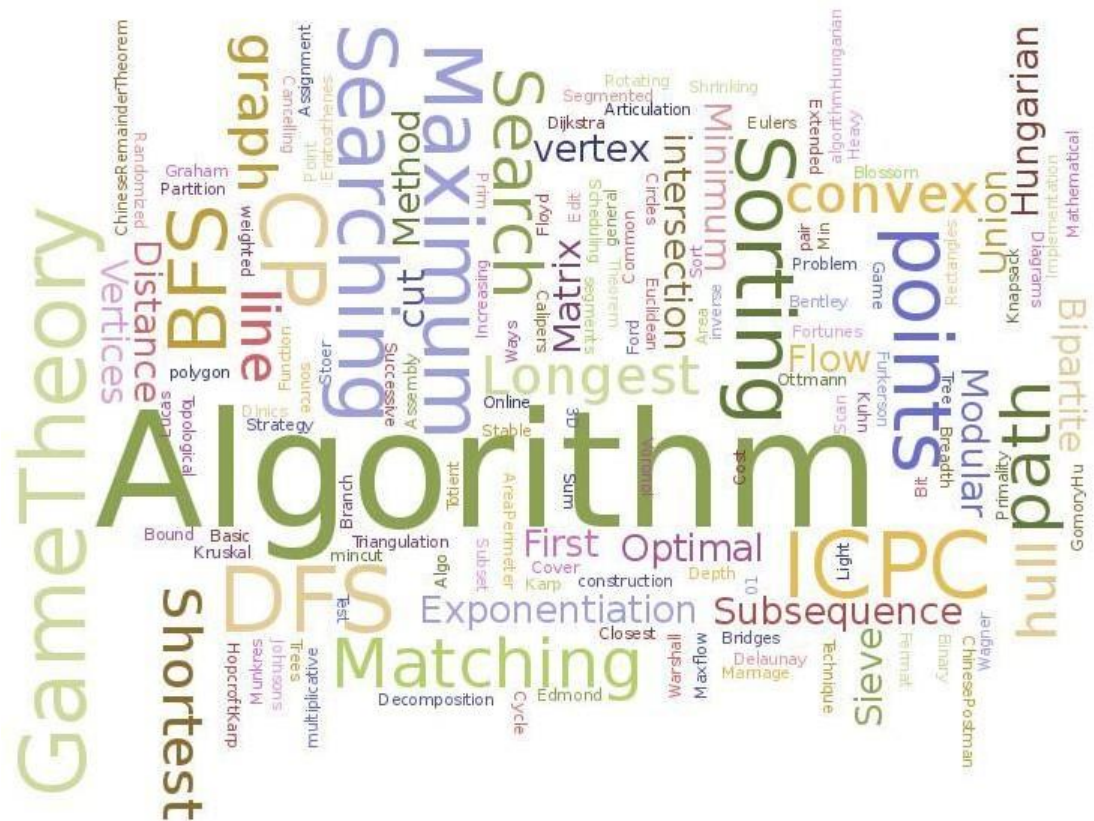




**SCHOOL OF  
COMPUTING**

# Design and Analysis of Algorithms Lab 3 Report

(Course Code: 23CSE211)



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## Programs and Their Space Complexities

Date: 27-11-2025

1. Write a program to find the sum of first  $n$  natural numbers using a function.
2. Write a program to find the sum of squares of first  $n$  natural numbers.
3. Write a program to find the sum of cubes of first  $n$  natural numbers.
4. Write a program to find factorial of a number using a recursive function.
5. Write a program to find the transpose of a  $3 \times 3$  matrix.
6. Write a program to print the Fibonacci series using recursion.

### Solutions:

Write a program to find the sum of first  $n$  natural numbers using a function.

```
#include <stdio.h>

int sumOfNums(int n){
    return ((n*(n+1))/2);
}

int main(){
    int n;
    scanf("%d", &n);
    int sum = sumOfNums(n);
    printf("The sum is: %d\n", sum);
}
```

**Justification:** Uses the formula  $n(n+1)/2$ , which calculates the total directly.

**Space Complexity:**  $O(1)$

Write a program to find the sum of squares of first  $n$  natural numbers.

```
#include <stdio.h>

int sumOfSquaresNums(int n){
    return ((n*(n+1)*(2*n+1))/6);
}

int main(){
    int n;
    scanf("%d", &n);
    int sum = sumOfSquaresNums(n);
    printf("The sum is: %d\n", sum);
}
```

