cout << "\nEdges in Minimum Spanning Tree:\n";
29
30     while (edges < n - 1) {
31         int u = -1, v = -1, min = INF;
32
33         // Find minimum edge
34         for (int i = 0; i < n; i++) {
35             if (visited[i]) {
36                 for (int j = 0; j < n; j++) {
37                     if (!visited[j] && graph[i][j] < min) {
38                         min = graph[i][j];
39                         u = i, v = j;
40                     }
41                 }
42             }
43         }
44
45         if (u != -1 && v != -1) {
46             edges++;
47             minCost += min;
48             visited[v] = 1;
49         }
50     }
51
52     cout << "\nMinimum Cost = " << minCost << endl;
53
54     return 0;
55 }

```

Enter number of vertices: 5
Enter adjacency matrix (0 for no edge):
0 2 0 6 0
2 0 3 8 5
0 3 0 0 7
6 8 0 0 9
0 5 7 9 0
Edges in Minimum Spanning Tree:
0 - 1 : 2
1 - 2 : 3
1 - 4 : 5
0 - 3 : 6
Minimum Cost = 16
...Program finished with exit code 0
Press ENTER to exit console.

```

29
30 while (edges < n - 1) {
31     int u = -1, v = -1, min = INF;
32
33     // Find minimum edge
34     for (int i = 0; i < n; i++) {
35         if (visited[i]) {
36             for (int j = 0; j < n; j++) {
37                 if (!visited[j] && graph[i][j] < min) {
38                     min = graph[i][j];
39                     u = i;
40                     v = j;
41                 }
42             }
43         }
44     }
45
46     cout << u << " - " << v << " : " << graph[u][v] << endl;
47     minCost += graph[u][v];
48     visited[v] = 1;
49     edges++;
50 }
51
52 cout << "\nMinimum Cost = " << minCost << endl;
53
54 return 0;
55 }
56

```

Practical 10 :- Write a program to determine the shortest path from a given node s to the other nodes of a graph using the Dijkstra's algorithm.

```

main.cpp
1 #include <iostream>
2 using namespace std;
3
4 #define INF 999999
5
6 int main() {
7     int n;
8     cout << "Enter number of vertices: ";
9     cin >> n;
10
11     int graph[20][20];
12     cout << "Enter adjacency matrix (0 for no edge):\n";
13
14     for (int i = 0; i < n; i++) {
15         for (int j = 0; j < n; j++) {
16             cin >> graph[i][j];
17             if (graph[i][j] == 0 && i != j)
18                 graph[i][j] = INF; // treat 0 as no connection
19         }
20     }
21
22     int src;
23     cout << "Enter source vertex: ";
24     cin >> src;
25
26     int dist[20]; // shortest distance
27     int visited[20]; // visited nodes
28
29     // Initialization
30     for (int i = 0; i < n; i++) {
31         dist[i] = graph[src][i];
32         visited[i] = 0;
33     }
34     dist[src] = 0;
35     visited[src] = 1;
36

```

input

```

Enter number of vertices: 5
Enter adjacency matrix (0 for no edge):
0 10 0 30 100
10 0 50 0 0
0 50 0 20 10
30 0 20 0 60
100 0 10 60 0
Enter source vertex: 0

Shortest distances from source vertex 0:
To vertex 0 = 0
To vertex 1 = 10
To vertex 2 = 50
To vertex 3 = 30
To vertex 4 = 60

...Program finished with exit code 0
Press ENTER to exit console.

```

```

36
37 // Dijkstra's main Loop
38 for (int count = 1; count < n; count++) {
39     int minDist = INF, u = -1;
40
41     // Pick unvisited vertex with smallest distance
42     for (int i = 0; i < n; i++) {
43         if (!visited[i] && dist[i] < minDist) {
44             minDist = dist[i];
45             u = i;
46         }
47     }
48
49     visited[u] = 1;
50
51     // Update distances
52     for (int v = 0; v < n; v++) {
53         if (!visited[v] && dist[u] + graph[u][v] < dist[v]) {
54             dist[v] = dist[u] + graph[u][v];
55         }
56     }
57 }
58
59 // Output
60 cout << "\nShortest distances from source vertex " << src << ":\n";
61 for (int i = 0; i < n; i++) {
62     cout << "To vertex " << i << " = " << dist[i] << endl;
63 }
64
65 return 0;
66 }
67

```

Practical 11 :- Write a program to solve the 0-1 knapsack problem using Dynamic Programming.

The screenshot shows a C++ IDE with a file named 'main.cpp'. The code implements a dynamic programming solution for the 0-1 knapsack problem. It prompts the user for the number of items, their weights, profits, and the knapsack capacity. It then calculates the maximum profit and displays it.

```

1 #include <iostream>
2 using namespace std;
3
4 int main() {
5     int n, W;
6     cout << "Enter number of items: ";
7     cin >> n;
8
9     int weight[n], profit[n];
10
11     cout << "Enter weights of items:\n";
12     for (int i = 0; i < n; i++)
13         cin >> weight[i];
14
15     cout << "Enter profits of items:\n";
16     for (int i = 0; i < n; i++)
17         cin >> profit[i];
18
19     cout << "Enter capacity of knapsack: ";
20     cin >> W;
21
22     int dp[n + 1][W + 1];
23
24     // Build DP table
25     for (int i = 0; i <= n; i++) {
26         for (int w = 0; w <= W; w++) {
27             if (i == 0 || w == 0)
28                 dp[i][w] = 0;
29             else if (weight[i - 1] <= w)
30                 dp[i][w] = max(profit[i - 1] + dp[i - 1][w - weight[i - 1]],
31                                dp[i - 1][w]);
32             else
33                 dp[i][w] = dp[i - 1][w];
34         }
35     }
36
37     cout << "\nMaximum Profit = " << dp[n][W] << endl;
38 }

```

The output window shows the following input and output:

```

Enter number of items: 4
Enter weights of items:
2 3 4 5
Enter profits of items:
3 4 5 6
Enter capacity of knapsack: 5
Maximum Profit = 7
...Program finished with exit code 0
Press ENTER to exit console

```

```

    cout << "\nMaximum Profit = " << dp[n][W] << endl;

    return 0;
}

```