**Justification:** Uses the formula  $n(n+1)(2n+1)/6$ , computes the sum directly.

**Space Complexity:**  $O(1)$

Write a program to find the sum of cubes of first  $n$  natural numbers.

```
#include <stdio.h>

int sumOfCubeNums(int n){
    return ((n*n*(n+1)*(n+1))/4);
}

int main(){
    int n;
    scanf("%d", &n);
    int sum = sumOfCubeNums(n);
    printf("The sum is: %d\n", sum);
}
```

**Justification:** Uses the formula  $[(n(n+1))/2]^2$ , which calculates the total directly.

**Space Complexity:**  $O(1)$

Write a program to find factorial of a number using a recursive function.

```
#include <stdio.h>

int factorial(int n){
    if(n == 0 || n == 1){
        return 1;
    }
    else{
        return n*factorial(n-1);
    }
}

int main(){
    int n;
    scanf("%d", &n);
    int res = factorial(n);
    printf("The factorial is: %d\n", res);
}
```

**Justification:** Uses recursive calls that reduce n step-by-step until the base case is reached.

**Space Complexity:** O(n)

Write a program to find the transpose of a 3×3 matrix.

```
#include <stdio.h>

int main(){
    int arr[3][3];
    for(int i = 0; i<3; i++){
        for(int j = 0; j<3; j++){
            scanf("%d", &arr[j][i]);
        }
    }

    for(int i = 0; i<3; i++){
        for(int j = 0; j<3; j++){
            printf("%d ", arr[i][j]);
        }
        printf("\n");
    }
}
```

**Justification:** Uses a fixed 3×3 array and stores each element directly in its transposed position during input.

**Space Complexity:** O(1)

Write a program to print the Fibonacci series using recursion.

```
#include <stdio.h>

int fibonacci(int n){
    if(n == 1){
        return 0;
    } else if (n == 2){
        return 1;
    }
    else{
        return fibonacci(n-1) + fibonacci(n-2);
    }
}

int main(){
    int n;
    scanf("%d", &n);
    for(int i = 1; i ≤ n; i++){
        printf("%d ", fibonacci(i));
    }
}
```

**Justification:** Uses recursive calls that expand until the base cases are reached.

**Space Complexity:**  $O(n)$

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# Sorting Techniques

Date: 04-12-2025

1. Bubble Sort in C
2. Insertion Sort in C
3. Selection Sort in C
4. Bucket Sort in C
5. Heap Sort in C (Max Heap)
6. Heap Sort in C (Min Heap)

## Bubble Sort in C

```
#include <stdio.h>

void bubbleSort(int a[], int n) {
    for(int i = 0; i < n-1; i++) {
        for(int j = 0; j < n-i-1; j++) {
            if(a[j] > a[j+1]) {
                int temp = a[j];
                a[j] = a[j+1];
                a[j+1] = temp;
            }
        }
    }
}

int main() {
    int a[] = {5, 1, 4, 2, 8};
    int n = sizeof(a)/sizeof(a[0]);
    bubbleSort(a, n);
    for(int i = 0; i < n; i++) printf("%d ", a[i]);
    return 0;
}
```

Output:

```
● PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc bubblesort.c
● PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe
  1 2 4 5 8
○ PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █
```

**Time Complexity (Worst):**  $O(n^2)$

**Justification:** Every pass compares and swaps almost all elements.

**Space Complexity (Worst):**  $O(1)$

**Justification:** In-place sorting using only a temporary variable

## Insertion Sort in C

```
#include <stdio.h>

void insertionSort(int a[], int n){
    for (int i = 1; i < n; i++){
        int key = a[i];
        int j = i - 1;

        while (j ≥ 0 && a[j] > key){
            a[j + 1] = a[j];
            j--;
        }
        a[j + 1] = key;
    }
}

int main(){
    int a[] = {12, 11, 13, 5, 6};
    int n = sizeof(a) / sizeof(a[0]);

    insertionSort(a, n);

    for (int i = 0; i < n; i++)
        printf("%d ", a[i]);
    return 0;
}
```

Output:

- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc insertionsort.c
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe  
5 6 11 12 13
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █

**Time Complexity (Worst):**  $O(n^2)$

**Justification:** Each new element may shift through the entire sorted portion.

**Space Complexity (Worst):**  $O(1)$

**Justification:** Uses the same array for sorting.

## Selection Sort in C

```
#include <stdio.h>

void selectionSort(int a[], int n){
    for (int i = 0; i < n - 1; i++){
        int min = i;
        for (int j = i + 1; j < n; j++){
            if (a[j] < a[min])
                min = j;
        }
        int temp = a[i];
        a[i] = a[min];
        a[min] = temp;
    }
}

int main(){
    int a[] = {64, 25, 12, 22, 11};
    int n = sizeof(a) / sizeof(a[0]);

    selectionSort(a, n);

    for (int i = 0; i < n; i++)
        printf("%d ", a[i]);
    return 0;
}
```

Output:

- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc selectionsort.c
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe  
11 12 22 25 64
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █

**Time Complexity (Worst):**  $O(n^2)$

**Justification:** Always scans remaining elements to find the minimum.

**Space Complexity (Worst):**  $O(1)$

**Justification:** Only one extra variable is used.



## Bucket Sort in C

```
#include <stdio.h>

#define MAX 100

void bucketSort(int a[], int n){
    int bucket[MAX] = {0};

    for (int i = 0; i < n; i++)
        bucket[a[i]]++;

    int k = 0;
    for (int i = 0; i < MAX; i++)
        while (bucket[i]--){
            a[k++] = i;
        }
}

int main(){
    int a[] = {4, 1, 3, 4, 2, 8, 7};
    int n = sizeof(a) / sizeof(a[0]);
    bucketSort(a, n);
    for (int i = 0; i < n; i++)
        printf("%d ", a[i]);
    return 0;
}
```

Output:

- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc bucketsort.c
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe  
1 2 3 4 4 7 8
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █

**Time Complexity (Worst):**  $O(n^2)$

**Justification:** All elements may fall into a single bucket.

**Space Complexity (Worst):**  $O(n + k)$

**Justification:** Requires extra buckets plus storage for all elements.

## Heap Sort using Max Heap in C

```
#include <stdio.h>

void heapifyMax(int a[], int n, int i){
    int largest = i;
    int left = 2 * i + 1;
    int right = 2 * i + 2;

    if (left < n && a[left] > a[largest])
        largest = left;
    if (right < n && a[right] > a[largest])
        largest = right;

    if (largest != i){
        int temp = a[i];
        a[i] = a[largest];
        a[largest] = temp;

        heapifyMax(a, n, largest);
    }
}

void heapSortMax(int a[], int n){
    for (int i = n / 2 - 1; i ≥ 0; i--){
        heapifyMax(a, n, i);
    }

    for (int i = n - 1; i ≥ 0; i--){
        int temp = a[0];
        a[0] = a[i];
        a[i] = temp;

        heapifyMax(a, i, 0);
    }
}

int main(){
    int a[] = {10, 7, 9, 2, 15};
    int n = sizeof(a) / sizeof(a[0]);
    heapSortMax(a, n);
    for (int i = 0; i < n; i++){
        printf("%d ", a[i]);
    }
    return 0;
}
```

Output:

- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc maxheapsort.c
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe  
2 7 9 10 15
- PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █

**Time Complexity (Worst):**  $O(n \log n)$

**Justification:** Each of the  $n$  deletions requires heapify ( $\log n$ ).

**Space Complexity (Worst):**  $O(1)$

**Justification:** Array-based heap uses no extra memory.

## Heap Sort using Min Heap in C

```
#include <stdio.h>

void heapifyMin(int a[], int n, int i){
    int smallest = i;
    int left = 2 * i + 1;
    int right = 2 * i + 2;

    if (left < n && a[left] < a[smallest])
        smallest = left;
    if (right < n && a[right] < a[smallest])
        smallest = right;

    if (smallest != i){
        int temp = a[i];
        a[i] = a[smallest];
        a[smallest] = temp;

        heapifyMin(a, n, smallest);
    }
}

void heapSortMin(int a[], int n){
    for (int i = n / 2 - 1; i ≥ 0; i--){
        heapifyMin(a, n, i);
    }

    for (int i = n - 1; i ≥ 0; i--){
        int temp = a[0];
        a[0] = a[i];
        a[i] = temp;

        heapifyMin(a, i, 0);
    }
}

int main(){
    int a[] = {12, 3, 19, 6, 5};
    int n = sizeof(a) / sizeof(a[0]);
    heapSortMin(a, n);
    for (int i = 0; i < n; i++){
        printf("%d ", a[i]);
    }
    return 0;
}
```

Output:

```
● PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc minheapsort.c
● PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe
  19 12 6 5 3
○ PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █
```

**Time Complexity (Worst):**  $O(n \log n)$

**Justification:** Same heap operations as max heap.

**Space Complexity (Worst):**  $O(1)$

**Justification:** Sorting is done in-place.

# Path Tracing Algorithms

Date: 11-12-2025

1. Breadth first search in C
2. Depth first search in C

## Breadth First Search in C

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

#define MAX 100

typedef struct Node{
    int vertex;
    struct Node *next;
} Node;

Node *adjList[MAX];
int visited[MAX];
int queue[MAX];
int front = 0, rear = -1;

void addEdge(int u, int v){
    Node *newNode = (Node *)malloc(sizeof(Node));
    newNode->vertex = v;
    newNode->next = adjList[u];
    adjList[u] = newNode;
}

void BFS(int start){
    visited[start] = 1;
    queue[++rear] = start;

    printf("BFS Traversal: ");

    while (front ≤ rear){
        int curr = queue[front++];
        printf("%d ", curr);

        Node *temp = adjList[curr];
        while (temp ≠ NULL){
            if (!visited[temp->vertex]){
                visited[temp->vertex] = 1;
                queue[++rear] = temp->vertex;
            }
            temp = temp->next;
        }
    }
}
```

```

int main(){
    int n = 5;
    for (int i = 0; i < n; i++)
        adjList[i] = NULL;

    addEdge(0, 1);
    addEdge(0, 2);
    addEdge(1, 3);
    addEdge(2, 4);

    BFS(0, n);
    return 0;
}

```

Output:

```

• PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc bfs.c
• PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe
  BFS Traversal: 0 2 1 4 3
○ PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █

```

**Time Complexity (Worst Case):  $O(V + E)$**

**Justification for Time Complexity:** BFS visits every vertex once and checks every edge once while exploring adjacency lists. Hence total work is proportional to the number of vertices plus edges.

**Space Complexity (Worst Case):  $O(V)$**

**Justification for Space Complexity:** The queue can hold up to  $V$  vertices in the worst case, and the visited[] array also requires  $O(V)$ . (Adjacency list is part of input storage.)

## Depth First Search in C

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

#define MAX 100

typedef struct Node{
    int vertex;
    struct Node *next;
} Node;

Node *adjList[MAX];
int visited[MAX];

void addEdge(int u, int v){
    Node *newNode = (Node *)malloc(sizeof(Node));
    newNode->vertex = v;
    newNode->next = adjList[u];
    adjList[u] = newNode;
}

void DFS(int v){
    visited[v] = 1;
    printf("%d ", v);

    Node *temp = adjList[v];
    while (temp != NULL){
        if (!visited[temp->vertex]){
            DFS(temp->vertex);
        }
        temp = temp->next;
    }
}

int main(){
    int n = 5;
    for (int i = 0; i < n; i++){
        adjList[i] = NULL;
        visited[i] = 0;
    }

    addEdge(0, 1);
    addEdge(0, 2);
    addEdge(1, 3);
    addEdge(2, 4);

    printf("DFS Traversal: ");
    DFS(0);

    return 0;
}
```

Output:

```
● PS C:\Users\sarva\OneDrive\Desktop\daa-lab> gcc dfs.c
● PS C:\Users\sarva\OneDrive\Desktop\daa-lab> ./a.exe
  DFS Traversal: 0 2 4 1 3
○ PS C:\Users\sarva\OneDrive\Desktop\daa-lab> █
```

**Time Complexity (Worst Case):  $O(V + E)$**

**Justification for Time Complexity:** DFS recursively explores every vertex and inspects all edges exactly once through the adjacency list, giving a total cost of  $V + E$ .

**Space Complexity (Worst Case):  $O(V)$**

**Justification for Space Complexity:** The recursion stack can grow up to  $V$  levels (in a straight-chain graph), and the `visited[]` array stores  $V$  entries.

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